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SUMMARY

Corruption as Constraint in SMEs Financial Management (I – Concept and Economic Impact)

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Abstract ***–The importance of the SMEs in economy and society is considerable, contributing to economic growth, stimulating entrepreneurship, innovation, employment or state budget revenues. However, SMEs face to many financial and organizational constraints, and various data and studies suggest that the effects of these constraints are much higher for SMEs than for large companies. Corruption is an element that reduces performance of businesses, whether we talk about petty of corruption (bribery, speed money, gifts, un-official fees) or grand corruption, kickbacks, or other interactions between interest of large companies, corrupt politicians or hidden commissioners. While some scholars consider bribery as a factor driving the rapid delivery of government services or an opportunity for SMEs representative to clever bypass some bureaucratic barriers, we have to admit corruption is a negative phenomenon, and SMEs have fewer chances to fight against them if they are not supported by strong measures from the authorities or society. In this first part of our work we aimed to investigate corruption that acts as a financial constraint on SMEs, decreasing their chances of growth and consolidation, affecting business and economic outlook, reducing society confidence in institutions and honest business.***

Keywords: ***SMEs, corruption, financial constraints, growth***

I. INTRODUCTION

SMEs represent in current society a vibrant reality that can hardly be ignored or discouraged. According to United Nations- Industrial Development Organization [1], out that of the 75 million companies existing across the globe, around 90% are small and medium-sized enterprises (SMEs), representing for many people not only o chance to life or welfare, but a dynamic way to create economic growth and employment, a sector where is produced an important part of the world industrial output [2].

The European Commission [3], cites that SMEs play a central role in the European economy, as a main source of entrepreneurial skills and innovation, enhance competition and thus has a positive impact to innovation and economic and productivity growth.

SMEs have an important share in employment and GDP all around the world, especially in developing countries, taking into account the informal sector. Thus, in developed countries, SMEs employ around 67 % of the formal employment in the manufacturing sector, in developing countries this number is around 45 percent. In term of GDP contribution, SME have around 49% in high-income countries and 29% in low-income countries, respectively [4]. SMEs stimulate employment in greater extent than large companies, being more labor intensive and contribute positively to a competitive market system [5], [6] . SMEs generate positive externalities or spill-over effects [7], [5], thereby helping to mitigate the dramatic effects of poverty, efficiently using the available resources offered by the authorities concerned in creation of a strong SME sector.

Furthermore, some scholars have demonstrated that an economy in expansion is necessarily associated with a dynamic SMEs sector [5], stressing, at the same time, that this dynamism and expansiveness of the SMEs should be supported, ”an effective business environment with regulatory conditions that favour SMEs is a necessary factor for SMEs to thrive and prosper” [7].

Starting from these attributes the researchers warn that we should not see SMEs as a panacea for all the problems of contemporary society and economy and the role of SMEs to the environment in which they operate should not be exaggerated. Thus, without diminishing the important role of SMEs in the field of employment and income, stability or innovation, there are numerous opinions that shows in many cases large companies offer a more stable employment, higher wages and other non-wage benefits, access to personal development, invest more in research and applicative new technologies, promote a sound governance principle, contributing not only to economic growth but to a more competitive society. Moreover, their market power, good

government relations or lobby activities can influence many political decisions.

Starting from these arguments, and not only, we have to understand that small businesses are not 'scaled-down versions' of large businesses, the process by which a large business has achieved its current size is of course one of evolution rather than scaling [8].

In developing economies, SMEs could contribute more to economic development than they currently do. Even there are a significant number of SMEs in developing countries, there size is still small both in employment, both in turnover. The fact that SMEs tend to be smaller in developing countries suggests that they face greater constraints to growth (financial, environment, regulation, market power etc.).

The main constraints which limited the growth and strengthening of SMEs are:

- insufficient resources, in terms of managerial, staff capabilities, technological, and informational access, and, very important, financial resources:

- the nature on capital and ownership. As if in the early stages, the centralized decision-making, involvement of the owner as manager in the SMEs business is essential, later, a body of professional managers is more suitable for consolidation stages. As a result, the more centralized decision-making for SMEs can be a limited factor for SMEs evolution

- SMEs has an ambivalent approach to innovative technologies, and, in an objective manner, have insufficient resources to invest in research and development. Comparing with large companies SME has a little protection to technological movement in external environment, are often less competitive, their product has a limited possibility to include technical progress, or to anticipate market shifts, have lower possibilities to access the external markets.

Although large firms generally face the same constraints, the general opinion is that the large firms are to be much less constrained by the lack of access to financing, at all income levels, comparing with small firms. According to World Bank research [4], SMEs face more severe financial constraint than do large firms, the smallest firms are most adversely affected by financial and non-financial constraints, and that these constraints are particularly severe in developing countries [5]. Specific constraints will have a disproportionate effect on SMEs from developing countries compared to SMEs from developed markets.

SMEs are faced with a multitude of constraints, but which can be reduced to three major categories – financial, legal, and corruption – all negatively affecting the chances to growth of these firms [5].

II. CORRUPTION AS A CONSTRAINT. TYPES AND EXTENT

Trying to have a concise definition of corruption is quite difficult, different countries have different answers or interpretation to these question, and international institutions or organization add a new perspective of this concept so we understand why a broad definitions of corruption may be one reason why prosecutions are so low. The OECD, the Council of Europe and the UN conventions hasn't a clear definition of "corruption", but establish a range of corrupt situations, interpreting as an offence offering bribery to (foreign) officials, or trading in influence and bribing public officials, embezzlement, misappropriation of property and obstruction of justice, illegal lobby, "improper influence", "abuse of public or private office for personal gain" [9].

Corruption and corrupt practices can take many forms, the most common being abuse of power, collusion (between two or more persons to limit competition), embezzlement (often defined as theft), extortion (illegal use authority to someone to get something through coercion or threats), bribery /kickbacks (a form of bribery in exchange for unlawful advantage, for example some incomes from a contract are returned to the person who facilitated that illegal advantage), nepotism and clientele's (patronage) - favours, functions and other benefits for family members and political supporters, granted regardless of skills, qualifications, merits, etc.

The most common practice of a corrupt administration seems to be the bribery [10], [11], this term covering a variety of forms, from small amounts of money as facilitation payments or gifts, to extortion or bribery in the form of large sums paid to win contracts of considerable amounts. Bribery is the interaction between two parties, and thus, in legal regulations systems there is a difference between active action, giving bribery, and passive action, receiving bribery, but both sides are committing a crime. Although legal definitions of taking / giving bribes vary from country to country, all treat bribery as a criminal offense [12].

Facilitation payments (or speed money) are a form of small cash bribes made in order to accelerate or facilitate the accomplishment of a common, routine, administrative service. Facilitation payments are usually required by lower level officials to speed up administrative procedures, often deliberately slowed to determine the payment for a service that otherwise, the person or company are legally entitled. In most countries this practice is illegal, but there are countries where this practice is normal - under certain conditions. Gifts are in the context of corruption, a form of bribes offered or asked in order to obtain an unjustified advantage or benefit. Gifts may include cash or goods given as gifts, political or charitable donations, hospitality in the form of expensive meals, hotels, travel as entertainment or sporting events. Gifts are often characterized by the so-called "grey zone" of corruption, because it is often very difficult to clearly distinguish between legal and illegal gifts and the distinction becomes more difficult in some cultures in Africa or Asia where the exchange of gifts is considered normal business practice as a way to help substantiate a trade [7], [13]. In principle, gifts can be considered as illegal when they are given an explicit goal of getting something in return, such as a contract.

Because corruption occurs in many forms, the classifications are also very different. Often the types of corrupt behaviour and the underlying factors were used as forms of corruption, which hindered their classification in a systematic way.

Thus we speak about the petty corruption, the daily corruption, which officials require small payments or gifts from individuals or public and private companies in exchange for facilitating government services or to speed up administrative processes. This type of corruption is described as a corruption of "survival" as is often done by lower level officials, poorly paid, based on such illegal annuity to provide income for themselves and their family. On the other hand we find large corruption or grand corruption, involving senior officials and politicians and, obviously, huge amounts of money: embezzlement of state funds by politicians, granting of "special" tax exemptions for large enterprises, or facilitating the conclusion of profitable contracts with the state.

Various forms of corruption have as correspondent a large range of entities that require or accept these practices such as: public officials in order to grant a large range of governmental permissions or to accelerate procedures, to evade laws and regulations, (for many SMEs owner this is the most damaging form of corruption); police extortion; various form of (bribe) requests from employees from so-called natural monopolies or "network industries"; corruption determined by private sector entities, for example bribery or extortion of employees of larger companies in order to obtain contracts; corrupt bank officials etc.

III. CORRUPTION IMPACT ON SMES AND BUSINESS ENVIRONMENT

A. Corruption as a destructive phenomena

What are the influences of corruption on the economy and society in general and SMEs in particular, to what extent we can interpret corruption as a real financial constraint on SMEs?

Surprisingly or not, the researchers opinions about the nature of corruption and its effects on society are not uniform. Thus, some researchers have considered corruption as cultural and political feature [14], [15], and all efforts to reduce the extent or effects are doomed to fail, recommending rather accepting it as a feature of each society, more visible and powerful in ones or weaker in others [16].

Literature does not reach any consensus on the effect of corruption on economic growth. Moreover, some researchers suggest that corruption may be desirable [17], [18], so corruption can be seen as a series of small payments made to officials, in order to induce to them a predisposition to provide more efficient public services. Thus, corruption offers a possibility for entrepreneurs to bypass inefficient regulations. From this perspective, corruption acts as a lubricant that eases operation and therefore increases the efficiency of an economy [19].

Most researchers, however, believe that corruption is a phenomenon fundamentally negative, and some countries seem to be stuck in a vicious circle of corruption and low economic growth, often accompanied of changing governments. According to Mauro, proved that there is a close association between corruption and slow growth, and between corruption and political instability in these countries and the relative degree of corruption is very persistent over the years [20]. A possible explanation advanced by Mauro is that when corruption is widespread, individuals and enterprises have no incentives to fight against corruption, even if everyone would live better without it. Mauro found that corruption has a significant negative effect on investment ratio to GDP, and these results are consistent with the view that corruption is harmful to economic growth, the channels through which corruption affects economic growth rate of GDP growth is investment, human capital, and political instability [20].

Moreover, addressing the link between corruption, public investment and political involvement, Tanzi and Davoodi reach the following conclusions: Corruption will reduce growth by increasing public investment and reducing its productivity, it can reduce growth by increasing public investment that is not adequately supported by subsequent activity (as maintenance, hiring qualified operators etc.). Corruption can reduce growth due to an improper infrastructure which increases the cost of business for government and enterprises, and thus leads to lower output and growth. Corruption can reduce growth by decreasing the government revenue needed to finance productive spending. "In sum, economists should be more restrained in their praise of high public sector investment spending, especially in countries where high-level corruption is a problem" [21].

Turning to the impact of corruption on SME we agree to the assertion that "The extent of [corruption] effect depends very much on firm size: The smallest firms are most adversely affected by all the constraints… [the] firms that operate in countries with underdeveloped financial and legal systems and higher levels of corruption tend to be more constrained in general" [22]. In this context, a lot of measures in the field of financial, legal, business environment have to be taken to reduce the pressure of these constraints, and "a marginal reduction in national corruption level helps relax these constraints most for the most-constrained groups of small and medium firms"[23].

All these factors and circumstances show that SMEs particularly suffer from a large range of resource constraints, and often these factors, related to the size or location, can make SMEs more vulnerable to corruption. For example, in a World Bank study, the problems of corruption in seen by SME as a major obstacle in their business (between 32,72 % for medium firms and 34,67% for small firms) but only 30,4% by large companies [1]. Referring to the formal sector, small firms (under 20 employees) and medium-sized (20 to 50

employees) reported a relatively equal proportion of bribery interaction comparing with large firms, but the effects of such payments burdened the business of small and medium enterprises in a greater proportion [23] (see table 1).

TABLE 1. Bribery incidence on enterprises, by size

Size of enterprise	Bribery incidents	Bribery as % of enterprise's turnover
Micro-enterprise	49,90%	4,40%
Small enterprise	56,70%	4,80%
Medium enterprise	57,60%	4,00%
Large enterprise	58,50%	3,40%
Very large enterprise	55.7%	3,00%

Source: The International Bank for Reconstruction and Development / The World Bank, "World Development Report 2005. A Better Investment Climate for Everyone", a co-publication of the World Bank and Oxford University Press, New York

B. The SMEs vulnerability to corruption

SMEs are vulnerable by corruption than large companies due to several reasons as:

a. SMEs' organization and structure, a more informal relation between staff or between staff and management stimulate a great permeability and tolerance to corruption, the SMEs has no a strategy or an internal education to deal with corruption, "the informal and centralized structure and leadership style of SMEs, relative to larger companies, may generate a corporate culture where corruption is more easily tolerated throughout the company"[7];
b. SMEs' short-term perspective, SME have to concentrate on present and short term future, so the possibility to resolve now a problems by giving bribe can be an acceptable alternative than thinking about the effect on long run or the accumulation of these "payments" over time;
a. SMEs' limited power and financial resources; in certain circumstances, SMEs cannot always risk to refuse to pay bribes, or to oppose to requests for unofficial payments and similar solicitations, "the ability of a business manager to successfully appeal for the correct treatment without paying bribes depends to certain extend on the size of the firm and on its resulting influence"[1];
b. SMEs' ownership; SMEs are often owned and controlled by an individual or a small group of persons (often family), without a clear line of separation between shareholders, management and board of directors, they shall not be obliged to take into account the impact of their decisions on public image or compliance with internal or external regulations as in the case of large companies.
c. Limited market power: The SMEs has a limited possibility to ask fairy treatment from authorities when interact with corruption practice, instead, large companies, due to their potential creating new jobs and investments, often generate close political relations; their complaints regarding requests for bribery have many chances to generate a positive reaction from authorities [1], [2].
d. Limited access to information, about rules and regulations, about the changes or clarification regarding the correct way to implement them, this will result in an arbitrary legal environment and will create opportunities for public officials to impose unjust penalties or ask facilitation payments from SMEs [2]. Thus, "the lack of access to information works as another transaction cost contributing to the uncertainty about how a company should conduct business on a market" [7].

Beyond these weaknesses that make SMEs vulnerable to corruption, we shouldn't ignore the internal and external determinants that turn managers or shareholders of SMEs to corrupt practices: concerns to maximize profit, to survive and beat competitors, to make connections in state bureaucracy or to obtain new markets segments. The probability of engaging in corruption is conditioned both to the level of respect and compliance imposed by a country's formal institution (legal system, courts, police, financial institutions, etc.), both and to the standards of behaviour (seen as country's informal institutions).

The studies shows there is a "strong correlation between the probability of becoming engaged in corruption, and a lack of confidence in the judicial system […] if an SME manager anticipates that the risks of getting caught, prosecuted and sentenced are low, or if the entrepreneur doesn't believe that the judiciary will impose high costs even if a prosecution is made, then the likelihood of engaging in corrupt practices is high" [1].

When a SMEs representative is involved in corruption, he measured the risks and costs of this decision, and this varies according to state, region or local environment. In terms of cost – benefit analysis, corruption is, and will be, a serious economic and business problem as long as corrupt behavior gains will outweigh the costs and risks involved, and here risk means the likelihood of being caught (and less the possibility of loss from bribery that do not brings the expected results). Often, the same corrupt behavior can be considered "risky" or "safe" according to the country, geographical area, the state institutions, moral etc..

Another issue that could cause the entry in corruption of a SMEs representative is the time factor, especially if the official terms of approval release are excessive and involves a successive approval from different authorities, regardless we talk about local, regional or central entities. If time costs are high, or unfair in comparison with similar requests made by large companies, SMEs feel entitled to use informal

action, of bribery, in order to speed up procedures, and to reduce the costs of delays.

In many cases mimetic behavior, the success of comparable companies by illegal means strengthens the idea that this is the only way to reduce bureaucracy and to ensure resolution of own request. This says more about the responsibilities and challenges for government (local or central) in order to shorten procedures, thus avoiding the image of bribery as the only way for SMEs to succeed in relation with the administration.

Another reason that SMEs are interested to engage in corruption is their intention to speed up procedures, and reduce the cost of delays, or if a SME manager perceive their environment as wholly corrupt, or there is no other direct options to realize an important transaction then the likelihood to become involved in corruption practices. For many SMEs representative is very important to seek and establish relation with those members of state administration perceived as "honest" bribe takers, who can delivered special services (information, licenses, opportunities, contract allocation).

"While it is clear that some SMEs, in some circumstances, make a voluntary choice about whether or not to engage in corrupt practices, it also important to recognize other cases where SMEs have little or no choice" and we can mention here extortion demands, or part of activities that it is not possible to survive without it, i.e. situation when- in an endemic widespread of corruption - one certain SMEs representative refuse to pay bribe, while most of their competitors do pay. As a result, the position of the SME on market will be seriously negative affected. "Small companies should not be judged according to whether they are corrupt or not, but according to their efforts to reduce their involvement in corrupt behaviour "[1].

IV. CONCLUSIONS

Authorities, politicians, the public, address the importance of SMEs with more optimism, stressing their positive role in the economy and society. However, measures to support this dynamic sector of the economy do not meet all expectations; SMEs are still facing a various factors with negative influence on their development. Between these type of financial constraint, corruption affects SMEs in multiple forms. Whether it's petty corruption - small payments to lower-level officials from public institutions in order to get different permissions, to expedite approvals and various services (legally, otherwise) which often exceed 5-6% of companies turnover, to the grand corruption, that negatively affects economic performance in general (unnecessary, inefficient, low quality public investment, illegal or uncompetitive favours and contracts routed to certain companies), all these are discouraging, burdensome effects of corruption for business in general and SMEs in particular.

SME's are more vulnerable to the effects of corruption due to internal characteristics (organizational structure, internal culture, managerial vision), insufficient resources which do not allow to long-term resistance to the claims of corrupt officials, limited access to information or, even availability of SMEs representative to engage in these acts in order to rapidly increase and exceed the direct competitors, or cultural environment more permissive to corruption. All these various aspects of corruption and its interactions with business environment and SMEs activities make that fight against this scourge to become extremely important for society, in order to reduce the spreading of this phenomenon and to counter its negative effects. On these success depends the chance for a performing economy, to overcome the underdevelopment and a real opportunity for individuals and businesses potential

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Corruption as Constraint in SMEs Financial Management (II – Some Evidence for Romania)

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***Abstract*-Corruption is a deeply negative phenomenon for society and economy, and small and medium enterprises suffer strongly on this effect, whether we talk about corruption "according to rule" and "against to rule", or we classify tolerance at corruption in the white, grey or black forms. Particular perverse and destructive effects occur when the political and administrative representative interests are intertwined with those of the privileged companies, with rent seeking behaviour, capture of state institutions by groups of interests or patron – client relationships.**

Corruption in Romania is recognized, domestic or international, as a major problem, being part of the country's business culture in a higher proportion than the EU average. Firms face, or expect to face, bribery in various situations, from simple permit to operating license, but the most affected area seems to be obtaining public contracts. Similar to global research results, Romanian SMEs suffer from these constraints in a much higher proportion than large firms, both in terms of market opportunities, but in a limited access to finance and thus, to the long-term growth.

Keywords: ***SMEs, corruption, financial constraints, growth***

I. INTRODUCTION

In the previous part of our paper we found that, although the role of SMEs in the economy is undeniable, they face many constraints, and the financial constraints tend to be extremely important. Among these types of financial constraint, corruption affects SMEs in many forms, whether we refer to petty corruption - small payments to lower-level public officials from different Institutions in order to get permissions, to expedite approvals and various services, or we refer to grand corruption (inefficient, low quality public investment, illegal or uncompetitive favours routed to certain companies). All have destructive effects for business in general and SMEs in particular. We found that SME's are more vulnerable to the effects of corruption due to internal characteristics, insufficient resources which do not allow long-term resistance to the claims of corrupt officials, limited access to information, or, in certain cases, availability of SMEs representative to engage in acts of corruption. These various aspects of corruption and its interactions with business environment and SMEs activities make that fight against corruption to become extremely important for society, in order to reduce the spreading of this phenomenon and to counter its negative effects. Transparency International, an international anti-corruption organization, makes a distinction between corruption "according to rule", if there is a situation where a person receiving an illegal payment for something that is required to do by law - for example when a state official requested bribes from a company to accelerate a routine, normal public service; and "against the rule", which refers to a situation where a bribe is paid to get a service when the recipient of bribe was not authorized to provide [1], [2].

Considering the degree of tolerance of an individual or a community regarding a deviant behaviour or an act of corruption, Heidenheimer made a "(tri)coloured" classification of corruption [3]. Thus, "black" corruption is the type of corruption condemned by most individuals and society who wish to see this corruption punished (we include here stock exchange fraud, corruption made by senior officials when their actions affected thousands of shareholders and employees, or by which citizens were taxed to cover major losses of state-protected companies). "Gray" corruption refers to a type of corruption that some people would like to see punished, while others do not, and the examples range from the widespread use of gifts and "attention" to state officials, to large practice "moonlighting" where most politicians condemn the action as diminishing state tax revenues, but many people find it acceptable [4], [5]. "White" corruption is a type of deviant

behaviour, which is usually considered as "acceptable" by everyone in a community.

Very suggestive for the following part of our paper, regarding the influences of corruption on economic environment, is the assertion of Klitgaard, cited by Word Bank Report," corruption is a crime of calculation, not passion. True, there are saints who resist all temptations, and honest officials who resist most. But when the size of the bribe is large, the chance of being caught small, and the penalty if caught meager, many officials will succumb"[6], [7].

II. SMES BETWEEN RENT SEEKING AND STATE CAPTURE

Understanding corruption and its relationship with the business, their influence on the performance of the SMEs starts to the fact that a society is characterized, therefore, by the emergence of tensions between the interests of companies (seeking for profit and long term survival, competition, etc.) and broader social interests, which generates a set of behaviours and policies able to promote corruption. Thus, we refer to the rent-seeking behaviour, a reduce credibility and legitimacy of public authorities, or political reaction outside of the appropriate institutional structure and performance.

A. Rent-seeking □ehavior

Public investments policy processes are extremely attractive for companies accustomed to rent-seeking behaviour, for public officials, or other interest groups that have such incentives to manipulate the design or implementation of investment policies, in order to meet their objectives. Here we find simple, but illustrative, examples, such as corruption and bribery as gifts, or over-valued prices, but there are practices, more subtle, in forms that do not violate the law or implies transfer of money, such as "captured" state institutions or patronage, clientelism, which undermines the development of a healthy investment climate.

Corruption seen as exploiting public office for personal gain, can affect the business climate and SME development in several ways, and when it implies the highest levels of government, it can distort the economic policy on a large-scale and undermines the credibility of government [8]. Even when corruption is pushed (apparently) from the upper level to the middle and lower government levels, corruption can be considered as a tax on entrepreneurial activity, a redirection of resources from the public purse, a way to create an election area. Investment Climate Surveys reports, conducted by The World Bank shows that most SMEs in developing countries is expected to pay bribes and corruption can vary by firm size and region. Unlike most productive processes, corruption is directly proportional to the results, an increase in rent-seeking activity, will make corruption more attractive and not vice versa, corruption is sustainable at higher levels, and it turn from productive activities more energy and efforts [7]. No country can claim to be immune to corruption, and in extreme terms, we refer to "predatory" state, which finds reason to consume economy surpluses and where government offices are treated as own property used for personal income.

Lack of competition and government intervention without justification are predisposing factors of corruption. The Investment Climate Surveys among companies confirmed that payments as bribes are higher when dealing with officials cannot be avoided [7], [9], [10], but in that countries, where are registered most frequent and extensive interference in business law, also tend to be more corrupted. Other favourable factors for corruption proliferation are lack of clear standards for public conduct, conflict of interest, abuse of power or influence, unjustified or unlawful group of interest.

Of course, an explanation for the behaviour of corruption, often invoked, is the low salaries, but the relationship is more complex. In many cases a significant increase of salaries of lower level public officials, might reduce the incidence of smaller-scale corruption, but this is not always feasible or cost-effective strategy [7], [11]. These measures have to be augmented by improving working conditions, the quality and professionalism of public service.

B. Capture of state institutions and patronage □ehavior

Investment policies and measures to improve the business environment may be distorted by rent-seeking behaviour under more subtle forms that do not implies law violation or cash remittances. When a group of influence, acting as representative for different economic or social structures (financial or industrial elite, consumers, unions) has a disproportionate influence, it can influence the design and implementation of policies, trying to create substantial and long terms privileges; on this we can add two related phenomena: the capture of state institutions and the patron-client relationship [7].

In the first case, of "state capture", businesses and other groups can influence state policy decisions for their advantage by lobbying (legal or informal), by controlling access to information, or a variety of other strategies. Thus regulatory agencies are vulnerable to be "captured" by industries that they need to regulate, and thus promote industry interests rather than public interests [12]. The concept of "state capture", has recently been used to describe how firms and other groups may influence the design of laws and policies (as opposed to implementation), through informal channels and influence occult, opaque, by controlling the political agenda. Companies or other groups that are affected by special

laws or policies will have stronger incentives to invest in influencing policy than consumers and other groups, and usually also face fewer difficulties in developing logistics coordinated views, to access valuable information or technical expertise than legislators or regulators [7].

When representative government distances himself from responsibility to the citizens, can fall into a patron-client relationship type when policy makers distribute political privileges to particular groups, often to the detriment of society as a whole. The development of investment policies presents many opportunities for entitlement and redistribution of resources to favoured groups and the good policies necessary to improve business climate are delayed, because they can't directly reward loyalty and don't help in strengthening privileged ties patron – client. As a result, many features of a good economic policy or regulations are designed to serve the particular voters: granting of (semi) monopolies, entry barriers for outside firms, cartels, all facts that suppresses the beneficial effects of competition and definitely reduces the chances of survival of SMEs [13].

Citizens really want to see their leaders able to implement policies to benefit society as a whole, but here the question is whether voters have access to valid information and can distinguish who are the suitable measures. The most suggestive examples are the government excessive exploiting of economics reports that shows the economies is set on a path of recovery (even temporarily) or images of large public works – the famous highway construction. It is already common in many countries, rich or poor, that public investment projects and tax incentives tend to proliferate around elections [7].

There is some evidence to suggest that the more widespread existence of direct contacts between business owners and politicians; the less is the quality of investment climate in that country [7], [14]. Various surveys and researches on SMEs, corporations or banks, confirm that firms that are part of the power/favoured circle are less likely to innovate, i.e. a difficult environment is more conducive to innovation [7], [15]. Unlike un-favoured companies, those who enjoy such favours are more concerned to maintain their influence and to enjoy the benefits, than to focus on improving their productivity.

III. DIMENSION OF CORRUPTION AS A FINANCIAL CONSTRAINT FOR ROMANIANS SMES

According to Transparency International, in the European area, Romania is seen, through the Corruption Perceptions Index (CPI), as one of the most corrupt countries in the region, together with Greece and Bulgaria [16], [17], (see table 1). Briefly, CPI Score relates to the degree to which corruption is perceived to exist among public officials and politicians by business people and country analysts, score ranges between 10 (highly clean) and 0 (highly corrupt). Related to the previous year, Romania remains at the same index as in 2010, but it's worsening the score of 0.1 from 2009. The only "consolation" comes from the fact that the two countries, with which Romania played their last three places in the EU ranking of corruption, were weaker development. Thus, Greece reduced its score from 4.6 in 2008 to 3.5 in 2009 and 3.4 in 2011 and Bulgaria – which was constantly better than Romania in 1999-2008 – from 3.5 in 2008 reached to 3.6 in 2009, 3.3 in 2010 and 3.4 in 2011.

TABLE 1. Corruption Perception Index – Europe (CPI 2011)

Country's rank (global)	Country's rank (Europe)	Country	CPI Score 2011		Country's rank (global)	Country's rank (Europe)	Country	CPI Score 2011
2	1	Denmark	9.4		30	16	Cyprus	6.3
2	1	Finland	9.4		31	17	Spain	6.2
4	3	Sweden	9.3		32	18	Portugal	6.1
6	4	Norway	9.0		35	19	Slovenia	5.9
7	5	Netherlands	8.9		39	20	Malta	5.6
8	6	Switzerland	8.8		41	21	Poland	5.5
11	7	Luxembourg	8.5		50	22	Lithuania	4.8
13	8	Iceland	8.3		54	23	Hungary	4.6
14	9	Germany	8.0		57	24	Czech Republic	4.4
16	10	Austria	7.8		61	25	Latvia	4.2
16	10	Great Britain	7.8		66	26	Slovakia	4.0
19	12	Belgium	7.5		69	27	Italia	3.9
19	12	Ireand	7.5		75	28	Romania	3.6
25	14	France	7.0		80	29	Greece	3.4
29	15	Estonia	6.4		86	30	Bulgaria	3.3

Source : Transparency International Romania, Indicele de Perceptie a Corup□iei. IPC 2011, http://www.transparency.org.ro/politici_si_studii/indici/ipc/2011/DateRegionaleCPI2011.xls

In the past 15 years, corruption perception index for Romania had a fluctuating evolution (but always below the EU12 or EU15 average), from 3.4 in 1997 to a minimum of 2.5 in 2002 to but then to rise slightly from a peak of 3.7 to 3.8 in 2008 and 2009.

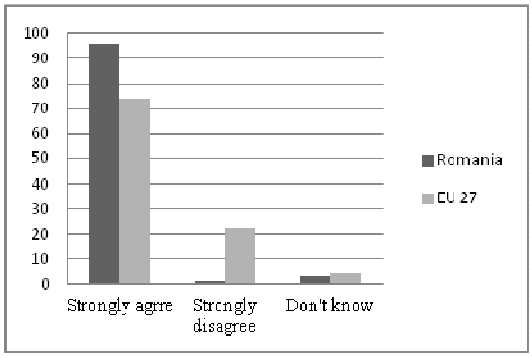

Fig.1. Corruption, as a major problems for Romanian/UE citizen
Source: European Comision, "Special Eurobarometer 374. Corruption Report", 2012, htttp://ec.europa.eu/public_opinion/index_en.html

In the European Commission's Eurobarometer survey on corruption published in February 2012, corruption is seen as a major problem in Romania, accumulating 96% of Romanian respondents' answers compared to only 74% in Europe.

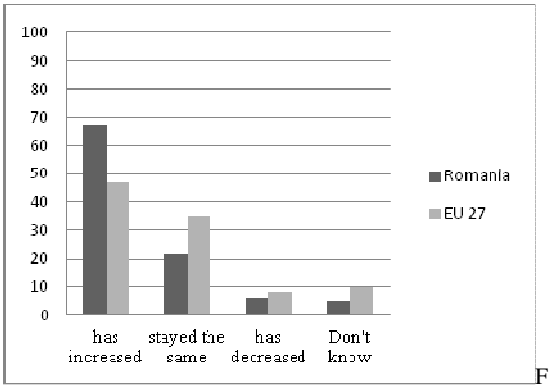

Fig.2. In the past three years, the level of corruption ….
Source: European Comision, "Special Eurobarometer 374. Corruption Report", 2012, htttp://ec.europa.eu/public_opinion/index_en.html

Corruption is a problem that gets worse from year to year (or is becoming increasingly in the Romanians perception) with 67% positive responses, compared to only 47% at EU level, considering it as part of culture business of our country, in a much higher extend than the EU average [17] (see Fig. 3).

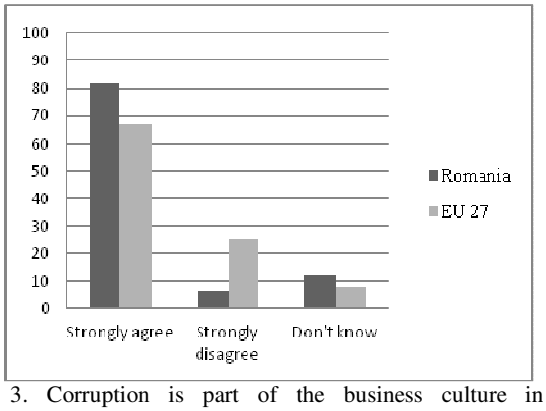

Fig. 3. Corruption is part of the business culture in Romania/EU
Source: European Comision, "Special Eurobarometer 374. Corruption Report", 2012, htttp://ec.europa.eu/public_opinion/index_en.html

Another relevant source of data in order analyse corruption in Romania are the Enterprise Surveys, conducted by Word Bank and International Finance Corporation, across all geographic regions, covering small, medium, and large companies, focused on the many factors that shape the business environment. These factors can facilitate the firm's expansion or can constraint the firms, and play an important role in development and prosperity of a country. These factors include infrastructure, trade, finance, regulations, taxes and business licensing, corruption, crime and informality, finance, innovation, labour, and perceptions about obstacles to doing business. The most recent Country Profile for Romania is based on data from the Enterprise Surveys conducted by the World Bank, between September 2008 and December 2008 [19].

Among the most important business environment obstacles as perceived by firms, we found the taxes (28%), labour quality (21%), access to finance (20%) and corruption (7.5%), and, in smaller proportions, interaction with central and local administration, labour regulations, access to licenses and permits. Regarding the top 3 constraints broken down by large, medium, and small firms in Romania we can notice that corruption is seen as very important (3rd rank), especially by medium-sized companies (20-49 employees).

As in many developing countries, corruption of officials is a major financial and administrative burden on SMEs, that undermine the operational efficiency of businesses and increase costs and risks, and these have to be added to the bureaucratic costs incurred in obtaining the necessary permits and licenses.

In this sense we find very suggestive to analyse a set of indicators promoted in by The Enterprise Surveys report (2009). Thus, the first set of indicators measure a composite index of corruption, called Graft Index, which shows the proportion of cases where companies

have estimated they paid or were asked to pay a gift / bribe or informal payments were made when they needed some public services. The second set of indicators identifies the extent to which firms are expected to pay or be required to pay bribes in contacts with representatives or officials of various public institutions (tax inspections, obtaining state contracts, etc.). The third set of indicators focuses on giving / requesting bribes to obtain licenses or special permits, and shows the share of companies expect to make such payments to secure import and operating licenses and to obtain construction permits [19].

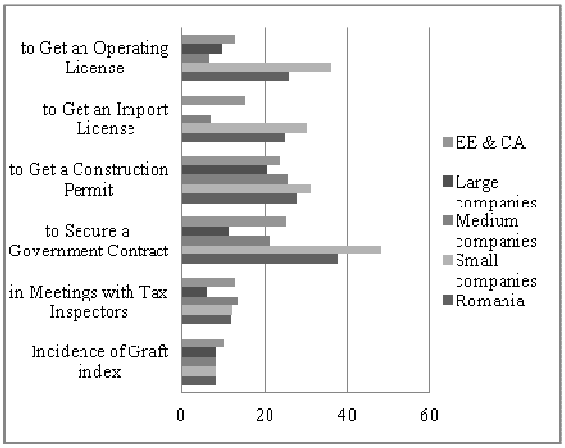

Figure 4. % of Firms Expected to Give Gifts …
Source: The World Bank, Romania Country Profile 2009
http://enterprisesurveys.org/~/media/FPDKM/EnterpriseSurveys/Documents/Profiles/English/romania-2009.pdf

Therefore, we notice (see Fig. 4) that Graft Index for Romania are 8, lower than the similar one recorded for the whole Eastern Europe and Central Asia (EE&CA). The highest (worst) scores in Romania are achieved when SMEs compete to obtaining public contracts, and it affects small firms in a higher proportion than large firms (48.3% vs. 11.3%). High levels, even higher than those of developing countries in the analysed area, are recorded when companies attempt to obtain a construction permit, an import license or operating licenses. But very striking is the difference between high scores of small firms and moderate (or even low) scores registered by large firms. One explanation may consist both in the absence of market power of these companies and the critical situation when these small firms are confronted with requests for a bribe from a public officials. Another explanation may lie outside corruption. Thus, large firms have qualified internal structures, able to draw and justify requests for authorization, according to law. Moreover, due to external relations, shareholders or managers, some of these permits and authorization documents are implicit, readily available and recognized in the EU. Remains clearly evident the unfavourable situation of small firms, burdened by corruption, as an important financial constraint hindering their development.

Another view about the impact of corruption on the business environment and SMEs in Romania could be analysed in the period of economic recession, of major imbalances in the economy. According to the investigation conducted by CNIPMMR, a representative employers' organization among small and medium enterprises in Romania, on a sample of 1723 entities, SMEs have to face with major difficulties and corruption seems to be a significant one, cumulating 36,10%, being a major problems for SMEs financing, next to high cost of the loans (27,80%), or bureaucracy (41,39%), [20], confirming our previous general assertions according to which corruption is basic element of the financial constraints for SMEs, and "the impact of constraints on firm growth is inversely related to firm size" [21].

IV. CONCLUSION

Although SMEs are a certainty and a hope for economic development, employment, innovation and efficient use of resources, measures to support this dynamic sector of the economy do not meet all expectations; SMEs are still facing a various constraint factors that limit growth and reduce their opportunities.

Researchers have identified a wide range of constraints; among them financial constraints appear to predominate. The purpose of this paper was to emphasize the importance of corruption as a financial constraint factor on the economy and society, but especially for the SMEs. SMEs vulnerabilities to the corruption come from internal characteristics, insufficient resources, limited access to information or, even availability of SMEs representative to engage in these acts, or cultural environment more permissive to corruption. Particularly serious are the links between the position of public officials and political or group interests which generates rent seeking behaviour, state capture or patronage relations.

For Romania, widespread corruption and the country's permanent placing in the lower rankings on corruption in the EU ceased to be surprising news. The problem is the perception about the worsening of the consequences of this phenomenon, the fact that most Romanians think that corruption is a part of business culture in Romania in a much higher proportion than in the EU. Companies are available, is expected, or bribes are just required for all kinds of permits and authorizations. Among these, obtaining a contracts with public authorities appears to be the situation about the companies report the higher number of corruption incidents, and small businesses are, by far, the most affected. Also, in the access to finance area, corruption

is considered as a constraint factor, threatening the survival and development of SMEs in Romania.

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Conjoint Analysis in Marketing Research

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***Abstract* – In today's competitive business environment unrealized gains erode profits because sellers cannot adequately determine what customers are willing to pay for product features. Companies cannot capture their markets randomly nor can the product managers develop haphazard product decisions. Competitive advantage will be achieved by those firms able to develop and price their products according to market preferences following adequate evaluation of how people value different features of an individual product. In doing so, companies rely on Conjoint analysis, a quantitative research tool widely employed in product management and marketing analysis. Present paper, after presenting the methodology behind this technique uses SAS programming to exemplify it.**

***Keywords:* marketing research; product management; quantitative research; consumers' choice.**

I. INTRODUCTION

Recent empirical studies have shown a great interest in quantitative application in business. Constangioara (2011) has recently publihed a paper addressing an interesting comparison betwwen the efficiency of linear and non-linear models in estimating the default probabilities of appliations of consumer loans. [1]. Same author has advocated over the years employing different quantitative techniques in operations management [2,3].

Covered over the years Present study continues the efforts to advocate the usage of quantitative studies in business, by presenting the methodology of Conjoint Analysis, a widely used quantitative technique in marketing research and product management.

Conjoint Analysis is a popular quantitative technique used in product management and marketing analysis for assessing how people value different features that characterize an individual product or service. Instead of directly asking the consumers' opinion about different features of a product, conjoint analysis asks respondents to evaluate different profiles of a product. Based on insights offered by conjoint analysis, managers can adequately understand how customers trade-off different price levels with the features of the product and thus they can formulate efficient pricing strategies. Conjoint analysis serves product managers to better understand the impact of distinct features of the product / service on the consumer choice. It also allows a better understanding of the must-have features of product by segment, consequently contributing to tailoring marketing efforts to different demographic or behavioral profiles.

Conjoint originated in mathematical psychology and was developed by marketing professor Paul Green at the University of Pennsylvania and Data Chan [4,5]. In 1988 professor Srinivasan developed a linear programming (LINMAP) procedure for rank ordered data [6]. The founder of Sawtooth Software, Richard Johnson also brought its contribution by developing the Choice – based approach to conjoint analysis [7]. More recently Green and Srinivasan offered a review of the literature on conjoint analysis in a prestigious marketing journal. [8]

Conjoint analysis is a main-effects analysis meant to estimate the joint effect of a set of independent variables measuring the attributes of a product or service on a dependent variable measuring the preferences of consumers. Preferences are the left hand-side, ordinally – scaled variable. Attributes are used as independent variables. Both continuous and categorical variables can be employed for measuring attributes.

As the literature on conjoint analysis underlines, the meaning of the word "Conjoint" has broaden over the years from an initial non-metric conjoint analysis to include today a metric approach to conjoint analysis. Both metric and non-metric conjoint analysis are essentially main-effects estimations (linear ANOVA models) meant to estimate the joint effect of a set of independent variables measuring the attributes of a product or service on a dependent variable measuring the preferences of consumers. Preferences are the left hand-side variable. Attributes are used as independent variables. Both continuous and categorical variables can be employed for measuring attributes. Conjoint analysis is based on linear ANOVA models and should not be confuse with discrete choice model, a different statistical technique based on nonlinear multinomial logit [9].

II. METRIC VERSUS NONMETRIC CONJOINT ANALYSIS

When preferences are modeled directly the conjoint analysis is known as "Metric". When attributed are categorical variables the model of conjoint analysis is:

$$Y = \beta_0 + \beta_{1i} + \beta_{2j} + \cdots + \beta_{km} + \varepsilon \quad (1)$$

We have here basically OLS estimation with a specific output. A detailed analysis of OLS estimations can be found in Constangioara [10].

The preferences are coded such as:

$$\sum \beta_{1i} = \sum \beta_{2j} = \cdots = \sum \beta_{km} = 0 \quad (2)$$

Zero sum condition for the categories of each contribution variable is the result of a main effect design matrix of the model required when CLASS statement is used with TRANSREG Procedure in SAS. The intercept (β_0) is the mean and ε is the error term. Estimated coefficients represent part-worth utilities, depicting the contribution of each level of an attribute to the estimated preference. Consequently the estimated overall utility of a combination of attributed defining a product is the sum of the estimated part-worth utilities:

$$\hat{Y} = \widehat{\beta_0} + \widehat{\beta_{1i}} + \widehat{\beta_{2j}} + \cdots + \widehat{\beta_{km}} \quad (3)$$

A second group of conjoint models is given by so called "nonmetricc". The difference between a nonmetric and metric conjoint analysis is the dependent variable transformation:

$$\theta(Y) = \beta_0 + \beta_{1i} + \beta_{2j} + \cdots + \beta_{km} + \varepsilon \quad (4)$$

There is a goodness-of-fit statistic of the model. In the case of nonnumeric analysis the goodness of fit is always larger than in the case of the numeric model with same specification. Nevertheless this does not mean that nonnumeric models are superior to numeric ones. Numeric models benefit of extra stability. Also note that although numeric models were derived from nonnumeric ones as a special case, they tend to be preferred today in most applications of conjoint analysis in business. [11]

III. CONJOINT ANALYSIS OF CONSUMERS' PREFERENCES OF CREDIT CARDS

A bank wants has examined its customer base in order to understand how the characteristics of its credit cards are valued by its customers. For the porpose of this paper assume that banks focuses on three characterstics of its credit cards: Brand (Master Card or Visa), Fees associated with the card (Yes, No) and Interest that customers have to pay for credit (10%, 15% per annum). Our analysis uses thereby three indipendent variables, all of them categorical with two categories. It results thereby a set of 2x2x2 profiles giving the possible combinations of existing classes of the employed variables. In order to conduct a conjoint analysis the banks asks its customers to rate each combination. Average ratings are presented in table 1.

TABLE 1 Average rating

Card brand	Fees	Interest	Rating
MasterCard	no	high	8
MasterCard	no	low	9
MasterCard	yes	high	6
MasterCard	yes	low	7
Visa	no	high	6
Visa	no	low	8
Visa	yes	high	4
Visa	yes	low	5

To conduct our conjoint analysis we employ SAS software. First we use the following code to introduce the data:

```
data credit_cards;
input Brand $10. Fees $ Interest $ Rating;
datalines;
MasterCard      No    High      8
MasterCard      No    Low       9
MasterCard      Yes   High      6
MasterCard      Yes   Low       7
Visa            No    High      6
Visa            No    Low       8
Visa            Yes   High      4
Visa            Yes   Low       5
;
```

The actual Conjoint Analysis is performed using PROC TRANSREG. The code used in this case is given below:

```
title 'Preference for CREDIT CARDS';
proc transreg utilities short data=credit_cards;
title2 'Metric Conjoint Analysis';
model identity(rating) = class(brand fees interest / zero=sum);
run;
```

The analysis variables and transformation specific options are specified in the MODEL statement. The option IDENTITY (RATING) requests an identity transformation of the dependent variable Rating which is specific to metric conjoint analysis. The CLASS specification identifies the independent variables as being categorical variables. An exhaustive presentation of PROC TRANSREG is found in SAS/STAT 9.2 User's Guide. [12] Main results obtained by running the TRANSREG procedures are presented in Table 2.

Table 2 reveals the part worth utilities corresponding to each class of the independent variables. Since all independent variables have two classes, we see that in table 2 two values of part worth utilities are reported for each attribute, and the sum of them is zero, as requested. The intercept has the significance of the average overall estimated utility.

TABLE 2. Main results of metric Conjoint Analysis

Label	Utility	Standard Error
Intercept	6.6250	0.1250
Brand MasterCard	0.8750	0.1250
Brand Visa	-0.8750	0.1250
Fees, No	1.1250	0.1250
Fees, Yes	-1.1250	0.1250
Interest, High	-0.6250	0.1250
Interest, Low	0.6250	0.1250

If we add up intercept and part – worth utilities corresponding to attributes that make up different sets of profiles, we obtain the predicted overall utility for those profiles, as depicted in Table 3.

TABLE 3. Overall estimated utilities

Card	Fees	Interest	Estimated Utility
Master	no	High	6.625 + 0.8750 + 1.125 -0.625 = 8
Master	no	Low	6.625 + 0.8750 + 1.125 + 0.6250= 9.25
Master	yes	High	6.625 + 0.8750 - 1.1250 - 0.1250=5.75
Master	yes	Low	6.625 +0.8750 -1.1250 + 0.6250=7
Visa	no	High	6.625- 0.8750 + 1.1250 – 0.6250=6.25
Visa	no	Low	6.625 – 0.8750 +1.1250 +0.6250=7.5
Visa	yes	High	6.625 – 0.8750 – 0.1250 – 0.6250=5
Visa	yes	Low	6.625 – 0.8750 - 0.1250 +0.6250=6.25

Note that the customers value most the combination (MasterCard, No Fees, Low Interest) with an overall utility of 9.25 and least the combination (Vista, Fees Yes, High Interest) with an overall utility of 5.

TABLE 4. Importance of attributes

Attribute	Importance (%Utility range)
Fees	1.125*2/(1.125*2+0.8750*2+0.6250*2)= 42.8%
Brand	0.875*2/(1.125*2+0.8750*2+0.6250*2)= 33.3%
Interest	0.625*2/(1.125*2+0.8750*2+0.6250*2)= 23.8%

The importance values (Table 4) shows that the fees play the most important role in buying decision. Thus, the attribute FEES has an importance of:

We can also perform a nonmetric conjoint analysis on the same data. SAS code for a nonmetric analysis in this case would be:

```
ods graphics on;
proc transreg utilities separators=', ' data=credit_cards plot =transformations ;
title2 'Nonmetric Conjoint Analysis';
model monotone(rating) = class(brand fees interest / zero=sum);
output;
run;
ods graphics off;
```

In this case the MODEL monotone (rating) requests a nonmetric conjoint analysis. Results show that algorithm has converged after twelve iterations. R-squared is slightly higher than before (96.78% compared to 95.45%). When estimating a nonmetric conjoint analysis standard errors are not corrected for the monotone transformation of preferences and consequently they are too small [10]. The estimated coefficients follow relatively closely those estimated with the metric model. They are presented in table 5.

TABLE 5. Estimated coefficients with nonmetric model

Label	Utility	Standard Error
Intercept	6.6250	0.00002
Brand MasterCard	0.9100	0.00002
Brand Visa	-0.9100	0.00002
Fees, No	0.9101	0.00002
Fees, Yes	-0.9101	0.00002
Interest, High	-0.9100	0.00002
Interest, Low	0.9100	0.00002

Yet using a monotone transformation of preferences is not particularly informative in this case since we see that the model does not reveals the trade-off between different attributes of products, which renders the estimation rather futile. Considering this I have found evidence that, in this case, the metric model is superior to the nonmetric ones, being more efficient in reveling the trade-offs between different characteristics of the product considered.

Using ODS statement in the code above we have requested that output delivery system produces a visualization of the monotone transformation of preferences (Figure 1).

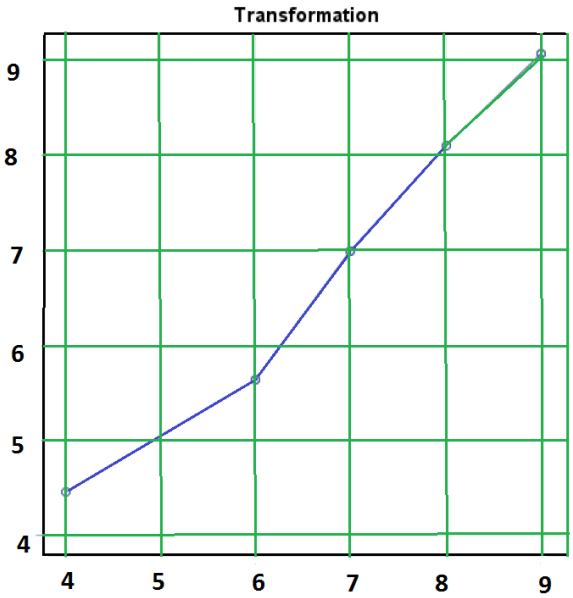

Figure 1. Monotone transformation of preferences

We see (Figure 1) that indeed the nonnumeric analysis is efficient in generating a monotone transformation of consumers' preferences.

IV. CONCLUSIONS

Conjoint analysis reveals to management the trade-offs that participants in a market research make between different attributes of a product / service.

In SAS we employ PROC TRANSREG to estimate a conjoint model. The specification MODEL MONOTONE requests a nonmetric conjoint analysis whereas the specification MODEL IDENTITY requests metric conjoint analysis. In the case of metric conjoint analysis the goodness-of-fit statistic of the model is lightly smaller in metric conjoint estimations, but the existing literature on conjoint analysis shows that numeric models benefit of extra stability. Indeed, in part three of the paper we have shown that although in nonmetric estimation the estimated coefficients follow relatively closely those estimated with the metric model, using a monotone transformation of preferences is not particularly informative in this case since we see that the model does not reveals the trade-off between different attributes of products, which renders the estimation rather futile. Considering this I have found evidence that, in this case, the metric model is superior to the nonmetric ones, being more efficient in reveling the trade-offs between different characteristics of the product considered.

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Numerical Modeling of Induction Hardening System of Gears

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Abstract ***This paper proposes a hardening method of gear wheels pinions with eddy currents using circular coil. The heating analysis of treat piece needs the solving of thermal diffusion problems coupled with the eddy currents problem. Therefore the experiments number in designing process can be decreased and a better knowledge of the process can be obtained.***

Keywords: ***Numerical simulation; finite element method; electromagnetic field coupled with thermal; thermal diffusion.***

I. INTRODUCTION

A modern and efficient way for surface heating can be obtained by inducing eddy currents to a depht that can be controlled by modifying the frequency of the inductor current.

The method can be used for all kinds of geometry types and they can consider the change of both the electromagnetic and thermal parameters accourding to temperature. Close to Curie point (normally, being under austenitic temperature), the B-H relation very dependend on temperature, passing from iron-magnetic environment form to air. In this case, the eddy current problems and thermal diffusion are strongly coupled in the Curie point zone. All the methods of numerical solving warn a kind of instability. Branded programs, adopt the linear pattern [1], where the B-H relation is linear, the magnetic permeability is adjusting according to the highest effective value of the magnetic induction. The pattern allows adopting the sinusoidal regime and the images too for the sizes of the electromagnetic field and its equations. The results are acceptable for specialists. Another refined method, such as "rough force" (see the FLUX package) or "harmonious balance" [2] is a big time and memory consumer and it doesn't lead to a better accurate solution.

The recommended solutions are analysed with FLUX-2D package programme.

II. ELECTROMAGNETIC FIELD MODEL

Being a parallel – plane structure, the model is described by the following equations [5], [8]:

$$-\operatorname{div}(\nu \operatorname{grad} A)+\sigma\frac{\partial A}{\partial t}=C\cdot J_0. \tag{1}$$

$$A=g_A \tag{2}$$

$$-\nu\frac{\partial A}{\partial n}=f \tag{3}$$

where

$$\nu=\frac{1}{\mu} \text{ and } \boldsymbol{J_0}=\mathbf{k}J_0;$$

where A - magnetic potential vector, σ - electrical conductivity, μ - magnetic permeability, J – curent density, C - constant.

The finite element method

Using nodal elements and Galerkin technique we obtain an algebraic system:

$$\sum_{i=1}^{N}\left(a_{ki}\alpha_i+a'_{ki}\frac{d\alpha_i}{dt}\right)=b_k,\quad k=1,2,\cdots,N \tag{4}$$

where a_{ki}, a'_{ki}, b_k are given in [5], [8].

Finally

$$A=A_0+\sum_{i=1}^{N}\alpha_i\varphi_i \tag{5}$$

where A_0 is a known component which has Dirichlet boundary condition $A_0=f_A$, and φ_i are given functions, lineary independent, which have null Dirichlet boundary condition (named form functions). Using Galerkin

procedure, we project the equation (1) on test function φ_k and we incorporate it in parts and obtain:

$$\sum_{i=1}^{N}\left(a_{ki}\alpha_i + a'_{ki}\frac{d\alpha_i}{dt}\right) = b_k, \quad k = 1,2,\cdots,N, \tag{6}$$

The thermal diffusion problem

This problem is being described by:

$$-\operatorname{div}\lambda \operatorname{grad} T + c\frac{\partial T}{\partial t} = p \tag{7}$$

where c is volume thermal capacity, λ is thermal conductibility and p volume power density.The boundary condition is given by:

$$-\lambda\frac{\partial T}{\partial n} = \alpha(T - T_e) \tag{8}$$

where: $T_e = 20°C$.

Numerically, this equation is being solved using a Crank-Nicholson technique, [5].

The coupled of thermal diffusion problems with eddy currents

The coupling of electromagnetic and thermal field problem is achieved by the fact that resistivity ρ, and magnetic permeability μ, depend on temperature[3], [4].

III. NUMERICAL SIMULATION AND RESULTS

Numerical simulation allows to determining accurately the relationship between the frequencies used, the power density and the desired treatment depth [7], [8].

The optimal frequency can be estimated by the penetration depth of induced currents.

The process consists in performing a single hardening at 8 kHz using an inductor as shown in figure 1.

The inductor is dimensioned in order to assure a distribution of the currents in the piece, which implies the optimal heat treatment.

The magnetic flux density depencence with the magnetic field strength and temperature of the steel is shown in figure 2 for the circular conductor.

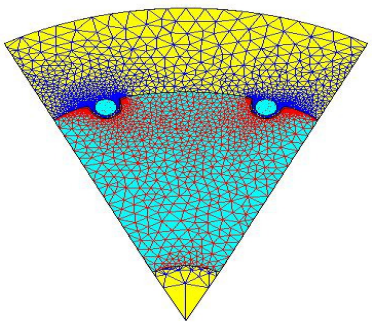

Figure 1. The model of the gear wheels with circular coil

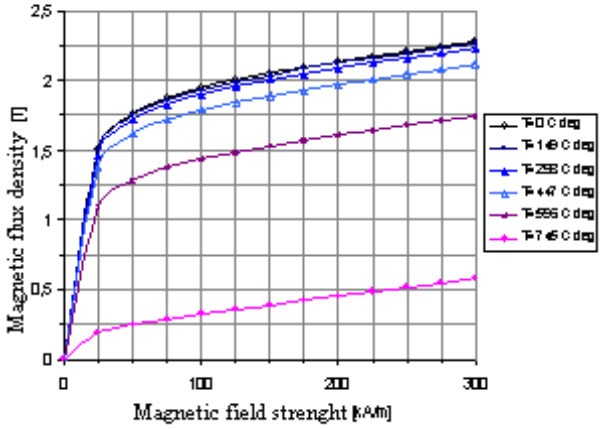

Figure 2. The magnetic flux density depencence with the magnetic field strength and temperature of the steel

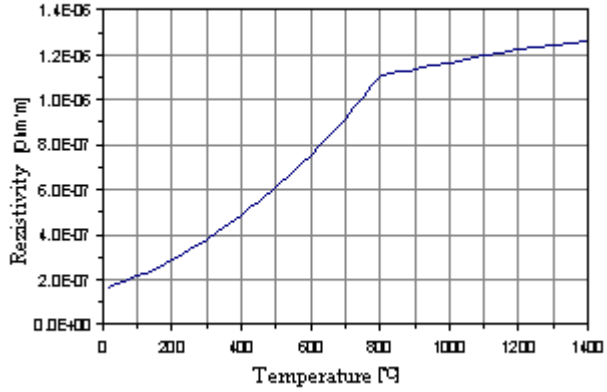

Figure 3. The rezistivity dependence with the temperature of the steel

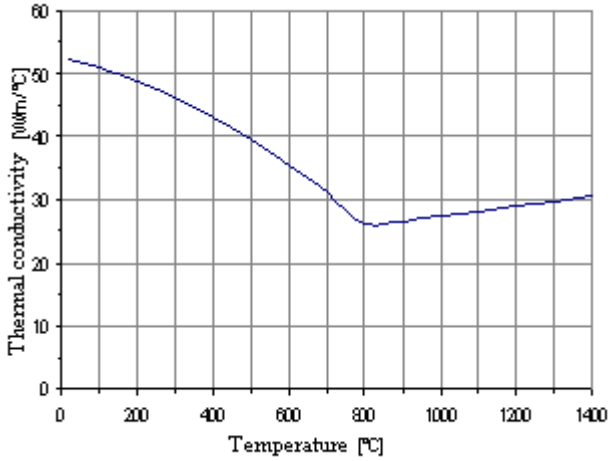

Figure 4. The thermal conductivity depencence with the temperature of the steel

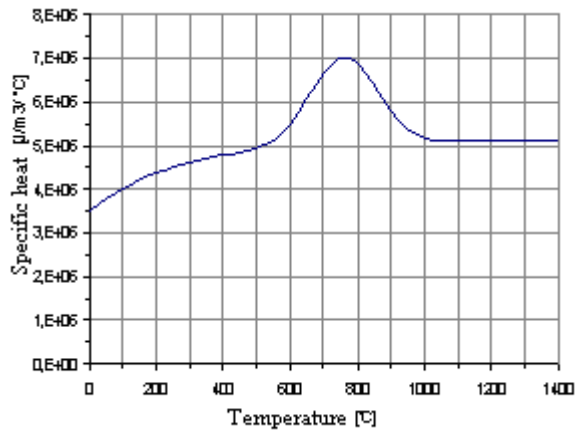

Figure 5. The specific heat dependence with the temperature of the steel.

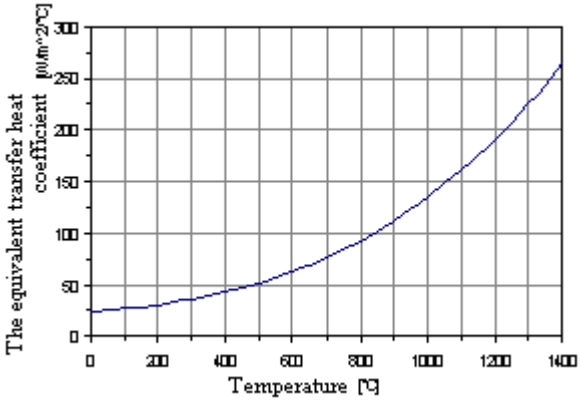

Figure 6. The equivalent transfer heat coefficient dependence with the temperature

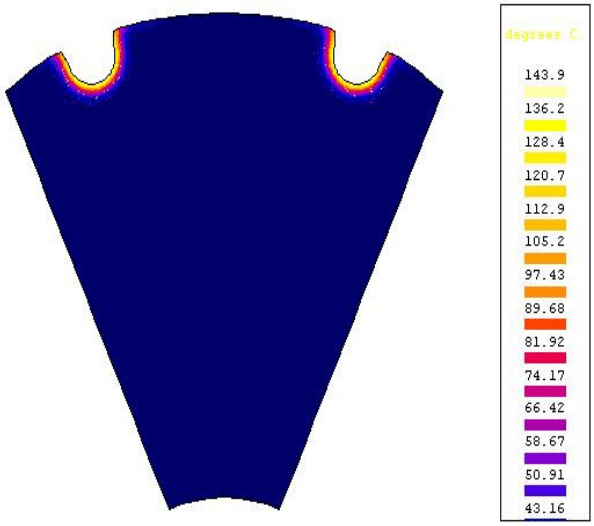

Figure 7. Thermal field distribution into the tooth of the gear wheels at time 0.1 sec

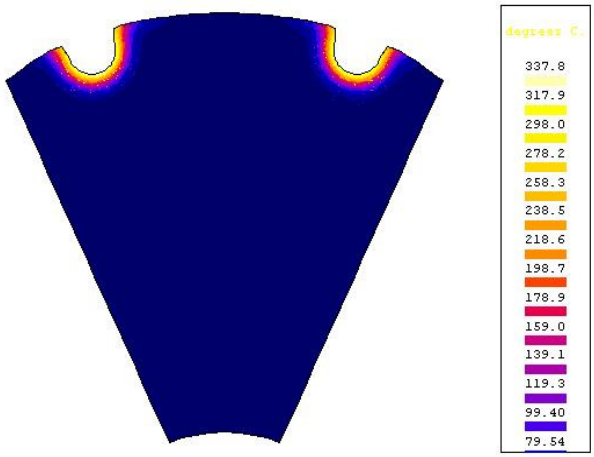

Figure 8. Thermal field distribution into the tooth of the gear wheels at time 0.4 sec

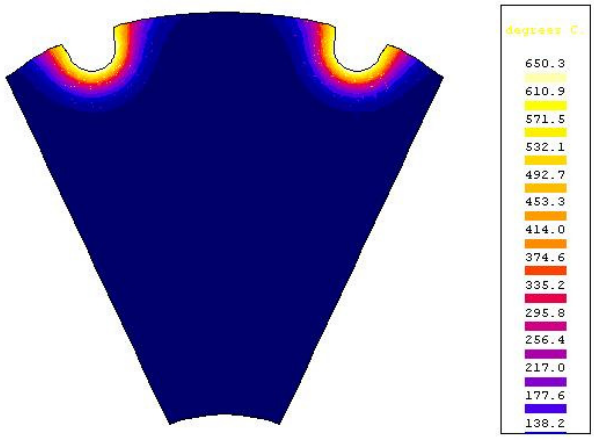

Figure 9. Thermal field distribution into the tooth of the gear wheels at time 1.35 sec

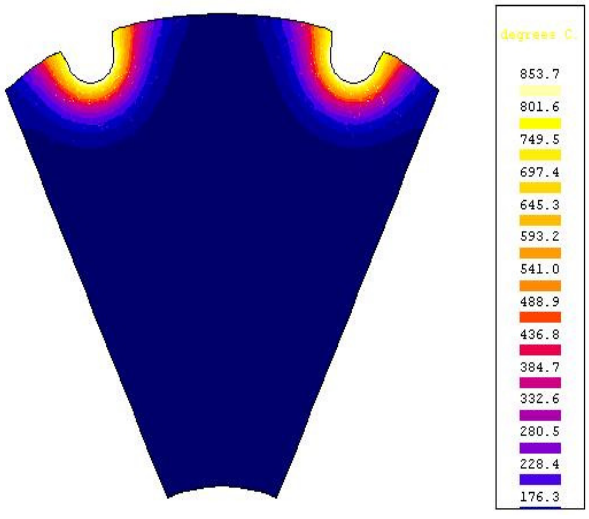

Figure 10. Thermal field distribution into the tooth of the gear wheels at time 2.62 sec

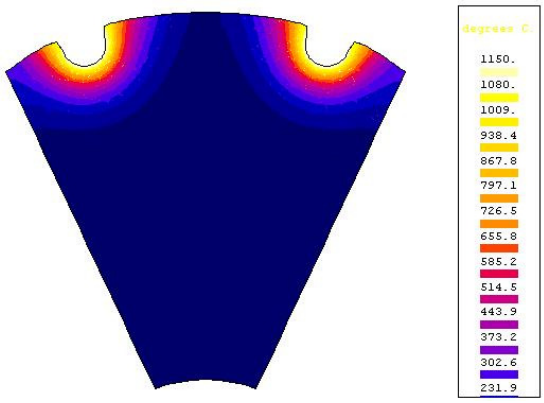

Figure 11. Thermal field distribution into the tooth of the gear wheels at time 4.61 sec

IV. CONCLUSIONS

In this paper was presented a model of electromagnetic field coupled with the thermal field in the hardening process of the serrated gear wheels. The numerical analysis, by means of FEM, was carried out with the commercial software Flux 2D. The numerical simulation results are useful for the recipients from the machines construction industry.

Through the modification of the power supply parameters (power and frequency) one can obtain optimal output parameters: hardening time, temperature distribution and the temperature speed of growth, requirements imposed by the technology.

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Aided Design Elements of Induction Heating Process for Hardening

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Abstract ***- The context of sustainable economic development, with high efficiency and low consumption of materials and energy, respectively the need for automatic control, determines the intense use of inductive heating devices in hardening processes. This paper presents a simulation of an installation of superficial heating treatment (hardening), performed with the help of the commercial software ELTA 1D, produced for inductive heating process. It highlights the links between different feeding electric parameters and constructive geometric parameters for maximizing electro-thermal effects that lead to a high quality heat treatment. The analysis of various material and electrical parameters during hardening is performed, in order to use these parameters in other environments for designing adjacent equipment.***

Keywords: ***simulation; design; induction heating; hardening, inductor.***

I. INTRODUCTION

Induction heating is widely used in a variety of industrial applications for melting, heating in volume, heat treatment, and household applications for water heating, cooking hobs, etc.

Modern technologies based on inductive heating have been developed rapidly in recent years, in the context of the need for saving materials and energy, respectively the need for automatic control.

Induction heating provides, by comparison with heating using resistance or that resulting from burining oils, advantages such as rapid heating inside the piece, precise location of the thermal effect by the appropriate configuration of the inductor and the choice of working frequency, the possibility of heating at very high temepratures with efficiency practically independent of temperature, very low thermal inertia, easy automation of equipment, process reproducibility, low pollution and good working conditions. The induction heating process can be easily integrated into the automated production lines of some complex installations as an intermediary process. The inductive heating method ensures high productivity, which is fully controllable, the heating of the material being performed inside with a special accuracy of processing. [1].

Electromagnetic induction heating involves three suggestive physical phenomena, the transfer of energy from inductor to the heated body, the transformation into heat (in the load) of electricity in the Joule effect, and heat transfer, by thermal conduction, across the entire mass. [3].

According to the classical heat theory, in order to warm a body, it is necessary to use a heat source at a temperature higher than that of the warmed element, but contrary to this theory, with the help of a inductor, which is slightly heated, a body may be heated at a much higher temperature than that of the inductor. [4].

Electromagnetic induction heating allows the generation of some high power densities, which significantly reduces heat loss. This property provides a high efficiency to induction heating.

The characteristics of inductive heating produced by induced current depend on several parameters such as magnetic flux crossing the body to be heated, electrical characteristics of the inductor and the load (i.e. the nature of the magnetic or the non-magnetic material), the magnetomotive force (ampere-turns per unity of length, and the characteristics of the magnetic circuit and its saturation), the magnetic characteristics (the size of the inductor and of the heated part, coupling), the current, frequency, the electrical parameters of the inductor and of the load (load and inductor resistivity at working temperatures, geometric characteristics of the inductor and of the load, the part of the load affected by the flow of current, current density distribution in this portion, the length of the circuit crossed by the induced current) etc. [2]. All these parameters have great significance because the penetration depth of the induced currents in the body to be heated, the quantity of

heat released, the distribution of heat in the load and the yield value for inductive heating are in a strong nonlinear interdependence.

The subassembly that influences, to a high degree, the technical-economic parameters of induction heating installation is the inductor built around the piece, by means of which the electromagnetic energy flow is transmitted to the heated material. In the inductor-piece system, eddy currents are displaced towards the outside conductor due to skin effect, which occurs at high frequency, and supports the influence of neighboring conductor currents, proximity effect. [4], [5].

A key feature of induction heating is the choice of frequency to obtain some superficial and very rapid heating, called induction - type heating, where the heat transfer phenomenon is secondary to the final structure of the thermal field. Radio frequencies are used in these processes, for instance in surface hardening treatments, continuous welding of pipes, soldering, total or local heating of small parts. [8].

For the heating in volume of large parts, where heat transfer is responsible for heating areas where induced currents are negligible, relatively low frequencies are used, compared to heating processes based on heat penetration from the outside in the part, where the heating rate is higher and more uniform.

One of the important applications of induction heating is superficial heat treatment,which uses the property of this procedure, namely the concentration in a layer at the body surface, layer whose thickness becomes smaller as the frequency increases in value.

Using high frequencies helps at getting higher values of power densities and rapid concentration of heat in a localized area. At the end of the process the region will have a changed metal structure, though the rest of the material properties will not be affected. Usually the purpose is to obtain high mechanical strength to surface, as compared to the rest of the piece properties, which does not change during the thermal treatment. [7]

II. NUMERICAL MODELLING OF THE INDUCTION HEATING PROCESS

Induction heating process can be simulated with a program dedicated to numerical modeling of electromagnetic and thermal coupled processes. Numerical modeling of induction heating process makes possible the observation of the installation operation characteristics, which allow making a decision on what the best solution would be so as to maximize two important requirements, namely reducing production cost and increasing the quality of the final product.

In this case, the numerical modeling of the induction heating process is done with the help of "ELTA" software, produced for the design and simulation of induction heating process and equipments, used in the education system, and which can be used to find the optimal connection between the heating time, temperature and the electrical power required. [10]

ELTA allows the user to achieve a very fast and accurate simulation of electromagnetic and thermal fields in induction heating installations using a single-dimensional approach. It can simulate cylindrical or plane, magnetic or non-magnetic induction systems, even multi-layer materials with arbitrary properties. [9]

The optimal design of an induction heating system must balance the time required in the heat profile needed in the workpiece. The ELTA software provides an overview over time, temperature and electrical power, during heating, allowing the user to modify the characteristics of the induction equipment so as to optimize superficial heating treatment. [9]

This paper presents the modeling of a superficial heat treatment (hardening) installation, achieved using 1D ELTA software. For the case studied, we present in Figure 1 the geometric shape of the workpiece and the heat treatment area to be subjected to induction heating. The area subject to heating treatment is an external one, with a length of 100 millimeters (Fig. 1).

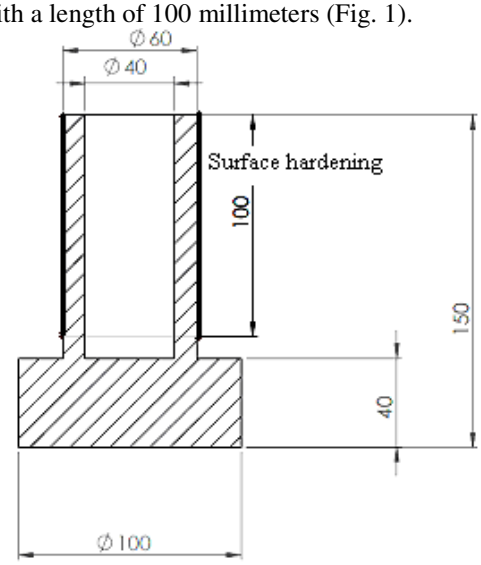

Figure. 1. Cylindrical workpiece

Figure 2 shows the geometry and the elements of the quenching system, consisting of induction and piece. The presented system has two stage: during the first stage heating is performed, and during the second one forced cooling will take place (in the versions presented by us, in case 1 and 2 cooling with air will be used, and water jet will be used in the third case).

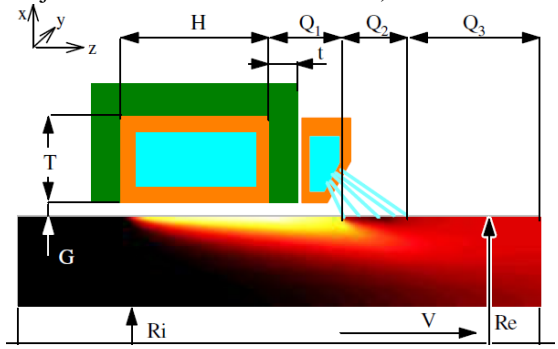

Figure. 2. The configuration of the hardening system [9]

The meaning of notations in Figure 2. is presented below, together with specific values of the case presented: Re (30 mm) – the semidiameter of the piece that is going to be quenched, Ri (20 mm) - inner radius of the workpiece (the difference Re-Ri represents the thickness of the piece wall), G (5 mm) - the distance between the spire and part (air gap), Q1 (0 mm) - the distance between the cooling system and inducer, Q2 (10 mm) - cooling zone (the distance on which the air blows and water falls), Q3 (50 mm) – the area on which water fell, H (7 mm) – total length of the inductor, T (10 mm) - the height of the inductor coils, t (10 mm) - width of the concentrator (the first two cases are without concentrator), V (5 mm/s) – the speed at which the piece moves.

We chose a copper spire with rectangular profile, having the height T (10 mm), the width H (7 mm) and wall thickness d (0.2 mm).

III. RESULTS OF MODELLING THE HARDENING PROCESS

The system used is one in two stages: during the first stage heating is performed, and during the second one forced cooling will take place; in the first and the second case cooling is done by compressed air jet, and in the third case cooling is done by water jet.

For all three cases presented, we chose a particular operating frequency f = 100 kHz, because we did not intend a depth of penetration larger than 0.2-0.3 mm. [9]

For the first case the power of the installation is of 35kw, the convection coefficient (heat exchange surface) α = 20, cooling is achieved with compressed air (air speed is 30 m/s) and the piece moving speed is of 0.8 m / s

Electrical parameters of the inductor are: Electrical Efficiency = 0.74385; Total Efficiency = 0.74017; Power Factor = 0.21289, Current Inductor, Inductor = 2188.2 A; Voltage = 76589 V; Power Inductor = 35000 W, Reactive Power = 164.59 kVAR, Inductor Impedance: Z = 0.035001 Ω, Resistance = 0.0073097 Ω; Reactance = 0.034375 Ω.

At the end of the modeling process, the temperature at the surface of the piece reached 1100 °C in 1.1 seconds, according to Figure 3.

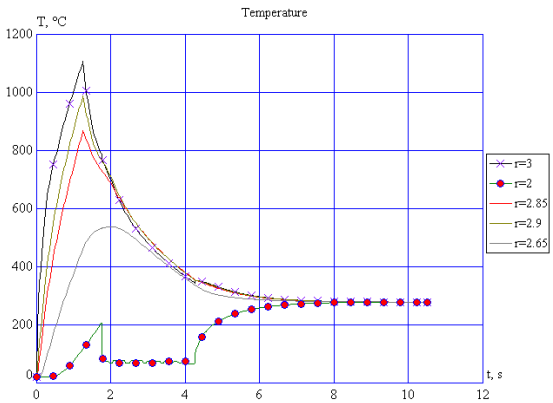

Figure.3. Temperature vs. time

Upon completion of the process, the temperature in the piece reached 290 ° C, as it can be seen in Figure 4, and efficiency is represented in Figure 5.

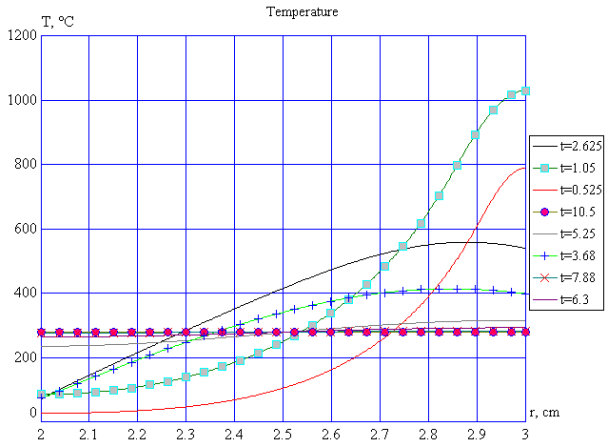

Figure. 4. Temperature. vs. radius of piece.

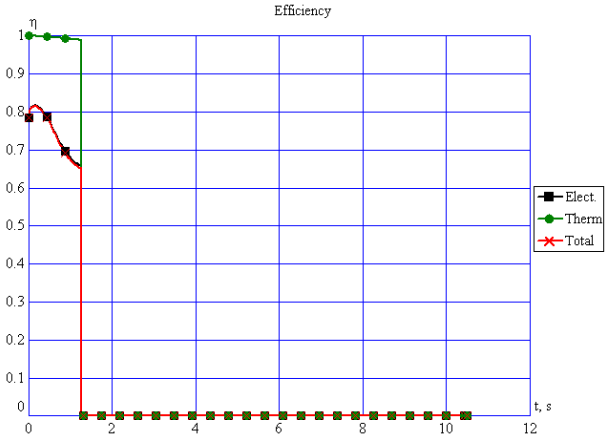

Figure. 5. Efficiency vs. time.

Inductor voltage is of 76.5 V and the current is of 2188.2 A (fig.6, fig.7)

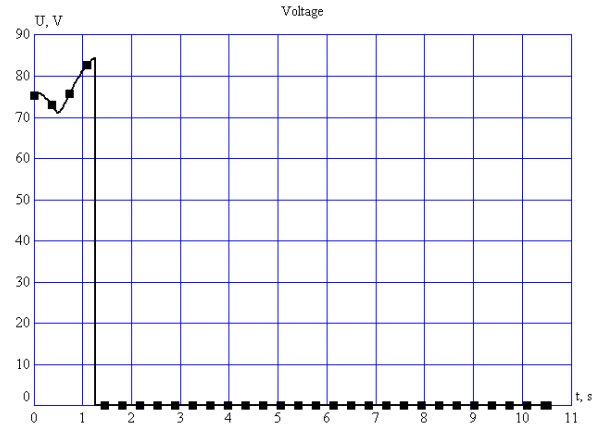

Figure. 6. Turn voltage vs. time.

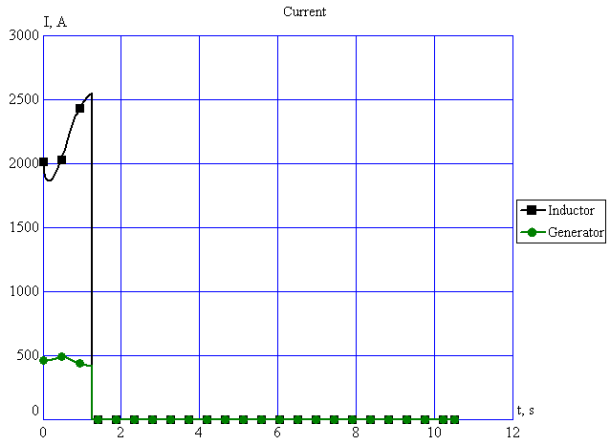

Figure. 7. Intensity current vs. time.

Capacity is of 50uF (Figure 8) and inductance is $6.3 \cdot 10^{-5}$ mH (fig. 9)

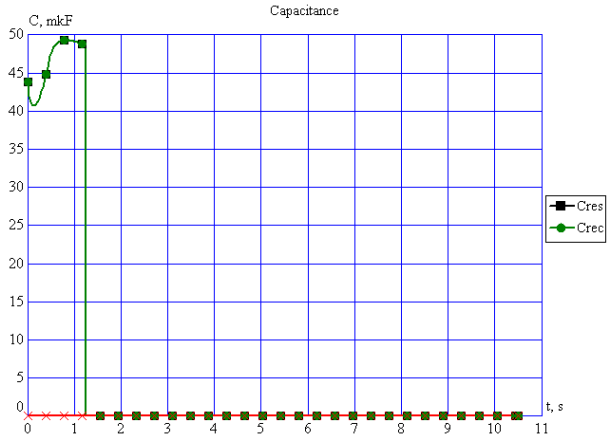

Figure. 8. Capacitance vs. time.

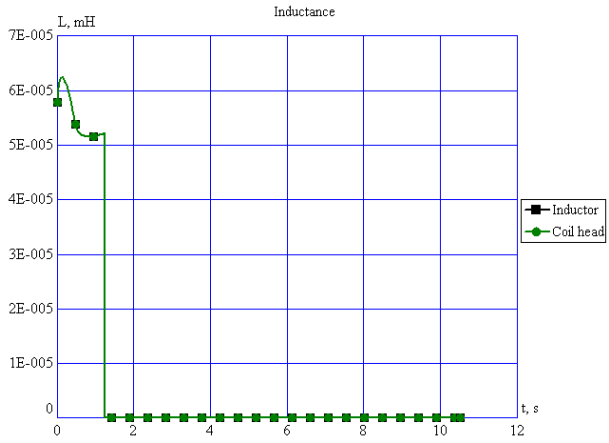

Figure. 9. Inductance vs. time.

The depth of penetration of heat in the piece can be seen best in Figure 10. The highest temperature, of 960 ° C, which is optimal tempering temperature, is at 0.1 mm in the piece, which subsequently decreases at 700 ° C at 0.2 mm.

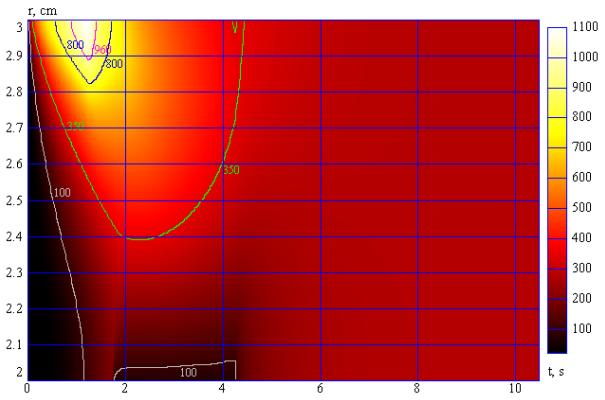

Figure. 10. Color map of temperature in the piece.

In the second case the speed of the piece movement decreased while the time needed for the surface parts of the piece to reach the temperature of 1100 ° C increased to two seconds, as indicated by Figure 11.

With decreasing velocity of the inductor, current has decreased from 2188.2 A to 1839.1 A, and voltage from 76,589 V to 65,108 V and the power used from 35kW to 25 kW.

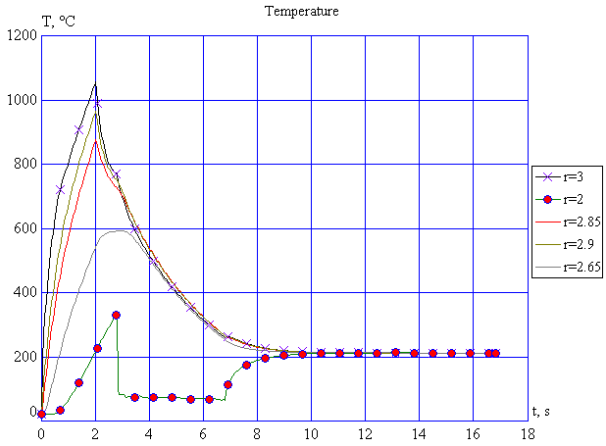

Figure. 11. Temperature vs. time

In the map marked as Figure 12, we can observe the depth of temperature penetration in the piece.

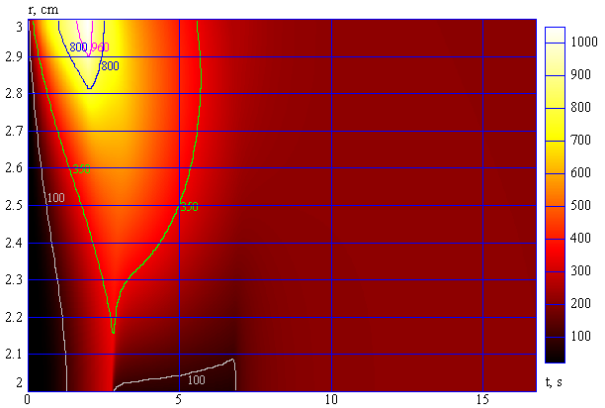

Figure. 12. Color map of temperature in piece.

Efficiency, in the latter case when speed was reduced from 8mm / s to 5mm / s (Figure 13), appears to be

approximately similar with that recorded in the first case.

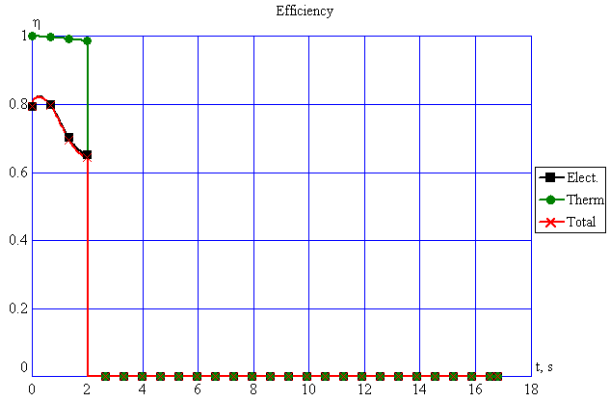

Figure. 13. Efficiency vs. time.

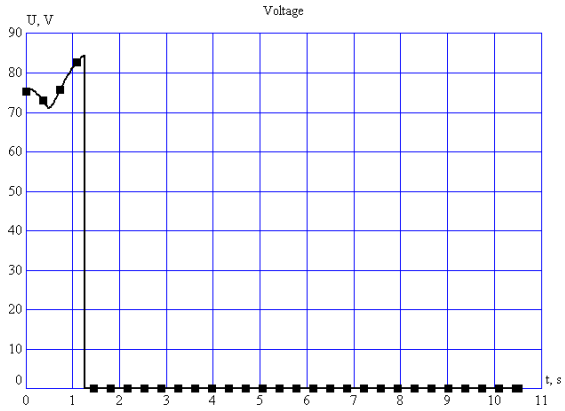

Figure. 14. Turn voltage vs. time.

If the third case, the speed at which the inductor moves, without concentrator to the piece, is of 5 mm/s, and cooling is ensured by water jet, running at speeds of 2 m/s.

The parameters of the inductor were not changed (Inductor Current= 1839.1 A, Inductor Voltage= 65.108 V, Inductor Power= 25000 W)

In all the three cases presented, the cooled area of the piece after inductor is of 5cm.

The time neede for the temperature to reach 1100 °C is of two seconds (Figure 15), but cooling is much better, the temperature of the piece after cooling is of 90 ºC.

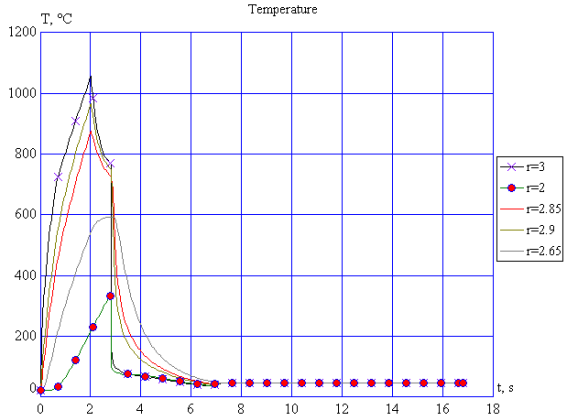

Figure. 15. Temperature vs. time

The map of temperatures is presented in figure 16.

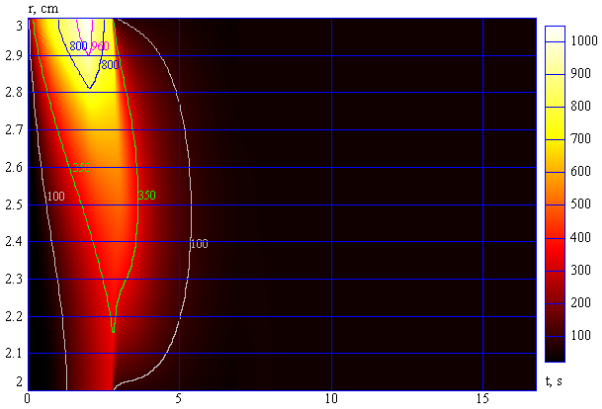

Figure. 16. Color map of temperature in piece.

IV. CONCLUSIONS

Numerical modeling is a relatively cheap process, which can be put into practice in a short period of time, offering an initial view of the thermal quenching process parameters.

Numerical modeling offers multiple solutions, from which a person interested may choose the best option.

Processing metallic materials in electromagnetic field is an important and up-to-date method in terms of its performance.

In all the three cases presented, the penetration depth of the thermal field does not exceed 0.2-0.3 mm. It appears that in the third case, when cooling is done by water jet, the best cooling of the piece was obtained (figura.15.).

When using water jet, the temperature of the piece after the completion of quenching reaches 90 °C, and when using compressed air jet, the temperature of the piece goes beyond 200 ºC.

Changing the moving speed of the inductor from 8 millimeters to 5 millimeters, its power could be reduced while preserving the quality of the finished product.

Heating by induction offers several advantages compared with other processes, among which the most important are: the possibility of heating at very high temperatures, with practical results actually independent of temperature; a rapid heating as a result of high values of power density; precise localization of the thermal effect by the appropriate configuration of the inductor and choosing the working frequency; very low thermal inertia; easy automation of the installation; low pollution and very good working conditions.

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Quality and Performance in Mass Media Industry in Times of Economic Crisis

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***Abstract* – Looking on the mass media industry management during economic crisis, we notice that this field is undergoing, even outside economic context, real bursts of crisis. In the first part of this study, we'll try to analyse briefly the way in which mass media is perceived and presented in recent articles and interviews written by different journalists or public figures. In the second part, we'll describe a few performance elements within Romanian mass media industry. In this respect, we suggest three analysis concepts: expansion, audience and income. The third part will focus on management by objectives. We will try to demonstrate the link between management objectives and results from a quality perspective. If the objectives are political, quality is not really important or is defined in a different way. In the last part of our study, the emphasis is on limits as well as on quality and performance proposals in mass media industry in times of economic crisis.**

***Keywords*: mass media; quality and performance; management by objectives**

I. INTRODUCTION

The communication area of modern society is mass media. Whether we think of newspapers, radio, television or internet, people from the entire world meet within this communication framework. The transfer of concepts, ideas and opinions takes place very quickly thanks to all these modern means of communication. There are many things people would be willing to give up, but probably just a few of them would give up internet, television or their friend from car, which is the radio.

II. PUBLIC OPINION ON PRESENT ROMANIAN MASS MEDIA QUALITY

People's opinion requires to be expressed either in public debates or in the intimate forum of small circles. They are often accompanied by enthusiasm, envy, hate or love. Each of these feelings is strong and enables us to personalize the messages from the communication process. Mass media is the place where opinions, the facts and subjects of public interest are debated. Blamed by some, used by others, appreciated or envied, mass media remains the meeting place of the seven billion inhabitants of the earth. It seems that every year the number of those who rush into this field is rapidly increasing. The public opinion on mass media is divided and for this reason we are trying to develop a brief study on the way press views mass media. Do the people involved in press appreciate the journalistic act positively? Can we talk about quality and performance within Romanian mass media industry? Is only economy undergoing crisis or is mass media undergoing an even profounder crisis than the economy? With these questions in mind, we are going to look at the recent articles about press. We have tried to find some articles in which the journalistic act and the quality of contemporary press are appreciated. We hoped that at least those belonging to this professional category would be enthusiastic about the way mass media looks like, and we refer here mainly to its content. But our efforts were in vain because we could only find critical views.

A. Romanian journalism has reached an unprecedented degradation

In *România Liberă* newspaper, the journalist Cristina Câmpeanu describes in words that are not at all flattering the condition of Romanian journalism, which has reached an unprecedented degradation: "One of the worst things that happen in Romania today is the unprecedented degradation of journalism, which leads to an equally alarming degradation of the public debate. In Romania, there are eight TV news channels, more than anywhere in the world. Neither California nor New York, the two places where television came into being, has so many channels. A profession which once was considered "noble", because it had been devoted to public service and self-abnegation, is dragged into mud by hysterical ladies, by bribed counselors, by actors without fame and any sense of humour and by enriched swindlers." [1]. In spite of the fact that we have eight TV news channels, which should result in competition and professionalism, we are witnessing a regression of the journalistic act and a decrease in its quality. An excellent job, which once was wished for and even well-

paid, has become, as the journalist from România Liberă puts it: "dragged into mud by hysterical ladies, by bribed counselors and by actors without fame."

One of the tasks of mass media is to establish the public agenda, but the famous "dog" that safeguards democracy has lost much of its power and today it seems to have become an instrument used by various groups of interest, as Mrs. Brînduşa Armanca suggests in an article published in February 2012 in Revista 22: "When Orwell said that «language … is meant to make lies credible and crimes worthy of respect and to give the wind an apparent strength», he referred to the political language, but this also suits very well to a certain way of practicing journalism. Taking into account nowadays advanced technology, image handling does not require certain skills any longer, but only some basic knowledge about camera position, such as: adjusting the focus in such a way that a small group of people becomes a huge crowd, choosing certain angles and scenes in order to add a dramatic note to a story, skipping over some information from various images, and so on." [2]. The issue that Brînduşa Armanca raises is quite a delicate one, because technological progress should normally lead to professionalism. Having competitive equipment, editing images, showing reality and details which haven't been noticed in the beginning is an advantage which, unfortunately, mass media people use not to convey the truth, but to present it in a distorted way, yet credible, well-arranged, as if this would be the reality. So, it seems that technological progress doesn't strengthen the ethical standards, but diminishes them. "The Romanian journalistic deontology has grown alarmingly flexible. This is true not only of the topics and opinions conveyed publicly by journalists, but especially of the way they do it via different mediators, that is via certain characters whose main concern is to express their views." [3].

B. Honourable action taken at NCA

In this context of the decline of journalism deontological standards, mainly in audio-visual area, just a few days ago, the famous pianist Dan Grigore resigned from the National Council of the Audio-visual, an institution which has a double function: to guarantee the public interest and to be the only authority which establishes regulations for the audio-visual programs. Here is an excerpt from his resignation: „I resign from the Council of Audio-visual because I cannot function in an institution where people are forced to work in a climate of permanent pressure, disrespect to rules, hypocrisy and systematic violation of some basic principles, huge dishonesty and a severe pollution of the public space; because my voice is drown with torrents of insults and threats; because I can't stand any longer a stress which does not generate the least public good after those many decades when we experienced the noble stress of concert stages, meeting our public from everywhere; because I anticipate an election campaign which is going to reach an unprecedented ferocity and in which obeying the law risks to become an infringement in the eyes of many, who believe that «the end justifies the means». And I see with great repugnancy that all this evil doing is leading us to chaos." [4]. The gravity of this situation is depicted in a torrent of arguments, some more shocking than the others. „Disrespect to rules" – we can only think what would happen in a hospital where rules are not obeyed. The patients would be operated on before any investigation had been done or before any blood tests or using utensils that were not sterilized. A society which disregards its rules is going to disintegrate. But the ex-member of NCA, Dan Grigore, speaks of „the violation of some basic principles" and here he referred not only to the press institutions, but also to that institution which is defined by law as „to guarantee the public interest". Even more than that, this famous pianist maintains that politicians are putting pressures on NCA to distort the truth and pollute the public space with their huge dishonesty.

The politicizing of NCA has lead to the weakening and, thus, to the inefficiency of this institution which has the authority to establish the regulations for the audio-visual programs. It seems that self-regulation which needs to be done by means of professional institutions of the journalists is not working either. In spite of the fact that each press institution was compelled in 2011 to publish its deontological code on the website, the result is far from being satisfactory. Hundreds of articles have been written, disapproving the television channel which broadcast that little film in which our ex prime minister was putting on his clothes in a locker room. Here is one of them: „This case of broadcasting those images with Emil Boc naked has revealed the moral confusion in which mass media and the political actors are wallowing, thus giving ethics a relative value in our society. It has also emphasized the lack of authority of journalistic community in establishing rules for this profession, in other words, we witness an auto-regulation failure. It has also shown that a politicized NCA, irresolute and slow in making decisions, brings about minor effects in present audio-visual practice. The ethical shallowness, moral and legal confusion prevail in public debates. As far as the broadcast of that film is concerned, Capatos brought a hypocrite and false argument, namely he expressed his great concern for Emil Boc's "safety" and for the lack of vigilance on the part of SPP [5]. This case cannot be discussed without launching an alarm signal with regard to the condition of mass media. Thus, it is imperative to bring back into discussion the necessity of applying the restrictions of journalistic ethics and to respect man's fundamental rights stipulated in Article 8 of the European Convention of Human Rights.

C. Is mass media still a power in the service of good?

The claim journalists usually have is that by their involvement they bring their contribution to the moral and spiritual growth of the public they address. We can agree that in our country we haven't really succeeded in

achieving this, but hope that the huge international press trusts are successful. However, looking at what is going on in mass media industry, we notice that the problems and struggles we face here, in Romania, can be found elsewhere too. Here is an example given by the journalist Cosmin Alexandru in the article *The good that you can (not) see*. BBC World Service produced a program at the beginning of 2012. The topic they approached was the role mass media plays nowadays. It was a program in which some people were invited in the studio to attend the debate and by phone they heard different journalists from BBC, CNN, Al Jazeera, a Russian TV channel and other channels. The presenter passed on the microphone to those present and the speakers had the opportunity to express their views on their own programs. Those from Al Jazeera channel emphasized their objectivity and independence to the western perspective on the events in Middle East, those from Russia claimed their ability to broadcast information which the public couldn't find elsewhere and CNN and BBC introduced themselves as being a „power in the service of good" and their journalists tried to prove that they not only inform people about what is going on around the world, but they also make an effort to change in good the people around them. The presenter interrupted the journalists' debate and asked the people that were in the studio how many believe that mass media is a power in the service of good. She asked them to show this by a raise of hands and then her question was followed by a few moments of silence. Her answer, which came with a slight change in her voice, was: „No show of hands." None of those present in the studio viewed mass media as a power in the service of good. Alexandru Cosmin makes the following comment: „In terms of the depth of that debate, a golden mine had just been dug out: world's top journalists were considering themselves a power in the service of good, but their public didn't view them in that way. Somehow, it was necessary that the debate should become a dialogue, and this is what really happened. From now on, it is more likely to reach a conclusion that brings together the two perspectives. This is the touchstone which Romanian society and mass media cannot overcome yet. The authentic or fake anger, which literally chokes each public exchange of opinion, prevents everyone from becoming a power in the service of good; of course, starting from the premises that someone would like to become this way." [6].

III. PERFORMANCE ELEMENTS WITHIN ROMANIAN MASS MEDIA INDUSTRY

Maybe mass media representation is not the best one. Sometimes the press reflection may have a high level of subjectivism. There can be many reasons why the press articles are not favourable ones. It's true that the general opinion is an aspect which those involved need to take into account, but eventually, what really matters is performance. If the results related to audience, expansion and income are good, then all the other aspects can be improved. When we refer to performance, we think of the way in which objectives are accomplished with the contribution of the members of a certain organization. Performance is closely connected to the efforts, abilities and perspective held by the people who, in our case, are involved in the journalistic activity.

A. Expansion and audience

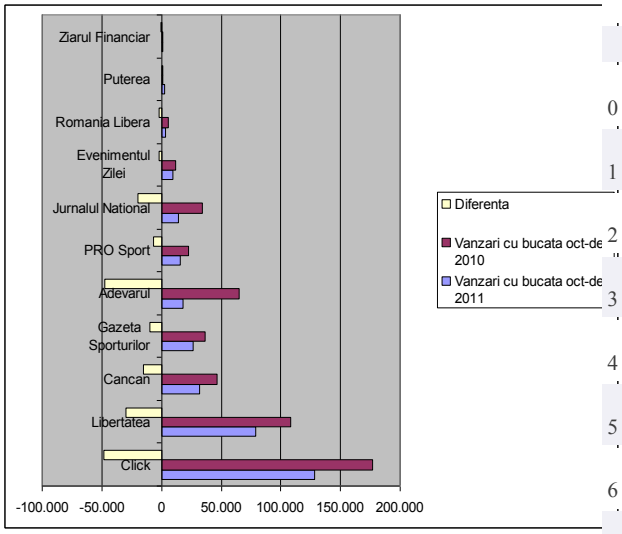
The first element of performance in mass media industry is the audience. In the terrible fight for audience, all the decision making and execution factors are involved. After all, it's no use having the best programs, if nobody is interested in them, so you cannot talk of performance in this case. Therefore, you need a lot of determination when you start this kind of projects, as the famous writer John Maxwell puts it: „Oscar Levant, the pianist with a great sense of humour, once joked: «As soon as I decide on one aspect, I am overwhelmed with hesitation.» Unfortunately, many people think this way. But no one can be irresolute and efficient at the same time. As Napoleon Hill confessed: «The starting point in all achievements is desire.» If you want to be an efficient leader, then you need to know what you want. This is the only way you can identify an opportunity when it shows up." [7]. I have included this quotation here in order to emphasize the idea that if you know what you want, we can fight and get excellent results in spite of the criticism.

Coming back to an analysis of the sales results of the main Romanian publications that were printed in 2011 in comparison to 2010, things don't seem to be satisfactory at all. In the following table and chart, you will find the report done by the Romanian Publications Audit Department.

Name of publication	Total sales Oct - Dec 2011	Total sales Oct - Dec 2010	Difference
Click!	154.593	208.884	-54.291
Libertatea	96.969	126.903	-29.934
Romania libera	37.118	40.909	-3.791
Gazeta Sporturilor	33.314	39.930	-6.616
Cancan	32.745	48.257	-15.512
Adevarul	26.332	75.340	-49.008
Pro Sport	25.354	31.423	-6.069
Jurnalul National	24.200	48.117	-23.917
Evenimentul zilei	15.058	18.197	-3.139
Ziarul Financiar	10.816	12.154	-1.338

Name of publication	Total sales Oct - Dec 2011	Total sales Oct - Dec 2010	Difference
Curierul National	3.157	3.137	38
Puterea	2.506	1.029	1.477

Source: Romanian Publications Audit Department



Source: Romanian Publications Audit Department

What we notice is that both tabloid newspapers and those claiming to be of high quality are experiencing a striking decrease in their sales. Even if in 2011 the Romanian economy showed a slight increase in comparison to 2010, people's interest for these mass media products is going down.

The most obvious decrease is that of **Click**, with a difference of 54.291 copies, followed by **Adevărul**, with 49.008 copies, and **Jurnalul Naţional**, with a decrease of 23.917 copies. But if we take into account the decrease in percentage, **Adevărul** decreased with 65%, **Jurnalul Naţional** with 50% and **Click** with 26%.

As far as TV channels are concerned, things are not less complicated. From the information GFK and Kantar has given us, none of the Romanian TV channels has a bigger audience than 2% of the Romanian population. Most of these channels come under 0,5%.

	JAN. 2011 Daily average		JAN. 2012 Daily average	
		Thousand people		Thousand people
1	Pro TV	410	Pro TV	423
2	Antena 1	282	Antena 1	335
3	Realitatea TV	164	Antena 3	288
4	Kanal D	157	Kanal D	184
5	Antena 3	151	Realitatea	150
6	TVR 1	117	Acasa	121
7	Acasa	110	Prima TV	109
8	Prima TV	101	TVR 1	99
9	OTV	84	Disney	85
10	Disney	76	B1TV	75
11	National TV	68	Romania TV	75
12	TVR 2	47	National TV	70
13	Cartoon Network	45	Cartoon Network	50
14	Minimax/ A+	40	OTV	49
15	Antena 2	39	ETNO	46
16	ETNO	38	TVR 2	43
17	Sport.ro	34	Minimax/A+	38
18	Eurosport	26	Pro Cinema	30
19	B1TV	26	Eurosport	26
20	Pro Cinema	25	Discovery	24

Source: http://www.paginademedia.ro

Antena 1 has 53.000 more viewers than last year, **B1** has an increase of 49.000 viewers and **Pro Tv** an increase of 13.000 viewers. On the other hand, **TVR 1** has a decrease of 18.000 viewers and **OTV** a decrease of 35.000 viewers. In general, we have a divided audience because there are many TV channels. For each type of format, competition is very high; therefore, on all channels audience is diluted. Probably switching channels is practiced daily in millions of houses. This spreading is obviously leading to journalists' scattering to this multitude of TV channels. Guests go daily to five or six TV channels repeating the same message. From the point of view of audience, we cannot say that in this period of time written press or television has got performance.

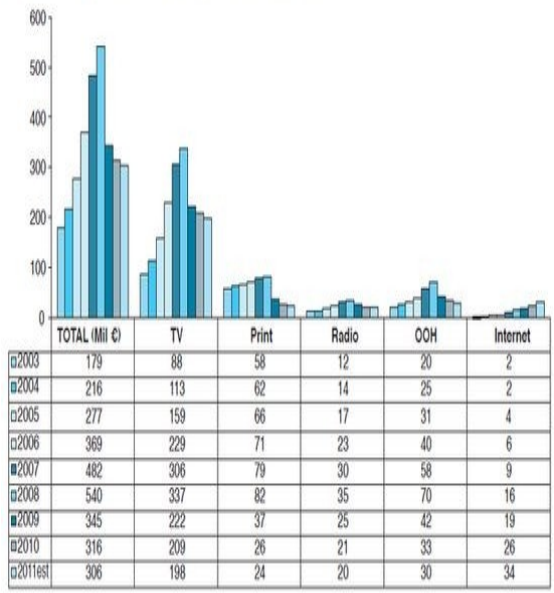
B. Money talks

If audience and public image are not the best cards of mass media industry, we will try examining the financial situation. In any society, income is decisive both when evaluating success and in thinking about future orientation. The starting point in forecasting resides in previous results. In his famous work, „Understanding mass media", Marshal McLuhan points out the

importance of money in mass media. „Money talks, because money is a metaphor, a transfer and a bridge. Just like words and language, money is a depositary of work, compensation and jointly acquired experience. But money also represents a specialized technology, as it is the case with writing. Writing intensifies the visual aspect of speaking and of order and a clock divides time from space visually; in the same way money divides work from all the other social functions. As a vast social metaphor, bridge or translator, money, just like writing, accelerates exchanges and consolidates interdependent relationships in all communities. Money provides a vast spatial extension and control of political organizations, just as writing and calendars do it. It involves an action which is done in the distance both in terms of space and time. In an extremely cultivated and fragmented society, „time is money", and money is the depositary of time and of other people's efforts." [8].

In this respect, for mass media industry, money that comes from publicity is essential.

Graph 1: Total net Ad-spend by medium (Mil €) - Estimation



	TOTAL (Mil €)	TV	Print	Radio	OOH	Internet
2003	179	88	58	12	20	2
2004	216	113	62	14	25	2
2005	277	159	66	17	31	4
2006	369	229	71	23	40	6
2007	482	306	79	30	58	9
2008	540	337	82	35	70	16
2009	345	222	37	25	42	19
2010	316	209	26	21	33	26
2011est	306	198	24	20	30	34

Source: http://www.mediafactbook.ro/mfb-2011

From the money record which came from publicity in Romania during 2003-2011, we notice a decrease of publicity income in all classic fields: television, print, radio, billboards. There is a slight increase in the case of internet, but here the amount of money that was invested is small in comparison to television or to the total amounts that were invested. According to financial data, it seems that not even in the money aspect we can speak of success in mass media.

IV. MANAGEMENT BY OBJECTIVES: QUALITY AND PERFORMANCE IN MASS MEDIA

The notion of management by objectives also called results based management was introduced by Peter F. Drucker. The idea is that managers will focus on those activities leading to efficient actions, that is to performance. Planning and control are key elements for any leader who seeks management by objectives. Establishing and defining objectives, planning to accomplish them, creating a system of self-control and periodic reexamination and evaluating performance are essential stages in the managerial process. „Management needs to focus on the results and on the efficiency of the company. Actually, the first task of management is to define those elements that make up the results and efficiency in a certain company – and this is one of the most difficult and controversial, yet very important tasks to be accomplished, as anyone, who has dealt with that, can testify. The reason for the management's existence is actually the results obtained by an institution. The management must start from the proposed results and organize the company's resources in order to achieve those results." [9]. The first objective of management by objectives is improving performances. That's why it is important to involve the employees in establishing the objectives. In this way, they will have the opportunity to express their views, to make proposals and to be part of the planning process. The key to success in this type of management is the high level of involvement of leaders and their subordinates. The success of results based management depends on identifying and accomplishing the strategic, operational and individual objectives. The role of the manager in this framework is to generate and implement strategies. As a consequence, strong and efficient companies will be established with a huge growth potential. If we see the Romanian mass media system from this perspective, we notice that economical targets, those relating to audience, sales or professional deontology are not reached. The fact that they are not accomplished on such a large scale gives us the impression that these are not the objectives either. Taking into account all these factors, it seems that the objectives of Romanian mass media industry are rather political and, as far as the economic activity is concerned, probably the survival stage is enough. If we think in this way, then things begin to take shape and we find an explanation for the multitude of TV channels having the same format, for the decrease in audience and for the modest economic results. Therefore, if the objective is political, quality is not really important or is defined in a different way.

I. CONCLUSIONS AND PROPOSALS

Success is planned. People need a path to follow, clear objectives and coherent strategies. No matter how much we want to believe that, when it comes to work, we can only function on instinct or pleasure basis, organizational performance has very few chances to reach its desired quality level if it is not supported by a plan in which objectives are supervised and carried out. „The first rule of somebody's focused efforts is to get rid of the past, which stops to be productive. Whether she likes it or not, the person involved should give up the past on a constant basis. Yesterday's decisions and actions, no matter how brave or wise, inevitably become

today's problems, crisis and mistakes. Each person involved should permanently use her time, energy and ingenuity to improve or abandon her own or her predecessors' past decisions and actions." [10]. Regardless of the reasons or how mass media industry has reached its present stage, things cannot and must not remain the same. In order that mass media becomes a power in the service of good, we think that it should accomplish some strategic objectives.

The first objective we propose is TRUTH.

We are not proposing an abstract philosophical concept, but a high professional ethics. Journalist's duty is to present the truth about the events he presents. As long as the filmed scenes are directed and more records are done, from which we choose one and edit in order to broadcast on the TV channel, we are far away from accomplishing this objective. However, there is still hope, as we have shown in the first part of this study, because both in Romania and in big press trusts there is a concern that mass media should become again a power in the service of good.

The second objective we propose is USEFULNESS.

We don't mean usefulness in the sense used by neoclassical economists, but rather in the sense of being helpful to the targeted public. To look for the good and interest of the audience can bring us greater benefits than if we seek to increase our audience at the cost of giving up moral standards. If we worry because some products make our body sick, maybe we should also stay away from those things that are harmful to our mind. Quality orientation is connected to usefulness and, first of all, it has to do with our mind's attitude and the way we relate to values.

The third objective that we propose is OPTIMISM.

Nowadays, most of the public messages in mass media are striving to prove what we haven't done well, what we don't do well and that we will not succeed in doing well in the future. Hate for the sake of good seems to be the strategy which needs changing. The perspective that we are proposing is to create a new opportunity out of this present situation. With the help of innovation and transformation, let's look for solutions to develop our abilities, relationships, products, markets and results. We should never forget that the greatest and most impressive changes are often born in times of crisis.

With these objectives in mind, the mass media industry will acquire quality and performance, the media products will become meaningful, adding extra value to the journalistic act and, as a direct consequence, the interest of the audience will grow, leading also to an increase in income.

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Anchor-free Localization Algorithm with Time of Arrival Node Distance Estimation

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Abstract *– In this paper, we describe a range-based anchor-free positioning algorithm and its simulation. This type of algorithm can be used for localization in a mobile ad-hoc network without presence of reference nodes with known position. The Time of Arrival method has been used to obtain the node distance via the wireless channel impulse response. Additionally, in order to improve the node distance estimation accuracy for the ToA estimation, it is distinguished between the Line-of-Sight (LoS) and Non Line-of-Sight (NLoS) communication. The simulations have been carried out in the MATLAB programming environment.*

Keywords: *anchor-free; localization; ToA; MANET.*

I. INTRODUCTION

In the field of mobile communications, the wireless node location problem has gained increasing interest. Several positioning algorithms have been developed so far. It is generally true that the location is determined by using several reference nodes and one of the triangulation localization algorithms. Such algorithms are called Anchor-based. Localization in the network without presence of reference nodes presents a problem. A special localization procedures are needed to be used. Such algorithms belong to the Anchor-free category.

The most important parameter in range-based positioning is the parameter estimation accuracy for node distance determination. There are different node distance estimation techniques that can be used in mobile ad-hoc network (MANET) positioning, such as Received Signal Strength (RSS), Time of Arrival (ToA) or Angle of Arrival (AoA) which provide different levels of accuracy and in addition, the complexity of implementation [6].

ToA is one of the most accurate node distance estimation technique, but very predisposed to the harsh multipath environment and in some cases heavy on implementation. Since the ToA parameter is determined using the time domain channel impulse response, knowing the channel profile is very important in order to maximize performance of the localization algorithms. The increasing system bandwidth enhances time-domain resolution of the ToA estimation accuracy [6]. In the case of fixed system bandwidth, the post-processing on the frequency measurement data is needed to be used. Several solutions have been introduced which solve this problem, such as Inverse Fourier Transform [6], Direct Sequence Spread Spectrum (DSSS) [6] and super resolution algorithms Matrix Pencil, Estimation of Signal Parameters via Rotational Invariance Techniques (ESPRIT) and Multiple Signal Classification (MUSIC) [7].

II. BRIEF OVERWIEV OF THE ANCHOR-FREE LOCALIZATION ALGORITHM

The localization algorithm runs for each node separately and uses only one-hop communication, which prevents the network congestion. It consists of two main steps:

A. Local Coordinate System (LCS) formation

This process is based on the Improved MDS-MAP technique introduced in [1] and it consists of the:

- **node distance estimation** based on the localization parameters measurement and
- on the **distance matrix formation** procedure.

B. Global Coordinate System (GCS) formation

This process is also called the Network Coordinate System building [2] in which the Local Coordinate Systems are unified in the same direction.

A. Local Coordinate System formation

The aim of this process is LCS formation of each node in the network, which consists of its relative position and relative position of its one-hop adjacent nodes. Each node forms its own local coordinate system, in which it is located at the centre. Its position is set to [0,0].

Node distance estimation based on localization parameter measurement. Some distance estimation techniques, such as Received Signal Strength - RSS or Time of Arrival - ToA, can be used in order to determine the node distance. Now, each node knows its distance to the one-hop adjacent nodes and fills the first row and column of the distance matrix.

Distance matrix formation. In this step the missing node distances are filled up in the distance matrix. This

process is based on the node communication procedure of such nodes, which belong into the LCS of the given node.

Node communication procedure. The node "ID1" sends a message containing its identification to the one-hop adjacent nodes in the network. They add the information to the message about the distance to the node "ID1" and send this message to their one-hop adjacent nodes. This procedure is repeated also by the third degree nodes. They add the information to the message about their distance to the node, from which they receive the message. These nodes send the message again to their adjacent nodes and they check:

- If "ID1" is identical with node ID, it stores the information about the distance between the nodes "ID2" and "ID3" into its distance matrix.
- For other nodes, if "ID1" is not identical with node ID, ignore this message and do not send it again.

The distance matrix is symmetrical and contains zeros in the main diagonal. The formed distance matrix is used as the input into the Multidimensional Scaling method in order to form a local coordinate system of each node.

B. Global Coordinate System formation

Now, the network node LCSs are formed, but they have different directions. The partial LCSs must be joined together, because they are shifted, rotated and mirrored according to each other. Using such operations, the partial LCSs can be joined into the one Global Coordinate System. The procedure of the GCS formation is explained on two LCSs of the nodes "A" and "B". For the sake of clarity, the nodes of the second LCS are marked by a comma, Fig. 1. The LCS(B) is joined with the LCS(A). Presence of the node "B" located in the LCS(A) (and vice versa, the node "A" located in the LCS(B)) is crucial. Similarly, it is advantageous, if the third node is located in LCS(A) and LCS(B) simultaneously.

At first the centre of the LCS(B) must be shifted to the node "A", Fig. 2. The procedure of shifting is carried out by subtraction of the coordinates of the node "A" from the coordinates of each node.

Next, both LCSs must be oriented in the same direction, in other words, LCS(A) must be rotated by an angle α and LCS(B) must be rotated by an angle β. They can be expressed for positive and negative y_B,y_B' respectively as, Fig. 3:

$$\alpha = \arccos\frac{x_B}{D_{AB}}; \quad \beta = \arccos\frac{x_B'}{D_{AB}'} \qquad (1)$$
$$\alpha = -\arccos\frac{x_B}{D_{AB}}; \quad \beta = -\arccos\frac{x_B'}{D_{AB}'}$$

$[x_B,y_B]$ represent the coordinates of the node "B" and D_{AB} represents the distance between the nodes "A" and "B". Similarly for $[x_B',y_B']$ and D_{AB}'.

Then both LCSs will rotate in the direction negative to the size of α or β. For this process it is necessary to calculate the angle δ, which represents the angle BAX_i (X_i represents i[th] node; $X_i \neq A,B$).

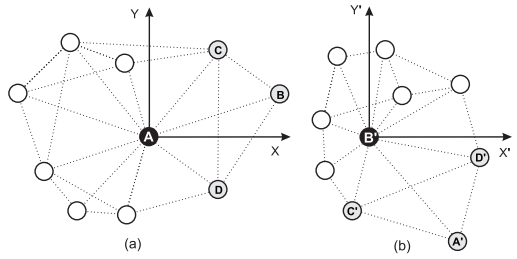

Fig. 1 LCSs of the nodes "A" and "B" used for problem explanation

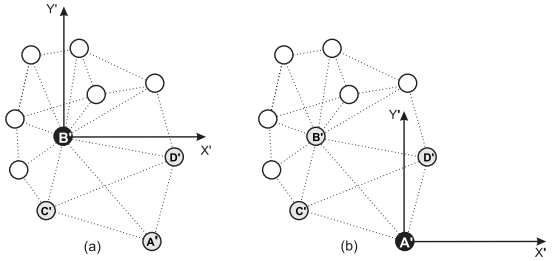

Fig. 2 LCS(B) shifted to the node "A", (a) before and (b) after shifting respectively

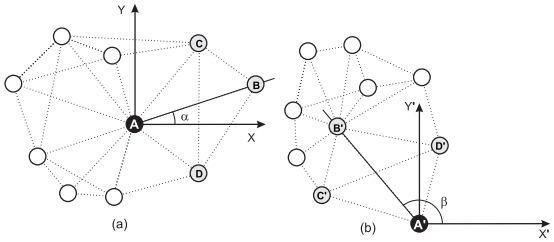

Fig. 3 Calculation of angles for rotation process

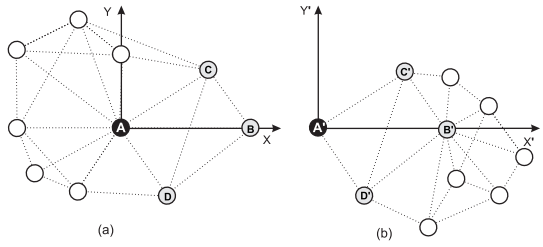

Fig. 4 LCSs oriented in the same direction

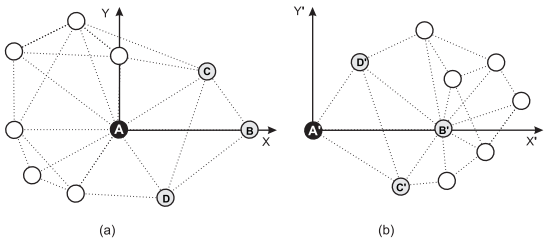

Fig. 5 Test for the need of mirroring (mirroring is needed)

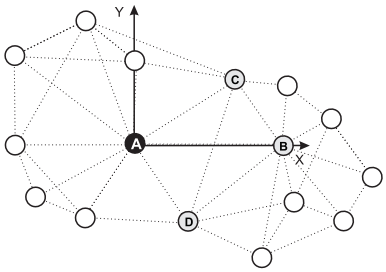

Fig. 6 LCS(B) joined to the LCS(A)

For positive and negative y_i respectively:

$$\delta_i = \arccos\frac{x_i}{D_{Ai}};\quad \delta_i = -\arccos\frac{x_i}{D_{Ai}} \tag{2}$$

The point coordinates will be recalculated for positive and negative result of $\delta - \alpha$ respectively as:

$$\begin{aligned} x_i &= D_{Ai}\cos(\delta_i - \alpha);\quad y_i = D_{Ai}\sin(\delta_i - \alpha) \\ x_i &= -D_{Ai}\cos(\delta_i - \alpha);\quad y_i = D_{Ai}\sin(\delta_i - \alpha) \end{aligned} \tag{3}$$

The same procedure can be applied also for the LCS(B) rotation.

After rotation, a point "C", which is common for both LCSs, must be found. According to its location, it will be decided about the need of mirroring. If "C" has not the same sign of the y-axis, mirroring is necessary, Fig. 5.

Mirroring is carried out by simple change of the sign of the y-axis for each node in LCS. Now both LCSs can be joined together, Fig. 6.

III. WIRELESS COMMUNICATION CHANNEL CLASSIFICATION

The channel impulse response between a transmitter and a receiver distant at distance *d* can be generally expressed as [4]:

$$h_d(t) = \sum_{i=1}^{L_p} \beta_i^d \delta\left[t - \tau_i^d\right] \tag{4}$$

where L_p is the number of multipath components, β_i^d is the location specific random complex amplitude and τ_i^d represents the random propagation delay of the i-th path. Impulse transmitted from the transmitter site arrives at the receiver site as the sum of multiple delayed impulses δ with different magnitude and phases due to multipath behaviour of the wireless communication channel. Wireless communication channel profile can be classified as [4][5]:

- **LoS (DDP)** – *Line-of-Sight with Dominant Direct Path*. The direct path is the strongest and first detected path in the channel profile and it can be detected by the receiver. Usually, there are no obstacles between the transmitter and the receiver.
  For range measurements in NLOS channel conditions face a more difficult challenge, since the direct path is either detected but attenuated or completely blocked [5].
- **NLoS (NDDP)** – *Non Line-of-Sight with Non Dominant Direct Path*. Line-of-Sight communication between a transmitter and a receiver does not exist. In NDDP channel profile the direct path is not the dominant strongest path of the channel impulse response, however, it is detectable because it is received above the detection threshold of the receiver. Direct path can be detected by a more complex receiver. It may happen that the receiver chooses the direct path incorrectly according to path with strongest energy.
- **NLoS (UDP)** – *Non Line-of-Sight with Undetected Direct Path*. In UDP channels, direct path arrives below the detection threshold of the receiver while other paths are still detectable. The receiver assumes the first detected peak as a direct path which causes considerable distance estimation errors.

IV. SIMULATIONS AND RESULTS

A. Time of Arrival estimation

The model for IEEE 802.15.4a technology [3] has been used in order to simulate the node communication as realistic as possible. It provides channel modeling for different frequency ranges and environments, with a distinction between the LoS and NLoS properties. In our simulations we have used the channel impulse response generation for "office" and "residential" environment via the ultrawideband (UWB) model, spanning the frequency range from 2 to 10 GHz.

The ToA parameter has been determined from the channel impulse response using three different algorithms:

The strongest peak – the ToA parameter is determined in accord with the time of arrival of the received path represented by the strongest peak.

ToA estimation algorithm with the LoS/NLoS identification – At first, wireless communication channel is identified using Kurtosis Parameter (KP) calculation. "The kurtosis is a statistical parameter that indicates the variance variation of the signal amplitudes. Thus, it indicates with high numerical values the signals with distinguishable amplitude peaks. It is mathematically defined as follows:

$$kurtosis(x) = \frac{1}{\sigma^4}\frac{\sum_i\left(x_i - \bar{x}\right)^4}{N} \tag{5}$$

where σ is the standard deviation of the variable x and $\bar{x}$ is the mean value of x. N is the number of samples of x" [8]. KP is characterized by a high value of the signal received via LoS communication (few peaks and very distinguishable from the natural noise), and by low value of the signal received via NLoS communication (the signal is more noise-like). In general, kurtosis has a smaller value if SNR of the received signal is smaller [8]. KP is compared with the threshold, which was

obtained from the experimental observations as an average value, where the KP was calculated from the thousand times generated channel impulse response for LoS and NLoS of both environments separately. The threshold was set on **112** for "office" and **16.5** for "residential" environment.

$$\begin{aligned} KI < threshold &\Rightarrow NLoS \\ KI \geq threshold &\Rightarrow LoS \end{aligned} \quad (6)$$

If the communication is classified as LoS, the ToA parameter is determined as the time of arrival of the strongest path. If the communication is classified as NLoS, the ToA parameter is determined as the time of arrival of the first detected path.

First detected peak – it does not distinguish between the LoS and NLoS communication. The ToA parameter is always determined as the time of arrival of the first detected peak.

B. Localization process evaluation

If the ToA parameter is known, the node distance D can be simply expressed as:

$$D = c \cdot ToA \quad (7)$$

where c represents the speed of light (3.10^8m/s) and ToA represents the estimated ToA parameter.

The simulations were carried out in MATLAB programming environment and for the statistical relevance they were repeated one hundred times. We used the network, which consisted of the 50 mobile nodes deployed in the area of 50x50m with all receivers' radio range of 15m. We have assumed the precise transmitter-receiver time synchronization. These localization parameters have been studied: the localization error, the node distance estimation error and the number of successfully localized nodes. The results of the first two were expressed in percentage according to the network size (50m=100%). The reader can find the simulation results in the *TABLE 1* and *TABLE II*.

TABLE 1 Localization algorithm evaluation in OFFICE environment.

OFFICE ENVIRONMENT			
ToA estimation algorithm	Total localization error [%]	Number of localized nodes	Average distance estimation error [%]
The strongest peak	18,97	48,48	2,47
LoS/NLoS detection	14,21	49,00	0,75
First detected peak	8,49	48,42	0,22

TABLE II Localization algorithm evaluation in RESIDENTIAL environment

RESIDENTIAL ENVIRONMENT			
ToA estimation algorithm	Total localization error [%]	Number of localized nodes	Average distance estimation error [%]
The strongest peak	20,78	48,82	8,75
LoS/NLoS detection	19,85	48,04	4,06
First detected peak	19,56	48,40	2,80

V. CONCLUSION

The simulations show that the knowledge of the channel profile improves the localization accuracy and that in the most cases it depends on the receiver complexity. The localization accuracy improves especially in the "office" environment.

ACKNOWLEDGMENT

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Optimal Linear Controller Design Method for SISO Systems Based on Minimum of Integral Square Error

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Abstract **– *This paper presents a time-domain method for designing optimal linear controllers based on minimum error criterion. It is applicable to continuous and discrete time systems. The paper considers linear single input single output (SISO) systems. The method exploits the nature of numerical solutions to set up a weighted performance index for finding the optimal coefficients of a linear controller. The index can be changed by merely changing the weighting function, thus rendering the method very flexible. Simulation results show that this method is often better than many other off line optimal control system design methods it is compared with.***

Keywords: ***Time-domain; Optimization; PID; Error criteria; Switched-time weighting***

I. INTRODUCTION

In finding the response of a control system by a digital computer a numerical algorithm is used to evaluate the system's response to a given input at discrete intervals of time *T*. Since the numerical procedures allow us to observe the response only at regular intervals of *T* seconds, numerical solution can be considered a sampling operation with a sampling period of *T* seconds. Thus, the computational model of the continuous-time system is a discrete-time process. For example, the step response of a linear system found using a digital computer is simply a set of observations of the system response at discrete instants of time. Such observations can be described by a difference equation and techniques for manipulating difference equations are applicable. It therefore follows that a method based on this realization is equally applicable to both continuous and discrete-time systems.

In section 2 traditional error criteria are discussed together with their frequency domain formulation. In section 3 the time-domain method is introduced. The method is based on evaluating the inverse of error function using an algorithm due to Liou[1] for evaluating the transients of the linear system shown in fig.1 although other appropriate Laplace transform inversion or integration procedures[2] may be used. This is followed with some examples in section 4. The conclusion in section 5 consists of discussions concerning the method and its implementation.

II. INTEGRAL SQUARE ERROR PERFORMANCE INDICES

Consider the continuous-time single-input single-output (SISO) control system with unity feedback shown in fig.1.

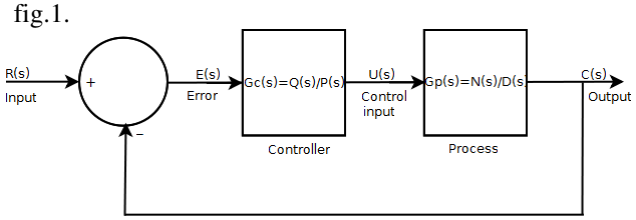

Fig. 1: Closed-loop control system with unity negative feedback

The closed-loop system can be represented by the following general strictly proper *s*-transfer function

$$G(s)=\frac{C(s)}{R(s)}=\frac{\beta_1 s^m+\beta_2 s^{m-1}\cdots+\beta_{m+1}}{\alpha_1 s^n+\alpha_2 s^{n-1}\cdots+\alpha_{n+1}} \quad (1)$$

where m and n are positive integers and $n > m \geq 0$. The constants α_i and β_i are real. $G_p(s) = N(s)/D(s)$ is the transfer function of the process. A general form of the linear controller in the SISO system in fig. 1 can be written as

$$G_c(s)=\frac{Q(s)}{P(s)}=\frac{q_1 s^l+q_2 s^{l-1}\cdots+q_{l+1}}{p_1 s^j+p_2 s^{j-1}\cdots+p_{j+1}} \quad (2)$$

where j and l are positive integers and $j, l \geq 0$. In optimal control system design, the parameters q_i and p_i of the controller are found by minimizing a certain performance index J, where

$$J = f(\boldsymbol{\theta}) \quad (3)$$

and $\boldsymbol{\theta} = (q_1, q_2, \ldots. q_{l+1}, p_1, p_2, \ldots. p_{j+1})$ is the parameter vector. Often J is an error or loss function. Usually, for continuous-time SISO systems, the performance index is the integral of square error (ISE).

$$J = \int_0^\infty e^2(t)dt \tag{4}$$

This can be written in the frequency domain, through Parseval's Theorem, as

$$J = \frac{1}{2\pi j}\int_{-j\infty}^{j\infty} E(s)E(-s)ds \tag{5}$$

where $j = \sqrt{-1}$ and $E(s)$ is the Laplace transform of the error $e(t)$ obtained from fig.1 as

$$\begin{aligned} E(s) &= \frac{P(s)D(s)R(s)}{P(s)D(s)+Q(s)N(s)} \\ &= \frac{b_1 s^m + b_2 s^{m-1} \cdots + b_{m+1}}{a_1 s^n + a_2 s^{n-1} \cdots + a_{n+1}} \end{aligned} \tag{6}$$

The expression for J in the frequency domain makes it amenable to mathematical manipulations. For example, it can be evaluated as the sum of the residues of the integrand in the complex s-plane[3]. It can be evaluated from the coefficients of $E(s)$ using the determinant method of Jury[4]. Its value in terms of the coefficients of the error function has also been tabulated in [5]. J can also be evaluated using the Åström's elegant recursive algorithm[6]. These properties of the ISE make it a popular performance index.

However, there are two major drawbacks in using ISE to find optimal control parameters for a linear system. Firstly, when the $E(s)$ has a zero at the origin the evaluation of the ISE is not straightforward. In particular, Åström's algorithm cannot be used to evaluate the ISE integral. Secondly, the ISE tends to produce responses with pronounced overshoot and long settling times, which may be practically unacceptable. Large overshoots may be indicative of large control input which, in reality, may force the process into saturation. For these reasons time-weighting is added to the ISE criterion resulting in a performance index of the form

$$J_t = \int_0^\infty t^v e^\mu(t)dt \tag{7}$$

where v and μ are positive integers. J_t can still be evaluated using the methods cited above provided $\mu = 2v$. In these cases the performance index in the frequency domain is written as

$$J_t = \frac{1}{2\pi j}\int_{-j\infty}^{j\infty} F(s)F(-s)ds \tag{8}$$

where $F(s) = \partial^v E(s)/\partial s^v$. An optimization program can be used to iteratively change the elements of the vector $\boldsymbol{\theta}$ until J in equation (5) or J_t in equation (8) is minimized. Efficient program for evaluating these indices can be found in [6].

III. THE ALTERNATIVE TIME-DOMAIN APPROACH

We now introduce an alternative approach to using the frequency domain indices. The error function in equation (6) can be expressed in a state-space form[7] as

$$\dot{\mathbf{x}}(t) = \mathbf{A}\mathbf{x}(t) \tag{9}$$

where $\mathbf{x}(t)$ is a state vector whose elements are the states of the system, $\dot{\mathbf{x}}(t)$ is the first derivative of the state vector with respect to time t and $\mathbf{A}$ is a companion matrix formed from the coefficients of the denominator of $E(s)$ as follows:

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ 0 & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ -a_{n+1} & -a_n & -a_{n-1} & \cdots & -a_2 \end{bmatrix} \tag{10}$$

The exact solution of equation (9) is

$$\mathbf{x}(t) = e^{\mathbf{A}t}\mathbf{x}(0) \tag{11}$$

where $\mathbf{x}(0)$ is the initial states vector. Liou[1] has shown that if the elements of the initial states are defined as

$$\begin{aligned} x_1(0) &= b_2 \\ x_2(0) &= b_3 - a_2 x(0) \\ x_3(0) &= b_4 - a_2 x_2(0) - a_3 x(0) \\ \cdots &= \cdots \\ x_n(0) &= b_{n+1} - a_2 x_{(n-1)}(0) - a_3 x_{(n-2)}(0) \cdots \\ &\quad - a_{n-1} x_2(0) - a_n x_1(0) \end{aligned} \tag{12}$$

then the states vector $\mathbf{x}(t)$ in equation (11) can be calculated recursively at regular intervals of time $t = kT$, $k = 0, 1, 2, \ldots$ from

$$\mathbf{x}[(k+1)T] = e^{\mathbf{A}t}\mathbf{x}(kT) = \mathbf{P}\mathbf{x}(kT) \tag{13}$$

where T is a fixed interval of time and $\mathbf{P} = e^{\mathbf{A}T}$ is the transition matrix. The solution to (9) at time kT is the first element of the vector $\mathbf{x}(kT)$. This element will be denoted by $x_1(kT)$. Thus the impulse response (or inverse) of $E(s)$ computed regularly at intervals of T seconds is given by $e(kT) = x_1(kT)$, $k = 0, 1, 2, \ldots$. Where numerical integration methods[2], such as the Runge-

Kutta, are used to get $e(kT)$ then T is the integration step size. Similarly, the output $c(kT)$ can be obtained from

$$C(s) = \frac{Q(s)N(s)R(s)}{P(s)D(s) + Q(s)N(s)} \quad (14)$$

The error $e(t)$ observed at time t can be directly evaluated by inverting (6) or indirectly by inverting (14) and then using

$$e(t) = r(t) - c(t) \quad (15)$$

where $r(t)$ is the inverse of the input $R(s)$. The values of $e(t)$ or $r(t)$ and $c(t)$ can be evaluated at discrete instants of time by means of equation (13). Therefore it follows that equation (15) can be written in discrete form as

$$e(kT) = r(kT) - c(kT) \quad (16)$$

The error is in form of a finite sequence. Each individual error element is now rendered accessible and can thus be individually weighted. That means a performance index of the following form can be set up

$$J = \sum_{k=0}^{N} w(kT)\,|e(kT)| \quad (17)$$

where N is a finite integer. Thus by individually weighting the errors observed at times $t = kT$, $k = 0, 1, 2, \ldots N$ it is possible to determine the optimal controller coefficients for achieving a response with minimum overshoot and settling-time. We may desire for a deadbeat response t_r seconds after the application of the input. This can be achieved by making $w(kT)$ to be a piece-wise linear function so that it weights sections of the response curve differently.

$$w(kT) = \begin{cases} 1 & kT < t_r \\ W & kT \geq t_r \end{cases} \quad (18)$$

where W is a large number, say 100. Errors occurring at t_r and later times are heavily weighted. Note that other error criteria are easily realized by modifying the weighting function in (17). For example, to get Integral Square Error (ISE) define $w(kT) = |e(kT)|$. For time weighted Integral of Absolute Error (ITAE) set $w(kT) = kT$. Setting $w(kT) = kT|e(kT)|$ gives the time-weighted ISE, etc. Note that the time weighting in equation (18) is switched into play at time t_r. For this reason it is appropriate to refer to this method of time weighting as switched-time weighting.

An alternative approach proposed in this article is to set up a time-weighted square error performance index of the following form

$$J = \sum_{k=0}^{N} w(kT)e^2(kT) \quad (19)$$

where N is the integer part of t_f/T and t_f is a period which is, at least, twice the setting time of the uncompensated closed-loop response of the system. The index in equation (19) would overcome the short-comings of the ISE. This approach enables formulation of a time-weighted performance index of the general form given in equation (7) without restriction on the values of μ and v. In addition, the time weighting can be fixed or defined in a flexible manner to suite purpose.

The first step in the design procedure is to determine the quantities t_r, t_f and T. The value of t_r can be defined as the required rise-time of the response and t_f should be at least twice the settling time of the uncompensated system response. Plotting the uncompensated response of the system (to a given input) may help one in selecting t_r and t_f . The guidelines regarding the choice of T (i.e. the integration step-size or sampling period) can be found in the literature. One could have used the closed-loop system bandwidth, but that information is not known until after the controller has been designed. A more practical approach is to use ω_c, the crossover frequency of the process. The integration step size is then selected within the range $\pi/(15\omega_c) \leq T \leq \pi/\omega_c$.

It is desirable to limit the control input $U(s)$ so that the process is not forced into saturation or for some other practical reasons. From Fig.1 and equation (6) the expression for $U(s)$ is derived as

$$U(s) = \frac{Q(s)D(s)R(s)}{P(s)D(s) + Q(s)N(s)} \quad (20)$$

The control input can be included in the minimization by including $u(t)$ in the performance index. The expressions for $U(s)$ and $E(s)$ have the same denominator. Thus we can write

$$E'(s) = \frac{D(s)R(s)[P(s) + \mu Q(s)]}{P(s)D(s) + Q(s)N(s)} \quad (21)$$

where $\mu \in [0, \ldots, 1]$ is a scaling factor signifying the relative contribution of $u(t)$ in the performance index. We can then replace $e(kT)$ in equation (19) with $e'(kT)$ and find the optimal controller coefficients that give minimum error and control input.

IV. EXAMPLES

For the purpose of demonstrating the proposed method we would use the most popular controller, which is the Proportional + Derivative + Integral (PID) controller. Its model is a special case of equation (2). For example, the transfer function of an ideal PID controller is

$$G_c(s) = K\left(1 + \frac{1}{sT_i} + sT_d\right) = K_P + K_I/s + sK_D \tag{22}$$

where T_i and T_d are the integral and derivative time constants. K_P, K_I and K_D are the controller proportional, integral and derivative gains respectively. Equation (22) can be written as

$$G_c(s) = \frac{q_1 s^2 + q_2 s + q_3}{s} = \frac{Q(s)}{P(s)} \tag{23}$$

where the controller parameters q_i are related to the PID constants in the following way

$$\begin{aligned} q_1 &= KT_d \\ q_2 &= K \\ q_3 &= K/T_i \end{aligned} \tag{24}$$

Once the coefficients q_i are found, the parameters in equation (22) can be recovered from equation (24).

The PID controller is susceptible to noise. Therefore in industrial applications a filter is often put on the derivative part giving a controller transfer function of the following form

$$\begin{aligned} G_c(s) &= \frac{Q(s)}{P(s)} = K_P + K_I/s + \frac{sK_D}{s\tau + 1} \\ &= \frac{(K_D + \tau K_P)s^2 + (K_P + \tau K_I)s + K_I}{s(s\tau + 1)} \end{aligned} \tag{25}$$

where τ is the filter time constant. In this case the coefficients q_i are

$$\begin{aligned} q_1 &= K_D + \tau K_P \\ q_2 &= K_P + \tau K_I \\ q_3 &= K_I \end{aligned} \tag{26}$$

When $\tau = 0$ the equations revert to (24). We now consider a few examples to demonstrate that the proposed controller designing method is a worthwhile technique for offline design of linear optimal controller.

The following model seems to have been used by several authors to compare their PID controller tuning techniques.

$$G_p(s) = \frac{1 - 5s}{(1 + 10s)(1 + 20s)} \tag{27}$$

The model was used by Varol and Bingul[8] to test their ant algorithm for tuning PID controllers[9]. In their paper the ant algorithm was compared with results obtained from Ziegler-Nichols (ZN) tuning rules [10], Iterative Feedback Tuning (IFT) technique [11] and Internal Model Control (IMC) method [12]. It was concluded that the ant algorithm and the IFT technique performed better than the other tuning techniques in terms of output characteristics.

Similarly, the model was used by Killingworth and Krstić[13] to demonstrate their Extremum Seeking (ES) algorithm. The ES technique was also compared with ZN, IMC and IFT tuning techniques. The authors found that, for the particular model, the ES method produced a step response very similar to that of IFT both of which yield no overshoot and small settling time compared with ZN and IMC.

It is also used by Mossberg[14] to demonstrate PID controller tuning using time-weighted absolute error criteria whereby the gradient information used during the minimization is obtained via the Iterative Feedback Tuning method of Lequin *et al* [11].

In this article the above-cited tuning techniques are compared with the proposed tuning method, which is based on minimizing the following integral.

$$J = \sum_{k=0}^{N} w(kT)e^2(kT) \tag{28}$$

where $w(kT)$ is the following weighting function

$$w(kT) = \begin{cases} 1 & k < M \\ 100 & k \geq M \end{cases} \tag{29}$$

where k and M are integers and M is the integer part of t_r/T. We would thus call the index in equation (28) switched-time weighted ISE (or *t*ISE).

Example 1

The proposed method is used to find the optimal PID controller for the model in equation (27). The PID parameters are as given in equation (23). The task is to find the parameter set (q_1, q_2, q_3) that will cause the unit-step response of the closed-loop system to settle with little or no overshoot.

The response of the system without the controller was plotted using MATLAB. It was found that the step response settles after 63s (i.e. settles within 2% of the steady state value). Therefore we set the value of t_f = 130s, which is just a little over twice the settling time. The integration step size was also deduced from the MATLAB step response as T = 1.3s. Thus N = int(t_f/T) = 100. The performance index in (28) is used with value of M in the weighting function initially set to M = 5. The inverse is evaluated at intervals of T seconds as described in Section 3. Hooke-Jeeves[15] optimization routine is used to search for q_i that will minimize (28).

The value of M is progressively increased until we got a satisfactory response at M = 14. The optimal parameters obtained are (q_1, q_2, q_3) = (18.6047, 3.1100, 0.1011) resulting in K = 3.11, T_i = 30.7616, T_d = 5.9831. The compensated unit-step response due to these parameters is shown in fig.2. Table 1 below shows the parameters obtained by each method.

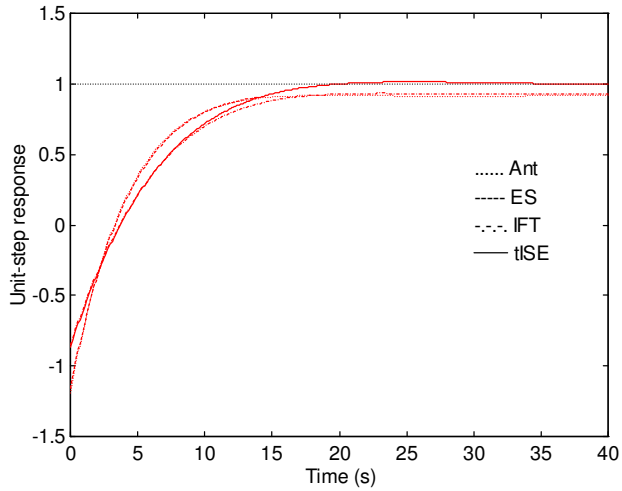

Fig.2: Step responses for Example 1

None of the cited methods attain steady state even after 40s as is clearly seen in fig.2. On the other hand the controller found using the proposed method makes the response to attain steady state within 20s.

TABLE 1. PID controller parameters for Example 1

Method	***K***	T_i	T_d
ES	3.3500	49.2000	6.4000
IFT	3.0279	46.3178	6.0793
*t*ISE	3.1100	30.7616	5.9831
Ant	K_P = 3.3358	K_I = 0.0661	K_D = 21.7854

The corresponding control inputs in example 1 are plotted in fig. 3. The control input resulting from the *t*ISE criterion has the second lowest absolute value compared with the other methods.

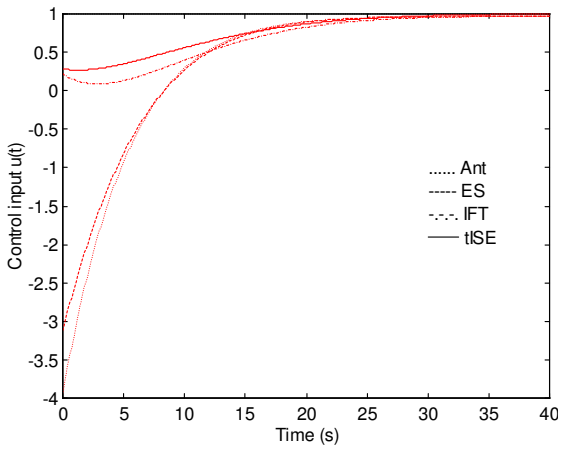

Fig.3: Plot of control inputs for Example 1

Example 2

In this example the First-Order-Plus-Time-Delay (FOPTD) process is considered. This type of model is often used by researchers to tune PID controller for industrial processes. It is also used in the following references [10, 9].

$$G_p(s) = \frac{e^{-5s}}{20s+1} \qquad (30)$$

It is required to control the delayed process to achieve short settling-time with a PID controller in closed loop. The system is excited by a unit-step function.

In this example, the 5s delay is approximated by a third order Padé approximation. The optimal controller is obtained by using the switched-time weighted ISE (*t*ISE) proposed in equation (28). The procedures followed to estimate the values of T, and t_f . in Example 1 are repeated here. The values used are T = 0.5s, t_f = 70s. The minimization of J was carried out using Hooke-Jeeves algorithm. The value of M in the weighting function was initially set to 10 and progressively increased. A satisfactory response was obtained when M = 25. The optimal PID parameters are found are (q_1, q_2, q_3) = (5.3448, 3.0916, 0.1444), which correspond with K = 3.0916, T_i = 21.41 and T_d = 1.7288. The unit-step response is shown in fig.4 and the controller parameters in Table 2.

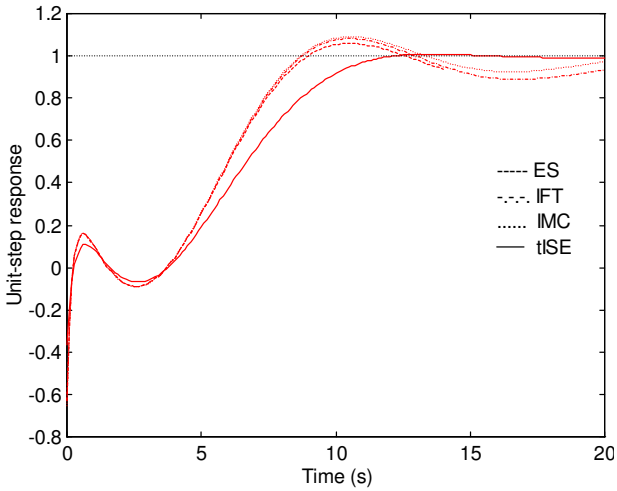

Fig. 4: Step response for Example 2

It is seen from fig.4 that the response, in the case of the controller found using the proposed *t*ISE method, settles within 12s (almost deadbeat response). The response for the cited methods did not settle even after 20s.

TABLE 2. PID controller parameters for Example 2

Method	***K***	T_i	T_d
ES	3.5800	27.8000	2.1500
IFT	3.6717	27.7222	2.1056
IMC	3.6177	22.4300	2.1824
*t*ISE	3.0916	21.4100	1.7288

V. CONCLUSION

A time-domain method for obtaining optimal parameters for linear controller is presented. SISO system with unity feedback is considered. Extension to cover systems with feedback $H(s) \neq 1$ is straight forward. Although a step input is used in the given example, the method can be applied for various types of input. For arbitrary input, the inverse $r(t)$ can be evaluated using the numerical method in section 3 and the error found using (11). The weighting function is what makes the method flexible. By redefining it various error criteria can be set up. In addition it can be defined piecewise, thus allowing the determination of custom optimal parameters. In addition, although the examples given here are for PID control, the method is applicable to linear controller of the form given in equation (2). Thus optimal lead and lag controllers can be designed using this method.

In many cases deadbeat or almost deadbeat response can be achieved. When there is an overshoot in the response this can be reduced by progressively increasing the value of M in the weighting function (29) by 1 until the required response is obtained. In fact, in practice, it is easier to simply set a value for M than determining it from $M = \text{int}(t_r/T)$. One can set $M = 2$ at the beginning of the optimization and continuously increase the value by 1 until a satisfactory response is obtained.

It should also be pointed out that the rise time can be improved by reducing the integration step size. However, as T is reduced the finite wordlength effect is aggravated. The initial control input $u(0)$ also tends to get high and intensive computations are required to evaluate the performance index.

The accuracy and efficiency of the method in continuous time systems depend on the accuracy and efficiency of evaluating the transition matrix **P**. In discrete time systems, **P** need not be evaluated and the inverse z-transform is evaluated by means of a simple recursive formula given in reference [16]. Therefore it would be more efficient when applied to discrete time systems. The disadvantage of the method is in the computational effort required. It is however a generally applicable method. This, coupled with the computational power of the present day computers, make the method worthy of implementation.

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Analysis of an 8/6 Switched Reluctance Motor using the Transient Magnetic Model

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Abstract* – The paper is intended to bring contributions to the analysis of an 8/6 Switched Reluctance Motor. It is a common variable-reluctance motor with an internal 6-pole rotor and an external 8-pole stator, for various applications. Its analysis is based on a Transient Magnetic model, realized with FLUX 2D software. The Transient Magnetic application allows the study of the phenomena created by a time variable magnetic field. In order to improve the existing model, there was implemented the electrical circuit for one phase of the SRM. Also, in order to improve the results, the study was made for different number of turns of the coil conductor, in order to find the best number without exceeding the magnetic saturation.

***Keywords:* Finite element method, Magnetic field measurement, Rotating machine transient analysis, Reluctance motors**

I. INTRODUCTION

A common construction motor 8/6 Switched Reluctance Motor (SRM) was considered to analyze. For this motor, a finite element method (FEM) analysis was started. By building finite element model for the motor, one can analyze the geometry and physical phenomena of the motor. This method offers the possibility to modify the model in order to obtain an optimization of it. The implementation of the finite element method was realized with FLUX 2D software. It is suitable for designing, analyzing and optimizing a rotating machine and other electromagnetic devices.

II. MOTOR DESCRIPTION

The SRM is a switched reluctance motor with an internal 6-pole rotor, an 8-pole stator and an air gap with toothed structure. For this case one must consider a construction of the motor, as it is depicted in Fig. 1, where the rotor, the stator and the four phases are represented.

The initial data of the SRM are given in Table 1.

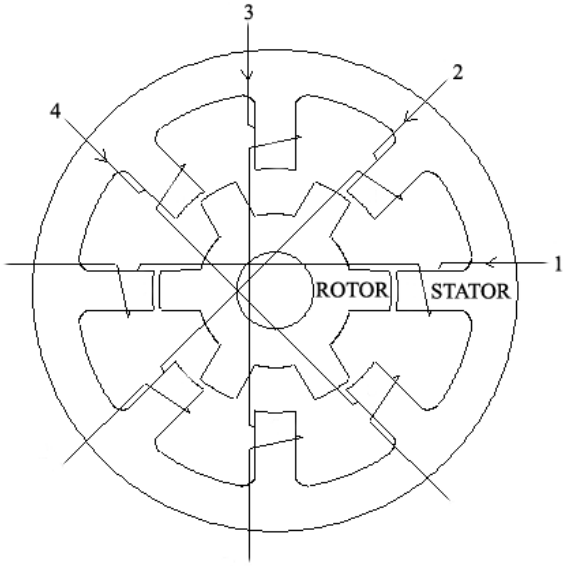

Fig. 1. Principled Rotor/Stator configuration of SRM

TABLE 1. Initial data of the motor

Magnitude	Symbol	Units	Value
Phase current	I	A	9
Phase voltage	T	V	200
Step angle	θ	°	15
Average phase inductivity	L_0	H	0.007
Resistive torque	M_r	Nm	0.1
Viscous friction coefficient	B	Nms	0.001

III. THE SRM MODEL IN FINITE ELEMENT

A. Geometry and Mesh

The geometry is built to represent the entire 2D plan of the motor (Fig. 2).

In order to limit the infinite domain around the motor was defined an Infinite Box Disc, having the role to close the study domain and the property to have a null field at infinity [1].

After the geometry is built and verified an important step follows, the implementation of Mesh. The mesh domain is depicted in Fig. 3.

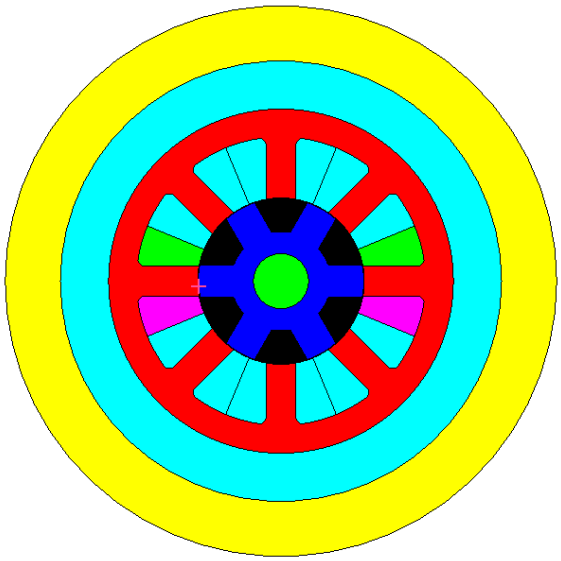

Fig. 2. Motor geometry including the Infinite Box Disc

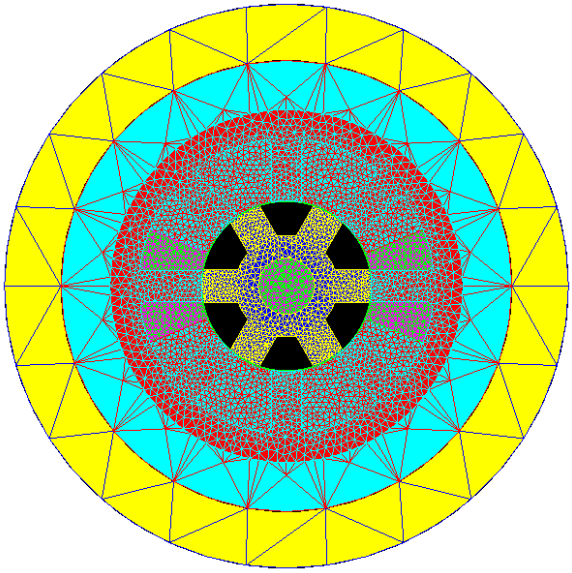

Fig. 3. Mesh of the domain

The mesh is based on MEF. The mesh point and mesh line are manually set. Also, the mesh generator for faces is set automatic and it is based on Delaunay Algorithm. Mesh construction represent the most time consuming step in defining the model. For this reason one may need to compromise between the quality of meshing and time/memory consumption. [1]

Transient magnetic application assumes a rotating air-gap. During the solving process, the mesh is rebuilt at each change in the position of the moving part. [1] Because the air-gap thickness is 0.2mm, building a mesh for air-gap with elements close to an equilateral triangle is possible only with a large number of nodes and this situation may cause a memory out error.

In the present case, the shape of triangle mesh elements of air-gap is close to the rectangular triangle. (Fig. 4)

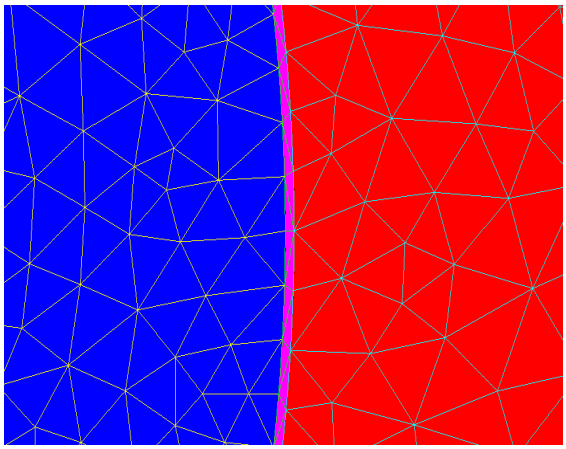

Fig. 4. Mesh in the air-gap zone

The mesh step is finished with a mesh check and the results are presented below:

"Surface elements:
Number of elements not evaluated : 0 %
Number of excellent quality elements : 93.39 %
Number of good quality elements : 1.55 %
Number of average quality elements : 1.96 %
Number of poor quality elements : 3.1 %
Number of abnormal elements : 0 %
Number of nodes : 17327
Number of line elements : 1150
Number of surface elements : 8652
Mesh order : 2nd order

Check Mesh executed"

B. Physical sets and solving

The model of motor is set to Transient Magnetic application which allows the study of the phenomena created by a time variable currents. [1]

All faces were grouped in regions according to the region they are representing, than the material was set for each region. For stator and rotor laminations the material used is M700–50A. After its definition with Material Database of Flux, a curve of magnetization was obtained, as shown in Fig. 5.

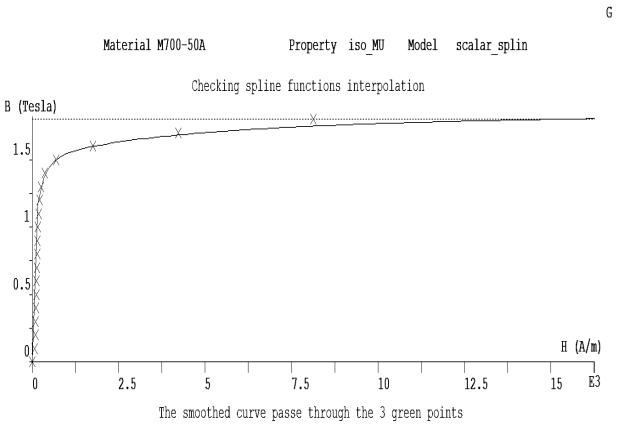

Fig. 5. Magnetization curve of M700-50A material

For the electrical part of the motor, only the coils of one phase was represented, the others coils are set as faces with air or vacuum. In 2D model, a coil is represented by two faces placed on both sides of a stator pole (Fig.6). The green region represents the "in" face, set with negative orientation of the coil, and the magenta region represents the "out" face, set with positive orientation.

From this point, the coils were defined with an electrical circuit.

The model was built having an electrical circuit, which describes the first phase of the motor. For each face representing a half of coil, a conductor was defined. Every coil was built of 60 turns. The electrical circuit for the model is depicted in the Fig. 7.

The solving process is time dependent with an imposed angular velocity. The problem was solved for an angular velocity of 3000 rpm with a time step equal to 8.33e-4s, 15°, and study time limit equal to 0.02s.

IV. POST-PROCESSING RESULTS

After solving the model of the SRM with a Transient Magnetic problem, a map of magnetic flux density is shown and represents the magnetic flux produced when one phase is powered with electrical circuit.

In Fig. 8, displacement is equal to 0°, the position to the powered phase is 45°and the magnetic flux density is depicted in color shade.

For the first and second step, 15° and 30° displacement, in Fig. 9 and Fig. 10 is presented the magnetic flux density, also in color shade.

In the third step, the displacement is 45°, the rotor poles are aligned with the stator poles and the reluctance is minimal as shown in Fig. 11.

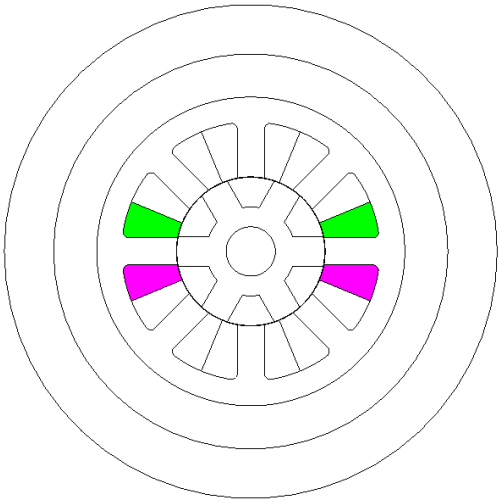

Fig. 6. Display of coils

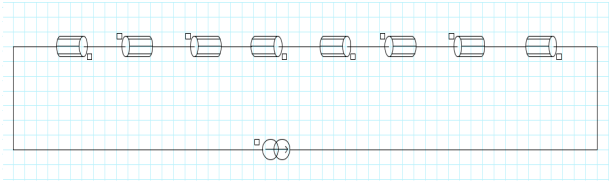

Fig.7. Electrical circuit

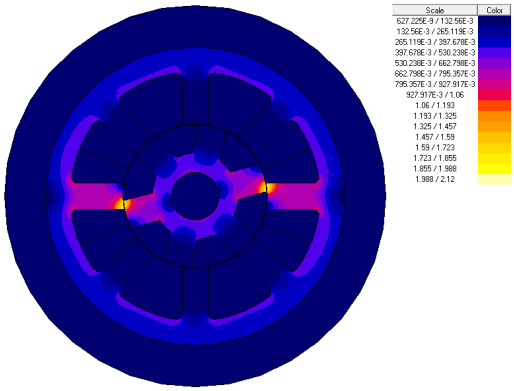

Fig. 8. Magnetic flux density, represented in color shade 0°

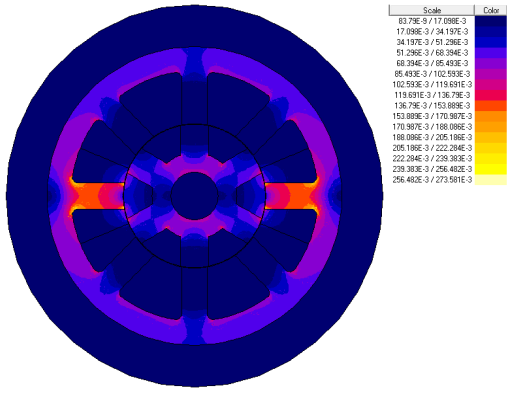

Fig. 9. Magnetic flux density, represented in color shade 15°

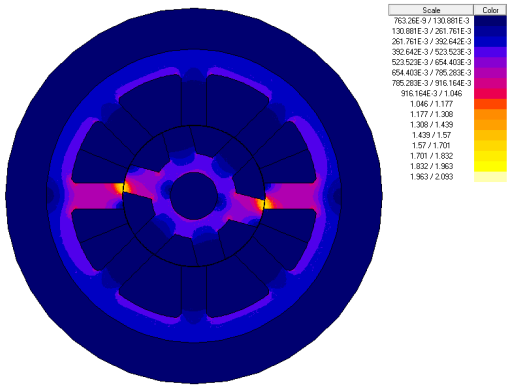

Fig. 10. Magnetic flux density, represented in color shade 30°

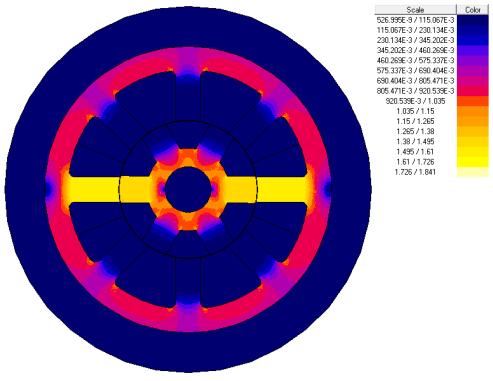

Fig. 11. Magnetic flux density, represented in color shade 45°

The magnetic flux can be studied too through an isovalues magnetic flux density representation (Fig. 12). The flux density will be as large as the lines are close to each other. Moreover, the magnetic flux density lines indicate the magnetic field direction which is tangent to the lines at all points. [1]

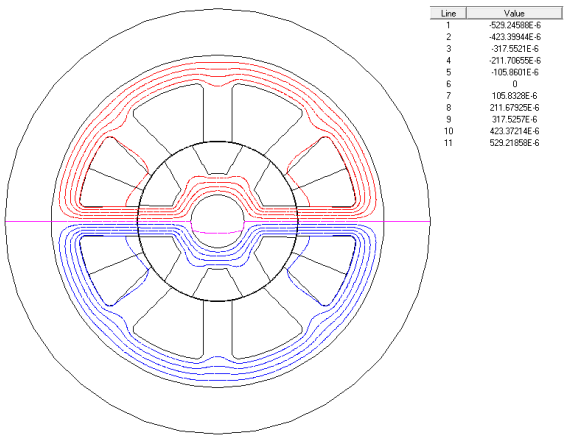

Fig. 12. Flux density isovalues results

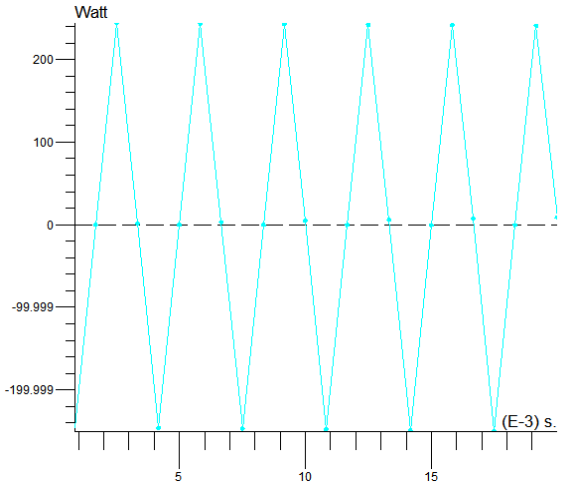

Fig. 13. Mechanical power variation in time

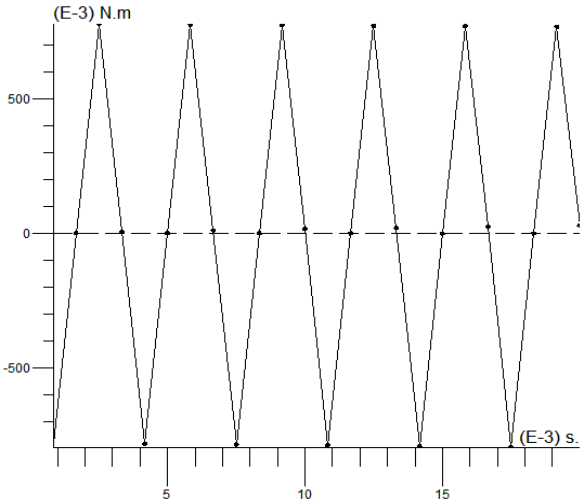

Fig. 14. Mechanical torque in time

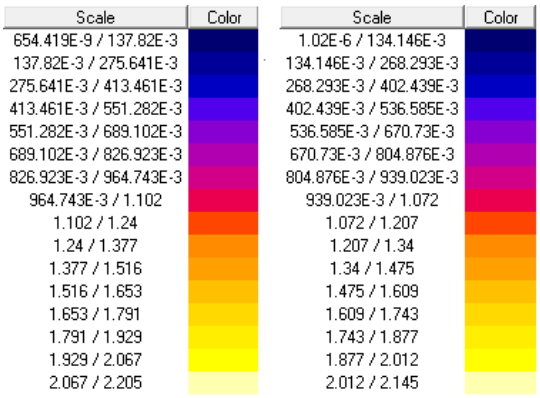

Fig. 15. The scales of values for magnetic flux density

In Fig. 13 the mechanical power curves are presented for the model with electrical circuit, and in the same way in Fig. 14 the electro-magnetic torque is depicted.

In an attempt to reduce the magnetic flux density in the motor, were performed some modification on the number of turns of the coil conductor.

The actual number of turns is 60 and there were made two other cases, for 110 turns and 90 turns, both for the model with electrical circuit. For these two cases, only the magnetic flux density was studied.

The Fig. 15 represents only the scales of values for magnetic flux density. The map of magnetic flux density remains the same. In the left of the figure is represented the scale for the model with 110 turns per coil and in the right the scale for the model with 90 turns per coil.

V. CONCLUSIONS

In general, the MEF implemented by Flux 2D environment can improve the design performances of the motor, as it facilitates the nonlinear study of magnetic saturation and thermal field.

The paper presented three models in finite element of the 8/6 Switched Reluctance Motor, first model with electrical circuit and the last two models are trying to find solutions at the magnetic flux density values. The modification of the number of turns was not sufficient. It is recommended a study with different number of turns and different diameters of the coil conductor. It is possible to consider a modification of the geometry, too.

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Applications of Microcontrollers in Automobiles Field

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Abstact *- This paper presents microcontrollers involvement in daily life, as a solution to ensure the security and integrity of road traffic participants, which due to auto industry explosion becomes more crowded and unreliable.*
The performances of this device can be increased of course, but the intent remains that those who attend road traffic to "remember to use dimmed headlight during the day" as a way of visual safety

Keywords: *microcontroller; photo resistor; power electronics*

I.INTRODUCTION

Microcontroller is the electronic component which effectively has revolutionized the standard of living today, from robots to large consumer goods.

In this paper we'll focus on a microcontroller manufactured by Microchip but with major improvements made by the English Company PICAXE for a much simplified use by students. This choice has been made precisely for an better understanding of the principle and operation of the device.

The proposed circuit will be composed of such an microcontroller that will analyze the signals originating from vehicle's electrical installation and the ambient so that at the vehicle start up, the dimmed headlight to be automatically turned on and adjusted according to environmental conditions, and to vehicle's stopping they will be switched off automatically.

II. BASIC SCHEME AND PROGRAMMING

Block diagram of the circuit and operating mode are shown in Fig.1.:

The 12V DC supply must be regulated to 5V using a voltage regulator (e.g. 7805 (1A capability) or 78L05 (100mA capability)). The full regulation circuit is shown below. The 1N4001 diode provides reverse connection protection, and the capacitors help stabilize the 5V supply. Note that voltage regulators do not generally function correctly unless the input supply in this circuit is approximately 8V or higher.

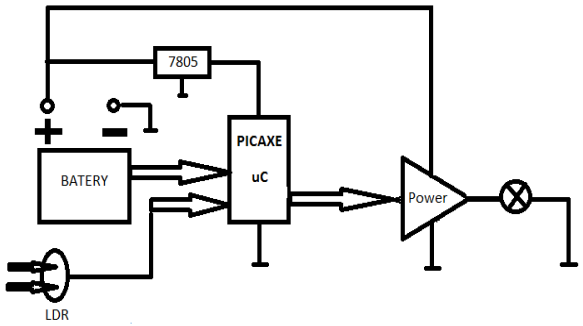


Fig.1. Block diagram

The capacitors shown are also essential. The microcontroller uses a power supply through a voltage stabilizer LM 7805, Fig.2. :

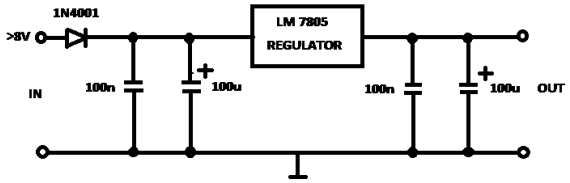


Fig. 2. Voltage stabilizer LM 7805

As shown in figure, reverse voltage protection is provided by 1N4001 diode and filtering is required because the voltage jumps and disturbances that occur in battery terminals, microcontroller power supply through a voltage stabilizer.

Through a resistive divider, the voltage from the terminals of the battery is applied to a digital analog input of the microcontroller, which processes the signal providing to output a signal which, applied to power circuit will start or stop functioning the vehicle's headlight. In the following scheme is presented a simple resistive divider with output voltage adjustment range Fig.3.:

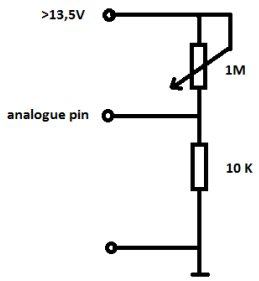


Fig.3. Resistive divider

The program that will perform activation or deactivation of microcontroller output is turning on or off the headlights is presented below:

```
main:
readadc C.4,b1 ; read value into b1
if b1 > 150 then switch on 2 ;switch on output c.2
endif
if b1 < 150 then flsh ;jump to flsh
goto main ; else loop back to start
flsh:
high c.2 ; switch on output c.2
pause 100 ; wait 0,1 seconds
low c.2; switch off output c.2
goto main ; loop back to start
```

LDR (Light Dependent Resistor) which is part of a resistive divider, will make, depending on level of light outside the vehicle, the headlights to be continuous or pulsed a particular frequency. For a better understanding of the functioning of LDR, let's remind the theoretical operation of these detectors..

Optical transducers are divided into two classes: photon detectors (or photo detector) and heat radiation receivers (or infrared sensors). The output signal of the photon detector is determined by the effects of interaction of photons with the detector material. These detectors have a small time constant (the order of us), narrow spectral sensitivity characteristics compared with heat radiation receivers and a high specific capacity of detectives.

Photon detectors are sensitive to photons with energy exceeding the inner energy or greater than the energetic band gap width of the detector material; their sensitivity reported to one watt of radiation incidence increases linearly with the size of the wavelength until critical wavelength (limit).

Photoconduction effect is used frequently; the reaction of the detectors whose function is based on this effect (photo resistive detectors) at incident photons, whose energy exceeds a certain energy level, depends on the structure of the semiconductor. Photons with energies which exceed the band gap width ie, generates free electron-holes pairs, which increase the average density of carriers and, consequently, the conductivity of the material. In the case of the semiconductor with impurities, the photon doesn't have enough energy to form electron-hole pairs, but it can produce the excitation of impurity center (eg, donor or acceptor atom type).This causes transition of charge carriers from the impurity energy level in the conduction or valence zone, so that an free carrier appears. The photocurrent depends linearly of light, if it has low levels, but this linearity is destroyed at normal levels of brightness. Dark current of these transducers has a substantial value, which is why they are used together with optical modulators. Absolute resistance and detector sensitivity depend on the state of life of the carriers. These effects are characterized by relaxation time, which is from few milliseconds to several seconds. The photo resistive transducers are usually cooled to expand the capacity of detection through its own noise reduction (e.g. liquid nitrogen).

As photo resistors volume detectors using semiconductors, of which CdS, CdSe, PbS and PbSe have high frequency. The CdS detectors have poor time characteristics (for low levels of brightness time constant reaches a few seconds), but are less sensitive to the fluctuations of temperature in comparison with CdSe-based detectors. However, they are commonly used because the spectral density. The typical values of rise time of the signal for transducers in CdS and CdSe are 25-125 ms.

Optical transducers parameters

Full sensitivity, is actually integral transmission coefficient of the sensor and determine by the ratio of the sensor output signal levels and incident radiation power. Sensitivity is more important in the field of IR where the radiation its very low. Because of this cooled transducers are used for noise reduction and improved functional characteristics.

Noise equivalent power Pn is determined as useful signal power needed to ensure the unit value of the signal-noise ratio at detector output. This parameter is measured for a specific wavelength and its size shrinks with the decreasing surface of the detector..

To compensate the dependence of the equivalent power of the surface noise of the detector the parameter D^* (related to Pn) is introduced, which is named detection capacity or specific capacity to discover radiation. By definition

$$D^x = \frac{\sqrt{A\Delta f}}{Pn\left[cm \cdot Hz^{\frac{1}{2}} \cdot W^{-1}\right]}$$

where A – is detector surface and Δf – pass band of the amplifier in the measuring path. This parameter is measured at a frequency in condition field observation hemisphere (collecting of the radiation field). The quantic output represents the number of photoelectrons that occur when a incident photon is absorbed, the dark current represents the current remarked, that exist in the absence of an incident radiation. An analogue sensor measures a continuous signal such as light, temperature or position. The analogue sensor provides a varying

voltage signal. The (discontinued) PICAXE-08 and PICAXE-18 used the internal comparator to do a low resolution ADC step comparison, providing 16 discrete analogue values. The other PICAXE microcontrollers all use the internal ADC to do a full 256 step (8 bit) conversion. Although the microcontrollers are technically capable of 10 bit conversions, this is converted by the read ADC command into byte (8 bit) values for ease of use via the byte (b1 etc.) variables, which makes the math easier for students. This gives a resolution of about 0.02V (at 5V supply) which is adequate for almost all educational projects. Most parts also have a separate 10 bit ADC read option (1024 steps), via the readadc10 command. This voltage signal can be represented by a number in the range 0 and 255 (e.g. dark = 0, light = 255). Such a circuit scheme is presented in Fig.4.:

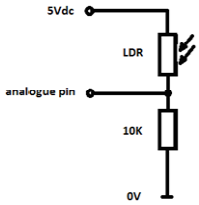


Fig.4. Optical transducer

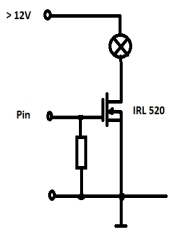
The program after which this circuit will be monitoring the light intensity is shown below:

```
main
readadc C.1,b1; read value into b1
if b1 > 50 then flsh ; jump to flsh if b1 > 50
if b1 >150 then endif
goto main ; else loop back to start
flsh:
high c.2 ; switch on output B.1
pause 100; wait 0.1 seconds
low c.2 ; switch off output B.1
pause 100 ;wait 0.1 second
goto main ; loop back to start
```

Due to frequency switching is preferable that the power circuit to be made with transistors.

The power circuit can be realized in duplicity, with transistors as well with relays (due to multiple Inputs / Outputs of the microcontroller) to increase the reliability of the circuit.

Below are presented two models of stages of power that can be adapted to these types of microcontrollers Fig.5. and Fig.6.:



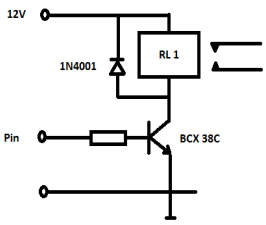


Fig.5. Power MOSFET Fig.6. Relay power

All programming methods use the same BASIC commands and syntax. The flowchart method simply provides a graphical way of joining the BASIC commands together, to save typing in programs. Flowcharting uses a smaller subset of the BASIC commands, and is generally used by younger students in the educational environment.

One advantage of flowchart programming is the very graphical on-screen simulation. This allows students to 'see' their program in operation before downloading to the PICAXE.

Most hobbyist and experienced educational users prefer the textual BASIC method of programming. It is much more powerful than flowcharts, which can become very complicated for large programs.

All flowcharts are automatically converted into BASIC programs prior to download to the PICAXE microcontroller. Therefore the main focus of this manual is on textual BASIC programming. PICAXE Programming Editor and the download/upload into the PC is made in through an serial port, there are two versions, USB and the old DB9 serial port..

To facilitate the microcontroller programming, PICAXE company made vailable to those interested, the program LOGICAL for PICAXE, with which programming is done using graphic boxes after the program will convert into BASIC the program made Fig.7.:

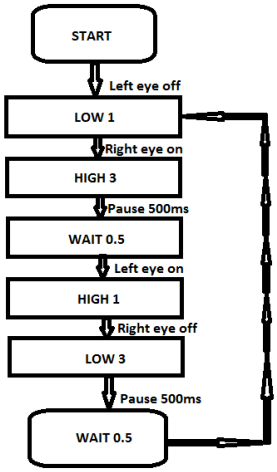


Fig.7. Flowchart programming

This method was chosen by producers in order to help students with a better and easier understanding of how microcontroller function which, as pointed before, there are in most large consumer goods.

Microcontrollers provided by PICAXE that can be used to achieve this device are PICAXE-8M, PICAXE-14M, PICAXE.

A PICAXE microcontroller is a standard Microchip PIC micro™ microcontroller that has been pre-programmed with the PICAXE bootstrap code. The boot strap code enables the PICAXE microcontroller to be re-programmed directly via a simple serial connection.

This eliminates the need for an (expensive) conventional programmer, making the whole download system a very low-cost simple serial cable!

The pre-programmed bootstrap code also contains common routines (such as how to generate a pause delay or a sound output), so that each download does not have to waste time downloading this commonly required data. This makes the download time much quicker.

As the blank microcontrollers purchased to 'make' PICAXE microcontrollers are purchased in large volumes, it is possible for the manufacturer to program the bootstrap code and still sell the PICAXE microcontroller at prices close to standard catalogue process for single un-programmed PIC microcontrollers. This means the cost of the PICAXE microcontroller to the end user is very economical.

The PICAXE bootstrap code is not available for programming into blank microcontrollers. You must purchase PICAXE microcontrollers (rather than blank, un-programmed microcontrollers) for use in the PICAXE system. The PICAXE system can be used with different physical sizes of PICAXE chip (8, 14, 18, 20, 28 and 40 pin). The primary difference between the sizes of chips is the number of input/output pins available – the larger chips cost a bit more but have more available input/output pins. The same BASIC language is common to all size chips.

Within a chip size there are also different variants (e.g. for the 20 pin PICAXE the20M2 and 20X2 variants are available). The principal difference between the variants is the amount of memory (i.e. how long a program can be downloaded into the chip). The higher specification variants also have some increased functionality (e.g. high resolution analogue inputs and i2c compatibility, as described in the next section). Any project can be upgraded to the next level variant at any point (e.g. if your program is too long for the variant of chip used) by simply replacing the microcontroller in your circuit with the upgraded variant.

As seen in this circuit, there are three pins that can be used as inputs/outputs and two pins which can be used one as input and one as output.

Below are shown the PICAXE-8M circuit pins, Fig.8.:

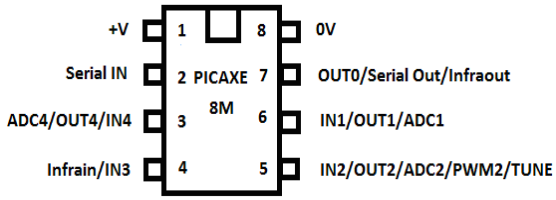


Fig.8. Pin out diagram

Also noted is the pin 5 who can supply to output a PWM signal.

III. CONCLUSIONS

The involvement of electronics and particularly of the microcontrollers, in ensuring the quality of life and increase safety in all areas of human activity makes their use to be indispensable. Therefore this work comes in support of those who will to implement new ways of using microcontroller.

The microcontroller programming, which is the subject of this work, was not given just because of the many possibilities that it can be done, remaining up executants decision.

Also still to be noted that once this device, as expected, can be made with other types of microcontrollers produced by various manufacturers.

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DC-Link Voltage Control of Unified Power Quality Conditioner using PI Fuzzy Self-tuning Controller

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Abstract *– the unified power quality conditioner (UPQC), is one of the best solutions towards the mitigation of voltage and current harmonics problems in distribution power system. PI controller is very common in the control of DC-Link Voltage of UPQC. However, one disadvantage of this conventional controller is the difficulty in tuning its gains (K_p and K_i). To overcome this problem, PI fuzzy logic self-tuning controller is proposed. The controller is a combination of fuzzy and PI controller. According to the error and error rate of the control system and fuzzy control rules, the fuzzy controller can online adjust the two gains of the PI controller to get better regulation performance of the DC-Link Voltage for any voltage or current harmonics distortions. Simulations using MATLAB / SIMULINK are carried out to verify the performance of the proposed controller. The results show that the proposed controller has fast dynamic response and high accuracy of tracking the DC-Link voltage reference.*

Keywords: *UPQC; DC-Link voltage; fuzzy self-tuning PI controller; voltage and current harmonics.*

I. INTRODUCTION

The extensive use of power electronic based equipments/loads almost in all areas made the point of common coupling (PCC) highly distorted [1]. This prolific use of non-linear power electronic loads, like static rectifiers, adjustable speed drives, dc/ac converters, etc., has indiscriminately increased the amount of voltage and current distortion in power distribution system. These distortions, which are caused by harmonics, are one of the major power quality concerns in the electric power industry. To solve these problems, passive power filters have been widely used for a long time. Although they are simple in structure and have a relatively low investment cost, they can cause unwanted resonance and amplify harmonic currents. To overcome the disadvantage of passive power filters and restrictions on their performance, research in active power filters has been carried out actively.

Active power filters can be classified as series or parallel by their system configuration. The combination of series and parallel active power filters is called the Unified Power Quality Conditioner (UPQC). Although its main drawback is its high cost and complexity of control, interest in UPQCs is growing due to its superior performance [2]. UPQC is mainly designed to inject compensating current and voltage into the system, in order to mitigate the system harmonics [3]. The UPQC have been studied and applied to regular three-phase power systems; however, there are no many applications of UPQC in single-phase systems [4].

The most common choice for the control of the DC-Link voltage of UPQC is the so called PI controller since it has a simple structure and it can offer relatively a satisfactory performance. The main problem of this simple controller is the correct choice of the PI gains and the fact that by using fixed gains, the controller may not provide the required control performance, when there are variations in the system parameters and operating conditions. Therefore, online tuning process must be performed to insure that the controller can deal with all the variations in the system.

Artificial Intelligence (AI) techniques such as neural networks, fuzzy logic (FL) and genetic algorithms (GA) are gaining increased interest nowadays. A lot of techniques have been proposed to tune the gains of PI controller based on AI techniques: Self tuning fuzzy logic technique is one of these methods proposed for the online adaptive tuning of PI controller. In such application, the controller gains are online tuned with the variation of system conditions. The advantage of these techniques is that they are model free strategies.

This paper introduces UPQC and its operating principle, also presents the proposed controller which is a combination of fuzzy and PI controllers. Fuzzy logic is used for tuning the PI controller online. Simulation results using MATLAB-SIMULINK were illustrated and discussed.

II. UPQC AND ITS BASIC OPERATION

The Unified Power Quality Conditioner (UPQC) which integrates a series and shunt active filter can compensate voltage and current harmonics.The UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. Finally, the UPQC is expected to be one of the most powerful solutions to high capacity sensitive loads. Figure 1 shows the general structure of an UPQC with the combination of a series and shunt active filter [3]. UPQC will be installed according to the need. Thus, it protects against network voltage perturbations in the load side or protects the other consumers in the sub-transmission side.

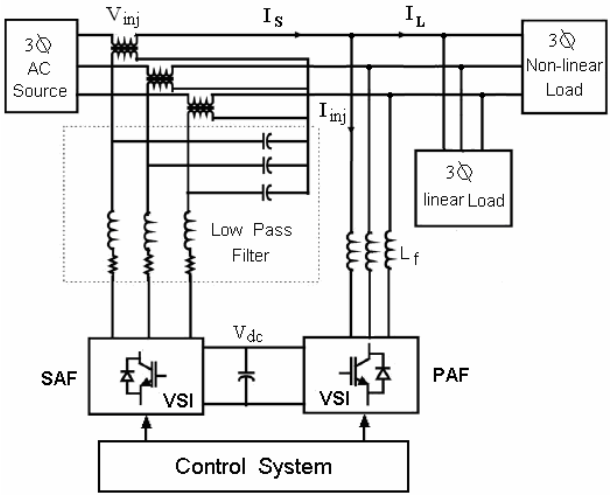

Fig. 1. UPQC general structure

A. Series Active Filter (SAF)

Series active filter is connected in series with the incoming utility supply through a low pass filter and a voltage injecting transformer (Figure 1). The low pass filter eliminates the high switching frequency ripple of the inverter. The filter may inject some phase shift, which could be load dependent, but suitable feedback control is designed to dynamically adjust this shift. SAF is responsible for compensating the deficiency in voltage quality of the incoming supply; such that the load end voltage remains insensitive to the harmonics included in utility supply.

B. Parallel Active Filter (PAF)

Parallel active filter (PAF) is connected in parallel with the nonlinear load through a boost inductor L_f,. The size of the inductor has to be chosen carefully, bigger size would cause slower response to current control and smaller size would cause the high switching frequency ripple of the inverter to be injected into the distribution system. The main purpose of the PAF is to suppress the load current harmonics from flowing towards the utility and it is operated in current controlled mode.

The dc link capacitor C provides the common DC-Link voltage to both SAF and PAF. Ideally once charged, the DC-Link voltage should not fall off its charge, but due to finite switching losses of the inverters, inductors and capacitors, some active power is consumed and the charge of the DC- Link voltage needs to be maintained in a closed loop control, through the PAF. It is to be noted that as the C is charged continuously through PAF, it does not require additional source of voltage support.

C. Control System

The aim of the control system is to maintain source current and load voltage profile sinusoidal. The control system of the general configuration typically consists of a voltage and current reference generation method which determines the reference voltage or current that should be injected by SAF or PAF and the VSI control which is in this work consists of PWM with PI controller. The controller input is an error signal obtained from the reference voltage or current and the value of the injected voltage or current (Figure 2). Such error is processed by a PI controller then the output is provided to the PWM signal generator that controls the voltage source inverter (VSI) to generate the required injected voltage or current.

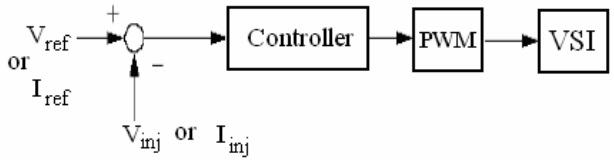

Fig. 2. UPQC control principle

D. Current and Voltage Reference Generation

Several control methods involved in generating reference signals have been discussed in literature among them being the Synchronous Reference Frame method [5]. This method is based on the transformation of the currents in a-b-c frame to synchronously rotating d-q-0 frame. Figure 3 explains the basic building blocks of the method and its implementation in MATLAB / SIMULINK for current reference generation. The DC-Link voltage regulation is done by PAF through SRF method as it is shown in figure 3. Voltage Reference for the series active filter can be determined based almost on the same procedure [6].

The abc_to_dq0 Transformation block computes the direct axis, quadratic axis, and zero sequence quantities in a two-axis rotating reference frame for a three-phase sinusoidal signal. The following transformation is used:

$$i_d = \frac{2}{3}\left(i_a \sin(\omega t) + i_b \sin(\omega t - 2\pi/3) + i_c \sin(\omega t + 2\pi/3)\right)$$

$$i_q = \frac{2}{3}\left(i_a \cos(\omega t) + i_b \cos(\omega t - 2\pi/3) + i_c \cos(\omega t + 2\pi/3)\right)$$

$$i_0 = \frac{1}{3}\left(i_a + i_b + i_c\right) \quad (1)$$

Where ω = rotation speed (rad/s) of the rotating frame and i_a, i_b and i_c are the load currents.
The reference frame is synchronized with the ac currents, and is rotating at the same frequency (ω=2πf). The angle of the transformation is detected by using a phase locked loop (PLL). i_0 is the zero sequence component which is equal to zero in 3-phase 3-wire balanced system, i_d and i_q are made up of a DC and an AC component, so that they may be expressed by:

$$i_d = \bar{i}_d + \tilde{i}_d \tag{2}$$

$$i_q = \bar{i}_q + \tilde{i}_q \tag{3}$$

Where $\bar{i}_d$ and $\bar{i}_q$ are DC components due to fundamental currents while $\tilde{i}_d$ and $\tilde{i}_q$ are AC components due to harmonic currents. In order to compensate reactive power and eliminate harmonic currents, the AC component of i_d is to be fed by PAF, while i_q must be fully fed by the PAF because it is also possible in this way to achieve reactive power compensation. The AC part of i_d is due to harmonic components, so if it is fed to the load by the PAF, grid (source) current remains sinusoidal, while the load keeps on receiving the same amount of harmonic and fundamental current. AC and DC components can be separated by a low pass filter.

To return back into a-b-c frame, the following transformation is used:

$$\begin{aligned} i_a &= i_d \sin(\omega t) + i_q \cos(\omega t) + i_0 \\ i_b &= i_d \sin(\omega t - 2\pi/3) + i_q \cos(\omega t - 2\pi/3) + i_0 \\ i_c &= i_d \sin(\omega t + 2\pi/3) + i_q \cos(\omega t + 2\pi/3) + i_0 \end{aligned} \tag{4}$$

One of the most important characteristics of this method is that the reference currents are obtained directly from the loads currents without considering the source voltages. This is an important advantage since the generation of the reference signals is not affected by voltage unbalance or voltage distortion, therefore increasing the compensation robustness and performance.

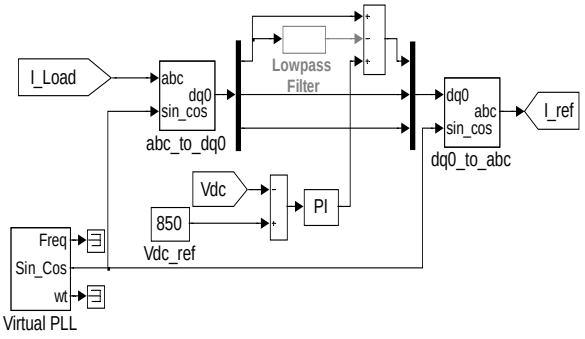

Fig. 3. Block diagram of the reference current extraction and Dc-Link voltage regulation through SRF method.

III. CONVENTIONAL PI CONTROLLER

The reason behind the extensive use of proportional integral (PI) controller is its effectiveness in the control of steady-state error of a control system and also its easy implementation. However, one disadvantage of this conventional compensator is the difficulty in tuning its gains. The conventional PI controller (Figure 4) has the form of Eq. (5), where U is the control output which is fed to the PWM signal generator. K_P and K_I are the proportional and integral gains respectively, these gains depend on the system parameters. ε is the error signal, which is the difference of the DC-Link voltage (V_{DC}) to the DC-Link reference voltage (V_{DC_ref}).

$$U(t) = K_P \varepsilon(t) + K_I \int_T \varepsilon(t) d(t) \tag{5}$$

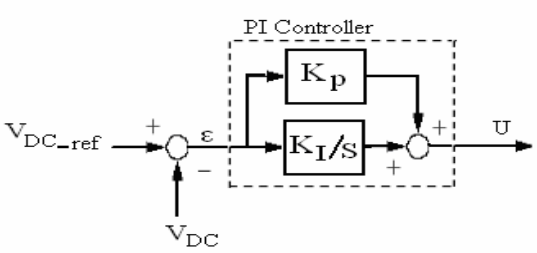

Fig. 4. Control of the DC-Link voltage by PI controller

IV. PI FUZZY SELF-TUNING CONTROLLER

PI fuzzy self-tuning controller as it is shown in Figure 5 is proposed. The determination of the output control signal, is done in an inference engine with a rule base having if-then rules in the form of

IF ε AND Δε, THEN K_P AND K_I

With the rule base, the values of the constants K_P and K_I are changed according to the value of the error signal ε, and the rate-of-error Δε. The structure and determination of the rule base is done using trial-and-error methods and is also done through experimentation.

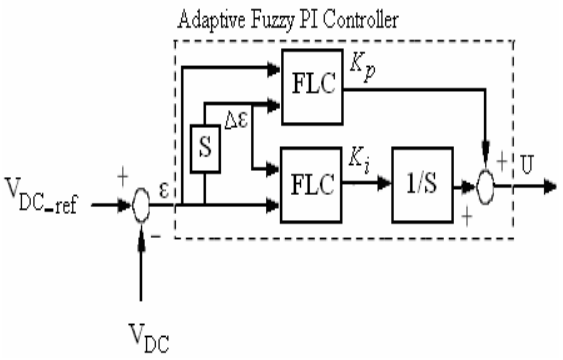

Fig. 5. PI gains online tuning by fuzzy logic controller (FLC)

The FLC consists of three stages: the fuzzification, rule execution, and defuzzification as shown in figure 6. In the first stage, the crisp variables ε and Δε are converted into fuzzy variables using the triangular membership functions shown in Figure 7. Each universe of discourse is divided into five fuzzy sets: NL (negative large), NS

(negative small), ZE (zero), PS (positive small) and PL (positive large). Each fuzzy variable is a member of the subsets with a degree of membership varying between 0 and 1.

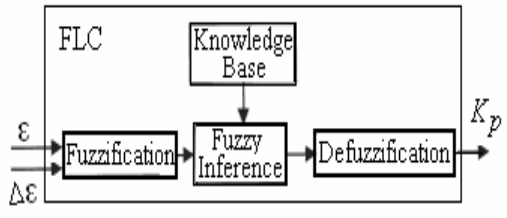

Fig. 6. Schematic of FLC

In the second stage of the FLC, the fuzzy variables of ε and Δε are processed by an inference engine that executes a set of control rules contained in (5×5) rule bases. The control rules are done using trial-and-error methods using simulation and are also done through experimentation. Different inference algorithms can be used to produce the fuzzy set values for the output fuzzy variable. In this paper, the max-min inference algorithm is used. The inference engine output variable is converted into a crisp value in the defuzzification stage. Various defuzzification algorithms have been proposed in the literature. In this paper, the centroid defuzzification algorithm is used, in which the crisp value is calculated as the centre of gravity of the membership function.

The definition of the spread of each partition, or conversely the width and symmetry of the membership functions, is generally a compromise between dynamic and steady state accuracy. Equally spaced partitions and consequently symmetrical triangles are a very reasonable choice. The universe of discourse is normalized over the interval [−2 2]. So, we need to multiply the controller input and output variables by adjusting gains (scaling factors) in order to accommodate these variables into the normalized intervals [7-9].

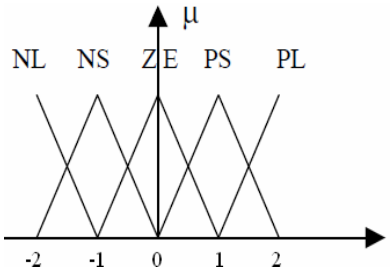

Fig. 7. Membership functions of the inputs ε and Δε and the output

V. SIMULATION RESULTS AND DISCUSSION

The proposed system configuration of Figure 1 has been simulated by Simulink of Matlab as it is shown in Figure 8. The task of this simulation is to evaluate the performance of the proposed controller compared to the classical PI controller in steady and transient state conditions in all possible cases that UPQC can face. So, four cases have been executed in simulation. These cases are: 1) voltage source (equivalent of power system at PCC) and load current including no harmonics, 2) harmonics only in voltage source, 3) harmonics in both voltage source and load current, 4) harmonics only in load current. For the sake of simplicity and clarity, only one phase is shown (phase a) for discussion of the results. But at the end, simulation of the four cases together of the three phases has been given in figure 12 to confirm that we are dealing with three phase system.

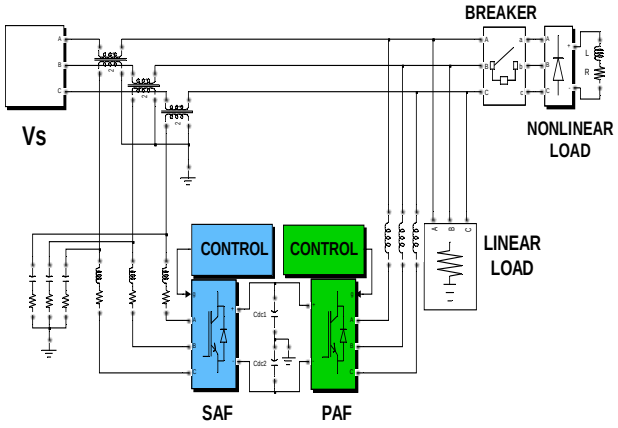

Fig. 8. MATLAB/SIMULINK model for the studied system configuration

In the following simulations, the main characteristics of the UPQC are set as: voltage source full-bridge IGBT based inverter controlled with PWM signal generator with commutation frequency of 12 kHz, capacitor energy storage bank 8.8 mF, coupling transformer ratio 1:1, nominal dc link voltage 850 V, phase voltage 220 V and source frequency of 50 Hz. The load consists of non linear load of 80 kVA and resistive load of 40 kW. The control of the injected harmonic currents and voltages is done by a conventional PI controller. The PI fuzzy self-tuning controller is used to control the DC-Link voltage of the common capacitor. The simulation results are shown in Figures 9, 10, 11and 12. From figures 9 and 10 we can observe:

1st case: voltage source and load current including no harmonics (0.1s -- 0.2 s).
The UPQC is in standby mode, no current or voltage harmonics are injected in the power system since source voltage and load current are sinusoidal. DC-link voltage has reached the stability at the reference value (850 V) for the proposed controller (fig. 11) but still going toward the reference value for PI controller (fig. 9).

2nd case: harmonics in voltage source only (0.2 s – 0.3 s)
In this case UPQC compensates only voltage harmonics thus; SAF is injecting the fifth and the seventh harmonics of amplitude (20%) and (14%) respectively. The THD of the source voltage was 24.62% and after compensation the load voltage THD becomes 0.66%. The DC-link voltage remains almost stable at 850 V with negligible oscillations (<1%) for the two controllers.

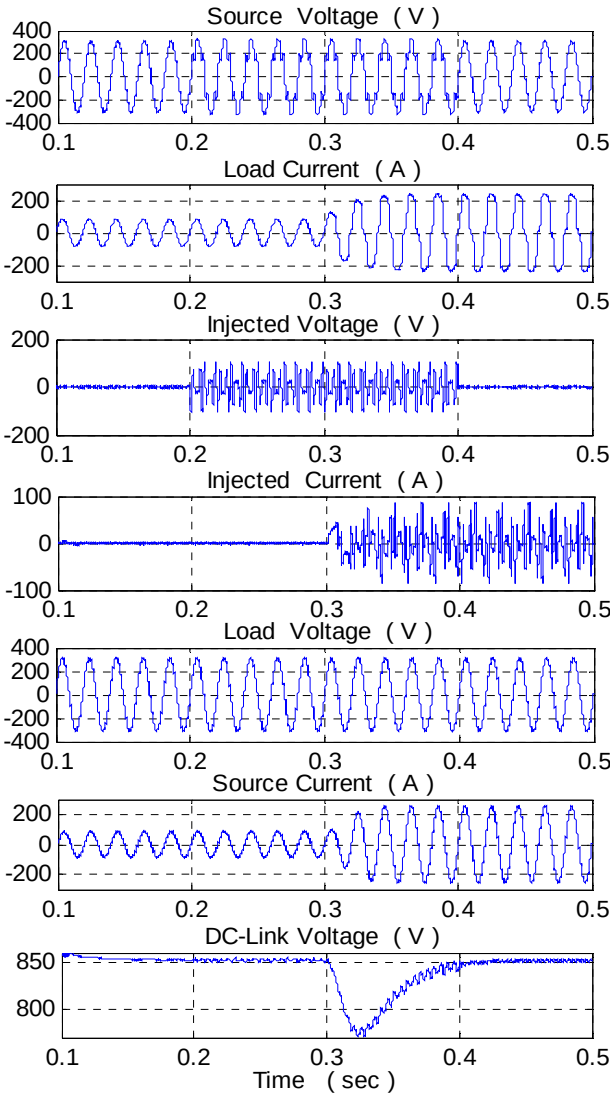

Fig. 9. UPQC performance in steady and transient state for the four cases for PI controller

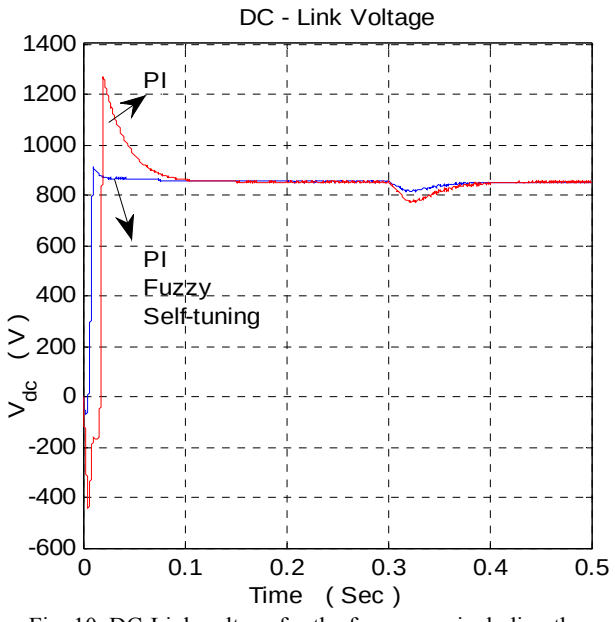

Fig. 10. DC-Link voltage for the four cases including the starting period of the two controllers.

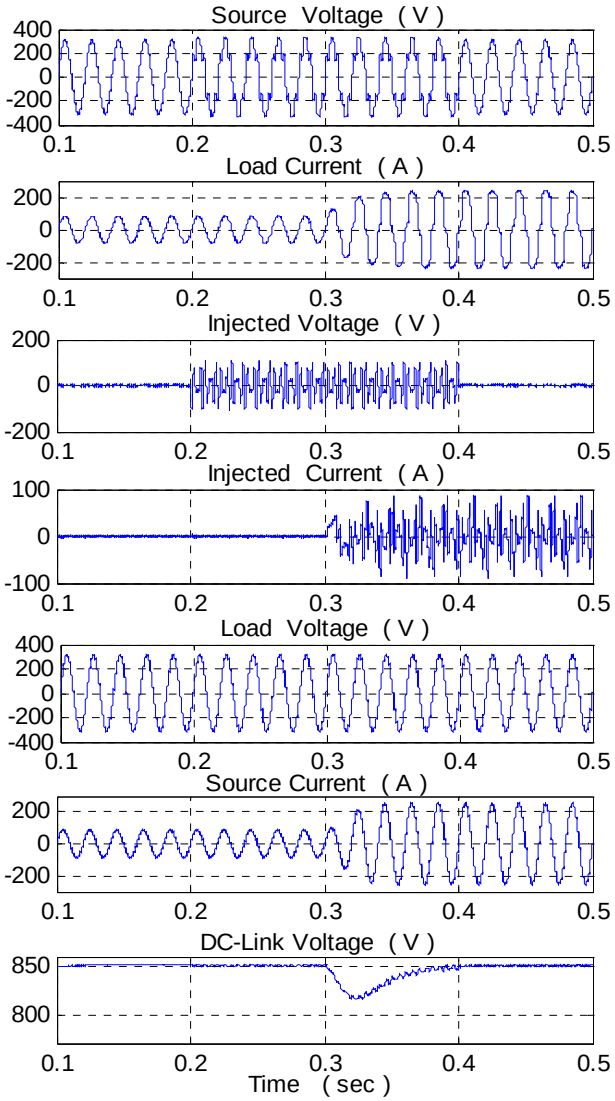

Fig. 11. UPQC performance in steady and transient state for the four cases for PI fuzzy self-tuning controller

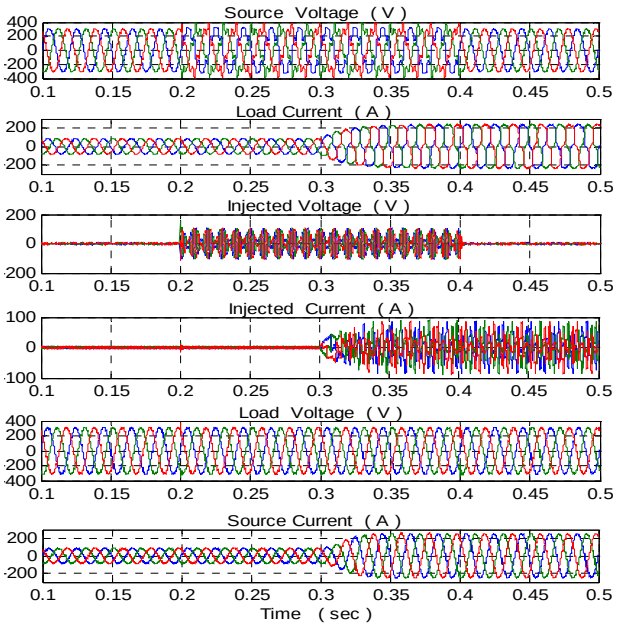

Fig. 12. UPQC performance in steady and transient state for the four cases (three phase system)

3rd case: harmonics in both source voltage and load current (0.3 s – 0.4 s).
In this case UPQC compensates the source voltage and the load current harmonics thus, SAF is injecting the fifth and the seventh harmonics of amplitude (20%) and (14%) respectively, and also PAF is injecting current harmonics of order 6k ± 1 (k natural number) which are generated by the non linear load. The THD of the source voltage was 24.62% and after compensation the load voltage THD becomes 0.66%, also The THD of the load current was 17.83% and after compensation the source current THD becomes 0.57%. The DC-link voltage drops to 770 V at the moment of the connection of the non linear load (0.3 s) and then recovers after 0.1 s for PI controller. But for the proposed controller The DC-link voltage drops only to 820 V and recovers after 0.085 s.

4th case: harmonics in load current only (0.4 s – 0.5 s).
In this case UPQC compensates only current harmonics thus; PAF is injecting current harmonics of order 6k ± 1. The THD of the load current was 17.83% and after compensation the source current THD becomes 0.57%. The DC-link voltage remains almost stable at 850 V with negligible oscillations (< 1%) for the two controllers.

Figure 10 shows the behaviour of the DC-Link voltage for all the cases together including the starting period of the two controllers. From this figure we can see an important overshoot of 49% for the PI controller against only 7% for the proposed one.

The starting point of the DC-Link voltage for PI controller is too negative (-440 V) which could not be allowed in practical case because it reverses the polarity of the capacitor. But for the proposed controller the DC-Link voltage starts at only -66 V which can be tolerated in practical case. The PI fuzzy self-tuning controller is very fast with respect to the PI controller because the first one reaches stability in 0.022 s whereas the second controller reaches stability at 0.15 s. Also, we can say that the proposed controller has fast transient response with respect to PI controller because at the point of introducing the nonlinear load (0.3 s) the DC-Link voltage falls by 3.5% and recovers after 0.085 s, whereas it falls by 9.4% and recovers after 0.1 s for PI controller. Finally, from these simulations, it is clear and obvious that the two controllers do not affect the compensation of voltage and current harmonics (because they are controlled by other controllers) but they have a great influence on the behaviour of the DC-Link voltage. The PI fuzzy self-tuning has shown better performance than the classical PI controller in steady and transient state conditions for all possible cases that UPQC can be found.

VI. CONCLUSION

UPQC is an effective custom power device for voltage and current harmonics mitigation; it injects the appropriate voltage and current harmonics into the power system in such away to keep the load voltage and the source current sinusoidal. In the present paper PI fuzzy self-tuning controller for DC-Link voltage regulation was proposed. The proposed controller combines fuzzy logic to classical PI controller to adjust online the PI gains. One of the major advantages of this controller is being less sensitive to the system parameters variation; in addition, this controller solves the problem of PI tuning. Simulation results analysis has shown that the proposed controller is characterized by fast transient state response and high accuracy of tracking the DC-Link voltage reference in steady state.

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Theoretical Concepts on Measurement and Analysis Process of Improvement the Organizational Programme

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***Abstract* – The main objective of this study is focused on the management and members of staff who are involved in development, definition, collection and analysis of organizational directives for metrics. The paper comprises the process description of the topic measurement and analysis, and explains target and handling of the process. The process is placed under obligation of all measurement programmes concerning the defined domain. Within the scope of the capability maturity model integration, process improvement programme as well as the fit for quality programme, it is intended to improve both understanding of and measures for quality, transparency and performance of processes and projects. Therefore, it is necessary to define and introduce measurement programmes into projects and to establish a process for identifying, implementing and reporting the appropriate metrics. The process will be initiated after availability of all changes to business and/or division goals and will generate a new and appropriate measurement programme with organizational directives for common reported metrics.**

***Keywords:* analysis, measurement, programme, organizational, metrics.**

I. INTRODUCTION

Many organizations measure just for the sake of measuring, with little or no thought given to what purpose and business objectives are being satisfied or what questions each measure is intended to answer. However, meaningful measurement is about transforming strategic direction, policy, and other forms of management decision into action and measuring the performance of that action. Effective measures express the extent to which objectives are being met, how well requirements are being satisfied, how well processes and controls are functioning, and the extent to which performance outcomes are being achieved. The basic goal of measurement and analysis is to provide decision makers with the information they need, when they need it, and in the right form. A process for measurement and analysis defines, implements, and sustains a measurement capability, ensuring that the information needs of decision makers are satisfied [1].

Measurement and analysis process describes what to do for establishing and maintaining an organization wide measurement program. Measurement and analysis includes identifying and defining organization information needs and measurement objectives, defining measures for projects and other support departments and procedures of data collecting, storing and analyzing metrics, and reporting and interpreting the results in a manner that can facilitate better project management and process improvement. Also, covers the planning and execution of measurement and analysis activities at project and organization levels [2]. Traditional measurement and analysis approaches are based on the principle of system decomposition and component analysis, where the first step is to decompose a system into its constituent components. Next, the individual components are prioritized, and only the most critical components are analyzed in detail [3].

Measurement capability may be integrated into individual projects or other organizational functions (e.g., quality assurance). The initial focus for measurement activities is at the project level. However, a measurement capability may prove useful for addressing organization and/or enterprise-wide information needs. To support this capability, the measurement activities should support information needs at multiple levels including the business, organizational unit, and project to minimize re-work as the organization matures. The integration of measurement and analysis activities into the processes of the project supports the following [4]:

- Objective planning and estimating;
- Tracking actual performance against established plans and objectives;
- Identifying and resolving process-related issues;
- Providing a basis for incorporating measurement into additional processes in the future.

The measurement and analysis process area in the capability maturity model integration provides a solid infrastructure for implementing a measurement program. From the capability maturity model integration, the purpose of measurement and analysis is to develop and sustain a measurement capability that is used to support

management information needs. When measurement and analysis is implemented, objectives and measures are established. Measurement results are then used to determine progress towards these objectives. Typical symptoms that occur when measurement and analysis is not performed well include few clear objectives, numerous measures defined but not used, or objectives are defined by rumor [5]. Capability maturity model integration focus on improving processes in an organization. Contain the essential elements of effective processes for one or more disciplines and describe an evolutionary improvement path from ad hoc, immature processes to disciplined, mature processes with improved quality and effectiveness [6].

Measurement and analysis of the product components provided by suppliers is essential for effective management of the quality and costs of the project. It is possible, with careful management of supplier agreements, to provide insight into the data that support supplier-performance analysis. The measurement and analysis process involves the following [4]:

- Specifying the objectives of measurement and analysis such that they are aligned with identified information needs and objectives;
- Specifying the measures, analysis techniques, and mechanism for data collection, data storage, reporting, and feedback;
- Implementing the collection, storage, analysis, and reporting of the data;
- Providing objective results that can be used in making informed decisions, and taking appropriate corrective actions.

Performance measurement analyzes the success of a work group, program, or organization's efforts by comparing data on what actually happened to what was planned or intended [7].

The program manager can update his or her decision-making needs or requirements based on the goal of reducing uncertainty. The decision-making needs or requirements are translated into revised information needs that are used to identify additional data that need to be collected. These data can be collected using a variety of mechanisms, including assessments, status reporting, and measurement. Over time, the reduction in uncertainty resulting from new data that are collected, analyzed, and reported should provide decision makers with more clarity regarding system performance. As a result, the reduction in uncertainty enables better decision making based on more objective data [1].

II. PROCESS DESCRIPTION

A. *Process roles and stakeholders*

Within this process the following roles are involved:

- Business goal responsible – initiates the process, responsible for definition of the organizational measurement programme;
- Engineering process group (EPG) – responsible for planning and coordination of process development/improvement;
- Affected operational process owner – responsible for process areas within the organizational scope, which are affected by the definition or change of the organizational measurement programme;
- Measurement programme – responsible for development and deployment of the organizational measurement programme;
- Measurement customer – member of organization/project/staff with dedicated information needs which can be served by metrics/measurements;
- Data supplier – responsible for collecting measurement data.

B. *Inputs and outputs process, entry and exit criteria*

Inputs process includes policy and business goals, internal and customer information needs, current measurement programme and consolidated lessons learned.

Outputs process include comprehensive documentation of organizational measurement programme, including measurement data descriptions (MDDs) for all metrics, which have to be collected, organizational notification concerning the measurement programme, training materials, metrics/measurement data, reporting data sheet template.

Entry criteria include definition of new or changed organizational goals and additional information needs.

Exit criteria: organizational measurement programme (including the measurement data descriptions) is released and published, training material are available and training is conducted, reporting templates are available, measurement programme has been verified, action items to achieve business and measurement goals are defined.

III. PROCESS ACTIVITIES AND FLOWCHART

C. *Definition of measurement goals*

Entry criteria: the change of the organizational measurement programme will be triggered by the definition of new or changed organizational goals and additional information needs.

Inputs: policy and business goals, internal and customer information needs, current measurement programmes and consolidated lessons learned.

Activity steps: update list of business goals and measurement customers in the measurement programme, derive new measurement goals from the overall business goals (e.g. assign attributes to each business goal), document and harmonies the measurement goals.

Templates/checklists: no templates/checklists defined.

Responsible: measurement programme responsible.

Stakeholder (and involvement): business goal responsible, measurement customers, engineering process group (EPG).

Outputs: completed list of measurement customers.

Exit criteria: measurement goals are defined, reviewed and released, results are documented.

D. Metrics define

Entry criteria: measurement goals are defined, reviewed and released, results of earlier activities are documented and stakeholders are informed.

Inputs: completed list of measurement customers and released measurement goals.

Activity steps: derive metrics from measurement goals, define and document each metric according to the directions given in the measurement data description (MDD) checklist, review each measurement data description (a template for defining measurements in detail), identify those metrics, which must be piloted, configure necessary tools and metric charts.

Templates/checklists: MDD template and MDD checklist.

Responsible: measurement programme responsible.

Stakeholder (and involvement): business goal responsible, measurement customers and data suppliers.

Outputs: documentation of metric relation to the measurement goals, documentation of metric definition within MDD, list of metrics which must be piloted.

Exit criteria: decision concerning necessity of piloting documented.

E. Pilot metrics

Entry criteria: decision on metrics which have to be piloted.

Inputs: list of metrics which must be piloted, MDD.

Activity steps: select and plan pilots, train relevant measurement customers and data suppliers, collect and validate measurement data, distribute chart, analyze piloting feedbacks and validate the results versus measurement goals, complete MDDs and metric reporting templates.

Templates/checklists: no templates/checklists defined.

Responsible: measurement programme responsible.

Stakeholder (and involvement): measurement customers and data suppliers.

Outputs: feedback from piloting and completed MDDs and reporting templates.

Exit criteria: metrics committed to be released.

F. Release measurement programme

Entry criteria: organizational measurement programme is ready to be officially released by the business goal responsible.

Inputs: comprehensive documentation of the organizational measurement programme (including MDDs).

Activity steps: release measurement programme and corresponding MDDs, define date, when measurement programme becomes effective.

Templates/checklists: no templates/checklists defined.

Responsible: business goal responsible.

Stakeholder (and involvement): measurement programme responsible, EPG, affected operational process owners.

Outputs: comprehensive documentation of the organizational measurement programme.

Exit criteria: measurement programme (including MDDs) is released.

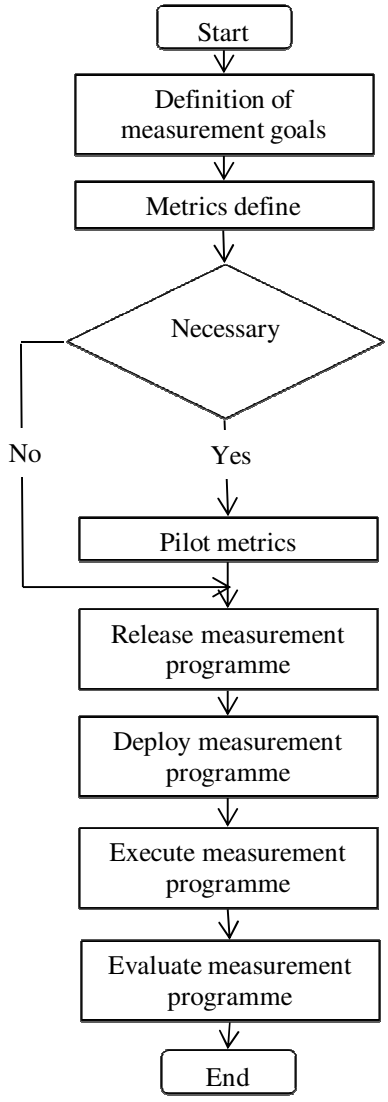

Fig. 1. Process activities flowchart

G. Deploy measurement programme

Entry criteria: measurement programme is released.

Inputs: MDD.

Activity steps: create necessary training material, make measurement programme available, inform all stakeholders concerning new measurement programme, and conduct necessary training.

Templates/checklists: checklist for review object.

Responsible: measurement programme responsible.

Stakeholder (and involvement): measurement customers and data suppliers.

Outputs: training materials, organizational notification concerning (revised) measurement programme (e.g. via e-mail, meeting with stakeholders etc.).

Exit criteria: measurement customers and data suppliers have been trained, measurement programme is deployed, and measurement programme (including MDDs) is published.

H. Execute measurement programme

Entry criteria: all responsible data suppliers have been trained to perform the process, collection of data is possible.

Inputs: MDD for each metric, reporting data sheet ("cockpit chart") and further templates to collect data, tool descriptions.

Activity steps: continuously collect and validate the measurement data, distribute the metric reports.

Templates/checklists: checklist for review object.

Responsible: measurement programme responsible.

Stakeholder (and involvement): measurement customers and data suppliers.

Outputs: filled templates for storing data (e.g. data bases, repositories), filled reporting data sheet (e.g. "cockpit chart").

Exit criteria: Data has been collected, stored in the measurement repository, analyzed and results have been interpreted and visualized, results have been distributed to all stakeholders.

I. Evaluate measurement programme

Entry criteria: measurement programme is deployed.

Inputs: policy and business goals, internal and customer information needs, current measurement programme and MDD for each metric, reporting data sheet ("cockpit chart").

Activity steps: continuously evaluate metric reports regarding suitability to monitor achievement of business and measurement goals, monitor achievement of business and measurement goals and derive actions.

Templates/checklists: checklist for review object.

Responsible: business goal responsible.

Stakeholder (and involvement): measurement programme responsible and measurement customers.

Outputs: no additional information

Exit criteria: measurement programme has been verified, action items to achieve business and measurement goals are defined.

IV. CONCLUSIONS

The measurement and analysis process defines a uniform action within the domain for the definition, collection and interpretation of organizational-wide measurement programmes (measurement directives). The process supports the objective metrics for the assessment of the project progress as well as the efficiency and effectiveness of the established processes.

The measurement programme defines the organizational directive for collecting metrics both in projects and in the organization. If necessary, additional metrics have to be defined within the different projects dependent on some local project needs. Therefore, the process measurements and analysis is divided into two process variants:

- Measurement and analysis performed on the organization level;
- Measurement and analysis performed on the project level.

These measures will, establish a common understanding within the organization, why and how metrics are to be defined and established, ensure that all projects are following dedicated organizational targets, force controlled, structured and repeatable project and process metrics, guarantee a standardized interpretation of measurement results, create a basis for measurable improvement of processes and projects and ensure that no important process activity will be missed. This common measurement programme initiated by the senior management is the basis for standardized definition, collection and analysis of (both process and project) metrics.

ACKNOWLEDGEMENTS

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Method for Optimization Production Systems by Computer Aided Modeling and Simulation

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Abstract* – Computer aided simulation can be defined as imitating the operations of various kinds of real-world facilities or processes, the process of designing a mathematical-logical model of a real system and experimenting with the model. Simulation does not been study the shop floor in terms of individual elements only, but the system as a whole considering the relationships and interactions between different types of lots, resources, operators and work rules. Because simulation models are dynamic, they take into account dispatching rules, batching, priorities and shift effects. This paper aims at identification and implementation of the most economic method to optimize the production flow of an assembly line, that the assembly line is modeled, and simulated using the Witness software. Witness provides an animated display of the model and with its simulation program; it is possible to run very large and complex. The paper also discusses the development of an informatics product for an automatic display of the daily production rate of the assembly line in a defined time. To achieve a simulation there is no single method recommended, but any simulation should be a proper representative model of the system (obviously mathematical models could also be considered). So, the main problem of obtaining a proper simulation is the problem of creating a realistic model.

***Keywords:* modeling; simulation; assembly line; optimization; Witness Software.**

I. INTRODUCTION

In today's highly competitive globalized market, manufacturers have to improve their manufacturing performance continuously in order to sustain their competitive advantage [1]. Modern manufacturing enterprises are facing increasing pressure to improve their responsiveness to 21st century market dynamics, due to customer expectations for shorter delivery lead times, greater agility, improved quality and reduced costs [2]. To characterize the impact of changing parameters on system performance, simulation has been widely used as a decision support for modeling, analysis, and design of systems. Thus, when direct measurement of the system parameters is inconvenient, simulation provides the means for observing the behavior of a system over time [3].

Specific fields of application of computer-assisted techniques are found mainly in systems modeling [4]. The recent trend of global software development enables large-scale software systems to be developed in a geographically distributed environment, which imposes a number of challenges on software trustworthiness [5].

Over the past few decades, computer simulation software, together with statistical analysis techniques have evolved to give decision makers tools equal to the task. Simulation uses a model to develop conclusions providing insight on the behavior of real-world elements being studied. Computer simulation uses the same concept but requires the model to be created through computer programming. Computer simulation can be classified as a branch applied mathematics. The use of computer simulation increased due to availability of computing power and improvements in programming languages. Added to this are inherent difficulties or even impossibilities to accurately describe complex real world systems using analytical or purely mathematical models. For these reasons, a tool that can represent these complexities accurately is required [6].

The advances in computing power and memory over the last decade have opened up the possibility of optimizing simulation models [7]. A model is a conceptual or mathematical representation of a phenomenon, usually conceptualized as a system. It provides an idealized framework for logical reasoning, mathematical or computational evaluation as well as hypothesis testing. The value of a model depends on its usefulness for a given purpose and not its sophistication. Simple models can be more useful than models which

incorporate many processes, especially when data are limited [8].

II. THEORETICAL NOTIONS ON UNDERSTANDING AND PROPER USE OF WITNESS SOFTWARE

Identification methods for modeling and simulating production systems involve the use of computer-aided simulation program. Manufacturing simulation for the purpose of performance analysis follows three main steps:

- Acquiring relevant data such as details of resources, parts, working rules, etc.;
- Modeling the required system, simulating, validating and getting simulated results;
- Analyzing the results and experimenting with model changes and assess their effects.

To drive the simulation was used random variables designed to overcome our lack of detailed knowledge of how the system will operate in practice. The random variable selected was drawn from a given distribution function e.g. normal, exponential, etc. This means that no two simulation runs will be the same so a large number of repeat runs will be required to give an adequate level of precision. It is also needed to select the appropriate distribution from either real data obtained from observations or a distribution that has been shown to be suitable from past experience. The selection of an inappropriate distribution or inaccurate parameters for the correct distribution (e.g. σ) can lead to faulty models that result in either too much or too little capital investment in a project, as a system that is modeled as unreliable will under estimate its capacity.

The procedure for starting-up is to simulate the system from zero transactions up to a given number and to repeat this process a given number of times. To study the shutdown of a system is set to simulate from a steady state and run until there are no further transactions to process and the completion recorded. Again the simulation would need to be repeated a number of times. The number of simulation runs required must be calculated to give the accuracy required from the study. Steady state is when the system has been running long enough to make the effects from start-up negligible.

When simulating a new or modified system a number of alternative models should be constructed and compared. Witness uses discrete-event simulation that steps through time, processing events in order. An event is a change of state within the model. Events may occur at the same time but each event will occur separately in the model. There are many different aspects to this software; however, the system used for the software package has many similarities to Microsoft Windows.

There are 3 steps in building a model:

- Define – the major elements that will form the „building blocks" of the model;
- Display – these elements to form a „pictorial" representation of the model;
- Detail – the characteristics of each element; for example, the parts that enter the machine, the cycle time of the machine, any labor needed, where the parts go on leaving the machine.

The basic designer elements are parts, buffers, machines and labor. A number of shifts can be used with a model to observe interactions and each main shift can be made up of sub-shifts, for example sub-shift day can be used to make the main shift week. Only main shift can be applied to elements like labor and machines. All times are entered in minutes.

To finely tune the behavior of the model, it may specify actions which are executed whenever a machine starts its cycle, finishes its cycle, breaks down, or finishes repair. When two or more elements compete for labor or parts Witness allows you to set the priority to determine which element receives the resource first [9].

III. CASE STUDY: MODELING AND SIMULATION OF AN ASSEMBLY LINE

In this paper, a case study based on a printed circuit board assembly has been analyzed for modeling and simulating an assembly line, and determining the most economical method of optimizing the production flow.

The objectives followed in this study are:

- Identify the existing bottlenecks in the assembly line and their removal;
- Identification of equipment with the highest load and reduce the load capacity to ensure production flow;
- Determining the expected daily output and identifies the most economical method to increase the daily output to 1800 parts;
- Achievement an informatics product of automatic display the daily production made on the assembly line.

All the assembly operations shown on the attached flow chart assemble on to a PCB which arrives as required as an individual. The line runs for 7.5 hours per day (450 minutes or 27.000 seconds), is fully automatic and two people are employed to repair the machines and carry out the rework operation.

Following the testing process are obtained 15% ship and 85% rework, and after rework process result 90% ship and 10% scrap.

There are three suppliers of parts for the line and they supply:

- R1, R2, and R3 in batches of 500 at intervals with a uniform distribution between 10.000 and 12.000 (166,66 and 200 minutes);
- C1, C2 and C3 in batches of 500 at intervals with a uniform distribution between 10.000 and 12000 (166,66 and 200 minutes);
- IC1 and IC2 in batches of 1000 at intervals with a uniform distribution between 19.000 and 21.000 (316,66 and 350 minutes).

To build the assembly line model it is required that data entered into the Witness to be as real and as accurate possible. Introduction of unreal data leads to

incorrect results and thus cannot identify solutions to optimize the assembly line.

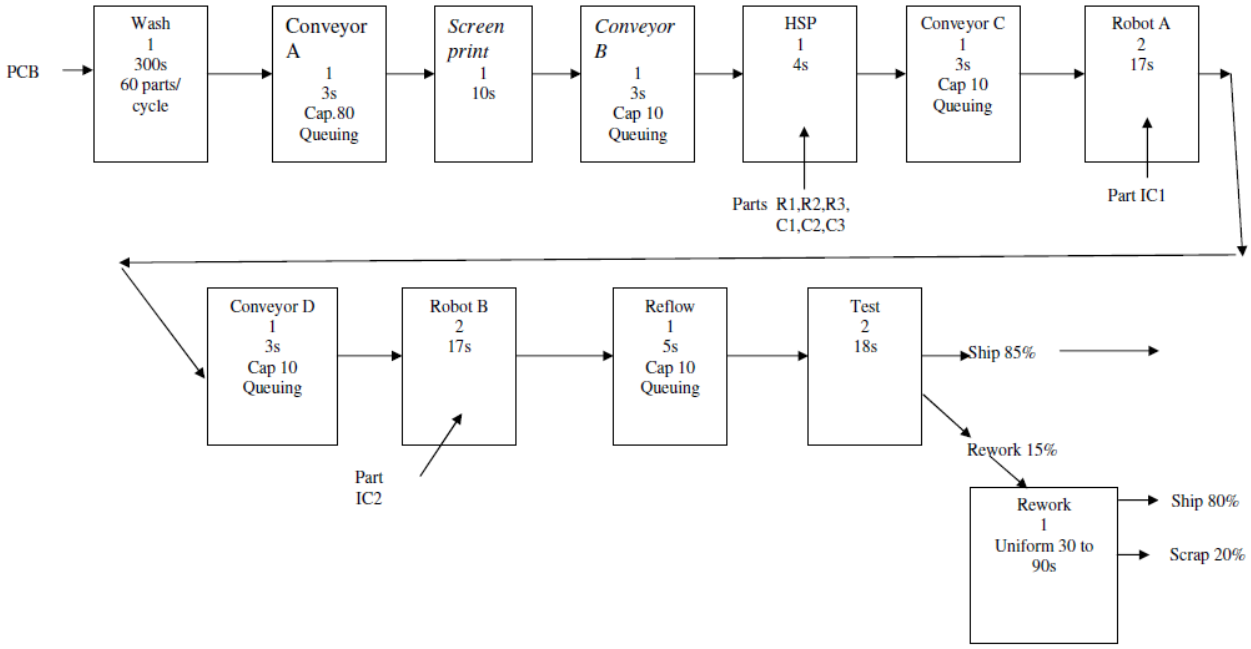

Fig. 1. Assembly line layout [9]

Necessary changes costs to identifying the optimization method of assembly line, refers to:

- Purchase a new washing machines: 50.000 £;
- A new conveyor with 2 seconds cycle time and capacity of 100 pieces: 20.000 £;
- A new machine type Screenprinter: 50.000 £;
- Three conveyors with 2 seconds cycle time and capacity of 20 pieces: 15.000 £;
- Three conveyors with 2 seconds cycle time and capacity of 50 pieces: 20 000 £;
- A new machine type HSP: 100.000 £;
- Purchase of tow robots: 80.000 £;
- A new O reflow machine: 60.000 £;
- A new test machine: 50.000 £;
- A rework station: 20000 £;
- Improved component delivery with guaranteed delivery: 1 £;
- Introduction of new intermediate buffers: 1.000 £ per buffers;
- Reduce delivery period: no cost;
- Purchase labor: 20.000 £ / person.

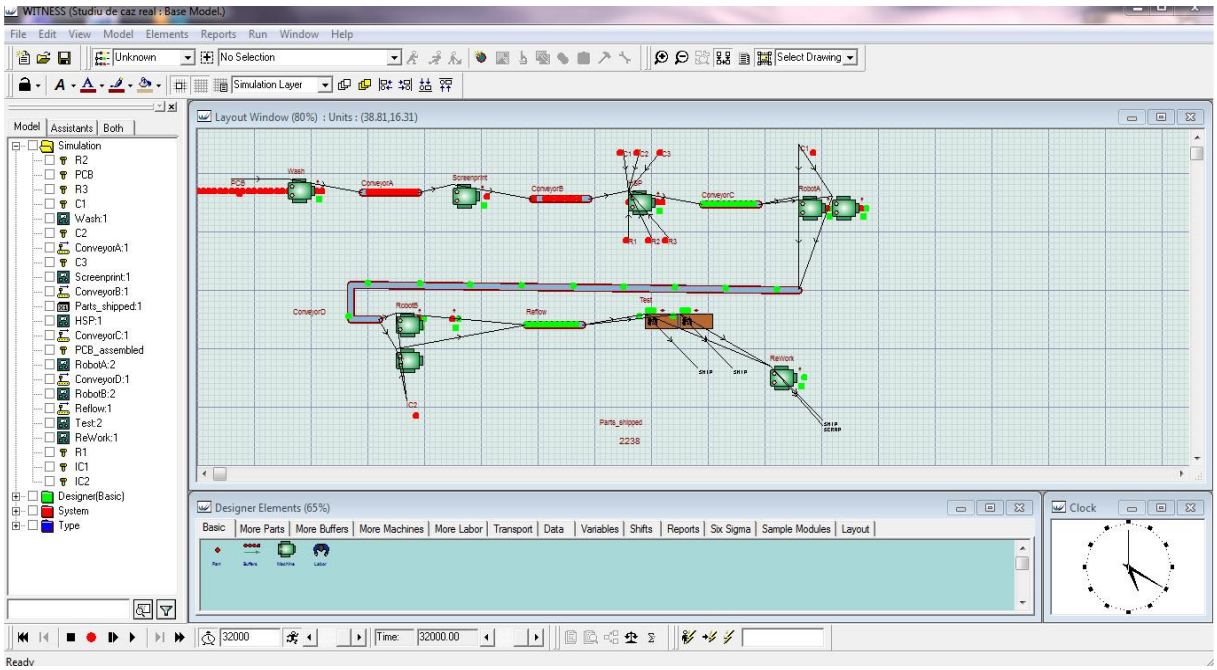

Fig. 2. Modeled and simulated PCB assembly line in Witness Software

After building the model in Witness, it was run for 7,5 hours, respectively 27.000 min, for a period of 5.000 min.

After completing the simulation process, it was observed that Screenprint has the larger load and the production line locks at HSP machine, resulting a production of 2.207 pieces.

TABLE 1. Statistical report on machines operation

Name	Idle[%]	Busy[%]	Blocked[%]	No. of Operations
Wash machine	0.00	42.15	57.85	37
Machine Screenprint	0.00	84.33	15.67	2277
Machine type HSP	4.84	33.76	61.4	2279
Robot A (1)	0.16	71.73	28.1	1139
Robot A (2)	0.16	71.72	28.09	1139
Robot B (1)	0.00	71.73	28.27	1139
Robot B (2)	0.00	71.72	28.2	1139
Test machine (1)	0.58	76.67	22.75	1150
Test machine (2)	0.32	75.22	24.46	1128
Reflow machine	21.26	78.74	0.00	369

After several repeated simulations, it was found out that the most economical method to increase daily production would be through introducing of new intermediate buffers with a capacity of 1.500 pieces (BR1, BR2, BR3, BC1, BC2 and BC3) and, 2.000 pieces (BIC1 and BIC2).

After introduction of the new buffers, it was found out that reduction of Screenprint machine loading with 16.69% and elimination the HSP machine blockage, finally resulting in a throughput of 1.804 finished parts. Costs on optimization the assembly line are 8.000 £.

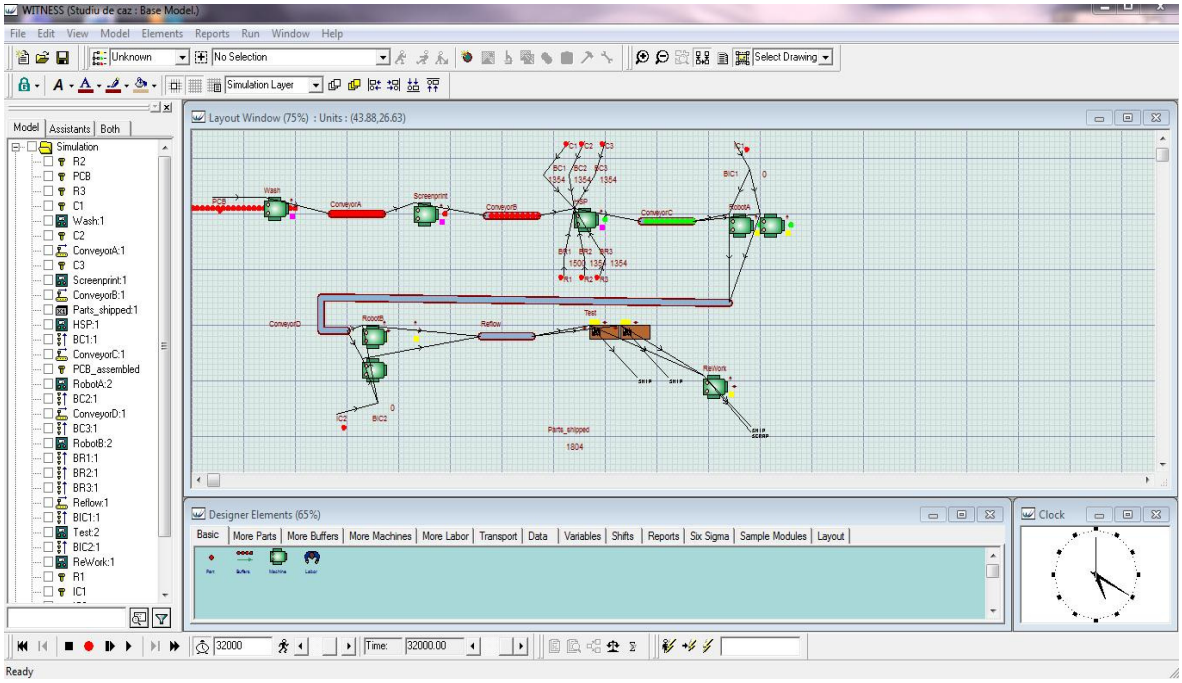

Fig. 3. Optimization of assembly line

TABLE 2. Statistical report on machines operation after optimization

Name	Idle[%]	Busy[%]	Blocked[%]	No. of Operations
Wash machine	0.00	34.44	65.56	31
Machine Screenprint	0.00	67.64	26.74	1827
Machine type HSP	40.42	26.96	26.58	1820
Robot A (1)	40.8	56.62	1.35	900
Robot A (2)	40.76	57.86	1.38	919
Robot B (1)	37.86	57.89	3.4	920
Robot B (2)	37.79	57.03	3.45	906
Test machine (1)	34.3	60.85	4.85	913
Test machine (2)	34.41	61.63	3.97	925
Reflow machine	64.71	35.29	0.00	318

As a method of automatically displaying the daily production made on the assembly line in a certain period of time, has been identified the possibility of achievement an informatics product.

The informatics product of automatic display the daily production made on the assembly line, received the name of parts which are made on assembly line, namely PCB.

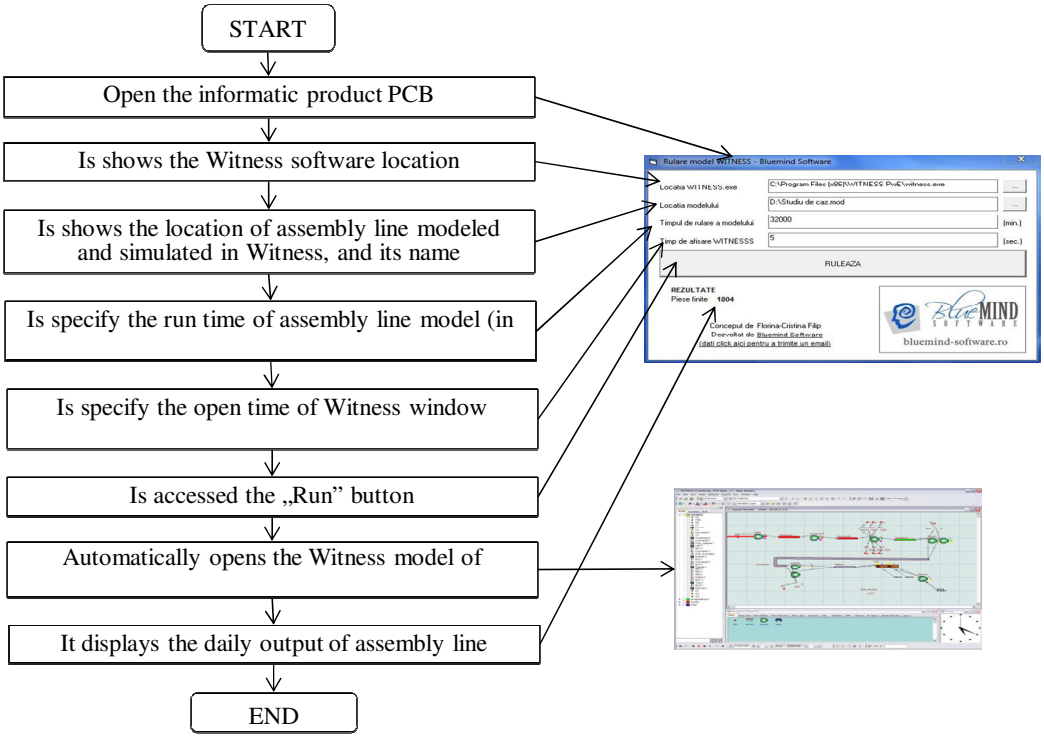

Fig. 4. Logical diagram of informatics product PCB

By achievement this informatics product was followed to get automatically the finished parts number made on the assembly line modeled and simulated in Witness software (fig. 3). PCB informatics product was developed using Visual Basic (fig. 5).

Fig. 5. Informatics product PCB

After completing entry data, by clicking on the "Run Witness" button, the model opens in Witness Software (depending on how many seconds have been indicated in "Waiting time after loading program" section) and then in "Number of finished parts" section is automatically displayed the production performed on the assembly line production in a period of time.

IV. CONCLUSIONS

Due to the emergence and improvement of electronic computers, simulation is now widely used in scientific research and design, being a technique that involves the use of mathematical and logical models that describe the behavior of a real system over a period of time and requires the use of electronic computer. Modeling complex systems such as production systems is a difficult task and as such, requires a simple and effective way to facilitate the simulation process. Simulation process is a representation based on models used to design, develop, analyze and optimize production systems, and most of the times provides for users, accurate design information and helps to find the maximum point of the performance process.

In industrial companies, production systems simulation is a very important tool because it allows system behavior to be prepared and tested. Simulation provides a low cost, a fast and reliable analysis tool. To reduce time and cost involved in achieving a product from conceptualization to production, more and more companies continue to develop advanced software, which costs less and for most industrial companies, time and efficiency are critical and essential. In recent years, modeling and simulation process has gained importance and provides designers the conception of new systems, enabling the quantification and observation of system behaviors. If the system is a production line, an operating room or emergency response, the simulation can be used to study and compare alternative designs or troubleshoot existing systems.

Reasons to using simulation techniques in industrial practice:

- Lack of mathematical formulations (formalized phenomena) that are concise and complete for the problem or meeting some difficulty in resolving whether the model exist;
- Simulation may be the only possible way of experimentation when using the real system is impossible (due to high cost);
- In time, simulation allows complete control of system analysis, allowing the development of phenomena, which leads to conclusions that otherwise, could not be known. This aspect of simulation is particularly usefully in scientific research or in assessing the behavior of technological equipment operation.

Simulation is one of the techniques available to study large and complex systems, is a collection of methods and applications designed to mimic the actual behavior of production systems. Today, there are many simulation tools available that can model all kinds of systems, regardless of their complexity. However, in terms of user, models can be created using the mechanism supplied by simulation facilities.

The most economic method identified in this work to optimize production flow, was the introduction of new intermediate buffers for the reduction of Screenprint machine loading and elimination of the HSP machine blockage.

The results from this applied study performed in this work, have led to data analysis and to identify a way for developing an automatic display method of daily production obtained on the assembly line, modeled and simulated in Witness. Thus, it has helped to identify the possibility to achieve an informatics product for the PCB assembly that can control the run and automatically display the number of finished parts madeon the assembly line with the model that was built in Witness Software.

ACKNOWLEDGEMENTS

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Management of the Waste Materials

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Abstract *– Present paper has the aim of establishing all the steps in management of wastes, including the EU directives in this field. There are given comparatives definitions of wastes, there are presented the main methods of disposal of wastes (landfill, incineration, recycling, sustainability, biological reprocessing, energy recovery, resources recovery, avoidance and reduction methods, Waste handling and transport, Technology. Finally there are comparative presented different waste management concepts.*

Keywords: *waste, hierarchy of waste management, glass ceramic.*

I. CONSIDERATIONS ABOUT WASTES

Waste is directly linked to human development, both technological and social. The compositions of different wastes have varied over time and location, with industrial development and innovation being directly linked to waste materials. Examples of different wastes include plastics, metals, composites and nuclear technology. Some waste components have economic value and can be recycled once correctly recovered. Waste is sometimes a subjective concept, because items that some people discard may have value to others. It is widely recognized that waste materials can be a valuable resource, whilst there is debate as to how this value is best realized. Such concepts are colloquially expressed in western culture by such idioms as "One man's trash is another man's treasure."

In according with Glossary of Statistical Terms /1/, *"Wastes are materials that are not prime products (that is products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded."*

According with European Directive 75/442/EC as amended, waste is assumed as an object the holder discards, intends to discard or is required to discard. In Fig. 1 the definition of waste in EU terms is illustrated.

There are many waste types defined by modern systems of waste management, notably including:

- Municipal Waste includes Household waste, Commercial waste, and Demolition waste
- Hazardous Waste includes Industrial waste
- Bio-medical Waste includes Clinical waste
- Special Hazardous waste includes Radioactive waste, explosives waste, and Electronic waste (e-waste)

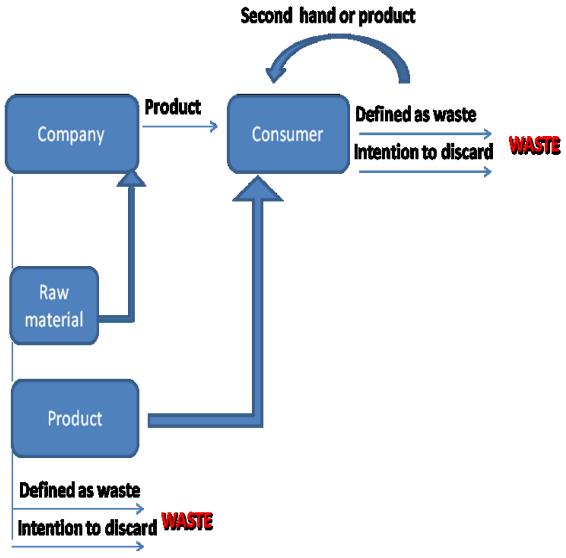

Fig. 1- Definition of waste after EU directives

Different ways of defining of the waste are given in **table 1.**

TABLE 1- Different definitions of the wastes

1. Non wanted things, non intentionally created, with no other aim.	In this category all productions with low market values, non useful, production wastes, etc.
2.Things and objects with a special aim, but becoming nonuseble after the ending of the aim.	This is the group of disposable products: most packaging, disposable c ameras
3. Objects with a definite purpose, but their performance has ceased to be acceptable	Products obsolete, outdated f urniture, batteries can not recharge, etc. arising from the demolition waste.
4. Objects with a defined purpose, acceptable performance, but their users failed using them in an entirely different purpose than that indicated by the manufacturer.	Products used in excess, pro ducts that owners will not keep them so. Products that are in perfect use, but which become waste due to incorrect action of the owner. In this class are found most waste

Waste management is the collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is a distinct practice from resource recovery which focuses on delaying the rate of consumption of natural resources. The management of wastes treats all materials as a single class, whether solid, liquid, gaseous or radioactive substances, and tried to reduce the harmful environmental impacts of each through different methods.

Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator.

II. METHODS OF DISPOSAL

2.1 Landfill

Landfill is posing of waste in a landfill involves burying the waste, and this remains a common practice in most countries. Landfills were often established in abandoned or unused quarries, mining voids or borrow pits. A properly designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. Older, poorly designed or poorly managed landfills can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin, and generation of liquid leachate. Another common byproduct of landfills is gas (mostly composed of methane and carbon dioxide), which is produced as organic waste breaks down anaerobically. This gas can create odour problems, kill surface vegetation, and is a greenhouse gas.

Design characteristics of a modern landfill include methods to contain leachate such as clay or plastic lining material. Deposited waste is normally compacted to increase its density and stability, and covered to prevent attracting vermin (such as mice or rats). Many landfills also have landfill gas extraction systems installed to extract the landfill gas. Gas is pumped out of the landfill using perforated pipes and flared off or burnt in a gas engine to generate electricity.

2.2 Incineration

Incineration is a disposal method in which solid organic wastes are subjected to combustion so as to convert them into residue and gaseous products. This method is useful for disposal of residue of both solid waste management and solid residue from waste water management. This process reduces the volumes of solid waste to 20 to 30 percent of the original volume. Incineration and other high temperature waste treatment systems are sometimes described as "thermal treatment". Incinerators convert waste materials into heat, gas, steam and ash.

Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and gaseous waste. It is recognized as a practical method of disposing of certain hazardous waste materials (such as biological medical waste). Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

Incineration is common in countries such as Japan where land is more scarce, as these facilities generally do not require as much area as landfills. ***Waste-to-energy*** or ***energy-from-waste*** are broad terms for facilities that burn waste in a furnace or boiler to generate heat, steam or electricity. Combustion in an incinerator is not always perfect and there have been concerns about pollutants in gaseous emissions from incinerator stacks. Particular concern has focused on some very persistent organics such as dioxins, furans, PAHs which may be created which may have serious environmental consequences.

2.3 Recycling

Recycling is a resource recovery practice that refers to the collection and reuse of waste materials such as empty beverage containers. The materials from which the items are made can be reprocessed into new products. Material for recycling may be collected separately from general waste using dedicated bins and collection vehicles, or sorted directly from mixed waste streams. Known as kerb-side recycling, it requires the owner of the waste to separate it into various different bins (typically wheelie bins) prior to its collection.

The most common consumer products recycled include aluminum such as beverage cans, copper such as wire, steel food and aerosol cans, old steel furnishings or

equipment, polyethylene and PET bottles, glassbottles and jars, paperboard cartons, newspapers, magazines and light paper, and corrugated fiberboard boxes.
These items are usually composed of a single type of material, making them relatively easy to recycle into new products. The recycling of complex products (such as computers and electronic equipment) is more difficult, due to the additional dismantling and separation required.

The type of material accepted for recycling varies by city and country. Each city and country have different recycling programs in place that can handle the various types of recyclable materials. However, variation in acceptance is reflected in the resale value of the material once it is reprocessed.

2.4 Sustainability

The management of waste is a key component in a business' ability to maintaining ISO14001 accreditation. Companies are encouraged to improve their environmental efficiencies each year. One way to do this is by improving a company's waste management with a new recycling service. (such as recycling: glass, food waste, paper and cardboard, plastic bottles etc.)

2.5 Biological reprocessing

Waste materials that are organic in nature, such as plant material, food scraps, and paper products, can be recycled using biological composting and digestion processes to decompose the organic matter. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes. In addition, waste gas from the process (such as methane) can be captured and used for generating electricity and heat (CHP/cogeneration) maximising efficiencies. The intention of biological processing in waste management is to control and accelerate the natural process of decomposition of organic matter.
There is a large variety of composting and digestion methods and technologies varying in complexity from simple home compost heaps, to small town scale batch digesters, industrial-scale enclosed-vessel digestion of mixed domestic waste. Methods of biological decomposition are differentiated as being aerobic or anaerobic methods, though hybrids of the two methods also exist.

Anaerobic digestion of the organic fraction of **municipal solid waste** has been found to be in a number of LCA analysis studies[1][2] to be more environmentally effective, than landfill, incineration or pyrolisis. The resulting biogas (methane) though must be used for cogeneration (electricity and heat preferably on or close to the site of production) and can be used with a little upgrading in gas combustion engines or turbines. With further upgrading to synthetic natural gas it can be injected into the natural gas network or further refined to hydrogen for use in stationary cogeneration fuel cells. Its use in fuel cells eliminates the pollution from products of combustion.

An example of waste management through composting is the Green Bin Program in Toronto, Canada, where Source Separated Organics (such as kitchen scraps and plant cuttings) are collected in a dedicated container and then composted.

2.6 Energy recovery

The energy content of waste products can be harnessed directly by using them as a direct combustion fuel, or indirectly by processing them into another type of fuel. Thermal treatment ranges from using waste as a fuel source for cooking or heating and the use of the gas fuel (see above), to fuel for boilers to generate steam and electricity in a turbine. Pyrolysis and gasification are two related forms of thermal treatment where waste materials are heated to high temperatures with limited oxygen availability. The process usually occurs in a sealed vessel under high pressure. Pyrolysis of solid waste converts the material into solid, liquid and gas products. The liquid and gas can be burnt to produce energy or refined into other chemical products (chemical refinery). The solid residue (char) can be further refined into products such as activated carbon. Gasification and advanced Plasma arc gasification are used to convert organic materials directly into a synthetic gas (syngas) composed of carbon monoxide and hydrogen. The gas is then burnt to produce electricity and steam. An alternative to pyrolisis is high temperature and pressure supercritical water decomposition (hydrothermal monophasic oxidation).

2.7 Resource Recovery

Resource recovery (as opposed to waste management) uses LCA (life cycle analysis) attempts to offer alternatives to waste management. For mixed MSW (Municipal Solid Waste) a number of broad studies have indicated that administration, source separation and collection followed by reuse and recycling of the non-organic fraction and energy and compost/fertilizer production of the organic waste fraction via anaerobic digestion to be the favoured path.

III.AVOIDANCE AND REDUCTION METHODS

An important method of waste management is the prevention of waste material being created, also known as waste reduction. Methods of avoidance include reuse of second-hand products, repairing broken items instead of buying new, designing products to be refillable or reusable (such as cotton instead of plastic shopping bags), encouraging consumers to avoid using disposable products removing any food/liquid remains from cans, packaging, ...[3] and designing products that use less material to achieve the same purpose (for example, lightweighting of beverage cans).[4]

IV.WASTE HANDLING AND TRANSPORT

Waste collection methods vary widely among different countries and regions. Domestic waste collection services are often provided by local

government authorities, or by private companies in the industry. Some areas, especially those in less developed countries, do not have a formal waste-collection system. Examples of waste handling systems include:

- In Europe and a few other places around the world, a few communities use a proprietary collection system known as Envac, which conveys refuse via underground conduits using a vacuum system. Other vacuum-based solutions include the MetroTaifun single-line and ring-line systems.
- In Canadian urban centres curbside collection is the most common method of disposal, whereby the city collects waste and/or recyclables and/or organics on a scheduled basis. In rural areas people often dispose of their waste by hauling it to a transfer station. Waste collected is then transported to a regional landfill.
- In Taipei, the city government charges its households and industries for the volume of rubbish they produce. Waste will only be collected by the city council if waste is disposed in government issued rubbish bags. This policy has successfully reduced the amount of waste the city produces and increased the recycling rate.
- In Israel, the Arrow Ecology company has developed the ArrowBio system, which takes trash directly from collection trucks and separates organic and inorganic materials through gravitational settling, screening, and hydro-mechanical shredding. The system is capable of sorting huge volumes of solid waste, salvaging recyclables, and turning the rest into biogas and rich agricultural compost. The system is used in California, Australia, Greece, Mexico, the United Kingdom and in Israel. For example, an ArrowBio plant that has been operational at the Hiriya landfill site since December 2003 serves the Tel Aviv area, and processes up to 150 tons of garbage a day.[5]

The criterion of separation of wastes from non-wastes in different European Countries are given in table 2**.**

TABLE 2- Criteria of separation of different wastes form non-wastes materials in some European Countries

Country	**Criterion of separation of wastes form non-wastes materials**
Austria	A substance should not be considered waste as long as: • is new, or is used for the intended use and complies with standards required by the user; • is used in a manner acceptable; • is recycled in the immediate neighborhood where it was used for the original purpose.
Belgium	A substance embedded in a production process is waste only if used in a function different from the destination.
France	A non-waste must: • To have a use value; • To have user-defined characteristics; • Be identifiable; • To have clear contractual relationship between producer and user.
Nederland	A non-waste must: • 100% used in a production process; • not be subject to a process comparable to that of waste disposal; • be transported directly from the producer to the user.
Great Britain	A recyclable material is not waste if: • A material that is out of business processes; • A material that can be used without going through the process of reconstruction; • A material that can be used as feedstock.

While waste transport within a given country falls under national regulations, trans-boundary movement of waste is often subject to international treaties. A major concern to many countries in the world has been hazardous waste. The Basel Convention, ratified by 172 countries, deprecates movement of hazardous waste from developed to less developed countries. The provisions of the Basel convention have been integrated into the EU waste shipment regulation. Nuclear waste, although considered hazardous, does not fall under the jurisdiction of the Basel Convention.

V.TECHNOLOGY

Traditionally the waste management industry has been slow to adopt new technologies such as Radio Frequency Identification (RFID) tags, GPS and integrated software packages which enable better quality data to be collected without the use of estimation or manual data entry.

- Technologies like RFID tags are now being used to collect data on presentation rates for curb-side pick-ups.
- Benefits of GPS tracking is particularly evident when considering the efficiency of ad hoc pick-ups (like skip bins or dumpsters) where the collection is done on a consumer request basis.
- Integrated software packages are useful in aggregating this data for use in optimization of operations for waste collection operations.
- Rear vision cameras are commonly used for OH&S reasons and video recording devices are becoming more widely used, particularly concerning residential services.

An example of management of waste materials /6,7,8,9,/ in obtaining of the glass ceramic materials is illustrated in Fig. 2.

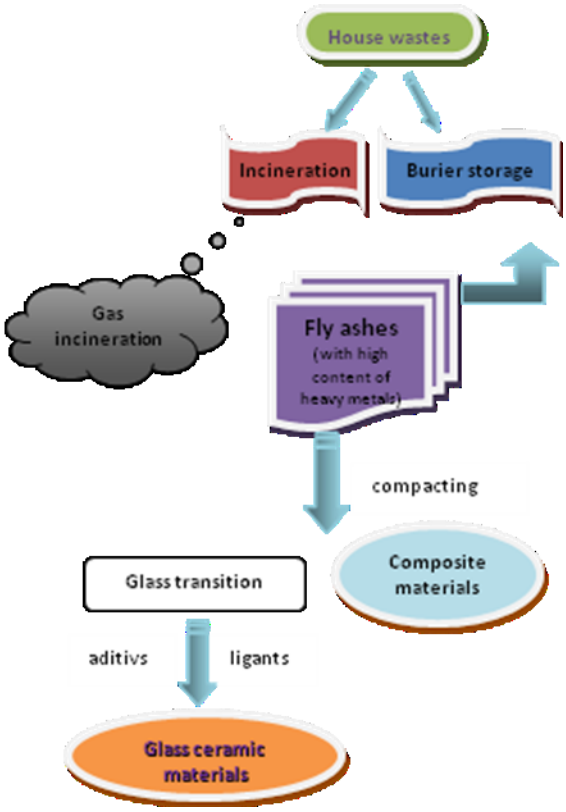

Fig. 2- Management of glass ceramic materials

V. CONCLUSIONS

There are a number of concepts about waste management which vary in their usage between countries or regions. Some of the most general, widely used concepts include:

Waste hierarchy - The waste hierarchy refers to the "3s" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimization. The waste hierarchy remains the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The waste hierarchy is like a pyramid, from the top (the prevention), minimisation- reuse- recycling- thermal treatment- energy recovery- the final disposal (the base), as is given in fig. 3.

Polluter pays principle - the Polluter Pays Principle is a principle where the polluting party pays for the impact caused to the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the waste.

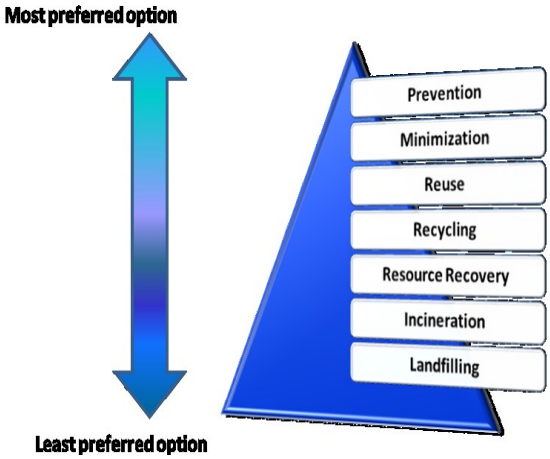

Fig. 3- Hierarchy of waste minimization /10-16/

The whole issue of relative responsibility for waste management (as well as overall sustainability) has become more and more contentious and political. ***The Sustainability Hierarchy,*** as is given in Fig. 4**,** identifies options that may or may not be applicable for various entities to take some responsibility for prevention, just as the ***Waste Management Hierarchy*** contains options that may not be feasible for a type of waste. As one may see, in Fig. 5, the problem of waste management implies not only preventing measurements, but also measurements of waste management, which may lead to reduce of all waste materials.

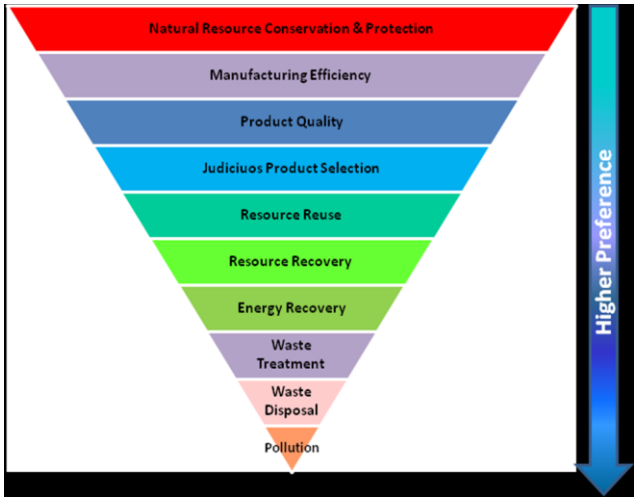

Figure 4- Sustainability Hierarchy /17/

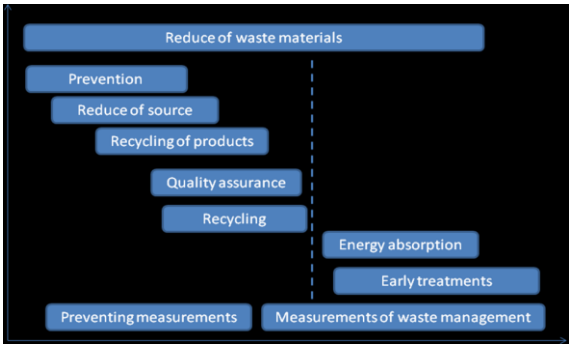

Fig. 5- Scheme of waste management

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Dynamics of Wastes for Electric and Electronic Use in Romania

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***Abstract* – Present paper reffers to the management of the electric and electronic wastes. There are presented the main types of materials, in a new vision, concerning the electronics and Information Technology, where the components and materials are the backbone. The management of materials for electric and electronic use is presented in a new concept, including electricity and energy, Intelligent Information Processing system, Media system, Computer network, electronic systems, eolectronic devices. The displacement of the Hierarcy of management for electric and electronic wastes materials is also presented. Finally, specific features of management of electric and electronic wastes in Romania are given, including dynamics of wastes on different category in Romania of the year 2008.**

Keywords: *waste for electric and electronic use, materials science, hierarchy of waste management.*

I. INTRODUCTION

Development of the society is deeply influenced on the existing of the materials. Materials science encompasses various classes of materials, each of them being constitute a separate field. There are several ways to classify materials, for instance by the type of bonding between the atoms or by the main applications. The traditional groups of materials are ceramics, metals and polymers based on atomic structure and chemical composition, as is fiven in Fig. 1**,** in which there are included the composite materials also**.** New materials has resulted in more classes, depending on physical-mechanical- chemical properties with specific applications, such as: Biomaterials, Carbon, Ceramics, Glass, Advanced Metals and metallic alloys, Nanomaterials, Polymers, Refractory, Semiconductors, Thin Films.

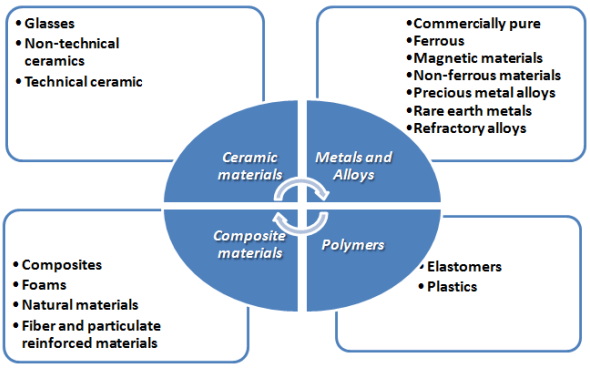

Fig. 1- Main typical classes of materials

Industrial applications of materials science include materials design, cost-benefit tradeoffs in industrial production of materials, processing techniques (casting, rolling, welding, ion implantation, crystal growth, thin-film deposition, sintering, glassblowing, etc.), and analytical techniques (characterization techniques such as electron microscopy, x-ray diffraction, calorimetry, nuclear microscopy (HEFIB), Rutherford backscattering, neutron diffraction, small-angle X-ray scattering (SAXS), etc.). Besides material characterization, very important problems are dealed with the extraction of materials and their conversion into useful forms. Thus ingot casting, foundry techniques, blast furnace extraction, and electrolytic extraction are all part of the required knowledge of a metallurgist/engineer. Often the presence, absence or variation of minute quantities of secondary elements and compounds in a bulk material will have a great impact on the final properties of the materials produced, for instance, steels are classified based on 1/10 and 1/100 weight percentages of the carbon and other alloying elements they contain. Thus, the extraction and purification techniques employed in the extraction of iron in the blast furnace will have an impact of the quality of steel that may be produced.

Concerning Electronics and Information Technology (IT) Hardware Sector the components and materials are the so-called the backbone. Electronic materials are at the core of design, development of electronic component manufacturing, while electronic components are the heart of electronic equipment hardware. Development in modern handheld gadgets such as cell phone, iPOD, Palm Top/LapTop computers, portable test & measuring equipments and other communications & competing gadgets etc. has been due to miniaturization of electronic components and advancement in assembly technologies etc. New technologies used for miniaturization of electronic hardware are driven by innovations in new materials and associated process technologies. Photonics, a cutting edge technology merging optics with electronics, is essential for generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. The applications of photonics are found in every field including information communication technologies, manufacturing, lighting, security, life sciences, medical sciences, fiber-optics, technological backbone of the World Wide Web, CDs, holograms, lasers, etc.

Historically, the amount of waste generated by humans was insignificant due to low population density, coupled with insignificant exploitation of natural resources. Common waste produced during early human history was mainly ashes and human biodegradable waste, and these were released back into the ground locally, with minimum environmental impact.

Before the widespread use of metals, wood was widely used for most applications. However, reuse of wood has been well documented. Nevertheless, it is once again well documented that reuse and recovery of such metals have been carried out by earlier humans.

The Maya of Central America had dumps, which exploded occasionally and burned. They also recycled. Homemakers brought trash to local dumps, and monthly burnings would occur. Many Mayan sites demonstrated such careless consumption. Consumption and waste of resources is probably related to supply available more than any other factor.

With the advent of industrial revolution, waste management became a critical issue. This was due to the increase in population and the massive migration of people to industrial towns and cities from rural areas during the 18^{th} century. There was a consequent increase in industrial and domestic wastes posing threat to human health and environment.

Waste has played a tremendous role in history. The Bubonic Plague, cholera and typhoid fever, to mention a few, were diseases that altered the populations of Europe and influenced monarchies. They were perpetuated by filth that harbored rats, and contaminated water supply. It was not uncommon for Europeans to throw their waste and human wastes out of the window which would decompose in the street.

France, specifically Paris seems to have been a leader in poor waste management.

"The famed Paris sewer system was created over a long period of time in the second half of the 19th century. The long delays were largely due to the virulent opposition of property owners, who did not want to pay to install sanitary piping to their buildings. The Prefect of Paris, Monsieur Poubelle, succeeded in forcing garbage cans on the property owners in 1887 only after a ferocious public battle. This government interference in the individual's right to throw his garbage in the street - which was, in reality, the property owner's right to leave his tenants no other option - made Poubelle into the 'cryptosocialist' of the hour. In 1900 owners were still fighting against the obligations to put their buildings on the public sewer system and to cooperate in the collection of garbage. By 1910 a little over half of the city's buildings were on the sewer system and only half of the cities in France had any sewers at all.

"Photos of early-twentieth-century Marseilles show great piles of refuse and excrement down the centre of the streets. Cholera outbreaks were common and ravaged the population. In 1954 the last city without, St. Remy de Provence, installed sewers.

"It was the gradual creation of an effective bureaucracy which brought an end to all this filth and disease, and the public servants did so against the desires of the mass of the middle and upper classes. The free market opposed sanitation. The rich opposed it. The civilized opposed it. Most of the educated opposed it. That is why it took a century to finish what could have been done in ten years" Adapted from John Ralston Saul, Voltaire's Bastards - The Dictatorship of Reason in the West.

II.CONSIDERATIONS ABOUT MANAGEMENT OF ELECTRIC AND ELECTRONIC WASTES

Environmental protection and pollution abatement towards sustainable development are the thrust areas throughout the developed world. The need to adopt more environmentally responsible manufacturing processes is forcing industry to make changes in the conventional processes, product and services offered, for sustainable development. Electronics waste is also growing in alarming rate and e-waste is the fastest growing item in the solid-waste stream. E-waste contains hazardous chemicals; therefore environmental friendly recovery of the e-waste is an important social responsibility. Examples of few processes/technologies being worked out for the development and optimal use of materials/ components include the following. Thick film paste materials (resistors, capacitors, hybrids and solar cells), Phosphors (PDPs, white LEDs), sensors, materials for information storage devices, ceramics for electronics devices and packaging, Electronics waste management technologies optical fibre communication, Biophotonics, Green Photonics, Special Optical Fibers-PCF (Photonic crystal Fibers), Optoelectronic Packaging, Nanophotonics, Photonic Crystal Fibres, Polymers for Photonics, Photonics Sensors etc.

Concerning the management of the materials for electric and electronic applictions, as is given in Fig. 2, there are implied the following specific features: electricity and energy (plasma and new energy), Intelligent Information Processing system (pattern recognition and artificial intelligence), Media system (computers and interfaces), Computer network (hardware and software), electronic systems (processing and comunications), eolectronic devices (semiconductors and highly functional devices).
The hierarcy of the management for electric and electronic wastes materials is illustrated in Fig. 3, where one may remark approximately the same steps as in clasic management of wastes, with fey differences due to early treatments. Also, when wastes comes from electric and electronic uses, preliminary treatment of surface must be made.

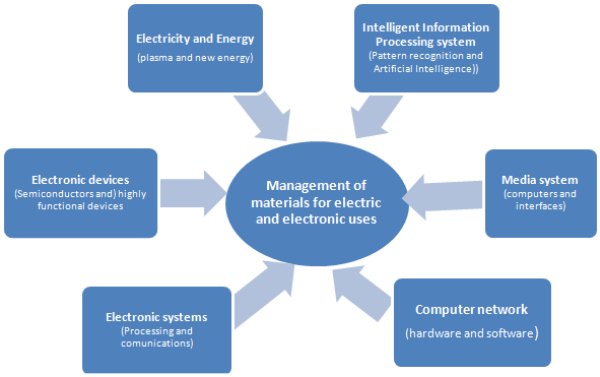

Fig. 2- Management of materials for electric and electronic uses

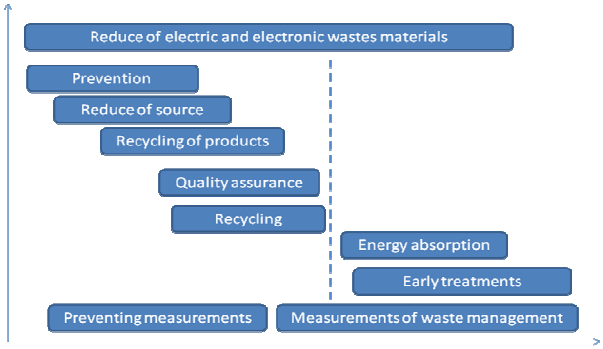

Fig. 3- Hierarchy of management for electric and electronic wastes materials

The traditional view of waste management was, and to a large extend still is, that the consumer took responsibility for the management of a product after it has been consumed. However various special wastes from households (e.g., automobile batteries, electronic devices, mercury lamps, etc.) that require special waste management have increasing catalyzed a debate about who should be responsible.

For example, there are advocates of Extended Producer Responsibility (EPR). EPR is based on the concept that all costs associated with a product throughout its life cycle (including waste management costs) should be figured into the market price of the product. In EPR application, the manufacturers of a product are responsible for the product after the product's useful life. The whole issue of relative responsibility for waste management (as well as overall sustainability) has become more and more contentious and political. ***The Sustainability Hierarchy,*** as is given in Fig. 4, identifies options that may or may not be applicable for various entities to take some responsibility for prevention, just as the ***Waste Management Hierarchy*** contains options that may not be feasible for a type of waste.

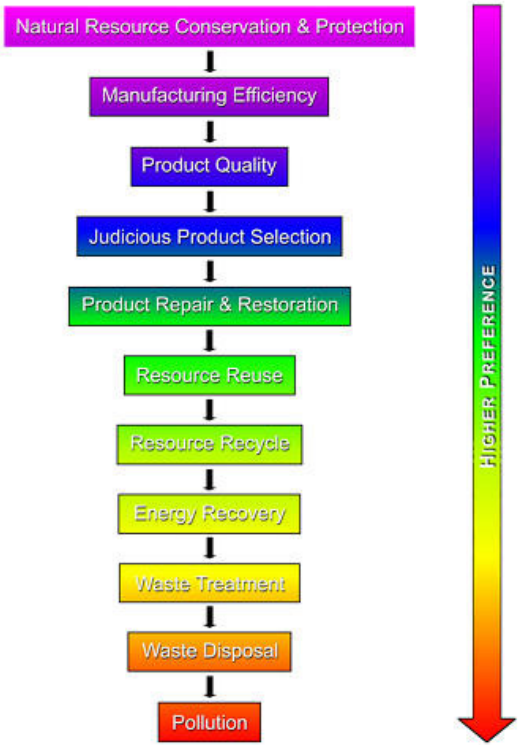

Fig. 4- Sustainability hierarchy /6/

Also the symbol that indicates that electrical and electronic equipment are the subject of a separate sump is a trash can with wheels crossed two lines in the form of X, as illustrated in Fig. 5.

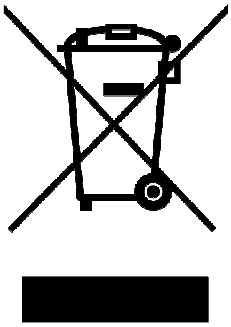

Fig. 5- The symbol for the marking electrical and electronic equipment /1/

The **Waste Electrical and Electronic Equipment Directive** (WEEE Directive) is the European Community directive 2002/96/EC on waste electrical and electronic equipment(WEEE) which, together with the RoHS Directive 2002/95/EC, became European

Lawin February 2003. The WEEE Directive set collection, recycling and recovery targets for all types of electrical goods, with a minimum rate of 4 kilograms per head of population per annum recovered for recycling by 2009. The Rohs Directive set restrictions upon European manufacturers as to the material content of new electronic equipment placed on the Market.

The Symbol adopted by the European Council to represent Waste Electrical and Electronic Equipment comprised a Crossed out Wheelie Bin with or without a single black line underneath the symbol. The Black line indicates that goods have been placed on the market after 2005, when the Directive came into force[1]. Goods without the black line were manufactured between 2002 and 2005. In such instances, these are treated as "historic weee" and falls outside re-imbursement via Producer Compliance Schemes.

Generally, the main EU batteries Directive Services (2006/66/EC) are connected with:

- Determination of compliance requirements
- Product labeling and documentation
- Identification of material and chemical restrictions
- Testing for restricted materials
- Registration with required bodies
- Implementation of collection and recycling system
- Identification of ongoing reporting requirements

Electronic waste substances

"Electronic waste" may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators. This definition includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal. Others define the re-usables (working and repairable electronics) and secondary scrap (copper, steel, plastic, etc.) to be "commodities", and reserve the term "waste" for residue or material which is dumped by the buyer rather than recycled, including residue from reuse and recycling operations. Because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable), several public policy advocates apply the term "e-waste" broadly to all surplus electronics. Cathode ray tubes (CRT) are considered one of the hardest types to recycle. CRTs have relatively high concentration of lead and phosphors(not to be confused with phosphorus), both of which are necessary for the display. Debate continues over the distinction between "commodity" and "waste" electronics definitions. Some exporters are accused of deliberately leaving difficult-to-recycle, obsolete, or non-repairable equipment mixed in loads of working equipment (though this may also come through ignorance, or to avoid more costly treatment processes). Protectionists may broaden the definition of "waste" electronics in order to protect domestic markets from working secondary equipment. The high value of the computer recycling subset of electronic waste can help pay the cost of transportation for a larger number of worthless pieces than can be achieved with display devices, which have less (or negative) scrap value.

Some computer components can be reused in assembling new computer products, while others are reduced to metals that can be reused in applications as varied as construction, flatware, and jewelry. Substances found in large quantities include epoxy resins, fiberglass, PCBs, PVC (polyvinyl chlorides), thermosetting plastics, lead, tin, copper, silicon, beryllium, carbon, iron and aluminum. Elements found in small amounts include cadmium, mercury, and thallium. Elements found in trace amounts include americium, antimony, arsenic, barium, bismuth, boron, cobalt, europium, gallium, germanium, gold, indium, lithium, manganese, nickel, niobium, palladium, platinum, rhodium, ruthenium, selenium, silver, tantalum, terbium, thorium, titanium, vanadium, and yttrium. Almost all electronics contain lead and tin (as solder) and copper (as wire and printed circuit board tracks), though the use of lead-free solder is now spreading rapidly. The following are ordinary applications: hazardous and non-hazardous substances, as is given in Fig. 6.

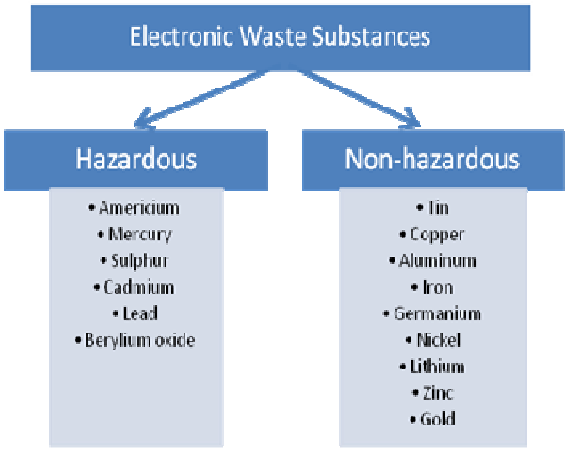

Fig. 6- Main electronic waste substances

Recycling raw materials from end-of-life electronics is the most effective solution to the growing e-waste problem. Most electronic devices contain a variety of materials, including metals that can be recovered for future uses.

By dismantling and providing reuse possibilities, intact natural resources are conserved and air and water pollution caused by hazardous disposal is avoided.
Additionally, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of new products. It simply makes good sense and is efficient to recycle and to do our part to keep the environment green.

III. SPECIFIC FEATURES OF MANAGEMENT OF ELECTRIC AND ELECTRONIC WASTES IN ROMANIA. CONCLUSIONS

Categories of electrical and electronic equipment covered by the Romanian Judgment 1037 / 2010 are represented in table 1.

TABLE 1- The main categories of the electrical and electronic equipments as is given in Judgment 1037/2010, after /1/

Category	Title of the category	Types of devices and equipments
1	Large household appliances	Large cooling appliances, refrigerators, freezers and other large appliances used for refrigeration, conservation and storage of food, washing machines, clothes dryers, dishwashers, stoves, electric stoves, electric hot plates, microwave ovens, Other large appliances used for cooking and other processing of food, electric heating appliances, electric heaters, other large household appliances for heating rooms, beds, seating furniture, fans, appliances for air conditioning, Other equipment for ventilation, exhaust ventilation and air conditioning
2	Small household appliances	Vacuum Cleaners, appliances for cleaning carpets and other appliances to be cleaned, and appliances used for sewing, knitting, weaving and other processing for textiles, Irons and other appliances for ironing, mangling and other care of clothing, toasters, deep fryers, Grinders, coffee machines and equipment to open or sealed containers or packages, knives, hair clippers, hair dryers, toothbrushes, shaving, massage and other body care appliances, alarm clocks, Watches and other equipment to be measured, indicated or recorded time, weighing scales
3	IT and telecommunications equipment	
	Centralized data processing	Central Unit,-computers that are specially, printers, electronic personal, personal computers (CPU, mouse, monitor and keyboard), laptop computers (CPU, mouse, monitor, and keyboard), small portable computers (computers very small, portable with touch screen laptop), Notepad computers, printers, photocopiers, electrical and electronic typewriters, Pocket and desk calculators, other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means
	Terminals and systems for the users	Fax, telex messages, phone calls, Pay telephones, cordless phones, cell phones, answering machines, other products or equipment of transmitting sound, images or other information by telecommunications
4	Consumer equipment	Radios, TVS, video cameras, video recorders, apparatus of high fidelity, audio amplifiers, musical instruments, other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound or image, than by telecommunications
5	Lighting Equipment	Luminaires for fluorescent lamps, with the exception of luminaires, straight fluorescent lamps, compact fluorescent lamps, high intensity discharge lamps, including sodium lamps to the high-pressure lamps and metal halide lamps, Low pressure sodium lamps and other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs
6	Electrical and electronic tools (with the exception of large-scale stationary industrial tools)	Drill, sawing, sewing machines, equipment for turning, milling, sanding, grinding, sawing cutting, shearing, drilling, punch holes, punching, folding, or similar processing of wood, Metal and other materials, Tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses, Tools for welding, soldering or similar use, equipment for spraying, spreading,
7	Toys, leisure and sports equipment	Electric trains or car racing in thumbnail, held video game consoles, video games, computers for biking, diving, running, boating, etc. , sports equipment with electric or electronic components, coin slot machines
8	Medical devices (with the exception of all implanted and infected products)	Radiotherapy equipment, cardiology, Dializoare, fans pulmonary, nuclear medicine, laboratory equipment for in-vitro diagnostic, analyzers, refrigerators, Fertilization tests, Other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability

9	Monitoring and control instruments	Smoke detectors, regulators of heat, thermostats, appliances for measuring, weighing or adjusted for household use or as laboratory equipment, other monitoring and control instruments used in industrial installations (for example in control panels)
10	Automatic dispensers	Automatic dispensers for hot beverages, Automatic dispensers for bottles or cans warm or cold, Automatic dispensers for solid products, Automatic dispensers for money.

In Romania the main objectives, as is given in HG 448/2005 on waste electrical and electronic equipment, are:

- the prevention of waste electrical and electronic reuse, recycling and other forms of recovery of these types of waste, to reduce, as far as the amount of waste disposed ;
- improve the environmental performance of all operators (producers, distributors and consumers) involved in the life cycle of electrical and electronic equipment and particularly to businesses directly involved in the treatment of waste electrical and electronic equipment.

As is raported by the end of 2008, the whole amount of wastes from electric and electronic equipments are about with a dynamic on each category as is shown in Fig. 6. Note that about 42% were in category 1, 29% of Category 3 and 24% of Category 4. The total amount collected, only 36 % have been treated, remainder at the end of the various economic operators.

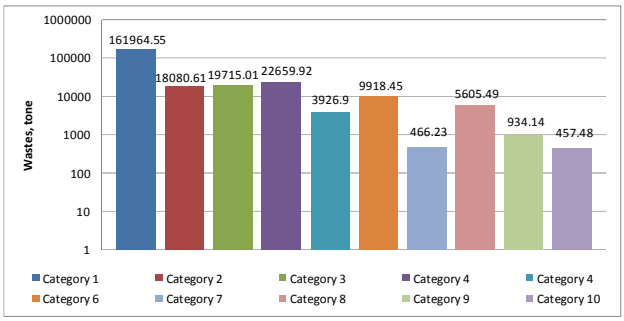

Fig. 6- Dynamics of wastes on different category in Romania of the year 2008

Another interesting consideration about dynamics of global resources extrusion in Romania, for the period of 2003-2008 is given in Fig. 7, from the data given by the Sustainable Europe research Institute in 2012.

The evolution of the domestic extrusion for the previous mentioned period in Romania shows that this was in the range of 165000-216000 kt, from the total quantity of extrusion , which was in the range of 295000-350000 kt.

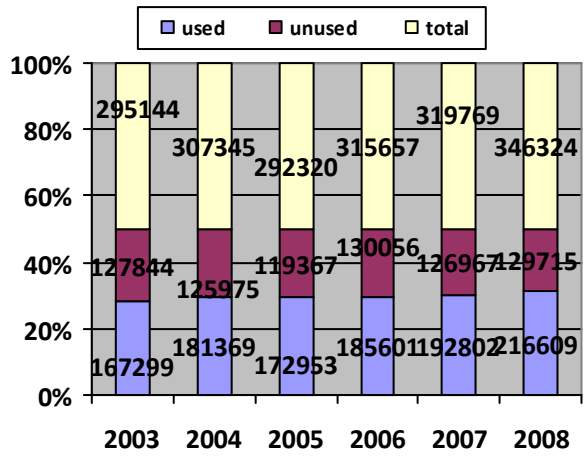

Fig. 7- Dynamics of Global Resource Extrusion in Romania for the period 2003-2008

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Word Clustering for a Slovak Class-Based Language Model

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***Abstract** – This paper proposes a method for designing better language model for a highly inflectional language, using a limited amount of training data. The model is enriched by inclusion of information about the grammar of the language. This information is extracted by using a word-clustering function and creating a class-based language model that describes relations between created word clusters. The word clustering function is heuristically designed and takes into the account morphological structure of the words. The class-based models are then interpolated with the baseline language model. Evaluation of the models shows significant decrease of the perplexity.*

***Keywords:** word clustering, class-based language model, suffix identification*

I. INTRODUCTION

Language modeling is important part of the automatic speech recognition. The biggest problem of the *n*-gram language models is data sparsity, where training set does not contain enough data to correctly calculate estimates of the probabilities of a word, based on its history using the most common maximum likelihood method. It is always necessary to use one of the techniques to estimated probability also for a word and history that have not seen in the training corpus.

This problem is even bigger in the case of the highly inflectional language [1, 2] with rich morphology and non-mandatory sentence word order, such as Slovak language. Large vocabulary means, that number of required word sequences in the training corpus is even higher. Most of the existing approaches [3] is designed for languages similar to English, and have limited use for this kind of languages.

This paper is structured as follows. The first section gives a brief introduction to the state of the art methods of the language modeling and dealing with the data sparsity problem. In the next section, a methodology for composition of a class-based language model using linear interpolation is introduced. Then, basic evaluation of the proposed method compared to the baseline language model is performed. The conclusion summarizes the whole approach and provides future directions of the research.

II. STATE OF THE ART

A. Language Model Smoothing

The classical way of dealing with missing word-sequences in the training corpus, the back-off scheme [4] is not sufficient for efficient estimating probability of a given word sequence,, and probabilities of *n*-grams in the language model have to be further manipulated.. Language model smoothing techniques move part of the probability mass from the events that were seen in the training corpus to the events that were unseen. Common methods are based on adjusting counts of *n*-grams, such as Witten-Bell [5] or modified Kneser-Ney [6] algorithms. The problem of this approach is that these methods are designed for languages that are not very morphologically rich. As it is showed in [7, 8] is that this kind of smoothing does not bring expected positive effect for highly inflectional languages with large vocabulary.

B. Linear Interpolation

Another common approach for estimating a language model from sparse data is linear interpolation, also called Jelinek-Mercer smoothing [9]. This method allows a combination of multiple independent sources of knowledge into one that is then used to compose the final language model. In the case of trigram language model, this approach can calculate the final probability as a linear combination of unigram, bigram and trigram maximum likelihood estimates. Linear interpolation is not the only method of combining of multiple knowledge sources, other possible approaches are maximum entropy [10], log-linear interpolation [11] or generalized linear interpolation [12].

In the case of the classical linear interpolation, the final probability is calculated as a linear combination of both sources P_1 and P_2 according to the equation:

$$P = \lambda P_1 + (1-\lambda) P_2 \qquad (1)$$

Interpolation parameter λ can be set empirically, or can be calculated by one of the optimization methods, e.g. by using expectation-maximization algorithm. The coefficient λ have to be chosen, such that the final language model composed from the training corpus fits best the target domain, represented by the testing corpus.

C. Class-Based Language Models

Another approach to overcome the problem of missing training data, class-based language models were proposed [13]. For word-based *n*-gram language model, there is a probability value for each *n*-gram, as well as back-off weight for lower order *n*-grams. On the other hand, for the class-based model, a whole set of words is reduced to a single class and class-based model describes statistical properties of that class.

This approach offers ability to group words into classes and work with a class as it was a single word in the language model [14]. The advantage is that the class-based models take into the account dependencies of words, not included in the training corpus. The same classical smoothing methods that were presented above can be used for a class-based language model as well.

Probability of a word, conditioned on its history $P(w_i \mid w_{i-1}...w_{i-n+1})$ in the class-based language model can be described using equation [13]:

$$P(w_i \mid w_{i-1}...w_{i-n+1}) = P(c_i \mid c_{i-1}..c_{i-n+1})P(w_i \mid c_i) \quad (2)$$

where $P(c_i \mid c_{i-1}...c_{i-n+1})$ is probability of a class c_i where word w_i belongs, based on the class history. In this equation, probability of a word *w* according to its history of (*n*+1) words is calculated as a product of class-history probability and word-class probability $P(w_i \mid c_i)$

D. Estimation of Class-Based Language Models

As it is described in [15] if using maximum likelihood estimation, *n*-gram probability can be calculated in the same way as in the word-based language models:

$$P(c_i \mid c_{i-1}...c_{i-n+1}) = \frac{C(c_{i-n+1}..c_i)}{C(c_{i-n+1}...c_{i-1})} \quad (3)$$

where $C(c_{i-n+1}..c_i)$ is a count of sequence of classes in the training corpus and $C(c_{i-n+1}...c_{i-1})$ is count of the history of the class c_i in the training corpus.

The word-class probability can be estimated as a fraction of a word count *C*(*w*) and class total count *C*(*c*)*:*

$$P(w_i \mid c_i) = \frac{C(w)}{C(c)} \quad (4)$$

III. WORD CLUSTERING FUNCTION

In order to construct a class-based model, a function that can put words to classes in the training corpus is required. This function should take into the account as much information about the grammar of the target language as it is possible.

In the Slovak language a single word can have many forms. A declination of a word carries information about the grammatical function in the sentence. For this purpose, a suffix extraction method has been designed. The suffix then can be used as a class for the word, so that words with the same suffix and same grammatical function would belong to the same class.

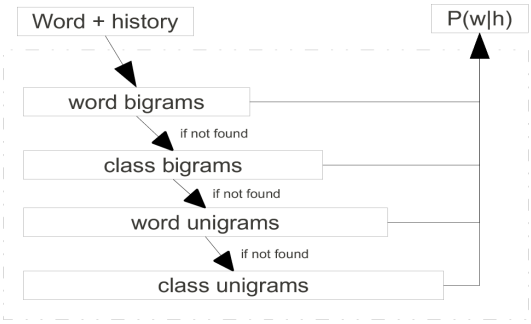
The rules for creating word forms are very difficult and there is a lot of exceptions. Some methods of extraction of morphological features are in [16, 17, 18]. The statistical approach seems to be a feasible way for obtaining a list of the most common suffices that can be later used for identification in the word. First necessary thing is a list of suffixes. This list can be obtained by studying a dictionary of words, or simple statistical count-based analysis can be used:

1. a dictionary of the most common words in the language has been obtained;
2. from each word longer than 6 characters, a suffix of length 2, 3 or 4 characters has been extracted;
3. number of occurrences of each extracted suffix has been calculated;
4. a threshold has been chosen and suffixes with count higher than the threshold has been added to the list of all suffixes.

If the list of the most common suffixes is created, it is possible to easily identify the stem and suffix and stem of the word using suffix subtraction method:

1. if the word is shorted than 5 characters, suffix cannot be extracted;
2. if word is longer than 5 characters, word ending of length $n = 5$ is examined. If it is in the list of the most common suffixes, it is the result. If the ending of length n is not in the list, algorithm continues with $n > 1$;
3. if no suffix has been identified, word is considered as a class by itself.

Figure 1: Class-Based Language Mode Back-Off



Disadvantage of this method is that it is statistically based and it is not always precise and some suffixes found might not be grammatically correct. Also, it is not able to identify a suffix in every case, because some words are just too short to correctly to be correctly split using the subtraction method.

IV. THE PROPOSED CLASS-BASED MODEL

Class-based language model utilizing grammatical features [19] consists of two basic parts that are put together using linear interpolation:

1. word-based language model;
2. class-based language model that was constructed using word clustering function.

TABLE 1. Class-Based Language Models Perplexity

Word Clustering method	Unigram count	Bigram count	Trigram count	PPL
1	924	262,271	3,277,939	266
2	37,704	4,767,125	11,616,339	62
3	44,692	4,126,071	9,491,228	68
4	65,072	6,636,168	12,533,250	42
5	91,171	10,121,937	13,470,470	23
Baseline	329,690	13,052,574	13,034,227	40

The first part of this language model can be created using classical language modeling methods from the training corpus. To create a class-based model, the training corpus has to be processed by the word clustering function that was presented above and every word has to be replaced by its corresponding class. From this processed training corpus, a class-based model can be built.

During this process, a word-class probability function has to be estimated as it is in Eq. 4. This function expresses probability distribution of words in the class. The last step is to determine the interpolation parameter λ, which should be set to values close (but lower) to 1.

If Eq. 2 and Eq. 3 are taken together, the final equation for the proposed language model is:

$$P(w|h) = \lambda P_w + (1-\lambda) P_g(g(w)|g(h)) P(w|g(w)) \qquad (5)$$

where P_w is probability returned by the word-based model and P_g is probability returned by the class-based model with the word-clustering function g that utilizes information about grammar of the language.

Looking at this equation, the proposed language model consists of the following components:

- *vocabulary V* that contains a list of known word of the language model;
- *word-based language model* constructed from the training corpus that can return word history probability $P(w|h)$. word clustering function $g(w)$ that maps words into classes;
- *class-based language model* $P_g(g(w)|g(h))$ created from a training corpus and processed by the word clustering function $g(w)$;
- *word-class probability function* that assigns a probability of occurrence of a word in the given class $P(w|g(w))$.
- *interpolation constant* from interval (0,1) that expresses weight of the word-based language model.

V. EVALUATION

Usual metric for the evaluation of the language model is called perplexity (marked as PPL). This measure expresses a weighted average of number of choices, that has to be made by the language model, when calculating probability of the given test text. Higher values of perplexity means, that the language model does not fit the testing set very much, lower number of perplexity, means, that the prediction of the testing set is good.

The focus of the experiments was given on the word clustering function. As it was mentioned, the main problem of the word-clustering function described above is that it is not able to assign a class to every word, In some cases, this feature can be taken as an advantage, because if the word is very common and unambugious, it can better serve as a feature for estimating probability of a future word and is better to not put it to the class. The question is, which words should be put into classes and which ones should be taken as they are.

Several variations of the word-clustering function using suffix subtraction have been set up:

- Method 1: List of 625 suffixed gathered by hand has been used.
- Method 2: List 7545 suffixes has been collected using a method described above. Words shorter than 5 characters have been marked as non-separable.
- Method 3: The same list of suffixes have been used and words longer than 7 characters had a suffix-based class assigned. On those words where suffix cannot be found, a morphological class have been assigned., from the morphological dictionary from [20, 21]. Morphological class was assigned only to those words, that have the same morphological tag in all contexts. Those words, that were shorter that 7 letters and does not have morphological tag were considered as a class alone.
- Method 4: is the same as the method 2, but words longer than 7 have been marked as non-separable.
- Method 5: is the same as method 3, but is using additional list of 70k common words that were also marked as non-separable.

Each method has been used to process the training corpus. The training corpus consists of the data gathered from web [22] and from data from the Slovak Ministry of Justice. The processed corpus then has been used to construct a class-based language model. The class-based language model has been evaluated for perplexity and results are displayed in Tab. 1.

TABLE 2. Interpolated Language models perplexity

Word Clustering method	PPL	PPL Decrease
1	37	7,5 %
2	30	25 %
3	28	30 %
4	25	37,5 %
5	23	42,5 %

The constructed class-based language models then has been interpolated with the baseline language model to match Eq. 5. Results of evaluations of these language models are in Tab. 2.

VI. CONCLUSIONS

Most of the class-based language models have higher perplexity that the baseline language model. The first class-based language model with word-clustering method with 675 identifiable suffices has very high perplexity. Higher count of non-separable words causes lowering of the perplexity, and final class-based model with method 5 has lower perplexity than the baseline language model.

The process of interpolation of the class-based language using word-clustering function model with the baseline language model has always caused significant decrease of the perplexity.

This set of experiments have shown, that utilization of the word-clustering function that takes grammatical structure of the language into the account can be used to build a language model that have much better prediction capability.

The future research should be focused on finding the best set of non-separable words that might bring even higher decrease of the language model perplexity. Language models build using this methodology then should be evaluated in the real-world task of the continuous speech recognition [23]. This approach can be usable to other languages that are similar to the Slovak language where the grammatical function of the word can be identified by the form of the word.

ACKNOWLEDGMENTS

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Regression Models of Force in Milling Sandwich Polymer Composites Materials – Benefit for Marketing

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Abstract *– The latest trends in materials' development proof that sandwich polymer composites do stay on top of materials, due to their interesting and special characteristics. Being used in various industrial filed, as automotive or spatial industries, this type of materials usually needs their rough edges to be machined. So, milling is widely used and therefore, the forces involved by the process must be known. For designing experiments and determining the force regression models, applied statistics methods have been used.*

Keywords: *regression models, experiments design, force, sandwich polymer composite, marketing.*

I. INTRODUCTION

First generation of composite material refers to an artificial system made of two, or three components, conceived so that to have higher performances when compared to those of component phases [1].

Second generation of composites involves matrix and strengthening materials (continuous or discontinuous fibers), so that the matrix transmits to fibers system the loading state. Third generation of composites is that of improved ones, whose matrix and strengthening fibers are accompanied by other types of materials, specific to the core part. So, there are the sandwich polymer composites defined as an assembly of two exterior layers and the middle, called core. Most of the times, the exterior layers are tough and high hardness one, while the core's characteristics are lower (as hardness and toughness) [2].

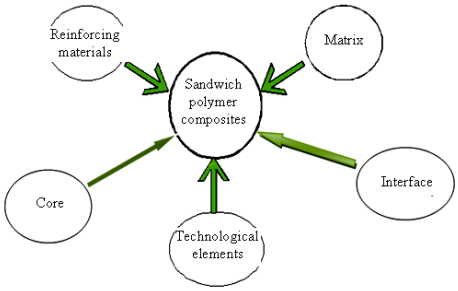
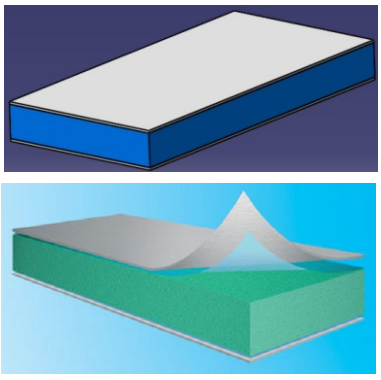


Fig. 1 Sandwich polymer composites structure



a.

b. [3]

Fig. 2 Model of sandwich polymer composites

Schematic representation of sandwich polymer composites' structure is shown in Fig. 1.

It is Fig. 2 that points out two models of sandwich polymer composites. The first one shows two reinforced glass fibers exterior layers and an extruded polystyrene core (a.), while the second one presents inner and outer skins over a DIAB structural foam core (b.).

There are a lot of industrial and practical application of sandwich polymer composites materials - see few examples in Fig. 3.

Fig. 3 Sandwich polymer composites application

[3]

Fig. 3 Sandwich polymer composites application - continued

Due to sandwich composites' various application, many times there is the need of machining, so that required shape and dimensions to be available. One of the most commonly used is milling – specially cylindrical milling.

Machinability of sandwich polymer composites has not been thoroughly studied and presented by specific references, so the existing data are poor and rather qualitative.

A direct method used in materials machinability studies is that of experimenting and analyzing the obtained data [4], [5]. So, specific process models could be obtained, referring to machinability aspects like: cutting tool durability, cutting force, cutting moments, surface roughness, etc.

This paper presents the steps followed in order to experimentally determine the cutting force regression models – knowing that it is important either to establish machining parameters values so that not to exceed a reasonable force value, or to estimate cutting force value, once machining parameters being set.

As observation, there should be the special attention when milling glass fibers reinforced layers sandwich composites, due to glass, dust and other elements that are dangerous to health.

The chips and dust resulted once milling the experimental samples was over, are evidenced by Fig 4.

Fig. 4 Resulted chips after milling the samples

II. STATISTICS METHOD APPLIED

The research presented by this paper is focused on determining force regression models in exterior cylindrical milling sandwich polymer composites with glass fibers reinforced exterior layers and extruded polystyrene core [6]. It involves statistical designed experiments and computer aided data processing.

A process developing within a certain technological system, is defined by relation (1):

$$Y = \Gamma\left(x_1, x_2, ..., x_j, ..., x_n\right) \tag{1}$$

called process function; where:

x_j , j = 1, 2, …., k represents the independent process variables (controllable inputs);

Y – the dependent process variable (output);

Γ - the type of dependence relation.

The studied variables are:

- independent variable, x_j: cutting speed, v_c [m/min]; cutting feed speed, v_f [mm/min]; radial cutting depth, a_f [mm];
- dependent variable, Y: cutting force components, F_z and F_y [N] (as the third component's values, F_z, proved to be of too small values) ;

First, there were determined dependence relation as:

$$F_x = A_{0Fx} \cdot v_c^{A1} \cdot v_f^{A2} \cdot a_e^{A3} \tag{2}$$

$$F_y = A_{0Fy} \cdot v_c^{A1} \cdot v_f^{A2} \cdot a_e^{A3} \tag{3}$$

where:

$A_j \left(j = 0,1,2,3,4\right)$ are polytropic coefficients.

The experiments design applied is conventionally named P 1.2 and it is a factorial fractional design type– see table 1,

Another kind of dependence relations (output depending on inputs) determined are the polynomial ones, meaning:

$$\begin{aligned} F_x =& a_{0x} + a_{1x} \cdot v_c + a_{2x} \cdot v_f + a_{3x} \cdot a_e + \\ &+ a_{12x} \cdot v_v \cdot v_f + a_{13x} \cdot v_c \cdot a_e + a_{23x} \cdot v_f \cdot a_e + \\ &+ a_{123x} \cdot v_c \cdot v_f \cdot a_e \end{aligned} \tag{4}$$

$$\begin{aligned} F_y =& a_{0y} + a_{1y} \cdot v_c + a_{2y} \cdot v_f + a_{3y} \cdot a_e + \\ &+ a_{12y} \cdot v_v \cdot v_f + a_{13y} \cdot v_c \cdot a_e + a_{23y} \cdot v_f \cdot a_e + \\ &+ a_{123y} \cdot v_c \cdot v_f \cdot a_e \end{aligned} \tag{5}$$

where $a_{jk} \left(j,k = 1,2,3\right)$ represent coefficients.

The experimental design type applied for these models is a Central composite design, conventionally called CCD – see table 1.

For regression analysis, there was used specific software, meaning:

- REGS –for P 1.2 experiment designs [7];
- DOE KISS - for CCD design [8].

TABLE 1 Experiments design

	Run	x_1	x_2	x_3
Fractional Factorial Design (P 1.2)	1	+1	-1	-1
	2	-1	+1	-1
	3	-1	-1	+1
	4	+1	+1	+1
	5	0	0	0
	6	0	0	0
	Run	x_1	x_2	x_3
Central Composite Design (CCD)	1.	-1	-1	-1
	2.	-1	-1	+1
	3.	-1	+1	-1
	4.	-1	+1	+1
	5.	+1	-1	-1
	6.	+1	-1	+1
	7.	+1	+1	-1
	8.	+1	+1	+1

III. EXPERIMENTS AND REGRESSION MODELS

As mentioned above, the sandwich polymer composites material studied is an exterior layers glass fibers reinforced one, whose matrix consists in a polyester type resin. HELIOPOL 9431 ATYX LSE. The core is an extruded polystyrene one. Samples, before experimenting, can be noticed in Fig. 5.

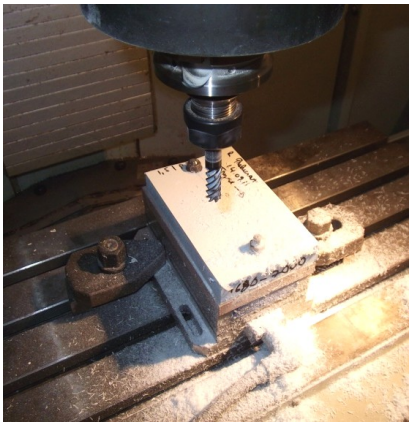
The milling tool is a special one, used in machining polymer composites, made by SANDVIC Coromat company – see Fig. 6

Fig. 5 Samples before experimenting

Fig. 6 The milling tool

a.

b.



c.

Fig. 7 Experimental stand

Milling process was performed on MCV 300 CNC machine, equipped with a KISTLER dynamometric device that enabled measuring each of machining process force's components (F_x, F_y, F_z). Data acquisition system was also used, so that fast and correct experimental data to be obtained. An image of the stand is shown in Fig/ 7 (a. – CNC machining centre, b. – before milling, c - after milling.).

Experiments were developed with both, limited variation domains, and certain well defined values of the independent variables studied – see table 2.

There should be mentioned that "real values" refer to real, experimental values (x_j) of the independent variables, while "coded" values refer to the ones (z_j) obtained by transformation below:

$$z_j = 2 \cdot \frac{x_j - \frac{x_{\min} + x_{\max}}{2}}{x_{\max} - x_{\min}} \quad (6)$$

TABLE 2. Independent variables values

	Coded values	Real values, for P 1.2 designs	Real values, for CCD design
v_c [m/min]	-1	62,8	62,8
	0	117,5	141,3
	+1	219,8	219,8
v_f [mm/min]	-1	480	480
	0	897,9	1080
	+1	1680	1680
a_e [mm]	-1	1	1
	0	2,3	3
	+1	5	5

TABLE 3 Experimental results – for P 1.2 design

P 1.2 design							
	Milling force component, F_x [N]						
	Exp. no.	1	2	3	4	5	6
		6,74	21,14	16,30	39,76	17,45	17,53
	Milling force component, F_y [N]						
	Exp. no.	1	2	3	4	5	6
		10,46	27,99	23,91	36,79	22,74	22,63

TABLE 4 Experimental results – for CCD design

CCD design							
	Milling force component, F_x [N]						
	Exp. no.	1	2	3	4	5	6
		5,11	13,03	20,69	28,15	4,93	14,27
		7	8				
		33,19	49,40				
	Milling force component, F_y [N]						
	Exp. no.	1	2	3	4	5	6
		9,92	20,68	21,80	31,18	6,90	23,29
		7	8				
		33,04	55,31				

Values of the obtained experimental data, for both milling force's components (F_x and F_y), are presented in table 4 (for P 1.2 design) and table 5 (for CCD design).

Thus, statistically processing the data with computer aided specialised software mentioned above (REGS and DOE KISS), there were obtained regression models of milling force's components – the ones aimed for this study.

The exponential type models, obtained with REGS software are presented by relations (7) and (8):

$$F_x = 0{,}072 \cdot v_c^{-0.012} \cdot v_f^{0.832} \cdot a_e^{0.486} \quad [\text{N}] \qquad (7)$$

$$F_y = 1{,}052 \cdot v_c^{-0.221} \cdot v_f^{0.565} \cdot a_e^{0.342} \quad [\text{N}] \qquad (8)$$

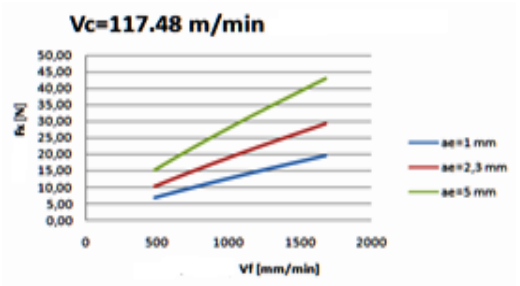
while, the polynomial type models, generated by DOE KISS software are shown by relations (9) and (10):

$$\begin{aligned} F_x = & -2.857 - 0.0152 \cdot v_c + 0.01009 \cdot v_f + \\ & + 1.883 \cdot a_e + 0.00005 \cdot v_c \cdot v_f + \\ & + + 0.00097 \cdot v_f \cdot a_e + 0.036 \cdot v_c \cdot a_e + \\ & + 0.0000034 \cdot v_c \cdot v_f \cdot a_e \end{aligned} \quad [\text{N}] \qquad (9)$$

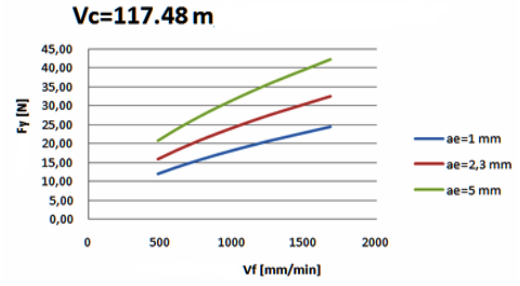
$$\begin{aligned} F_y = & \, 3.064 - 0.058 \cdot v_c + 0.031 \cdot v_f + \\ & + 2.556 \cdot a_e + 0.000065 \cdot v_c \cdot v_f + \\ & + 0.004 \cdot v_c \cdot a_e - 0.00093 \cdot a_e \cdot v_f + \\ & + 0.00001 \cdot v_c \cdot v_f \cdot a_e \end{aligned} \quad [\text{N}] \qquad (10)$$

Based on the obtained regression models, there were plotted some 2D graphs for better evidencing how the considered independent variables do influence the dependent variable values (F_x and F_y).

There are Fig. 8 (for REGS models) and Fig. 9 (for DOE KISS) that present the above mentioned graphs.

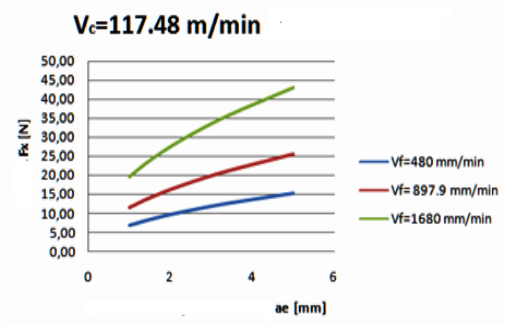


$F_x = f(v_f)$

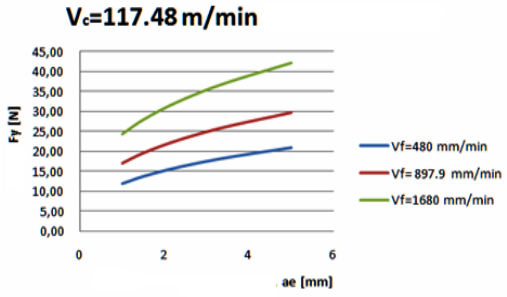


$F_y = f(v_f)$

Fig. 8 Graphs of milling force's components variation – REGS models

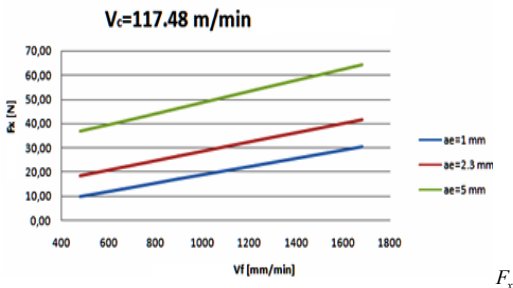


$F_x = f(a_e)$

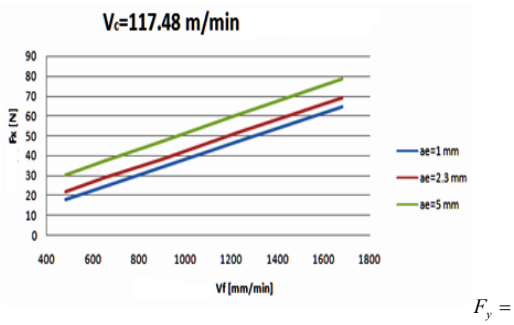


$F_y = f(a_e)$

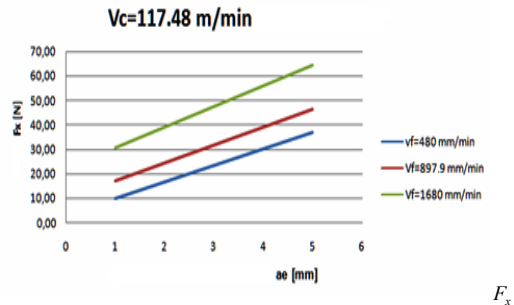
Fig. 8 Graphs of milling force's components variation – REGS models - continued



$F_x = f(v_f)$

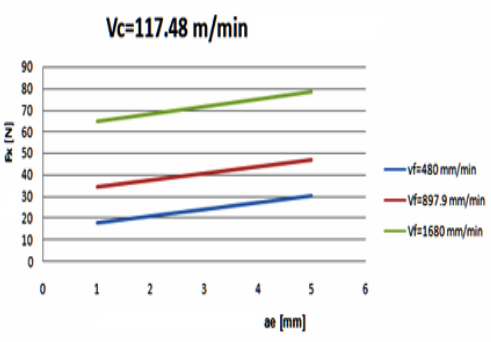


$F_y = f(v_f)$



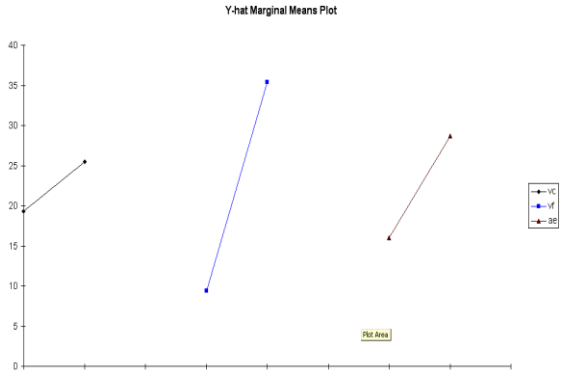
$F_x = f(a_e)$

Fig. 9 Graphs of milling force's components variation – DOE KISS models

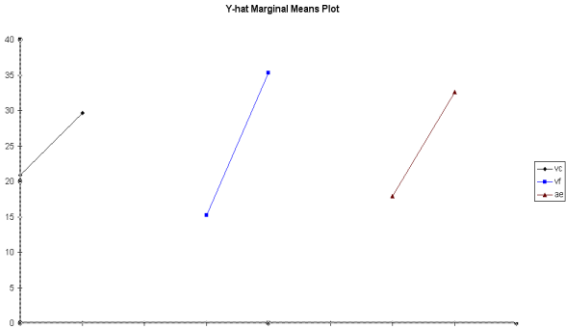


$F_y = f(a_e)$

Fig. 9 Graphs of milling force's components variation – DOE KISS models - continued



F_x component



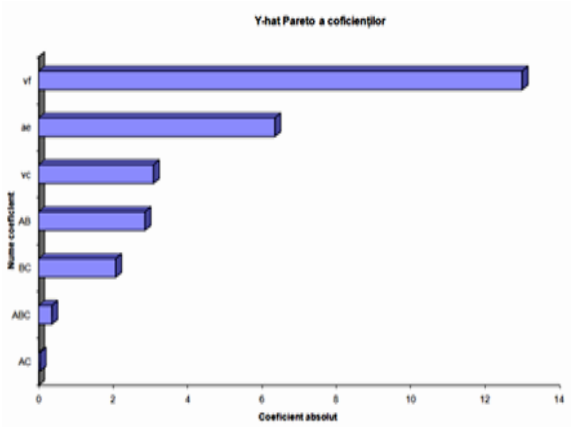
F_y component

Fig. 10 Marginal means graphs – DOE KISS models

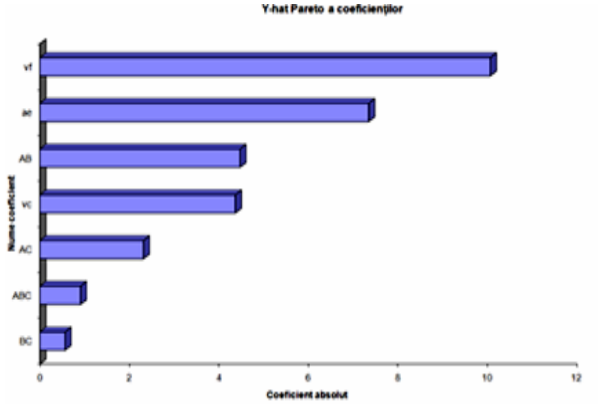
The DOE KISS software also enables the plot of marginal means plot, so that to evidence how strong the influence of each inputs, on the output is - see Fig. 10.

There is the Pareto chart of coefficients to be plotted, too. It shows the influence of each independent variable, as well as of their interactions on the milling force's value – see Fig. 11.

It is possible, by DOE KISS software, to optimize the regression models obtained, meaning to establish the minimum / maximum of force value and then automatically to have indication on corresponding inputs values for that required output magnitude.



F_x component



F_y component

Fig. 11 Pareto chart of coefficients – DOE KISS models

IV CONCLUSIONS

Sandwich polymer composites materials have many industrial and practical application. One of the most commonly used machining procedure of these materials is represented by milling – specially cylindrical milling.

This papers presents the steps followed in order to experimentally determine the cutting force regression models – knowing that it is important either to establish machining parameters values so that not to exceed a reasonable force value, or to estimate cutting force value, once machining parameters being set.

The regression models, once determined, should be integrated within a computer aided system of monitoring the milling process, with real time control, so that whenever a force value out of control limits would appear, the process could stopped.

Because of sandwich composites materials' wide application filed, there is a high demand for them on the worldwide market. So, regression models, as important part of a process monitoring system, would generate high benefit when selling the system to the interested and specialized market.

Applied statistics methods, like experiments design and regression analysis have been used to obtain milling force's components regression models. All of these involved the use of two specialised software, like REGS and DOE KISS.

All the determined regression models have proven to be adequate, the decreasing independent variables' influence being: cutting feed speed, v_f, radial cutting depth, a_e, and cutting speed v_c,

Both software proved to be a similar influence of independent variables considered on the output, but more, DOE KISS enabled to evidence the inputs interactions on the milling force components values

Further research development would deal with the study of more other process parameters and with some other different models type.

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Management of Uncertainty Evaluation Process in Calibrating a Force Measuring Device

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***Abstract* – The measure of how good a result is, can be defined as uncertainty. It is worth knowing the uncertainty value whenever test laboratories studies are involved or, when result evaluation of a particular measurement is needed. Steps developed for uncertainty analysis of linear calibrating a force measuring device are presented by this paper.**

Keywords: *uncertainty, management, calibration, error, measurement, load, strain*

I. INTRODUCTION

Uncertainty is a measure of the "goodness" of measurement results [1]. Based on its value, it is possible to appreciate the fitness of results as the basis for making decision on studied phenomena.

Each measurement process is "accompanied" by errors. These errors may be generated either by measurand properties, or measuring instrument's characteristics, or measuring process sequence of steps.

As already established [2], an uncertainty statement assigns credible limits to the accuracy of a reported value, stating to what extent that value may differ from its reference value. So, in ISO Guide to the Expression of Uncertainty in Measurement (GUM), uncertainty id defined as "parameter associated with the result of measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand". Uncertainty depends on repeatability of the instrument, the reproducibility of the result over time, the number of measurement of the test result and on all the sources of random and systematic error that could contribute to the "disagreement" between the result and its reference value [1].

The measurement method involves precision, related to random error and bias. While random errors can not be corrected, bias can be corrected or eliminated from the measurement result.

ISO (GUM) approach to classifying sources of error is the one that follows.

◘ Type A error - uncertainty components are evaluated by statistical methods.

Some specific random errors are the next ones:

- time dependent, like short-term (repeatability, imprecision), day-to-day (reproducibility) and long-term (stability) errors;
- errors caused by specific condition of measurement (instrument, operator, temperature, humidity);
- errors caused by material that is not homogeneous

The sources of bias relate to the specific measurement environment like: instruments, operators, configuration, geometries, etc.

◘ Type B error - uncertainty components are not determined by statistical methods.

Some sources of these errors are:

- physical constants used in calculating the reported value;
- environmental effects that can not be sampled;
- reference standards calibrated by another laboratory;
- possible incorrect configuration / geometry in the instrument;
- instrument's lack of resolution.

All the aspects mentioned above prove that evaluation of uncertainty is an ongoing process, time and resources consuming. Still, there are cases when it has to be done, like when laboratories or industries do participate in inter-laboratory studies or, when there are one-of-a kind-measurements [3], [4], [5].

The last mentioned, can be considered the case of a special designed machining forces measuring device. It has been designed and manufactured so that to be used in various types of machining procedures and, therefore, before exploitation, specific calibration equations had to be determined.

So, evaluation of uncertainty had to be done, the case being that of uncertainty in linear calibration.

II. EVALUATING UNCERTAINTY STEPS

The tasks that need to be performed in order to obtain an evaluation of uncertainty associated to measurement results are mentioned next:

- specify measurand, identifying the parameters for which uncertainty is to be estimated
- identifying all sources of uncertainty;
- classifying the sources of errors into type A or B;
- estimating the standard uncertainty for each source of uncertainty;
- computing the combined uncertainty, u_c;
- computing the expanded uncertainty, U;
- reporting the results.

A short and simplified summary of the general route to evaluation of uncertainty is schematically shown in Fig. 1. It is applicable in most circumstances and the steps involved are "easy" to follow.

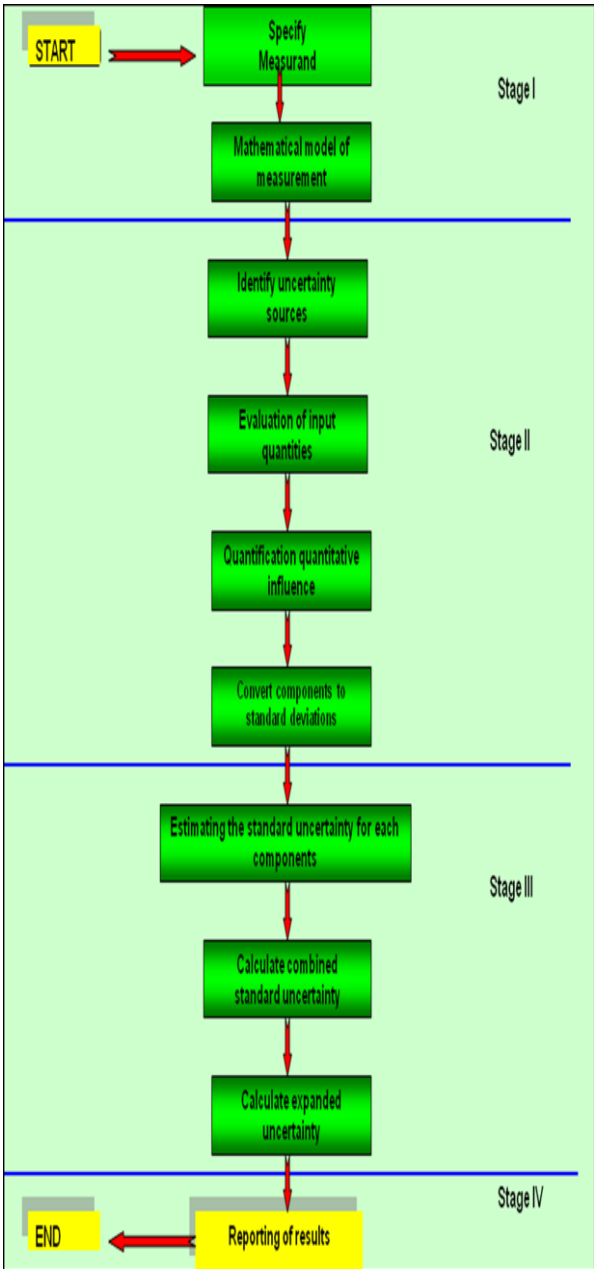


Fig. 1 Steps of the uncertainty evaluation process

III. EXPERIMENTAL CONDITIONS

The special studied device was designed so that to enable measuring of each machining forces' components, in various machining procedures [6], [7].

It is characterized by elastic element (see Fig. 2) whose shape is a real innovative one.

There are transducers, Hottinger resistive gauges, whose position on the elastic element was established as result of ANSYS simulation.

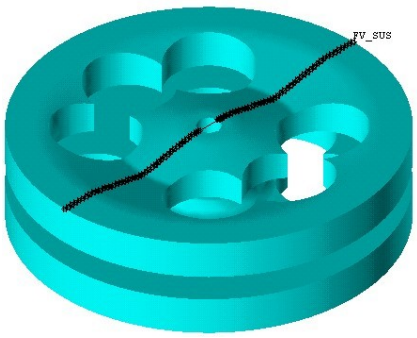
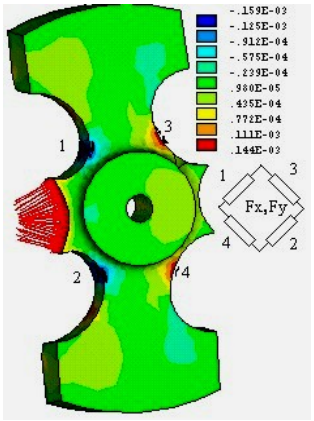
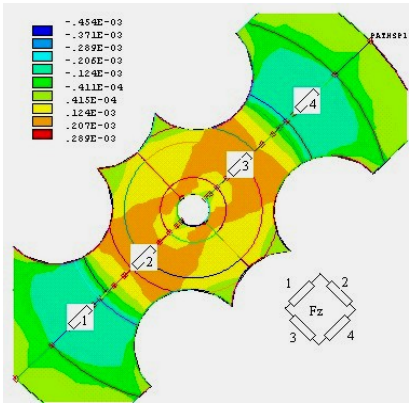


Fig. 2 Elastic element innovative shape, 3D model



transducers for F_x and F_y measurement

a.



transducers for F_z measurement

b.

Fig. 3 Transducers position and connection

Transducers position and connection, so that all three components of machining force (F_x, F_y and F_z) to be, relatively, independently measured is evidenced by Fig. 3 (a. and b.).

In order to obtain calibration equation, the device should be submitted to various loading (specific to different machining procedures) and the resulted deformation to be measured. Thus, the F_ρ (ρ = x, y, z) loading force does generate the $\varepsilon_{\rho x}$, $\varepsilon_{\rho y}$, $\varepsilon_{\rho z}$ signals to each of "C_x", "C_y" and, respectively, "C_z" voltage bridge channels.

Schematic representation of F_x, F_y and F_z loading are shown in Fig. 4 (a., b. and c.).

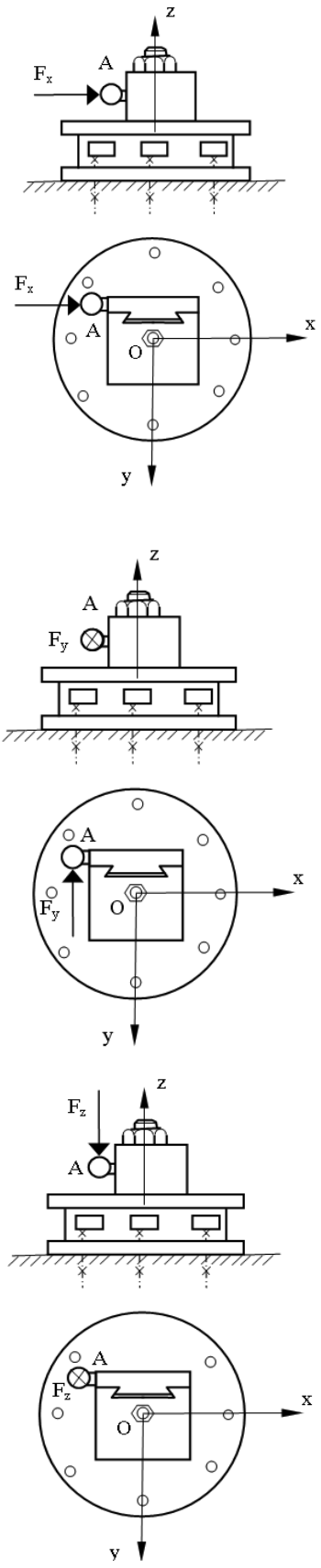
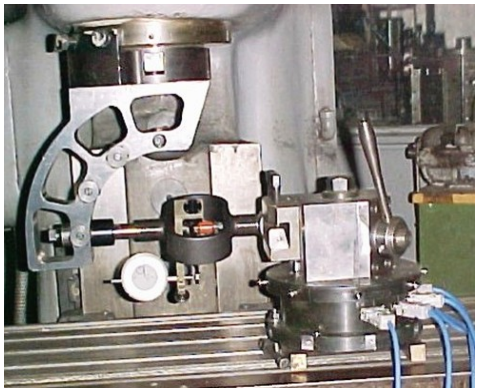
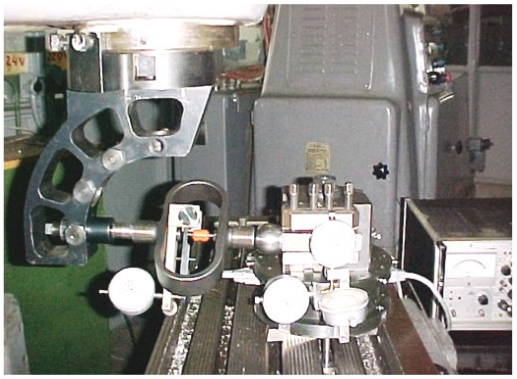


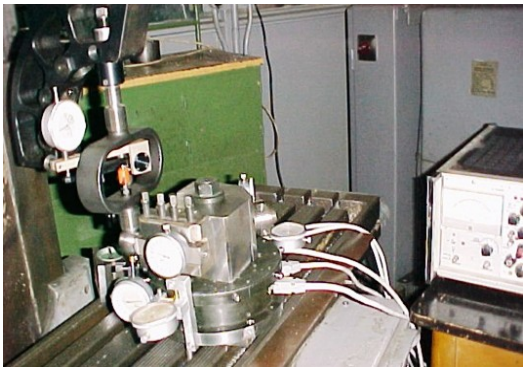
Fig. 4 Schematic representation of force loading - - in calibrating


a.

F_x loading


b.

F_y loading


c.

F_z loading

Fig. 5 Images captured while experimenting

Images captured while experimenting can be noticed in Fig. 5 (a., b. and c.). One comment should be about the fact that both, F_x and F_y loadings, are similar ones.

Based on preliminary experimental data analysis, it has been considered that calibration equations are of linear type, such as:

$$\varepsilon_{\rho\theta} = a_{\rho\theta} \cdot F_{\rho} + b_{\rho\theta} \quad (1)$$

$$\rho = x, y, z, \quad \theta = x, y, z$$

So, considering all the aspects mentioned above, there can be plotted Ishikawa chart of uncertainty sources in device's linear calibration – see Fig. 6.

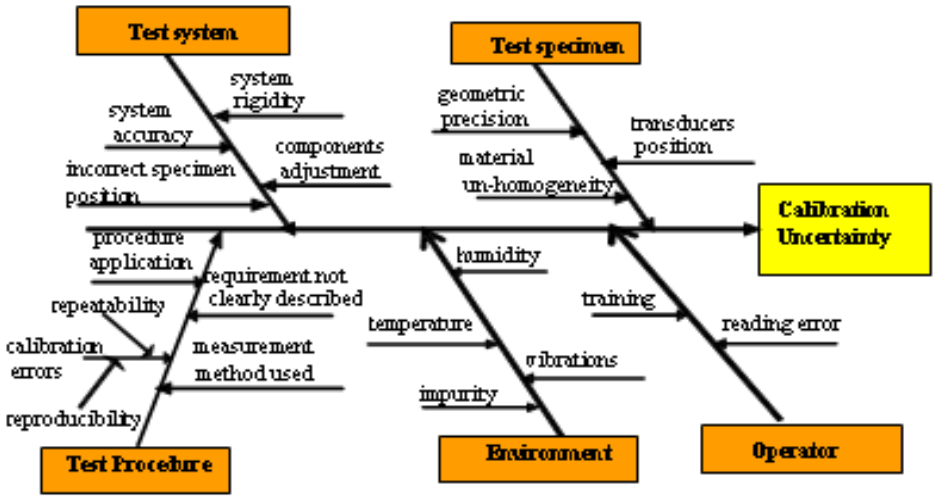


Fig. 6 Ishikawa chart of uncertainty sources

TABLE 1 Tests results

x_1			x_2			x_3			x_4			x_5			F_x loading
0			50			100			150			200			[daN]
y_1			y_2			y_3			y_4			y_5			
r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3	r1	r2	r3	
0	0	0	225	233	226	464	476	470	668	678	676	842	854	845	[μm/m]
mean			mean			mean			mean			mean			
0			228			470			674			847			[μm/m]
x_1			x_2			x_3			x_4			x_5			F_y loading
0			50			100			150			200			[daN]
y_1			y_2			y_3			y_4			y_5			
r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3	r1	r2	r3	
0	0	0	210	230	205	421	435	425	640	658	646	818	824	821	[μm/m]
mean			mean			mean			mean			mean			
0			215			427			648			821			[μm/m]
x_1			x_2			x_3			x_4			x_5			F_z loading
0			50			100			150			200			[daN]
y_1			y_2			y_3			y_4			y_5			
r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3	r1	r2	r3	
0	0	0	210	230	196	486	505	500	682	700	694	868	883	880	[μm/m]
mean			mean			mean			mean			mean			
0			212			497			692			877			[μm/m]

IV. UNCERTAINTY EVALUATION

The model for linear calibration is:

$$Y = aX + b + \varepsilon \quad (2)$$

there : Y is a measurement on a reference standard;
X – known value of a reference standard;
ε - measurement error
a, b – coefficients to be determined

A minimum of five reference standards and a minimum of two measurements on each reference standard is required for linear calibration curve. The repetitions should be separated in time by days or weeks [1].

Basic assumption regarding measurement errors associated with the instrument are the next ones: free from outliers; independent; equal precision; normal distribution.

So, based on all the above, tests have been done and the obtained results are presented in table 1.

There should be mentioned that Y represents the elastic element deformation, Δ [μm/m], while X stands for loading force value, F [daN].

Using a special software, CurveExpert 1.3, there were determined the estimated coefficients value of linear model, meaning (see as example, Fig. 7 – for F_x loading):

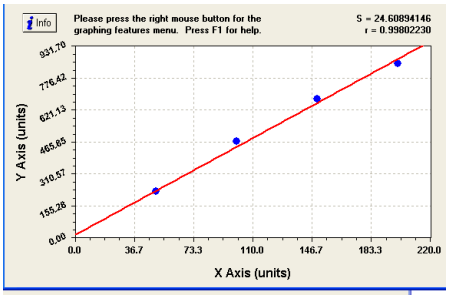


Fig. 7 Data analysis with CurveExpert 1.3 – for F_x loading

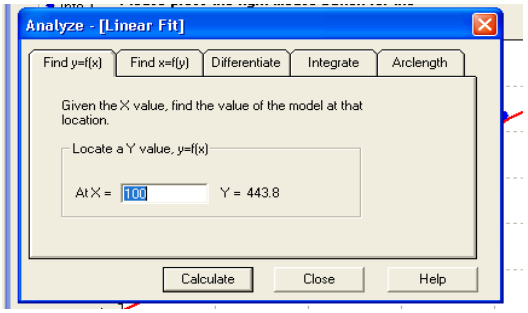


Fig. 8 Data prediction with CurveExpert 1.3

- F_x loading case

$$\widetilde{Y} = 4.28X + 15.8 \tag{3}$$

where: s = 24.6089 is the standard error
r = 0.9980 is the correlation coefficient

- F_y loading case

$$\widetilde{Y} = 4.15X + 7.2 \tag{4}$$

s = 14.9699 and r = 0.9992

- F_z loading case

$$\widetilde{Y} = 4.68X + 8.8 \tag{5}$$

s = 31.6944 and r = 0.9969

Calibration of future measurements can be done by obtaining predicted values, y_{ipred}. The CurveExpert 1.3 software was also used for estimation, obtained results being presented in table 2. It is Fig. 8 that shows an example of one predicted value (for F_x loading case).

TABLE 2 Predicted values

x_1	x_2	x_3	x_4	x_5	F_x loading
0	50	100	150	200	[daN]
y_{1pred}	y_{2pred}	y_{3pred}	y_{4pred}	y_{5pred}	
15.8	228	470	674	847	[μm/m]
x_1	x_2	x_3	x_4	x_5	F_y loading
0	50	100	150	200	[daN]
y_{1pred}	y_{2pred}	y_{3pred}	y_{4pred}	y_{5pred}	
8.4	215.6	422.8	630	837.2	[μm/m]
x_1	x_2	x_3	x_4	x_5	F_z loading
0	50	100	150	200	[daN]
y_{1pred}	y_{2pred}	y_{3pred}	y_{4pred}	y_{5pred}	
8.8	232.2	455.6	679	902.4	[μm/m]

Based on further statistical calculi, the uncertainty value is being evaluated - see relations below.

$$s_y = \sqrt{\frac{\sum_{i=1}^{N=5}(y_i - y_{ipred})^2}{N-2}} \tag{6}$$

$$s_{x_0} = \frac{s_y}{a} \tag{7}$$

$$x_0 = \frac{y-b}{a} \tag{8}$$

$$s_{xx} = \sum_{i=1}^{N=5}(x_i - \bar{x})^2 \tag{9}$$

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N=5} x_i \tag{10}$$

$$u(x_0) = s_{x_0}\sqrt{\frac{1}{p} + \frac{1}{N} + \frac{(x_0 - \bar{x})^2}{s_{xx}}} \tag{11}$$

$$U(x_0) = k \cdot u(x_0) \tag{12}$$

where: a, b represent linear regression model's coefficients;

p - the number of measurements for x_0;

$u(x_0)$- the combined uncertainty

$U(x_0)$- the expanded uncertainty;

k – the coverage factor, selected on the basis of required confidence level.

For a normal probability distribution, the most generally used value for coverage factor is 2, which corresponds to a confidence interval of 95% .

The values of the above mentioned parameters are presented in table 3.

TABLE 3 Uncertainty parameters values

F_x loading						
s_y	s_{x_0}	x_0	s_{xx}	$\bar{x}$	$u(x_0)$	$U(x_0)$
9.1221	2.1313	106.122	25,000	100	1.5586	3.1172
F_y loading						
s_y	s_{x_0}	x_0	s_{xx}	$\bar{x}$	$u(x_0)$	$U(x_0)$
15	3.6145	101.1566	25,000	100	2.6397	5.2794
F_z loading						
s_y	s_{x_0}	x_0	s_{xx}	$\bar{x}$	$u(x_0)$	$U(x_0)$
31,6944	6.7722	104.3162	25,000	100	4.9490	9.8980

Experimental obtained values have been further processed, based on relation (1) and, also, on CurveExpert 1.3 software. So, the force measuring device's calibration equation has been determined as:

$$\begin{bmatrix} F_x \\ F_y \\ F_z \end{bmatrix} = \begin{bmatrix} 0{,}2402 & -0{,}0052 & -0{,}0218 \\ -0{,}0092 & 0{,}2443 & -0{,}0181 \\ -0{,}0100 & -0{,}0237 & 0{,}2361 \end{bmatrix} \cdot \begin{bmatrix} \varepsilon_x - 6{,}200 \\ \varepsilon_y - 17{,}600 \\ \varepsilon_z + 4{,}000 \end{bmatrix} \quad (13)$$

or, equivalently :

$$\begin{aligned} F_x &= 0{,}2402 \cdot \varepsilon_x - 0{,}0052 \cdot \varepsilon_y - 0{,}0218 \cdot \varepsilon_z - 1{,}4849 \\ F_y &= -0{,}0092 \cdot \varepsilon_x + 0{,}2443 \cdot \varepsilon_y - 0{,}0181 \cdot \varepsilon_z - 4{,}3150 \\ F_z &= -0{,}0100 \cdot \varepsilon_x - 0{,}0237 \cdot \varepsilon_y + 0{,}2361 \cdot \varepsilon_z + 1{,}42352 \end{aligned} \quad (14)$$

These equations above, allow each of the machining force's components (F_x, F_y anf F_z) to be independently determined.

So, for example, the measurement results and their corresponding uncertainty are mentioned next:

- machining force's component, F_x

  464 ± 3.117 [daN]

- machining force's component, F_y

  421 ± 5.279 [daN]

- machining force's component, F_z

  486 ± 9.898 [daN]

An image taken while using the designed device in a real machining process (exterior cylindrical turning) is shown in Fig. 9.

Fig. 9 Exploitation of the force measuring device

IV. CONCLUSIONS

Measurement uncertainty is the basic parameter that characterizes result's quality of measurements.

More and more often, specially in industrial environment and in test / calibration laboratories, the measurement's quality is a requirement that according to quality management system, facilitates information exchange and cooperation between laboratories testing / calibration and harmonization of standards, procedures and other regulations specific to measuring process.

The objective of measurements quality assurance is to reduce measurements errors to tolerable limits and to provide a mean of ensuring that the measurements results have a high probability of acceptable quality.

Management of uncertainty evaluation process so that to provide confidence in measurement results involves some important steps, as: method development and validation; validating data; reference measurements; production of reference materials; inter-laboratory comparisons; training, etc

For the study presented by this paper, some relevant conclusions can be considered the ones below.

- Evaluation of measurement uncertainty provides the starting points for optimizing test procedures through a better understanding of the test process

- Statement on expanded uncertainty can represent a direct competitive advantage by adding value and significance to the measurement result

- The knowledge of quantitative effects of single quantities on the test result improves the reliability of the test procedure. Corrective measures may be implemented more efficiently and hence become more cost-effective.

- Calibration costs can be reduced if it can be shown from the evaluation that particular influence quantities do not substantially contribute to the uncertainty.

- Proper evaluation of uncertainty is good professional practice and can provide laboratories and customers with valuable information about the quality and reliability of the result.

- Calibration of a special designed forces measuring device is essential, as it provides trustful information on the interest characteristic that is machining force components' values.

Once calibration equation determined the measurement results can be trusted, as uncertainty value proves to be small enough.

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The Promotion of Banking Services

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Abstract: ***The purpose of the scientific approach is to demonstrate the usefulness of the adoption of modern promotion techniques in the actual financial-banking sector, in addition to the classical techniques. To achieve this end, the investigation of the Romanian financial-banking sector has been deeply conducted, by evaluating the market relations existing between the financial and banking institutions and individuals, as well as promotional techniques adopted by banks, during the communication process deployed with them.***

Thus, in order to "survive", banks were forced to diversify its product range and use all methods to promote them. As a variable under the control of the company, promotion serves a multitude of objectives and practices the most diverse forms. Promotional activities have a bearing on, firstly, characteristics, especially intangibility, variability and inseparability. Thus, the specific of promotion services is determined by the difficulty of presenting an intangible product, not created in the moment of promotion and being able to vary. Olteanu Valerică in his "Financial-banking Marketing" states that the "nature of most products is too technical and financial and banking services plus lower level of economic culture of the customer provides a particularly important role promotion".

Integrated marketing communication offers the smooth coordination and effective control of communication steps across banks, ensuring coherence and synergy required in a highly dynamic business environment. A policy effective promotional will result in attracting new customers, maintain existing customers, informing staff in promoting, forming a positive image and enhancing overall financial banking service quality perception, eliminating concerns about variability of performance. Currently, banks are facing new challenges: must shift from mass marketing to highly individualized marketing and promotional mix elements of classical, traditional techniques - combined advertising, personal selling, sales promotion, public relations and direct marketing have become sufficiently tailored marketing objectives of major banking conglomerates.

Keywords: ***promotion; banking marketing; quality of service; customer loyalty; financial services marketing; marketing mix; promotion techniques.***

I. INTRODUCTION

In the last years, the evolution of the financial-banking domain has suffered some unprecedented modifications, thus emphasizing the importance of marketing and client orriented strategies, in order to preserve and enlarge the market shares and profitability. The income circular flow implies a powerfull financial-banking infrastructure, a sound intermediation institutional system to allow fund mobilization and to ensure the national economy funding. In this context, marketing has proved to be of a great importance in approaching the complex problems, aimed at elucidating the main aspects of the market-related policy of the economic agents.

As part of the company's communication system with the environment, promotion is basically the link between its activities, reflected in the product, price, distribution and customers, actual or potential. Promoting banking services, that is all activities, means and techniques for the purposes of advertising and sales operations, is founded on the institution's communication system and upgrading its customer so as to provide an accurate picture of the state institution, such as the customer and media. In the promotion of banking services the whole personnel of the institution is involved, whereas through its attitude, it helps to increase customer loyalty and demand for banking products and services. Marketing of banking must be regarded with interest in the light of such services, which meet in Romania lately evolved strongly. Banking environment becomes increasingly complex. Thus, mergers, privatizations taking place, increased competition; customers become more sophisticated results in a diversification of services offered by a bank and an improvement in their quality. Entry of new banks in the system led to increased competition. Banking services were introduced us to increase the efficiency of operations (use the SWIFT network for electronic transfers of payments and receipts) and to meet various customer requirements (payment cards used in Romania

and abroad by natural and legal persons, ATMs, certificates of deposit with maturities different short-term, factoring services, corporate banking services) [1].

In the same time, while the costs increase, productivity stagnating and quality tends to deteriorate, becoming more aware of the importance of credit institutions and bank marketing that appeals to it [2]. It can be said that marketing is "the management processes that lead to clients' financial needs in a profitable manner for the bank."[3]. Banking marketing takes over the concept and the general framework of the asset marketing "[3].Banking marketing takes over the concept and the general framework of the asset marketing. As the asset marketing, the bank is facing actual and potential satisfaction of consumer (user) with maximum efficiency [4]. It has two essential components, "marketing research and marketing policies, which is a fundamental element of marketing mix"[5].

Unlike traditional mix, including price, product, promotion and placement for the banking sector are those two other new elements of the marketing mix: staff and physical premises - "physical aspects accompanying service delivery activities"[6].

II. RESEARCH METHODS

The continuous evolution of the Romanian banking system was characterized by development and diversification of financial and banking products and services, increase speed and diversification of the disbursement instruments, accounting and control system modernization, computerization of the data transmission systems such as accounting, statistics and those regarding the transfer process. Also the capitalization efforts and competitive pressures have led banks to expand / upgrade branch network continuously.

Meeting the need of financial-banking services is done through consumption, act preceded by a sequence of actions, where the consumer purchase decision is taken according to their requirements. In order to optimize customer relationships, banks must identify the particular behavior of the banking consumer, to better meet their needs, to anticipate reactions and turn them into opportunities to expand cooperation.

In order to shift towards consumer needsand market demands, respectively the financial institution - bank should aim, first, thorough knowledge of these requirements, the systematic tracking and even anticipating their scientific bases, designing and applying appropriate investigative tools . In one approach, consumer behavior can be defined as "a multidimensional concept par excellence, as a specific outcome of a system of dynamic relationships between the processes of perception, information, attitude, motivation and effective expression that characterize the integration of the individual or group in the space described by all the consumer goods and services in society at a time, through individual and group decision-making acts relating to them"[7].

Investigation of consumer behavior requires an interdisciplinary approach, due to the fundamentally different nature of the acts and decision processes that compose it. As a component of the company's communication with the environment, promoting is the link between activities, reflected in the product, price, distribution and clients, actual or potential. Promotion is what determines the place and role of advertising in the marketing mix, its content is strongly influenced by characteristics, creation and delivery system characteristics and purchasing behavior. It also puts the mark on promotional activity, and specific features of these services especially those characteristics of intangibility, variability and inseparability. In the same time we show that in services the specific of promotion lies in the difficulty of the presentation of intangible product, promotion and not created in the moment of promotion, being able to vary a lot over this time.

III. RESULTS AND SOLUTIONS

The characteristics of services provide specific features and promotional activities carried out in rolling out new "products", in which case, their absence or the delay is not just the absence of information but is a negative communication. A similar situation occurs when information provided is not consistent with the characteristics of the target, is due to ignorance of these features [8].

Obtained negative effects can be amplified by attracting, unwantedly, a new segment of customers who, in the services where the role of consumers is high, can lead to an incompatibility of the segments [8].

These issues highlight the role of promotional activities highlighting the consequences of its conduct without professionalism. Place and role of politics in the promotional marketing mix is given and the perception that the consumer generally has on services and on the communication system.

The trust given to personal sources of information situates their transmission range technique "by words" ("word of mouth") on a leading position among media advertising. Perception of higher risk in purchasing services customize the content of messages sent to reducing promotional offer only promised to deliver what is possible. These considerations on the place and role of advertising in service highlight diverse and complex nature of its defined role of all components of business communication, diversity of means of communication and significance of communications protocols, especially those made customers' word of mouth ". The complex and diverse nature of promotional activity raises a number of problems in developing marketing programs, problems can be overcome by meeting rigorous guidelines [9]:identifying and using tangible elements that make the product better understanding of the services to be offered (appealing to specific attributes, symbols, etc.), promoting continuously (permanently) the promise of what can be offered, the collection ("capitalization") effects obtained

by promoting the "word of mouth", targeting promotional activities by their employees. The complexity and diversity of promotional measures in services is determined among others and the diversity of banking services means communication. The specific of banking services properly marks all communication activities. These features are found both in content activities and the means and strategies used. To "survive", banks were forced to diversify its product range and use all methods to promote them. Otherwise the initial stage of bank marketing research has focused on market demand and incentives and attracts customers' needs. Intense competition and increasing customer requirements from banking has a growing number of banks to resort to marketing, the development of strategic marketing plans to offer banking deal.. Promotion policy includes shares of companies to make known and appreciated by the products they offer. Policy objective is to promote the demand curve shift to the right.

Direct contact with the client, is one of the fundamental characteristics of the bank and its customers. The relationships have but a continuous character. The profitability of banks is based on customer loyalty, both depositors and borrowers. This loyalty is especially important in developed countries, where the whole banking market is on a quasi-saturated. Communication policy is also the only weapon that can be handled by the bank and whose implementation difficulties related to the complexity of the bank in promoting the role of marketing. The result is complex, from facilitating communication to inform and educate the public which is addressed.

The main policy objectives in a banking institution are:

- attracting new consumers - in order to maintain the turnover of long-term bank. Generally, new customers are attracted by two ways: attracting customers from competing banks and launch of products to match the offer and / or price of a new segment;
- maintaining current customers. The cost of attracting new customers is five to six times higher than that of maintaining the bank's clients. Promotion has a major role in maintaining and developing relationships with current customers, respectively, customer loyalty;
- staff information - through internal focus and consumers. In banks, the staff has a key role in meeting the needs of consumers and their loyalty. Employees are often part of the service purchased by customers, so communication with them is very important;
- forming a positive image of the bank - by creating and "design" a stable organization among consumers, employees and the rest of the people with whom the bank has relationships. At the base of a bank customer relationship is full confidence of both parties based on the seriousness and soundness of the organization.
- strengthening the perception of service quality, promoting its role to highlight certain elements to ensure it and to soothe the consumer. The most common use is the expression of quantitative, qualitative assessments of allowing measurement of service by using numbers or combination of images (symbols) in an "aggressive" way which reduce consumer fears related to the variability of supply and at the same time is a way to a "tangibility " service.

Promoting banking services is influenced by factors whose impact increases the difficulty of it and its efficiency. These factors are related to characteristics, the typology of consumers, the regulatory environment and other components of the external environment of the organization. The main factors to be taken into consideration in promoting banking services are:

- consumer apathy that causes many consumers not to be motivated enough to buy banking services. Many services are "unexpected", which makes it difficult to promote this product more attractive and motivating;
- high risk because, although the involvement of consumers in the purchase of a banking service is great, there is no possibility for testing before purchase. Also, because of intangibility, it can not be evaluated the benefits of services and long-term duration contracts when buying it;
- low credibility of information sources.
- minority consumer market to promote efficiency by influencing the existence on the market a small proportion of individuals in state "ready to buy" at any time.

Competition between similar banking services in raising the number of suppliers of banking services market and the similarity between them.

IV. CONCLUSIONS

Important marketing activity is demonstrated by the existence of competition in the banking sector is in continuous development, despite the high entry and exit barriers from the market. Globalization and high interest in this market players make the intensity of commercial actions in this sector to meet high quotes. In successful process of marketing, financial institutions subscribing customer orientation should pursue the following issues:

- Identifying markets that are profitable in their relationship to their work;
- Analysis of current needs and future customers;
- Drawing up plans and marketing strategies to achieve goals.
- Since the ultimate objective of promotion of any product or service is the sale, any marketer should take into account the control of communication and promotion in every stage of

sale, so that it can measure consumer response to promotional messages.

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Functional Analysis of Congestion State Caused by Pilgrims Crowd Using SADT Aiding on the Design of a New Supervisory System

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Abstract ***–This paper is devoted to the use of SADT (Structured Analysis and Design Technique) method for a functional analysis of the congestion state caused by the pilgrims crowd during Al-Hajj season: one of the complex discrete event and real systems in the world. Such functional analysis will be a useful step for the design of a human centered supervisory system allowing a real time supervising and monitoring of the dynamic movement of the pilgrims in safety conditions. This work is focused on studying the dynamic movement of the pilgrims on Al-Jamarat bridge as the most important area in Al-Hajj stages where the congestion problem may happen. This functional analysis covered the different steps of pilgrims' dynamic motion all along the bridge considering to Al-Hajj rules. SADT method is used for this functional analysis with different required levels of details.***

Keywords: ***Functional analysis; Congestion problem; SADT; Supervisory system; Al-Hajj season.***

I. INTRODUCTION

In general, when a specific area reaches an occupation level greater than its capacity, people safety becomes in danger. In 2005 over 250 pilgrims were crushed during the Hajj, and over 80 were crushed at the lantern festival in Beijing. The management and control of crowd's areas is then a crucial problem for human life and safety [1-3]. Most of works interested on crowd problems were focused on either crowd density estimation or studying evacuation processes. Many strategies and observation systems are suggested for this purpose. These investigations, proposed the use of different means like computer vision, images processing and multi-scale local texture analysis to estimate and measure crowd density or for a real-time analysis of crowd congestion [4-8]. Nevertheless, most of these works don't focus on their functional analysis helping on control models' design.

Among the few works which suggested a specified models for people crowd situations, we may mention the following related works: In [9] a model for simulating a school of fish and a flock of birds using a particle systems method is developed; The model proposed by [10] is interested on studying the crowd behavior and then simulate the motion of a generic population in a specific environment. This work explored an approach based on the relationship between the autonomous virtual humans of a crowd and the emergent behavior originated from it. In [11] a crowd dynamic model of pedestrian movement in a main railway station at China is developed and has been based on simulating the global movement of each individual under the influence of the surrounding crowd. This study concluded that the crowd movement speed of people is dominated by two factors: (1) the front–back inter-person effect which gives a logarithmic relationship between the crowd speed and crowd density and (2) the pedestrian's self-driving motivation which depends on the individual's motivation driven by people trying to divorce themselves from the control of the crowd movement.

The present study concerns one of the important and biggest people gathering in the world: Al-Hajj season. This big people assembly is not like any other kind of people crowd, it may be accompanied with congestion states and collision causing injuries and sometimes death accidents. Offering flexibility and safety of pilgrims motion during this people gathering is a most important and noble objective. To carry out this objective, we think the implementation of functional supervising and controlling system of pilgrims' motion for a real time observing and monitoring is crucial. Therefore, to insure a successful design of such system, a phase of a functional analysis and modeling of the people's dynamic motion is then essential which allow describing different parameters and activities required for such system implementation.

Functional analysis is a suitable approach used to explain the working of complex systems. There are many synonyms for "functional analysis" such as: specification, functional specification, structured analysis, and functional description.

The basic idea of functional analysis is that the system is viewed as compound function. Functional analysis

assumes that such processing can be explained by decomposing this compound function into a set of simpler functions that are computed by an organized system of sub-functions. The hope is that when this type of decomposition is performed, the sub-functions that are defined will be simpler than the original function, and as a result will be easier to explain.

In 1983, Cummins provided a very detailed treatment of functional analysis. He proposed three stages that define functional analysis. The first stage, concerns how to define the main function of concerned system. In a second stage, concerns how to perform the system analysis. The third phase covers how to decompose the main function representing the system into an organized set of simpler functions. This analysis can proceed recursively by decomposing some (or all) of the sub-functions into sub-sub-functions. In the third stage, analysis is stopped by subsuming the bottom level of functions [12].

In this work, we propose a functional analysis for the pilgrims crowd using SADT method. SADT is a diagrammatic notation method designed specifically for describing systems as a hierarchy of functions and used in this investigation to describe the different functions and their relationships of the system. This functional analysis will cover the different steps of pilgrims' dynamic motion all along the bridge considering to Al-Hajj rules.

This paper is organized as follows. In section 2, we start by a description of Al-Jamarat bridge and the main reasons of congestion problems. A discussion of SADT method is given in section 3. In sections 4 we present the functional analysis of the pilgrims crowd problem. Finally, we conclude in section 5 by some comments on the proposed analysis and a briefly description on-going extensions of this work.

II. PROBLEM DESCRIPTION

A. Overview about Al-Jamarat bridge and history

Al-Jamarat bridge is the most important area in Al-Hajj stages where the congestion problem may happen. Different expansions of Al-Jamarat Bridge are made, but the bridge has entered a new level of arrangement and development only in 1995. In that time, it was constructed ground floor and a first floor.

In 2005 new modifications had happened, included the structure of the bridge, modifying the shape of the troughs from the circular shape to elliptical one, and the emergency exits manner. The new modifications also had included an improvement in the guidance boards to guide the pilgrims.

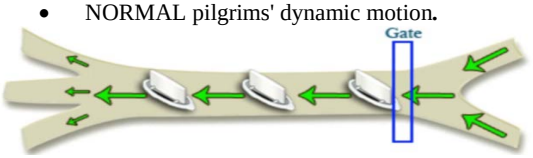
Since 2006, all these evolutionary projects of the bridge had directed to implement the first and second levels that included the removing the old bridge and the construction of the new bridge roots that includes required diggings, tunnels, ground floor and the first floor.

By the end of 2009, the building of the all five floors had been accomplished. Presently, the current situation of the bridge measurements had increased so far and the width of each floor became 80m and the length up to 950m. The grounded floor has one entrance and two exits and for each other floor has two entrances gathering in one way, it ends with two exits.

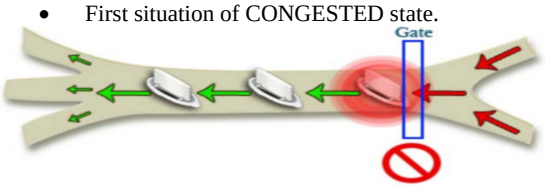
B. Description of one floor of Al-Jamarat bridge

The following figures give an idea on the different situations of pilgrims' dynamic motion all along Al-Jamarat bridge.

- NORMAL pilgrims' dynamic motion.



- First situation of CONGESTED state.



- After the gate is closed, the congestion get decreased until more space is freed on the Jamarah, the congestion is decreasing.

- If the CONGESTED is finished the gate is opened a gain and the flow is back to normal.

C. Reason of congestion problem might happen

Although the expansion of Al-Jamarat bridge, many limits are there. The most important limits are:

- Hard for new pilgrims to see the entrances of the ground floor in the crowd.
- No enough tools to arrange and control the crowd.
- Lack to deliver the information for all pilgrims in their positions upon the bridge.
- No enough tools, instruments and methods that helps to discover the problem before it grows up.
- Time shortage: About 3 millions pilgrims have only short time to throw their jamarats. Then it is hard to handle all this number of pilgrims smoothly with no collisions.
- Ignorance of some pilgrims:
  - Pilgrims come from different cultures with different views and different languages, some of them take al-Jamarat throwing as a matter of life and death, so they might lose control and disturb the safety, thinking about

their own, so it can be a matter of fear, misunderstanding, illusion and misbehavior.
- Some of pilgrims don't know from where to start and where to go, so they just make a lot of mistakes, besides repeating the action many times can be a reason for slowing the motion, actions and the flowing.
- Other pilgrims don't interact and listen to the guiding of the control unit a big number of them mostly don't understand the local language and the meaning of the guidance boards.
- Some pilgrims bring their luggage with them and that cause a lot of disturbing and crowd.

- Gathering on specific position.
  - Gathering around the Jamarah causing crowd around it, or specially gathering on the right side of the Jamarah according to the Sonnah.
- Limited monitoring tools.
- Limited communications tools.

III. PRESENTATION OF THE SADT METHOD

The SADT (Structured Analysis Design Techniques) method [13] represents an attempt way to apply the concept of focus groups specifically to complex systems description, eliciting data from groups of stakeholders or organizational teams. SADT is characterized by the use of predetermined roles for group/team members and the use of graphically structured diagrams [14]. It enables capturing of proposed system's functions and data flows among the functions.

SADT, which was designed by Ross in the 1970s [15], was originally destined for software engineering but rapidly other areas of application were found, such as aeronautic, production management, etc. Although SADT does not need any specific supporting tools, several computer programs implementing SADT methodology have been developed. One of them is Design: IDEF, which implements IDEF0 method [16]. SADT: IDEF0 represents activity oriented modelling approach (Fig.1).

IDEF0 representation of a physical system consists of an ordered set of boxes representing activities performed by the system. The activity may be a decision-making, information conversion, or material conversion activity. The inputs are those items which are transformed by the activity; the output is the result of the activity. The conditions and rules describing the manner in which the activity is performed are represented by control arrows. The mechanism represents resources (machines, computers, operators, etc.) used when performing the activity [17]. The boxes called ICOM's input-control-output-mechanisms are hierarchically decomposed. At the top of the hierarchy, the overall purpose of the system is shown, which is then decomposed into components-subactivities. The decomposition process continues until there is sufficient detail to serve the purpose of the model builder [18,19]. SADT: IDEF0 models ensure consistency of the overall modelled system at each level of the decomposition. Unfortunately, they are static, i.e. they exclusively represent system activities and their interrelationships, but they do not show directly logical and time dependencies between them. SADT defines an activation as the way a function operates when it is 'triggered' by the arrival of some of its controls and inputs to generate some of its outputs. Thus, for any particular activation, not all possible controls and inputs are used and not all possible outputs are produced. Activation rules are made up of a box number, a unique activation identifier, preconditions and postconditions.

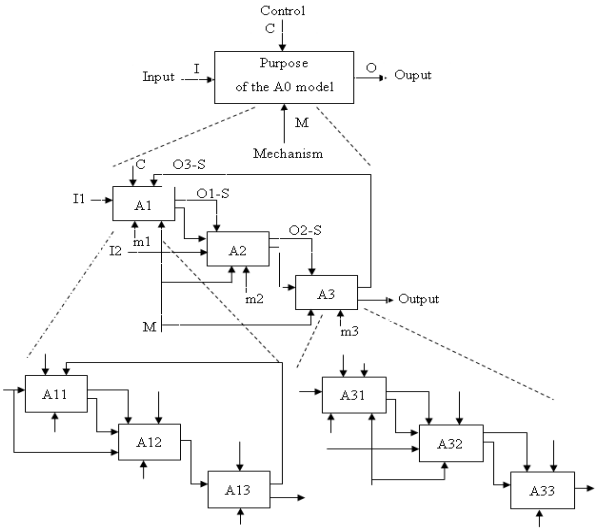


Fig 1. Top-down, modular and hierarchical decomposition of SADT method.

For SADT diagrams or function boxes, two events are considered for representing the activation states of the activities. The first event represents the instant when the activity is triggered off, and the second event represents the ending instant [20].

SADT method has got the following main advantages [21-24]:

- Large field of applications such as automation, software developments, management systems and so on.
- Facility and universality of the basic concepts.
- Existence of a set of procedures, advises and guidelines.

IV. ANALYSIS OF THE PILGRIMS CROWD

In this part, we present the application of SADT method for the functional analysis of the pilgrims crowd. The point of view followed in this analysis is that for the purpose of designing of a future supervising and control system. So, this SADT model will be composed exclusively of actigrams. It starts with the main function 'To supervise the move of pilgrims' (Fig.2). Then, this function is broken into sub-functions (Fig.3) and this process is developed until the last decomposition level has been reached (levels A1, A2 and A3).

Recall that SADT techniques are semi-formal; however, for the same subject, different correct models can be built without having to know with certitude which model is the good or, at least, the best. In fact, this kind of model allows users a sufficient freedom in its construction and so the subjective factor introduces a supplementary dimension for its validation. That is why the validation step on the whole necessitates the confrontation of different points of views.

As to the SADT performance, users can follow rules or recommendations to the level of the coherency of the model, such as distinction between the different types of interfaces, numeration of boxes and diagrams, minimal and maximal numbers of boxes by diagram, etc. One intends, by coherency application of the heritage rule i.e. when data are placed at a N decomposition level, it is explicitly or implicitly present at the inferior levels. However, a complementary mean to check coherency of actigrams is a confrontation between actigrams and datagrams, which is not possible in our case.

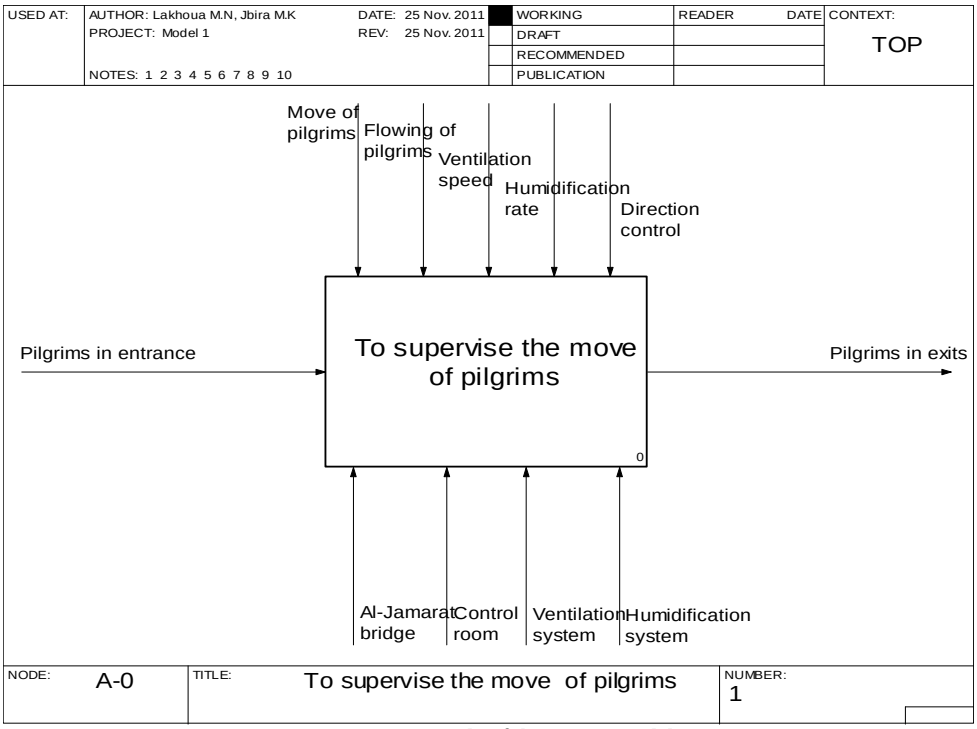


Fig 2. A-0 node of the SADT model.

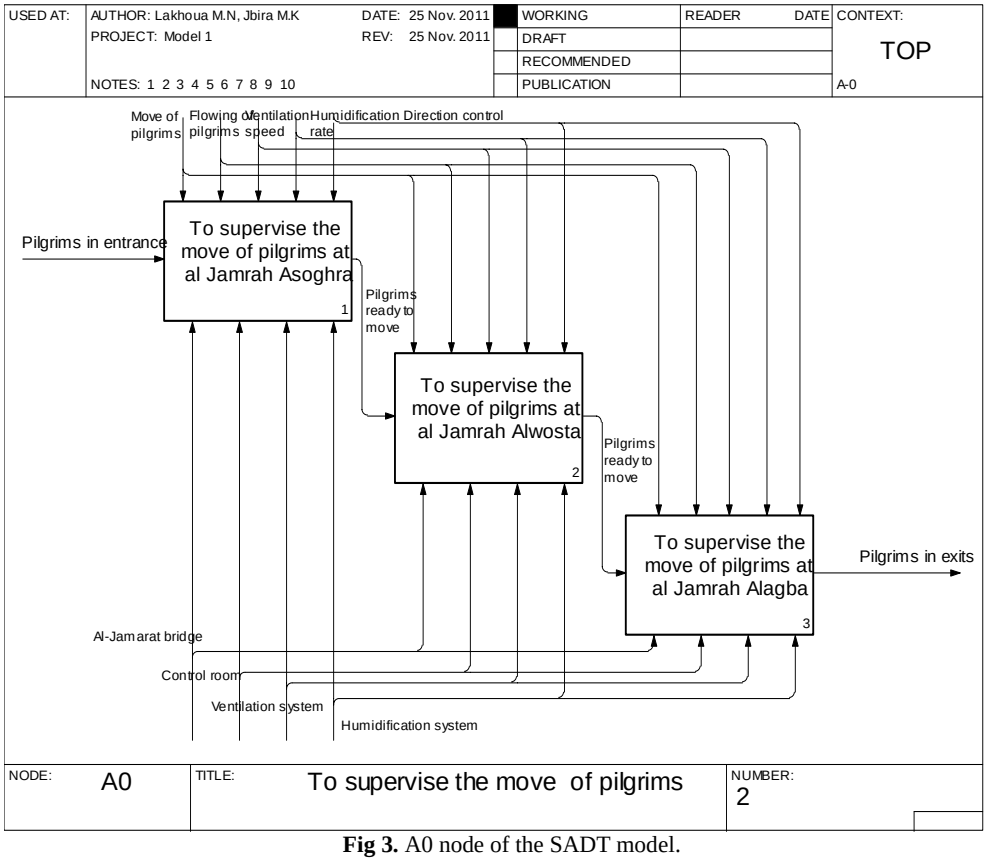


Fig 3. A0 node of the SADT model.

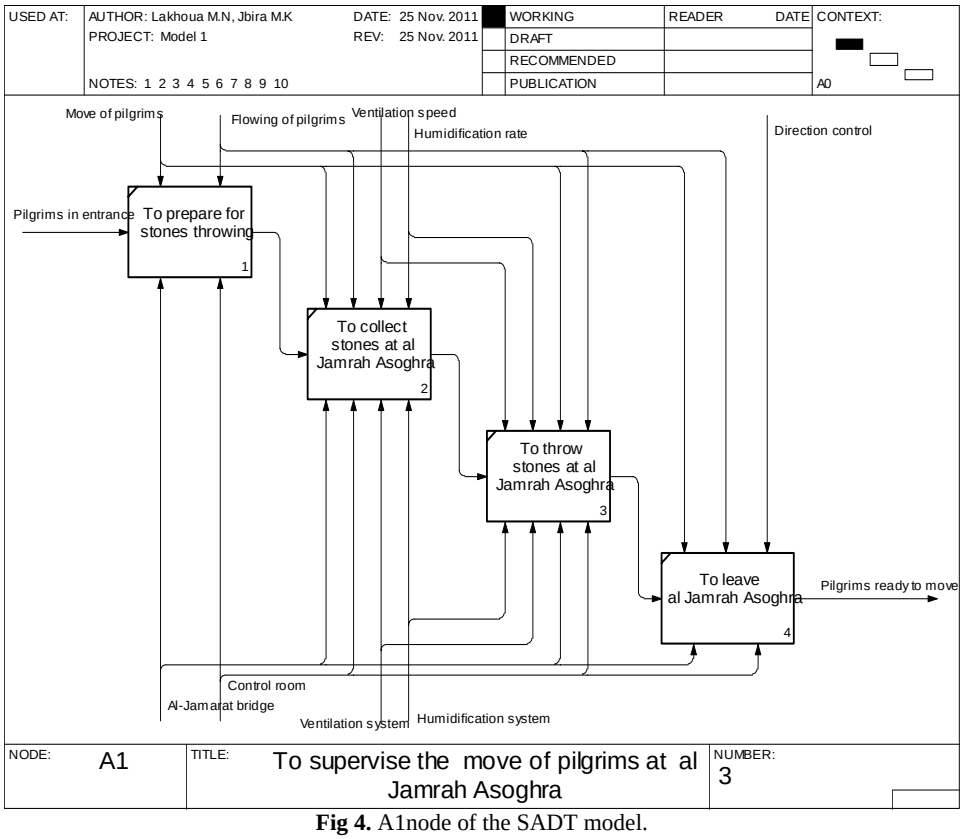


Fig 4. A1node of the SADT model.

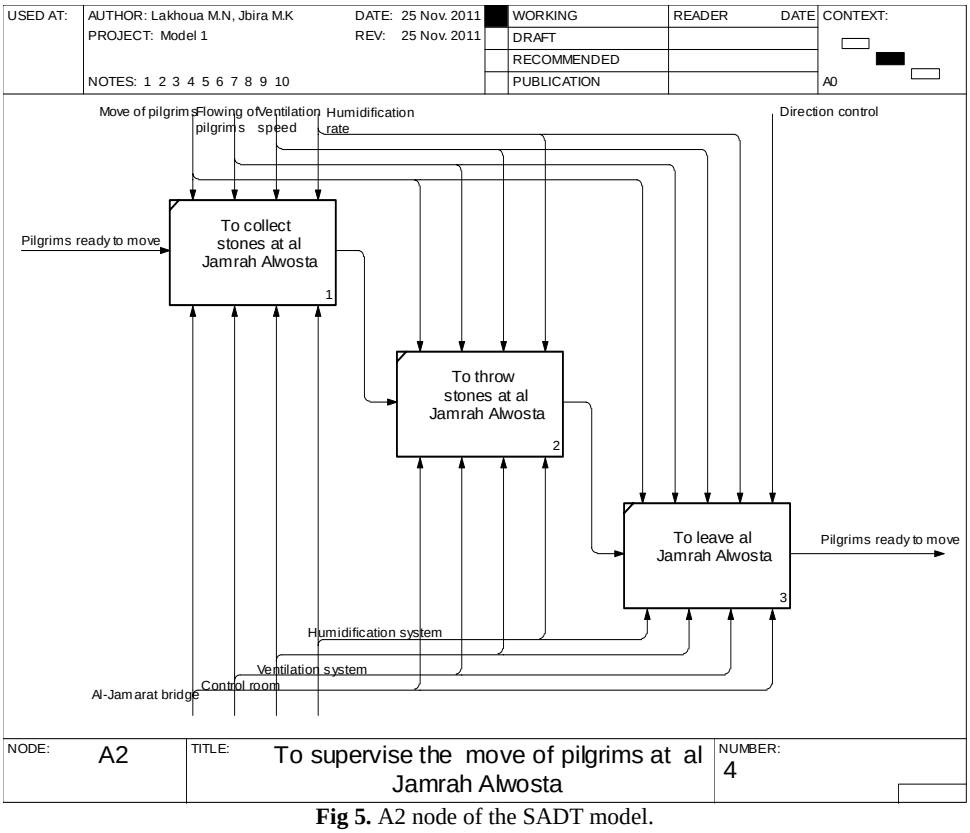


Fig 5. A2 node of the SADT model.

V. CONCLUSION AND FUTUR WORK

In this paper, we presented a functional analysis of the pilgrims' movement around the Jamarat Bridge. The developed description covered the different steps of pilgrims' dynamic motion all along the bridge. This functional analysis proved the useful use of SADT method and its ability of describing complex dynamic systems characterized by congested and conflict problems.

This analysis will allow an easy stage of a parmetric modelling and implemention through the development of a control algorithm helping in the design of a supervising and monitoring system of the pilgrims' motion on each floor of Al-Jamarat bridge. When implemted on a PC connected to some electronic devices (cameras, display boards…), desired supervising and control system will form a suitable automatic surveillance and real time control, and if any congestion of pilgrims can happen around each Jamarah the system should be able to stop the flowing of pilgrims in the input gate, until the congestion is decreased.

Staring from this functional analysis discussed in this paper, work is in progress to develop robust control strategy for a dynamic and automatic control in real time of pilgrims' dynamic motion all along Al-Jamarat bridge and for similar real cases over the world.

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Accelerated GPU Powered Methods for Auditing Security of Wireless Networks Using Probabilistic Password Generation

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***Abstract** – The main goal of this paper is to discuss new & faster methods for testing the strength of security used in today's wireless networks. This paper discusses probabilistic password generation methods for testing the real security of networks protected by WPA/WPA2 PSK (Pre-shared key) standard (also known as Personal mode). The main advantage of using those techniques in comparison with a traditional dictionary attack is the speed. The first section discusses the using of a modern graphics cards as an additional, very effective processing power for better performance during a key recovery process. The second part of this article describes the statistical proposal which could be implemented and used for testing the real security of keys used to protect the network. This statistical method, when properly implemented can also significantly reduce the total time required for a wireless audit.*

***Keywords:** Wireless security; GPU acceleration; GPGPU, password recovery.*

I. INTRODUCTION

Security and protection of information is very important. If it is necessary to build a secure wireless network, the designer of such a network must have tools and technologies which can be used to test the real security of this network. In each security model, the weakest part of the model is the human. Even if all of the standards which are used in the network infrastructure are properly implemented but the user chooses a weak password, the entire effort to secure such network is meaningless [1].

This article discusses several methods and proposals for effective testing of passwords used to protect wireless networks in order to determine the improper security level caused by weak passwords.

II. OVERVIEW TO WPA/WPA2 PSK PASSWORD RECOVERY PROCESS

WPA/WPA2-PSK is a subset of IEEE 802.11 WPA/WPA2 that skips the complex task of key distribution and client authentication by assigning every participating party the same pre shared key. This master key is derived from a password which the administrating user has to pre-configure e.g. on his laptop and the Access Point (AP). When the laptop creates a connection to the Access Point, a new session key is derived from the master key to encrypt and authenticate following traffic. The "shortcut" of using a single master key instead of per-user keys eases deployment of WPA/WPA2 - protected networks for home- and small-office - use at the cost of making the protocol vulnerable to brute force or dictionary attacks against its key negotiation phase.

Every password which is used in WPA/WPA2 PSK network has to contain from 8 to 63 printable ASCII characters. This is the first, very important security aspect, because it prevents people from choosing very short and easy-to-guess passwords. The second thing which makes the password audit in such networks complicated is the implementation of hashing functions used for generation of the keys which are used to encrypt the transmitted packets. Since the entered passphrase is hashed multiple times using WLAN network SSID (Service Set Identifier – max 32 ASCII characters) as the salt (4096 iterations of HMAC-SHA1), the speed which can average two core processor reach while testing the passwords against a captured handshake is about 1 000 passwords per second [2].

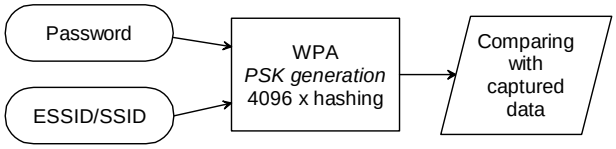

Figure 1: WPA PSK hash key cracking using password and SSID and multiply hashing function.

Researchers around the world discovered that they can use processing power available in modern graphics cards for complex mathematical tasks (GP-GPU – General Purpose computation using Graphics Processing Units, and there is also programming language for CUDA Nvidia GPU - Compute Unified Device Architecture) [3]. One of such tasks is testing hundred thousands of passwords against a captured hash in order to save a lot of time needed for audition of a wireless

network's security [4]. The *second* method which could improve the search speed by around 30 times is the statistical approach to password searching [5].

The research on the subject of password recovery showed, that most people choose password which can be called "meaningful". Testing of those statistical methods discovered that they were very successful in discovering such passwords which were not present in any password wordlist but were "meaningful".

III. PRECOMPUTED LOOKUP TABLES IN PASSWORD RECOVERY

Another attack against WPA/WPA2 personal can be done using pre-computed lookup tables (also known as rainbow tables [6] implemented also on FPGA - Field-programmable gate array [7] and expansions [8]).

It's been known for a while that WPA-PSK was vulnerable to brute force attack. Tools like Aircrack [9] and Cain [10] and EWSA [11] took advantage of this weakness and provided a way to test keys against password dictionaries for many languages.

The problem is that it's a very slow process. Each passphrase is hashed 4096 times with SHA-1 and 256 bits of the output is the resulting hash as mentioned above. This is then compared to the hash generated in the initial key exchange. A lot of computing power is required for this hash procedure, because it needs to be repeated for every SSID of the tested wireless network.

The problem is that the hash key for specified password is different depending on the network it's implemented on. The SSID and the SSID length is seeded into the passphrase hash. For example assume the word 'password' is the key which is used to protect the network. This means that the resulting hash will be different on a network with the SSID of 'linksys' than it will be on a network with the SSID of 'default'.

When this attack was tested in order to get results for this paper it showed that although this approach is a lot faster than dictionary attack, for most networks found in the area where the measurements were performed the attack was not so effective [12]. The reason is simple - only 19% of the networks which were found in the test area had a SSID for which the table is already precomputed. The second reason is that the precomputed passwords used were from English speaking countries, and many users use localized passwords for securing the local networks. So that's why the statistical method discussed in this paper is the most effective in terms of speed and success.

IV. DETECTING AND TESTING THE SECURITY OF WIRELESS NETWORKS WITH HIDDEN SSID

Some wireless networks use security feature which allows hiding those networks from detection by not transmitting the network's SSID. This will make the person who does not know the SSID of the network not able to connect to it. In standard Windows dialog for connection to the wireless networks, which uses NDIS5.1 (Network Driver Interface Specification) as an interface for communication with the network adapter this network will not be displayed at all. In newer NDIS6, which is used in Windows Vista/ Windows 7 this network will be showed as *unnamed network (see Fig. 2)*. However for testing the strength of the security of a WPA/PSK network the knowledge of a network name is necessary. As it was mentioned, the network name is used in key generation process for the stations which communicate with the network.

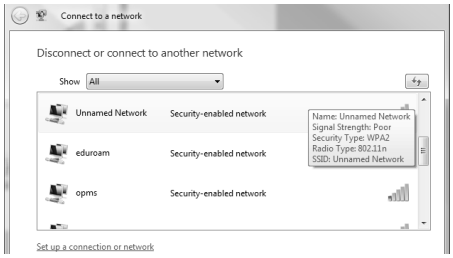

Figure 2: Hidden SSID showed as "unnamed" network in the available networks list using NDIS 6 interface.

When the network is not identifying itself with an SSID the process of getting the SSID depends on the fact whether there are any stations currently connected to the network or not.

This could be done by scanning the band of the channel where the network broadcast is identified. Since the name of the network is not known, only the MAC address of the network access point (BSSID – Basic SSID) can be seen. When the information about the network (BSSID and Channel) is collected, the process of getting ESSID (Extended SSID – usually the network name) can be started. First (and less disturbing) method is using *active node discovery*.

Active node discovery is a method of detecting wireless Access points by broadcasting *probe request packets* on a channel where they originally operate. The broadcasting of probe request will force most access points to identify themselves by broadcasting their ESSID.

Second (more straight forward) method is by forcing the reassociation of the clients which are connected to the access point which do not broadcast its ESSID. This method will disconnect all clients from the network (using some network attack – for example overload of the used channel by strong transmitter with noise or dummy traffic). During the process of reconnecting and reauthenticating the clients sends the ESSID of the network, and what is even more important, the WPA/WPA2 PSK handshake can be captured [13]. When this handshake is successfully captured, the process of testing the strength of the key used to protect the security of the network may be launched.

IV. GPU ACCELERATION IN PASSWORD RECOVERY

The main idea of GPU acceleration in password recovery is to use the enormous computational power of

modern graphic cards to speed up the password recovery process [14].

The speed of processors used in personal computers compared to the computing power of modern graphics card depends on how the task code is parallelized. For example ATI HD 6850 graphic card has 800 MADD (multiply-add) cores (called Stream Processors) that are grouped in 160 5-dimensional groups[1]. Of course task that cloud be massively parallelized (similar to graphic tasks) could be rapidly quicker on GPU hardware.

TABLE 1. Price and speed during password recognizing using Intel CPU compared to GPU processor.

Type of processor	**Speed** passwords/sec	**Price** € (Eur)
Dual-Core E5700	500	62
Core 2 Duo E8400	1 000	169
Core 2 Quad QX9550 – 2 830 MHz	2 000	200
ATI HD 6850 (1xGPU - 625 MHz)	40 000	150

Hardware specification of workstation which was used during testing of the applications for WPA password breaking: Intel Core 2 Quad (QX9550) 2.83 GHz, 8 GB RAM, running Windows XP SP3 OS.

As can be seen from the previous table, one professional graphic card is about 20 (and more) times faster when used for password recovery in comparison to one quad-core Intel processor. This gives cryptographers a unique chance to build machines in which the main processing power will be based on GPU providing exceptional performance during the cryptanalytic process. The second important advantage of GPU usage is the fact that it allows large cost savings. When one graphic card which costs approximately 300 € could provide the performance of 50 Intel Quad processors in password recovery task, the saving is around 99,7%.

V. PROPOSED STATISTICAL APPROACH TO PASSWORD RECOVERY

As previously mentioned, testing security of wireless networks protected by WPA/WPA2 PSK is very intensive in terms of computing power. Let us give an example. One professional graphics card can provide speed of around 100 000 passwords per second. When we assume that a professional dictionary used for testing passwords for WPA-protected networks consists of about 1 000 000 000 passphrases, the time required to go through this dictionary is about 160 minutes. If the password is not found, tester must decide what other tests should be performed. Let us assume that the password which was not found by the traditional dictionary attack is formed for example by mangling two words and concatenating the result. This is a chance for statistical attacks to solve the problem.

Statistical attack dramatically boosts the Brute-force attack speed by skipping password checks of nonsensical combinations of characters [15]. It uses a large built-in table of frequencies of different combinations of letters in specific language [16].

Let us assume that the network is protected by the password “sweetemily”. This combination of letters probably does not exist in a dictionary. In a traditional dictionary you will find the word “sweet” as well as “Emily”, but not “sweetemily”.

If such a password should be recovered the brute force attack which means trying all possible combinations of chars, is useless because for 10 character password it means trying 26^10 (141 167 095 653 376) passwords. When this number of passwords should be tried using even 10 most modern GPUs, it would take around 39 213 hours which is unacceptable.

When statistical attack is used the speed of search is about 40 times faster so the required time is only 1000 hours. Although it is a lot faster than the brute force, the time required remains big. This is why the statistical approach offers additional options that further decrease the total time required for a key recovery.

The *Known Pattern*: The Known Pattern defines a part of a password which is known. When this information is known before starting the recovery process, it can be used to speed up the password recovery even further.

The tester can define the level of statistical attack by choosing between Low, Medium and High.

The *High level* checks only the most common combinations of letters skipping all the combinations that are not typical. This level is about *100 times faster* than brute force attack.

The *Medium level* is a trade-off between speed and complex testing. This level also checks less frequent combinations and provides a higher likelihood of finding the password. This level is about *40 times faster* than brute-force attack.

The *Low level* is the most complex in terms of trying "meaningful" combinations of letters. It provides 95% success rate in recovering of "meaningful" passwords with the speed about *20 times faster* than brute-force attack.

When all previously discussed methods of password recovery are combined together, it is possible to achieve recovery speed which is about 1000 times faster when compared to simple (and most used) dictionary attack performed on regular processors using John the Ripper application [17].

The password usage realized by one of the leading companies in password recovery business revealed that lots of users *do not change their default passwords* which they get from the internet service provider (ISP). Another password usage survey discovered that *77%* of computer users use *one password for all* of their password-protected resources.

[1] http://www.notebookcheck.net/ATI-Mobility-Radeon-HD-5850.23069.0.html

As can be seen from this survey, it is very important to take into account the psychological and social aspect of a mankind in the technical procedures when examining the safety of networks [18]. It is important to realize that 77% of users working with computing systems are not educated in the area of computer safety.

VI. CONCLUSIONS

The research of wireless network security in eastern Slovakia showed that the total number of unsecured wireless networks is still high. What is worse is the fact that most unsecured networks are owned by organizations, schools and companies instead of individuals. For example lots of ISPs (Internet Service Providers) have their WiFi (Wireless Fidelity) networks unsecured. Those providers are connecting individuals to the internet using those unsecured networks. Although an individual user secures his connection in his house, the final data which he transmits to his ISP are not encrypted and thus can be sniffed [12].

The second problem that the research has revealed is the fact that lots of secured networks are using old and weak WEP. The usage of secure WPA is rising, but this is where the importance of strong passwords comes in. It is not enough to use a proven security standard with weak password. The results of tests made show a necessity for better education for people who want to use wireless networks for connection to the internet. Another important fact that should be mentioned is the fact that tracking down illegal activities made from a badly secured, or even worse, unsecured WiFi networks are almost untraceable. When a person who is going to make an illegal activity finds and connects to a foreign WiFi, the legal owner of the network will not be able to identify the attacker. Under normal circumstances person connecting to the network is not asked to send any identifying information except for the password. In some cases the MAC (Media Access Control) address of the connecting person is compared against a list of allowed addresses. When the password was weak and thus it was cracked, MAC address can be falsified too and the attacker is not likely to be found.

This is why the proper security of wireless networks is important because in unsecured networks even police and state security agencies are not able to trace and punish criminals.

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Solution for Some Nonlinear Multivariable Processes Control

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***Abstract** – Systems with inverse model represent one of the successful solutions for the real-time control of the nonlinear processes. The use of these structures imposes solving some specific problems, like determination of static characteristic of the process, construction of inverse model or robust control law design. The paper proposes a structure and the correspondent methods of designing and implementation of inverse model command for control of a multivariable process with nonlinear characteristics. The applicability of the method is proved using a real-time structure with RST control algorithms. In the end, its software implementation and the obtained results are also shown..*

***Keywords:** control systems, inverse model, robustness, multivariable processes*

I. INTRODUCTION

Preserving the closed-loop performances in case of non-linearity, structural disturbances or process uncertainties represent the essential condition for the real-time function of a control system. A valuable way to solve these problems is inverse model command or also named direct command.

About inverse model numerous ancient and recent papers and researches exists. Few of this, with a very fortuity choosing procedure, can be mentioned: [1], [2], [3] etc.

In these researches there are a lot of inverse model proposed structures. According to them, the paper proposes a very simple and efficient structure presented in Figure 1. This solution supposes adding of two commands: the first one "a direct command" generated by inverse model command generator, and the second generated by a classic and very simple algorithm (PID, RST etc.).

The first command, based on process static characteristics, is dependent on set point value and is designed to generate a corresponding value to drive the process's output close to imposed set point. The second (classic) algorithm generate a command that, correct the difference caused by external disturbances and according to set point, by eventual bias error caused by mismatches between calculated inverse process characteristic and situation from real process.

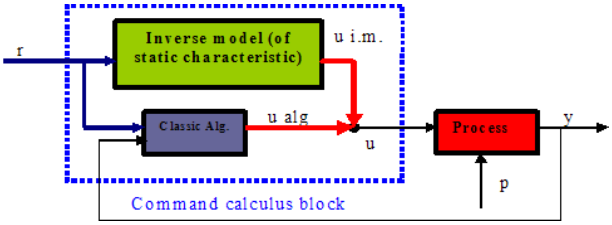

Fig. 1. Proposed scheme for inverse model structure

Presented solution proposes treating of these inverse model mismatches that "disturb" the first command as a second command classic algorithm's model mismatches. This solution imposes designed of classic algorithm with a corresponding robustness reserve. For this reason designing of the second algorithm is made in two steps:

- designing of a classic algorithm base on a model identified in a real functioning point – choused fortuity or, on the middle of process characteristic;
- algorithm's robustness cheking and improving of this, if it is necessary in a new (re)designing procedure;

On Figure 1, the blocks and variables are as follows:

- Process – physical system to be controlled;
- Command calculus – unit that computes the process control law;
- Classic Alg. – control algorithm (PID, RST);
- y – output of the process;
- u – output of the Command calculus block;
- u alg. – output of the classic algorithm;
- u i.m. – output of the inverse model block;
- r – system's set point or reference trajectory;
- p – disturbances of physical process.

Related to classical control loops, inverse model control need addressing some supplementary specific aspects:

- Determination of static characteristic of the process;
- Construction of inverse model;
- Robust control law design.

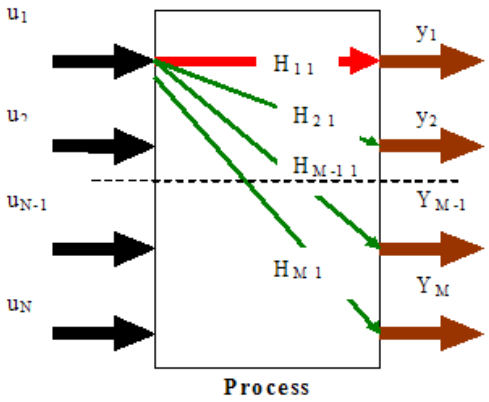

Fig. 2. Decupling or decomposition procedure for an MIMO process

The structure presented before can be used to control multivariable processes that support decupling procedures.

Decupling procedures supposes decomposition of an MIMO (N inputs and M outputs) process in a max(N,M) (usually N=M) parallel processes. A singular process has a main "canal" from u_i to y_i and a lot of secondary "canals" from u_i to y_j, where i≠j.

All secondary "canals", which represent connections between parallel processes, can be considered as a disturbances, nonlinearities, process identification mismatch etc. for main "canal". Figure 2 present the main and secondary "canals" for u_1 to y_1 process.

Particular, for a process with 2 inputs and 2 outputs the control algorithm is presented in Figure 3. Here, the blocks and variables are similar to figure 1.

On next sections we will focus on the most important aspects meted on designing of the presented structure.

II. INVERSE MODEL DESGN PROCEDURE

As is mentioned above, for inverse model control proposed structure, the supplementary specific aspects are: determination of static characteristic of each parallel processes, construction of inverse model and robust control law design. We will present these on next sections.

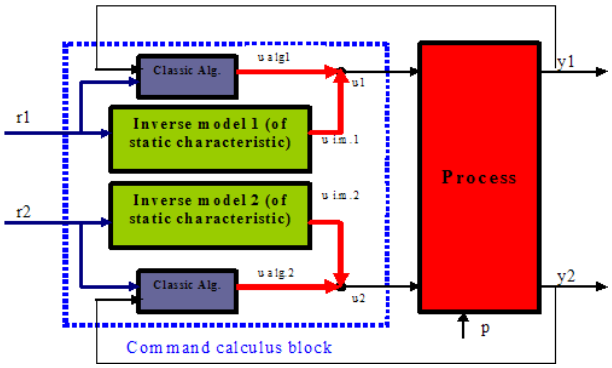

Fig. 3. Decupling or decomposition procedure for an MIMO process

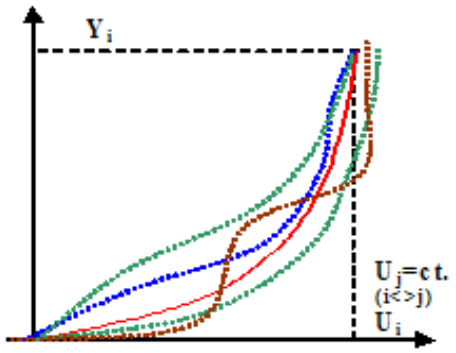

Fig. 4. Determination of static characteristic of the process. Continuous line represents the final characteristic.

A. *Determination of Static Characteristic*

This operation is based on several experiments of discrete step increasing and decreasing of the command *u(k)* of main "canal" and measuring the corresponding stabilized process output *y(k)*. The command *u(k)* cover all possibilities (0 to 100% in percentage representation). Because the secondary "canals", witch will have all important combinations during experiments, can affect the main "canal", and because the process is disturbed by noises, usually the static characteristics are not identically.

The final static characteristic is obtained by meaning of correspondent position of these experiments. Figure 4 present this operation. The graphic between two "mean" points can be obtained using extrapolation procedure.

According to system identification theory the dispersion of process trajectory can be finding using expression (1):

$$\sigma^2 = \frac{\sum (x_i - \bar{x})^2}{n} \qquad (1)$$

This can express a measure of superposing of secondary "canals", noise that action onto process, process's nonlinearity etc. and is very important on control algorithm designed robustness. Other possibility is to find the position and the value *mg* of the maximal distance from "mean" characteristic.

B. *Inverse Model (Characteristic) Construction*

This step deals with the „transposition" operation of the means process's static characteristic. Figure 5 presents this construction. According to this, *u(k)* is dependent to *r(k)*. This characteristic is stored in a table; thus we can conclude with this, for the inverse model based controller, selecting a new set point *r(k)* will impose finding in this table the corresponding command *u(k)* that determines a process output *y(k)* close to the reference value.

C. *Control Law Design*

Control algorithm's duty is to eliminate the disturbance and differences between inverse model computed command and real process behavior. A large

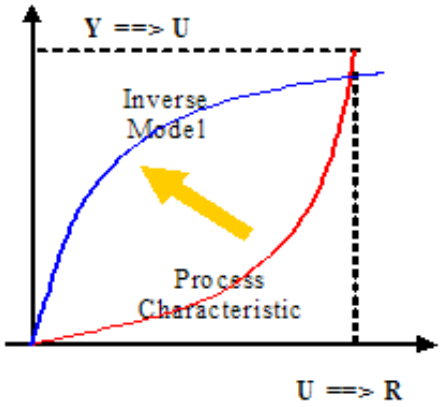

Fig. 5. Construction of inverse model (inverse static characteristic)

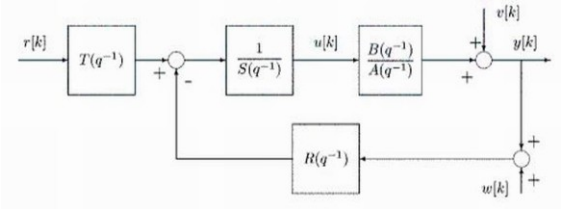

Fig. 6. RST control algorithm structure

variety of control algorithms can be used here, PID, RST, fuzzy etc., but the goal is to have a very simplified one.

For this study we use a RST algorithm. This is designed using pole placement procedure [4]. Figure 6 present a RST algorithm.

Where R, S, T polynoms are:

$$\begin{aligned} R\left(q^{-1}\right) &= r_0 + r_1 q^{-1} + \ldots + r_{nr} q^{-nr} \\ S\left(q^{-1}\right) &= s_0 + s_1 q^{-1} + \ldots + s_{ns} q^{-ns} \\ T\left(q^{-1}\right) &= t_0 + t_1 q^{-1} + \ldots + t_{nt} q^{-nt} \end{aligned} \tag{2}$$

Algorithm pole placement design procedure is based on identified process's model.

$$y(k) = \frac{q^{-d} B(q^{-1})}{A(q^{-1})} u(k) \tag{3}$$

where

$$\begin{aligned} B\left(q^{-1}\right) &= b_1 q^{-1} + b_2 q^{-2} + \ldots + b_{nb} q^{-nb} \\ A\left(q^{-1}\right) &= 1 + a_1 q^{-1} + \ldots + a_{na} q^{-na} \end{aligned} \tag{4}$$

The identification is made in a specific process operating point and can use recursive least square algorithm exemplified in next relations developed in [4]:

$$\begin{aligned} &\hat{\theta}(k+1) = \hat{\theta}(k) + F(k+1)\phi(k)\varepsilon^0(k+1), \forall k \in N \\ &F(k+1) = F(k) - \frac{F(k)\phi(k)\phi^T(k)F(k)}{1+\phi^T(k)F(k)\phi(k)}, \forall k \in N \\ &\varepsilon^0(k+1) = y(k+1) - \hat{\theta}^T(k)\phi(t), \forall k \in N, \end{aligned} \tag{5}$$

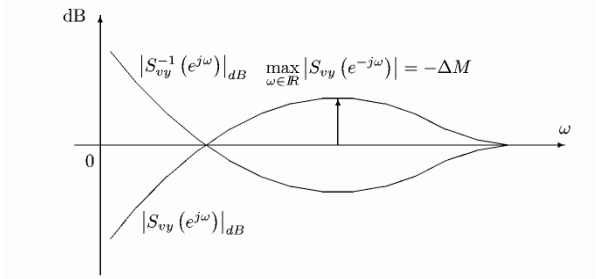

Fig. 7. Sensibility function graphic representation

with the following initial conditions:

$$F(0) = \frac{1}{\delta} I = (GI)I, 0 < \delta < 1 \tag{6}$$

The estimated $\hat{\theta}(k)$ represents the parameters of the polynomial plant model and $\phi^T(k)$ represents the measures vector.

This approach allows the users to verify, and if is necessary, to calibrate algorithm's robustness. Next expression and Figure 7 present "disturbance-output" sensibility function.

$$\begin{aligned} &S_{vy}(e^{j\omega}) \overset{def}{=} H_{vy}(e^{j\omega}) = \\ &= \frac{A(e^{j\omega})S(e^{j\omega})}{A(e^{j\omega})S(e^{j\omega}) + B(e^{j\omega})R(e^{j\omega})}, \quad \forall \omega \in R \end{aligned} \tag{7}$$

In the same time, the negative maximum value of sensibility function represents the module margin.

$$\Delta M\big|_{dB} = -\max_{\omega \in R} \left| S_{vy}(e^{j\omega}) \right|_{dB} \tag{8}$$

Base on this value (Landau et al., 1997), in a "input-output" representation, process nonlinearity can be bounded inside of "conic" sector, presented in Figure VIII, where a_1 and a_2 are calculated using next expression:

$$\frac{1}{1-\Delta M} \geq a_1 \geq a_2 \geq \frac{1}{1+\Delta M} \tag{9}$$

Finally, if is imposed that all nonlinear characteristics to be (graphically) bounded by the two gains, or gain limit to be great or equal to process static characteristic maximal distance $\Delta G \geq mg$, a controller that has sufficient robustness was designed.

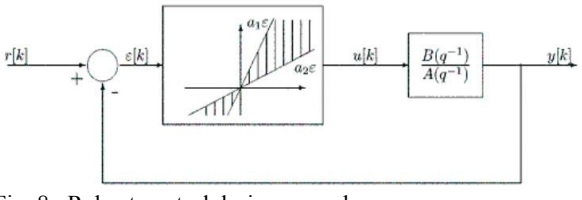

Fig. 8. Robust control design procedure

III. PROPOSED STRUCTURE ANALYSIS

In this section we will present few advantages, disadvantages or limitation and some possible developing ways of presented structure.

A. Advantages

The main advantage consists in using of classics procedure in designing of the control algorithm and determination of inverse command blocks comparative to multivariable control design procedures. There are used well know procedure for identification and control law design. As will be shown in experimental tests all procedures for inverse model characteristic identification can be included in a real time software application.

Because the global command contains a "constant" component generated by an inverse model command block, according to set point value, the system is very stabile.

Inverse model command generator can be replaced by a fuzzy logic bloc that can "contain" human experience about some nonlinear processes.

Because the control law is not very complex real time software and hardware implementation don't need important resources.

B. Desadvantages or Limitations

The main limitation is that this procedure can be applied just for the processes that support decupling control scheme.

This structure is very difficult to use for the system that doesn't have a bijective static characteristic and for systems with different functioning regimes.

Another limitation is that this structure can be used only for stabile processes. In situations where the process is "running", the global command is very possible to not have enough flexibility to control it.

The increased number of experiments for determination of correct static characteristic can be other disadvantages of the structure.

C. Possible Developing

In situation when the control law becomes very complex, situation cased by difficult determination of process characteristics, the system can be "divided" in two or more components, becoming a "multiple inverse model system".

These systems can be easily implemented on PLC structures.

IV. EXPERIMENTAL RESULTS

We have evaluated the achieved performances of the proposed scheme (Figure 3) based on inverse model control on an experimental installation presented in Figure 9. On this installation the user can control two parameters: pressure and temperature and the value of the first have important influence on variance of the second. So, there is a secondary "canal" from pressure to temperature. The influence from temperature to pressure is very small and can be considered null.

Fig. 9. Experimental installation Elwe LTR 701

The data acquisition and storage are made using a real-time (ProcTest) software application developed on National Instruments's LabWindows/CVI [5] developing system and an Advantec PCL812PG [6] acquisition card. The interface of this application is presented on Figure 10.

A second real-time software application (RegTest) implement the scheme proposed in Figure 3 and allows the user to control the installation (Figure 11).

We consider two separate loops: pressure and temperature. For temperature in open loop there are made a set of 6 tests for determination of static characteristics. For each of them the command of heating resistance was increased from 0% to 70% (Figure 12) and the value of pressure is constant to 40%, 50%, 70%, 70%, 80% and 90%.

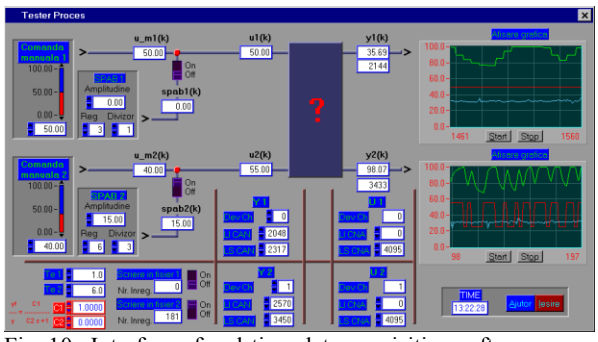

Fig. 10. Interface of real-time data acquisition software application

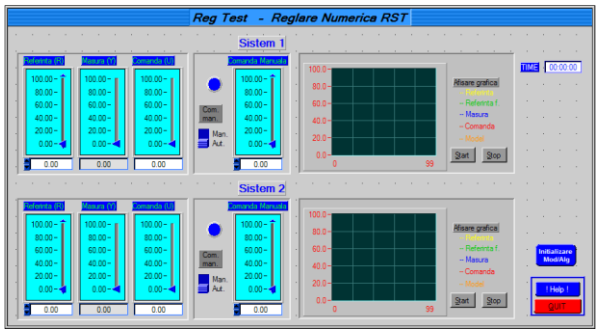

Fig. 11. Inverse-model multivariable controller real-time software application – main window

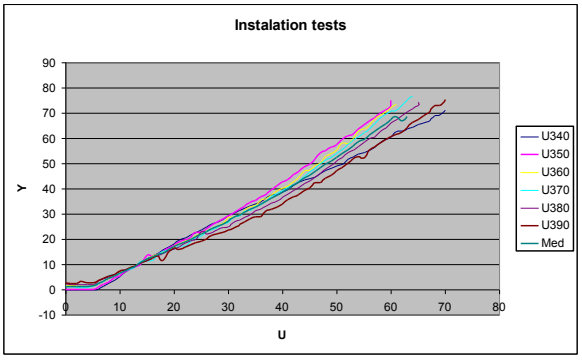

Fig. 12. Construction of inverse model (inverse static characteristic)

The absolute maximal difference between medium and maximal characteristics is equal to 6.3.

Using Te=0.2 s sampling time and Least Square identification method from Adaptech/WinPIM the model for pressure process is:

$$M_{pres} = \frac{0.140114 + 0.027110q^{-1}}{1. \; - 0.606531q^{-1}}$$

The corresponding controller (using pole placement): (for Tracking performances: second order dynamic system with w0=1.0, x=1.2, Disturbance rejection performances: second order dynamic system with w0=1.0, x=0.8, using WinReg)

$$R(q^{-1}) = 0.388623 \; - 0.508020q^{-1}$$
$$S(q^{-1}) = 1.0 \; - 1.160131q^{-1} + 0.137424q^{-2} + 022707q^{-3}$$
$$T(q^{-1}) = 5.980003 \; - 10.564644q^{-1} + \; 4.704038q^{-2}$$

The simulation test for pressure close loop are presented in figure 13.

And, using Te=3.0 s sampling time and Least Square identification method from Adaptech/WinPIM the model for temperature process is:

$$M_{temp} = \frac{0.093260 + 0.101130q^{-1}}{1.0 - 1.423072 \;\; q^{-1} + 0.486752q^{-2}}$$

The corresponding controller (using pole placement): (for Tracking performances: second order dynamic system with w0=0.1, x=1.2, Disturbance rejection performances: second order dynamic system with w0=0.1, x=0.8, using WinReg)

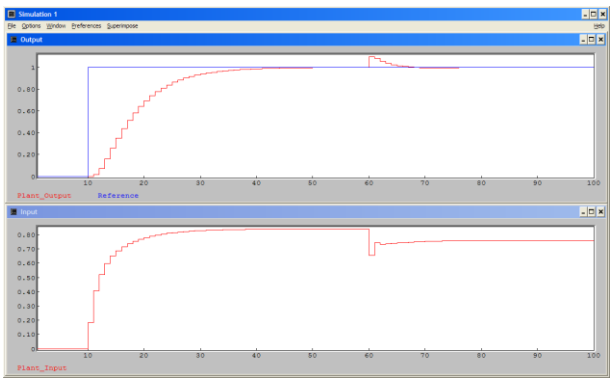

Fig. 13. Simulation of pressure close loop

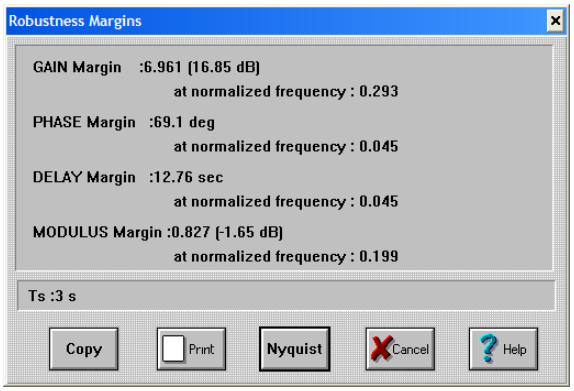

Fig. 14. Close loop performances

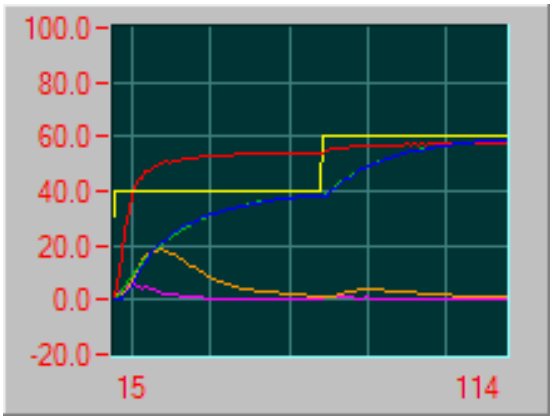

Fig. 15. Structure stability tests on different functioning point for temperature loop

$$R(q^{-1}) = 1.858775 \; - 1.904586q^{-1} + \; 0.410773q^{-2}$$
$$S(q^{-1}) = 1.0 \; - 0.730547q^{-1} \; - 0.269453q^{-2}$$
$$T(q^{-1}) = 5.144298 \; - 7.962539q^{-1} + 3.183204q^{-2}$$

The corresponding performances for temperature close loop (using WinReg software application) are presented in Figure 14.

It can be observed that gain margin is 6.91 a greater value that maximal static characteristics difference (6.3). For this reason the designed RST algorithm has enough robustness to control the process. The pressure loop is completely independent and work very good.

On this figure the evolution curves are represented using next color code:

- yellow – set point;
- green – filtered set point;
- blue – process output;
- red – control structure output (total command);
- purple – RTS algorithm output;
- orange – identified model output;

On this test it can be observed that:

- there are no shocks on set point changing;
- the system is stabile on different functioning points;

- after each system stabilization the RST command value decrease to zero that mean that the inverse model is correct determinate;
- Process's output and filtered set point are very close that mean good performances on set point tracking;

V. CONCLUSIONS

The paper proposes an inverse model structure as a solution for multivariable nonlinear processes. For this structure for each component there are presented the design methods. These are based on experimental tests and classics identification and close loop pole placement.

The performances of the classic algorithm the control law is evaluated using robustness criterions.

There are made some analysis about advantages and disadvantages of proposed structure.

On experimental results section there are presented the evaluated results obtained using a real time software implementation of proposed control structure. The test are made on software simulator an on an experimental installation.

During exploitation (inverse model) does not impose complex operations, it is very easy to use, but it is limited from the nonlinearity class point of view and processes with variable parameters.

ACKNOWLEDGMENT

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Optimization Solution for Multiple Model Control Structures

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Abstract – ***The multiple model structures are specific control solutions for some classes of systems with important nonlinearities or different functioning regimes. One of these structures' specific problems is the determination of the models number: an increased number leads to superior performances but very complex structure. The paper presents an original methodology for models number reducing without decreasing the performances.***
This solution is of practical importance allowing facile implementation on PLC and process computers. The experimental results prove the structure's performances.

Keywords: ***multiple model, nonlinear process, compensator, structure optimization.***

I. INTRODUCTION

The multi model systems represent a relative new approach for the nonlinear systems control. Since the 90's, different studies on multi model control strategies have been developed. The Balakrishnan's and Narenda's first papers propose several stabile and robust methods using classical switching and tuning algorithms [1].

Further research in this field determined the extension and improvement of the multi model control concept. Magill and Lainiotis introduce the model representation through Kalman filters. In order to maintain the stability of the minimum phase systems, Middelton improves the switching procedure using an algorithm with hysteresis. Landau and Karimi have important contributions regarding several particular multiple model adaptive structures [2]. Dubois, Dieulot and Borne apply fuzzy procedures for switching and use sliding mode control.

This paper proposes a multi model control structure which contains, for each model/controller pair, a nonlinearity compensator. It is based on the determination of each model's static characteristic. This solution reduces the number of models and a decreases the overall complexity of the global structure.

This structure can be applied in the case of processes with important nonlinearities.

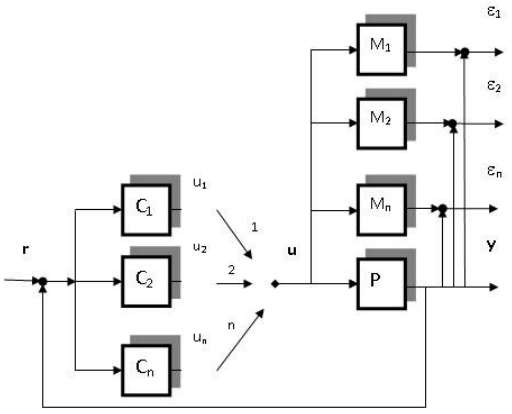

Fig. 1. Multi model control structure.

II. CLASSIC MULTI MODEL APPROACS

The classic control solution implies choosing a set of models M, and on a set of the correspondent controllers C:

$$M = \{\mathcal{M}_1, \mathcal{M}_2, \mathcal{M}_3 \ldots \mathcal{M}_n\}, \quad C = \{C_1, C_2, C_3 \ldots C_n\}$$

Based on these model/controller pairs the closed-loop configuration is the one presented in Fig. 1.

The input and output of the process P are u and y respectively, and r is the set point of the system. The M_i ($i=1, 2, \ldots n$) models are determined a priori. For each model M_i a controller C_i is designed in order to assure the nominal performances for the pair (M_i, C_i).

The main idea of the multi model structure construction is based on dividing the process functioning region in n small disjoint and adjacent zones, for which the models are simpler and the n corresponding control algorithms have low complexity (Figure 2).

One of the principles used in zones' choosing is that the absolute value of the difference between the static characteristic and its linearization has to be smaller than the imposed threshold.

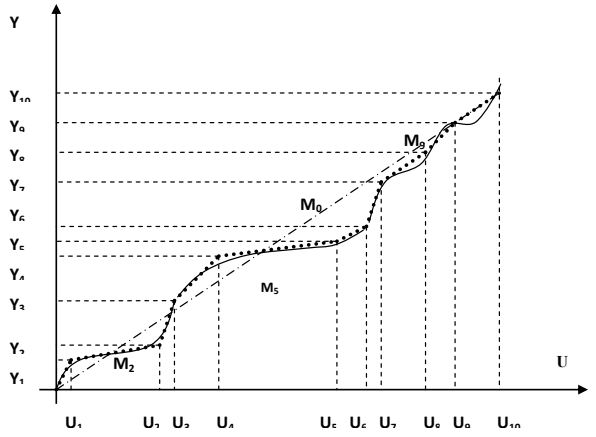

Fig. 2. Construction of the set of process's models

This does not impose using a linear model for the region. It is very possible to have a second or third or *m* order model and a complex corresponding control algorithm. A very complex algorithm can determine better performances but uses important hardware resources on real time implementation.

In real situations there must be a balance between complex control algorithms and complex real time hardware/software architectures.

In Figure 2 the continuous line represents the process static characteristic, the dotted line the linear models for a large number of zones and dashed and dotted line is global linear model.

The difference between the global model and the process characteristic is large (maximal distance in *U6, Y6* point).

Using a single controller provides poor performances. For high performances and robust implementation a more complex control strategy must be used.

III. PROPOSED SOLUTION FOR MULTIPLE MODEL STRUCTURE

This paper proposes a multi model control structure which, for each controller, provides a nonlinearity compensator [3]. This solution allows a reduced number of models and a reduced complexity for each control algorithm. This solution is named "control system with inverse model" [10].

In literature proposes a lot of inverse model structures. For the presented control solution a very simple and efficient structure, presented in Figure 3, is employed. This solution sums two commands: the first one "a direct command" generated by the feed forward command generator, and the second generated by a classic and very simple algorithm (PID, RST etc.).

This structure is added to all the model/controller pairs of the multi model structure. For each controller, the first command, based on the process static characteristics, is dependent on set point value and is designed to generate a corresponding value to drive the process's output close to imposed set point value. The second (classic feedback) algorithm generates a command that corrects the difference caused by external disturbances and, accordingly to the set point, by eventual bias error caused by mismatches between calculated inverse process characteristic and the situation from real process.

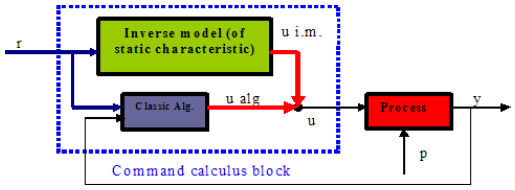

Fig. 3. Proposed scheme for inverse model structure

The presented solution proposes treating these "inverse model" mismatches that "disturb" the first command as a second command classic algorithm's model mismatches. This solution imposes designed a classic algorithm with robustness reserves. For this reason, designing the second algorithm has in two steps:

- design of a classic algorithm based on a model identified in a functioning point – selected fortuitously or, on the middle of the corresponding segment process characteristic;
- verification of algorithm's robustness and improving, if necessary - (re)designing procedure;

In Figure 3, the blocks and variables are as follows: Process – physical system to be controlled; Command calculus – unit that computes the process control law; Classic Alg. – control algorithm (PID, RST); y – output of the process; u – output of the Command calculus block; u alg. – output of the classic algorithm; u i.m. – output of the inverse model block; r – system's set point or reference trajectory; p – disturbances of physical process.

This solution used in the context of a multi model structure has three important aspects:

- Selection of a reduced number of zones where the nonlinearity is important but lower than an imposed threshold.
- Construction of the compensator block for each zone.
- Designing the correspondent controller for each zone.

All three will be presented in next sections.

A. *Zones Selection*

The number of zones must be reduced (*2, 3* or maximum *4*) and these can consist in the medium or "local" tendencies of the nonlinear characteristic [4], [5]. Figure 4 presents an example for this aspect.

It can be imposed that the difference between the tendency and the real characteristic must be less or equal to an imposed margin.

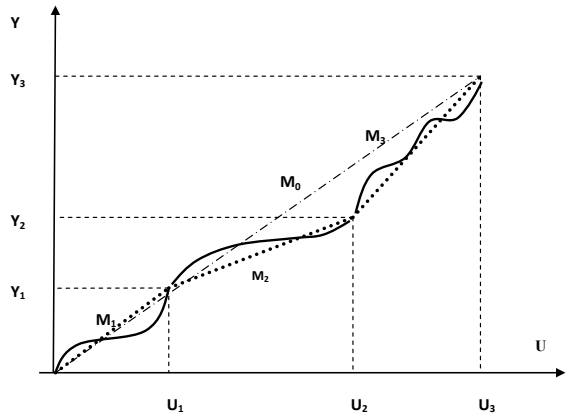

Fig. 4. Selection of major zones

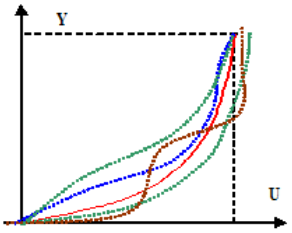

Fig. 5. Determination of static characteristic of the process. Red (continuous) line represents the final characteristic

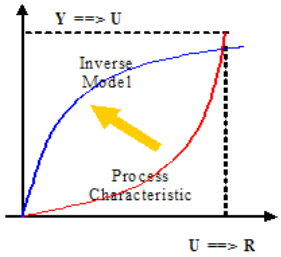

Fig. 6. Construction of inverse model

In Figure 4 the continuous line represents the process static characteristic, the dotted line – the linear models and dashed and dotted line the global linear model.

B. Construction of Nonlinear Compensator Blocks

This operation is based on several experiments. The command *u(k)* is increasing and decreasing and the corresponding stabilized process output *y(k)* is measured. The command *u(k)* covers all possible values (*0 to 100%* in percentage representation). Because the process is disturbed by noises, the measurements of the static characteristics are not identically. The final static characteristic is obtained by meaning these experiments. Figure 5 presents this operation. The graphic between two "mean" points can be obtained using an extrapolation procedure.

According to system identification theory [4] the dispersion of process trajectory can be found using expression (1):

$$\sigma^2 = \frac{\sum (x_i - \bar{x})^2}{n} \tag{1}$$

This can express a measure of noise, process's nonlinearity etc. and is important for robustness perspective during the design of the control algorithm [7], [8].

The next step in obtaining the nonlinear compensator block deals with inverting the process's static characteristic. Figure 6 presents this construction. According to this, *u(k)* is dependent to *r(k)*. This characteristic is stored in a table; thus, for the inverse model based controller, selecting a new set point *r(k)* means searching in this table the corresponding command *u(k)* that determines a process output *y(k)* close to the reference value.

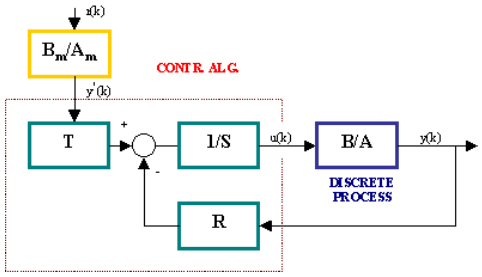

Fig. 7. RST control algorithm structure

C. Controllers Design

The zones control algorithm's duty is to eliminate the disturbances and differences between inverse models' computed command and real process behavior. A large variety of control algorithms can be used here, PID, RST, fuzzy etc., but the goal is to have a simplified one.

For this study we use a RST algorithm. This is designed using a pole placement procedure [2]. Figure 7 presents the RST algorithm:

Where R, S, T polynoms are:

$$\begin{aligned} R(q^{-1}) &= r_0 + r_1 q^{-1} + \ldots + r_{nr} q^{-nr} \\ S(q^{-1}) &= s_0 + s_1 q^{-1} + \ldots + s_{ns} q^{-ns} \\ T(q^{-1}) &= t_0 + t_1 q^{-1} + \ldots + t_{nt} q^{-nt} \end{aligned} \tag{2}$$

Pole placement algorithm makes use of the identified model.

$$y(k) = \frac{q^{-d} B(q^{-1})}{A(q^{-1})} u(k) \tag{3}$$

where

$$\begin{aligned} B(q^{-1}) &= b_1 q^{-1} + b_2 q^{-2} + \ldots + b_{nb} q^{-nb} \\ A(q^{-1}) &= 1 + a_1 q^{-1} + \ldots + a_{na} q^{-na} \end{aligned} \tag{4}$$

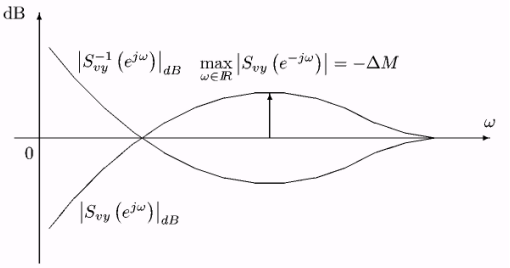

Fig. 8. Sensitivity function graphic representation

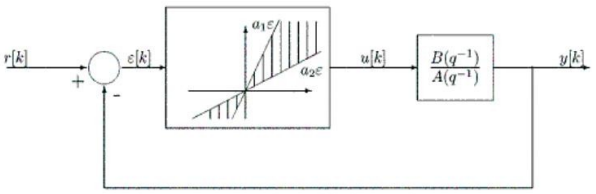

Fig. 9. Robust control design procedure

The identification is made in a specific process operating point and can use recursive least square algorithm developed in [2].

This approach allows the users to verify, and if is necessary, to calibrate the algorithm's robustness. The following expression and Figure 8 present the "disturbance-output" sensitivity function.

$$S_{vy}(e^{j\omega}) \overset{def}{=} H_{vy}(e^{j\omega}) = \\ = \frac{A(e^{j\omega})S(e^{j\omega})}{A(e^{j\omega})S(e^{j\omega}) + B(e^{j\omega})R(e^{j\omega})}, \quad \forall \omega \in R \tag{5}$$

The negative maximum value of sensitivity function represents the module margin.

$$\Delta M\big|_{dB} = -\max_{\omega \in R} \left| S_{vy}(e^{j\omega}) \right|_{dB} \tag{6}$$

Based on this value [2], in a "input-output" representation, process nonlinearity can be bounded inside of "conic" sector, presented in Figure 9, where a_1 and a_2 are calculated using next expression:

$$\frac{1}{1-\Delta M} \geq a_1 \geq a_2 \geq \frac{1}{1+\Delta M} \tag{7}$$

Finally, if it is imposed that all nonlinear characteristics should be (graphically) bounded by the two gains, or if the gain limit should be greater or equal to process static characteristic maximal distance $\Delta G \geq md$, then a controller that has sufficient robustness was designed.

D. Global Architectures

Partitioning the nonlinear characteristic like in Figure 4 and combining the multi model structure (presented in Figure 1) with the control structure (presented in Figure 4 determines) the global architecture of multi model control system presented in Figure 10.

On Figure 10, the blocks and variables are as follows: Process – physical system to be controlled: Command calculus – unit that computes the process control law; Alg. *i* – i control algorithms (PID, RST); *y* – output of the process; *u* – output of the Command calculus block; *u i.* – output of the *i* control algorithm; *r* – system's set point or reference trajectory; *p* – disturbance of physical process.

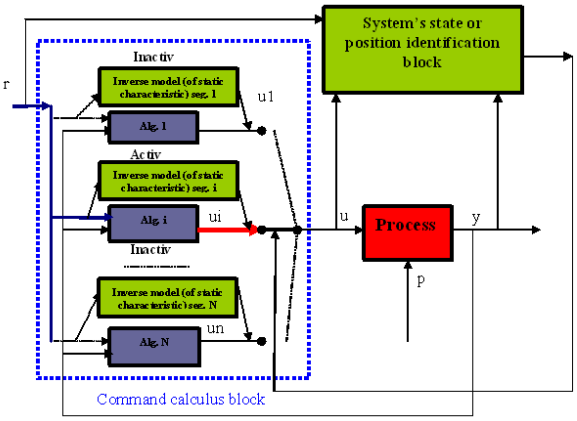

Fig. 10. RST control algorithm structure

IV. ADVANTAGES AND DISADVANTAGES OF THE PROPOSED STRUCTURE

A. Advantages

The main advantage consists in using a simplified and performance operating control structure. Designing procedure is based on classic pole placement and determination of inverse command blocks. Well known procedures are used for dynamic and static models' identification.

Because the global command contains a "constant" component generated by an inverse model command block, the system has good stability margin.

The inverse model command generator can be replaced by a fuzzy logic bloc or neural network that can "contain" human experience about some nonlinear processes.

Due to the fact that the control laws are not very complex, real time software and hardware implementation doesn't need important resources.

B. Disadvantages

The main limitation is that this procedure can be applied only for the processes that permit the construction of the static characteristic.

This structure is very difficult to use for systems with non bijective characteristic and for systems with different functioning regimes.

Another limitation is that this structure can be used only for stable processes. In situations where the process is "running", the direct (feed forward) command is very possible to not have enough flexibility to control it.

The increased number of experiments for determination of the mean static characteristic can be another disadvantage of the structure.

C. Possible Developing

For special situations, the direct command generators (feed forward) included in multi model structure can be constructed as a single general block. This block

compensates the process nonlinearity and allows using simplified control laws in multiple controller structure.

These systems can be easily implemented on PLC structures particularly, and real time control systems, generally.

V. EXPERIMENTAL RESULTS

We evaluate the achieved performances of the proposed control structure using an experimental installation presented in Figure 11, where the position of an object contained in the vertical tube must be controlled using an air flow generator.

The nonlinear process static characteristic is presented in Figure 12.

For this, there are selected 12 zones (Figure 12) for a classic multi model structure (Figure 1). The models and corresponding area (output %) are: M1: 0-35%, M2: 35-50%, M3: 50-54%, M4: 54-60%, M5: 60-69%, M6: 69-72%, M7: 72-75%, M8: 75-78%, M9: 78-84%, M10: 84-86%, M11: 86-95%, M12: 95-100%. All 12 are first order models. For example, for M1 using Te=0.2 s sampling time and Least Square identification method from Adaptech/WinPIM the model is:

$$M_1 = \frac{0.487180}{1 - 0.79091 q^{-1}}$$

The corresponding controller (for Tracking performances: second order dynamic system with w0=2.0, x=0.95, Disturbance rejection performances: second order dynamic system with w0=1.1, x=0.8, using WinReg) is:

Fig. 11. Experimental installation

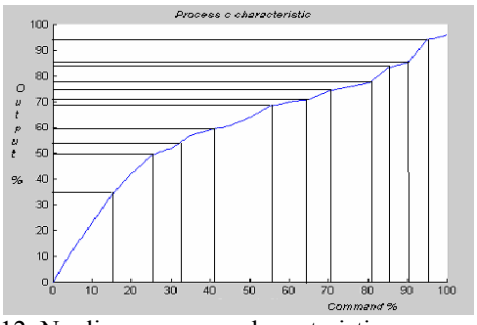

Fig. 12. Nonlinear process characteristic

$$R(q^{-1}) = 0.263281 - 0.179872\ q^{-1}$$
$$S(q^{-1}) = 1.000000 - 1.000000\ q^{-1}$$
$$T(q^{-1}) = 2.052629 - 3.412794\,q^{-1} + 1.443573\ q^{-2}$$

The RST control algorithm can be written as follows:

$$u(k) = \frac{1}{s_0}[-\sum_{i=1}^{n_S} s_i u(k-i) - \sum_{i=0}^{n_R} r_i y(k-i) + \sum_{i=0}^{n_T} t_i y^*(k-i)]$$

where *R, S, T* polynomials are presented in relation (2) and n_S, n_R, n_T express the corresponding degrees and also the memory dimension for the software implementation of the algorithm. For example, if $n_R=2$, then three memory locations must be reserved for the process's output: *y(k), y(k-1), y(k-2)*. Respectively, the same rule applies for *u(k)* and $y^*(k)$.

To calculate the corresponding command the controller presented before, there are used 7 multiplication and 7 addition or subtraction operations.

Because the multi models control structure must assure no bump commutations, all of the 12 control algorithms must work in parallel [6]. This condition gives the total number of operations: 12 x 7 = 84 multiplications and 12 x 7 = 84 additions/ subtractions.

For the proposed control structure, with nonlinear blocks there are selected 3 zones Z1: 0-50%, Z2: 50-80% and Z3: 80-100%, presented in Figure 13.

The models are:

$$M_1 = \frac{0.0964 - 0.19647 q^{-1}}{1 - 1.06891 q^{-1} + 0.22991 q^{-2}}$$

$$M_2 = \frac{0.01297 + 0.05397 q^{-1} + 0.03674 q^{-2}}{1 - 0.76251 q^{-1}}$$

$$M_3 = \frac{0.02187 + 0.05668 q^{-1} + 0.06048 q^{-2}}{1 - 0.93161 q^{-1} + 0.02741 q^{-2} + 0.09863 q^{-3}}$$

In this case, we have computed three corresponding RST algorithms using a pole placement procedure from Adaptech/WinREG platform.

The same nominal performances are imposed to all systems, through a second order system, defined by the dynamics $\omega_0 = 1.25$, $\xi = 1.2$ (tracking performances) and $\omega_0 = 2$, $\xi = 0.8$ (disturbance rejection performances) respectively, keeping the same sampling period as for identification.

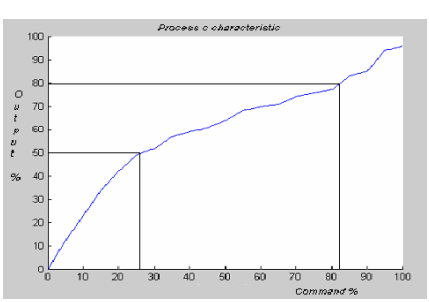

Fig. 13. Selection of the three zones of nonlinear characteristic

$$R_1(q^{-1}) = 1.863259 - 2.027113q^{-1} + 0.520743q^{-2}$$
$$S_1(q^{-1}) = 1.000000 - 0.554998q^{-1} + 0.445002q^{-2}$$
$$T_1(q^{-1}) = 3.414484 - 4.931505q^{-1} + 1.873910q^{-2}$$

$$R_2(q^{-1}) = 2.309206 - 1.624937q^{-1}$$
$$S_2(q^{-1}) = 1.0 - 0.815278q^{-1} - 0.106427q^{-2} - 0.078295q^{-3}$$
$$T_2(q^{-1}) = 9.645062 - 14.928993q^{-1} + 5.968200\,q^{-2}$$

$$R_3(q^{-1}) = 1.72482 - 1.611292q^{-1} - 0.03784q^{-2} + 0.292903q^{-3}$$
$$S_3(q^{-1}) = 1.0 - 0.725187q^{-1} - 0.095205q^{-2} - 0.179608q^{-3}$$
$$T_3(q^{-1}) = 7.192692 - 11.645508q^{-1} + 4.821405\,q^{-2}$$

To calculate the corresponding command for the *C1* controller there are used: 9 multiplications and 9 additions or subtractions, for *C2*: 9 multiplications and 9 additions or subtractions and for C3 11 multiplications and 11 additions or subtractions, giving a total number of 29 multiplications and 29 additions or subtractions.

For the proposed control structure, in addition to the command calculus operation, here is the calculus for the direct command. This depends on the software implementation. For PLC, particular and real time process computers, where (C) code programming can be used, the implementation is:

```
// segment determination
segment = (int)(floor(rdk/10));
// segment gain and difference determination
panta = (tab_cp[segment+1] - tab_cp[segment]) * 0.1;
// linear value calculus
val_com_tr = uk + 1.00 * (panta * (rdk - segment*10.0)
+ tab_cp[segment]);
```

One needs 10 multiplications and 4 additions or subtractions. The total operations number for the proposed structure is: 59 multiplications and 41 additions or subtractions.

It is obvious that the proposed structure needs a diminished number of multiplications if compared to the classic multi model solutions and a comparative value for the number of additions and subtractions. This means that the system with nonlinear compensators is faster or needs simplified hardware and software architecture.

VI. CONCLUSIONS

In this paper there is proposed a multi model control structure which contains, for each model/controller, a nonlinearity compensator.

This solution allows a reduced number of models and a reduced complexity for global structure. The analysis on the advantages and disadvantages of proposed structure is made.

The experimental results done on laboratory installation present a case where the proposed structure is a faster solution then the classic multi model structure.

This structure can be easily implemented on PLC and real time process computer.

ACKNOWLEDGMENT

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Using Parallel Computing Methods in Business Processes

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Abstract* – In computer science, engineers deal with the issue how to accelerate the execution of extensive tasks with parallel computing algorithms, which are executed on large network of cooperating processors. The business world forms large networks of business units, too, and in business management, managers often face similar problems. The aim of this paper is to consider the possibilities of using parallel computing methods in business networks. In the first part, we introduce the issue and make some assumptions which have to be fulfilled so that business units and their relations resemble to networks of interconnected processors. Consequently, we present some of the networks suitable for parallel cooperation – complete binary trees, hypercubes, meshes and tori. Then we introduce well-known measures of parallel cooperation performance. Finally, we discuss the main issues of introducing parallel computing methods in business process management. Besides the costs of parallel redesign and of redefinition of responsibilities, the parallel engineering would impose strict requirements on collective work capabilities, training and discipline. Efficient communication system and clear and unambiguous protocol of communication are also necessary. Synchronization is also an important point which requires attention, as well as signaling system in case when barrier synchronization is to be implemented. We suggest designing sparse networks to reduce coordination effort and the cost of network.

Keywords: **parallelism; business process; cooperation**

I. INTRODUCTION

Recently, mutual relations of business entities have received the attention of many economic scientists. The contemporary business world is organized into structures which can be thought of as networks of business units [4]. Business units form large networks with various mutual connections and relations. In this context, we speak of business networks. Freeman [3] suggested the use of graph theory to formalize these structures, which seems to be a natural approach. Business units are represented by nodes and relationships between them by edges of the graph.

Often, business units have to cooperate on the solution of a problem. If only one business unit is solving the problem, we speak of sequential or serial work. In the opposite situation, we speak of parallel work.

The graph representation of networks is similar to the formalism used in parallel computing. This raises the question whether this apparatus could also be used in the field of business process management. In this paper, we will try to combine the two approaches together.

Let us first introduce the background of parallel computing. Because of the fact that the development of single core processors will soon reach its physical limits, computer scientists have focused on parallel computing as a possibility of further increasing the computer power. A comprehensive theory of parallel computing has begun to be studied. A great number of models and algorithms which allow optimal or nearly optimal use of parallel structures have been designed for parallel computers, such as parallel reduction, parallel prefix sum, collective communication algorithms, parallel routing algorithms, parallel algebra algorithms etc.

Nowadays, the basic parallelism is widely used e.g. in current personal computers, mobile phones or game consoles. The real massive parallelism is used by supercomputers for special applications such as numerical mathematics and physics (weather forecast), statistics (large sets of data), theory of numbers (cryptography) and computer science (visualization, management of large databases). Advanced parallelism is also used in common tasks such as Internet search engines, audio/video providers or social networks.

In the economic world, the motivation is not very different. In the global competitive environment, an efficient parallel cooperation of business units could help companies or other types of organizations reduce costs and time and increase satisfaction of customers through shorter delays in the supplied service.

However, the basic assumption of the use of parallelism in business networks is that multiple units cooperating on the solution of a problem are able to finish the work faster than if the operations were carried out sequentially.

The results of empirical research on whether parallelism of tasks can reduce the overall time are mixed.

Ould [12] summarizes that if two parts of a sequential process A and B take time $t_a + t_b$, parallel redesign of the process can lead to time $\max(t_a, t_b)$. However, according to some authors like Hammer [5], parallel work design and management cause more complex coordination of activities which negatively affects the performance gains. Several past empirical studies (for example, [1], [6], [10]) show that parallelization of tasks, if correctly applied, can lead to a speedup of business processes.

Zapf et al. [13] summarized nine past empirical studies on the effects of parallelization on the time gains in product development: "Most of the listed publications state the effect of paralleling as positive regarding the reduction of development time. But the achievable gains are valued extremely different: Starting from 2% gains go up to 53%. Some authors do not value the paralleling gains and Handfield mentions even a performance loss of 76% regarding the time to delivery for the enhancement of already developed products".

II. BASIC ASSUMPTIONS AND CONSTRAINTS

In order to use parallel computing methods in business networks, some assumptions have to be made on business units (BUs) and their relations so that they resemble to networks of interconnected processors.

1) The business network is composed of identical business units. This is perhaps the strongest assumption.
2) The business units are subordinated to a central authority. This is more common in business world.
3) Each business unit has an executive system (which can be represented by brain, hands, workers, whole departments etc.), a memory (human memory, database, files) and communication system (eyes and mouth, Internet, mail service, shipment service). The definition of these elements is dependent upon the level of abstraction of the appropriate business network.
4) The communication can take place between two business units (one-to-one communication) or between multiple business units (one-to-all, all-to-all communication etc.)
5) The communication system can be either one-directional or bi-directional (a person cannot speak and listen at the same time, but postal services or a computer may send and receive messages at the same time).
6) The communication system can have one input-output interface (port), which means the BU is able to receive and send only one message in one moment, or multiple interfaces.
7) A message can be of tangible (physical packages, provisions, products etc.) or intangible (information) nature.
8) The operations are carried out synchronously stepwise.
9) Each business unit can be either active or passive (idle) in a certain step.
10) The coordination effort, e.g. "managing dependencies between activities" [10], is increasing with the number of edges of the business network.

III. NETWORKS SUITABLE FOR PARALLEL COOPERATION

We define shortly some terms from the theory of graphs.

- A **graph** is a couple $G=(V,E)$ where $V=(V,G)$ is the set of nodes and $E=(E,G)$ is the set of edges.
- Two nodes are **neighbors** if they are edge-connected.
- The **degree** of a node $\deg(u)$ is the number of its neighbors.
- The **length of a path** $P(u,v)$ between two nodes u and v is the number of edges in $P(u,v)$, denoted by $len(P)$.
- The **distance** $dist(u,v)$ between two nodes u and v is the length of the shortest path.
- The **diameter** $\Phi(G)$ of a graph is the maximum distance between any two nodes of the graph.
- The **connectivity** of G $\kappa(G)$ is the minimum set of nodes whose removal disconnects the graph.
- The **fault diameter** of G $fdiam(G)$ is the maximum diameter of any graph obtained from G by removing at most $\kappa(G)-1$ nodes.
- The **tree** is a connected acyclic graph.
- The **rooted tree** is a tree where a particular node is distinguished from the others and called the root.
- The **parent** of a node is the node connected to it on the path to the root.
- A node without children is called the **leaf**.

An **edge** usually represents data or material exchange between business units and can include several phases susceptible to cause delays: preparation of data or material to be sent, transfer through the communication channel, and reception and analysis and further manipulation with data or material.

It is desirable to reduce the number of edges in the graph in order to reduce costs and possible losses and errors.

The requirements on the properties of business network topologies are straightforward:

1) Low degree of nodes, since additional links are more expensive.

2) Low diameter, which implies less communication links, less messages and reduces errors and congestion.
3) Low fault diameter. This is a measure of a network's stability and ability to bypass overloaded or congested nodes or edges. Indeed, Knight [7] argues that individuals and organizations can learn to collaborate, and they can also unlearn or forget, so the connections can dissolve. Breakdowns can also lead to a demise of utilizable edges of the network graph.
4) Further, the networks should be regular, reproducible and understandable. Additional complexity increases the coordination effort and reduces overall performance [10].

In the following section, we will deal with several topologies used in parallel computing for which numerous efficient algorithms have been developed – trees, hypercubes, meshes and tori. These are only examples; there exist other topologies, such as cube-connected cycles, star graphs and much more.

A. Complete binary tree

A **binary tree** is a structure defined by a finite set of nodes which does not contain any node, or is composed of three disjoint sets of nodes: a root, a binary tree called left subtree and a binary tree called right subtree. A complete binary tree CBT_n is a binary tree which has $2^{n+1}-1$ nodes and $2^{n+1}-2$ edges.

The tree is a suitable representation of the functional and divisional organizational structure of a firm. The management is represented as the root and subordinated units as children. It is also a useful tool in the design of business processes and programming of activities.

B. Hypercube

A **hypercube** (*n*-cube) belongs to the simplest topologies. We denote a binary hypercube of dimension *n* by Q_n. Formally, it is possible to define a hypercube as a graph

$$Q_n = K_2 \times Q_{n-1} \quad (1)$$

where K_2 is a complete graph with 2 nodes, Q_0 is a trivial graph with one node, and $\times$ is the operator of Cartesian product. The set of nodes of a hypercube is defined by binary sequences (i.e. strings of zeros and ones) of length *n*. This sequence is an algebraic expression of the node's coordinates.

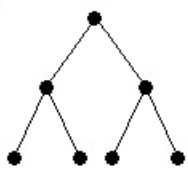

Fig. 1 Complete binary tree CBT_2

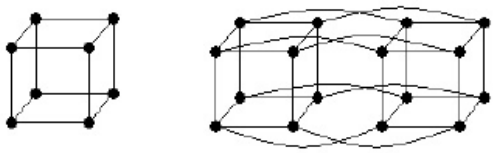

Fig. 2 Examples of hypercubes Q_3 and Q_4

The total number of possible combinations is 2^n. Two nodes are neighbors (connected with an edge) if and only if their coordinates differ in one bit. As follows, every node has exactly *n* neighbors. A transition from one node to another can be expressed as a negation of a certain bit in the node's coordinates.

By negating a bit on a position *k*, we traverse in the dimension *k* on an edge connecting two nodes, whose coordinates differ in *k*-th bit.

It follows that the diameter of a hypercube is exactly *n*, because it is necessary to negate all bits to get to the farthest node. The number of neighbors in a hypercube is constant and the same for all nodes.

C. Mesh

A node of a *n*-dimensional mesh $M(z_1, z_2, , , , z_n)$ is defined by a sequence of positive integers of length *n*. The element at the *i*-th position of the sequence takes values from $\{0,1,..., z_i\}$. A one-dimensional mesh $M(z)$ is a linear array of length *z*. For multi-dimensional meshes, the following equation holds:

$$M(z_1, z_2, , , , z_n) = M(z_1) \times M(z_2) \times ... \times M(z_n) \quad (2)$$

Two nodes are neighbors if and only if the difference of their coordinates in a certain dimension is one. It follows that each node, except the utmost nodes of the mesh, has two neighbors in all dimensions. Unlike in the case of a hypercube, the number of neighbors is not constant. In business management, the two-dimensional version of this topology is known as matrix structure. However, it can be generalized to any number of dimensions.

D. Torus

A torus of dimension *n*, denoted as $T(z_1, z_2, , , , z_n)$ is defined as a Cartesian product of cycle graphs. A cycle $T(z)$ is a set of nodes connected in a single chain.

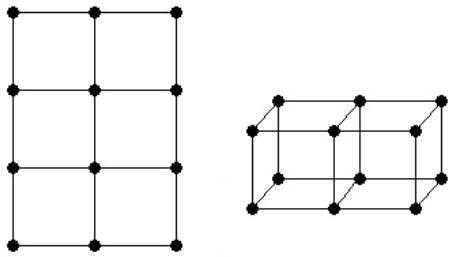

Fig. 3 Examples of meshes M(3,4) and M(3,2,2)

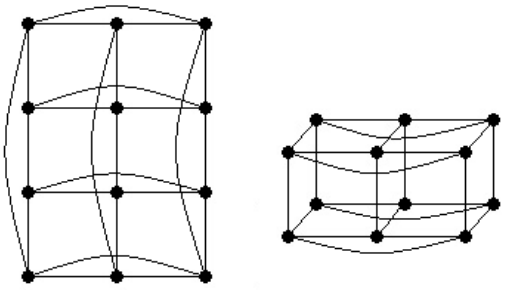

Fig. 4 Examples of tori T(3,4) and T(3,2,2)

The torus is similar to the mesh, but the building blocks are not linear arrays but cycles, so

$$T(z_1, z_2, , , , z_n) = T(z_1) \times T(z_2) \times ... \times T(z_n) \quad (3)$$

The set of nodes of a torus $T(z_1, z_2, , , , z_n)$ is the same as of a mesh of the same dimension $M(z_1, z_2, , , , z_n)$, but there are additional edges connecting the utmost nodes.

Two nodes are neighbors if the difference of their coordinates in a certain dimension is one modulo z_i. Each node has two neighbors in all dimensions, so the total number of neighbors for each node equals $2n$. This topology is also sometimes used in economics. (It is the way the current assets circulate, or it is used in the Klein-Goldberger macroeconomic model.) However, in business management, tori are not widely used.

E. Meshes of trees

The mesh of trees MT_n is a hybrid topology between trees and meshes. It can be visualized by replacing the rows and columns of the mesh M(2^a,2^b) by complete binary trees. MT_n is a subgraph of $CBT_n \times CBT_n$. The number of nodes is $3n^2 - 2n$ and the number of edges is $4n(n-1)$.

When designing a business network topology, the manager has to consider carefully the requirements on time efficiency, costs, reliability and complexity, which are in a tradeoff relationship. Meshes and tori suffer from large diameter and large degree, whereas hypercubes and trees suffer from small connectivity and fault diameter.

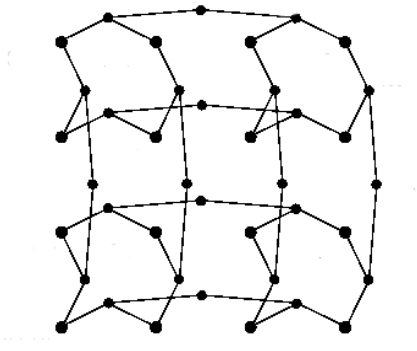

Fig. 5 Example of mesh of trees

Meshes of trees combine low diameter and high fault diameter.

It is also important to consider the overall complexity and understandability of the network, since a more complex network could cause an increasing coordination effort and reduce overall efficiency.

IV. MEASURING THE PERFORMANCE OF PARALLEL COOPERATION

In this section we introduce the common measures of the performance of parallel work in parallel computing. These measures can be used to measure the efficiency of parallel cooperation in business networks as well. For example, man-hours (MH) represent a common unit for measuring the time complexity of business projects.

We begin with the definition of time complexity of task solving. The complexity is dependent upon the size of the task. It is common in computer science to deal with the asymptotic behavior of functions, i.e. the behavior of functions when the size of input arguments approaches infinity.

Let $f(n), g(n) : N \to R^+$ be two functions of natural numbers. Then

- $f(n)$ **has the order at most** $g(n)$, written $f(n) = O(g(n))$, if and only if there exists a positive constant c for which $\exists n_0 \in N : \forall n \geq n_0 : f(n) \leq c.g(n)$
- $f(n)$ **has the order at least** $g(n)$, written $f(n) = \omega(g(n))$, if and only if there exists a positive constant c for which $\exists n_0 \in N : \forall n \geq n_0 : f(n) \geq c.g(n)$,
- $f(n)$ **has the order of** $g(n)$, written $f(n) = \Theta(g(n))$, if and only if $f(n) = O(g(n))$ and $f(n) = \omega(g(n))$.

This notion is not relevant for any finite interval, since it describes the behavior of functions when the size of input grows beyond all limits.

When multiple business units are cooperating on the solution of a problem, usually they solve it faster than if only one business unit was working on the problem.

When solving a task of a parallel nature, we can measure the **time complexity** *T(n,p)*, where *n* is the size of the task and *p* is the number of cooperating business units. *T(n,p)* can be determined by counting the parallel steps from the beginning to the end of the task.

Let *SU(n)* denote the upper bound on the time complexity of a sequential problem which only one BU is solving. We define the **parallel speedup** as

$$S(n, p) = \frac{SU(n)}{T(n, p)} \quad (4)$$

The theoretical upper bound on *S(n,p)* is *p*, in which case we speak of linear speedup.

The linear speedup is an ideal, yet it is achieved only exceptionally. Sublinear speedup is a more realistic objective. Superlinear speedup can also be achieved, but only in specific tasks, such as parallel state space search.

Another measure which can be used to evaluate the performance of parallel cooperation is the **parallel cost**. It is the total number of operations if all the business units were working from the beginning until the end, i.e. an estimate of the upper bound of the time complexity. The parallel cost can be specified as

$$C(n, p) = p.T(n, p) \quad (5)$$

Further, we can define **parallel work** as the total number of operations. Let T_i denote the number of operations executed by a business unit i during the task solving. Then the parallel work can be specified as

$$W(n, p) = \sum_i T_i \quad (6)$$

It can be shown that

$$SU(n) \le W(n, p) \le C(n, p) \quad (7)$$

Finally, we define the **parallel efficiency** as a ratio of sequential and parallel cost

$$E(n, p) = \frac{SU(n)}{C(n, p)} \quad (8)$$

Time- and cost-optimal algorithms with linear speedup have constant efficiency.

V. PRACTICAL ISSUES

Some issues arise when implementing the parallel cooperation into a business network, especially concerning the heterogeneity and stability of the network, the requirements on network nodes and edges, and coordination effort.

If efficient parallelism is to be implemented into a business, managers have to deal with the following problems:

1) The first issue is to introduce the parallel business process into a company. This would include the **redesign** of existing sequential processes and definition of new responsibilities. The redesign not only imposes strong analytical skills on the designer, but also implies some inevitable redesign costs, including the replacement of existing assets (tangible or intangible) and training of staff.
2) The business units have to be reliable in terms of working in parallel. If they are not, the whole cooperation process will be delayed, which is undesirable. This imposes requirements of cooperation abilities of BUs - **collective work capabilities**.
3) If the business units are not identical, which is a realistic assumption, they will differ in performance, and the step duration will be determined by the weakest business unit. Therefore, business units should have comparable knowledge and skills, which raises the need of **training**.
4) The business units have to stay in subordinated positions to a central respected authority. This imposes requirements on **discipline**.
5) One of the main problems is keeping the BUs working synchronously. This requires some **synchronization system**. The simplest solution would be imperative time-stamps given by the central authority. Another approach is to use so-called barriers, when no BU can continue until all BUs have finished the step. (This approach requires some **signaling system**). If the BUs are badly synchronized, it will cause delay in the whole parallel process.
6) The cost of communication must not exceed the benefits. Otherwise, the sequential solution of the problem would be a more economic rather than parallel solution. This raises the need of **efficient communication system** to reduce the coordination efforts. This aspect seems to be the major obstacle to efficiency gains by a parallel redesign of business processes (see for example [13]) and can be reduced by using information systems to automate the parallel tasks [2].
7) The coordination efforts are greater for dense networks; therefore, we suggest using **sparse networks.**
8) The communication protocol has to be **clear and unambiguous** to avoid possible errors. The nature of messages, their structure and encoding/decoding have to be well specified.

It is clear that if these issues are not resolved, positive gains of the use of parallel processes in business practice are not certain.

VI. CONCLUSION

The intention of this paper was to consider the use of parallel computing in business process management. Although the theory of parallel algorithms is still being developed, some of its results could be used in the field of business networks, which have recently received attention from economic scientists.

In the first part of the paper, we presented some necessary assumptions on the properties of business units so that they resemble to networks of interconnected processors.

Consequently, we presented common network topologies in parallel computing – tree, hypercube, mesh, torus and mesh of trees – some of which could be suitable for use in economics because numerous efficient algorithms have already been developed for these networks by computer engineers. There exist much more interesting topologies, but their detailed description would be out of scope of this paper. Network topologies have various properties, such as density, diameter, or reliability, which a manager has to consider when designing the business network, because time efficiency, costs, reliability and complexity are often in a tradeoff relationship.

In the following section, we introduced the measures of parallel performance – time complexity, parallel speedup, parallel cost, parallel work and parallel

efficiency – which could be used to assess performance of parallel business processes as well.

In the final part, we dealt with the possibilities of implementing parallel cooperation into companies.

An introduction of parallel business process raises the need of inevitable redesign costs, and parallel cooperation imposes requirements on business units reliability, ability to cooperate with other business units, and discipline. Business units have to have similar performance, which could require training. One of the major challenges in parallel cooperation is the synchronization of business units. We suggested the use of imperative time-stamps or barrier synchronization used commonly in the world of computer science. Sparse networks are better suited for parallel cooperation since edges of the business network graph cause additional coordination efforts. Collective communication has to be quick and efficient, and the communication protocol, which defines the nature of messages, their structure and encoding/decoding, has to be unambiguous and clear. Information systems are one of the ways which can be used to automate tasks and improve performance gains.

In the global competition, especially in saturated markets, an efficient parallel cooperation of business units could help companies or other types of organizations gain competitive advantage, reduce costs and time and increase the satisfaction of customers. However, since the field of parallel algorithms belongs primarily to the domain of computer science and computing tasks, efficient algorithms for common business tasks have yet to be developed. In addition, empirical evidence is needed to verify the applicability of advanced parallelism in business process management, which should be the next direction of the research in this field.

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Design and Simulation of Q-Enhanced CMOS RF Active Inductor Based on Negative Resistance

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***Abstract** – This paper presents the design of a single-ended CMOS radio frequency (RF) active inductor for use in applications around 2-2.4 GHz, that is suitable for RF filtering and many other applications in RFIC design. Our approach is based on a conventional grounded active inductor topology, where added negative resistance circuit is applied to increase the quality factor (Q) of the active inductor. The novelty of the proposed architecture for enhancing the Q of the inductor is increasing the parallel resistor of equivalent RLC model of the basic active inductor circuit with a negative resistance. Simulation results using the Advanced Design System(ADS) simulator with TSMC 0.18um RF CMOS process show inductance of above 2.35nH and Q-factor of over 994 around 2.2 GHz under a 1.8V supply voltage.*

***Keywords:** Active inductor; CMOS; Negative resistance; Quality-factor.*

I. INTRODUCTION

In the near decade, for the increasing demands of wireless communication systems, low cost and a high integration level of the front-end wireless transceiver are required to reduce the production cost and the system dimension. According to these requirements, CMOS technologies have become the best choice in this regard. A critical issue for RF CMOS front-end circuit design is the inductors, and high quality inductors are difficult to be implemented in CMOS due to parasitic losses. CMOS passive inductors have found a broad range of applications in RFICs and it should be noted that mainly, the passive inductor is the major chip area consuming building block [1]. According to these cases today's, the usage of passive inductors is degrading due to their large chip area, low quality factor, and less tunability.

Fortunately, it is possible to emulate the operation of a passive inductor with the combination of transconductors and capacitors, which provides the electrical behavior of a passive inductor without consuming large chip area. However, these active inductors have some disadvantages compared to spiral passive inductors that limit their use in RFIC and MMIC designs such as their higher noise, nonlinear behavior, power dissipation, sensitivity to process, and voltage and temperature variations, but it should be noted that large inductance value with small die area and also large and tunable resonance quality factor, and self-resonant frequency has led to that active inductors have been applied extensively in design of critical building blocks of transceiver ICs, such as RF filter [2], LNA [3], RF phase shifter [4], and oscillator [5]. For high frequency applications, the active inductance can be realized with CMOS transistors that is based on the gyrator principle. A gyrator is a two-port analog circuit used to transform an element on one port into its dual on the other port. It consists of two ideal voltage controlled current sources (or transconductors) connected in a back to back configuration. When one port of the gyrator is connected to a capacitor, as shown in Fig. 1, the network is called the gyrator-C network [6]. Note that the transconductors have opposite polarity, and their positions are interchangeable.

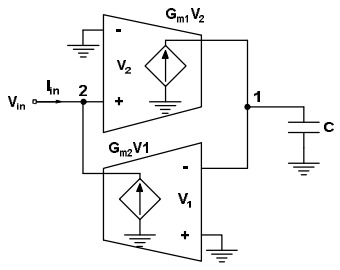

Fig. 1. Active inductors based on gyrator-C networks.

In this paper, we proposed a new type of CMOS active inductor based on the conventional grounded one, in order to obtain a higher quality factor and a higher resonant frequency. The rest of this paper is organized as follows. In section II, the basic operation of conventional grounded active inductor will be described. In section III, a novel Q-enhanced active inductor circuit structure is proposed, and some related concepts will be elaborated. Simulation results is shown in section IV and conclusion is in section V.

II. ANALYSIS OF GROUNDED ACTIVE INDUCTOR

One of the most common types of the gyrator based active inductor circuit is called grounded active inductor. Fig. 2(a), shows the circuit topology of conventional grounded active inductor. Back to back connection of two transistors acts as a gyrator-C architecture that converts parasitic capacitances of transistors to inductive reactance [7]. If each CMOS transistor be replaced by small-signal model, two port equivalent circuit can be achieved as Fig. 2(b).

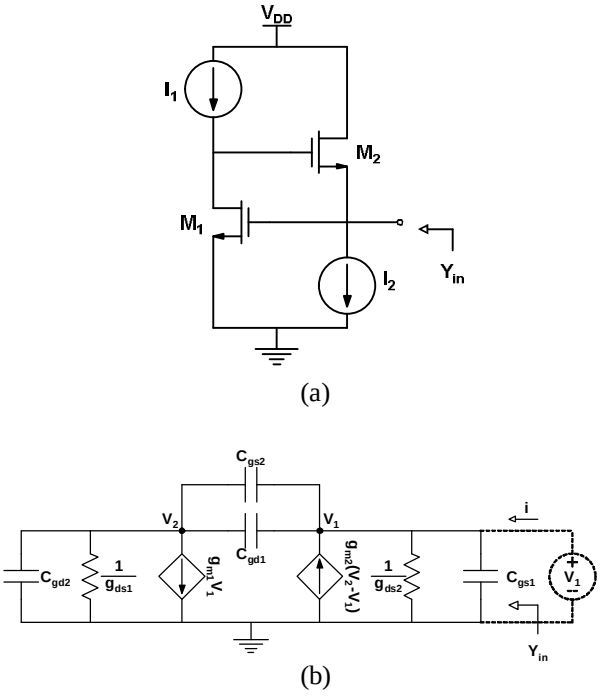

Fig. 2. (a) Schematic of grounded active inductor (b) Small signal equivalent circuit.

Admittance parameters of two-port can be expressed as:

$$\begin{bmatrix} -g_{m_1}+S(C_{gs_2}+C_{gd_1}) & -g_{ds_1}-S(C_{gd_1}+C_{gd_2}+C_{gs_2}) \\ -(g_{m_2}+g_{ds_2})-S(C_{gs_1}+C_{gs_2}+C_{gd_1}) & S(C_{gd_1}+C_{gs_2})+g_{m_2} \end{bmatrix} \quad (1)$$

Assuming that $g_m >> g_{ds}$ and $C_{gs} >> C_{gd}$, then the input admittance of this circuit can be drived as:

$$Y_{in} = y_{11} - \frac{y_{12}y_{21}}{y_{22}} = g_{m_1} + SC_{gs_1} + \frac{g_{m_1}g_{m_2}}{SC_{gs_2}+g_{ds_1}} \quad (2)$$

The equivalent model of the active inductor presented in Fig. 3, and model parameters can be listed as:

$$L = \frac{C_{gs_2}}{g_{m_1}g_{m_2}} \quad (3)$$

$$C = C_{gs_1} \quad (4)$$

$$R_S = \frac{g_{ds_1}}{g_{m_1}g_{m_2}} \quad (5)$$

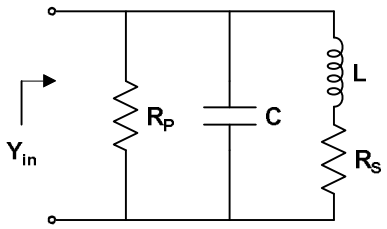

Fig. 3. Equivalent circuit model of grounded active inductor.

$$R_P = \frac{1}{g_{m_1}} \quad (6)$$

Notice that general form of R_S is $1/(g_{m2}\times A_V)$ where A_V is the voltage gain of M_1. However, $A_V \approx g_{m1}/g_{ds1}$ for single common-source amplifier, $A_V \approx (g_{m1}/g_{ds1})^2$ if M_1 is cascaded, and $A_V \approx (g_{m1}/g_{ds1})^3$ if M_1 is regulated cascaded. Quality factor of the inductance(Q_L) is a function of frequency and is defined as:

$$Q_L(w) = \frac{\mathrm{Im}(Z_{in})}{\mathrm{Re}(Z_{in})} \approx \frac{wL_{eq}}{r_s} \quad (7)$$

r_s shall not be confused with the R_S in drived RLC model, which is series resistance in pure R-L circuit. It seems that the quality-factor of the inductor can be increased by reducing the output conductance effectively of transistor M_1. In order to achieve a higher inductance and a higher quality factor, a cascode circuit topology was proposed to reduce the output conductance (g_{ds1}) [8].

III. PROPOSED ACTIVE INDUCTOR STRUCTURE

Complete schematic of the proposed active inductor is shown in Fig. 4. As shown in Fig. 4, M_3 stacking on top of the M_1 to reduce equivalent conductance g_{ds1} [8]. The added feedback resistance R_f between M_2 and M_3 can improve the equivalent inductance and quality-factor in consequence [9].

As reported at [10] this improved version of conventional grounded configuration of active inductor has a model like the small signal model that drived for basic conventional one. Notice that the equivalent circuit

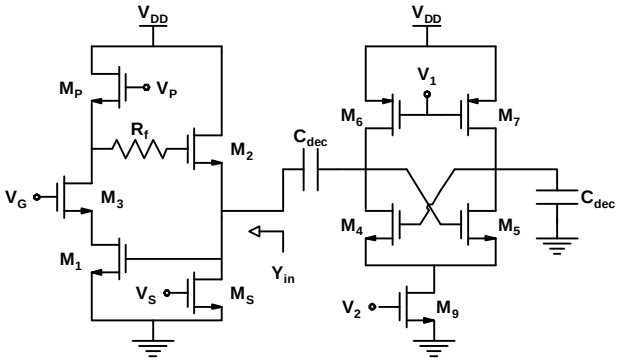

Fig. 4. A Q-enhanced active inductor.

elements value are affected with feedback resistance(R_f). If consider parallel resistor of its equivalent model with R'_P then for proposed circuit, we can drive equivalent parallel resistor as:

$$R_T = R'_P \left\| R_{neg} = \frac{-|R_{neg}| \times R'_P}{-|R_{neg}| + R'_P} \right. \quad (8)$$

The desired goal is that R_T be more than R'_P and ideal condition is to be infinity, for nail to this goal R'_P must be less than abslute value of R_{neg} and in optimum condition be equal to it. If two transistors of the cross-coupled pair (M_4 and M_5) have the same size, the negative resistance of it, is $-2/g_{m4}$ that is paralleled with a capacitance $C_{gs4}/2$ [11], then with a suitable choice of cross connected transistor size it's possible to control negative resistance value compared to R'_P. Decoupling capacitors (C_{dec}) role is that variation in negative resistance value will don't change the current through other transistors of the circuit and thus their transconductance [12],[13],[14].

IV. SIMULATION RESULTS

In order to demonstrate the performance of the described circuit, the proposed CMOS active inductor was simulated in Advance Design System (ADS) simulator by TSMC 0.18μm CMOS process. For simulation of quality factor and inductance value, we use their basic definitions Q=Image(Z_{in})/Real(Z_{in}) and L=Image(1/ω×Y(1,1)). These parameters of the proposed circuit can be obtained from the one port S-parameters simulation.

All DC current sources are implemented by using simple current mirrors.

The simulated Q-factor of the inductor with and without negative resistance is given in Fig. 5. It seems that Q-factor is enhanced by using negative resistance and the circuit has a good bandwidth. The maximum quality factor of 994 corresponding to an inductance of 2.35nH at 2.2GHz was obtained.

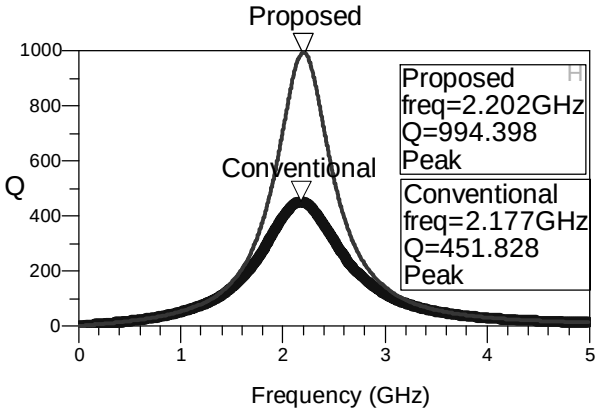

Fig. 5. Quality-factor vs frequency.

Fig. 6, shows inductance value of proposed circuit versus frequency.

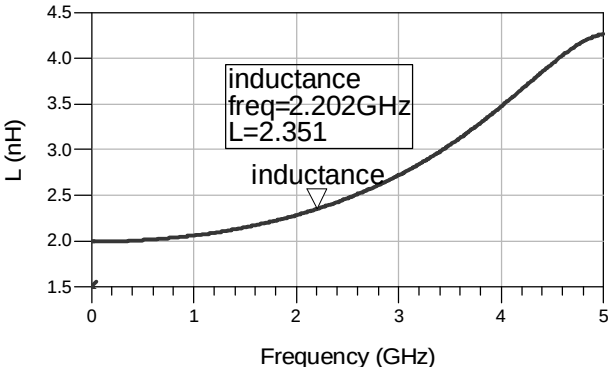

Fig. 6. The inductance of the circuit vs frequency.

Fig. 7, is layout of the proposed circuit. Total active chip area without including I/O pads is 48.5um×29.6um.
Power consumption of the circuit is 2.8mW for 1.8V supply voltage.

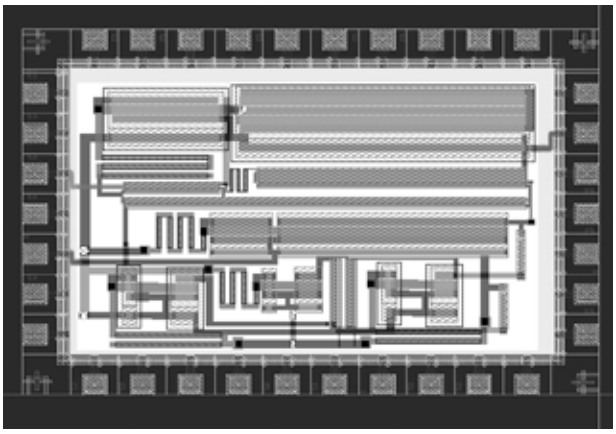

Fig. 7. Circuit layout.

Table 1 contains a brief summary of the final designed circuit.

TABLE 1. Performance of the final designed circuit.

Parameters	Simulation results
Technology	TSMC 0.18um
Power supply	1.8 V
Center frequency	2.2 GHz
Inductance value	2.35 nH
Quality-factor	994
Chip size	48.5um×29.6um
Power consumption	2.8 mW

V. CONCLUSIONS

A CMOS Q-enhanced active inductor structure is presented in this paper. The proposed Q enhancing technique employs a cross-coupled pair as a negative resistance to increase Q factor of improved conventional grounded active inductor. The proposed circuit was simulated in TSMC 0.18μm 1P6M CMOS technology. The simulation results agree with theoretical analysis reasonably well and show that the inductor is a good replacement of the spiral inductor for on chip circuit design.

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Types of Inductive Heating in Volume for Lengthy Pieces

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Abstract *– Further development and quality requirements imposed on production processes lead to determining new research to find optimal process parameters and configurations of the electromagnetic induction heating system. This work analyzes the process of mass heating for lengthy pieces by numerical modeling to obtain a uniform temperature by using multiple heating stages with different geometrical and electrical parameters. An important aspect treated in this paper is inductive heating stages alternating with phases of uniform temperature without heat. To achieve the intended purpose we used a commercial software for numerical modeling that has simulation facilities for the induction heating process in several stages. The results obtained by numerical modeling allow us to analyze several cases of induction heating, in a short time and to choose the best solution that provides a uniform heating of the work piece with low cost of material for devices and minimum power consumption.*

Keywords: *induction heating; simulation; uniform; inductor.*

I. INTRODUCTION

Electromagnetic induction heating is a complex process that has as a source an electromagnetic field and heating within the material developed by the Joule effect. Note that energy transfer from source to piece is without contact, which brings many benefits to the final configuration of the heating system. Because of the technological development today we can dose the amount of energy transmitted so that heat will be controlled. Advantages of induction heating are numerous and detailed in [1], [2], [3].

Due to the complexity of induction heating, classical analytical design does not provide a complete picture of the phenomena taking place and thus requires a design using numerical modeling techniques with much better approximations describing this process. In this manner of the modeling / numerical simulation various mathematical techniques have been introduced with strengths and weaknesses in the induction heating process simulation, among which the finite difference method (MDF) and the finite element method (FEM), which lately has become the advantages offered and detailed in [1]. Mathematical modeling is based on Maxwell's equations describing the electromagnetic field and the Fourier heat equation is used.

The numerical modeling of the induction heating process is used to solve the problem of the electromagnetic field whose result is electromagnetic losses by the Joule effect and then the thermal transfer problem. These problems are linked through a mesh network. Given the above and that the electromagnetic source is directly responsible for the transfer of energy to the heated part in this work we give particular importance to the electromagnetic field configuration source for the uniform heating of long bars with circular cross section. It should be noted that the heated piece is so long that it is not possible to build a single inductor and at the same time is not efficient [4]. The numerical modeling using computer techniques offers the possibility of studying the induction heating process from both the quantitative and the qualitative point of view, through the magnetic and thermal field measurements.

II. STAGES OF THE HEATING PROCESS AND RESULTS

Heating is achieved by converting the electromagnetic losses in a layer which is denoted by δ, that is the penetration depth of electromagnetic field in the heated piece and in the rest of the piece heating is achieved by heat conduction. By solving the mathematical equations that describe the two phenomena we can observe that the power of the source electromagnetic parameters and material properties affect heating. [5] Another important issue of the heating process is the shaped inductor, which ideally should be very close to the heated piece and must have the same geometric configuration.

In this paper we will analyze the numerical modeling of the inductive heating system for a piece made of steel, OL40, to achieve a uniform heating of the piece. The

piece has the length of 400 cm and 8 cm in diameter and the material properties (resistivity, thermal conductivity, specific heat, density and magnetic permeability) are variable with temperature and are detailed in various specialized treatises [6], [7].

As explained above, to obtain a uniform heating it is necessary that the layer in which the heat grows be as high as possible or be heated more, and then a period of time must pass for the temperature to equalize in the piece. From the analyzes performed by numerical modeling we observed that when there is no heat source the heat conduction in the material and losses by convection heat are more important and lead to lower temperature in the work piece [8], [9].

To obtain uniform heating of the work piece in a short time that offers high efficiency we proposed to use alternating stages of heating and a uniformity stage of temperature. The inductors are powered with different currents and frequencies. In our research we first analyze the numerical modeling of uniform heating to a temperature of 1000 °C when the piece is heated successively in different inductors with an equal number of turns but with different parameters of power supply. Between the stages of heating we have inserted periods of time for temperature equalization. During the first stage of heating, the inductor has the following parameters of power supply: frequency f = 2500 Hz, 102.5V voltage and current I = 1700 A. The first stage of inductive heating takes 20 seconds, followed by a period of 20 seconds without induction heating. The second stage of inductive heating takes 30 seconds followed by 15 seconds to smooth temperature. The final stage of inductive heating takes 25 seconds and then the last period, without an induction source of heating, to obtain a uniform distribution of temperature in piece takes 25 seconds. The total time to obtain a uniform heating for OL45 steel bar is 135 seconds. It is worth mentioning that the choice of power supply frequency was achieved by observing efficiency by power consumption and time required for the uniform heating of the work piece.

A second model was considered when the inductors are connected to different power and variable increasing frequency. In the second case the inductor 1 is supplied with a voltage of 88.6 V, current of 3000 A and frequency of 1000 Hz and the heating time is 20 seconds. After a first heating period there is a period of 20 seconds for temperature uniformity. The second inductive heating period lasts 20 seconds, and the inductor is supplied with voltage of 85.7 V, current of 2500 A and frequency of 1500 Hz. The second stage of heating is followed by a period of uniformity of temperature of only 15 seconds. The last stage of heating takes 20 seconds where the power inductor has the following parameters: voltage of 67.8 V, current of 1500 A and frequency of 2000 Hz. Finally, to achieve the intended purpose of obtaining uniform heating are still needed 20 seconds for the piece to have a uniform temperature.

In the third significant case presented in the paper we heated the piece through three inductors supplied with different powers and frequencies, without any waiting period for temperature uniformity between the 3 stages of induction heating. Thus, the first inductor is supplied with voltage of 120.8 V, current of 2000 A and frequency of 2500 Hz for a period of 20 seconds. In the second stage the inductor is supplied with voltage of 93.6 V, current of 2100 A and a frequency of 2000 Hz for 30 seconds. The third inductor is supplied with voltage of 43.3 V, current of 1200 A and frequency of 1500 Hz for a period of 30 seconds, after that, to obtain a uniform distribution of temperature, we still needed to wait 25 seconds.

Given the heating mode, with three inductors and areas for uniformity temperature in the piece, Figure 1 shows the schematic configuration of the heating system when it is necessary to use a uniformity stage of temperature after each inductive heating. Figure 2 shows the system configuration with uniform area only at the end of the three stages of heating. The piece will move through three inductors with a velocity v determined from the total time of heating.

In Figures 3, 7 and 11 are shown different situations of power consumption versus time. Temperature distribution in the piece is presented both by a color map (Figures 4, 8 and 12) and the line graph representing the temperature at the surface and in the center of the piece (Figures 5, 9 and 13). For each case under consideration are presented variations of efficiency depending on time, shown in Figures 6, 1 and 14.

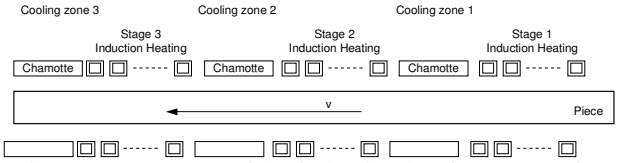

Figure 1. Geometry of the induction heating system for case 1 and 2.

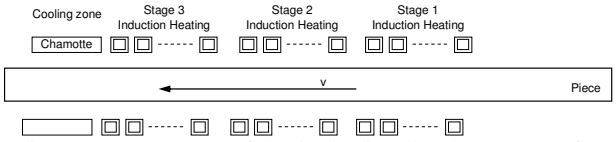

Figure 2. Geometry of the induction heating system for case 3.

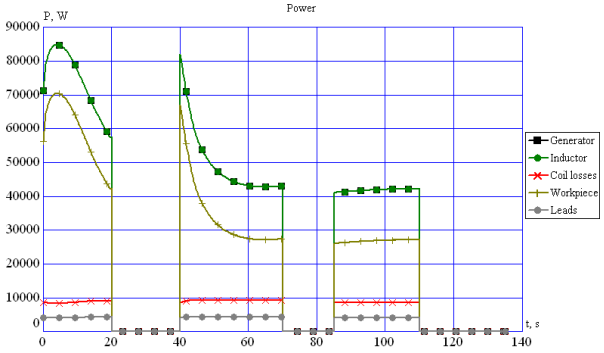

Figure 3. Power vs. time for case 1.

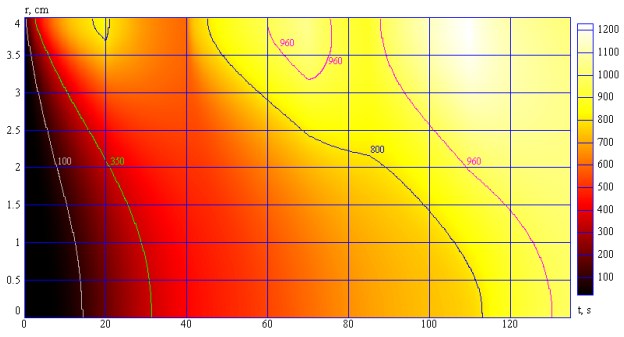

Figure 4. Color map of temperature for case 1.

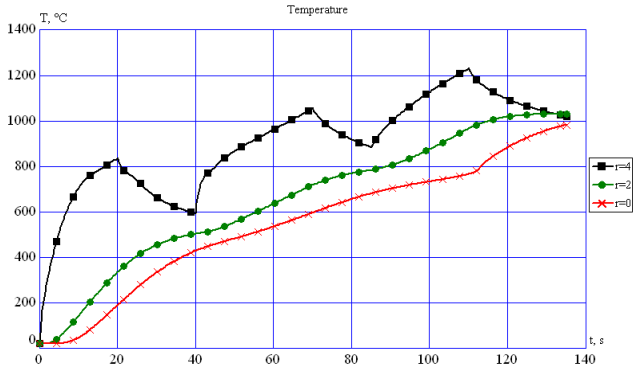

Figure 5. Temperature vs. time in the heated piece for case 1.

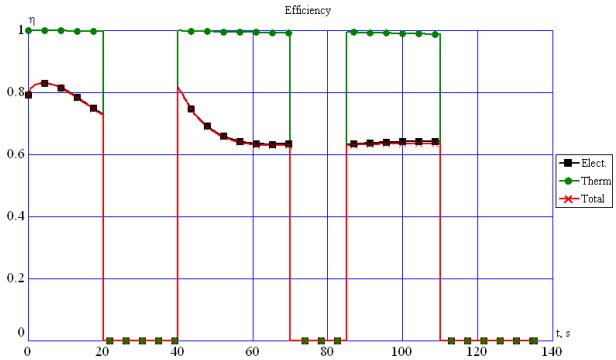

Figure 6. Efficiency of the system for case 1.

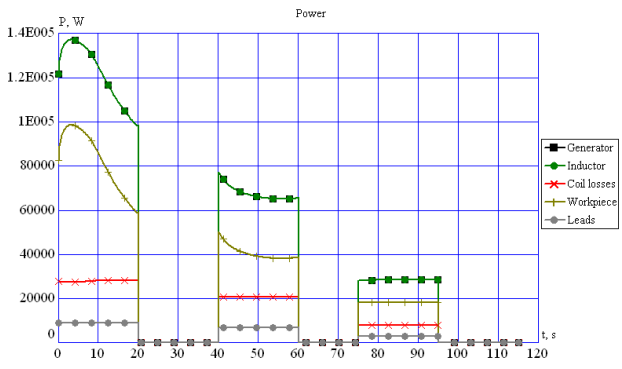

Figure 7. Power vs. time for case 2.

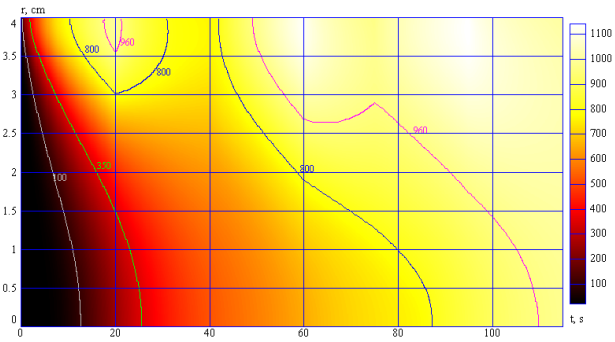

Figure 8. Color map of temperature for case 2.

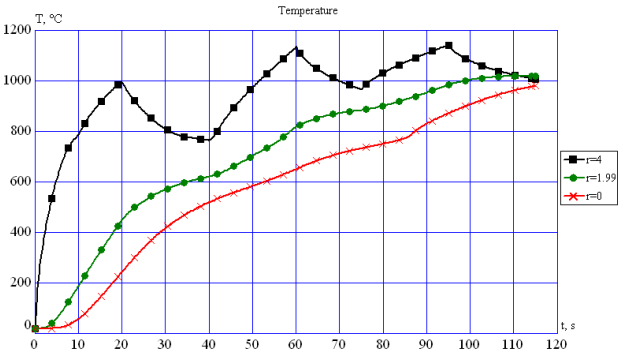

Figure 9. Temperature vs. time in the heated piece for case 2.

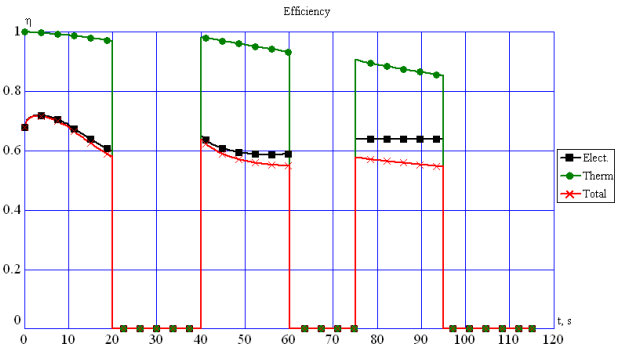

Figure 10. Efficiency of the system for case 2.

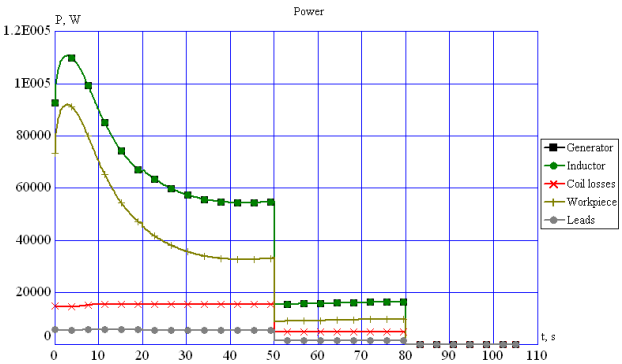

Figure 11. Power vs. time for case 3.

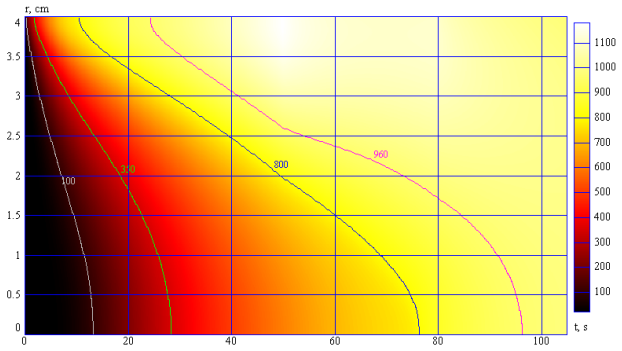

Figure 12. Color map of temperature for case 3.

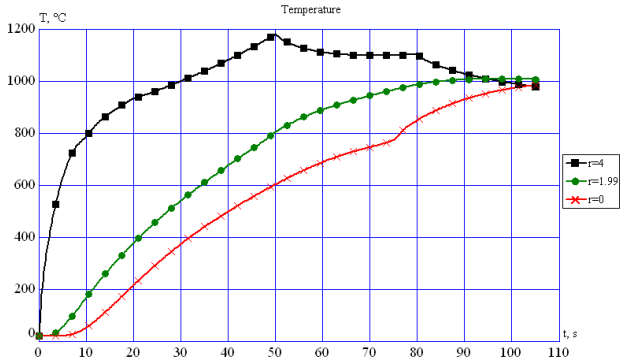

Figure 13. Temperature vs. time in the heated piece for case 3.

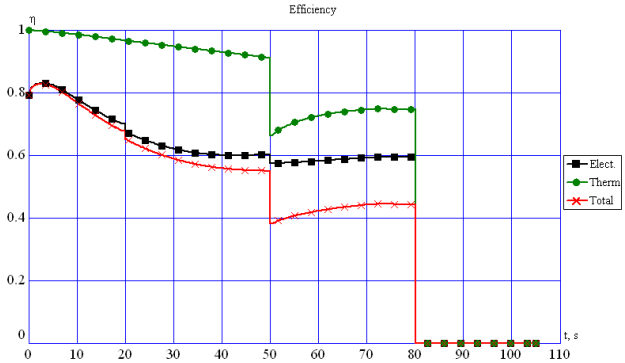

Figure 14. Efficiency of the system for case 3.

III. DISCUSSIONS AND CONCLUSIONS

Numerical modeling is a powerful tool for analyzing the thermal field coupled to determine electrical and geometrical parameters of inductive heating in a very short time. Uniform induction heating of long work pieces is a great challenge due to the complexity of the plant and thermal phenomena occurring while achieving this goal. From the analysis and the obtained results it can be seen that the uniform heating in volume depending on the thickness of the material requires more time than heating only a portion. In the same manner, we observed that the frequency and material properties are an important factor in achieving this. For case 1 when we achieved a high efficiency and inductors are connected to the same electrical parameters we have major advantages. The disadvantages of this solution is long time to obtaining uniform heating in the induction heating process, though it takes only 75 seconds. Case 2 highlights the relation between induction heating time and power consumption, thus the short time of heating leads to high power consumption. For the third case we can obtain a reduced time and power consumed for the uniform heating of the work piece, when the intermediate waiting periods for temperature propagation in the piece are eliminated. Results are obtained in a short period of time and are very important for the designer and the end-user to choose the best solution that fulfils the most requirements of the technological process and leading to a cost reduction for the design phase and also for the production phase, by increasing the efficiency and the quality of the end product.

ACKNOWLEDGEMENTS

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A Piezoelectric Energy Harvesting Converter For Charging Lithium-Ion Battery

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Abstract *– Generating energy from the environment, extend the time for using electronic devices. Saving energy is important, but most current systems are powered by batteries without having a permanent connection to the mains electricity power supply. Wireless sensors need energy and this can be compensated using piezoelectric sources. Mechanical vibrations are widespread: in a car or sensors in the ambient environment. Piezoelectric crystals are the most efficient solution for energy from random motion - from renewable resources. An ultra-low power electronic converter is needed to transfer energy from the piezoceramic crystal to an energy storage device (supercapacitor, battery). The paper analyzes the optimal conditions for collecting energy from the piezoceramic element. This study is useful for ways to convert energy in conjunction with its storage, in Lithium-Ion batteries.*

Keywords: *Energy Harvesting, Wireless Sensors, Piezoelectric, Low Power, Converter. .*

I. INTRODUCTION

Modern electronic systems tend to have a power consumption, more low. Under these conditions the energy demand varies from 100nW to 20MW. Piezoelectric generators have the capacity to provide sufficient energy. Using multiple piezoelectric crystal is just an extension of the electronic architecture often used.

Lithium-ion batteries are increasingly used and are absolutely necessary for a continuous energy supply in portable electronic systems or electronic systems that have lower power consumption.

The independence of energy supply is an important goal. Low power and very low power converter is coupled with the generators; which use ambient energy sources.The piezoelectric harvester could provide power for biomedical implants. Electrical power supply range [8] does not exceed 10mW.

Using the power harvested is possible to convert energy from human source, but only to recharge the battery. Direct use of energy collected is more difficult to integrate into electronic devices.

II. PIEZOELECTRIC GENERATORS

Some materials have the ability to generate electricity, in response to applied mechanical strain. The amount of electrical voltage resulting from pressure, this is the piezoelectric effect. The piezoceramic material used for power generation are: PZT (Titano-Zirconate de Plomb), PVDF Polyvinylidene Fluoride and MFC Macro-Fibre Composite.

The equations [12] for a piezoelectric material are:

$$\delta = \frac{\sigma}{Y} + dE \qquad (1)$$

$$D = \varepsilon E + d\sigma \qquad (2)$$

- δ is mechanical strain;
- σ is mechanical stress;
- Y is Young's modulus of the material;
- d is the piezoelectric strain coefficient;
- E is the electric field;
- D is the charge density;
- ε is the dielectric constant of the piezoelectric material.

The piezoelectric generator can be uses, by equivalence with of a current source [5], which has a parallel resistor R and capacitor C. Construction of the piezoelectric crystal in interaction with the mechanical parts will generate energy, not only in terms of resonance [8]. Basically it will collect energy in random vibration conditions at different frequencies. Simulated model is close to real. Electrical parameters values are common in other experiments.

There are numerous studies that examine the capability of human body as an energy source. A good energy-efficient solution consists of placing piezoceramic generators in shoes. During walking, the energy collected can be up to 8W.

Extracting energy from piezoelectric generator can be achieved in different frequency bands (10Hz, 2kHz), (10Hz, 500Hz) (10Hz, 200Hz). New piezoelectric structures are designed to provide energy from random vibration, not necessarily in resonance conditions. The electronic system presented in modeling and simulation work in range (10Hz, 2kHz), and is suitable new piezoelectric materials (ceramics, fibers).

II. HARVESTING PIEZOELECTRIC ENERGY

Diode rectifier for piezoelectric energy harvesting is an AC-DC converter whose input is the piezoelectric energy source.

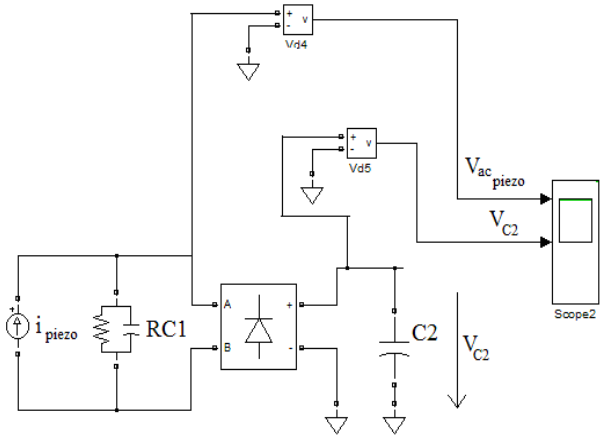

Fig.1. AC-DC converter.

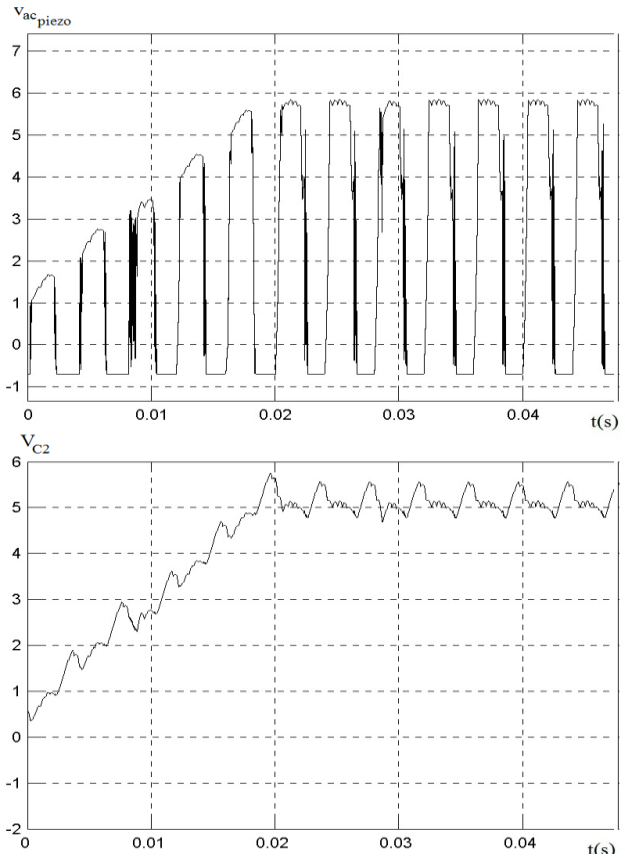

Fig.2. AC-DC converter - dynamic evolution.

The piezoelectric generator can be uses, by equivalence with of a current source, which has a parallel resistor R and capacitor C. Resistance R-value is very high ($M\Omega$) and the current generated is input to AC-DC converter.

The input voltage and output voltage, of the rectifier bridge Fig.1., are traced in the signal diagrams of Fig.2.

The capacitor C1 and C2 stores energy and them makes filtering Voltages.

A. DC-DC converter

It is a Buck DC-DC converter in which the electronic switch is a MOSFET transistor [10]. When the transistor is blocked, the current i_L will keep the flow direction and will be directed by D1.

$$i_L(t) = I_L + i_{L_{ripple}}(t) \quad (3)$$

$$I_L = Iout = \frac{V_{out}}{R_{load}} \quad (4)$$

$$i_{C_3}(t) = i_{L_{ripple}}(t) \quad (5)$$

The resulting average:

$$V_{in}I_{in} = V_{out}I_{out} \quad (6)$$

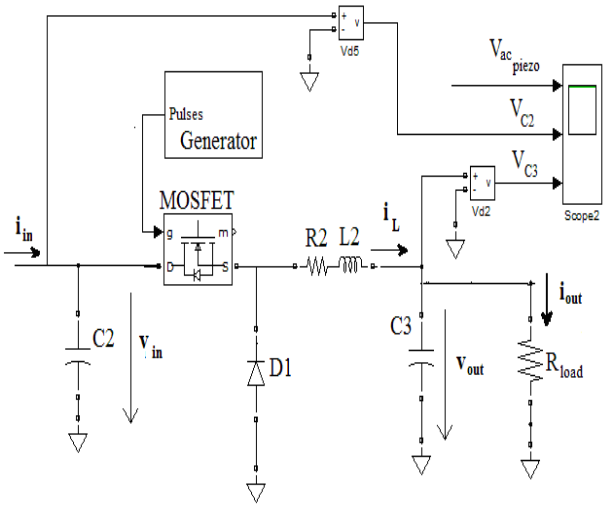

Fig.3. DC-DC converter.

The scheme is designed for continuous conduction mode, as current flows continuously through the inductor L2.

DC-DC converter is optimized by simulation. The two voltages are displayed on an oscilloscope: $v_{in} = v_{C2}$ and $v_{out} = v_{C3}$. Waveforms can be viewed in Fig.4.

A rectangular voltage generator will control the gate of the MOSFET transistor. The frequency is fixed. There are considerations of the optimum transfer of energy.

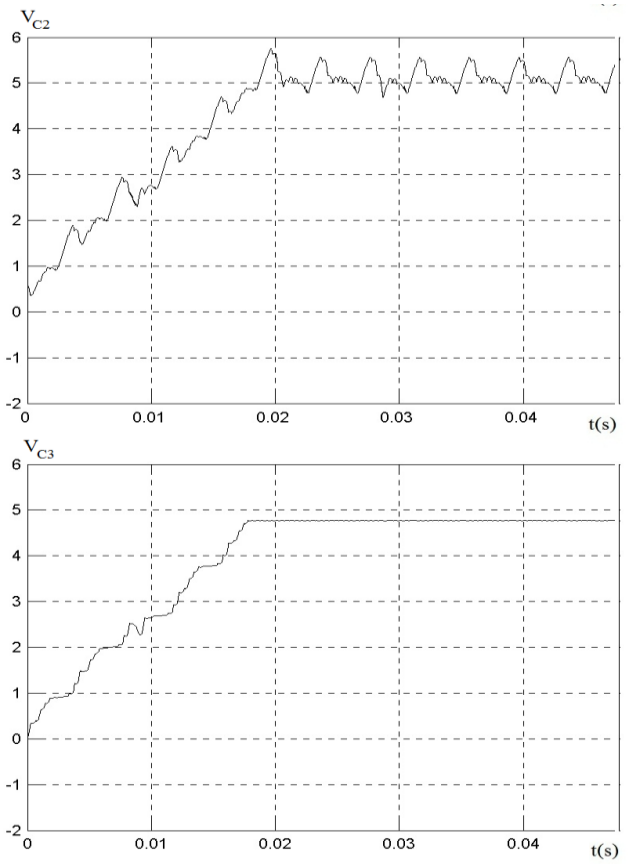

Fig.4. DC-DC converter - dynamic evolution.

B. Charging a battery

The energy harvested from piezoelectric crystal is very small. There is a need to use a storage device under intermittent supply of energy. This method of obtaining energy is useful for electronic devices that have a very low consumption.

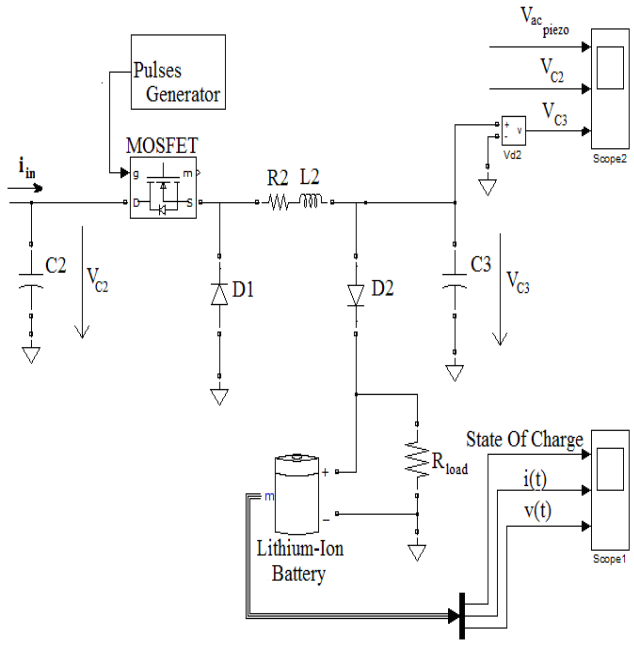

Fig.5. Charging a battery.

Values characteristic of Lithium Ion battery are:

$V_{max} = 4.3V$;

$V_{rated} = 3.7V$;

$Q_{rated} = 890mAh$ the rated capacity is the minimum effective capacity of the battery;

$Q = 900mAh$ maximum battery capacity;

SOC = initial value State of Charge = 35%;

State of Charge $SOC = \left(1 - \frac{\int_0^t idt}{Q}\right)$

$R_{int} = 4m\Omega$.

Mathematic model is offered by Matlab-Simulink for Lithium-Ion battery charging

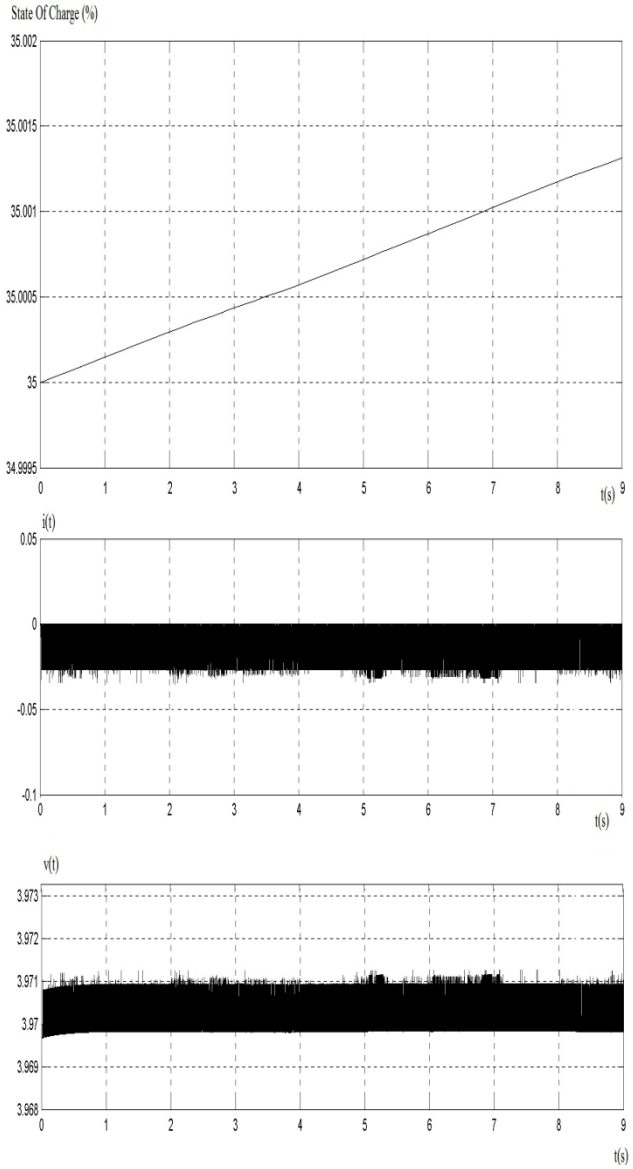

Fig.6. Charging a battery - dynamic evolution.

The battery used is similar to a mobile phone battery. In Fig.6. can see that SOC increases by 0001% in 7s. A similar simulation for a long time in one hour, providing an increase in SOC = 2.8%, respectively, within 24 hours, growth is SOC = 67%. It is obvious that energy is small, but is still significant for a long time. For energy independence in mobile communications, this solution is justified.

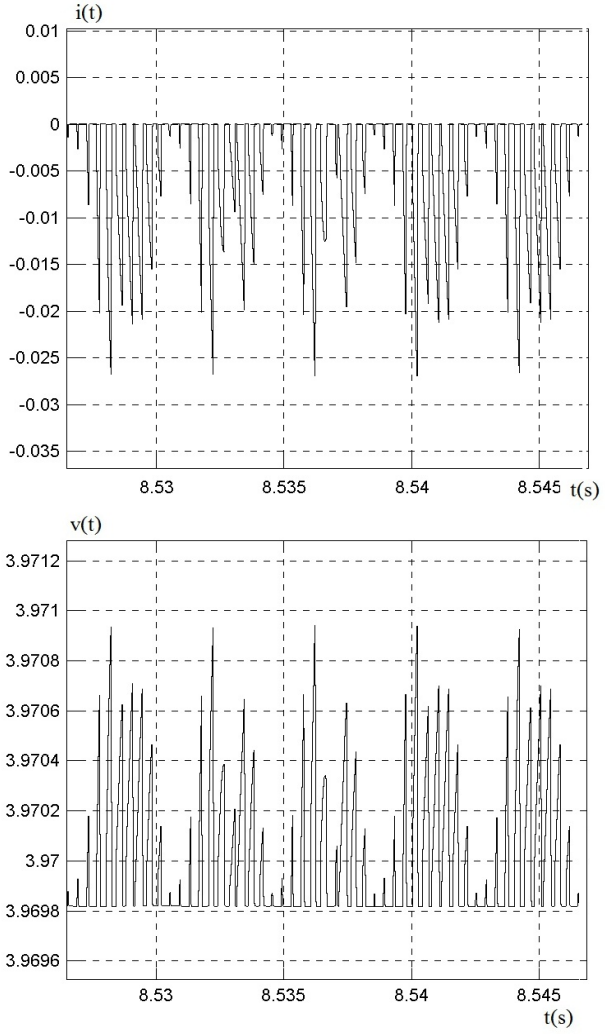

Fig.7. Charging a battery,
short-time dynamic i(t) and v(t) evolution.

Graphs of signal i(t) and v(t), for battery charging are shown in Fig.7. The current is negative because the battery is in charging current. The positive direction of current is the battery-powered electric consumer. Voltage v(t) is in an adequate range of variation, which was higher than $V_{rated} = 3.7V$.

IV. CONCLUSIONS

A model was developed, in which energy is harvested from a piezoelectric generator. Current theoretical considerations are implemented in a simulation scheme so determination optimization of low power electronic converters for a proper design.

Real values of electrical parameters are used for both piezoelectric structures and for Lithium-Ion battery. Moreover, they are modeled in the simulation blocks to follow the evolution of their dynamics.

Energy conversion using a high efficiency DC-DC converter is performed in accordance with piezoelectric source and what it will charge the battery without connecting to power sources.

In considerations of the methodology presented in the paper system can properly size the energy from renewable sources, using various electronic devices properly chosen to achieve maximum recoverable energy.

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Aspects Regarding the Optimization of the Induction Heating Process using Differential Evolution

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Abstract ***This work is focused on the optimization of the induction heating process by using differential evolution (DE). The main advantages of DE are finding the global optimum and rapid convergence. The algorithm is based on the population evolution as genetic algorithms use similar operators: crossover, mutation and selection. DE is applied in the optimal design problem of an induction heating device and the results are compared with those obtained using genetic algorithms.***

The algorithm seems to be a promising approach to optimization problems in engineering.

Keywords: Optimization; Differential Evolution; induction heating.

I. INTRODUCTION

In 1995, Storn and Price proposed a new evolutionary optimization method, the differential evolution method [2],[4], [5], [8], [9], [10], [11]. The differential evolution algorithm is a stochastic, population-based optimization algorithm. The basic idea of DE is a scheme for generating trial parameter vectors. It adds the weighted difference between two population vectors to a third vector. In this way, the user does not need to have separate probability distribution, as need the other evolutionary algorithms, which makes the scheme completely self-organizing. The algorithm uses 3 operators: crossover, mutation and selection. The main advantage of DE relies on mutation operation. This operator is based on the differences of randomly selected candidate solutions in the population and it behave as a search mechanism. The selection operator behaves similar to other evolutionary algorithms and it directs the search. DE also has a non-uniform crossover operator that use information provided by one parent more often than it does from the others.

In this paper the DE algorithm is used in the optimal design problem of an induction heating device.

The next chapter refers to previous work concerning the induction heating device and presents aspects regarding the modeling of the induction heating process and the results obtained by using genetic algorithms (GA).

The rest of the paper briefly introduces DE algorithm. Then it focuses on how it was applied in the design problem, presents the obtained results and the conclusions.

II. MODELLING THE INDUCTION HEATING DEVICE

This chapter refers to previous work presented in [7]. It performs numerical investigation and modelling of an induction heating system. We have built a physical model for induction heating in volume of a cylindrical workpiece. In figure 1 we present the induction heating device of a cylindrical workpiece. The inductor is used to heat the cylindrical workpiece using the heating in longitudinal field.

In this figured we can observe:

1- cillindrical workpiece
2- inductor turns
3- water (couling liquid).

The cylindrical workpiece that we will heat in inductor is built from steel, and has a diameter of 80 mm and 200 mm in length.

As variable parameters the inductor length and the air-gap between the workpiece and inductor are considered.

The workpiece is heated by eddy-curent loses produced by the magnetic field.

The electromagnetic and thermal fields are coupled and have a 2D axis symmetric structure in cylindrical coordonates (r,z). The coupled problems are further modelled by means of Finite Element Method (FEM),

taking into consideration the temperature dependence of material characteristics.

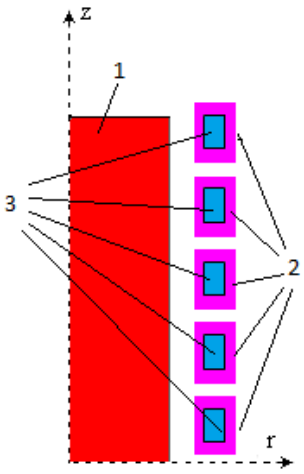

Figure 1. Induction heating of cylindrical work piece

The mathematical models of electromagnetic and thermal fields, based on the specific laws of this phenomena are described by partial differential equations with non-linear coefficients.

The equations that describe the mathematical model of cvasi-static harmonic field expressed in complex vector potential ***A,*** [1], [3]:

$$\mathrm{rot}\left(\nu \mathrm{rot}\boldsymbol{A}\right) + \mathrm{j}\omega\sigma\boldsymbol{A} = \boldsymbol{J} \tag{1}$$

The heat diffusion equation is given by relation (2):

$$c\frac{\partial T}{\partial \mathrm{t}} - \mathrm{div}\lambda\mathrm{grad}T = p \tag{2}$$

where c is the specific heat, λ is the thermal conductivity and p is the volume density of the power.

The two-dimensional electromagnetic problem is coupled with a transient thermal problem. These problems are solved by using the PDE toolbox in Matlab (which applies FEM) combined with an iterative loop. The algorithm consists of two numerical solvers, one for the electromagnetic equation and the other for the heat equation, also considering the convection and radiation conditions. The electromagnetic problem was solved taking into account the temperature dependence of material properties, while in the thermal problem the temperature dependence of the thermal coefficients was taken into account. The algorithm evolved iteratively and the described steps were repeated until the final desired temperature in the work piece is reached, while the time step was continuously adapted to the average temperature difference resulted in each of iteration. When the Curie temperature was approached, the time step was decreased, considering the sharp decrease of the relative permeability, [7].

The aim of induction heater design is to provide a uniform temperature distribution in the work piece and to assure a high electrical efficiency. The optimization is carried out to find the heater's geometric parameters and the frequency of the supplied power which lead to a final temperature distribution as uniform as possible and to a high electrical efficiency, without exceeding a maximum average temperature in the work piece.

If deterministic algorithms are used in the optimization task, typically assumptions concerning the properties of the objective function are considered. Some of these assume that the problem is linear, convex, the search space is continuous, derivatives or other auxiliary information on the objective function is available, that the problem is available in analytical form and others. If the objective function does not satisfy some of these assumptions, the optimization algorithm is not suitable and the results will not be appropriate. In such cases, evolutionary algorithms perform well, having as disadvantage the high computational costs, [13], [14].

In order to solve the optimal design problem, the FEM analysis becomes the evaluation step of an optimization algorithm which has the ability to find the global optimum of a nonlinear problem subject to constraints on the variables, as presented in figure 2.

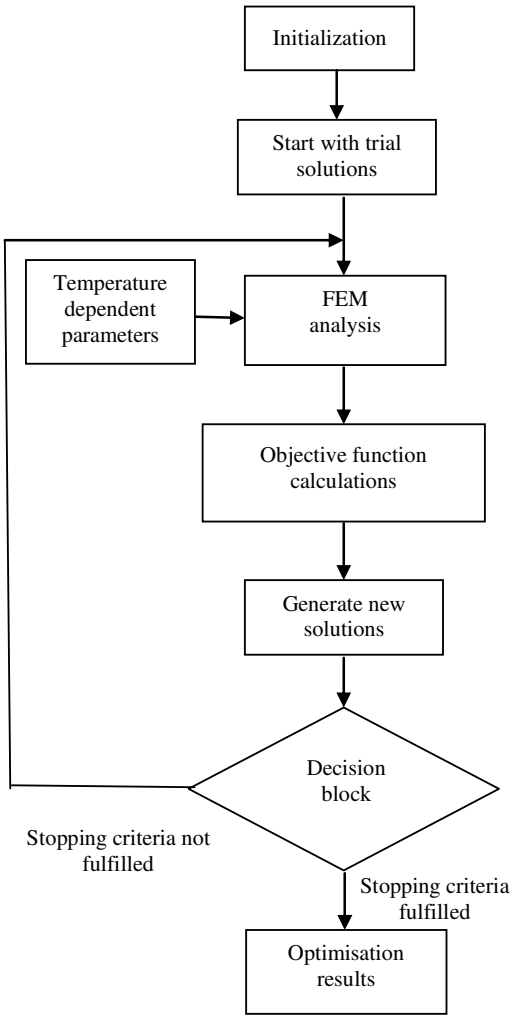

Figure 2. An optimization algorithm using the FEM analysis in the evaluation step

As for optimization algorithm, different solutions may be applied, for example may be used one of the

evolutionary algorithms, which are suitable to search the global optima of a nonlinear complex problem. In [7], genetic algorithms were used. Table 1 presents the best results obtained with GA, where *rand* stands for electrical efficiency and *ecart* for the temperature gap in the work piece at the end of the heating.

Table 1. The solutions obtained with GA

f [Hz]	Lind [m]	h [m]	ecart [°C]	rand [%]
1102.0975	0.1450	0.0010	204.8767	69.11
913.0529	0.1442	0.0010	164.6998	69.89
907.1050	0.1442	0.0010	163.0130	69.86
828.6229	0.1277	0.0012	132.6263	69.42
927.8151	0.1313	0.0010	129.2788	69.16
632.0527	0.1449	0.0010	116.9644	68.41
819.3478	0.1343	0.0034	114.4589	67.77
910.2839	0.1290	0.0021	116.3087	68.75
985.8491	0.1292	0.0055	112.0084	67.26
1420.4631	0.1224	0.0102	103.0639	63.79
2995.9575	0.1138	0.0115	93.1985	52.00

The next section briefly introduces DE. This algorithm is further applied in the optimization process of the same problem, having the goal of investigating the power of DE algorithm in this type of engineering problems.

III. DIFFERENTIAL EVOLUTION ALGORITHM

DE belongs to the class of biology-inspired algorithms and uses operations of selection, crossover and mutation applied on a population of potentially solutions in order to find the minimum of an objective function by evolving the initial population. DE is a stochastic search algorithm, which generates trial parameter vectors. It adds the weighted difference between two population vectors to a third vector in such a way that the user does not need to have separate probability distribution.

The main advantage of DE relies on mutation operation. This operator is based on the differences of randomly selected candidate solutions in the population and it behave as a search mechanism. The other advantage of DE relies on the selection operator which directs the search, as is the usual case in the evolutionary algorithms. DE also has a non-uniform crossover operator that use more vector information provided by one parent more often than it does from others, [12].

In DE, a population of NP solution vectors is randomly established. The dimension of the vectors is related to the number of the parameters derived from the optimization task. The initial population is iteratively improved by applying the DE operators: mutation, crossover and selection.

The main steps of the DE algorithm are the following:

Initialization
Evaluation
Repeat
Mutation
Crossover
Evaluation
Selection
Until (termination criteria are met) [12]

The initial population is represented by candidates which are D-dimensional vectors, where:

$\overrightarrow{X_i}(t) = [x_{i,1}(t), x_{i,2}(t), ..., x_{i,D}(t)]$ is the *i*th vector of the population at the current generation, at time t. The population members are called chromosomes or genomes [8].

The objective of the algorithm is to find a solution $x^* \in X$ for the function $f: X \subseteq \mathbb{R}^D \to \mathbb{R}$, such that, $f(x^*) \leq f(x), \forall x \in X$, where *f(x)* is the objective function, which is to be minimized.

If the *j*th parameter of the vector has its lower and upper bound x_j^L and x_j^U then the $x_{i,j}$ component is initialized as follows:

$$x_{i,j} = x_j^L + rand(0,1) \cdot (x_j^U - x_j^L)$$

where $rand\ (0,1)$ is a random number between 0 and 1, that is randomly select the initial component vector values uniformly in the intervals, $[x_j^L, x_j^U]$, [5].

The initial population should cover the entire parameter space, as uniform as possible. Usually a uniform probability distribution for all random decisions is assumed. In case the user already has a preliminary solution, the initial population might be generated by adding normally distributed random deviations to this solution, [9].

After the initialization stage, all the population members are evaluated by making use of the objective function. It has to be noted, that in the case of the design problem approached in this paper, the FEM analysis module is to be applied for each population member. The direct consequence of this fact is the increased computational cost of this algorithm.

In each generation, to change a population member, $\overrightarrow{X_i}(t)$, a donor vector $\overrightarrow{V_i}(t)$ is created. The difference among various DE schemes is given by the method of creating this donor vector.

DE produces new vectors by adding the weighted difference between two other vectors to a third vector. The resulting vector is evaluated. If it has a lower objective function value than a given population member, the new vector replaces the vector, with which it was compared, in the next generation; otherwise, the old vector is retained. This process is repeated a given number of iterations (called generations) or until another stopping criteria is meet, such as finding the exact solution or the solution's error is less than a given value that was set a priori by the user.

There are variants of DE where more than one weighted difference vector can be added to an existing vector. Several variants of DE, which are developed to improve optimization performance, are described in literature. [2], [4], [5], [8], [9], [10], [11]. The performance of DE depends on the mutation and crossover strategy, as well on the parameter values. Different problems may require different mutation and crossover strategies and different parameter values. The

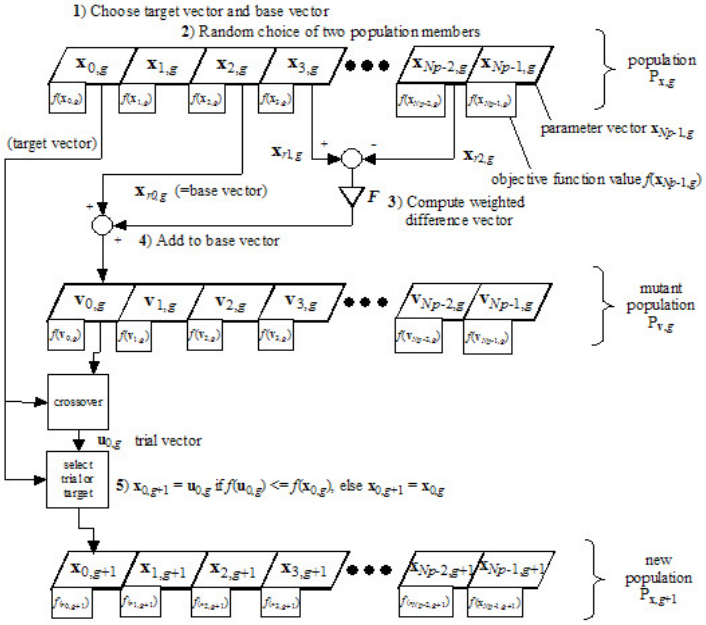

Figure 3. DE algorithm, [4]

available computation resources also influence the choice of these parameters. The algorithm used by the evolutionary algorithm in this paper is presented in figure 3, [4].

The DE algorithm has the following control parameters: number of population members N, scaling factor F and crossover rate CR.

The crossover rate controls how many and which components are mutated in each member of the population. It is the probability of mixing between trial and target vectors $0 \leq CR \leq 1$.

The scaling factor F is a positive number and its value influences the probability of trapping a local optimum . It must be above a certain minimal value, but a large value of F leads to an increased number of objective function evaluations, drastically increasing the computational costs.

The problem specific parameters of the DE algorithm are the maximum generation number G_{max} and the number of vector components defining the problem dimension D.

The values of these two parameters depend on the problem to be solved, [6].

By the other hand, a larger population requires a larger number of objective function evaluations and leads to a slower convergence rate. Usually, to balance the speed and the performances, the following classical settings for the DE algorithm are to be established: set the number of N to 10 times the number of components of the candidate solution vectors, select weighting factor F=0.8 and crossover constant CR=0.9.

It has been found [4] that selecting F from the interval [0.5, 1.0] randomly for each generation or for each difference vector, a technique called dither, improves convergence behaviour significantly, especially for noisy objective functions.

It has also been found [4] that setting CR to a low value, e.g. CR=0.2 helps optimizing separable functions since it fosters the search along the coordinate axes. On the contrary this choice is not effective if parameter dependence is encountered, something which is frequently occuring in real-world optimization problems rather than artificial test functions. So for parameter dependence the choice of CR=0.9 is more appropriate.

Another interesting empirical finding, [4] is that rasing NP above, say, 40 does not substantially improve the convergence, independent of the number of parameters, [4].

IV. USING DE FOR OPTIMAL DESIGN OF THE INDUCTION HEATING DEVICE

The heater selected for this experiment has the following dimensions: workpiece length h_2 = 0.200 m, workpiece diameter d_2 = 0.080m.

The goal is to obtain an optimum design which willl fulfill two criteria:

- Obtaining the maximum value of electrical efficiency
- Obtaining a temperature distribution as uniform as possible, that is obtaining the minimum value of temperature gap at the end of the heating (ecart).

We have used an optimization program, that implement differential evolution algorithm (DE) in Matlab, with constant current density ji=22 A/mm^2.

The piece is heated from the initial temperature θ_i=20°C to the mean value of workpiece temperature at the end of the heating, θ_f=1300°C.

The design parameters are the following ones:

- the first parameter is frequeny

f ∈ [50 3000] Hz;

- the second parameter is the inductor lenght/2
  Lind ∈ [0.100 0.145] m;
- the third parameter is the air-gap
  h ∈ [0.003 0.015] m.

Since this design has multiple and conflicting objectives, the optimization problem implies a multiobjective search strategy. This type of problems have no one single solution, but a set of sulutions called Pareto set. A number of stochastic search strategies such as evolutionary algorithms, have been developed to solve such problems and some of these are based on Pareto dominance [12].

In this work, the two opposing objectives are combined in a scalar number by using the weighting coefficients method, combined with a scaling method, as presented in [7].

Firstly, since the two objectives belong to different domain values, a scaling function is needed. Having this goal, two simplified problems were firsly considered, each of them having only a single objective. Thus, we considered in turn the problem of maximizing and minimize the efficiency respectively the temperature gap in the work piece. DE was applied and the following results were obtained:

- ecart_min=20;
- ecart_max=800;
- rand_min=0.10;
- rand_max=0.90.

where:

- ecart_min and ecart_max stand for the minimum, respectivelly the maximum temperature gap in the work piece at the end of the heating process by ignoring efficiency values;
- rand_min and rand_max stand for the minimum, respectivelly the maximum electrical efficiency, ignoring the temperature gap in the work piece at the end of the heating process.

These values were used in the scaling procedure and also in obtaining the single, scalar objective function used further in the design process, taking also into consideration that the efficiency is to be maximized, while the temperature gap is to be minimized, as given in relation (3)

$$F_{obj} = w \cdot \frac{(ecart - ecart_{\min})}{(ecart_{\max} - ecart_{\min})} + (1 - w) \cdot \frac{(eff_{\max} - eff)}{(eff_{\max} - eff_{\min})} \quad (3)$$

In relation (3), w is a weighting coefficient belonging to [0, 1] interval and F_{obj} is to be minimized.

Using the objective function given by relation (3), DE was applied for a population of 40 individuals and the algorithm evolved 40 generations, weighting factor F=0.8 and crossover constant CR=0.9. In order to find the Pareto set, multiple runs were performed for different values of the weighting coefficient: w=0; 0,1; ... 0,9; 1.

The obtained results are presented in table 2.

Table 2. The solutions obtained with DE

w	f [Hz]	Lind [m]	h [m]	ecart [°C]	rand [%]
0.0	1007	0.129	0.005	114.9	0.675
0.1	840	0.143	0.003	143.5	0.689
0.2	785	0.140	0.003	123.1	0.681
0.3	929	0.125	0.005	133.7	0.67
0.4	652	0.145	0.005	111.5	0.664
0.5	1222	0.132	0.011	92.72	0.526
0.6	1109	0.124	0.008	125.5	0.650
0.7	1000	0.127	0.003	115	0.67
0.8	1063	0.127	0.006	105.2	0.56
0.9	1547	0.117	0.004	82.52	0.514
1.0	1941	0.115	0.007	110.67	0726

Temperature distribution map in a workpiece at the final of the heating process is presented in figure 4.

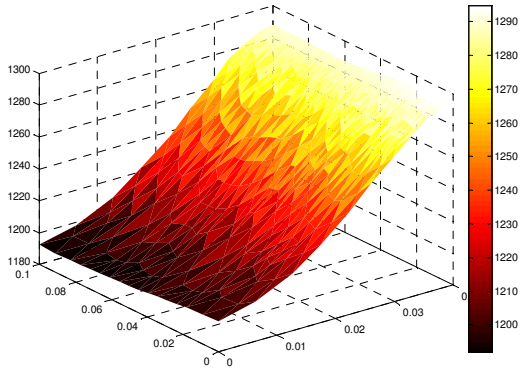

Figure 4. Temperature distribution map in workpiece at the final of the heating process

By examining the obtained results, it can be seen that DE perform well in solving optimal design problems. parameters estimation problems. DE have speed to get the solutions, for example DE computes the solution in 1 hour and 40 minutes, while GA computes the solution in about 5 hours. However, comparing the results obtained by using the GA with those using DE, that is Table 1 with Table 2, it can be seen that GA performed better.

V. CONCLUSIONS

The presented paper is trying to find alternative ways for optimal design problems of electromagnetic devices, increasing the flexibility of the techincs and empowering user with advanced techniques, e.g. simulation models and novel search techniques.

Based on the obtained solutions, it can be concluded that DE are an alternative technique that can be successfully used to solve the proposed problems. It was proven that DE is robust, global and straightforward.

The main disadvantage of using DE consists in its high computational cost, due to the complexity of the electromagnetic phenomena, which in this case is reflected in the complexity of the FEM analysis. It has to

be noted, that this disadvantage tends to decrease with the currently increasing computing power.

Compared to other search procedures such as GA, the perfomed simulations obtained better values with GA. However, this work can be continued considering different values for the parameters of DE.

ACKNOWLEDGMENTS

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Improving Robustness of the SCORPIO Robot Speech Interface by Iterative Spectral Subtraction

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***Abstract* – The paper describes an approach to improve robustness of the SCORPIO speech interface via increasing speech recognition accuracy in street noise conditions. The SCORPIO speech interface serves for controlling secondary functions of the service robot SCORPIO, which is developed with aim to serve for booby-trap disposal. The main workspace of the robot is a noisy outdoor environment. Therefore street-noise robustness of the speech interface is an important issue. The speech enhancement based on spectral subtraction method was used to achieve this goal. Experiments with simulated outdoor environment were done using recordings with different levels of signal-to-noise ratio. Comparison of basic, modified and iterative algorithm showed significant improvement especially in the case of iterative spectral subtraction.**

***Keywords:* speech enhancement; spectral subtraction, automatic speech recognition; noisy environment; service robot;**

I. INTRODUCTION

A service robot is a mobile device carrying out services either partially or fully automatically [1]. Their primary application domains are services like manipulation, movement and monitoring.

With the expansion of robotic systems, the speech-based human–machine interaction increases its importance. A lot of various functionalities makes difficult to control the robot only by hands (using keyboard, buttons and joysticks) and in such situation the speech modality can be helpful to control secondary functions of the robot.

The common problem of integrating the speech interface for controlling service robots is that its main working area is an outdoor, noisy environment. Therefore, it can be more difficult to reach satisfied accuracy of the speech recognition process. In our previous paper [12] we described also the results of experiments which were done with simulated outdoor environment. The conclusion of mentioned experiments let us to find some robustness improvement methods, because the speech interface seems to be unusable when SNR was smaller than 5dB.

The possible solutions for improvement robustness of speech recognition in noisy environment are model compensation, use of robust features and recognition algorithm and speech enhancement [13].

At the beginning we decided to use the speech enhancement techniques for improving robustness of SCORPIO speech interface. Specially, spectral subtraction method and its modifications are usually used with positive impact on the system robustness.

The simple speech enhancement toolkit was prepared, which enables three enhancement methods (Spectral subtraction, Wiener filtration and MMSE algorithm). This toolkit was used as a preprocessing unit in SCORPIO speech interface and is described in more detail in [18].

A set of recordings, which contain commands for service robot, were recorded, annotated and processed for comparison of basic, modified and iterative spectral subtraction algorithms. Then a set of tests were carried out with different level of signal-to-noise ratio.

The paper is organized as follows. In the next section, the service robot SCORPIO as well as its speech interface is described. Then, in third section, the spectral subtraction principle and selected methods are introduced. Fourth section brings information about experiments which were done and discussion of results.

II. SCORPIO SPEECH INTERFACE

A. The SCORPIO service robot

For the purpose of our work the SCORPIO service robot was adopted as the experimental function model. The SCORPIO is a mobile service robot for booby-trap disposal, especially underneath vehicles, developed by the ZTS VVU Kosice, a.s. company [2]. The system has two parts – the mobile robot vehicle and the control unit (panel). Both are depicted on Fig. 1.

The vehicle bears cameras, direction finding lasers, rangefinders and lights. The control unit has a form of briefcase with an embedded computer with display and control panel with control buttons, keyboard and joystick. The main functionalities of the panel are displaying the video from cameras, displaying values measured by the vehicle, controlling the movement of the vehicle (by joystick) and turning on/off cameras, lights and rangefinders of the robot (by a set of buttons). The communication with the mobile robot vehicle runs using a wireless network.

B. The SCORPIO Speech Interface

The main reason for implementing speech interface was the limitation of control panel interface caused by large number of functionalities, which are difficult to be controlled simultaneously by human operator. Therefore take speech as an input-output modality seems to be a suitable accessory.

The Scorpio Speech Interface (Fig. 1.) has been designed and implemented for controlling secondary functions of the service robot. Upon analysis of robot's functionalities and usage scenarios a set of voice commands and pronunciation dictionary were prepared and acoustic models were trained.

Then the speech interface was integrated into the control panel. It consists of two modules: an automatic speech recognition engine (ASR engine) and a control panel interface (CPI). The ASR engine adopts as its background open-source libraries described in [3]. The control panel interface transforms and delivers the speech commands to the control panel software. The SCORPIO Speech Interface is described in our previous paper [12] in more detail.

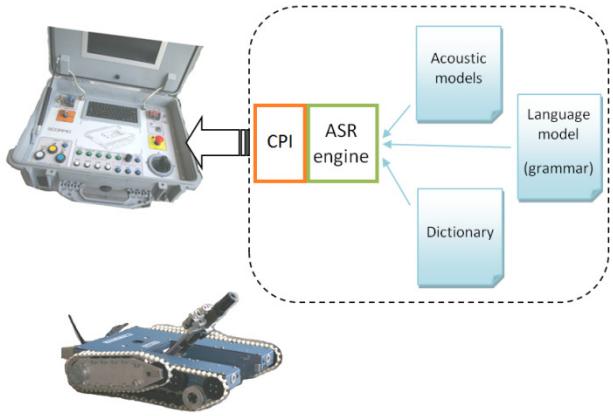

Fig. 1. SCORPIO service robot speech interface

III. SPECTRAL SUBTRACTION AND ITS MODIFICATIONS

The basic assumption is, that the noisy speech signal *y(n)* consists of speech signal *s(n)* and additive noise signal *d(n)* [15] as follows:

$$y(n) = s(n) + d(n) \quad (1)$$

In the frequency domain, equation (1) is expressed as

$$Y(\omega) = S(\omega) + D(\omega), \quad (2)$$

where $Y(\omega)$, $S(\omega)$ and $D(\omega)$ are spectra of signals *y(n)*, *s(n)* and *d(n)*.

$Y(\omega)$ can be expressed in exponential form as

$$Y(\omega) = |Y(\omega)| e^{j\phi_y(\omega)}. \quad (3)$$

If the noise spectrum $\hat{D}(\omega)$ can be estimated, then an approximation of speech spectrum $\hat{S}(\omega)$ can be computed from final signal spectrum $Y(\omega)$:

$$|\hat{S}(\omega)|^p = |\hat{Y}(\omega)|^p - |\hat{D}(\omega)|^p, \quad (4)$$

where *p* is the power exponent.

The equation (4) represents the general algorithm of spectral subtraction. If *p=1* then it is the basic version of spectral subtraction of magnitude spectra. If *p=2* then it is the algorithm of power spectral subtraction [14].

The spectral subtraction can give negative values of speech spectrum approximation, when the estimated noise spectrum is greater than final signal spectrum. There are several solutions to deal with this problem. The simplest one, proposed by Boll [7], is to let the spectrum has zero values and implements following relationship:

$$|\hat{S}(\omega)|^2 = \begin{cases} |Y(\omega)|^2 - |\hat{D}(\omega)|^2, if\ |Y(\omega)|^2 > |\hat{D}(\omega)|^2 \\ 0, otherwise \end{cases} \quad (5)$$

A different approach proposed by Berouti et al. [14] is based on using the flooring factor β. Their method consists of subtracting an overestimate of the noise power spectrum, while preventing the resultant spectral components from going below a preset minimum value (spectral floor) [15]. The realization follows next equation:

$$|\hat{S}(\omega)|^2 = \begin{cases} |Y(\omega)|^2 - \alpha|\hat{D}(\omega)|^2, if\ |Y(\omega)|^2 > (\alpha+\beta)|\hat{D}(\omega)|^2 \\ \beta|\hat{D}(\omega)|^2, else \end{cases}, \quad (6)$$

where α is the oversubtraction factor ($\alpha \geq 1$), and β ($0 < \beta << 1$) is the spectral floor parameter. As is mentioned in [15], these parameters enable a great amount of flexibility to the spectral subtraction algorithm. The parameter α affects the amount of speech spectral distortion caused by the subtraction. The parameter β controls the amount of remaining residual noise and the amount of perceived musical noise. Optimization of speech recognition accuracy can be reached by varying these parameters.

A. LIMA framework for Spectral Subtraction

Kleinschmidt in [13] presents modified LIMA (likelihood-maximising) enhancement technique for spectral subtraction, where the values of power exponent *p* and β floor parameters are optimizing to best fit the instantaneous relationship between clean speech and noise signals. The proposed modification removes the need of access the state models and the state sequence information. Only access to full utterance likelihoods and word sequences is required. This approach is well suitable for using with stand-alone or third-party speech recognition engines [13].

As a criterion for maximization the word recognition accuracy was taken. Results of the experiments proposed in [13] show the possibility blindly optimize spectral subtraction parameters using only utterance level scores (Accuracy, Word Error Rate). The second important fact proposed in [13] is, that there is the potential to achieve better performance when the values

of p and β are not constrained to their traditionally used values.

B. Iterative spectral subtraction

The main disadvantage of using spectral subtraction speech enhancement technique is the occurrence of musical noise in enhanced signal and distortion of speech. Speech distortion becomes severe when the degree of noise reduction is larger. Distortion can be reduced by several modification of basic subtraction algorithm. Some improvement can be achieved using an approach proposed in [14] and by adjusting α and β parameters.

The next promising approach is using iterative spectral subtraction technique, as is proposed in several articles (e.g. [8], [9], [11] and [16]). As Xiangbin wrote in [16], the principle of iterative spectral subtraction lies in the fact, that the former enhanced speech becomes latter input signal, so music noise is seen as input noise to reduce again. The results published in mentioned papers show improvement potential especially in second iteration. According [17], lower amount of musical noise is observed after using iterative "weak" spectral subtraction, when rather less noise is subtracted in particular iterations.

IV. EXPERIMENTS

A. Setup of the experiment

At the beginning we realized a set of testing recordings with 60 participants. Recordings were recorded with video eyewear iWear™ VR920, which are intended to use by operator of the service robot. This device contains an integrated USB audio system with a built-in microphone (in eyewear frame). Recordings were done in a room with office background quality (SNR around 25dB). Each recording contains all commands for controlling the SCORPIO robot. The overall length of all recordings is about 100 minutes. After that all recordings were annotated.

For the simulation of the real outdoor conditions we took recording of noisy street (with noises of cars, buses and trams) from the JDAE-TUKE database (Joint database of acoustic events and backgrounds), which was created in our laboratory [4].

The software tool FaNT (Filtering and Noise Adding Tool, described in [5]) was used for creating a mix of the clear test recordings and the street noise. Two groups of recordings were prepared with specific signal-to-noise ratios (SNR) of 10dB and 0dB.

All recordings were tested using the SCORIO speech interface and the overall WER (Word Error Rate) were calculated. Tests were done with phoneme-based acoustic models trained on SpeechDat-Sk database [6] with 256 numbers of PDF mixtures. The context-free speech grammar was used as a language model, which has a form of parallel network of 62 commands. Models were described in our previous paper [12] in more detail.

B. Reference test

At the beginning, the reference values of WER for clear recordings as well as noisy recordings without enhancement were obtained in offline test (see Table 1.).

TABLE 1. The reference results (without enhancement)

SNR (dB)	**25**	**10**	**0**
WER (%)	2.76	16.78	61.81

Recordings with SNR=10dB has WER higher about 14% against clear recordings. When SNR was 0dB, speech recognition system is rather unusable (61.81% of WER). Therefore, in the next experiments we used spectral subtraction methods for enhance speech signal and to decrease Word Error Rate.

C. Experiments with spectral subtraction based on modified LIMA framework

As was described in [13], there is the potential to achieve better speech recognizer performance when the values of p and β are optimized according speech recognition accuracy. We assume that together with power exponent and floor parameter also oversubtraction factor α can be adjusted to bring more robustness in speech recognition in noisy environment. At the beginning we decided to adjust only α and β parameters and to let the power exponent p equal *2*.

According these assumptions, more than 20 tests were done, where α was in interval *<0.5, 2>* and β was in interval *<0.1, 1>*. Prepared *Speech Enhancement Toolkit* was used for applying spectral subtraction algorithm with varying parameters. Results, where WER decreased, can be seen in Table 2.

TABLE 2. The results of experiments with spectral subtraction enhancement with varying α and β parameters

		WER [%]	
α	β	SNR = 10dB	SNR=0dB
without enh.		16.78	61.81
2	1	14.62	62.81
2	0.5	13.05	60.5
1.5	0.5	12.72	51.17
1	0.5	12,27	50.47
0.5	0.5	**12.16**	**50.62**

As we can see in the Table 2. the best recognition performance was reached when oversubtraction factor α was about *0.5* and flooring factor β was also about *0.5* (so called "weak" spectral subtraction [17]).

As we supposed, speech recognition accuracy is higher (and WER is lower), when spectral distortion of speech is rather low (α has lower value) and there is rather higher amount of remaining residual noise and lower amount of musical noise, which is affected by factor β. The best result, in our case was reached, when β was about *0.5*.

D. *Experiments based on iterative spectral subtraction and modified LIMA framework*

As was presented in part B. of section III., iterative using of spectral subtraction can have positive impact on amount of musical noise in enhanced speech. Therefore we joined iterative approach together with method used in previous experiments and we tried to bring further improvement of speech recognition robustness.
A lot of experiments were done with two and three iterations and with different setting of α and β parameters in particular iterations, because there are a large number of possible combinations. Table 3. contains results of tests, where improvement was reached.

TABLE 3. The results of experiments with spectral subtraction enhancement with varying power and floor parameters

1.iteration		**2.iteration**		**WER [%]**	
α	β	α	β	SNR = 10dB	SNR=0dB
without enhancement				16.78	61.81
2	0.5	2	1	12.5	48.23
2	0.5	1	0.5	**9.81**	48.56
2	0.5	0.5	0.5	13.2	49.01
0.5	0.5	0.5	0.5	11.6	**42.37**
0.5	0.5	2	1	12.23	47.46
0.5	0.5	1	0.5	10.11	42.52

When SNR was about 10dB, the best value of WER was 9.81%. In this case, we were able to subtract more noise (higher α parameter) as in situation, when SNR was 0dB. When the level of noise was so high, we had to be more carefully and the weak spectral subtraction was more successful.

V. CONCLUSIONS

In proposed paper we presented the approach based on spectral subtraction for increasing robustness of the robot speech interface in noisy environment. The best results were reached by using combination of modified LIMA framework and iterative approach. WER was decreased significantly. Our next work will be focused on automatic setting of spectral subtraction parameters according speech recognition accuracy and noise condition.

ACKNOWLEDGMENTS

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Corporate Governance: Principles and Regulations

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Abstract – Corporate governance is only part of the broader economic context in which firms operate and includes, for example, macroeconomic policies, competition, or the markets of production factors. Contemporary debate on corporate governance refers in particular to the principles mentioned in three papers published after 1990: the UK Cadbury Report (1992), OECD Principles of Corporate Governance (1998 and 2004), and the Sarbanes-Oxley Law in the U.S. (2002). Cadbury and the OECD reports present general principles around which a firm must operate in order to ensure good governance, while the Sarbanes-Oxley Law is more like a request of U.S. government authorities to regulate several principles of good governance, including many of the principles recommended in the Cadbury and OECD reports. Corporate governance affects firm performance in a variety of channels such as monitoring and control of the owners, concentration degre of ownership, independence of the Board and its separation from executive management, company characteristics and operating environment, the behavior of shareholders, market mechanisms (acquisition or merger) or the incentives granted to managers or to the Board.

Keywords: corporate goernance, essential principles, regulations.

I. INTRODUCTION

Corporate governance is a relatively new concept in the economic theory, and its senses rely to both the term corporation and the term governance.

Corporate governance has become the activity and organization as a company that can and must be reconciled interests, sometimes conflicting, between shareholders and managers, between majority and minority shareholders or, finally, yhaat are involved and other stakeholders in development goals company. However, strict observance of precise objectives, but limited, such as profit maximization, financial performance or, conversely employment goals too large, dangerous to the survival of the firm, is as sterile, and may overshadow the measures and correlations between different actions and entities inside and outside the companyable to provide for her overall performance, growth and long-term stability.

We are now presenting several interpretations associated with the term “corporate governance” (see also Badulescu and Badulescu 2008):

- Shleifer and Vishny (1997: 737-783) define the field of corporate governance, as the study of the processes by which the resources suppliers – reduced to the only financial investors – guarantee the profitability of their investment

- Charreaux (1997: 421-469) considers that the corporate governance system covers all the mechanisms that govern the managers’ behavior and delineate their discretionary latitude. This broader definition covers the preceding one and presents the advantage of giving the manager the role of central actor (but non-single) in the value creation process

- Michel Albert considers that corporate governance is about giving to the managers a unique objective: maximizing the profits and dividends. corporate governance is, thus, the end of the managers’ era. (Albert, 1994).

The term corporate governance took on different ways of understanding, often confusing, including theobject of analysis and li-mits its applicability.
In the narrow sense of its definition (so called Shareholders model),corporate governance is understood as a formalized system of higher level of management accountability to shareholders and in its roader meaning (stakeholders model), term corporate governance can be used to describe formal and informal network of relationships involved in the operation of corporations (Mahler and Andersson, 1999). Although different at first glance, the two approaches have many common points and the theory and practice in recent years emphasizes the contribution the stakeholders can havelong-term performance of the company and thereby increase shareholder value (Badulescu and Badulescu 2008). One of the most popular definitions of corporate governance (Cadbury Committee) refers to "the system by which companies are directed and controlled", so understanding how they balanced the various interests of partiesinvolved in a company (Cadburry Commitee, 1992). In the view of IFC, corporate governance refers yo structures and processes that determine direction and control of the company, or more precisely to "a set of relations between top executives, board of directors, major shareholders (who own the company) minority shareholders and other stakeholders [...], a structurethat establish business goals, the means to achieve these objectives and the way performances are monitored" (OECD, 2004).

Note that whatever vision promoted (shareholders vs. stakeholders) debates on corporate governance focuses on the status of the owners (shareholders), gradually remove the tacit or explicit, in decision-making and management trends and use in their own interest, overlapping of powers (often discretionary) within the company. Concentration, almost excessive, on both the above-mentioned coordinates, thus revealing an adversarial relationship between management and

investors, and an attitude of mutual suspicion that has led many authorities or institutions to draw up codes of corporate governance are laid down in detail how they should conduct relations between management, shareholders and other interested partiesbased on the transparency, consistency and a clear definition of strategic objectives (long-term) policy toward employees, the environment and the community, customers and vendors, the observance and implementation of the legal framework, professional and business conduct, etc. Remember the Cadbury Report instance to the United Kingdom in 1992, the Sarbanes-Oxley Act of 2002 in the USA, the OECD Principles of Corporate Governance (OECD Principles), International Corporate Governance Network (ICGN) Corporate Governance Principles, The EU Transparency Directive in 2007, Report on Corporate Governance for South Africa (King II) in 2002.

II. ESSENTIAL PRINCIPLES OF CORPORATE GOVERNANCE

Corporate governance is only part of the broader economic context in which firms operate and includes, for example, macroeconomic policies, competition, or the markets of production factors. Corporate governance framework also depends of legal, institutional and environmental regulations. In addition, factors such as business ethics and the degree of awareness as regards the corporative, social and environmental interests of social communities in which a company operates can also have an impact on its reputation and long-term success. At first sight, the principles of corporate governance focus on governance issues arising from the separation of ownership from control, but nevertheless, it is recognized that the meaning of these principles go beyond the relationship between shareholders and management, although it remains their core element.

Corporate governance principles also fulfil a complementary role in the process of checking and ensuring a balance in the company, so as to improve relevant decisions as regards anti-corruption, or other ethical issues.

As shown in OECD documents, there is no single model of corporate governance. However, research in both OECD and non-OECD countries identified some common elements underlying good corporate governance and the principles based on these common elements are formulated so as to encompass as much of the various models existing on the market (OECD Ad Hoc Task Force on Corporate Governance, OECD Principles of Corporate Governance, Paris, 1999).

Principles are not binding and are not intended as amendments to national legislation; instead they seek to identify objectives and suggest various means for achieving them, serving as a reference point. They can be used by policy makers in analyzing and developing legal and regulatory frameworks for corporate governance, specific to given circumstances of economic, social, legal and cultural nature, which also take into account participants to the process and existing market practices (OECD Ad Hoc Task Force on Corporate Governance, OECD Principles of Corporate Governance, Paris, 1999).

Principles are evolutionary in nature and should be reviewed periodically in the light of significant changes in circumstances. To stay competitive in a changing world, corporations must innovate and adapt their corporate governance practices so that they can meet new demands and opportunities. Similarly, governments have an important responsibility to develop an efficient and flexible regulatory framework to allow markets function effectively and respond to shareholders and other stakeholders.

Contemporary debate on corporate governance refers in particular to the principles mentioned in three papers published after 1990: the UK Cadbury Report (1992), OECD Principles of Corporate Governance (1998 and 2004), and the Sarbanes-Oxley Law in the U.S. (2002). Cadbury and the OECD reports present general principles around which a firm must operate in order to ensure good governance, while the Sarbanes-Oxley Law is more like a request of U.S. government authorities to regulate several principles of good governance, including many of the principles recommended in the Cadbury and OECD reports.

The most important principles from the documents mentioned above can be summarized as follows:

a. Ensuring the rights of all shareholders and their fair treatment. Organizations must respect the rights of shareholders and assist them to exercise these rights through a transparent and efficient communication of information and encourage shareholders to attend general meetings (The UK Cadbury Report, 1992, available at http://www.ecgi.org/codes/documents/cadbury.pdf, the Sarbanes-Oxley Law from 2002 in the USA, available at http://www.soxlaw.com/, OECD Principles of Corporate Governance (OECD Principles), available at http://www.oecd.org/document/49/0,3746,en_2649_34813_31530865_1_1_1_1,00.html).

b. The interests of other stakeholders. Organizations must recognize that their legal, contractual, social and market obligations, as well as those relating to non-shareholders, namely employees, investors, creditors, suppliers, local communities, customers and policy makers (OECD Principles of Corporate Governance (OECD Principles) .

c . The statutory role and the responsibilities of the Board of Directors. People included in the Board of Directors need relevant skills and the ability to review and improve systems of ensuring the performance of management. To these one may add the necessity to ensure an appropriate dimension and level of independence and commitment, appropriate so as to fulfill responsibilities and obligations (OECD Principles of Corporate Governance (OECD Principles), *op. cit.* and Cadbury Report, *op. cit.)*

d. Integrity and ethical behavior. Integrity should be a fundamental requirement in electing the

representatives and members of the Board. Organizations should develop a code of conduct for executives and managers to promote ethical and responsible decisions (The UK Cadbury Report, Great Britain, *op. cit*. and Sarbanes-Oxley Law from 2002 in the USA, *op. cit.)*

e. Ensuring communication and transparency. Organizations should clarify and publicize the duties and responsibilities of the Board and provide stakeholders with clear, transparent and accountable information. They should also implement procedures to independently verify and safeguard the integrity of the company's financial reporting, to ensure that all investors have access to useful, clear and balanced information. (OECD Principles of Corporate Governance (OECD Principles), *op. cit*. and Cadbury Report, *op. cit.)*

For example, we present below the principles of corporate governance established in the Stock Exchange of Australia. Thus, according to the document of principles and best practices established at this institution, a company should (Australian Stock Exchange Corporate Governance Council, (2003), *Principles of Good Corporate Governance and Best Practice Recommendations*, pp.9-11):

a. Build solid foundations for the management and supervision of activities, to accept and make public the duties and responsibilities of the Board and senior executives.

b. Ensure that the Board will generate value, and it would have a composition, size and commitment able to properly fulfill required responsibilities and obligations.

c. Actively promote decision-making processes in an ethical and responsible manner

d. Ensure integrity in financial reporting, create structures of independent verification and protect the integrity of the company's financial reports.

e. Ensure regular and balanced publication of all significant aspects concerning the company.

f. Respect the rights of shareholders and facilitate the effective exercise of these rights.

g. Identify and manage risks, establish a sound system of supervision, risk management and internal control.

h. Encourage the improvement of performance, honestly and efficiently.

i. Remunerate fairly and responsibly; the level and structure of remuneration should be sufficient and reasonable, and the relationship to corporate and individual performance should be better defined.

j. Recognize and respect the legitimate interests of stakeholders

III. REGULATIONS

Contemporary references on corporate governance generally use the material contained in three important regulations or codes published after 1990, namely the UK Cadbury Report (1992), OECD - Principles of Corporate Governance (1998 and 2004), and Sarbanes-Oxley Law from 2002 in the U.S. While Cadbury and the OECD reports present and promote a series of general principles around which the company must be organized in order to ensure good governance in achieving objectives, Sarbanes-Oxley Law is an attempt by U.S. federal authorities to legalize most of the principles recommended by Cadbury and OECD reports. Besides these we find corporate governance codes in most countries, of which we remind those of:

Country/ International organization	Issuer	Name of code/regulation	Date of issue (last modification)
Germany	Government Commission	Corporate Governance Code	amended 2010
France	A.F.E.P.- Association Française des Entreprises Privées	Corporate Governance Code of Listed Corporations	amended 2010
Great Britain	Institute of Directors	Corporate Governance Guidance and Principles for Unlisted Companies in the UK	2010
	Financial Reporting Council	The Uk Corporate Governance Code	2010
The United States of America	The Business Roundtable, An Association of Chief Executive Officers Committed to Improving Public Policy	Principles of Corporate Governance	2002
	National Association of Corporate Directors	Key Agreed Principles to Strengthen Corporate Governance for U.S. Publicly Traded Companies	2008
Russia	The Co-ordination Council for Corporate Governance	The Russian Code of Corporate Conduct	2002
China	China Securities Regulatory Commission	The Code of Corporate Governance for Listed Companies în China	2001
Japan	Tokyo Stock Exchange	Principles of Corporate Governance for Listed Companies	2010
Australia	Australian Stock Exchange	Principles of Good Corporate Governance and Best	Amended 2010

Country/ International organization	Issuer	Name of code/regulation	Date of issue (last modification)
	Corporate Governance Council	Practice Recommendations	
Romania	International Center for Entrepreneurial Studies, University of Bucharest	"Corporate Governance Initiative for Economic Democracy în Romania", Corporate Governance Code	2000
	Bucharest Stock Exchange	The Corporate Governance Code of Bucharest Stock Exchange	2008
United Nations Organization	United Nations Conference on Trade and Development	Guidance on Good Practices in Corporate Governance Disclosure,	2006
OECD		OECD Guidelines on Corporate Governance of State-Owned Enterprises	2005
		OECD Principles of Corporate Governance	2004

Source: European Corporate Governance Institute, Codes & Principles, available at http://www.ecgi.org/codes/all_codes.php, Bucharest Stock Exchange, available at http://bvb.ro/Regulations/Regulamente.aspx?t=2 (pentru România),

IV. CONCLUSIONS

How corporate governance can affect firm performance is different and this influence is through many channels, not just those associated with the degree of monitoring and control which they exercise ownership, but also by other factors, such as the concentration property, Board independence and separation from the executive management, company features and operating environment, the behaviour of shareholders and using market mechanisms, and finally by the incentives of managers, the Management Board. Also understand how to achieve business objectives and achieve a satisfactory financial and economic performance for shareholders (and for other stakeholders – stakeholders) requires consideration of other elements, directly or indirectly related performance such as encouraging investment, innovation and enterprise, increase company reputation, promote corporate social responsibility and ethical behavior of business, the availability and transparency of information, good behaviour the community.

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Some Considerations on the Merits and Limits of Corporate Governance Models

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Abstract – From the beginning of theoretical and practical basics, corporate governance traditionally claimed itself from the theory of the "principal-agent" or "the theory of the agency", i.e. the situation when the person(s) holding the company are not the same with the person who manages or controls the company concerned. The size of the firm, the complexity of the economic environment, the specialization of human capital requires that capital owners or financial investors should hire persons (managers) able to manage the business, to increase shareholder value and the profits thereof. On the other hand, these managers - people with considerable professional skills or experience, with clear vision to achieve a result – are not numerous in the labor market and from their personal point of view they would need significant funds to achieve their goals and ambitions. Thus, a separation between financing and respectively managing the company was observed, i.e. a separation between ownership and control.

I. INTRODUCTION

Before investigating models of corporate organization, we should mention that, historically, or from the perspective of corporate governance forms of evolution, the principle of the centrality of shareholders in a company dominated the understanding of a firm's objectives, and methods of achieving them. However, in the second part of the twentieth century, a second model also stood out, in which companies were directed taking into account the interests of other entities concerned with the good functioning of the company, for instance customers, the public or employees. Regardless of the main current to which they are tributary, both models are subject to the effects of the owners – managers relationship, which led to numerous changes in internal structures, control instruments and incentives, so that shareholders, managers and stakeholders might effectively (and in a motivated manner) perform their specific actions.

For example, the table below shows how to identify the objectives supported by the two models in corporate governance and how ownership (concentrated or dispersed) can influence management patterns (International Chambers for Commerce, Corporate Governance, *A business guide for practitioners everywhere*)

Shareholders' model	Stakeholders' model
Maximizing shareholder value and pursuing their interests	Attempting to find a balance to satisfy the interests of all stakeholders in the company, including public interest
Insistently seeking to ensure profitability and efficiency	Orientation towards long-term growth, for survival and stability
Looking for opportunities and obvious commercial orientation	Focus mainly on value, rather than on profit

Concentrated ownership	Dispersed ownership
Ownership concentrated in the hands of a few powerful shareholders, domination over management, sometimes through a powerful CEO	Dispersed ownership may ensure that managers have more freedom, but leaves the company at the disposal of market forces, of takeovers or internal fights for domination
A weak protection of minority shareholders, requiring specific regulation or more independence for the executive president	The need to protect the interests of all shareholders, alongisde a careful supervision of management's actions

The diversity of corporate governance patterns can also result from management structures and organization within the company board. Thus, there is one Board of Directors on a single level, according to the shareholders' model, often encountered in the U.S. and Britain, and respectively a Board of Directors on two levels, most commonly used in France, Germany, Eastern Europe etc (International Chambers for Commerce, Corporate Governance)

Council on one level	Council on two levels
The anglo-saxon model, where executive and non-executive directors form the same council	The European (continental) model, where the Supervision Council is made up exclusively of non-executive members and a level subordinated to the Board of Directors, made up of executive directors directly involved in the operational activities of the company
The president of the Council closely collaborates with the CEO, but there are also audit, monitoring and remuneration committees.	The Supervisory Board is totally independent of the Board of Directors.

It is difficult to say which is the best model of corporate governance, because, with all the effects of globalization, economic and social practices, as well as traditions of capital organization differ significantly from country to country, and uniformity is far from being a priority in the construction of corporate governance Whatever the model chosen, most researchers and practitioners (whether they are shareholders in the supervisory structure, or business executives) interested in the effects of good governance, show that there are some important features and objectives to be pursued (crystallized what we discuss in the following paragraphs, referring to the "principles of good governance"): respect for the rights of shareholders, regardless of size of shareholding in the company; maximizing the value of assets; regular and transparent reports; checking and monitoring activities done with honesty, transparency and trust

I. THE SHAREHOLDER MODEL

According to the shareholder model, 'a company's objective is to maximize shareholder wealth through an efficient, productive and dynamic allocation of resources, i.e. the maximization of profits" (Maher, Maria; Andersson, Th. (1999), *op. cit.*, p.6). The performance criteria imposed by this model are relatively simple, and are understood as market value, dimension of dividends, etc. Therefore, managers and directors are required to ensure that firms are run in the interests of shareholders. The problem that underlies corporate governance in this version starts from what economic theory calls the principal-agent relationship, i.e. the separation between the holder and beneficiary of property on the one hand and executive decision makers on the other hand, which, in most cases, cannot ensure the preservation of the primary objective of the company, to maximize profits. Managers, as they are not owners of the company, cannot be held accountable, more exactly they cannot assume the entire cost or benefits associated with their action.

Therefore, although managers can meet expectations of maximizing shareholder value, they may also have other objectives such as maximizing their own or their teams' salaries, increasing market share, or a special attachment for certain investment projects etc.(The principal-agent problem is also found in the works of Coase, Williamson, Jensen and Meckling and others, as part of the incomplete contracts theory).

One way of alleviating this problem would be to write "complete contracts" specifying precisely, ex ante, what managers should do with resources available, to whom and how to distribute benefits, which are future projects and what is the expected value of the company in a reasonable time period. However, complete contracts are impossible, because it is difficult to predict or describe all possibilities and future developments of actions, and thus one makes use of incomplete contracts, which stipulate "residual rights of control", i.e. rights to make decisions in unexpected situations or circumstances not covered by the agreement, in other words, quoting Hart, "governance structures can be seen as a mechanism to make decisions that were not specified in the original contract" (Hart, O. (1995)).

Residual control rights are not a final, resolution tool, available to shareholders, by which they can avoid making decisions in circumstances not covered by the contract. Corporate governance must also manage another drawback of the manager-shareholder relationship, namely the asymmetric information, meaning that managers are better informed and know the best alternative use of investors' funds, which turns residual rights of control in a valuable instrument in the hands of managers, in their relation to shareholders. The immediate consequence is that the accumulation of rights leads to problems of abuse of power and rent extraction on the part of managers, suggesting that corporate governance should establish the limits of managers' discretionary power and the transparency of their actions, .i.e. the achievement of performance targets in conditions of full responsibility, the so-called performance accountability.

One immediate economic result of the possibility of which managers may benefit, to use the diminishing of results due to shareholders, that is what we call the expropriation of rents or opportunistic behavior, is reducing the amount of resources that investors are willing to allocate ex-ante, in order to finance the company (Grossman, S. and O. Hart (1986)), the so-called hold-up problem (Williamson, O. E. (1985); Grossman, S. J. and O. D. Hart, 1986, Holmström, B. și Roberts. J. (1998). Tirole, J. (1988), Rogerson, W. (1992), which was widely debated in literature.

Therefore, the aim of corporate governance, seen through the shareholder model, refers to finding ways to align managers' interests with those of investors, while ensuring the flow of external funds for the company, funds to be sufficiently motivating as rewards for investors / shareholders.

To overcome these problems of abuse of trust and monitoring, in order to minimize agency costs and hold-up associated with separating ownership from control, the shareholder model of corporate governance uses several approaches, as follows:

- promotion of compensation schemes for managers, stock options, direct monitoring of the Board of Directors etc., to motivate an efficient activity and align managers' interests with those of shareholders;
- strengthening shareholders' rights so that these shareholders have both stronger incentives and means to monitor and influence the management team. This approach refers to the strengthening of investor rights, legal protection against managers' tendency to expropriation, the implementation of shareholder rights, prohibitions against insider (unfair) dealing etc.
- another method is to use indirect means of corporate control, such as those provided by capital markets or labor market, for instance takeovers, corporate control, the threat of hiring a new manager, etc.

II. MERITS AND DEFICIENCIES OF THE SHAREHOLDER MODEL

One of the strengths of this model is that of highlighting the differences between the forms of concentration of ownership in a company and their relationship with management monitoring arrangements. Thus, this model clearly shows that ownership is preferably concentrated in the hands of dispersed ownership, as in such a situation monitoring incentives are more consistent, and "free-ride" forms of behavior are avoided, on which some shareholders rely thinking that other shareholders will do the monitoring, thereby sharing the benefits but not the costs of monitoring (Maher, Maria; Andersson, Th. (1999)*)*. In a situation where there is only one, majority shareholder, this may find a balance between benefits and efforts for monitoring management.

One criticism to the shareholder model was built on the assumption that in a firm, conflicts between managers and shareholders are inherent, that managers are strong, agile and abusive, and shareholders are weak and dispersed. This led to the focus being placed, almost exclusively, both on analytical work and on reform efforts, aimed at solving the problems of monitoring and limiting the power of managers, as main corporate governance issues (Maher, M.; Andersson, Th. (1999)*)*

Nevertheless, research shows that most firms have relatively concentrated ownership, ex ante prevented about the weakness and lack of protection of small investors, often centered on a family or group of interest, holding cross-shares or holdings, opposing managers power an alternative variant of concentrating residual rights of control in the hands of shareholders.

Another criticism of the approach of corporate ownership is that the emphasis is on aligning the interests of managers and shareholders, ensuring a flow of external financing for the company in question, ignoring the role and involvement of other processes or entities in the success and performance of the firm, such as work environment and teamwork, management of suppliers, employees, creditors, suppliers and customers. The corporate governance issue must be supplemented with better care for the influence of cross-holdings, the holdings or other mechanisms whereby dominant shareholders exercise control, often at the expense of minority investors whose situation, in this case, becomes critical.

The shareholder model must address more carefully the way in which policymakers can develop reforms that would preserve the benefits of monitoring provided by concentrated ownership and at the same time, to stimulate the flow of external funds to firms, in the context in which these flows implicitly ‘dilute’ ownership concentration.

III. THE STAKEHOLDERS MODEL

The stakeholders’ model, of interested parties, promotes a broader vision of the company and its place in society. According to the traditional model, a corporation is responsible for a larger group of constituent elements, the so-called interested or involved parties other than shareholders.

The category of "other stakeholders" may include contractual partners such as employees, suppliers, customers, creditors, or social components such as members of the community in which the company operates, environmental interests, local and national authorities, and society in general.

According to this model performance is appreciated by a large community, interested in employment, market share, the growing trade relations with suppliers and customers as much as in financial performance.

Although seductive in terms of social aspects, this model has a small number of active supporters just because it is difficult, if not impossible, to ensure that companies can meet these large objectives in parallel with economic performance; the model "even fails to provide managers some clear methods by which to expand social circle of beneficiaries of corporate results; moreover, it did not provide any mechanism to give certainty to companies that they will survive their social obligations" (Blair, M. (1995), Maria; Andersson, Th. (1999)*.)*.

However, given the potential consequences of corporate governance for economic performance, the idea that corporations have a responsibility in relation to third parties, other than shareholders, should be considered very seriously, important being the impact on the behavior and performance of the company and on economic development that all interested entities, or those determined to enter in a relationship with a firm, may have. Any assessment of the implications of corporate governance on economic performance must take into account the incentives and discouragements faced by all participants who can contribute to the performance of the company.

In this respect, the stakeholder model was recently redesigned with emphasis on identification of stakeholder interest. Therefore, the "new model" of stakeholders specifically defines stakeholders as those actors who have contributed to the specificity of company assets. This redefinition of the stakeholder model is also consistent with the "transaction costs" theory and the theories of "incomplete contracts" in which a company may be regarded as a "set of contracts" (Coase (1937), Williamson, Oliver E. (1971), Williamson, O. E. (1985), Jensen, M.C., Meckling, W.H., (1976)) In this sense the company with the best results is that which considers the motivated and / or directly interested parts in the smooth running of the company, namely key suppliers, customers and employees, observing that this "selective" variant of the stakeholder model is an improved version of the shareholders model (Maher, Maria; Andersson, Th. (1999)). For this model, firm performance resulting from investments in specific assets is due to the teamwork, and finally the recognition of product quality on the

market and maintaining a positive image of the firm in the minds of customers is also the result of teamwork.

It is therefore in the interest of shareholders to take account of other stakeholders, and promote the development of long-term relationships, trust and commitment among different stakeholders in investing in specific assets, with the purpose of creating wealth, workplaces and the durability of financially healthy enterprises (OECD Principles of Corporate Governance (OECD Principles),

IV. MERITS AND DEFICIENCIES OF THE STAKEHOLDER MODEL

The stakeholder model has the merit that, identifying some of the inadequacies of the shareholder model, tries to bring a series of solutions (even limited) to the issue of insufficient investment in business by giving workers more rights, the possibility of investing in / crediting the company, by encouraging providers and distributors to be involved in financing the company etc.. However, there are many criticisms and reservations that this model does not fully solve the problem of opportunistic behavior of managers, and its immediate consequence: an underinvestment and reduced cooperation of stakeholders, such as reduced availability of providers to invest in the company (e.g. deliveries on credit, financing of new projects, reduced interest on the labor market for that company, etc..)

V. CONCLUSIONS

The corporate governance issue must be supplemented with better care for the influence of cross-holdings, the holdings or other mechanisms whereby dominant shareholders exercise control, often at the expense of minority investors whose situation, in this case, becomes critical.

The shareholder model must address more carefully the way in which policymakers can develop reforms that would preserve the benefits of monitoring provided by concentrated ownership and at the same time, to stimulate the flow of external funds to firms, in the context in which these flows implicitly 'dilute' ownership concentration.

It is quite obvious that the stakeholders model, both in its traditional and its modern form, tries the to improve the underinvestment problem by encouraging active cooperation between stakeholders to ensure long term profitability of the company, but it cannot completely remove fears (and criticism) that directors or managers can use the existence of "stakeholders" to justify the company's poor performance and not help to establish priorities, to establish a mechanism for the efficient firm and stimulate teamwork.

One of the most difficult tasks in reforming corporate governance is the way to develop frameworks and mechanisms to determine socially efficient levels of investment from all stakeholders, at the same time with the responsibility of achieving the performance expected by shareholders.

We believe that, for a better solution to this requirement, corporate governance issues should be tackled separately, by creating two types of mechanisms:

- some centered on promoting the investments of stakeholders and encouraging cooperation in close relationship with preventing managerial abuse;
- others, aimed at setting the goals and priorities of the company, focused primarily if not exclusively on the shareholder-manager relationship.
- finally, a clear definition, in both plans, of some specific objectives, achievable and transparently monitored.

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Opportunistic Networks and Security

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Abstract **– *The opportunistic networks (OppNets) are characterized as a most challenging evolution of Mobile Ad - Hoc Networks (MANET). OppNet provide possibility to exchange messages between mobile nodes (users) even in such a disconnected environment by opportunistically selection any nearby device to move messages closer to the final nodes. Based on this assumption, the security play important role. The security ideas are the primary and very important area of research. In this article, the basic security issues are introduced, described and there are displayed basic security mechanisms and algorithms. We show that we need design strong and robust security solutions for secure transmittion of data between source and mobile nodes.***

Keywords: ***opportunistic network, security, secure opportunistic routing, trust management.***

I. INTRODUCTION

MANET is defined as a collection of communication devices or nodes that communicate without any fixed infrastructure and pre-determined organization of available links. The OppNet, also called any path routing, is characterized as a necessary evolution of traditional MANET with providing wireless networks properties. OppNet consist of human - carried mobile devices (nodes) that communicate with each other without any infrastructure [1]. OppNets are more general than MANETs, because dissemination communication is the rule rather than conversational communication.

OppNets are formed by individual nodes. All nodes can be disconnected for some time intervals, and that opportunistically exploit any contact with other nodes to forward messages [2]. Each nodes computes the best paths based on its knowledge. The messages are routed and transmitted by "store-carry-forward" model (Fig. 1).

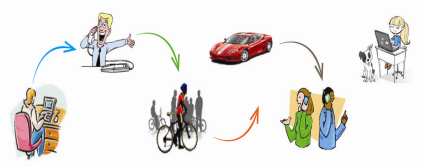

Fig. 1 Example of opportunistic network

The main philosophy of OppNet is to provide ability to exchange messages between source and destination nodes. Nodes can be of two types: mobile and fixed. They are responsible for control and management decisions by locally available information.

In order to providing the effective communication between nodes, there is necessary to consider different aspects (disconnections, mobility, partitions, etc. as norms instead of the exceptions). The mobility in OppNet is used to provide efficiently communication between unconnected groups of nodes.

In MANET, the security mechanisms are based on the assumption that there is/are a connection between source and target nodes (end-to-end connections). In OppNet, we require the security solutions, which provide security for all nodes, all services and application that participate on routing and transmitting process. There is sporadic connectivity of nodes and we need to provide secure delivery of the messages from source node to destination node.

In this paper we discuss the security issues related to OppNets. We present also the security key issues and challenges. We will shortly introduce the security ideas in OppNet with main interest on security on routing and forwarding mechanism. In last part of article we introduce our research activities.

II. SECURITY IN OPPNETS

Security is an important issue in OppNet. Based on principle of OppNet, there is necessary to study and design new algorithms to provide secure communication between source and destination nodes. Due to the special nature of OppNet environments the traditional security mechanisms, used in MANET, are not always applicable [2]. For example, end-to-end confidentiality using traditional encryption mechanisms requires the sender to know a recipient-specific encryption key.

The main threats for OppNet can be classified following:

a) Protection of transmitted messages in transit for malicious purposes e.g. for masquerading attacks,
b) Protection of the network against malicious use of OppNet resources.
c) Protection of the denial of service e.g. by mounting amplification attacks [13] in which a node uses the replay properties of OppNet protocols and unaware nodes for generating large amounts of traffic to the network.

To provide security in OppNet, we need to ensure following fundamental objectives:

- ***Authentication*** **-** in OppNets, there is necessary to provide useful and effective methods for authentification of the mobile nodes, that are participate in communication between users, in order to distinguish legitimate mobile users from unauthorized users. All nodes need to have possibilities to verify, that all dates and information was sent from authorized node with legitimate class of service.
- ***Confidentiality*** **-** the disadvantage of mobile wireless links is vulnerability to passive security attack (eavesdropping), we need to ensure protection of private and sensitive information from unauthorized mobile nodes during transmittion of the date. This process can be achieved by modern end-to-end encryption based on mutual authentication and key agreement between the source and the destination nodes.
- ***Integrity*** **-** based on confidentiality the security solution has to provide suitable mechanisms in order to protection of the data. Integrity services have to provide and ensures that all transmitted data cannot be modified.
- ***Privacy/Anonymity*** – is specific kind of security services necessary for different type of application. These services have to provide confidentiality of exchanged messages but also privacy of the sender and receiver.

A. *Classifications of the attackers*

The main ideas of the security solutions are providing secured transmittion of the messages. Based on this consumption we need to efficiently protect the data forwarding mechanisms. First of all, we need to identify the potential attacker. We can classify the potential attacker into two groups:

- *Internal attacker* – it is a participant on routing and dissemination process. This kind of attacker can be selfish and malicious. Selfish attacker performs an attack only if directly participates on routing or dissemination. A malicious node can be viewed as a who simply cause damage to the network
- *External attacker* – have the limited permission to access to the OppNets.

B. *Classifications of the attacks*

From a security point of view, it is useful to distinguish between authorized, internal OppNet nodes, and unauthorized, external nodes. Internal security protects internal nodes against other internal attacks, while external security protects internal nodes from external ones. External attacks are passive reconnaissance attempts with the goal to disclose node identities or traffic flows. From a attack mechanism can be used to attack following mechanisms:

- *Attacks on the data dissemination mechanism* – can change the behavior of other participants
- *Attacks on wireless communications* – cannot change the behavior of the other participants but can change physical parameters of the wireless channel.

III. SECURITY SOLUTIONS FOR OPPNETS

OppNets are vulnerable to many security threats and also introduce a number of new security challenges. This section disscuss about practical solutions about the key security objectives and they implementation to the OppNet. There are introduces the basic ideas of security mechanisms and algorithms.

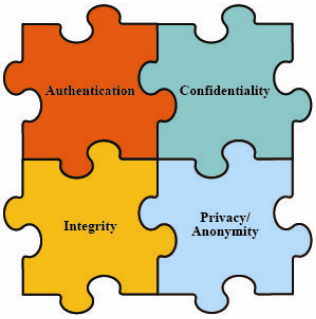

Fig. 2 Key security objectives for OppNet

A. *Privacy*

In OppNet, data and messages content are carried and transmitted by nodes with integrated wireless technologies and communication happens between user's by physical proximity. That means that the user's device will pass information or information wishes without notice, this may conflict with user privacy needs. The privacy is the ability of a user to stop information about himself from becoming known to other users.

In opportunistic networks, it should be possible for a user to express an information wish or offer an information item to others without creating the possibility that this action can be linked back to himself, especially for applications that aim at passive collaboration. The privacy is separated based on this criteria's:

- *Behavioral or media privacy:* you need to know information that is gathering information about user.
- *Territorial privacy:* provide possibilities to have a private place where nobody is allowed to enter without permission. In the virtual world, we can consider, for instance, do not allow access when someone is in a specific place, in a meeting or teaching in a classroom.
- *Communication privacy:* The right to communicate whatever type of information you want.
- *Informational privacy*: The right to know how and what is done with a person's personal data and which personal data is being gathered.

- *Bodily privacy*: The privacy of a person's physical self against invasive procedures.

In OppNet we need to design solution to protect the following problems:

- *Exposure of the message content* – is necessary to design strong encryptions mechanisms and algorithms. Authors in [1] design key encryptions methods in order to elimination of this problems.
- *Tracing of the messages over the OppNet* – in order to deduction of topologies of OppNet [3].
- *Social information is used in order to routing process* and this information can be leaked to unauthorized parties [3], [5].
- *Based on routing information, the location* of the user can be disclosure [4], [6].

Fig. 3 Main security research field in OppNets

B. Trust management

Trust management presents very important parts of security research and become a cornerstone for information security and privacy in order to enable secure data sharing between users. The main idea of every security system that involves multiple users is the establishment of trust. Based on these ideas the research team starts to follow the trust relationship between mobile nodes in order to establish the security associations for opportunistic networks. There are many definitions what trust is. Trust is a particular level of the subjective probability with which an agent assesses that another agent or group will perform a particular action, both before he can monitor such action (or independently of his capacity ever to be able to monitor it) and in a context in which it affects his own action [6]. Trust is often based on past user interactions such as in reputation systems relying on ratings.

In opportunistic network, the trust is separated to three main groups:

- *Social trust* - established through consciously defined friend ties, making use of the fact that mobility helps peer-to-peer security. This kind of trust is based on social relationships [6].
- *Environmental trust* is inferred from the familiarity of the surrounding peers leveraging the complex network structure [8], [9] .
- *Similarity trust* is assessed based on the correlation of the ratings or opinions among different users in networks [10].

C. Key management

In OppNets, the key management is still on the beginning. Key management is necessary to provide secured end-to-end communication between nodes but in OppNet there is a lack of connectivity [10]. Indeed, nodes cannot establish end-to-end security associations nor rely on an online, centralized authority or security server. Based on mobile communication networks, there are specified two main approaches:

- *Authority based* - rely on trusted authorities in charge of distributing and managing keys.
- *Fully self-organized* - nodes generate keys and authenticate with each other through fully distributed mechanisms and do not and do not require any trusted authority.

D. Security in routing

In OppNet there are designed many routing protocols. These protocols can be classified to two groups with infrastructure and without infrastructure. Problem is that a very few of them consider the security, trust and privacy issues in their designs. The security routing approaches used for the fixed networks and MANET are not feasible due to the salient characteristics of OppNet. The main routing approaches proposed in the literature based on the amount of context information of users they exploit. We identify two classes, corresponding to *content-based* and *context-aware protocols*.

In content based routing protocol authors deals with forwarding strategies based on the match between different nodes through social context information of users [11], [12], [13]. Main interest of the research teams is privacy, which is a crucial issue in content-based networking. Research works solve problems of advertisements and published content. These ones are forwarded through opportunistic intermediate nodes that are not necessarily trusted. Another kind of routing security problem in content based routing protocol is *secure routing tables* and *look-up process*.

Security mechanisms for secure routing tables are used in order to correctly forwarding messages and packets relaying on trust, that all nodes must construct own forwarding tables based on encrypted receivers' advertisements. In look – up process, all nodes can make forwarding decision based on its forwarding table and they must be able to take correct forwarding decisions whenever it receives encrypted content.

In context based routing protocols, the messages and packets are forwarded between source and destination nodes rely on the context (e.g. social information or location) instead of explicit addressing as in MANET. A few research teams solve the security problems that can be classified into *Data confidentiality, User privacy and Computation assurance* [1]. In real world, the data confidentiality is primary goal of

security mechanism. In OppNets, the researches teams solve problems how to provide that the content of any messages should only be authorized to destined nodes with no rely on an end-to-end key management mechanism. The research is oriented to the field of the using cryptographic encryption algorithms.

IV. CONCLUSION AND FUTURE WORKS

OppNet is promising technologies for next generation mobile networks. Research in the OppNet is still in the beginning. The process of design the secured and robust routing technique for OppNet is generally a difficult task due to the absence of knowledge about the network topology. Opportunistic routing is vulnerable to attacks by many malicious nodes. We can identify several directions of our future research:

a) *Design and implementation of the OppNet layer model to the simulator OPNET modeler.*

Today, we are working on design and programing the network and process layer model to the simulator OPNET modeler. The possibility of integrating this security solution to the OPNET will be analyzed [14].

b) *The implementation of the privacy algorithms to existing opportunistic routing protocol.*

We design the modification of existing forwarding protocol (ExOR) in order to implementation to the privacy model based on terrestrial and communication privacy ideas to the simulator OPNET modeler.

c) *We are working on design of trust model based on ideas of localization based methods (indoor and outdoor).*

We incorporate the concept of trust to OppNet, build a simple trust model to evaluate neighbors' forwarding behavior and apply this model to opportunistic routing in order to provide the secured transmittion of data that can be offers unprecedented opportunities for security attacks, and allows attackers to compromise information integrity, authenticity, user privacy and system performance.

Next steps of research will be also focused on modification of modified security service vector that have been designed for MANET. We studied and analyzed the possibilities to create model that will enable the cooperation between MANET and OppNet. OppNets will require revisiting all security aspects of communication due to their specific requirements in order to providing secure communication between members of a community.

V. CONCLUSION

This paper gives a short overview of the main research security challenges in OppNets. We have provided some details about security objectives and mechanism. We can see that there are a lot of problems and objectives. Based on following ideas, we can say that research is only at the beginning. In comparison with MANET, security solutions for OppNet are more sophisticated and complicated.

ACKNOWLEDGMENTS

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Routing Strategies in Opportunistic Networks

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***Abstract* – Opportunistic network provide possibility to exchange messages between mobile nodes (users) even in such a disconnected mobile environment by opportunistically selection of any mobile devices, with implemented wireless technologies, in order to move messages closer to the destination nodes. This paper provides the detail information about routing/forwarding ideas for Opportunistic networks. We describe the main ideas of different routing/forwarding techniques. There are also introduced our research activities in the field of routing.**

***Keywords:* opportunistic network, opportunistic routing/ forwarding, routing algorithms, context based routing, content based routing.**

I. INTRODUCTION

The Opportunistic networks (OppNets) are characterized as a evolution of the multi-hop mobile ad hoc network (MANET). The definition of MANET is as a collection of communication devices or nodes that communicate without any fixed infrastructure and pre-determined organization of available links [1]. It is a communications network that is capable of storing, transmitting and forwarding packets temporarily in intermediate nodes, during the time an end-to-end route is re-established or regenerated.

OppNets are more general than MANETs, because dissemination communication is the rule rather than conversational communication. All nodes have to possibilities to opportunistically exploit any pair-wice contact in order to sharing and forwarding content without any existing infrastructure.

OppNet is characterized as an evolution of traditional MANET with providing wireless networks properties and is also called multi path routing. OppNet consists of human - carried mobile devices (mobile devices - such as smart phones, PDA, mobile devices etc.) that communicate with each other without mobile or fixed infrastructure [1].

OppNets are also compatible with Delay Tolerant Networks (DTNs) and can be seen as a special type of DTNs. In OppNets, no a-priori knowledge is assumed about the possible points of disconnections and nor existence of separate Internet-like sub-networks is assumed [1].

We can say that OppNet is a category of networks where diverse devices, not employed originally as its nodes, join the original set of seed nodes to help the OppNet realize its goals. In other word the new nodes become helpers for their OppNet.

In MANET, traditional routing algorithms and protocols are based on routing schemes, which can find a path for a given node pair according to various metrics and data packet are transmitted from one intermediate relay node to the next specified relay based on physical condition of wireless channels.

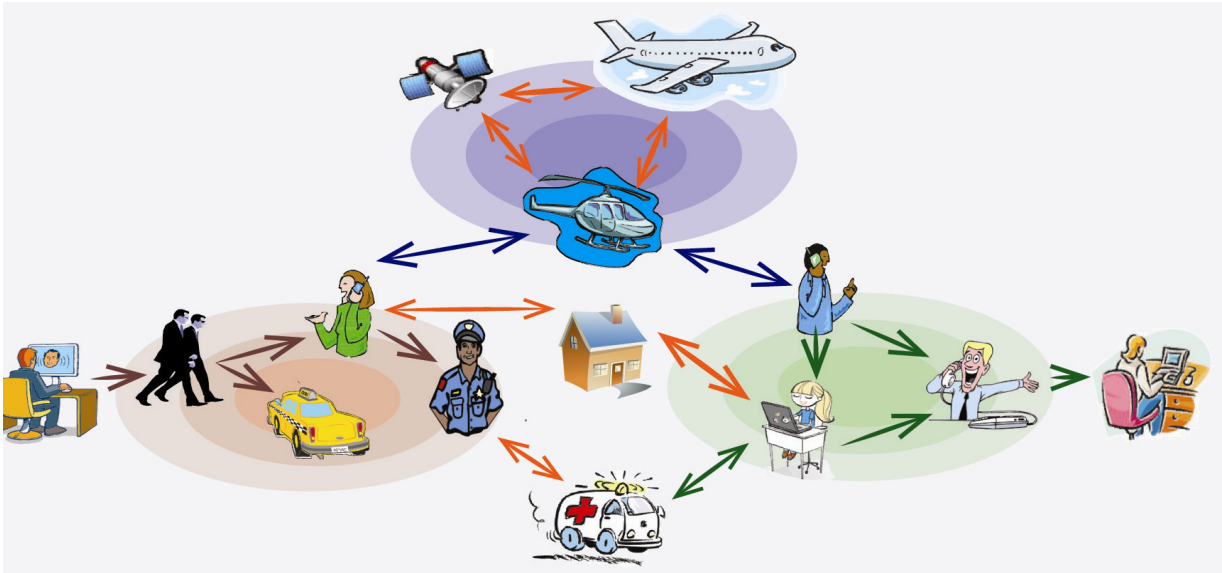

Fig. 1 Example of the opportunisic networks

Main differences between OppNet and traditional mobile networks are usability of the sources and expansion of the networks. In traditional networks there are all nodes of a single network situated together, based on the size of the network and locations of its nodes pre-designed [2]. On the other hand, in OppNet, the initial seed OppNet (which presents the basic part of OppNet) can be expanded into an expanded OppNet by considering different foreign nodes.

In this article we present an overview of the opportunistic networks and describe basic functionality of the network. We start by short description of components of the network. Then, we focus on routing techniques for establishment of the communication. At the end, the next research contribution is introduced.

II. OPPORTUNISTIC NETWORK OVERVIEW

OppNet is characterized by communications where continuous end-to-end path has not to be created prior to exchange messages between a source and destination nodes. It means, if a routing nodes have a message copy but they are not connected to (i.e. not in the range) another node/nodes, it stores the messages or packets until an appropriate communication opportunity arises (see Fig. 1).

A. *Architecture of the OppNets*

Mobile devices (PDA, mobile phones, notebooks etc.) may be just sporadically connected to mobile network, which can be caused by turn them or they get out of reach of other nodes, or due to the intrinsic variability and instability of wireless links [2].

Nodes store messages and they have to forward and carry them until encountering another node deemed more suitable to bring the message (closer) to the eventual destination. This mechanism is suitable to pervasive networking environments with respect to the legacy MANET assumptions.

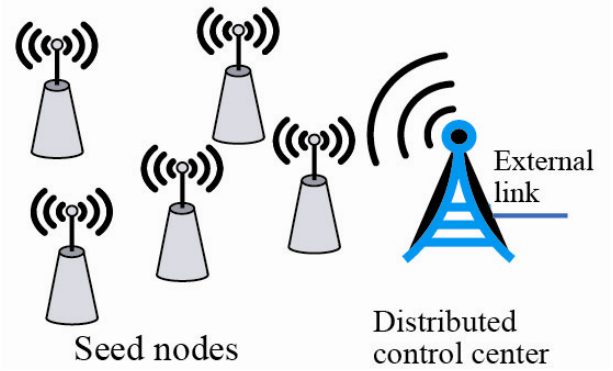

Fig. 2 Basic components of OppNets

Main functional part of network is initial seed OppNet (see Fig. 2). Initial seed is a group of nodes that are employed together at time of initial OppNet deployment. The seed is pre-designed and can be viewed as a network in its own right. It might be very small, in the extreme consisting of a single node. A subset of seed nodes constitutes a Distributed Control Center that can grow admitting other nodes, and can shrink expelling any of its nodes. The seed OppNet can be expanded into the larger network by extending invitation to join the seed nodes foreign devices, node clusters, networks, or other systems which it is able to contact (see Fig. 3). These nodes are called OppNet helpers.

Helpers create a certain tasks. Helpers are classified to two classes: invited or ordered to participate in (add communication, computing, sensing, storage, and other resources). By integrating helpers into its fold, a seed OppNet grows into an expanded OppNet. The set of potential helpers for OppNet is very broad, including communication, computing and sensor systems, wired and wireless, freestanding and embedded.

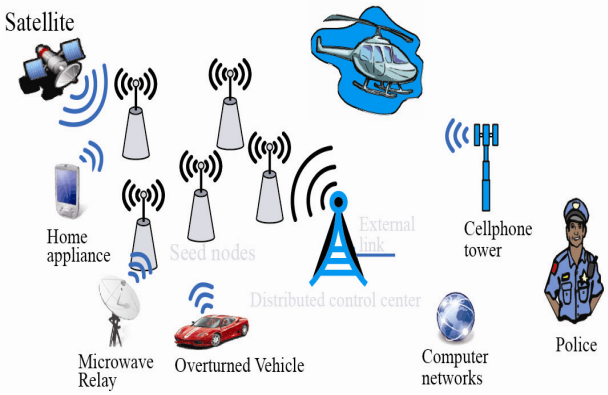

Fig. 3 Expansion of the OppNets

As computing devices continue to become more and more pervasive, the pool of candidates will continue increasing dramatically around us: in infrastructures, buildings, vehicles, appliances, our pockets, etc.. In Fig. 3 there is displayed the expanded network with following helpers:

- *A computer networks – enables connection to the computer networks and internet.*
- *A cellphone infrastructure enables connection to the mobile networks (2G, 3G, 4G, WLAN etc.).*
- *A satellite - enables connection to the satellite networks.*
- *A smart home appliance enables access to a home network.*
- *A microway relay enables access to microway network.*
- *Police – OppNet enables access to police networks.*
- *A vehicular computer network, connected with wearable.*
- *Computer networks on, and possibly within, the bodies of the occupants of a car (VANET, BAN etc.).*

B. *Main functionality of OppNet*

The OppNet have to provide following functionality:

- *Find opportunity* - is the main functionality of the OppNet and mobile nodes must be able to find the nodes located within direct communication range in order to start collaboration.

- *Message exchange* - presents ability of sharing data between nodes when two nodes successfully discovered each other and can share data in user awareness. Nodes send data to its discover neighbour nodes and data is distributed to all the nodes through the information sprinkler.
- *Information sprinkler* - is not mobile and it is fixed in dedicated location in opportunistic network. Information sprinkler works as other opportunistic network node. Data collect form one information sprinkler is distributed to other information sprinkler with in short period of time.

C. Classification of the OppNet

Typically, the OppNet can be classified to following classes:

- *Class 1* - Opportunistic Networks (also called Opportunistic Communications Networks) [3] - there is limited usability of the capabilities available in their environment. OppNet is used only to establish communication ability by reconnecting previously disconnected devices. Mobile devices within communication range of each other can initialize and configure network.
- *Class 1,5* - Opportunistic Networks (also called Opportunistic Data Dissemination Networks) [4] - presents extension of the Class 1. This type of network have the possibilities to disseminate data and nodes or network initiate a dynamic interconnection with other detected components (nodes or networks) in order to propagation of the data.
- *Class 2* - Opportunistic Networks (also called Opportunistic Capability Utilization Networks) [5], [6] - provides different type of capabilities (resources, services, skills, and so on, such as processing power, storage, sensing and actuating, and specialized skills) not limited to those involving communication or data dissemination.

III. ROUTING APPROACHES IN OPPNETS

Routing strategy in OppNet is very challenging and difficult task. The design of efficient routing methods for OppNet is a complicated task due to the absence of knowledge about the topological of the network. Routing performance improves when more knowledge about the expected topology of the network can be exploited [7]. Performance of the routing mechanisms depends on knowledge about the expected topology of the network [8].

Context information is a key piece of knowledge to design efficient routing protocols. Context information represents users working address and institution, the probability of meeting with other users or visiting particular places. It represents the current working environment and behavior of users. It is very helpful to identify suitable forwarders based on context information about the destination.

Opportunistic forwarding protocols work well under fading conditions, as it leverage the fact that wireless networks inherently use broadcast transmissions and that errors are mostly location and channel dependent. With multiple nodes distributed in space, the chance increases that at least one of them succeeds in receiving the packet and acts as a forwarder.

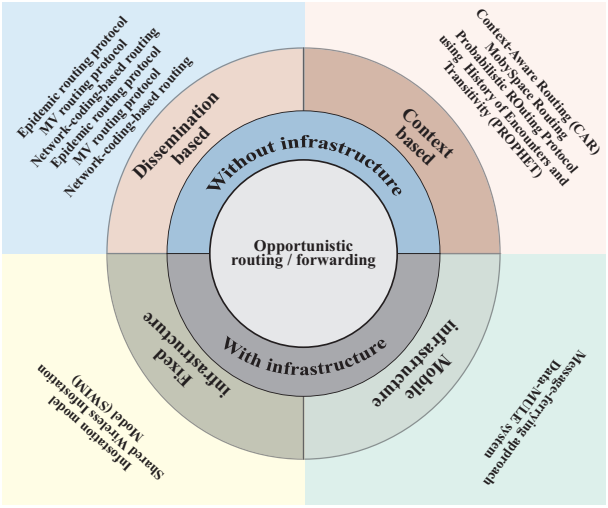

Fig. 4 Classification of the routing protocols in OppNet

There are many classifications of the routing and forwarding strategies for OppNets. Based on the number of copies of a message forwarded by the node, OppNets are classified to two routing schemes: forwarding-based (single copy) approach and flooding-based (multiple copies) approach. In the forwarding-based approach, there is only one single custodian for each message to help forwarding the message to destination.

In the forwarding-based scheme, based on what type of knowledge nodes use to select the appropriate or the best path to destination node, the prior studies can be classified into three categories:

- **Direct-transmission** - after the source node generates a message, the message is hold by the source node until it reaches the destination node. The main advantage of this scheme is that it incurs minimum data transfers for message deliveries. On the other hand, although having minimal overhead, this scheme may incur very long delays for message delivery since the delivery delay for this scheme is unbounded [10].
- **Location-based** - nodes will choose the neighbours who are closest to the destination to pass the message [11], [12].
- **Estimation-based** - based on certain knowledge about the network, the source and intermediate

nodes decide which node to forward the messages as well as whether it should transmit the message immediately or hold the message until it meets a better node [8], [13], [19].

Based on the literature, the routing mechanisms in OppNet can be classified to the main routing approaches based on the amount of context information of users they exploit (see Fig. 4).

In without infrastructure (*infrastructure-less*) opportunistic networks, there are two routing approaches: dissemination-based and context-based routing.

In with infrastructure (*infrastructure*) opportunistic networks, there are two routing approaches: routing based on fixed infrastructure and routing based on mobile infrastructure.

A. *Dissemination-based routing algorithms in OppNet*

Dissemination-based algorithms are based on the controlled flooding schemes, and differentiate themselves for the policy used to limit flooding. In this kind of networks there is no knowledge of a possible path towards the destination; consequently a message should be sent everywhere.

Routing protocols are based on a random evolution of the network and will be discussed in the following and obviously work well in highly mobile networks where contact opportunities, which are needed for data diffusion, are very common [9]. They tend to limit the messages delay, but they are also very resource hungry.

Typical representative of dissemination - base routing is epidemic routing (ER) [14]. ER provides the final delivery of messages to random destinations with minimal assumptions of topology and connectivity of the network.

Final message delivery depends on only periodic pair-wise connectivity between mobile devices. The ER protocol is based on the theory of epidemic algorithms [14] where each host maintains two buffers. One buffer is used for storing messages that it has originated and second for messages that it is buffering on behalf of other hosts. Each mobile device stores a summary vector that contains a compact representation of messages currently stored in buffer.

The Meet and Visit (MV) routing protocol is an expansion of the ER and provides more sophisticated method used to selection of the messages to forward to an encountered node [16]. In this algorithm, the messages are changed during pair-wise contacts as in epidemic routing and the choice depends on the probability of encountered nodes to successfully deliver messages to their eventual destinations. The delivery probability relies on recent-past observations of both the meetings between nodes and the visits of nodes to geographical locations [15].

Network-coding-based routing is special group of dissemination based protocols but takes an original approach to limit message flooding [16]. Messages are combined together (encoded) at nodes before being forwarded. Then, the codes produced are sent out instead of the original messages. Codes are spread in different directions like in other dissemination-based routing protocols. The number of codes generated is higher than the number or original messages combined together. This is to allow much more robustness against both packet and path loss [16]. Encoding is performed at both source and intermediate nodes.

B. *Context-based approaches routing algorithms in OppNet*

Context-based approaches usually do not adopt flooding schemes, but use knowledge of the context that nodes are operating in to identify the best next hop at each forwarding step. Context-based routing exploits more information about the context nodes are operating in to identify suitable next hops towards the eventual destinations. The usefulness of a host as next hop for a message is hereafter referred to as utility of that host. This approach requires a huge amount of bandwidth and storage capacity and can result very energy inefficient.

Musolesi et al. [17] design the Context-Aware Routing (CAR). This protocol enables an asynchronous communication for message delivery and each node in the network is in charge of producing its own delivery probabilities towards each known destination host. If a message cannot be delivered synchronously, the message is sent to a host that has the highest probability of successful delivery and acts as a message carrier. Delivery probabilities are exchanged periodically so that, eventually, each node can compute the best carrier for each destination node. The evaluation and prediction of context information is calculated by using Kalman filters and is used during temporary disconnection and the process is continued until it is possible to guarantee certain accuracy [18].

In MobySpace Routing, the mobility pattern is used as context information [18]. The MobySpace uses a multi-dimensional Euclidean space, where is possible contact between couples of nodes. The contacts are represented by each axis and the probabilities of those contacts to occur are measured by the distance along axis. Two nodes that are close in the MobySpace, have similar sets of contacts. The best forwarding node for a message is the node that is as close as possible to the destination node in this space [18].

Both CAR and MobySpace Routing require full knowledge of possible destinations to enable forwarding.

Author Lindgren et al. [19] describe the Probabilistic Routing Protocol using History of Encounters and Transitivity PROPHET. The estimated parameter delivery predictability is used to estimation of the probability successfully delivering a message to the destination from the local node. Main idea of PROPHET is similar as the ER.

When two nodes meet, they exchange summary vectors containing the delivery predictability vector which is based on the delivery predictability information. In theory, if two nodes are often

encountered, they have high delivery predictability to each other. On the other hand, if a pair of nodes does not encounter each other in a while, they are intuitively not good forwarders of messages to each other.

C. Routing based on fixed infrastructure in OppNet

In routing based on fixed infrastructure, the source node can send a message through a base station which provides Internet access or acts as a router. Infrastructure based networks, a source node usually wants to send a message through a base station which provides Internet access or acts as a router. There are two possibilities Infostation model and Shared Wireless Infostation Model (SWIM).

Infostation model is an example of direct communication between node and base station [2]. The latter allows the communication between neighbour nodes if the node is not in the range of the base station. The neighbour node will eventually forward the message to the base.

Shared Wireless Infostation Model (SWIM) allows both node-to-base-station and node-to-node communications. A source node that is wishing to send a message to a destination node, delivers the message to the base station directly, in the case, that node is located within communication range. If node cannot deliver message, it delivers the message opportunistically to a near node that will eventually forward it to the base station when encountered [20].

D. Routing based on mobile infrastructure in OppNet

In routing based on mobile infrastructure, some/all nodes in the network act as mobile data collectors. These nodes move around in the network area following predetermined routes or random movements, and gather messages from the neighbors' nodes. They move around in predetermined or arbitrary routes, and gather messages from the nodes they pass by. These special nodes are called as carriers, supports, forwarders, MULEs, or even ferries.

They introduces the entities responsible for messages delivery, only in the case, when node-to-carrier communications are allowed, or they can simply help increasing connectivity in sparse networks and guaranteeing that also isolated nodes can be reached. Delivery of messages is accomplished both by carriers and ordinary nodes, and both node-to-node and node-to-carrier communication types are allowed.

Well example of these routing techniques is Message ferrying protocol [21]. Protocol is a proactive mobility-assisted approach which utilizes a set of special mobile nodes. These nodes are called message ferries and are used to provide communication services for nodes in the network. Message ferries move around the deployment area according to a given, well known trajectory and take responsibility for carrying data between nodes.

Another one is Data-mule system [22] which is used to data retrieval from sparse wireless sensor networks. Data-mule is very similar to a message ferrying protocol and is designed for sparse sensor network in order to energy saving.

IV. FUTURE STEPS

There is necessary to design useful and effective mechanisms to providing all communication for all type of class of forwarding. OppNets requires a paradigm shift toward human-centric solutions to establish trust for interactions between users.

In our research, we will be oriented to problems of opportunistic routing with regard to security and QoS. Our next research will by focus on following challenging areas:

- *field of simulation in OPNET modeler*

We are working on new routing strategies for dissemination and context based routing protocols with implementation of the QoS and security mechanism to the network simulator OPNET modeler.

- *field of routing algorithm and mechanism based on selection of the optimal candidates to transporting of the messages*

We are design on the robust and resistant routing algorithms to increase the reliability and to further decrease the cost of routing. Our routing algorithms will decrease latency and latency jitter of the transmittion of the packets based on the effective selection of the candidate nodes. These candidate nodes will be selected based on localization algorithms. Algorithms will reflect actual position of the mobile nodes.

- *implementation of QoS and security for opportunistic routing and forwarding to the simulator OPNET modeler*

Another part of research will focused on implementation QoS and security related mechanism in order to provide secure transmittion of the messages. We will work on optimalization processes that are necessary for decreasing of the routing overhead.

- *we analyze the possibilities to implement cross layer optimalization framework to enhance privacy services*

We also will develop a cross-layer optimization framework incorporating opportunistic routing and QoS/security based on modified security service vector (SSV) [23],[24], designed for MANET, to enhance privacy of provided user's services.

- *field of implementation of the routing strategies and algorithms with regard to QoS and security to the real OppNet in our laboratory.*

Designed routing protocols will be tested and analyzed on real devices.

V. CONCLUSION

The OppNets provides the relatively new and dynamically developing the research areas and are designed as an evolution of the multi-hop MANET. We can say that it is an interesting evolution of the traditional MANET. OppNets can be used for many application domains (e.g. home application, emergency and crises situation, army infrastructures, healthcare, defense against catastrophic terrorisms etc.).

The research is still at the beginning and getting growing interest in networking research community. Research fields are oriented on different layers of a protocol stack. We can say that the design of efficient and robust routing protocols for OppNet is very difficult task with regards to properties of OppNet (the absence of knowledge about the network topology).

ACKNOWLEDGMENTS

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Grid-tied Multilevel Inverter With Predictive Current Control

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Abstract – ***The paper presents a grid-tied cascade H-bridge inverter with predictive current control and reactive power control. The 15-level cascade inverter consists of three H-bridge inverters with separated DC sources is proposed. At the output of the cascade inverter an L filter is used. The predictive current regulator and one-phase synchronous reference frame phase-locked loop (PLL) are designed with help of Rapid Control Prototyping. The grid-tied cascade inverter is controlled by the mean of RT-Lab. The proposed control method uses a discrete model of the filter and grid to predict the behavior of the system. Verification on a laboratory model is described.***

Keywords: ***cascade inverter, phase locked loop, predictive current control, RT-Lab***

I. INTRODUCTION

The solar energy and especially photovoltaics is one of the fastest growing industries in the world. There is a demand for high quality electrical energy and thus the use of photovoltaics is almost impossible without modern power electronics. Whether it is a stand-alone photovoltaic (PV) electrical generator or a grid-connected system there is a demand to change the DC voltage to the AC voltage, to maximize the energy yield and to monitor the whole system. This is done by the mean of a PV inverter. There are several types of PV inverters according to the topology. However, there is little experimentation with alternative inverter topologies [1]. The most widely used topology employs full-bridge (H-bridge) voltage source inverter.

The cascade H-bridge inverter is an alternative to the single H-bridge inverter in photovoltaic systems. Its advantages over the single H-bridge inverter are lower total harmonic distortion of the grid current (THDi) and THDu of the output voltage, requirements of smaller filters, ability to transfer more power and smaller du/dt stresses. There is a need to increase the lifetime of photovoltaic inverters as well as their reliability. High voltage stresses decrease the lifetime of many electrical components [2]. Lower du/dt stresses of components in multilevel H-bridge inverter can help to meet these needs.

The lifetime of PV generators is in the range of 25 years and their reliability is high. However, the lifetime of typical inverter is in the range of 5 – 10 years (in 2006) [1]. It means that the inverter needs to be replaced several times during the lifetime of the PV generator. According to several biggest PV inverter producers, the PV inverter lifetime of 20 years cannot be achieved (mainly due to poor reliability of capacitors) and the price of the inverter is more important than its lifetime. On the other hand, the cost reduction and the reliability increasing can be achieved by using new topologies of PV inverters [1]. The topologies of utility scale PV inverters are moving towards multilevel structures mainly because of lighter filtering components and better harmonic spectra [9].

Progress in the field of photovoltaics and increasing penetration of grid-tied distributed renewable energy sources leads to potential problems with those power sources. Small grid connected PV systems are usually connected to the low voltage grid. In Germany, which has more than 20 GW of grid connected PV systems installed, is approx. 80% of installed power fed to the low voltage grid. [8]

Such a huge power supplied from renewable energy sources can significantly influence the low voltage grid. The PV plants are thus moving from pure grid feeders to sources at least partially responsible for power quality. As will be shown, the reactive power control can significantly influence the performance of grid-tied PV inverter.

II. CASCADE H-BRIDGE INVERTER

A. Multilevel Converter Topologies

Multilevel inverters have been used for many years in high-voltage, high-power applications. Their capability to divide the net voltage and power between several smaller cells and to produce higher quality voltage and current were the reason for their spreading in these areas. The most widely used topologies in industry are cascade inverter, diode-clamped neutral point clamped (NPC) inverter and capacitor-clamped (flying capacitor) NPC inverter.

Multilevel inverters usually need several separated dc sources which is one of the biggest problems they have.

However, in the area of photovoltaics, the separated dc sources with galvanic isolation are not a problem and a dc/dc converter at each H-bridge inverter input can be used [12]. Even though, not all above-mentioned multilevel topologies are suitable for PV inverter. The diode-clamped NPC inverter has a complicated active power control and the capacitor-clamped NPC inverter has low efficiency when it has to transfer the active power [3].

B. *Cascade H-bridge Inverter*

A single-phase structure of a general 7-level cascade H-bridge inverter is shown in Fig.1. The number of output phase voltage levels n is defined by:

$$n = 2d + 1 \tag{1}$$

where:
d – is the number of separated dc sources.

However, by using asymmetrical DC voltages at the cascade inverter input, where the next DC source voltage level is two-times the previous DC voltage level, the number of output voltage levels can be increased to:

$$n = 2^{d+1} - 1 \tag{2}$$

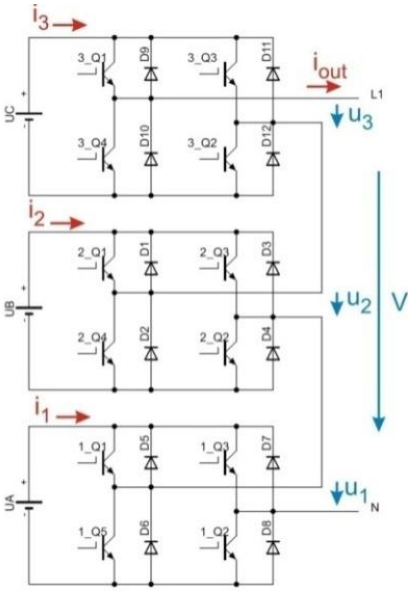

Fig. 1. Single-phase cascade H-bridge inverter with three separated DC sources (UA = 40V, UB = 20V, and UC = 10V), capable of creating 15 voltage levels at its output.

Each H-bridge inverter can create positive, negative or zero voltage on its output with magnitude equal to the dc source voltage. Thus there are 15 possible combinations for the cascade H-bridge inverter with 3 separated dc sources (2).

The measured partial voltages at the output of each H-bridge inverter are shown in Fig.2. It can be clearly seen that each H-bridge inverter is switching with different frequency, which is increasing as the voltage of the H-bridge inverter is decreasing (natural decrease of switching losses). There is discontinuous power transfer at the output of each bridge cell.

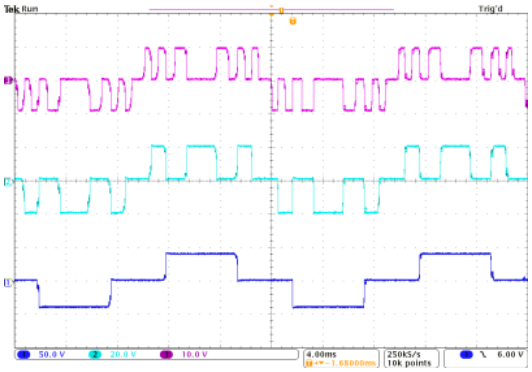

Fig. 2. Measured partial output voltages u1, u2, u3 of the cascaded H-bridge inverter (amplitudes: 40, 20 and 10V), ma = 0,8, mf = 2

C. *Output Filter*

An output filter is necessary to suppress higher order harmonics of current and voltage in output of the inverter and to comply with electrical standards. The grid voltage in the point of coupling is influenced by the current supplied to the grid by the inverter. There are three main filters used as output filters in inverters: L, LC and LCL. The higher the order of the filter, the better the attenuation is. However, when considering ideal

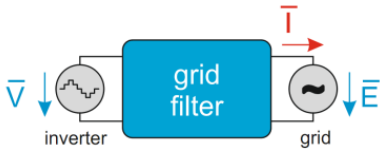

Fig. 3. The grid filter between the inveretr and the grid

grid (no higher order harmonics), there is no difference between L and LC filter in terms of transfer function between output current I and the inverter voltage E.

The L filter has the attenuation of 20 dB/dec. The L filter is of the first order and has no resonant frequency. The transfer function of the L filter is:

$$\left.\frac{I}{V}\right|_{E=0} = \frac{1}{sL} \tag{3}$$

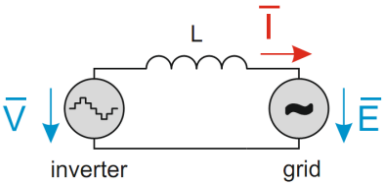

Fig. 4. The L grid filter between the inveretr and the grid

The LCL filter has the attenuation of 60 dB/dec for frequencies higher than the resonant frequency :

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{L_S + L_G}{L_S L_G C}} \quad (4)$$

The transfer function of the LCL filter is:

$$\left.\frac{I}{V}\right|_{E=0} = \frac{1}{s^3 L_S L_G C + s(L_S + L_G)} \quad (5)$$

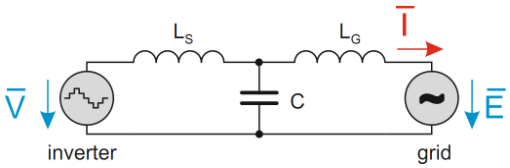

Fig. 5. The LCL grid filter between the inveretr and the grid

III. CASCADE INVERTER CONTROLLER

The cascade inverter controller (Fig. 6) consists of several parts: grid measurements, PLL, reference current generator, predictive current controller and coder.

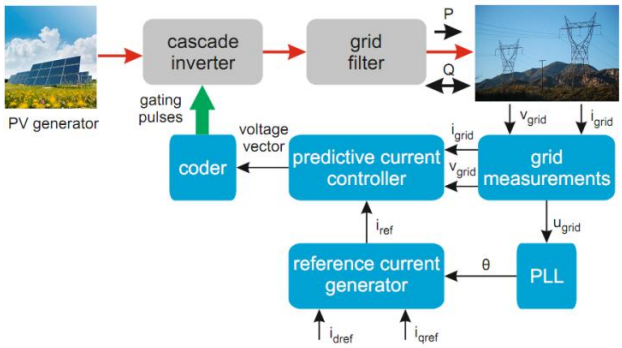

Fig. 6 Current control of grid connected PV system

A. *Phase Locked Loop*

The PLL (Phase Locked Loop) is a mean how to synchronize the grid connected system to the grid voltage. The synchronization is needed for power factor control. PLL synchronization techniques can be divided into two groups: open loop and closed loop. The most widely used technique in three-phase system is synchronous reference frame PLL (SF-PLL). The SF-PLL has good performance with the grid which is not highly distorted [10].

The SF-PLL is based on direct Clark transformation of the three-phase system into two-phase system and the subsequent Park transformation into synchronous reference frame. Thus two voltages v_d and v_q are produced. One of these voltages is by a mean of PI controller set to zero which results in the reference being locked to the grid. The output from the PLL is a phase angle which is used to generate the reference three-phase currents through direct Park transformation (dq→αβ) and subsequent reverse Clark transformation (αβ→abc).

The SF-PLL can be used for one-phase systems as well. However, it is not possible to use the direct Clark transformation because only one voltage is presented. The solution is to create artificial two-phase system based on the one-phase grid voltage [10][11].

The property of the stationary reference frame is that two voltages v_α and v_β are orthogonal. If the grid voltage corresponds to the v_β voltage, than the v_α can be created as follows:

$$\begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \begin{bmatrix} V_m \sin(\omega t - \pi/2) \\ V_m \sin(\omega t) \end{bmatrix} \quad (6)$$

There are several possibilities how to create the 90 degrees phase shift of the grid voltage to produce the v_α voltage (e.g. storage elements, filters). One of them is to use second-order low-pass filter [10][11]. Based on the comparison in [10] the best performance is achieved by PLL with second order filter artificial voltage generator and SF-PLL. When the input voltage v_{grid} passes through the second-order low-pass filter, where the damping ratio $\zeta = 1/\sqrt{2}$, the undamped natural frequency ω_n has the same value as the estimated frequency, a signal with a phase-angle difference of $\pi/2$ and amplitude of $V_m/\sqrt{2}$ is obtained [10]:

$$v_\alpha = -\sqrt{2}\frac{V_m}{\sqrt{2}}\sin\left(\omega t - \frac{\pi}{2}\right) = V_m \cos(\omega t) \quad (7)$$

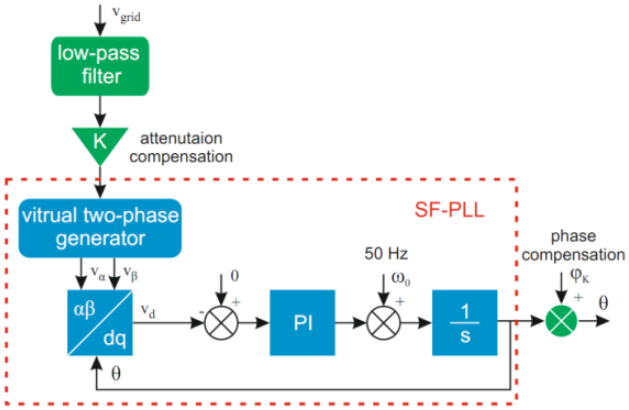

Fig. 7 One-phase synchronous reference frame PLL (virtual two-phase generator is 2nd order low-pass filter)

The one-phase synchronous reference frame PLL is shown in Fig. 7. The input is a grid voltage which passes through a low-pass filter. The amplitude and phase of that filter is compensated, as suggested in [10].

The PLL is implemented as discrete model and filters' coefficients are obtained by using Tustin transformation.

B. *Reference Current Generator*

The reference current generator consists simply of direct Park transformation. The i_α is set as reference current i_{ref} for current regulator.

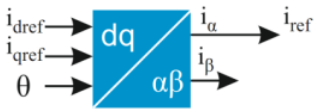

Fig. 8 Reference current generator

C. Predictive Current Controller

There are various control techniques to control the output of the inverter. When using the PWM control there is a need to linearise the model of the inverter and this control technique can lead to cascade regulation structure which has slow response time. The predictive control offers the possibility to control the inverter's output current and voltage with high dynamics without the need to face the problem of non-linear nature of semiconductor power converters [6].

In [7], authors use trajectory based predictive control for current control of three-level diode-clamped NPC inverter. This control technique has been adapted to the proposed 15-level cascade H-bridge inverter. This control technique can be broadly classified as trajectory based.

The basic principle of used predictive control technique is that the cascade H-bridge inverter can create only limited number of voltage levels at its output.

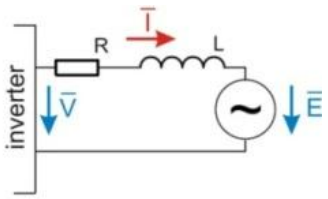

Fig. 9 The L filter between the inverter's output and the grid used to decouple the output voltage and the grid and to filter higher harmonics.

The PV inverter connected to the grid through L filter is depicted in Fig. 9. The variable of interest is the current supplied to the grid I. This current is influenced by the inverter voltage V. The goal is to predict the behaviour of the load current I for each possible voltage vector generated by the inverter cascade. For the system in Fig. 9, the future value of the load current I can be predicted form the model of the system as:

$$i(k+1)=\frac{T_S}{L}\left(v(k)-e(k)\right)+i(k)\left(1-\frac{RT_S}{L}\right) \quad (8)$$

The (8) is used to predict the future value of the load current. For the trajectory based predictive control there is a need to create the trajectory which will the grid current follow. However, the future value of the reference current $i^*(k+1)$ is unknown. In order to determine the next value of the reference current, in [7] Lagrange quadratic extrapolation is used, that at each point assume the corresponding value of the function:

$$i^*(k+1)=3i^*(k)-3i^*(k-1)+i^*(k-2) \quad (9)$$

For predictive control, there is a need to create the cost function which will be evaluated in each sampling time and will define the behaviour of the system. The function can be chosen as a filter to remove certain harmonics and so on. [6] The cost function was chosen as:

$$z(k)=\left|i^*(k+1)-i(k+1)\right| \quad (10)$$

The simulation of the cost function evaluation is shown in Fig. 10 for sampling time Ts = 200 μs.

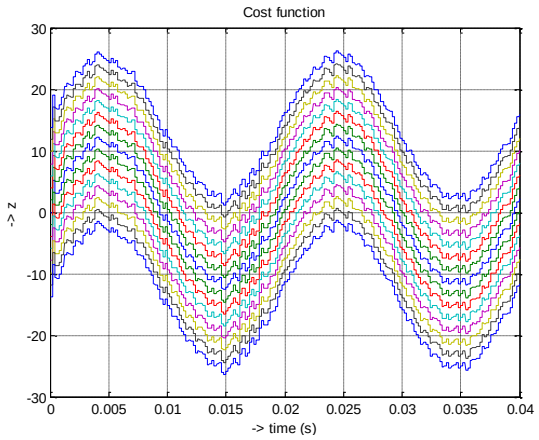

Fig. 10 The cost function evaluation in time

The controller structure is shown in Fig. 11. The inputs are grid voltage and current and the reference current from the reference current regulator. The discrete model of the system is calculated for each voltage vector and the voltage vector that minimise the cost function is chosen. The output of the predictive current regulator is the desired voltage vector which is fed to the coder. The coder is responsible for the control of switching states of H-bridges to create the desired voltage level at the inverter's output.

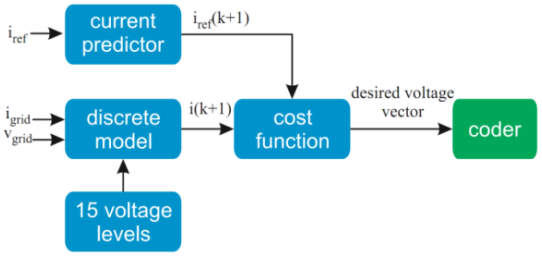

Fig. 11 The predictive current controller

IV. EXPERIMENTAL RESULTS

A. *Laboratory setup*

The after-mentioned current control technique was used to control the laboratory model of a 15-level (three DC sources: 240V, 120V and 60V) cascade inverter. The current regulator was designed using Rapid Control Prototyping technique (RCP) with help of Matlab/Simulink and RT-Lab. When using RCP, which is a part of the Hardawre in the Loop simulation, the regulator is simulated on a computer in real time and is connected to a real plant. This technique can easily verify the controller design. The plant is the 15-level cascade inverter with 3 separated DC sources in this case. Simulink was used to create a program scheme of the regulator and RT-Lab was used to simulate the regulator in real time.

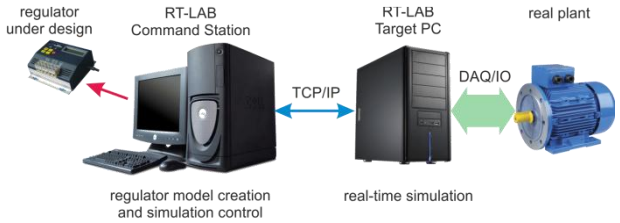

Fig.12 Interconnection of simulated regulator and real plant using RT-Lab during RCP procedure

The connection between the real-time system and a real hardware is accomplished by a mean of DAQ card with digital and analog inputs/outputs. The dead time needed to prevent short circuit in H-bridge leg is realized by the hardware driver circuit. The current regulator is sampled with sample time T. With current system configuration the sample time can be set as low as 50 µs.

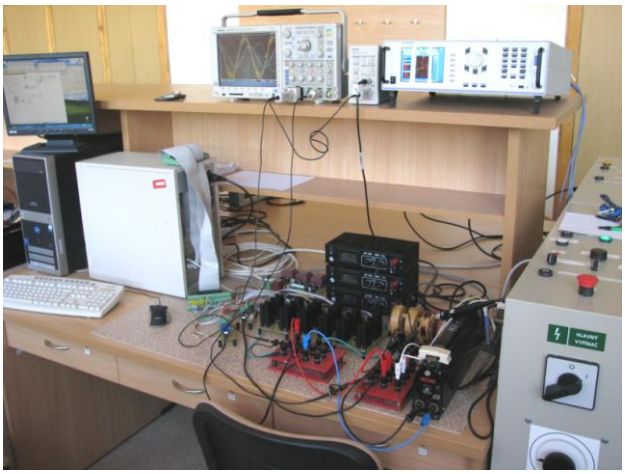

Fig.13 The laboratory setup with grid-tied cascade inverter, RT-Lab command and target PCs, digital osciloscope and power analyzer

B. *Measurements results*

With measurements on the 15-level cascade H-bridge inverter, the tracking capability of the load current and the power factor control were verified. The full power (3.6 kW, ~230 V/ 50 Hz) laboratory model is built. For measurements, the system parameters were set to: R = 5 Ω, L = 7 mH, T_S = 100 µs, U_A = 40 V, U_B = 20V, U_C = 10 V (voltage sources) as only the designed control technique was verified. The inverter was connected to the single-phase grid ~22V/50Hz and controlled by RT-Lab.

The reference current was set to i_{dref} = 3 A, i_{qref} = 0 A, thus the power factor is 1 and the power is supplied to the grid. The active and reactive power as well as phase shift was measured by power analyzer. The real phase shift was 2 degrees into inductive region thus the reactive power was consumed by the inverter (Fig. 14).

Then the reference current was set to i_{dref} = 1 A, i_{qref} = -2 A. The active, as well as the reactive power, was supplied to the grid (Fig. 15).

In both cases was the THDi of the grid current below 4% which is satisfactory when regarding the output power of the inverter.

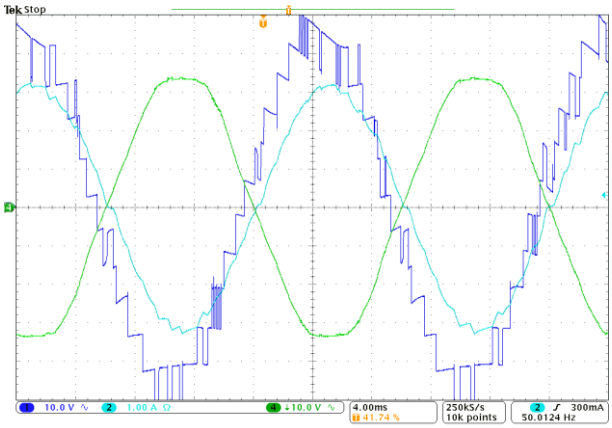

Fig. 14 Output current of cascade inverter with current control: CH1: inverter voltage, CH4: grid voltage, CH2: grid current (T = 100µs, R = 5Ω, L = 7mH, UA = 40V, UB = 20V, UC = 10V), I_g = 2,24 A, THDi = 2,8%, P = 56 W, Q = 1,9 W, cosφ=0,99, φ= -178° capacitive, i_{dref} = 3 A, i_{qref} = 0 A

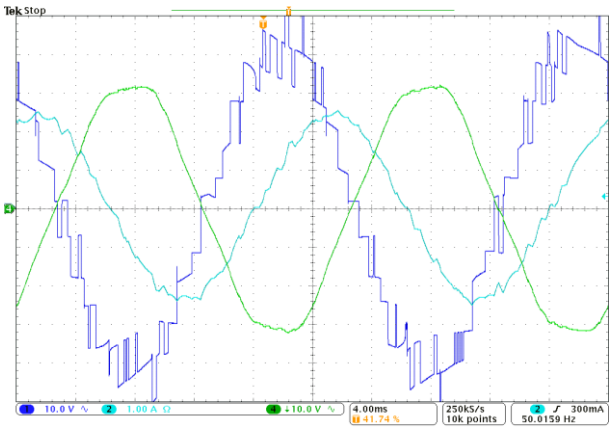

Fig. 15 Output current of cascade inverter with current control: CH1: inverter voltage, CH4: grid voltage, CH2: grid current (T = 100µs, R = 5Ω, L = 7mH, UA = 40V, UB = 20V, UC = 10V), I_g = 1,68 A, THDi = 3,5%, P = 17 W, Q = 16,9 W, cosφ=0,43 capacitive, φ= -115°, i_{dref} = 1 A, i_{qref} = -2 A

V. CONCLUSIONS

The 15-level grid-tied cascade H-bridge inverter with predictive current control technique is presented.

From the experimental results can be concluded that the proposed current regulator and PLL synchronisation work properly.

Also the reactive power control is ready to be used with full output power of the inverter. Although only the simple L filter is used, the THD of the grid current is satisfactory. Connection to the PV generator and design of MPPT (Maximum Power Point Tracking) control, which is essential for a PV inverter, is needed to be designed. Also the problem with unloaded dc sources (partial PV generators in real system) needs to be solved. Replacing the simple L filter with a filter of higher order (LCL filter) and dealing with active damping is the next challenge. The used cost function is simple and by creating more sophisticated cost functions, the control technique can be improved. However, the work shows promising results and by using computer control and RT-Lab, the controller can be easily modified.

ACKNOWLEDGMENT

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Researches Regarding WINPISA Software Commands Influence of an Rehabilitation Equipment

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***Abstract* – The paper presents some researches regarding WINPISA software commands influence on a lower limb bearing rehabilitation equipment. The equipment realizes continuous passive motion for the rehabilitation of the leg actuated by a pneumatic muscle. The equipment is connected to a computer by a SPC200 controller, which is programmed by WINPISA software through NC commands. With NC commands has been conceived different programs in which are specified the motion to be done by the slider.**
The results of experiments show the behavior of the equipment: slider position, speed and acceleration in time – under different commands.

Keywords: ***rehabilitation equipment; WINPISA; performances; pneumatic muscle.***

I. INTRODUCTION

The main objectives in this study consist of a rehabilitation equipment of bearing joints of lower limb testing and performance evaluation. The performance evaluation of the rehabilitation equipment was made by researches regarding the effects of different NC commands on equipment functioning.

The software used to conduct experimental research is: FluidSIM-P to achieve electro-pneumatic actuation schemes and WINPISA for training rehabilitation equipment slider after certain cycles and drawing diagrams of movement.

It is desired for the equipment to have a smooth motion, because the recovery medicine is a painful one and the incidence of the patients with post-traumatic disabilities of the bearing joints of the inferior limbs is high.

It have been examined the influence of several NC commands, used in WinPISA programs, analyzing the accuracy of the programmed positions, the form of the speed curves and those of the acceleration.

The researches will be continued with a optimization of the equipment design for reducing the vibrations and with choosing the optimum command from the ones analyzed.

The results of experiments show the behavior of the equipment: slider position, speed and acceleration in time – under different commands.

II. BEARING JOINTS OF LOWER LIMB REHABILITATION EQUIPMENT

A. Mechanical and pneumatic structure

The rehabilitation equipment used for the researches presented below is shown in Fig.1.

Fig. 1 Bearing joints of lower limb rehabilitation equipment

It is composed of a metal frame to support the affected leg connected with a slider which makes the continuous passive motion [2], [3]. As actuator is used a pneumatic muscle, achieved from FESTO Company, of 20 mm diameter and 750 mm length. A pneumatic muscle increases the diameter and shortens the length under the action of compressed air, acting like a spring and obtaining a linear motion.

The used muscle is presented in Fig.2.

Fig. 2 FESTO pneumatic muscle [4]

It is known that technical features of the pneumatic muscles provide a maximum stroke of 20% of its initial state. A mobile pulley, fixed between the slider and the muscle, ensures amplification of the displacement and obtaining the required value of 300 mm.

Pulley system has the advantage of doubling the displacement made by slide, but with the disadvantage that the sliding force is half of that provided by pneumatic muscle.

The positioning system used for this application offers flexibility, speed, a low-price and sufficient precision for the concrete functional requirements [3], [5].

The positioning system consists of:

- A position transducer with the measuring stroke of 300mm and maximum positioning velocity of ± 10 m/s (Fig. 3);
- A SPC200 controller (Fig. 4) for numerical commands (according to DIN 660) programming of the working positions, motion types and sequences;
- SPC–AIF Interface(Fig.5), for transmission of information from the transducer to the controller and of the commands issued by the controller to the proportional valve;
- MPYE proportional directional control valve 5/3 (Fig. 6) with operating pressure of 6 bar, flow rate at nominal pressure, max.750 l/min and operating voltage 24 V DC
- WINPISA Software (Fig. 7) with system requirements: processor 80486, 4 MB RAM, 30 MB Harddisk, 1,44 MB Disk drive, Serial interface.

Fig. 3 Position transducer [4]

Fig. 4 SPC200 [4]

Fig. 5 AIF Interface [4]

Fig. 6 MPYE proportional directional control valve [4]

Fig. 7 WINPISA Software[4]

Control variable is a displacement relative to the origin of which is measured by displacement transducer. The system allows programming of one or more cycles of rehabilitation exercises, depending on the degree of mobility of the individual patient.

Pneumatic structure of the rehabilitation equipment actuating is realized by FluidSIM-P software and is presented in Fig. 7.

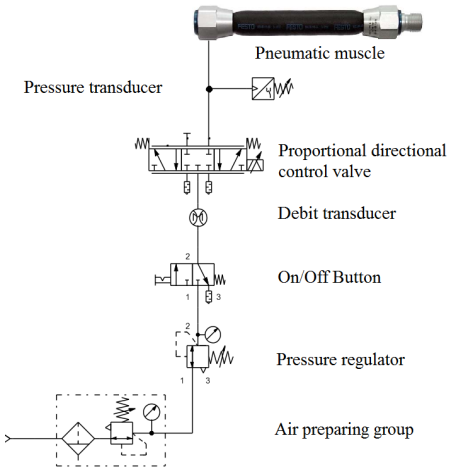


Fig. 7 Pneumatic scheme of the equipment

B. WINPISA Software

B1. Generalities

WinPISA software from FESTO Company is conceived for planning, programming and troubleshooting pneumatic axes which contains a SPC 200controller. Its main functions are to manage online multiple simultaneous pneumatic axes, commissioning and diagnostics, as well as positioning systems programming in accordance with DIN 66 025. With this software can be also drawn graphs that describe the time evolution of distance, velocity and acceleration of moving elements.

A typical screen of this software is shown in Fig.8.

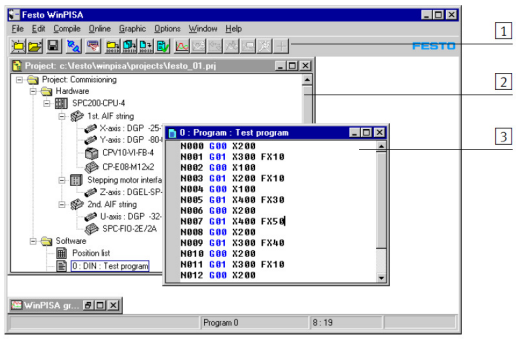


Fig. 8 WinPISA interface

Notations in the figure are:

1. Buttons toolbar;
2. Window for working project;
3. Window for NC code.

A positioning application realized by WinPISA software consists of several programs and data files recorded to a "project".

WinPISA project includes:

• a configuration for the controller SPC 200;

• a configuration and a set of application parameters for each pneumatic axis;

• a list of positions for NC commands;

• a number of NC positioning programs [1].

Any project written by WinPISA program supposes five steps: 1. Configuring the system, 2. Specifying parameters for pneumatic axes, 3. Specify or adjust the parameters for application 4. Realization of NC program 5. Testing programs.

Each project can be used only after its transfer to the SPC 200 controller memory. For this is done on-line connection between PC and controller through a serial link.

B2. Description of the main commands and syntax

The following NC operators were used in the NC programs utilized for testing the proposed rehabilitation equipment:

TABLE 1. NC Operators

Symbol	Description
N	Identifies the number of the line
G	Positioning conditions
M	Auxiliar functions
X, Y	Identifies the axes
F	Velocity (in G01 andG02 commands)
;	After this symbol can write comments

N000 – Identifies the number of the line

Each line of a program written in WinPISA must begin with line number identifier, such as shown in the example below:

…….

N002 G01 X100.00 FX10

N003 G04 100

N004 G01 X150.00 FX10

N005 G04 100

…….

G01 – Positioning motion with controlled velocity

A program line with G01 command is:

N000 G01 X50.00 FX10

G01 command indicates a positioning movement with controlled speed to a given position Xn, speed control being required with FXn command [1]. G01, in example, controls movement at a distance of 50 mm on the X axis from the origin, with a speed controlled of 10 percent from maximum speed.

G02 – Smooth positioning motion with controlled velocity

Command structure is identical to that of the G01, except that this command produces a smooth motion at beginning and at end; acceleration feature in function of time in these phases has a proportional form to sin^2 function. The effect of this variation is to avoid sudden movements [1].

G04 – Delay time

An example of use of this command is:

N003 G04 100

N003 line specifies a delay movement of one second until the following command execution [1].

G08 – Control of the starting acceleration

The structure of a command line program that contains G08 can be:

N005 G08 X50

where the value 50 after X means that for X axis the starting acceleration will be 50% of the maximum [1].

G08 – Control of the ending acceleration

Command structure is identical to the previous one, except that the numerical value after X means that, for X axis, the stopping acceleration will be 50% of the maximum [1].

F - Speed of motion

F command is designed to establish the speed of motion for a pneumatic axe. The syntax of this command is highlighted from the following example: *N004 G01 FX10 X150.00*

The line above indicates a controlled speed displacement on up to X = 150 mm, with a speed equal to 10% of maximum speed.

M30 - Ending program with repeat

Command structure is composed of the command line and M30. The role of this command is to continue the program from its first line.

……..

N007 M30

III. RESEARCH ON THE EFFECTS OF DIFFERENT NC COMMANDS OF THE REHABILITATION EQUIPMENT FUNCTIONING

A. Comparison of the effects of G01 and G02 commands

To analyze differences induced by the two commands into the rehabilitation equipment functioning, are presented two similar programs, in which the slider perform a movement from the 50 mm to the 200 mm, with a speed of 10 % of the maximum possible. The difference between the programs is that the movements are executed by commands G01, respectively, G02, and in both cases there is a delay of 2 seconds at the end of the displacement.

N000 G01 X50.00 FX10	*N000 G02 X50.00 FX10*
N001 G01 X200.00 FX10	*N001 G02 X200.00 FX10*
N002 G04 200	*N002 G04 200*
N003 M30	*N003 M30*

In Fig. 9 are presented, for the two programs, graphics that describe the actual and the reference motion of the slider in function of time.

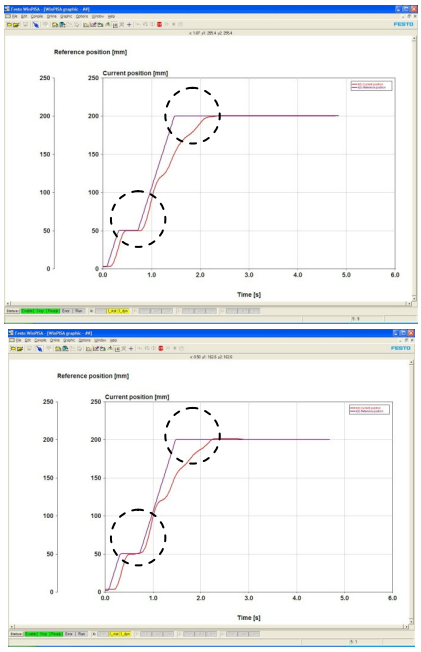


Fig. 9 s = f(t)

Starting from quota of 50 mm, time to reach the position of 200 mm, when using G01 command is 1.54 s with a delay of 0.86s from the reference value. For the G02 command, time to reach the proposed quota is 1.62 s, with a delay of 0.8 s from the reference value.

Although the delay in achieving the proposed quota is higher for G02 command, its use is preferred because it provides a less brusque acceleration or deceleration displacement.

Fig. 10 presents the evolution of the velocity in function of displacement (form 0 to 200 mm).

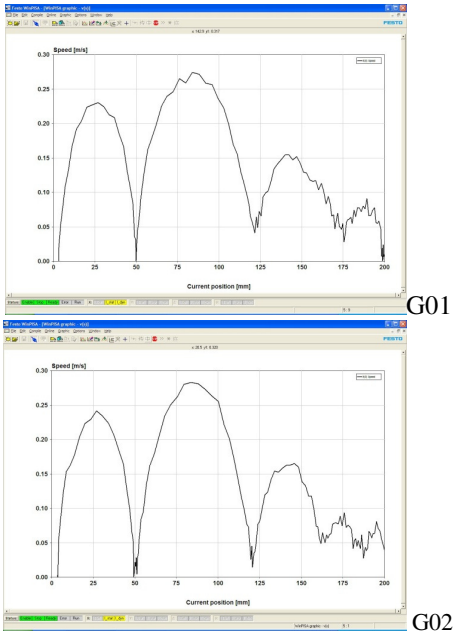


Fig. 10 v = f(s)

For G01 command maximum speed is 0.274 m / s, reached at a quota of 83.9 mm; for the G02 command, speed is 0.284 m / s, obtained at a distance of 83.5 mm. Fig. 11 presents the evolution of the velocity in function of time.

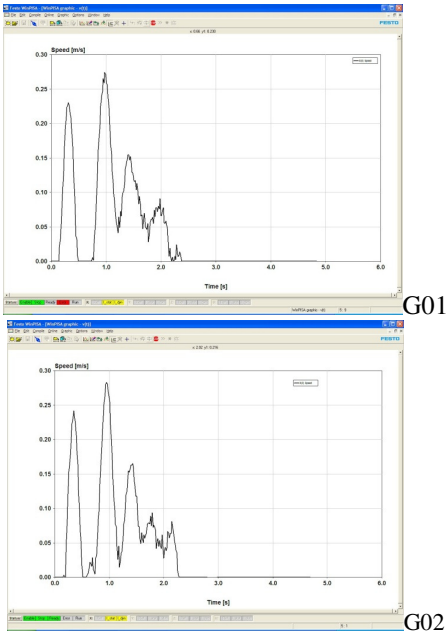


Fig. 11 v = f(t)

Accelerations obtained by the equipment slider is limited in the range [-7.2 ... 5.6] m/s^2 for command G01, respectively, in the range [-6.7 ... 6.3] m/s^2 for G02 (Fig. 12). The limit ranges of accelerations has similar sizes, graphics of acceleration does not allow separation of conclusions on the choice of one or other of the two commands (G01 or G02).

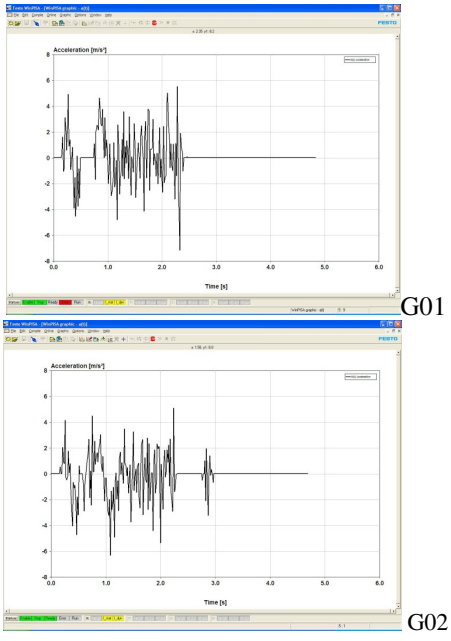


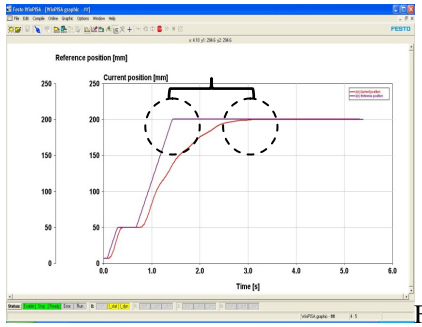
Fig. 12 a = f(t)

B. Comparison of the effects of FX10 and FX90 commands

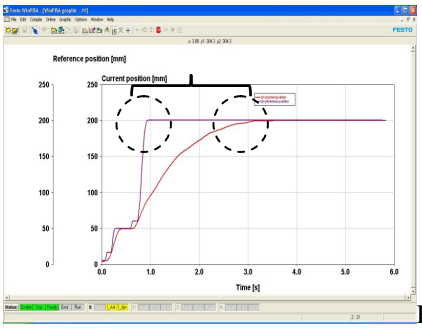
Below are two programs proposed for analyzing of the differences in behavioral rehabilitation equipment for a speed of 10% (FX10 command) and 90% (FX90 command) of the maximum programmed.

N000 G01 X50.00 FX10	*N000 G01 X50.00 FX90*
N001 G01 X200.00 FX10	*N001 G01 X200.00 FX90*
N002 G04 200	*N002 G04 200*
N003 M30	*N003 M30*

From Fig. 13 it is noted that the delay between the time of achieving the controlled position (200 mm) and the reference time is higher at FX90 command. The existence and size of such difference between the two times, has no influence on exercise rehabilitation.



FX10



FX90

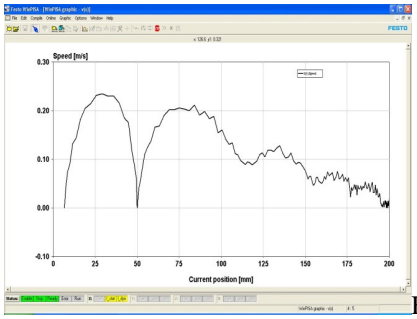
Fig. 13 s = f(t)

Fig. 14 and 15 present the evolution of the velocity in function of displacement and in function of time.

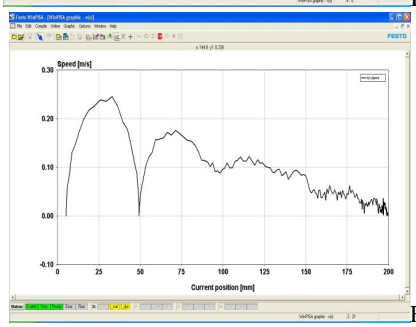
Maximum speeds obtained are 0.23 m/s, when is used FX10 command and 0.25 m /s for FX90 command. Both values are obtained during the movement of the slider between 0 and 50 mm. Although the two velocities have very close values, practically is recommended FX10 command.

A lower speed is necessary to adapt the affected leg more easily to motion.

Fig. 14 presents the evolution of the velocity in function of displacement (from 0 to 200 mm).



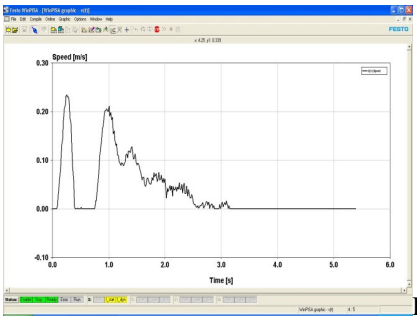
FX10



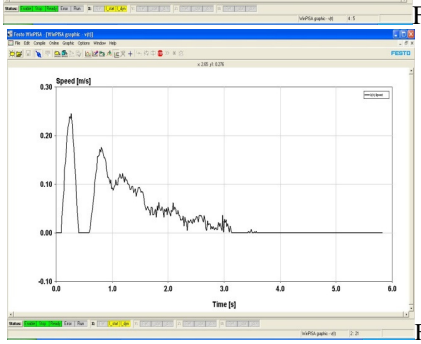
FX90

Fig. 14 v = f(s)

Fig. 15 presents the evolution of the velocity in function of time.



FX10



FX90

Fig. 15 v = f(t)

The influence of the two commands on the rehabilitation equipment slider acceleration results from Fig. 16.

It may be noted that the range of acceleration is higher for FX90 command (13.68 m/s2) compared with the value from FX10 command (11.54 m/s2), which also leads to the idea of using for the various rehabilitation exercises the FX10 command.

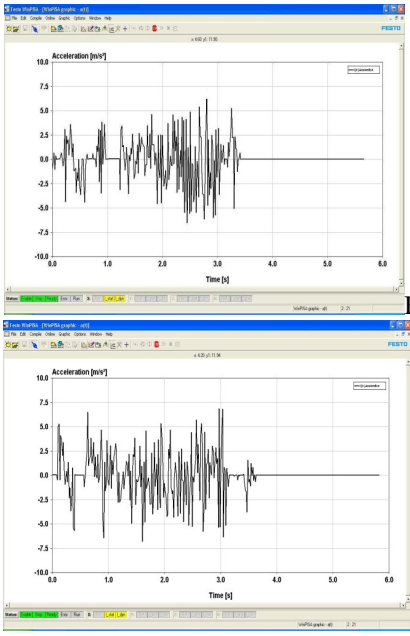


Fig. 16 a = f(t)

III. CONCLUSIONS

The paper presents the behavior in functioning of rehabilitation equipment, actuated by pneumatic muscles. It had been presented the influence of some WINPISA software commands and the comparison of their effects on the equipment.

The equipment functioning is desired to be smooth because the pain for the patients is high during the rehabilitation exercises.

For the chosen example, the optimal commands are G01 – of controlled velocity positioning motion and FX10 of 10% speed of the maximum imposed. Those commands ensure a smooth functioning, with reduced vibrations.

Rehabilitation equipments, like the one proposed for testing in this article, bring benefits to the patients like significantly reducing of the period of recovery with a smaller necessity of pain medication and from here, the decreasing of the total costs of recovery.

ACKNOWLEDGEMENTS

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Pneumatic Muscle Diameter Evolution under Compressed Air Action

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Abstract *– The proposed article presents the experiments made on a pneumatic muscle for establishing the evolution of its diameter, under different load and pressures. The experimental stand consists in a pneumatic muscle achieved from FESTO AG&Co. with code MAS-20-750N-AA-MC-O-ER-BG, which is fixed on a support structure and connected to compressed air. At the free end are attached different loads (10 and 20 kilos). Pressures used have values between 0 and 6 bar. The results of the pneumatic muscle testing show the evolution of the diameter of the muscle and the functions of the curves resulted.*
For each situation (no load, load of 10kg and load of 20 kg) has resulted different functions. The three functions of the diameter evolution in function of pressure were validated by three methods – the correlation coefficient (r), the coefficient of determination (r^2) and by graphical form of the residual values.
Keywords: *pneumatic muscle, actuator, load, compressed air*

I. INTRODUCTION

The paper presents a FESTO pneumatic muscle with MAS-20-750N-AA-MC-O-ER-BG code behavior under different loads applied and different pressures of the compressed air. It is determined the evolution of the external diameter of the muscle succesive inflated and deflated.

The experimental stand is conceived especially for this determination.It consists of a pneumatic muscle of type presented above, a support structure for the muscle, the pneumatic actuator system, transducers and interface for connectig with computer.

The experimental studies highlights the evolution of the diameter while the pneumatic muscle is set on the experimental stand and the functions of the curves resulted.

For each situation (no load, load of 10kg and load of 20 kg) has resulted different functions. The three functions of the diameter evolution in function of pressure were validated by three methods – the correlation coefficient (r), the coefficient of determination (r^2) and by graphical form of the residual values.

The goal of the article is to find a connection between pressure of the compressed air and the diameter evolution.

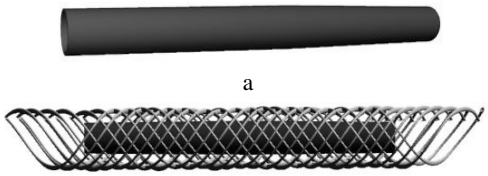
The future work is to study the possibility of using this muscle as actuator for a rehabilitation equipment.

II. PNEUMATIC MUSCLE

Pneumatic muscles (Fig. 1) became a better option for the electric or other drives met in present, because their favorable characteristics.

Fig.1 Pneumatic muscle[4]

The construction of a pneumatic muscle (Fig. 2) is simple and their function principle simulates a spring.
It is consist of a cylindrical tube made by neoprene rubber covered with a tissue made by nylon [1], [2].



a

b

Fig.2 Pneumatic muscle construction: a - elastic tube; b – nylon tissue

Acting like a spring, its diameter increases and its length shortens under the action of compressed air, as can be seen in Fig.1 [3], [5].
The stroke s resulted from the functioning of the muscle can have the value of 20% maximum 30% of the pneumatic muscle in its initial unpressurized state.

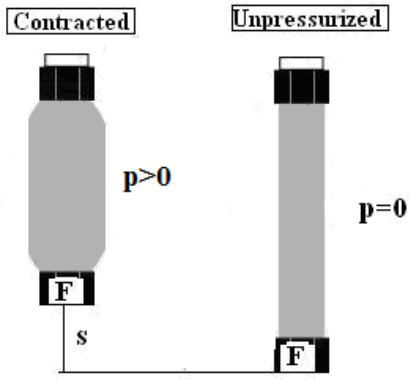


Fig. 3 Working principle of a pneumatic muscle

The pneumatic muscles have many characteristics that make them being easy to use and with great performances. Some of these characteristics are: shock - absorbing, adjustability, simulating capability, storage capable, safeness, lightweight, natural compliance and shock resistance [6].

They are used in applications for robotics, biorobotics, biomechanics, artificial limb replacement and industry.

Some examples are in the area of industrial robots - pneumatically actuated arm (developed by J.L. Mc Kibben) – Fig. 4, the stepping robot WAP 1 (developed by Waseda University of Tokyo) – Fig.5, the humanoid robot (developed by Festo and Technical University of Berlin) – Fig.6, airic arm - Fig.7 or industrial applications like assembly tables, presses, lifting equipment [6].

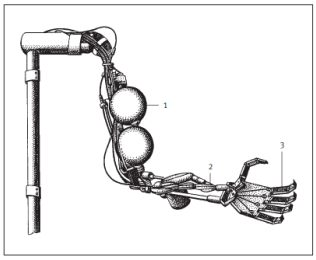


Fig. 4 Pneumatically actuated arm

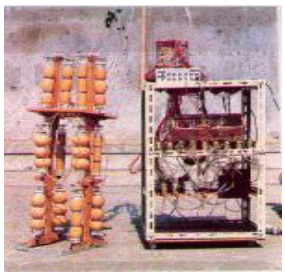


Fig.5 WAP 1

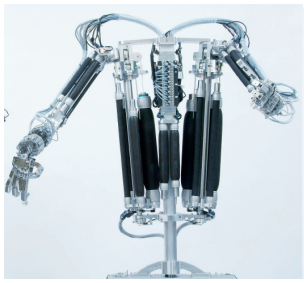


Fig.6 Humanoid muscle-robot

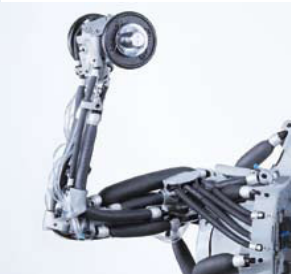


Fig.7 Airic arm

There are many possible applications for the pneumatic muscles, those replacing very well and with better results other types of actuators.

III. EXPERIMENTAL STUDIES

A. Experimental stand

The experimental stand used for determining the pneumatic muscle diameter evolution under compressed air action was assembled in Festo Fluidtronics Laboratory of the Transilvania University of Braă ov, Department of Technological Engineering and Industrial Management. The experimental stand is presented in Fig. 8.

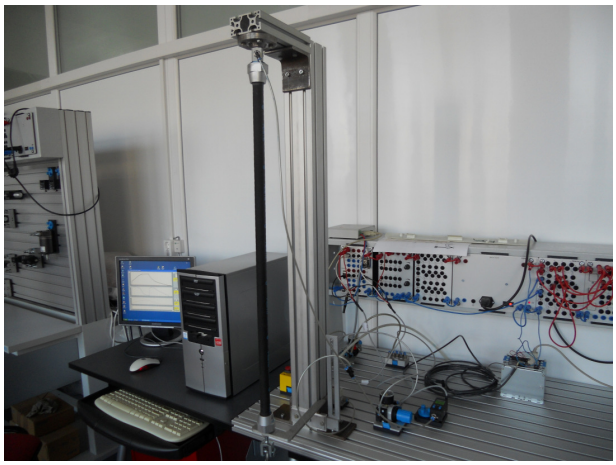


Fig.8 Experimental stand

The stand is composed by:

- MAS-20-750N-AA-MC-O-ER-BG pneumatic muscle of 750mm length and 20mm diameter, achieved from FESTO AG&Co (Fig.1);
- Support structure of the pneumatic muscle, made from FESTO profiles of 40x40mm;
- Pneumatic actuator system (compressor, compressed air preparing group, pneumatic distributors(Fig. 9), quick exhaust valve (Fig. 10));


Fig. 9 Pressure regulator[4] Fig.10 Quick exhaust valve[4]

- Flow rate transducer (Fig. 11) with flow rate:5-50l/min, operating pressure – max 7 bar, operating voltage – 12-24V ;
- Pressure transducer (Fig. 12) with LCD display, freely programmable switching function, adjustable hysteresis and analogue output for direct measured data acquisition. Technical features are: power supply 15-30V DC, switching output PNP, analogue output 0-10V DC, pressure measuring range 0-10 bar, pneumatic connection via QS-4 push-in fitting;


Fig.11 Flow rate sensor[4] Fig.12 Pressure sensor[4]

- EasyPort DA acquisition data (Fig. 13) used for connecting the equipments to computer;
- On/Off button (Fig. 14) – 3/2 distributor, normally closed – pressure range 0-8 bar, maximum flow of 60l/min;


Fig. 13 EasyPort DA acquisition data [4] Fig. 14 On/Off button[4]

The components above are achieved from FESTO Ag&Co.

At these components it is added the computer necessary for processing the data.

Pneumatic structure of the experimental stand is realized by FluidSIM-P software and presented in Fig.15.

FluidSIM-P is a FESTO software, used for obtaining electro-pneumatic actuation schemes, and to simulate their operation.

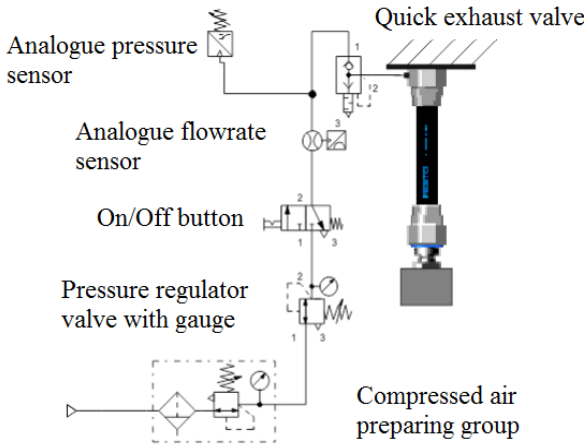
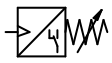
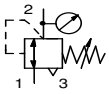
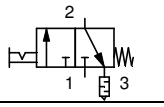
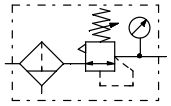
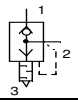


Fig.15 Pneumatic scheme of the experimental stand

The used symbols are presented in Table 1.

TABLE 1. NC Operators

Symbol	Description
	Pressure analog sensor
	Flow rate analog sensor
	Pressure regulator valve with gauge
	On/Off button with retention
	Compressed air preparing group
	Quick exhaust valve

With pressure regulator with gauge is set the compressed air pressure from the compressed air preparing group, and then act the on/off button for pneumatic muscle loading. Flow and pressure measurement is performed using compressed air flow analog sensor, positioned after on/off button, respectively, with the pressure transducer, positioned near the inlet of the muscle. The compressed air passes through a quick exhaust valve, used for rapid release of air pressure from the muscle.

B. Obtained results

Experiments made highlighted the behavior of MAS-20-750N-AA-GC-A-ER-BG pneumatic muscle – the evolution of the diameter, while the pneumatic muscle is gradually fed with different pressures from 1 ... 6 bar,

and with different external loading forces (m=0 kg, m=10 kg, m=20 kg).

Dimensional parameters of pneumatic muscle tested (MAS-20-750N-AA-GC-A-ER-BG) are: inner diameter = 20 mm; at rest length = 750 mm. For this muscle were made several series of measurements for determining the evolution of its external diameter under different tasks and application of different pressures.

Exterior diameters of the muscle were measured using an electronic caliper; results are presented in Tables 2- 4.

Table 2 presents obtained values for no load.

TABLE 2. Diameter evolution for m=0 kg

p [bar]	Diameter[mm]					
	1	2	3	4	5	Mean
0	23,47	23,4	23,21	24,35	23,94	23,674
1	27,35	29,67	27,58	28,28	30,23	28,622
2	33,91	35,49	34,29	35,81	34,51	34,802
3	36,98	37,73	36,92	37,72	36,88	37,246
4	38,36	38,76	38,57	38,61	38,41	38,542
5	39,02	39,31	39,23	39,39	38,76	39,142
6	39,91	39,51	39,81	40,04	39,74	39,802

In Fig. 16 it is represented the evolution of the muscle diameter while the muscle has no load (m=0 kg).

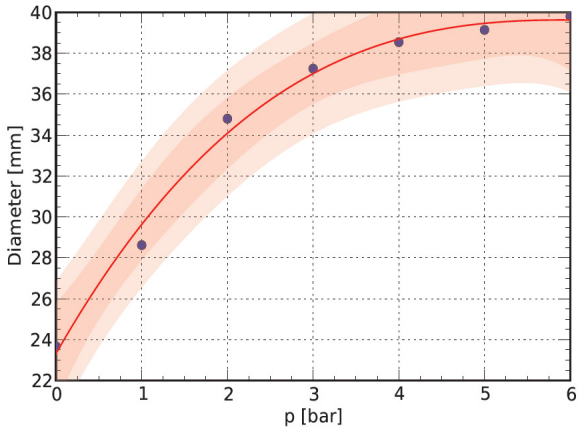


Fig. 16 Diameter evolution for m=0 kg

With blue are represented the values of the obtained diameters, with red is represented the polynomial regression and with pink are represented the confidence values (95%).

The function that describes the evolution of the diameter at no load and pressures of 1...6 bar is:

$$F(x) = 2{,}33+7{,}34x-1{,}08x^2+5{,}18X^3 \quad (1)$$

The correlation coefficient (r) is 0,995 and the coefficient of determination (r^2) is 0,991.

A function is suitable as a pattern if correlation coefficient r value is close to 1. It is considered that:

r = 0.8 to 0.9 high coefficient (best model)

r = 0.7 good model

r = 0.3 to 0.7 insufficiently developed model

r = 0 to 0.3 model incorrectly

The determination coefficient r^2 offers a percentage interpretation of the obtained curve for the experimental dates.

The obtained values show that the function is the best model for the analyzed situation.

Another method of validation of the function is by graphical form of the residual values. The residual values represent the difference between the experimental values and the ones obtained through mathematical calculation.

For the function determined to be validated residuals chart must follow the two conditions:

- Residual values are independent (there is no particular pattern of these, they are arranged at random);
- Residual values are normally distributed (Gaussian) with mean 0.

In this case, those conditions are respected and the method validates the function obtained, as can be seen in Fig. 17.

In Table 3 are presented the experimental dates obtained for m=10 kg.

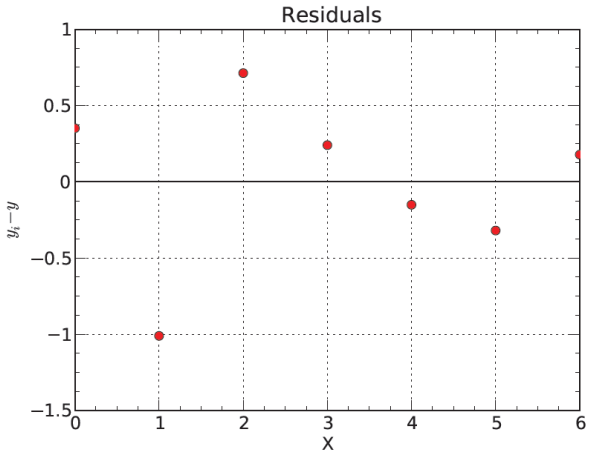


Fig.17 Residual values of the function for m=0 kg

In Fig. 16 it is represented the evolution of the muscle diameter.

The function that describes the evolution of the diameter at load of 10kg and pressures of 1...6 bar is:

$$F(x) = 2{,}26+6{,}65x-8{,}39x^2+3{,}02X^3 \quad (2)$$

TABLE 3. Diameter evolution for m=10 kg

p [bar]	Diameter[mm]					
	1	2	3	4	5	Mean
0	22,5	23,05	23,11	23,04	23,09	22,958
1	27,38	27,35	27,71	27,57	27,41	27,484
2	33,46	33,78	33,65	33,58	33,21	33,536
3	34,89	36,45	36,36	36,5	36,24	36,088
4	37,43	37,42	37,64	37,82	37,96	37,654
5	38,35	38,42	38,6	38,61	38,12	38,42
6	39,35	39,27	38,9	38,92	39,06	39,1

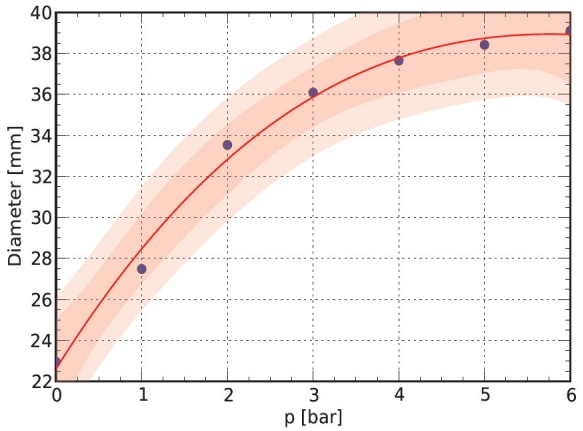


Fig. 18 Diameter evolution for m=10 kg

The values of the obtained diameters are represented with blue, the polynomial regression is represented with red and the confidence values (95%) are represented with pink.

The correlation coefficient (r) is 0,996 and the coefficient of determination (r^2) is 0,992 meaning an accepted function.

The graph from Fig.19 validates the obtained function.

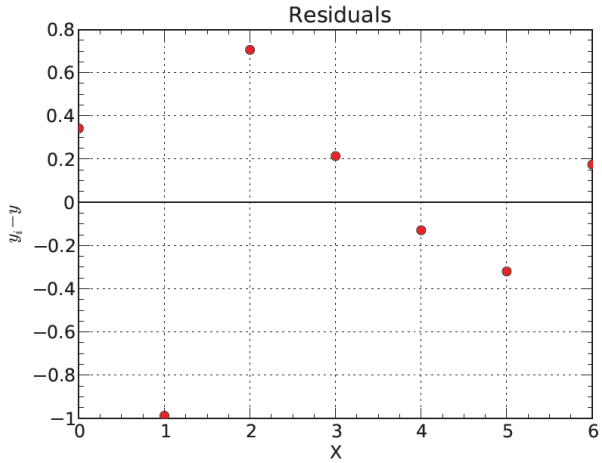


Fig.19 Residual values of the function for m=10 kg

Table 4 presents the experimental dates obtained for a load of m=20 kg.

TABLE 4. Diameter evolution for m=20 kg

p [bar]	Diameter [mm]					
	1	2	3	4	5	Mean
0	22,18	22,37	22,62	22,46	22,3	22,386
1	25,1	24,81	24,82	24,75	24,66	24,828
2	30,52	29,92	29,32	29,52	29,83	29,822
3	34,56	34,01	33,73	33,9	34,42	34,124
4	36,79	36,5	36,43	36,28	36,44	36,488
5	37,76	37,75	37,26	37,41	37,81	37,598
6	38,79	38,15	38,39	38,95	38,45	38,546

In Fig. 20 it is represented the evolution of the muscle diameter while the muscle has a load of 20kg (m=20 kg).

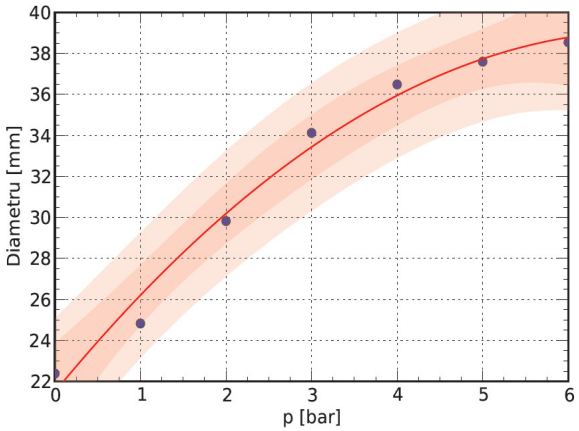


Fig. 20 Diameter evolution for m=20 kg

The codes for representations are the same as presented below: blue – for diameters, red – for polynomial regression and pink – for confidence values.

The function that describes the evolution of the diameter at applied load of 20kg and pressures of 1...6 bar is:

$$F(x) = 2{,}15+5{,}08x-3{,}66x^2 \quad (3)$$

The correlation coefficient (r) is 0,992 and the coefficient of determination (r^2) is 0,985 meaning an accepted function.

The graph from Fig.21 validates the obtained function.

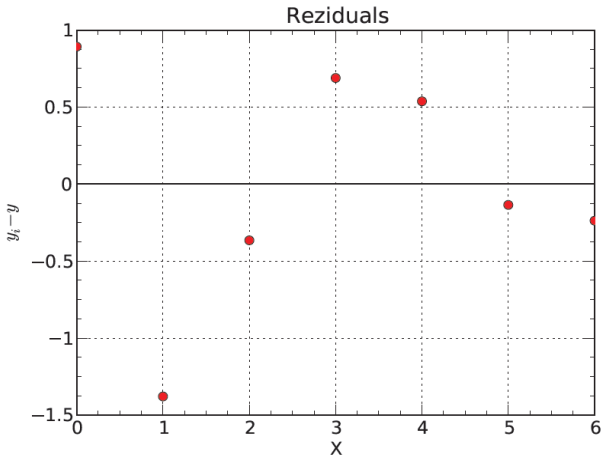


Fig.21 Residual values of the function for m=20 kg

All curves that describe the evolution in function of pressure of the exterior diameters media can be compared in Fig. 22.

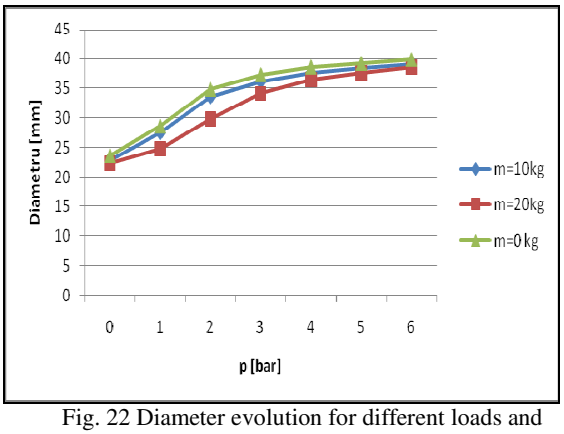


Fig. 22 Diameter evolution for different loads and pressures of 1…6 bar

It is noted that the exterior diameter of the muscle increases as the pressure increases. It is also remarkable that the diameter increase inverse ratio to the muscle mass attached.

The contraction of the muscle decreases while the load of the muscle increases. The maximum contraction of the pneumatic muscle tested is obtained in situation in which load applied is zero, and the minimum is obtained for a load of 20 kilos.

III. CONCLUSIONS

The experimental research carried out highlighted that the pneumatic muscles offers many advantages and disadvantages in terms of their behavior in operation.

The evolution of the diameters of the muscle depends on the pressure and on the load applied. The pneumatic muscle inflates and shortens more when has no load and when the pressure increase.

The interior tube made by rubber offers the advantage of adjustable compliance, smooth and natural movement and fast contraction [3].

The pneumatic muscle will replace in future the single action cylinders in more and more applications.

ACKNOWLEDGEMENTS

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Voice Quality Measuring Setup with Automatic Voice over IP Call Generator and Lawful Interception Packet Analyzer

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***Abstract* – This paper describes the packet measuring laboratory setup, which could be used also for lawful interception applications, using professional packet analyzer, Voice over IP call generator, free call server (Asterisk linux setup) and appropriate software and hardware described below. This setup was used for measuring the quality of the automatically generated VoIP calls under stressed network conditions, when the call manager server was flooded with high bandwidth traffic, near the bandwidth limit of the connected switch. The call generator realizes 30 calls simultaneously and the packet capturer & analyzer could decode the VoIP traffic, extract RTP session data, automatically analyze the voice quality using standardized MOS (Mean Opinion Score) values and describe also the source of the voice degradation (jitter, packet loss, codec, delay, etc.).**

***Keywords:* lawful interception; packet analysis; call generation; VoIP; voice quality.**

I. INTRODUCTION

The computer networks play a very important role in information exchange between people all over the world. The information usually transferred contains not only text (emails, documents, databases, websites, etc.) but also multimodal communication data – voice, pictures, video, flash applications, 3D visual data, CAD documents, position, broadcast radio or IPTV channels, captured online streams of surveillance applications, etc. It could be said that the information could be transferred all over the world in a moment using internet today. This is a big advantage but also a big security problem.

Many threats and security risks are closely related to internet traffic so the development of secure and privacy policy respecting applications is relevant. The ethical issues play a very important role in this type of applications, because the privacy of the captured data needs to be guaranteed, and also the data could not be accessible before the decision of lawful authority approves the examination of the captured data [1].

The lawful interception applications are developed in scope of the INDECT project [2], and of course these tools should be compared with industry standard professional applications. Our laboratory setup could play this important role, and the setup was initially used for testing the ability to capture the specified traffic, analyze the packets, store the specified data and analyze also the extracted application level data streams as VoIP calls (H323, SIP, MEGACO), emails (SMTP, POP, IMAP), web traffic, instant messages of different types (also from proprietary networks) [3], FTP/SMB (Windows Samba directory sharing) – file transfers and directory listings, DNS – domain name queries, IPTV/R broadcast and multicast streams, database queries from different protocols (MySQL, MS SQL, Oracle, etc.), old unencrypted remote console TELNET sessions, etc.

The initial VoIP traffic analysis setup was realized with cooperation with professional call generator capabilities, to help to setup a measurable traffic and load for call server, which could lead to better QoS measurements [4]. Of course our initial analysis cover mainly unencrypted VoIP communication, which could be modified using security recommendations [5] and then of course the content will be protected also before lawful interception applications. But there is a research that describes methods for detection of special spoken phrases or the speaker in encrypted VoIP traffic (not only SIP but also proprietary VoIP systems) thanks to widely used variable bitrate codecs and training specialized mathematical models (acoustical - based on measuring the length of the encoded packets; and language) for this purpose [6] [7] [8].

First of all the laboratory setup with description of the used hardware and software components is described in the following Section II. The lawful interception functionality and also another packet analyzing capabilities of this laboratory setup was tested and reported in Section III. In Section IV the description of the installed call generator is provided. The Section V describes the VoIP call quality experiment, the processing workflow and the evaluation results, which are discussed in the last Section VI.

II. LABORATORY SETUP

The laboratory setup was designed with respect to the fact that no traffic from external sources will be

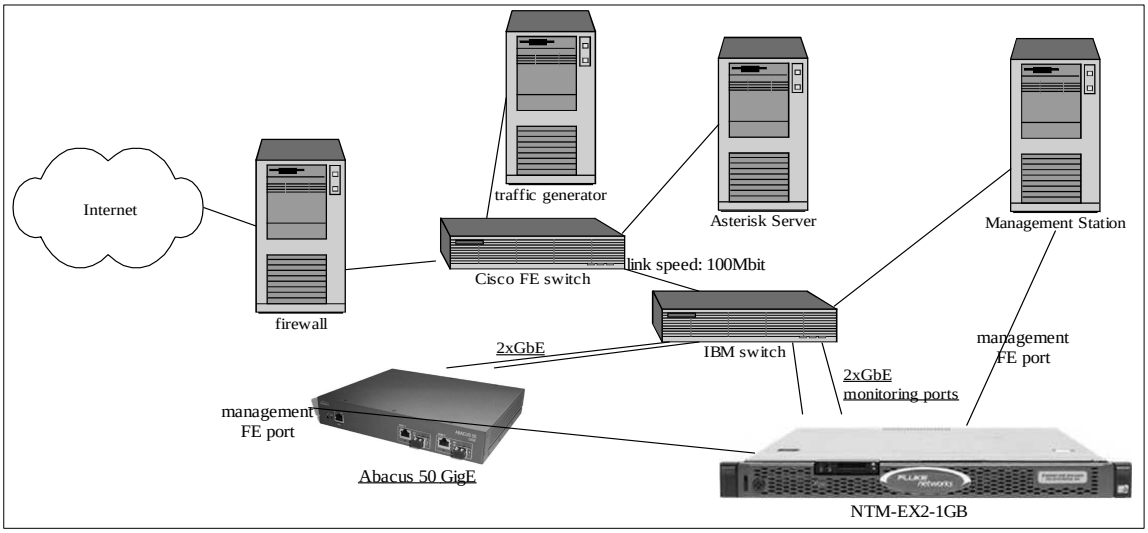

Figure 1: Laboratory testing VoIP setup under stressed network conditions using packet analyzer with lawful interception capabilities (all connections are copper wires)

examined - to take in account privacy of the transferred packets that could be delivered to the packet analyzer with lawful interception capabilities.

The main privacy component in our setup was the manageable IBM switch, where the administrator could set the port for mirroring to packet analyzer specialized monitoring ports. Access to this switch management is password protected and could be done only locally using serial console link. But in fact, trough our laboratory switch are mainly no private data transferred because there is no personal computer connected, only servers used for mathematical computing tasks from our department. During our tests only the ports transferring data from the call generator VoIP packets was captured and analyzed. All other tests was done offline using publicly available captured packets files for different packet analysis software evaluation [9] [10] etc.

Our laboratory setup is depicted on the Fig.1 and consists of:

1. packet analyzer (*Fluke Networks* ClearSight Network Time Machine – CSN/NTM-EX2-1G) with packet analyzer software included (ClearSight Analyzer),
2. manageable switch with port mirroring capabilities (*IBM* Ethernet Switch B24C - NetIron CES 2024C - 24x1 GbE copper/fiber with four combination 100/1000 SFP ports),
3. call generator (*Spirent* Abacus 50 Ethernet A50GE, 2xGbE generator ports, 1xFE management port and Abacus 5000 management software [11]),
4. free SIP server (*Asterisk 1.6.1.9* running on virtual machine using KVM – kernel based virtual machine using 2 cores from 16 available on server used for mathematical simulations, using 1xGbE port only for KVM machine and call server),
5. SIP server switch (*Cisco* Catalyst 2960 WS-C2960-24-S, 24xFE port LAN Lite Entry switch), this Cisco switch is used for switching the flooding packets from traffic generator server to Asterisk server and limiting the maximum load to 100Mbit/s traffic, which will be the threshold for stressed network tests,
6. network traffic generator server (Linux Ubuntu 10.0.4 LTS server using ping flooding mechanism - multiply instances of: *ping -s 65500 –f SystemUnderTest*) [12],
7. management station (PC with NTM Agent Viewer Software with integrated ClearSight Analyzer, and Abacus 5000 management software) with serial interface to control the IBM switch mirroring configuration.

III. LAWFUL INTERCEPTION CAPABILITIES OF THE INSTALLED PACKET ANALYZER

The installed dedicated server with 2xGbE (copper and fiber each) packet capturing FPGA cards is capable to constantly monitor and store 1TB of packets in circular buffer (RAID0 - stripping configured internal HDD storage), and specified timeslot packets could be analyzed and stored for evidence (in case of lawful authority threat detection approval) or archive purposes.

The dedicated server used was: Intel Core 2 Quad Q9400 CPU, 2.66 GHz, RAM 3.25 GB, running Windows XP SP3 OEM. The storage configuration consists of ICH9 Intel RAID with 2x 1.5TB Seagate HDDs partitioned to 2 volumes:

- 1.2TB system volume with all software and driver installation (is important to have a backup of this volume in case of HDD failure in RAID 0 configuration),
- 1.5TB volume only for continuous packet buffering during monitoring state.

The packet analyzer could analyze the selected timeslot from packet buffer using smart filtering capabilities and make a vizualization of specified data streams as depicted on Fig. 2 below.

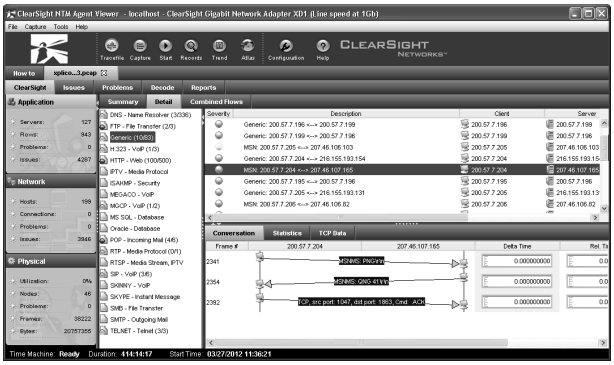

Figure 2: Packet analysis of captured packets timeslot using ClearSight Time machine built-in analyzer

During initial funcionality tests these protocols decoding algorithms were tested:

- extracting RTP audio streams and listening to the VoIP conversations (Fig. 3),
- SIP, H323 (H225 - RAS), MGCP signaling protocols analyzed and depicted,
- extracting email conversations, full emails extraction from not encrypted POP/SMTP transfers,
- capturing of all not encrypted webcontent transferred (including all pictures),
- full Telnet sessions recovered from captured packets,
- FTP sessions including files transferred, list of directories and files examined,
- extracting of DNS queries.

Of course there are more protocols that could be analyzed, and the conversations / sesions depicted as it is listed on Fig. 2 and 3 in the left frame list.

After the decoding also a detailed analysis of possible threats using issues as: login rejected, access forbidden, VoIP registration failed etc. is realized. After that it is possible to generate a detailed PDF reports and statistics for every analyzed protocol.

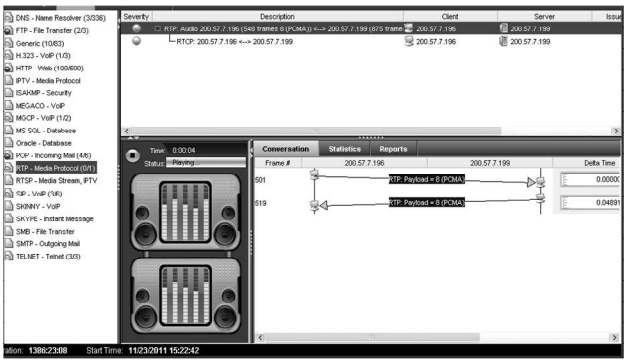

Figure 3: Listening to captured VoIP conversation from decoded RTP stream using built-in packet analyzer

IV. CALL GENERATOR

The call generator plays an important role in our VoIP measurement setup. It could be very complicated to place enough calls manually and having a valuable results. So the chosen equipment for automatic call placement was Spirent Abacus 50 GigE which provides two Gigabit copper/fiber Ethernet interfaces for VoIP calls originate and terminate, one FastEthernet management port and a serial port for initial IP configuration.

The generator is FPGA device running BusyBox Linux environment, which could be controlled using specialized scripts. Using Abacus 5000 software tool, the scripts could be automatically generated / lunched using configuration entered in user friendly graphical interface shown on the Fig. 4 below.

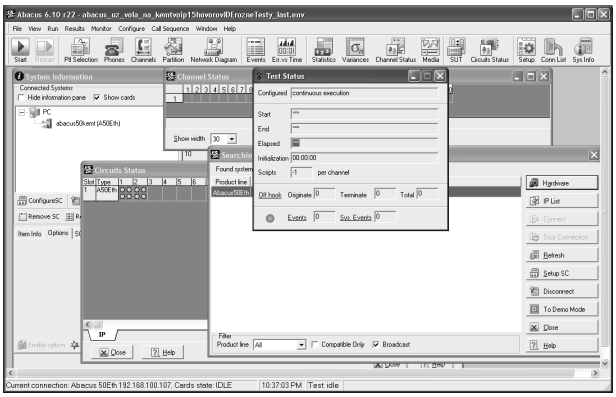

Figure 4: The call generator graphical configuration, controlling and call evaluation environment

The call generator could be configured for different VoIP migration, evaluation and testing scenarios. Our chosen configuration is depicted on Fig. 5, when the call origination and also the termination are performed in the generator, and the call is transferred trough to our SIP proxy call server – called System Under Test (SUT).

Using this setup we plan to test also the network infrastructure, the SUT call server and the security of the interactive voice response system which was migrating from analogue to VoIP call routing [13] [14].

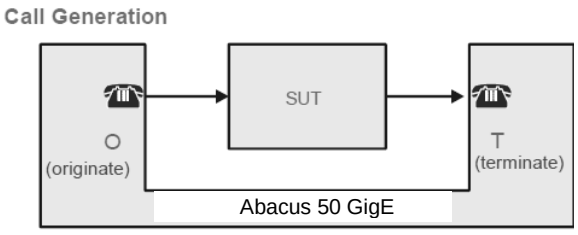

Figure 5: The call generator is responsible for originating and terminating the calls using tested Asterisk call server – SUT (System Under Test)

The SIP call sequence with detailed message exchanges is shown on Fig. 6. It should be noticed, that the call generator during tests tries to place the call without authentication first, and after denial of service

the second message contains also authentication sequence. This leads to the exact number of errors resulted in packet analyzer protocol for VoIP call service, which equals to number of placed testing calls.

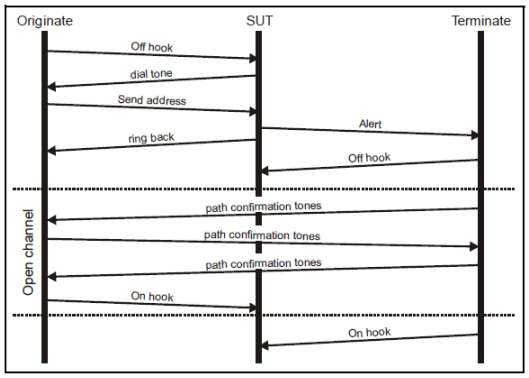

Figure 6: Typical call sequence during testing the SUT (System under Test) server under stressed network conditions

V. EXPERIMENTS

The laboratory VoIP quality experiment, which also verified the whole lawful interception setup, was based on configuring 30 simultaneous calls (duration ≈ 120s) during 15 minutes repeatedly, placed at the same time from call generator, and monitoring the VoIP service protocols from professional packet (network) analyzer.

After configuring the call generator (Abacus) to place and authenticate to our SIP call server, the IBM switch (Fig.1) was configured to mirror the Abacus GbE ports to the NTM packet capturer and analyzer ports. This means that all traffic between Abacus and the call server was monitored and analyzed.

Then the MOS (Mean Opinion Score) was evaluated from the NTM packet capturer analyzing software in low and close to overloading network traffic (generated using neighboring server). The codec used was G711 μ-law, with standard MOS 4.38 (low traffic environment) and the measured degradation after flooding the call server with dummy packets close to Cisco switch (see Fig. 1) overload was 4.31 [12]. The network analyzer also assess that the degradation was caused by increasing of the packet delays, which was reported in pdf files generated for network administration purposes.

VI. CONCLUSIONS

During the building of the described lawful interception laboratory setup many bugs in standard configuration was discovered and solved.

The VoIP quality analysis experiment shows, that the free Asterisk call server setup is a suitable and stable solution as an alternative for fixed line services when we could control the QoS parameters of the network to prevent the overloading of the whole packet route [3]. We plan to repeat the test with routing the packets trough wireless LAN route, using also low bitrate codecs, for testing the VoIP functionality in WLAN environment and widely used mobile clients.

This laboratory setup is also important for security research and for evaluating the security applications developed among INDECT project partners [2], and especially their lawful interception functionalities with improved threats detection [15].

ACKNOWLEDGMENTS

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Modified Viterbi Decoder for Long-Term Audio Events Monitoring

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***Abstract* – One of the common solutions of intelligent audio surveillance system is to use Viterbi decoder for long-term audio-events monitoring. The classical approach how to control the decoder is to evaluate the hypothesis after detecting the end of the event (utterance) in the front-end. The end of the event is detected using UBM (Universal Background Model) or some kind of energy features with adaptable threshold, etc. The paper deals our idea to modify the Viterbi decoding process in such way, that the detection of the event end in the front-end will be not necessary. The frontend will be simpler, and the decoder will decide by himself, when to evaluate the hypothesis. Our first approach to this modified decoding algorithm is presented and evaluated by simple experiment.**

***Keywords:* HMM; audio event; Viterbi decoder; audio surveillance; noise monitoring.**

I. INTRODUCTION

Audio event monitoring task is very important issue these days, also because the video surveillance is limited to the view angle and it is a big problem to cover large urban areas. Also with PTZ (Pan Tilt Zoom) cameras, the important event could happen just in the moment, when the camera covers another area.

One approach is to control the camera using acoustic radar [1] and try to detect the position of the interesting / *foreground* audio event source (gunshot, scream, breaking the glass, etc.) [2] and using the audio samples buffered during detection process the classification of the spotted *foreground* event [3].

The SVM (Support Vector Machine) classifier [4] [5], HMM based decoders [6] [7] or GMM (Gaussian Mixture Models) binary trees [8] are very popular for audio event classification task, especially according to smart room environment tasks [9].

Other approach for long-term audio monitoring is to monitor only the sound (without any video surveillance) and use it for detection of specific events, covering very large areas (using noise monitoring stations), for example marine mammals and human related activities detection from ocean hydrophone data [10] are also investigated.

Also this approach could be used for supporting emergency services, when malicious audio events could be detected from large urban areas covered with outdoor noise monitoring microphones / stations [11], or for supporting other security forces in the scope of the European 7-th framework INDECT project [12], which aims also at developing tools for enhancing the security of citizens.

A. Viterbi decoder modification motivation

We decided to build our own audio event detector based on Viterbi decoding, as an alternative to classical approaches used by some of INDECT project partners [1] [3] [13]. The purpose of this decoder should be a long-term nonstop noise monitoring of urban areas with alerting mechanism when suspicious event will be detected.

We divided the audio utterances to *background* (all sounds and events which are not suspicious and do not need to produce any alarms) subset and *foreground* (scream, gunshot, breaking the glass) subset. Of course if more models will be trained for each subset - specific for every type of audio event (if enough training data will be collected in the database [11]) then the accuracy of the event detection should be higher. Our experiments with audio event modeling and detection using MFCC (Mel-frequency Cepstral Coefficient) and MPEG-7 features are described in [14]. But it should be noticed that these experiments was realized offline - on annotated recordings from JDAE-TUKE database [11].

When dealing with nonstop long-term monitoring of the audio streams from outdoor microphones, the detection algorithms, and especially decoder and audio preprocessor (*frontend*) module was not suitable for this purpose, as we decided.

The first problem was that the *decision time* - time when the decoder evaluates the most probable path from all available hypotheses - was not clearly defined. Usually the decision time is the end of the recording when dealing with offline detection/classification or a background /silent utterance detected using UBM, VAD (Voice Activity Detection) or energy features monitoring with adaptable threshold [13].

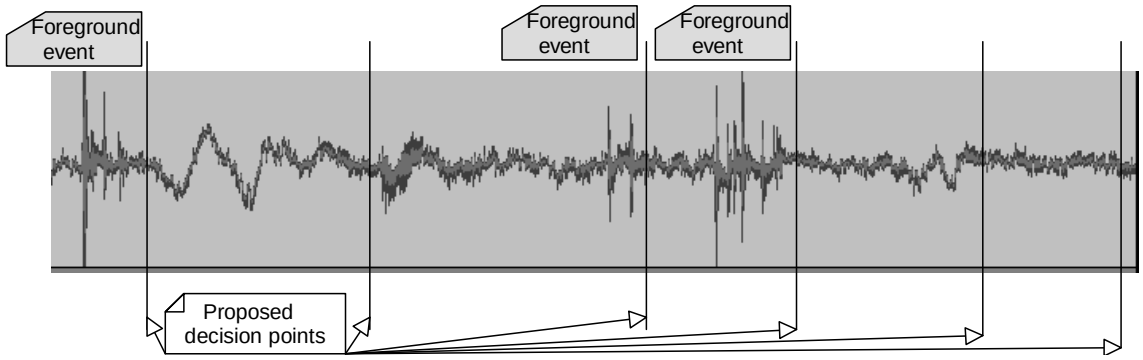

Figure 1: Audio events timeline with proposed decision points, note that there are decision points also when no foreground event occurred and they are also after every foreground event also when noisy background events could suppress them.

B. Decision point detection

When dealing with online decoding, the *frontend* process the audio frames, calculate the feature vectors, and using Kullback-Leibler (KL) distance measure or UBM models (or other algorithms mentioned above) tries to define the end of the *foreground* events - the *decision point*.

When the *decision point* is detected, the Viterbi decoder will evaluate the most probable hypothesis and *generate the resulted identified models*.

In this particular task, the background models detected in the stream are not so interesting for the purpose of suspicious events detection. These models also will not produce any alarm to the end-users.

So, we decided to simplify the frontend module by discarding the module of *decision point detection* and *modify the Viterbi decoding procedure* this way, that the decoder will not evaluate the hypothesis (generate result of detected models) using *decision points from frontend* module, but he will *track the history* of the available hypotheses paths and waiting for repeating of the models from background subset on the end of the most probable hypotheses. When the most probable are the background models for configurable number of last frames, the result will be generated and the decoder will start from scratch as it is depicted on the Fig. 1 above.

The result is then analyzed by postprocessor and only suspicious events with probability above configurable threshold will be sent to emergency services.

C. Modification advantages

This modification leads to next improvements. Most of the online HMM decoders deals with one problem: If there are *after* some *foreground* events (shout, gunshots or words - in case of speech recognition) some *background* events with *high energy* (strong wind, lightning, cheering crowd passing microphone, loud music, plane, helicopter, siren, etc.) the decoder is waiting for the decision point from frontend (energy, KL, UBM, etc.) and:

- the result could be significantly delayed or
- the decoder will produce so much different hypotheses from different new paths trough different background models, that the memory or CPU usage will consume all available resources and the decoder will crash after some period of time.

Both results could lead to system instability / unreliability and then the decoder should be not suitable for long-term security monitoring. Our modification should lead to increasing of the result generation speed, lower CPU / memory utilization, better control on the decoding process (in classical approach decoder could not be forced to produce an alarm when suspicious event is detected) and finally in the future the developer could control also the result generation before the foreground events finished (if the foreground event lasts for longer time and the alarm should be generated as soon as the duration a probability will be above defined threshold).

II. MODIFIED DECODER DESCRIPTION

We created our own audio event detection system that includes our modified Viterbi decoder and frontend. We created the modified system (Fig. 3) as alternative to classical approach where in order to decoder to output results an assistance of a frontend is required (Fig. 2).

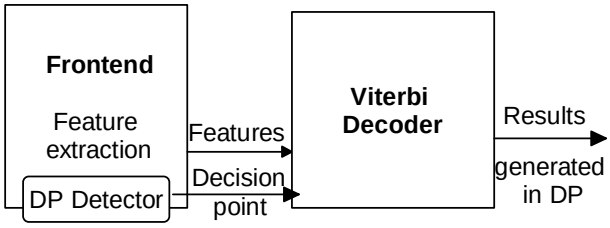

Figure 2: Classical approach to detection of decision points (DP) and controlling the decoder results generation

Audio preprocessing is done by our fontend designed to be modular and extensible. Every step in processing is done by separate and configurable modules. In this case we have used the frontend for conversion of audio signal into MFCC. Please note that frontend contains neither decision point detection nor similar system to voice activity detector (in case of speech recognition). This way the frontend is simpler and it's running constantly without any interruption in workflow of audio signal.

Decoder that we used is based on classical approach of time synchronous Viterbi decoding mechanism and token passing algorithm [15] with few modifications.

Every decoder is using a network (search space) created from knowledge sources, in our case from acoustic model. This search space can be created before decoding as static or during decoding as dynamic. In our system we decided to use static network as the search space is small for a limited models of acoustic events. We also wanted the decoder to be general as possible and open for further extensions and modifications. In order to achieve proper generality we used Weighted Finite State Transducers (WFST) as a representation of the search space. In this way decoder can be simpler and not restricted to specific topology or knowledge sources. Search space is created before running detection system from acoustic model and dictionary of acoustic events. In our first approach we used simple search space where all models are placed parallel between initial and final state. The final state is then connected with initial state in order to allow repetition of models. This approach can be easily extended by adding new knowledge sources or changing topology of search space and optimization operation can be also applied. For further information about constructing search space based on WFST is reader referred to [16][17][18]. In addition to Viterbi decoding algorithm the decoder contains also traceback structure for tracking the path of a token (remembering hypothesizes) and decision point detector to produce result of detection.

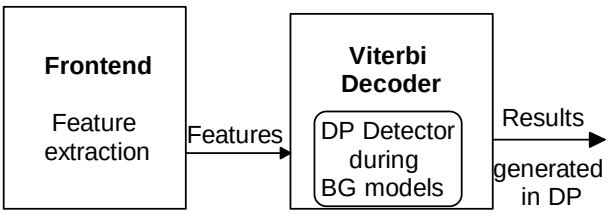

Figure 3: Modified approach to decision point (DP) detection, when the DP is generated when the most probable is the one of the background models for configurable number of frames.

After running the detection system frontend starts converting audio signal into MFCC and the decoder process them. Decision point detector in decoder is monitoring tokens in final state in search space. If there is a token that contains the same hypothesis for given time an output will be generated for further analysis where will be decided if the decoder will be set to initial state. We used simple rule that states if this hypothesis ends with one of the background models the decoder should be set to initial state and all hypothesizes will be erased (Fig. 3).

Moving decision point detection from front-end to decoder gave us more control over whole process and space to optimize the decoder for long-term processing by controlling when and under what conditions the decoder will be set to initial state so no further memory will be used for remembering hypothesizes.

III. EXPERIMENTS AND DISCUSSION

We decided to prove our presumption of high memory and CPU utilization when decoding a noisy audio event stream by measuring these values during live decoder run (online mode) with classical architecture.

The first test setup was done using *clear* audio events with no noisy background. Then a *noisy* setup was realized when during the foreground audio events a high energy background events of different types was played with no low energy (quiet) moments, which could be used by frontend for generating a decision point a then the result will be printed on screen.

The setup was realized on embedded computer environment for real-time audio monitoring with embedded Intel x586 compatible CPU - 1GHz (TM5800), OS: Linux Debian 6, 500MB of memory, 4GB of storage for OS and applications (SD card), Sweex USB audio card and a headset.

The recognizer setup was optimized for speed and low memory consumption because of small free utilization resources on testing environment. The setup was built on 3-state HMM models with 16 PDF (Probability Density Functions) mixtures, sampling frequency 8kHz (it will be more for final audio events monitoring setup), frame shift 10ms, window size 25ms, 39 MFCC feature set (the feature set will be also modified according to recent research in our lab [14] especially MPEG-7 features will be used).

For measuring the CPU utilization the "time" command was used and the Real Time Factor computed based on following formula:

$$RTF\,[\%] = \frac{CPU\ time\ consumed\ by\ the\ process\ [s]}{Test\ duration\ [s]} \times 100\,[\%]. \qquad (1)$$

TABLE 1. Utilization of live classical architecture Viterbi decoder core using different background conditions.

Test type (2 minutes)	RTF [%]	Memory [kB]
Clear events	15,9%	4500
Noisy background	47,1%	14504
Utilization increase	2,9 times	3,2 times

In Table 1 above you can see that the CPU utilization during 2 minutes (about 20 foreground events occurred in each setup) of recognizer run (of course if no foreground/background events occur the utilization do not increase at all) was increased 2.9 times and the memory consumption was 3.2 more when problematic "noisy background" setup was tested. Of course the CPU utilization could be increased only to RTF=100% because then the recognizer will have no time to process the frames in real time. So this could be a big problem for long-term monitoring applications. The memory limit is not so crucial on modern computer/server setup, but it could be problem for embedded systems, where every application should have a precise specified maximum memory consumption limit, because then other important part of the system could be affected.

According to problem of *results delay*, of course in noisy setup the result was generated only after the test finished. So the *delay* of the "noisy background" setup result was *more than 1 minute*. It should be mentioned

that in classical decoders / frontends there could be a limit for maximum length of one segment – of course this will control the decoder from overloading the memory (the CPU could be overloaded before the default used limit), but the result could be generated in the middle of some event, and then the result is degraded by this wrong segmentation. In our approach, the recognizer tries to do the segmentation at the end of *foreground* events (the background events could be segmented without losing important information), especially when the HMM model enters the exit state. This will help the long-term audio events monitoring setup to produce the alarm for every foreground event with no significant delays.

Of course for comparison *the modified decoder* was tested under the same conditions, but there was *no utilization increase* in case of noisy background setup.

IV. CONCLUSION AND FUTURE WORK

After finishing experiments it could be concluded that modifying the decoder and frontend could significantly help in specialized tasks. For example audio events long-term monitoring is a task which is very sensible for problems of classical approach Viterbi based HMM decoders.

We plan to build a specialized laboratory nonstop noise monitoring setup (including outdoor noise monitoring microphone) and evaulate the results from this continuous run also among our partners and finnaly implement our decoder in INDECT project framework.

ACKNOWLEDGMENTS

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Identifying and Removing Systematic Error due to Resistance Tolerance from Measurement System of Inclinometer

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Abstract **- This paper is focused on the effect produced by systematic error of measurement devices in monitoring of a system, dam. The effect produced by systematic error in dam monitoring consist in a wrong description of dam evolution. Measurement errors lead in a deflection of the dam from the normal evolution. The physical parameter, inclination, needs to be measured with an accuracy of 0.05%. The sensor used is a full differential output voltage. In a measurement device an error source is the electronic components imperfections. The performance of measurement instruments depend on resistance tolerance. The error produced by tolerance on a measurement device is a systematic error and in monitoring process become a random error. The measure of transducer with Wheatstone-bridge supposes to use high accuracy resistance of 0.01%. But a high accuracy resistor increases the cost o instruments. The source of systematic error can be eliminated if the transducer is measured without resistance divider. To obtain positive voltage at sensor output this is power supply relative to common mode voltage of analog converter. In this case the measurement error depends just by ADC. The acquisition is made with a differential converter. To obtain an accuracy of measurement of 0.05% is used a 14 bit converter. The ADC has auto calibration function so the offset and gain errors are internally compensated.**

Keywords: sistematic error, inclinimeter, dam

I. INTRODUCTION

This paper is focused on monitoring of dams inclination. The hydro-energetic buildings are monitored with a sensors network placed inside of dam. In each block are placed an inclination sensor that is read periodically with a data-logger measurement system, aims to detect the movement of each individual block. Data obtained from each inclinometer data-logger are saved in a data base; these describe the time evolution of dam. In dam safety analysis the result of measurement need to be accurate and satisfy. Dams must be operated and maintained in a safe manner. For a proper interpretation of the data collected by the instruments, it is accepted a measurement error by 0.05%. So, the measurement data-logger needs to be high accuracy and to ensure portability of data until database. The below figure present the structure of a monitoring system of inclination of a concrete dam.

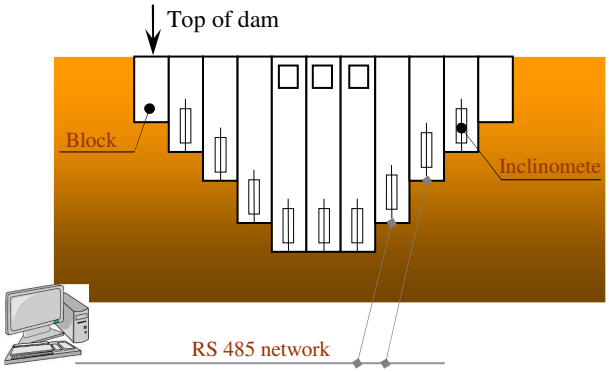

Fig.1 Structure of dam monitoring system

II. DATA MODELING

The data obtained from each measurement is a quantity that is described by the equation [1]:

$$x_i = x_{i_{true}} + \varepsilon_i + \eta_i \,,\ \text{i=1,…, I} \qquad (1)$$

Where – ε_i is the part of random error occurring at every -*i* repeated measurement, and η_i is the systematic effect present in all measurement results. If x_i is the mean of "*I*" repeated measurements, theoretically the total random error is $\sum_i \varepsilon_i = 0$, whose distribution is $\varepsilon_i \sim N(0,\sigma^2)$. Practically, for a lot of data the total random error tends to become zero, $\sum_i \varepsilon_i \to 0$. Through a data processing the random error can be removed.

The systematic error (term η_i in eq. 1) cannot be detected and removed through data processing. $\sum_i \eta_i \neq 0$, $\eta_i \sim N(\mu,0)$. These errors are highlighted by comparing the result of measurement with data obtained with a reference instruments. Generally, the systematic error is caused by imperfection of measurement instruments. This error can be reduced through adjustment in measurement circuit. Taking in consideration the above observations, the result of measurement x_i can be re-write like:

$$x_i = x_{i\ \text{true}} + \eta_i \quad i = 1, \ldots, I \qquad (2)$$

The result of measurement is affected mostly by the systematic error. In monitoring of dams inclination, the measurement errors lead in a deflection of dam from the normal curve of evolution [2]. In each bloc, of concrete dam, are placed an inclination transducer and a measurement instrument [3]. If each measurement instrument has its own systematic error, under error influence, the amplitude of movement will vary from block to block. Looking to the dam like a system, the equation (2) can be re-write like:

$$x_{i,j} = x_{i,j\ \text{true}} + \varepsilon_{i,j} + \eta_{i,j};\ i = 1,..,I;\ j = 1,..,J; \qquad (3)$$

Where - j is the index denoting the measurement instruments. In equation (3), the systematic error $\eta_{i,j}$, becomes a random error whose distribution is $(\varepsilon_{i,j} + \eta_{i,j}) \sim N(0,\sigma^2)$. The cause of systematic error can be improper topology of measurement circuit or the electronics component errors e.g. the tolerances. Through calibration procedure the systematic error can be reduced. But some time calibration is a complex procedure. At any intervention over measurement instrument (service) these need to be recalibrated. From these reason in accurate measurement instruments the electronics components and measurement circuit need to be carefully selected. In the below figure is shown, with red line, the probable influence of the systematic error over dams behavior. The effect of systematic error measurement consists is a chaotic motion of blocks. To verify the dam is functioning monolithically, the movement, if any, can be measured. Is measured the relative movement from the zero time, when the measurements instruments are placed inside of dam.

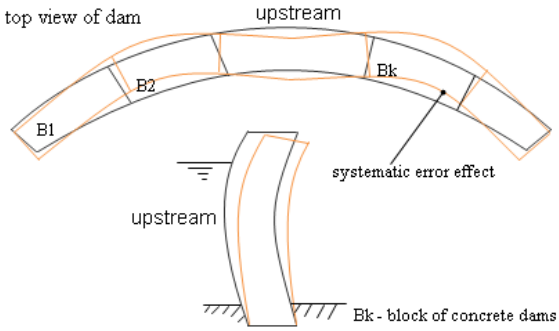

Fig.2 Movement of dams block under systematic error influence of measurement system

III. THE DIFFERENTIAL MEASURE CIRCUIT TO THE INCLINIMETER

In this section are analyzed two measurement circuits of inclinometer. The circuits take into account the measurement requirement. The accuracy is of 0.05% and the range of sensor output signal is ±2.5V.

The tilt sensor is designed for monitoring inclination of dams blocks, it is a differential device. This type of sensor is also called In Place Inclinometer (IPI). IPI sensors are specifically designed for rapid automatic real-time monitoring. The IPI ranges are of ±80mm/m, which make them ideal for those installations that deviate excessively from the vertical [5].

The first one is a classic resistive differential circuit, Wheatstone-bridge [4]. At this circuit the source of systematic error is the tolerance of resistances.

The second circuit is the improved version of the first one. Generally the resistance is a constant source of error. To eliminate the systematic error is developed a measurement circuit with no resistive divider.

These circuits are analyzed in order to identify the optimum method of measurement in term to reduce of systematic error of measurement instrument.

III.1. WHEATSTONE-BRIDGE CIRCUIT

The sensor outputs are fully differential voltage (output signals are noted with VH, VL, and VH = -VL), even if sensor is power supplied with a positive voltage. The Fig.3 shows the characteristic of inclinometer. A positive voltage indicates movement towards the downstream direction and a negative result indicate movement toward upstream direction [5].

Resistive elements configured as Wheatstone-bridge circuit are used to measure the differential output voltage from sensors. The circuit use a small number of components and is easy implemented. From this reason, in a lot of case, Wheatstone-bridge is the method used to measure differential voltage.

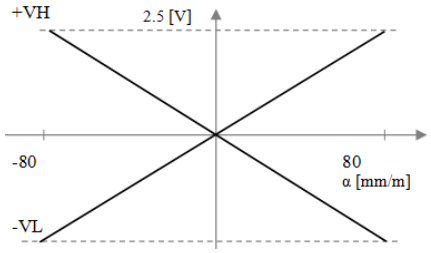

Fig.3 Tilt sensor output signal

To work only with positive voltage the common mode voltage of Wheatstone-bridge circuit is equal with reference voltage of ADC, the circuit is in fig.4.

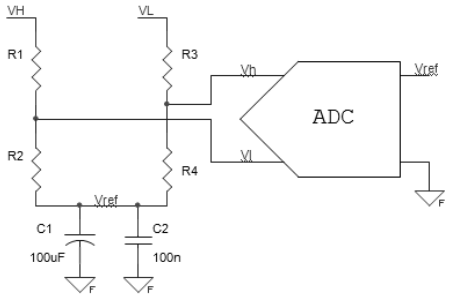

Fig.4 Wheatstone-bridge circuit used to measure IPI sensor

The differential input voltage is :

$V_D = Vh - Vl$, and $V_D = f(\alpha), \alpha$ [mm/m],

$f(\alpha)$ - is the calibration equation of IPI sensor

$$V_D = \frac{VH \cdot R_2 + V_{ref} \cdot R_1}{R_1 + R_2} - \frac{VL \cdot R_4 + V_{ref} \cdot R_3}{R_3 + R_4} \quad (4)$$

If resistors R_1, R_2, R_3, R_4 are equal:

$$V_D = \frac{Vh - (-Vl)}{2} = Vs; |Vh| = |Vl| = Vs \quad (5)$$

The accuracy of differential circuit is affected by the resistor tolerances, noted with δ. The error is a systematic error η_i.

$$\eta_i = f(\delta); \delta = \pm \max\left(\frac{R - R_n}{R}\right) \cdot 100; [\%] \quad (6)$$

R - real value, R_n – nominal value.

The Wheatstone-bridge circuit output voltage is modeled with next equation.

$$V_D = V_{D\,true} + \eta_{V_D}(\delta) \quad (7)$$

Where $-\eta_{V_D}(\delta)$ is the systematic error caused by resistance tolerance. The value of systematic error is obtained applying error propagation rule, with Wheatstone-bridge unbalanced, ($R_1 \neq R_2 \neq R_3 \neq R_4$). The output voltage depends by each resistor $V_D = f(R_1, R_2, R_3, R_4)$.

$$\eta_{V_D}(\delta) = \sqrt{\sum_{k=1}^{4}\left(\frac{\partial V_D}{\partial R_k} \cdot \delta\right)^2} \quad (8)$$

In equation (8) all resistors have the same tolerance class, the maximum value of systematic error is:

$$\eta_{V_D}(\delta) = \delta \cdot V_{ref} \cdot \sqrt{2} \quad (9)$$

The purpose of equation (9) is to compute the maximum tolerance of resistor when is known the measurement accuracy. A systematic error of 0.05% results with a tolerance resistance of $\delta = 0.01\%$.

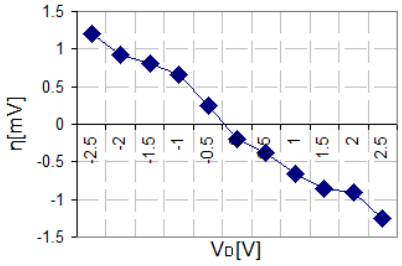

Fig.5 Wheatstone-bridge circuit error with $\delta = 0.01\%$

To reduce the effects of the systematic error, η_i it is required to use high accuracy resistors. The systematic error is proportional with resistance tolerance. If the design conditions are satisfied the data obtained from all measurement instruments have the uncertainty result form systematic error ($\pm\eta_{V_D}(\delta)$). A measurement system with four high accuracy resistors is expensive. If low cost resistors are used, each measurement instrument needs to be calibrated. The effect of systematic erro is presented in Fig. 2.

III.2. MEASUREMENT CIRCUIT WITH DIFFERENTIAL -ANALOG TO DIGITAL CONVERTER

The second measurement circuit uses the IPI sensor in a differential connection without resistors. The aim is to eliminate the source error. The sensor is power supplied with a positive voltage, relative to ADC common mode voltage.

$$V_{CC} = V_{DD} + Vz, \text{ and the outputs signals,}$$
$$V'h = VH + Vz < Vref \quad (10)$$
$$V'l = VL + Vz \geq 0$$

With relative power supply (VCC) is controlled the output signal, it will be a positive voltage relative to ground of ADC.

$$V_D = \frac{VH - VL}{2} \quad (11)$$

The sensor and the ADC not share the same ground. The measurement circuit is shown in below figure.

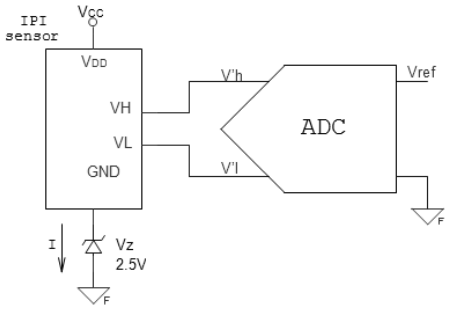

Fig.6 Measurement circuit of IPI sensor with differential ADC

In circuit from Fig.6 the sensor current consumption is equal to operating current of shunt voltage reference. The value of shunt voltage reference is $V_{ref}/2$ = 2.5V. Unlike the circuit from Fig.3 in the measurement circuit from Fig. 5 the differential voltage is independent by external component. The common mode voltage of ADC is equal with shunt voltage. An error of shunt voltage reference has as effect a limitation of measurement range of inclination. This does not affect the quality of data obtain inside of range.

$$V_D = \frac{(VH + Vz) - (VL + Vz)}{2} = V_S \quad (12)$$

The result of conversion is independent by common mode voltage of sensor. The acquisition is made with a differential converter. To obtain an accuracy of measurement of 0.03% is used a 14 bit converter. The ADC has auto calibration function so the offset and gain errors are internally compensate [6].

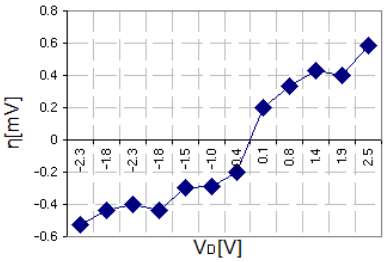

Fig.7 Measurement circuit error

III. SYSTEM IMPLEMENTATION

In this section is presented the measurement data logger. The measurement circuit is based on the method presented in section III 2. The sensor used to monitor the block dam inclination is a biaxial produced by Soil Instruments. The two directions of movement correspond with dam movement: up-down stream and right-left bank. The directions of sensor are independent. To measure two direction, the selection are made with a multiplexer circuit. The block structure of measurement data logger is presented in the next figure.

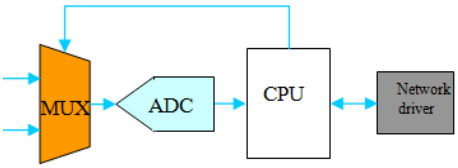

Fig.8 Structure of measurement data logger

The selection device (MUX) is accomplished with relays. The IPI sensor is a biaxial inclinometer. The role of selection circuit is to connect a single axis to be measured. For a long life, the IPI sensor is power supplied only when is measured. The measurement system is shown in the figure below.

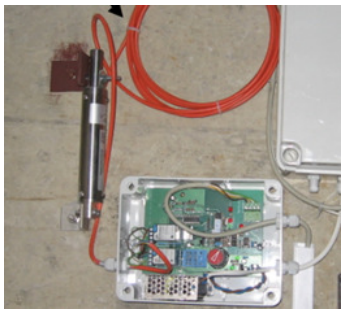
Fig.9 The imagine of measurement data logger

Data obtained from IPI sensors, place inside of dam are send to a data base. The time evolution of two dam blocks is obtained on visualization of data from data base. An overview shows that the motion of the two blocks is correlated. For a detailed analysis of block movement is required a large number of data.

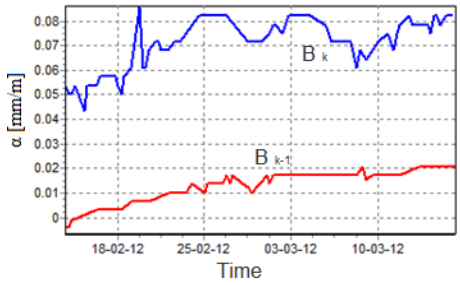

Fig.10 Inclination of two dam blocks

IV. ACKNOWLEDGMENT

These results were obtained on research grants with Hidroelectrica S.A in 2011.

V. CONCLUSION

The hydro-energetic building is monitored with a sensor network. Sometime the sensors are measured with individual systems. Each instrument has its own error produced by imperfection of the electronics components. When the data collected from each instrument are analyzed together is important that this to describe fair the evolution of monitored system. The erroneous data describe wrongly the evolution of construction. An uncertainty source of dam behavior is the systematic error. In the measurement system of inclinometer the source of error are resistors. The systematic error can be decreased using high accuracy components. To measure the inclinometer sensor, with Wheatstone-bridge with a precision of 0.05%, the resistance tolerance is by 0.01%. Precision components increase the cost price of the system. To eliminate the systematic error is developed a measurement circuit whose transfer function depends by a small number by external component.

To reduce the error the inclinometer is connected directly to ADC. The measurement accuracy is better than the requirement of 0.05%.

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Entrepreneurship Education and e-learning: A Perfect Match

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Abstract *– This paper presents an overview of the entrepreneurship education in Romania, the e-learning as an efficient tool for teaching entrepreneurship, and the experience of two entrepreneurship education projects implemented through e-learning. These projects were designed to satisfy the entrepreneurship education needs of rural communities to make them capable of taking advantage of local business opportunities. The targeted group of people was geographically dispersed in 41 counties in the eight development regions. Furthermore, the curricula and the e-learning platforms of both projects are described. The impact of projects is noticeable, among the most important being the following: 2530 beneficiaries so far, number of start-ups, projects that received structural funds on various sectoral operational programs (26 based on reported figures), and increase in turnovers of existing businesses. The projects are still open and new beneficiaries subscribe to them.*

Keywords: *entrepreneurship; e-learning; projects.*

I. INTRODUCTION

In the past decade the entrepreneurship education took a considerable ascendant trend since its role in the economic growth was worldwide recognized [1], [2], [3], [4].

Entrepreneurship is considered to be an innovative process through which entrepreneurs identify business opportunities and exploit them by allocating resources, and creating value.

The European Commission Green Paper: Entrepreneurship in Europe, states that "Entrepreneurship is the mindset and process to create and develop economic activity by blending risk–taking, creativity and/or innovation with sound management, within a new or an existing organization", further suggesting that:

- entrepreneurship is relevant for all sectors, technological or traditional, for small and large firms and for different ownership structures, such as family businesses, firms quoted on the stock exchange, social economy enterprises or non-profit driven organizations;
- entrepreneurship contributes to job creation and economic growth and competitiveness, unlocks personal potential and provides a focal point for many local communities.

The positive impact of entrepreneurship education in starting new businesses is recognized all over the world in various studies, Charney and Libecap [5], Vestergaard [1], Odunaike [2], Kilengthon et al. [3].

Numerous GEM reports show that education accounts for 40 percent of the cross-national variation in the total rate of entrepreneurial activity [6].

As far as entrepreneurship in Romania is concerned, the figures of the GEM Global Report 2011 improved significantly compared with those of 2010. Thus, in terms of perceiving business opportunities Romania has a rate of (17.5%) 36.1%, entrepreneurial intentions 24.7%, while the EU average[1] is 11.56%. The Entrepreneurship as a Good Carrer Choice is seen by 67.9% of all interviewed non-entrepreneur Romanian population, while the EU average is 57.75%. Yet, the same publication ranked Romania on the Total Early-Stage Entrepreneurship Activity with a rate of 9.9% up from 4.3% in 2010, and with an EU average located at 7.45%, and for comparison Hungary accounts for 6.3%.

This improvement in entrepreneurship in Romania recorded in GEM 2011, might be due to the running of various education and training programs in this field, and launched starting from 2009 which targeted a quite large number of population.

In order education to penetrate large number of population an efficient and very used tool since many years by now, is e-learning.

According to Global Industry Analysts, Inc. the e-learning is one of the most rapidly growing markets in the worldwide education and training industry projected to reach USD 107.3 billion by the year 2015, with a five-year growth rate for Eastern Europe estimated at approximately 23%. The different types of e-learning are:

synchronous e-learning (real-time communication) such as video conferencing, teleconferencing, and on-line chat programs;

asynchronous e-learning (do not require real time responses), such as web e-learning modules and knowledge databases;

[1] computation based on figures of 20 countries ranked in the report

blended e-learning (web interaction and in-person interaction) a combination of the previous two plus live face-to-face formal and informal education.

Advantages of e-learning in education are multiple and valuable. Broadly speaking, it is affordable, saves time, and produces measurable results. With its conceptual versatility and advancing technology, e-learning currently has increasingly limitless potential.

II. AN OVERVIEW OF E-LEARNING IN ROMANIA

In Romania, even though since the 90's a series of projects of introducing ICT in education have been developed, having as primary goals the improvement of schools infrastructures and their connection to Internet, a national program of such kind with a major impact being RoEduNet (extending the Romanian information network), about the e-learning can be spoken after 2000.

Another example is SEI program (Education IT-Based System) which was started in 1998 but concrete actions were taken beginning 2001 [9]. The program is implemented in partnership by the state administration and the private sector represented mainly by SC SIVECO Romania SA, HP Romania, and IBM Romania, and its goal is introducing IT as a teaching/learning tool in lower and upper secondary education.

As a portal for the SEI program in 2002 was set up the communication platform portal.edu.ro, at the web address www.portal.edu.ro, a platform to support the education system mainly providing teaching aids materials.

The core of the SEI program is the AeL (Advanced e-learning) application which offers support for teaching and learning, evaluating and grading, curriculum design and content management.

Another project is E-learning.Romania, started in 2006 and developed by TEHNE (Centre for Innovation and Development in Education), ASTED (Association for Education Sciences, and the National Foundation for Community Development), and Institute for Education Sciences, and two research centers in University of Bucharest and University Politehnica of Bucharest. This project aims to raise the quality and the efficiency of the computed-assisted education area, through offering theoretical support, disseminating best practices in e-learning, promoting solutions and systems for e-learning, and so forth.

As Istrate [9] pointed out, "regarding the (Romanian) higher education system, the level of implementation of the new learning technologies as well as of up-to-date ICT infrastructure is quite high, mainly due to the involvement of Romanian higher education institutions within European and international projects in the field of technology-enhanced learning or aiming at institutional development".

was gathered by the use of 41 questions per questionnaire, with the occasion of the inception local conferences organized in each county between March to May 2009, where the program and its curricula were presented and promoted as well. Out of 942 interviewed

The above statement is also supported be Crahmaliuc [10] who claimed that 58% of Romanian universities use e-learning solutions.

Additional to the above national programs different other organizations and individuals have undertaken over the years various projects and initiatives aiming to support the innovation in education. Examples are projects such as the Rural-Manager and the Rural-Antreprenor.

III. THE RURAL-MANAGER and RURAL-ANTREPRENOR PROJECTS

A. Rural-Manager Project

The Rural-Manager project was developed within the Sectoral Operational Program Human Resources Development, and implemented over a period of 16 months, between January 2009 and April 2010. The project was implemented by a partnership between The National Foundation of Young Mangers (FNTM) Romania, Training and Development Center of Bavarian Employees Associations (bfz) gGmbH Germany, S.C. Siveco Romania SA, and Euro < 26 Association.

The general objective of the project was the developing of entrepreneurial and managerial knowledge, skills and behavior in the rural areas. The target group of the project was people over 18 years old, with a minimum education of high school or vocational school, entrepreneurs or potential entrepreneurs, located in the rural areas of 18 counties from three developing regions North-East, Center and South-East. The proposed mean for conveying entrepreneurial education to targeted group is e-learning trough a platform designed and implemented by SC SIVECO Romania SA, partner in the project.

Additional worth to mention objectives were:

- the offering of consultancy services through 18 consultants, one for each county, organized in 9 regional Help-Desks network, one for each two counties;
- the setting up of an e-business platform designated for promotion of products and services of the beneficiaries.

The education and counseling needs were identified through a qualitative and quantitative research, undertaken by Social Research Office [11]. The research comprised a survey research, 3 focus groups, 3 brainstorming sessions and 30 face-to-face interviews. The sample size of the survey research was 942 persons selected from 493 localities (on average 2 persons for each locality) from the 18 targeted counties. The selection method used was probability sampling, randomly selected from an unstratified population with an error of +/- 3.2%. The information

persons, 23 participated in focus-groups, 22 at brainstorming sessions, and 30 face-to-face interviews.

The type of e-learning used in this project is asynchronous. The main windows of the platform are the Library window containing the curricula of the

Fig. 1 – The homepage of the Rural-Manager platform

program, the Forums window where messages between students, instructors and administrator are exchanged, and the Reports window where statistical data of the program are recorded and interrogated.

The curriculum of the education program contains five learning modules: strategic management, managerial finance, project management, business plan, and IT for businesses. On the Library window, the student can get sequential access to eleven courses packages and three evaluation tests including the final. In total, the entire program has 110 lessons presented in 3068 slides, and 301 testing questions.

Fig. 2 – The platform window of the course support index

On the Forum, there are eight discussions subjects, one for each module, and the rest of three being: business opportunities, student poster board, and program poster board.

On the Report window, various statistical data are computed and made available for instructors (number of students, average number of study for each individual student, the student progress of education, etc.) in a selective manner.

The results of the project were noteworthy. Between August 2009 and March 2010, 401 people have received entrepreneurship education with the e-learning platform, spending on average 204.6 hours.

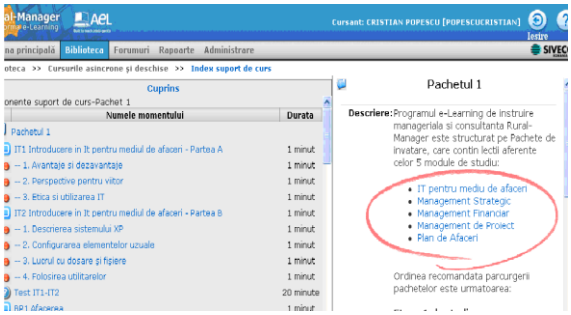

Fig. 2 – The platform window of the course support index

On the Forums there were discussed 279 topics, and exchanged 1168 messages.

There were 980 consultancy services delivered through Help-Desks network to 395 beneficiaries.

A business network of over 200 persons was developed among beneficiaries, having as main purpose partnerships and business cooperation development.

The e-business platform contains an e-business catalogue comprising over 480 registered firms and their products and services.

Another noticeable result of the project is its web site, www.ruralmanager.ro, which became an ongoing developing resources center, having over 73.000 accessed pages.

The project is still open and new participants subscribe to it.

B. Rural-Antreprenor Project

The Rural-Antreprenor project is an extension of the Rural-Manager project for 23 counties from the rest of 5 developing regions North-West, West, South-West Oltenia, South-Muntenia and Bucharest-Ilfov, not targeted by the Rural-Manager project. The implementation of the project is done by a partnership between The National Foundation of Young Mangers (FNTM) Romania, PROJOB GmbH Germany, Formastur SA from Spain, S.C. Siveco Romania SA, and Euro < 26 Association. The target group of the project was also people over 18 years old, for which the education and counseling needs were identified through the same research method, qualitative and quantitative, completed through survey research, focus groups, brainstorming sessions and face-to-face interviews.

Other additional objectives of this project are:

- ✓ the offering of consultancy services through 24 consultants, one for each county, organized in 12 regional Help-Desks network;
- ✓ the setting up of an e-commerce platform, and a project website: www.ruralantreprenor.ro
- ✓ designated for promotion of products and services of the beneficiaries.

The education and counseling needs were identified through a qualitative and quantitative research, undertaken by Social Research Office. The research comprised a survey research, 5 focus groups, 5 brainstorming sessions and 50 face-to-face interviews. The sample size of the survey research was 1527 persons, 60% men, selected from 683 localities from the 23 targeted counties. The selection method used was probability sampling, randomly selected from an unstratified population with an error of +/- 2.5%.

It was used asynchronous e-learning, and the curricula of the program comprises the following learning modules: Firm and its Economic Environment, Entrepreneurship and Innovation, Business Management, Business Marketing, Business Finance and Accounting, Business Communication and Negotiation, IT for Business. The Rural-Antreprenor e-learning platform is shown in Fig. 3.

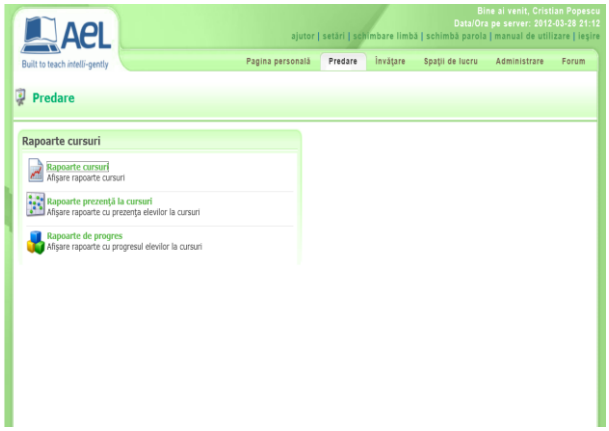

Fig. 3 – The Rural-Antreprenor e-learning platform

The current number of learners registered on the platform is 954 people. The project is in progress.

IV. CONCLUSIONS

Entrepreneurship education in Romania needs more attention and development. Improved figures from GEM 2011 as opposed to those of 2010, demonstrates that entrepreneurship programs developed started to show their fruits.

By keeping an eye on the top trends in e-learning industry and implementing the appropriate e-learning tools, a solid education system can be developed.

As regard to the Rural-Manager and Rural-Antreprenor projects, the impact of them is considerably. A total of 2530 persons were recorded as beneficiaries of the projects so far. Other effects such as increases in turnovers of existing businesses, number of start-ups, projects that received structural funds on various sectoral operational programs (26 based on reported figures), and more to come, reveal the positive impact of entrepreneurship education.

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LeCroy & Tektronix Oscilloscopes Remotely Controlled with LABView Drivers on LAN / GPIB Communication Protocol

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***Abstract* – This paper presents a method to remote control oscilloscopes from LeCroy and Tektronix manufacturers. These drivers can be built to work for more models than one. As programming/ implementation software it is used LabView, version 8.5, developed by National Instruments. These devices are remote controlled via Ethernet communication protocol or GPIB. By building device drivers for these devices, it is offered the possibility to integrate them into measuring or validation systems or other applications with educational purpose.**

Keywords: *Oscilloscope; Remote Control; Drivers; LABView; LAN*

I. INTRODUCTION

Electronic devices and components are passing from the development phase to the final product phase in about 2/3 years. These years are needed for one product to reach the maturity level. But during development are several small steps which consist in testing/verification and integration. Basically in every electronic control unit or component is a validation/measuring/testing part.

In this step, where is verified the maturity of the product, are two methods: testing manual or testing automatic. No matter which of these two types is chosen, during the testing process much equipment is involved. From these devices, for sure it is needed for one device that can measure the electrical signals. This can be a digital multimeter or an oscilloscope. Depending on the part where is needed the selection of the measuring devices is taken by the test engineer.

One important part in product development is the documentation part. Here is described how the product should behave. From this documentation are created test specifications and test requirements. But when the results are obtained, after testing a product against requirements, then is another important part: to store the results and to create test reports.

In all this steps for sure one oscilloscope is needed. With the option of saving pictures on a local hard-drive, to measure all parameters of electrical signal and with the option to remotely control this device, a LeCroy oscilloscope represents a good option for a measuring process. One problem that is common in the LeCroy series is that for these devices it is needed to be built the drivers for remote control with LABView[1]. LABView, is a product of National Instruments, which allows user to remote control more devices over GPIB, LAN or RS232.

A problem which this paper is trying to solve is the lack of drivers in LABView for LeCroy & Tektronix oscilloscopes: 4xx and XS series from LeCroy, DPO2xxx from Tektronix. In this paper are presented some built device drivers which eliminates the lack of remote control drivers. These devices, controlled over LAN or GPIB, can save pictures on local hard drive and save measured parameters of electrical signals like amplitude, rise time, fall time, frequency, pulse width, overshoot and others[2][4].

Also, these drivers can be used into standalone application like: automated measuring/ testing systems, educational or research [5][6]. Depending on project goal, drivers can be modified or further improved.

II. SOFTWARE PROGRAMING LANGUAGE

These 2 devices are presenting more possibilities for remote control. Starting with LeCroy oscilloscope remotely controlled over LAN or RSR232. For this paper it has been chosen to remote control over LAN this type of oscilloscope. Two reasons behind this decision:

- Picture size: it is taking too long to save a picture on RS232.
- Option to remote control via wireless.

For Tektronix oscilloscope are two possibilities to remote control, over LAN and GPIB. Speed for both protocols is high enough. Selection is made based on user's wish or equipment availability can be a decision factor.

Either way, LabView is the application software selected to create drivers. Here both protocols can be managed with success. Selection of LabView was based on:

- Option to build graphical user interface (GUI)
- Algorithm implementation easily made

- Structured way of work: virtual instruments for each module/ option desired.

Basically, LabView is working with virtual instruments (VIs). A virtual instrument consists in two parts: front panel and block diagram. In front panel is built the GUI and in block diagram is built the algorithm/ execution software.

In LabView is important to understand how is performed a program. Instructions are performed from left to right and from top to bottom. Depending on the place of the bloc diagram where VIs are used, these ones can be sooner or later executed. LabView is accepting also parts of code written in C or C++ and can perform mathematical operations with signals or values. In Tools Pallet are already built functions for signal analysis, like: timing, spectral, Fourier analysis, curve fitting and statistics.

Link between front panel and block diagram is created by user when are defined inputs and outputs for one VI. Inputs are considered all buttons with the option to set some features of the oscilloscope and outputs are considered each information that has user interest of: measurements or pictures. Each VI has his own front panel and block diagram. These inputs and outputs are conferring the flexibility needed for one application like this. By reconfiguring this inputs and outputs new application can be built or new features can be inserted.

GUI means front panel for one VI which is considered to be main. In block diagram this VI is linked to other VIs creating a tree structure. It is important to create a GUI with following proprieties: user friendly and intuitive/ easy to be used. In the next figure is presented the GUI used.

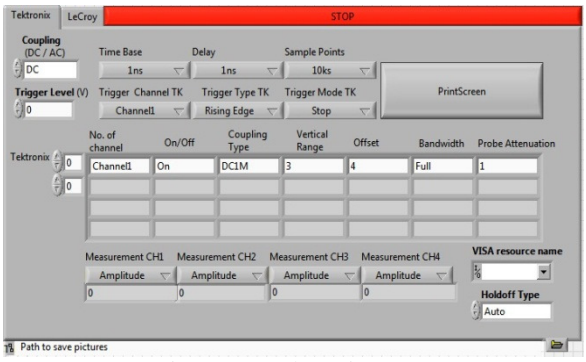

Figure1.a Tektronix GUI

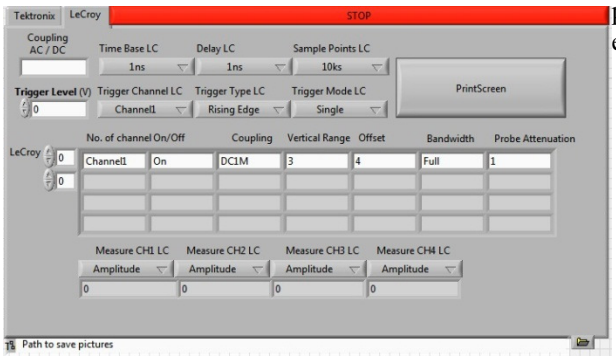

Figure1.b LeCroy GUI

In these GUIs it can be observed that main functions for oscilloscopes are included. There is the possibility to choose between these two devices in the control tab. There, the two options are named with the same name as the device remote controlled. This GUI confers access to all features of one device. It can be complete configured to do a single measure or can be configured to do more measurements and to save the results obtained.

The front panel for this application is split in different sections:

- Trigger section
- Channel setup
- Channel Measurement
- Time base setup

For the trigger section there is the possibility to set:

- Trigger Channel
- Trigger type : Rising edge, falling edge, pulse width
- Trigger mode : single, auto, stop
- Trigger level

It can be observed that main functions for trigger set are covered. In a testing laboratory these are the most used functions for trigger setup during one measurement.

For “Time Base” section there is the possibility to set:

- Time Base as time/division
- Delay, there is the trigger start point and it is important to be used associated with time/division. But of course can be set also independently from this time/division value.
- Sample Points

For the Channel setup there is the possibility to set:

- Channel number
- Enabled or not
- Coupling type : AC/DC
- Vertical range in units/division, in quite oft situations is in V/division but can be also in A/div
- Offset , where should one signal be positioned with respect to middle of the screen where is considered the reference point 0 or reference point
- Bandwidth
- Probe Attenuation

For the Channel measurement section, there is the possibility to measure one value for each channel that is enabled:

- Amplitude
- Area
- Base
- Cycles
- Delay
- Duration
- DutyCycle
- FallTime (90-10)
- Fall time (80-20)
- Frequency
- Maximum

- Mean
- Median
- Minimum
- Overshoot (negative)
- Overshoot (positive)
- Rise Time (10-90)
- Rise Time (20-80)
- Pulse width
- Peak2peak
- Standard deviation
- Top
- Base
- Width positive
- Width negative
- Standard deviation

In figure 3 is presented how one selection is made:

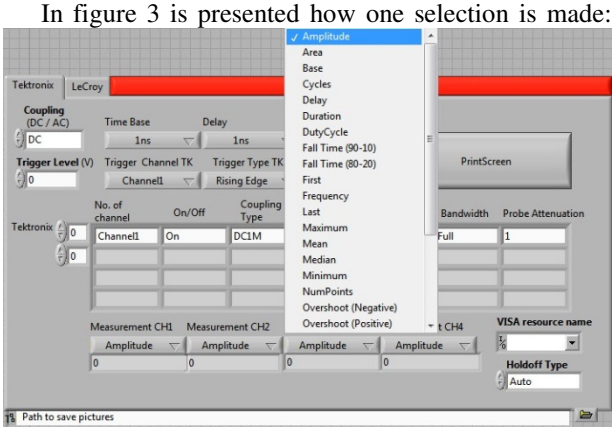

Figure3. Measurement selection for one channel

From the front panel it is possible to save pictures from both oscilloscopes. This is a good feature when is desired one picture to be inserted into a test report. The path for the saved file can be inserted, when not, it is chosen a default path established from before or automatic by LABView.

Because this application is used in a testing laboratory for now is semi-automated, user must insert these inputs manually. One important feature present into Tektronix equipment is the possibility to connect with this instrument over GPIB. LeCroy oscilloscope has only the possibility to connect over LAN and this is the reason why was selected a fixed IP.

In the Bloc Diagram from LABView this software is implemented in a structural way.

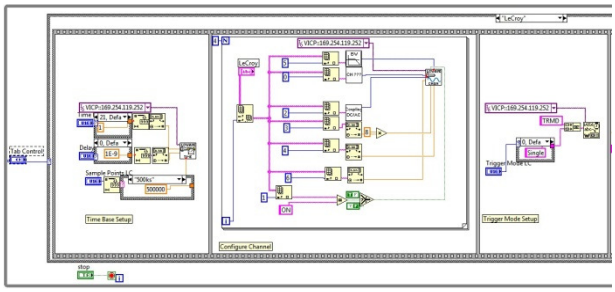

Figure4a. Part one of implemented algorithm

There is a while loop and this loop is active until is pressed the STOP button from the front panel. The role of this loop is to keep the application running for how long is desired by the user. This bloc diagram is split in 6 parts:

- Time Base Setup
- Trigger Mode Setup: single, stop, auto
- Trigger Voltage level and coupling setup
- Channel Setup
- Channel Measurement
- Picture Saving

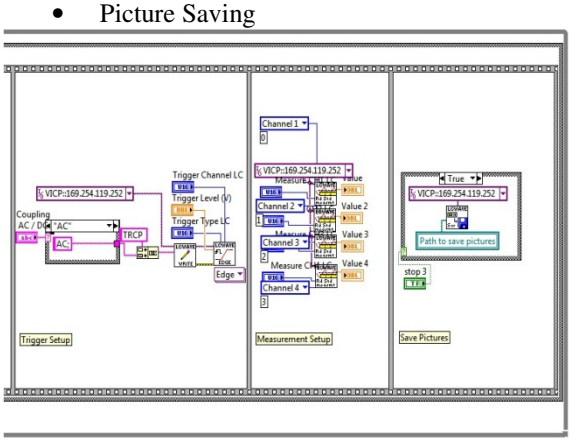

Figure4b. Part two of implemented algorithm

In general there are more VIs interconnected. Through the connector, in LABView it is possible to define the inputs and the outputs for a VI.

From LeCroy oscilloscope user's manual were taken the syntaxes to build up the drivers.

As an example in figure 5 will be presented how the trigger command for LeCroy oscilloscope is built.

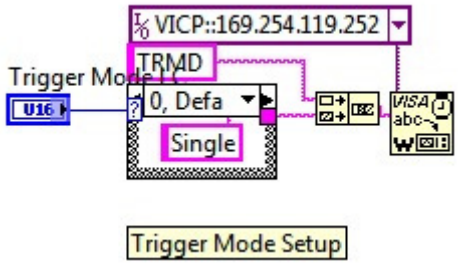

Figure5. Trigger mode syntax in LABView

From user's manual the syntax for trigger mode is: TRMD Single / Auto / Stop. To create such a string it is used a case structure with the 3 cases, each of them containing a string selected by the controlled tab Trigger Mode from the front panel. When desired string is selected it is concatenated with TRMD and send to VISA write. All commands are built in this way.

III. RESULTS AND DISSCUSSIONS

This application was used in a lab to be connected to different oscilloscopes and to configure remote controlled preferred settings on these devices. Also this application has the great advantage to save pictures directly on PC local hard drive.

In figure 6 is presented a picture saved with this application. Another advantage is that in a short time,

the oscilloscope is set to desired configuration and also there is the possibility to save the new configuration and the next time when is needed just to be opened. Improvements can be done in this application.

This application is built to be structured in more blocks so it can be used in pieces or in other applications. Also this can be adapted to user needs and a new connector should be designed or another front panel adapted to users needs.

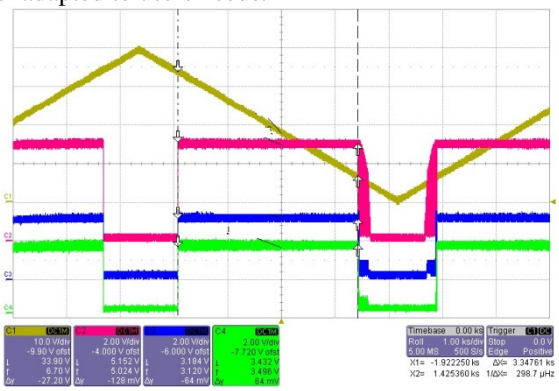

Figure6. Results

III. CONCLUSIONS

This application is simple to be built and can easily remote control every oscilloscope from LeCroy producer or Tektronix DPO2xxx series. Also it can be extended for other devices as well.

This application can handle GPIB communication for Tektronix oscilloscopes and LAN communication protocol for LeCroy oscilloscope. Due to the fact that it is desired a feature to save pictures, RS232 protocol was not implemented.

Every device is easy to be configured from the front panel and this application is fit to get quick results. When it is desired a quick configuration of a device than this application can represent a solution

All important parameters to be set, in one measurement with these oscilloscopes, are covered in the front panel.

It is possible to save pictures directly on the local hard drive, where this application is installed.

It is possible for this application to be integrated in other applications. The linking connector can be redesign for user's needs.

Also this application is built structural, for each step there is a separate VI.

This application can be used for LABView learning, this represents a good opportunity for students to learn about hardware equipment's remote control, something about communication protocol GPIB and something related to measurement setup/ oscilloscope setting.

ACKNOWLEDGMENT

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LMP with Secure Bilateral Transactions in Deregulated Electricity Markets

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Abstract *– One of the major responsibilities of the independent system operator is to ensure feasible and secure bilateral transactions before their commitment. Another important responsibility of the ISO is to provide and manage the reactive power deployment as an important ancillary service for secure and reliable operation of the system. The main objective of the work is (i) to determine secure transactions and utilize them to find their impact on nodal prices of real and reactive power, (ii) to incorporate reactive power cost models for determining reactive power cost of generators, and (iii) to study the impact of secure transactions and reactive cost models on LMPs of both real and reactive power. The results have been obtained for hybrid electricity market model using Non-linear Programming (NLP) approach with MATLAB and GAMS interfacing. The proposed approach has been tested on IEEE 24-bus Reliability Test System (RTS).*

Keywords: *Locational marginal price; reactive power cost model; hybrid electricity market; secure bilateral trabnsactions.*

I. INTRODUCTION

The real time transmission pricing has become a central issue for accurate transmission pricing giving better economic signal for market operation. The reactive power service is essentially required for transmission of active power, control of voltage, and reliable and secure operation of the power system. The reactive power support service has been identified as one of the key ancillary services in the competitive electricity market structures. Therefore, real time reactive power pricing also addresses an important issue of providing information to both utility and consumers about the actual burden on the system. Since generators' are the main source of reactive power generation and the cost of the reactive power should be considered for their noticeable impact on both real and reactive power marginal prices. Therefore, with the growing interest in determining the costs of ancillary services needed to maintain the quality of supply, the spot price for reactive power has also gained recently a considerable attention in competitive electricity markets. The concept of spot pricing was introduced in the late 1970's. Schweppe et al. utilized the concepts of classical economic dispatch and DC load flow to obtain the essential parts of spot price and provided the foundation for transmission price concept [1]. However, the authors have not considered the pricing of reactive power. Many authors presented reactive price calculation models in [2-7]. Advance pricing structure with the decomposition of the spot price to obtain the different pricing components were proposed in [9-14]. A methodology for reactive power prices calculation with decoupled optimization, practical proposals for the procurement and charging of reactive and voltage control services using different programming approaches was presented in [15-25]. However, the nodal prices issue with secure transactions with change in operating conditions has been left unaddressed.

In a deregulated environment, the number of bilateral transactions has grown rapidly which changes the pattern of transmission flows and economic dispatch of generators thus having impact on LMPs. It is therefore essential for the system operator to evaluate their impacts on the system operation and nodal prices. The ISO can not allow the infeasible bilateral transactions as it may cause congestion, threaten system security, reliability and alter economic dispatch schedule.This important issue of bilateral transaction determination and their security has been studied by many authors. Many authors studied their security and feasibility assessment for only bilateral market model utilizing DC distribution factors [26-28]. A new modified approach using more accurate distribution factors for secure bilateral transaction in hybrid market models [27-28]. Recently authors presented transmission pricing approach for hybrid market model [29]. This paper attempts a transmission pricing issue with secure bilateral transactions and reactive cost models.

The main objectives of the work are:

(i) to determine secure transactions and utilize them to find their impact on nodal prices of real and reactive power,

(ii) (ii) to incorporate reactive power cost models for determining reactive power cost of generators, and

(iii) to study the impact of secure transactions and reactive cost models on LMPs of both real and reactive power.

The results have been obtained for hybrid electricity market model using Non-linear Programming (NLP) approach with MATLAB and GAMS interfacing [30-31]. The proposed approach has been tested on IEEE 24-bus Reliability Test System (RTS). The comparison has been given for different reactive cost models for IEEE 24-bus reliability test system.

II. SECURE BILATERAL TRANSACTION MATRIX FOR HYBRID MARKET MODEL

The conceptual model of bilateral dispatch is that sellers and buyers enter into transactions where the quantities traded and the trade prices are at the discretion of these parties and not a matter of the ISO. These transactions are submitted to the ISO with a request that transmission facilities for the relevant amount of power be provided. The ISO ensures that there is no violation of static and dynamic security, and dispatches all requested transactions and charges for the service.

The bilateral transaction concept can be generalized to the multi-node case where the seller, for example a generation company called **G**encos, may inject power at several nodes and the buyer bus called **D**iscos also draw load at several nodes. The bilateral contract model used in this paper is basically a subset of the full transaction matrix proposed in [26]. There are some intrinsic properties associated with this transaction matrix *GD*. These are column rule, row rule, range rule, and flow rule. These properties have been explained in [27-28]. The general problem formulation for determination of secure transaction matrix for hybrid market model has been well presented in [27-28].

Table 1. Proposed Bilateral Transaction Matrix, GD_{ij}^{0}

Value of transaction between generator and load bus (p.u)				
GD(1,1)=0.5	GD (1,2)=0.3	GD (1,3)=0.3	GD (1,15)=0.1	GD (1,18)=0.4
GD (2,10)=0.2	GD (2,13)=0.3	GD (2,15)=0.4	GD (2,18)=0.5	GD (2,19)=0.2
GD (7,9)=0.2	GD (7,10)=0.2	GD (7,13)=0.4	GD (7,15)=0.5	GD (7,18)=0.0
GD (13,18)=1.5				

Secure bilateral transaction matrix [29] have been obtained using GAMS CONOPT solver 21.3 [30-31]. The impact of different percentage of ***GD*** (%age of total demand) on the pattern of transaction matrix has been obtained. These secure transactions have been utilized to analyze the impact on LMPs of both real and reactive power. The secure transactions have been obtained for GD=5% to GD=50% with a step increase of 5%. However, the results have been provided for GD=10% and GD=50% for two cases only and shown in Figs. 1-2.

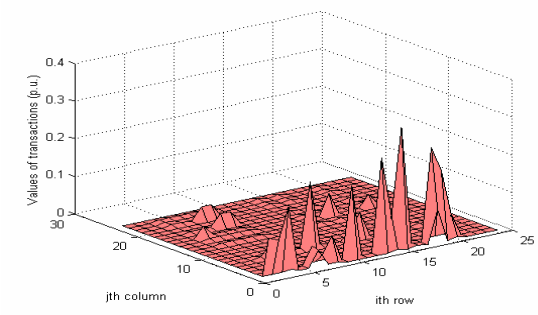

Fig. 1 GD share of 10% of the total demand

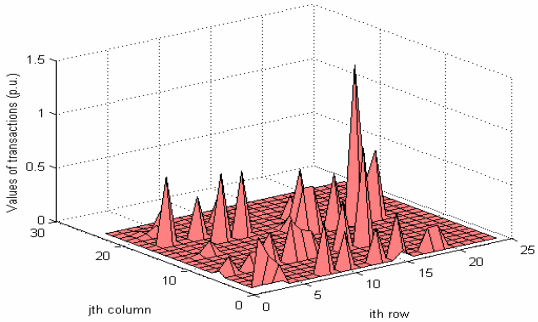

Fig. 2 GD share of 50% of the total demand

III. LMPS OF REAL AND REACTIVE POWER WITH SECURE BILATERAL TRANSACTIONS

The general form of the problem formulation can be represented as.

$$\text{Min } F(x,u,p) \quad (1)$$

Subject to equality and inequality constraints defined as

$$h(x,u,p)=0 \quad (2)$$

$$g(x,u,p)\le 0 \quad (3)$$

where,

x is state vector of variables V, δ;

u are the control parameters, P_{gi},Q_{gi}, P_{GB}, $P_{GP,}$;

p *are the* fixed parameters $P_{di,}$ P_{DB}, P_{DP}, $Q_{d,}$ GD_{ij};

The objective function can be represented as:

(a) Objective function

$$\sum Cost(P_{gi})+Cost(Q_{gi}) \quad (4)$$

The objective function consist two cost components as cost of real power and cost of reactive power. These can be represented as:

$Cost(P_{gi})$ = Cost function of real power

$Cost(Q_{gi})$ = Cost function of reactive power

$$Cost(P_{gi})=a_pP_{gi}^2+b_pP_{gi}+c_p \ \ \$/h \quad (5)$$

$$Cost(Q)=a''Q^2+b''Q+c'' \ \$/\text{hr} \quad (6)$$

where, a'', b'', c'' are constants depending on power factor *(*cos *θ)* and are calculated as follows from power triangle are [25] as

$$a'' = a_p \sin 2\theta,\ b'' = b_p \sin\theta,\ c'' = c_p \quad (7)$$

$Cost(P_{max})$ − $Cost(P_{max} - \Delta P)$: Reduction in the cost of active power due to compulsory reduction in active power generation *(ΔP)* which happens due to generating

reactive power with the amount of Qi . This represents the cost of reactive power production [29]:

$$Cost(Q_i) = \frac{P_{\max} - \Delta P}{P_{\max}} Cost(P_{\max}) - Cost(P_{\max} - P_i) \text{ \$/hr} \quad (8)$$

$$Cost(Q_{Gi}) = Cost(S_{G\max}) - \sqrt{Cost\left(S_{G\max}^2 - Q_{Gi}^2\right)} * k \text{ (\$/h)} \quad (9)$$

Where $S_{gi,max}$ is the nominal apparent power of the generator at bus i; Q_{gi} is the reactive power output of the generator at bus i; k is the profit rate of active power generation, usually between 5% and 10%. In this work, the value of k has been taken as 5%.

(b) Set of equality constraints are: Power Injection at buses

$$P_i = P_{gi} - P_{di} = \sum_{j=1}^{N_b} V_i V_j \begin{bmatrix} G_{ij} \cos(\delta_i - \delta_j) \\ + B_{ij} \sin(\delta_i - \delta_j) \end{bmatrix} \forall i = 1,2,\ldots N_b \quad (10)$$

$$Q_i = Q_{gi} - Q_{di} = \sum_{j=1}^{N_b} V_i V_j \begin{bmatrix} G_{ij} \sin(\delta_i - \delta_j) \\ - B_{ij} \cos(\delta_i - \delta_j) \end{bmatrix} \forall i = 1,2,\ldots N_b \quad (11)$$

$$\sum_{i=1}^{Ng} P_{gi} - P_{di} - P_{loss} = 0 \quad (12)$$

$$\sum_{i=1}^{Ng} Q_{gi} - Q_{di} - Q_{loss} = 0 \quad (13)$$

(c) Equality constraints for bilateral transactions along with pool (Hybrid market model)

$$\mathbf{P}_{DB} = \sum_{i \in sb} GD_{ij} \quad (14)$$

$$\mathbf{P}_{GB} = \sum_{j \in bb} GD_{ij}, GD_{ij}^{\max} = \min(P_{GB,ij}^{\max}, P_{DB,ij}) \quad (15)$$

$$\mathbf{P_g} = \mathbf{P}_{GB} + \mathbf{P}_{GP} \; \mathbf{P_d} = \mathbf{P}_{DB} + \mathbf{P}_{DP} \quad (16)$$

$$\mathbf{P_{fb}} = DF(\mathbf{P}_{GB} - \mathbf{P}_{DB}), \mathbf{P_{fp}} = DF(\mathbf{P}_{GP} - \mathbf{P}_{DP}) \quad (17)$$

$$\boldsymbol{P}_f = \boldsymbol{P}_{fb} + \boldsymbol{P}_{fp} \quad (18)$$

Where GD = bilateral transaction matrix
P_{DB} = vector of bilateral demand
P_{DP} = vector of pool demand
P_{GB} = vector of bilateral generation
P_{GP} = vector of pool generation
i and j are the sets of the seller and buyer buses, respectively.

(d) Power generating limits

$$P_{gi\min} \le P_{gi} \le P_{gi\max} \quad (19)$$

$$Q_{gi\min} \le Q_{gi} \le Q_{gi\max} \quad (20)$$

(f) Voltage limits

$$V_{i\min} \le V_i \le V_{i\max} \quad (21)$$

(f) Phase angle limits

$$\delta_{i\min} \le \delta_i \le \delta_{i\max} \quad (22)$$

(g) Reactive Power Capability Curves limit for generators:

$$P_g^2 + Q_g^2 \le (V_t I_a)^2 \quad (23)$$

(h) Transmission Line flows:
The real and reactive power flow equations from bus-i to bus-j can be written as:

$$P_{ij} = V_i^2 G_{ij} - V_i V_j (G_{ij} \cos\delta_{ij} + B_{ij} \sin\delta_{ij}) \quad (24)$$

$$Q_{ij} = -V_i^2 (B_{ij} + B_{sh}) - V_i V_j (G_{ij} \sin\delta_{ij} - B_{ij} \cos\delta_{ij}) \quad (25)$$

$$S_{ij} = \sqrt{P_{ij}^2 + Q_{ij}^2} \le S_{ij}^{\max} \quad (26)$$

The results have been obtained using the GAMS 21.3 / CONOPT solver and utilizing interfacing with MATLAB [30-31]. The flow chart of the proposed method for LMPs determination with secure bilateral; transactions and reactive power cost model has been presented in Fig. 3.

IV. RESULTS AND DISCUSSIONS FOR IEEE-24 BUS TEST SYSTEM

The results have been obtained for different cases utilizing secure transactions share with different reactive cost models of reactive power cost calculation. The results obtained with different models of reactive power cost calculations termed as M-1, M-2 and M-3 are categorized as follows-

Case 1: Results with different share of secure bilateral transactions using M-1
Case 2: Results with different share of secure transactions using M-2
Case 3: Results with different share of secure transactions using M-3

Results for all the cases have been obtained and presented for nodal prices, real power loss, and generation patterns. The plots of the marginal cost for real and reactive power for Case 1 to Case 3 using different methods (M-1, M-2, M3) of reactive power cost model is shown in Figs. 4 to 9.

From Fig. 4, it is found that nodal prices reduce at each node with the increasing share of secure bilateral transactions. For lower share of GD, the variation of the real power prices is also high. However, with the increase in the share of GD, the nodal prices become lower and more uniform. At GD=50% of the total demand, the nodal prices of real power are almost similar at all buses. At GD=5%, LMP of real power is maximum at bus 1 of value 97.705$/MWh and minimum at bus 23 of value 32.9287$/MWh. The LMPs of reactive power as shown in Fig. 5 have maximum negative value at bus 7 with different share of GD. There is reduction in the LMPs at each bus with GD share however, the impact of GD share on LMPs at various buses is observed less prominent as observed in case of LMPs of real power. LMPs of reactive power are both positive and negative at the buses as Lagrange multiplier can be both the +ve or –ve at the buses. At bus 3 and 24, with higher *GD* share it is found to be positive. From Fig. 9, similar observations are found for case 2 and case 3 also. It is found that nodal prices reduces at each node with the increasing share of GD. For lower share of GD, the variation of the real power prices is also high. However, with the increase in the share of GD, the nodal prices become lower and more uniform. At GD=50% of the total demand, the nodal prices of real power are found minimum at all buses. Reactive power LMPs become almost uniform above GD share of 35% of total demand. The values of reactive power LMPs are observed to be minimum at all

buses for GD=50% compared to all other GD shares. The values of reactive power LMPs are observed to be minimum at all buses for GD=50% compared to all other GD shares.

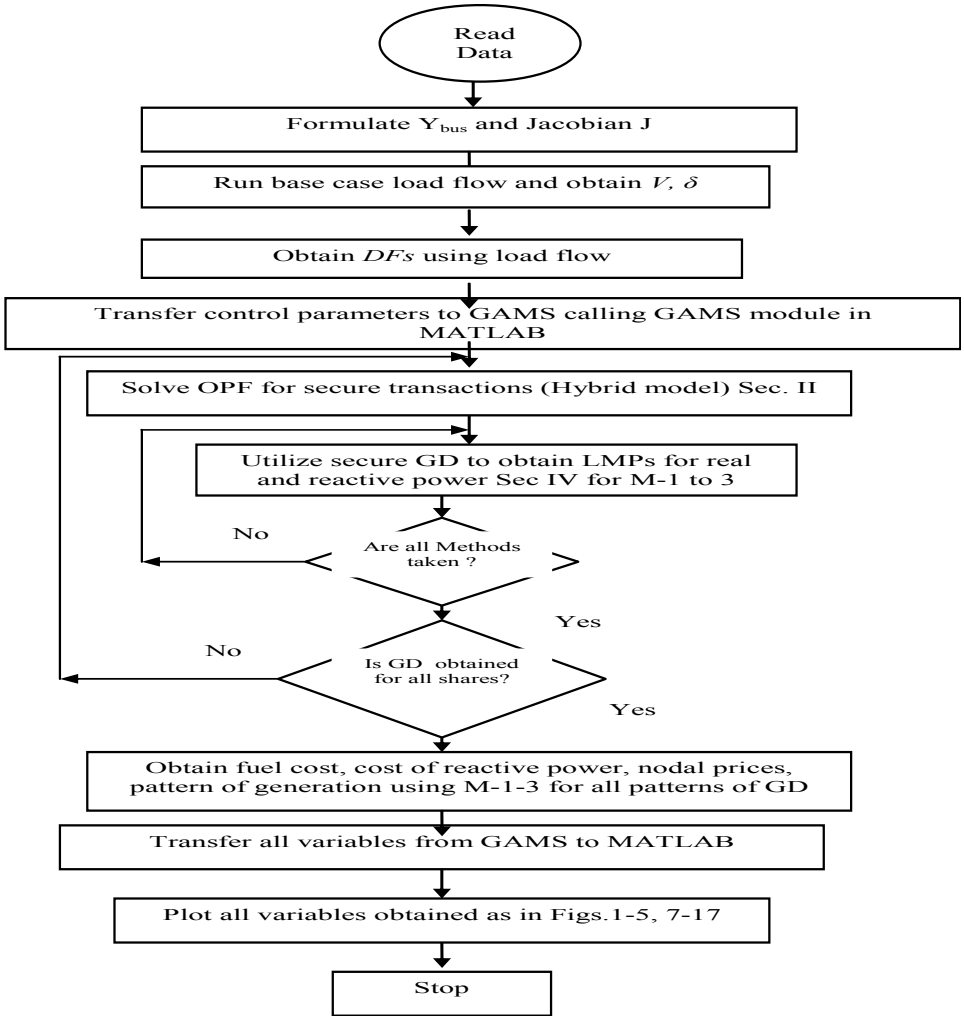

Fig.3. Flow Chart for determination of LMPs with secure transactions and reactive cost models

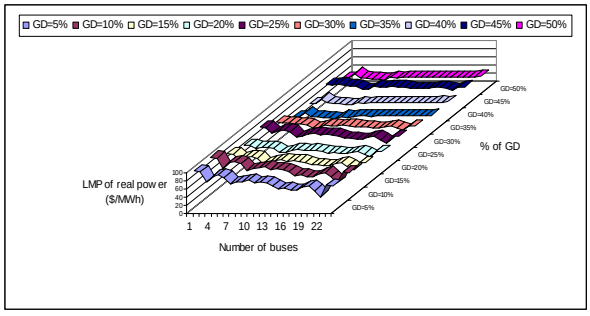

Fig. 4. LMP of real power (Case 1)

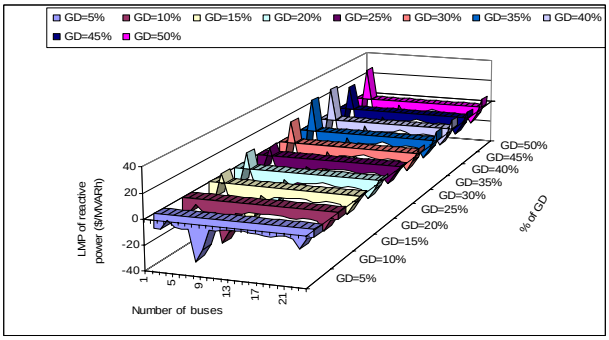

Fig. 5. LMP reactive power (Case 1)

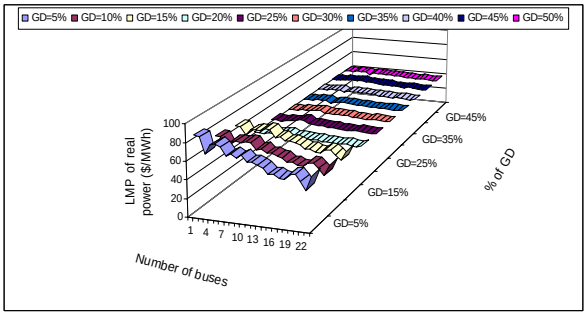

Fig. 6. LMP of real power (Case 2)

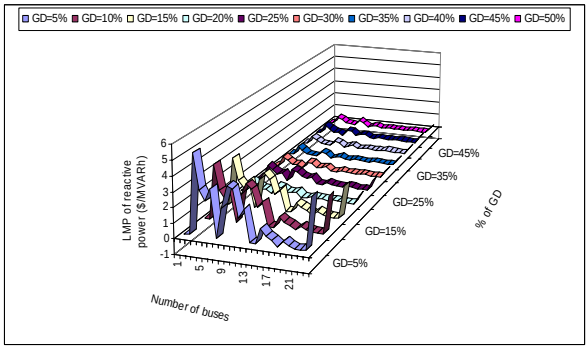

Fig. 7. LMP of reactive power (Case 2)

Comparing the LMPs for M-1 to M-3, it is observed that LMPs of real power are minimum for M-1 at GD=50%. LMPs for reactive power are found minimum for M-2 at GD=50% compared to all other methods. With the increase in GD share above 50%, it is found that the LMPs for both real and reactive power increase at all the buses. Thus, from the results obtained for LMPs of real and reactive power for all the cases with different GD share, it is observed that the LMPs varies with GD share along with the methods adopted for the reactive power cost calculation of reactive power in the model. The LMPs are found to decrease with increased share of GD due to the counter flows and reduction in losses of the system.

The real and reactive power cost for all cases with different GD share are Table 2. Fuel cost is found lower for M-3 compared to M-1 and M-2 for all GD shares. Different fuel costs are obtained for all the cases due to the different generation pattern obtained for share of generators for pool and bilateral demand as given in Table 2 for M-1 to M-3. Simlarly, the reactive cost of genertors' reactive power are different for all the cases. It also varies with different GD share. For most of the cases of GD shares, the minimum reactive cost component is found lower for M-3 and for few cases of GD, it is obtained lower for M-2. For M-1, the reactive cost component is found higher for all GD share. The real power loss reduces with increase in GD share. It is found lowest at GD=50% of the total demand. The reduction in the real power loss is due to the fact of counter flows occurring in the system with higher GD share.

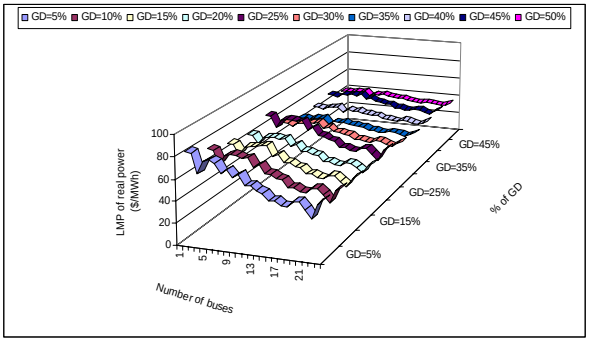

Fig. 8. LMP of real power (Case 3)

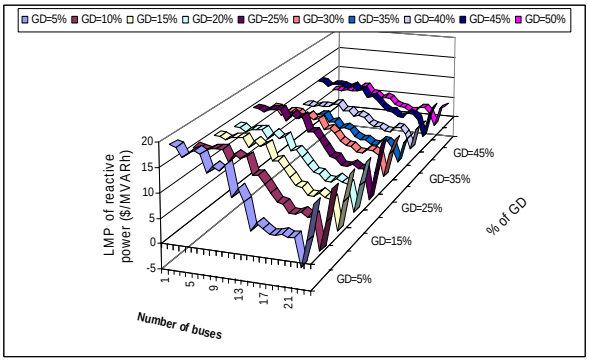

Fig. 9. LMP of reactive power (Case 3)

TABLE 2. RESULTS FOR IEEE-24 BUS SYSTEM FOR CASE-1

	GD=5%	GD=10%	GD=15%	GD=20%	GD=25%	GD=30%	GD=35%	GD=40%	GD=45%	GD=50%
Fuel cost ($/MWh) M-1	114042.3	116028.2	118106.2	116818.9	115365.5	118950.9	122099.9	121672	119746	123224.6
Fuel cost ($/MWh) M-2	112599.8	114213.9	118067.2	117946	115425.8	120018.1	122244	122365.3	120950.2	123336.2
Fuel cost ($/MWh) M-3	112497.6	114402.6	117343.1	116165.2	114537.6	118548.1	121947.4	121503.9	119529.9	123059.8
Reactive Power Cost ($/MVARh) M-1	5039.56	3685.45	4158.32	5892.34	5046.47	6018.81	6921.34	6858.59	6185.33	7298.9
Reactive Power Cost ($/MVARh) M-2	2074.67	22.5602	1774.34	461.75	150.84	83.78	1714.73	724.53	284.75	1591.03
Reactive Power Cost ($/MVARh) M-3	1783.56	1729.05	1741.36	1529.42	1725.36	1370.54	791.36	834.66	1194.74	594.12

VI. CONCLUSIONS

In this work, impact of secure bilateral transactions and reactive power cost model on nodal price of real and reactive power has been studied. Based on the results, the conclusions are as follows:

(i) The nodal prices reduces with increase in GD share and are observed to be minimum for GD=50% for all cases.

(ii) There is noticeable impact of GD share on reactive power marginal prices and they are found to reduce at higher GD share and are observed minimum for GD=50%.

(iii) Fuel cost is found minimum for case 3 with all Methods M-1 to M-3 with all GD share.

(iv) Real power losses reduce with increase in GD share for all methods of reactive power cost model.

(v) Generation patterns for pool and bilateral demands are different with GD share and methods of reactive power cost calculations. G1, G7, G13, and G22 have dominant share for bilateral demand and G15, G16, G18, and G23 have dominant share for pool demand.

Based on the results, it is essential for the ISO to study the impact of secure transactions with different operating scenario on LMPs of both real and reactive

power. The reactive cost models have noticeable impact on nodal prices and must be incorporated for accurate price signal. This study will help the ISO to provide market participants better economic operation of the system. The LMPs with different bilateral and pool shares will provide information to energy management system for congestion occurrence and available transfer capability for further commercial activity. This study will also pave the way for LMPs forecast for future market operation.

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Performance Comparison of The Impact of High Dielectric Permittivity of 2-D Numerical Modeling Nanoscale SOI Double-Gate Mosfet Using Nextnano Simulator

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Abstract *– For the investigation of sub-10nm field effect transistors , 2-D numerical simulations using nextnano have been conducted to evaluate and compare the variation of the threshold voltage, swing subthreshold effects, the leakage current and the drain-induced barrier lowering when gate length (L_G) decreases, using SiO_2 and HfO_2 gate oxide with respect to different gate bias (V_G). Furthermore, quantum effects on the performance of DG MOSFETs are discussed. Quantum drift diffusion method is used to study the electronic structure. A good agreement with numerical simulation results is obtained, for which the simulations show significant improvements compared with SOI DGMOSFET using an SiO_2 gate dielectric.*

Keywords: *SOI-DGMOSFET; Nextnano3d; Quantum effects; tunneling current .*

I. INTRODUCTION

Since fundamental physical limits pose virtually impenetrable barriers to tetra scale integration, in spite of progress in silicon technology, the end of Mosfet scaling can be anticipated for the year 2015. We study, using numerical simulation [1], the influence of the channel length and high k gate dielectric [2] on the electrical performance, is improving while scaling down the metal–oxide–semiconductor field-effect transistor (MOSFET) gate length.

The main idea of a SOI Double Gate MOSFET is to control the Si channel very efficiently by choosing the Si channel width to be very small and by applying a gate contact to both sides of the channel. This concept helps to suppress short channel effects and leads to higher currents as compared with a MOSFET having high dielectric permittivity as gate oxide [3]. In this work, the effect of short channel and influences of quantum mechanical on nanoscale SOI DG-MOSFETS [4] are also highlighted.The model of simulation tool is based on the self consistent solution in two dimensions to the poisson equation and Schrödinger equation system.The electronic structure is calculated within a single-band or multiband k.p envelope function approximation [5]. The thinner oxide lets more current leak between the gate and the substrate, driving up power consumption and better on- and off-state control [6], 2D density-gradient drift-diffusion model, is adopted in this work

II. STUDIED DEVICES

The 2006 edition of the ITRS [7] forecasts a minimum feature size of 18nm-node a physical gate length of 7nm. At this channel length limits, the susceptibility of the transistor to short channel effects (SCE) is monitored in several ways such as threshold voltage (V_{TH}), leakage current (I_{OFF}) and drain induced barrier lowering (DIBL) . The studied structure consists of a p-type doped Si channel, that is embedded between two heavily n- doped source and drain regions of length 10 nm that are connected to source and drain contacts, The dopant of channel and source/drain are 0,001 x 10^{18} cm^{-3} , 1 x 10^{20} cm^{-3} respectively. The gates are separated from the Si channel by a 5nm thick oxide layer (Fig.1).

The width of Si channel takes 5nm. The work function of polysilicium gate is 4.1eV and the power supply voltage V_{DD} is 0.7V. Moreover, the N^+/P junctions are assumed to be abrupt. The 7nm length is chosen to study the performances of device, taking different Oxide thikness (5nm and 1.5nm) with the two Si channel width (5nm and 3nm) for both SiO_2 and HfO_2.

III. THEORETICAL ASPECTS

The nextnano[8] simulator deals with realistic geometries, it focuses on an accurate and reliable treatment of quantum mechanical effects and provides a

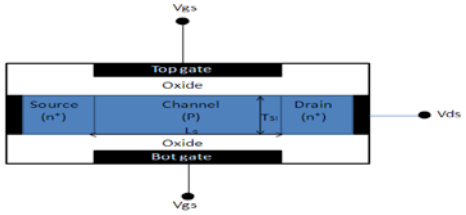

Fig.1 Symmetrical DG-MOSFET considered in this work.

self- consistent solution of the Schrödinger, poisson and current equations. The electronic structure is calculated within a single-band or multiband k .p envelope function approximation.The included model is a Wentzel–Kramer–Brillouin (WKB)-type approach that we termed the quantum-drift-diffusion (QDD) method[5]. The charge density is calculated for a given applied voltage by assuming the carriers to be in a local equilibrium that is characterized by energy-band dependent local quasi-Fermi levels $E_{FC}(x)$ for charge carriers of type *c* (i.e. in the simplest case, one for holes and one for electrons)

$$n_c(x) = \sum_i \left|\psi_{ic}(x)\right|^2 f\left(\frac{E_{Fc}(x) - E_{ic}}{k_B T}\right) \quad , \qquad (1)$$

These local quasi-Fermi levels are determined by global current conservation $\nabla \cdot j_C = 0$, where the current is assumed to be given by the semi-classical relation :

$$j_c(x) = \mu_c n_c(x) \nabla E_{FC}(x) \quad . \qquad (2)$$

The carrier wave functions ψ_{ic} and energies E_{ic} are calculated by solving the multiband Schrodinger-Poisson equation [9].

The EOT [10] (Equivalent Oxide Thickness) used in this work is that obtained by classical Electrostatic theory in planar devices where :

$$EOT = \frac{k_{SiO_2}}{k_{high-k}} T_{high-k} \quad . \qquad (3)$$

The SiO_2 and HfO_2 permittivities (k_{SiO2}, k_{high-k}) are 3.9 and 21.2 respectively, T_{high-k} : high-k material thickness.

IV. RESULTS

The intent is to have a model that is capable of doing rudimentary first order comparisons of the threshold voltage with respect to dimension and oxide gates, for a given oxide thickness (EOT). Reliability of SiO_2 as gate dielectric material below 1nm thickness is also an important concern. Use of high k dielectric materials seems to be ultimate solution to this problem [7].To take into account the quantum effect, for EOT=5nm, we first examine The $I_D(V_{GS})$ curves at $V_{DS}=V_{DD}$ for both SiO_2 and HfO_2 gate dielectrics, which are plotted in Fig.2 and Fig.3, these figures show the variations of the drain current with the gate voltage for SOI DGMOSFETs device of channel lengths 7,13,18 and 25nm respectively.

The subthreshold current rises dramatically as the gate voltage increases . It can be seen that the drain current depends on the channel length [11], consequently the threshold voltage should also be channel length dependent . In the range of 25nm down to 7nm, SiO_2 dielectric,The off-state current I_{off} at V_{GS}=0V is varying from : 2,0793 A/m to 472,048,18 A/m, is unacceptably high in the case of 7nm . Also in the same range When applying HfO_2, The off-state current I_{off} at V_{GS}=0V is varying from: 2,34 A/m to 76,1365 A/m, (respectively 25nm to 7nm). The HfO_2 I_{off} is much less than SiO_2 at 7 nm channel length.

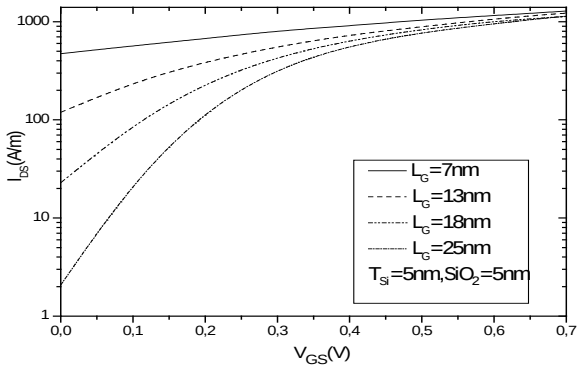

Fig.2 : I_{DS} versus V_{GS} characteristics of DGMOSFETs with SiO_2 gate dielectric and for 25 to 7nm gate length

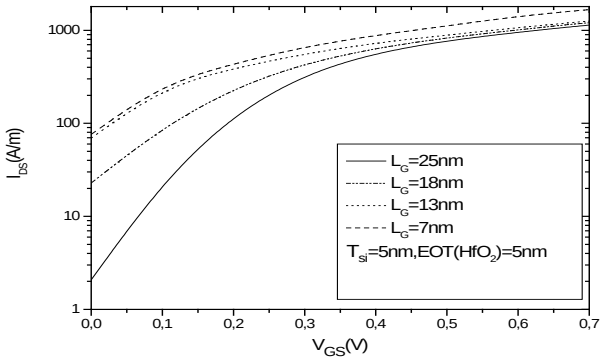

Fig.3 : I_{DS} versus V_{GS} characteristics of DGMOSFETs with HfO_2 gate dielectric and for 25 to 7nm gate length

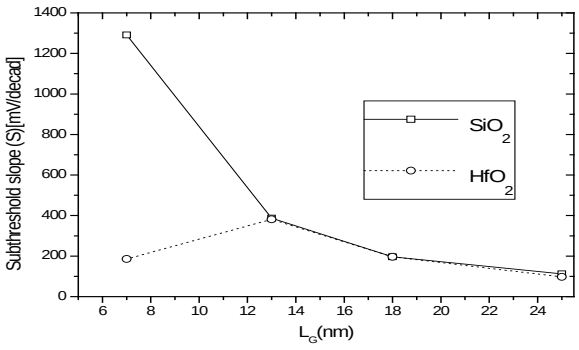

Fig. 4:Threshold voltage versus different channel lengths

In the Fig.4, we examine The effect of high permittivity on subthreshold slope for different channel lengths. The most significant effect is observed at L_g=7nm having S=1291mV/dec besides L_g=25nm which has S=112,3mV/dec while The HfO_2 subthreshold slope gets : S=97,3mV/dec to S=186mV/dec (respectively 25nm to 7nm).The HfO_2 dielectric subthreshold characteristics of SOI DGMOSFET are clearly better than SiO_2; remains far from ITRS recommendation as the subthreshold slope S should not be higher than 80mV/dec.

Fig.5 shows that the threshold voltage (V_{TH}) is proportional to channel length, the reduction of L_G decreases the threshold voltage, V_{TH} remains practically constant after 13nm channel length for SiO_2 and 18nm for HfO_2, that we can observe a V_{TH} shift (about 150mV for SiO2, and 90mV for HfO_2) which is due to quantum effects. In order to have better subthreshold slope and weak leakage current , at the EOT=1.5nm, device performances increase once again with HfO_2, while T_{Si}=5nm, The subthreshold slope is achieved as 114mV/dec, and is more better when T_{Si}=3nm, that it is equal to 90mV/dec, as schown in Fig.6.

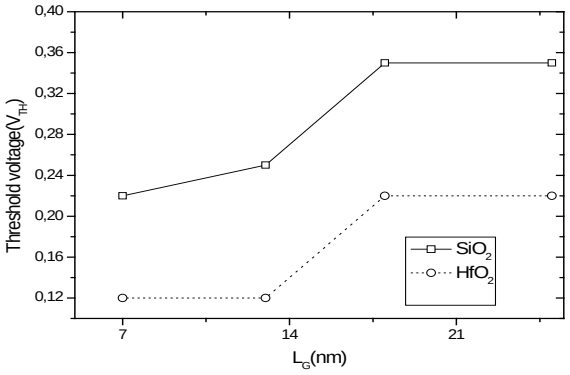

Fig.5 :Subthreshold voltage versus different channel lengths

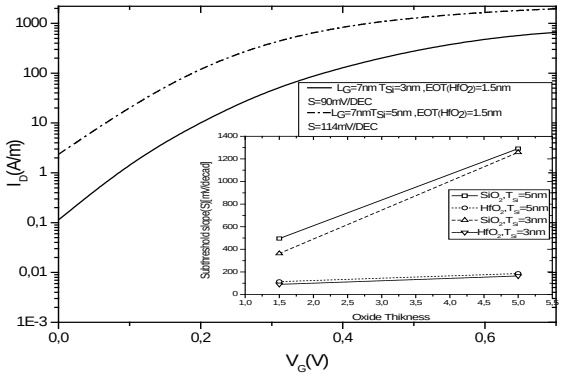

Fig.6: I_{DS} versus V_{GS} characteristics of DGMOSFETs with HfO_2 gate dielectric and 7nm gate length for T_{Si} =5nm and 3nm (in the inset : the subthreshold slope versuss oxide thikness for T_{Si} =5nm and 3nm)

An even higher ON-current can be obtained as be shown by The I_D-V_D characteristics of SOI-DGMOSFET at V_{GS}= V_{DS} = V_{DD} for the same length 7nm in Fig.7 . The I_{on} current at V_{DD}=0.7V is 3416,22 A/m in the HfO_2 is higher than SiO_2, which is equal to 3126,55 A/m.The I_{on} HfO_2 current is a bit less than ITRS recommendation [7].The transconductance g_m is improved as the permittivity increases :1958 S/m for the HfO_2 and 928 S/m for SiO_2.

The conduction band evolution along the DG in the centre of the body (y=T_{Si}/2) is plotted in Fig.8, Fig. 9 for different bias voltages The evolution of the barrier for V_{DS} varying between 50mV and 0.7V illustrates clearly the Drain induced barrier lowering (DIBL), appears to be weaken at T_{Si}=5nm that's varying from 0.01eV for T_{Si}=5nm and 0.06eV for T_{Si}=3nm (as shown in the nset). In the SiO_2 case (DIBL), the same for HfO_2 that's varying from 0.01eV for T_{Si}=5nm and 0.02eV for T_{Si}=3nm (as shown in the Inset). We can conclude that HfO_2 has a great impact on the reduction of DIBL.

The gate direct tunneling current becomes an increasingly important such when reducing T_{Si} at 1.5nm physical thickness, and becomes much higher when replacing SiO_2 with HfO_2 such with reduced width channel thus the gate current at V_{DS}=V_{DD}=0.7V,

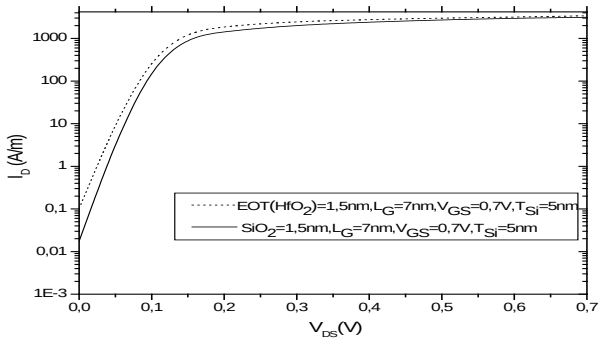

Fig.7: I_{DS} versus V_{DS} characteristics of DGMOSFETs with SiO_2 and HfO_2 gate dielectric and 7nm gate length

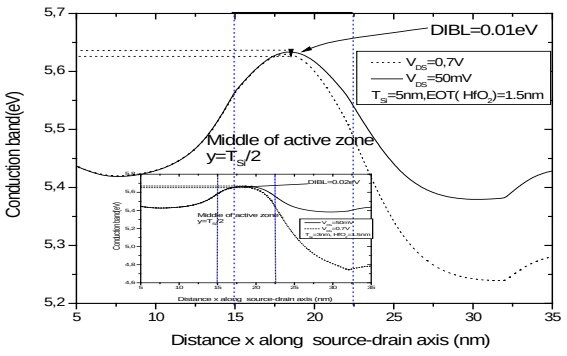

Fig.8: Conduction band of HfO_2 along the x-axis at y=T_{Si}/2(T_{Si}=5nm) and V_{GS}=0V.The inset: Conduction band of HfO_2 along the x-axis at y=T_{Si}/2(T_{Si}=3nm).

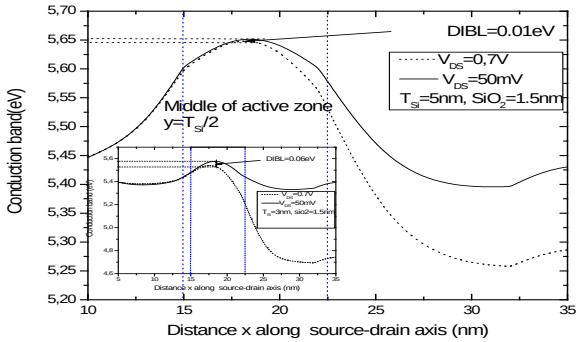

Fig.9: Conduction band of SiO_2 along the x-axis at y=T_{Si}/2 (T_{Si}=5nm) and V_{GS}=0V.The inset: Conduction band of SiO_2 along the x-axis at y=T_{Si}/2(T_{Si}=3nm)

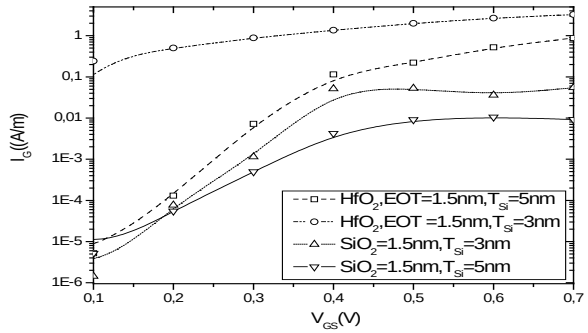

Fig.10 : Gate current versus gate voltage

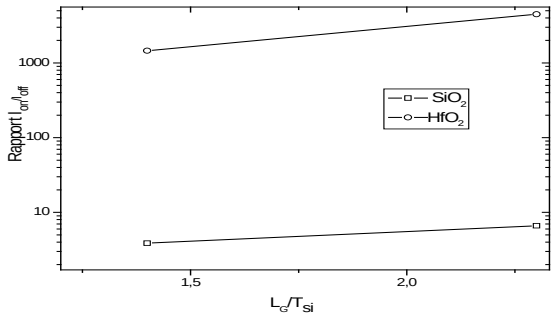

Fig.11: I_{on}/I_{off} ratio as a function of L_G/T_{SI}

is varied from 0,00921 at T_{Si}=5nm to 0,0545 A/m at T_{Si}=3nm for SiO_2 and from 0,87352 at T_{Si}=5nm to 3,25742 A/m T_{Si}=3nm for HfO_2 .The SiO_2 gate current has an negative impact on the transistor performance, Fig.10 illustrates clearly the orders of magnitude of this current. The high permittivity increases I_{on} and decreases I_{off}. More ever the I_{on}/ I_{off} ratios for HfO_2 dielectric are better than SiO_2 dielectric which is illustrated in (Fig. 11).The I_{on}/ I_{off} HfO_2 ratio reaches 4485 presents a challenge for scaling, which indicates that SOI-DGMOSFET with HfO_2 permittivity is a promising candidate to achieve better-than-ITRS low-standby-power switch performance. However SOI- DGMOSFET with SiO_2 permittivity would not have the best performance due to the I_{off} highly current[12].

V. CONCLUSION

The potential performance of DGMOSFET with high k dielectric gate (HfO_2) has been studied using nextnano simulator based on two-dimensional self consistent Poisson- Schrödinger model which takes into account the quantum mechanical effects are used with appropriates boundary conditions to explore the short channel effects and the influences of quantum effects as channel length varies in the range of 25nm down to 7nm. The evolution of charecteristics such as DIBL, subthreshold slope, threshold voltage, leakage current are analysed according of reducing silicon film thickness and high dielectric constant . HfO_2 dielectric with gate length of 7nm and the 3nm width of channel, maximizing the ratio of I_{on}/ I_{off} to 4485. We have demonstrated that Mosfet with HfO_2 dielectric have an excellent scaling potential and are good candidates for high performance, low power digital application for the 18nm technology generation.The performance of the studied devices steadily increases with the scaling in respect to gate lengths.

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Performance of Controllable Triangular Split Structure Metamaterial

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Abstract **– *Metamaterials are artificial period ic structures, which provide the possibility of changing the overall properties of a material by simply adjusting the metallization geometry or properties of the substrate. The response of conventional materials to electromagnetic fields is determined by their constituent molecules. In contrast metamaterials owe their properties to much larger units, though still less than the wavelength of radiation. These artificial inhomogeneous materials are tailored for specific applications and exhibit unusual behavior. In this paper, we propose and introduce a novel structure designed as Triangular Split Structure (TSS), which exhibits metamaterial characteristics. The aim of this paper is to investigate the performance of Triangular metamaterial structure by bringing the variation in geometrical parameters of the proposed structure. The structure exhibits good phase reversal characteristics in the desired band of 13.5 to 15.5 GHz resonating at 14.4 GHz alonwith the negative permeability. A verification of the left handedness and performance analysis is presented by simulations using electromagnetic simulator FEKO.***

Keywords: ***Left-Hand Materials (LHM); Metamaterial (MTM); Negative Index Material (NIM); Triangular Split Structure (TSS).***

I. INTRODUCTION

Split Rings Resonators (SRRs) have opened the door to new design strategies, where miniaturization and compatibility in planar circuit technology are key aspects. Originally proposed by Pendry [1], the concept was first conceptualized experimentally by Smith et al. [2]. Only in the last few years Negative Index Material (NIM) has been realized in practice by the combination of metallic wires and rings assembled in a periodic structure [3]. The rings are referred to as Split Ring Resonator (SRR), because of which the material exhibit negative permeability (μ) and wires produce the effect of negative permittivity(ε) in the overlapping range. Such periodic arrangement has the property of showing negative ε and μ in the frequency band of the interest and thus a negative index of refraction. Although all known naturally occurring materials exhibit positive indices of refraction and obey Maxwell equation and all fundamental laws of physics, the possibility of materials with negative refractive index also do not violate any fundamental laws. The method of forming a metamaterial is convenient from the standpoint of design and analysis, because a complete numerical solution of Maxwell's equations, the field and current equations modeling the wave propagation in a Metamaterial medium can be obtained from consideration of one unit cell of a periodic structure [4]. The direction of energy flow, given by E x H, is reversed with respect to the direction of propagation giving the name Left-Hand Materials (LHM).

Due to the difficulty in fabricating the Left handed metamaterials with the recent structures, consisting a combination of split-ring resonator and metal wire [3, 5] in high frequency regime, new planar structure designs were pioneered for achieving the LH property. Planar metamaterials are well suited for most applications in terms of feasibilities of design and fabrication [6]. They are also advantageous in easy excitation and easy matching with conventional planar

circuits[7] . Paper is divide into four sections, Section 2 highlights the design parameters of the proposed structure, exhibiting the metamaterial charactersitics. Section 3 deals with the results obtained by bringing the varaitions in the physical parameters of the structure and its effect on the structure performance. Finally, section 4 gives the conclusion and comparison table.

II. DESIGN OF TRIANGULAR SPLIT STRUCTURE

The design of MTM based on shape and geometry is the most challenging work especially, the design of split rings to construct a new type of MTMs [8]. Numerous types of different ring and ring like structures such as circular, square, U-shaped, S-shaped and others are used to create new MTMs. In the light of the known structures, we decided to design a new structure, triangular in shape having offset inclusions reported in Fig.1. The split-triangular resonator has a split in its triangle, which causes the structure to resonant at much higher frequencies than a closed triangle of the same size. Although the current in the triangle of a configuration does not find a closed path due to the split, the current will still flow due to the strong capacitance between the two concentric triangles [9] giving the desired capacitive effect.

Since in the split ring structures the capacitive and inductive effects nullify, the μeff has a resonant form. This happens due to the resonant interaction of the inherent inductance of the structure and the capacitive effect due to the gap and, hence at resonant frequency, electromagnetic energy is shared between the magnetic field and the electrostatic fields within the capacitive structure. Hence the effective permeability is negative only in a certain frequency band which is around and above the resonance frequency, in general.

A. *Geometry of the Structure*

The cellule is printed on a thin dielectric substrate, RT Duriod 5880 with thickness of 0.787 mm, permittivity of 2.2 and loss tangent 0.0004.The triangle is equilateral with side length of outer triangle as 20.078mm, and inner triangle has length of 16.46mm.It is fed at 4.5 mm from centre with a gap of 2mm. The width of each side of the triangle is 2mm and the spacing between them is 2 mm. The structure is offset fed and is simulated using commercial software simulation package and depicted in Fig. 1.

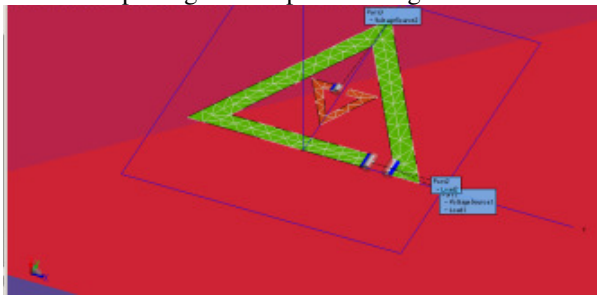

Fig. 1 Triangular Spilt Structure

B. *Basic Metamaterial characteristics*

To check the feasibility of the structure behaving as a metamaterial , the effective s-parameters, transmission and reflection coefficients are retrieved [10] alongwith their amplitudes and phases. Fig. 2 depicts the magnitude of reflection coefficient (return loss) S_{11} of -13.4 dB at 14.4GHz and-28.8dB at around 18.2GHz. The phase of S_{11} and S_{21} coefficient show abrupt phase changes of 180 degrees at the given frequency. The dip in the phase of S_{21} indicates the presence of negative region observed around14.4 GHz [11]. The structure exhibits good phase reversal characteristics in the band of 13.5 to 15.5 GHz resonating at 14.4 GHz

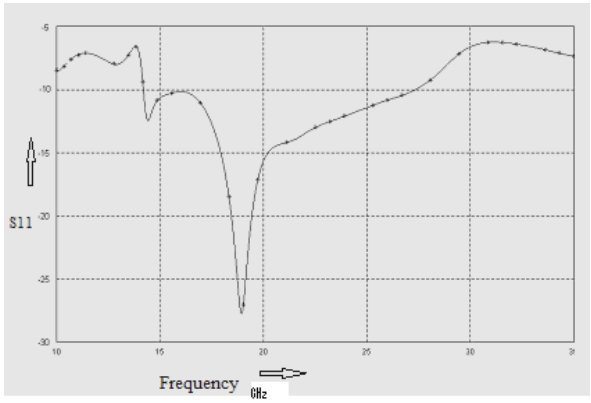

Fig. 2 Return loss S_{11} -13.4 dB at 14.4 GHz

III. ANGULAR VARIATIONS OF SPLIT

Our study focuses on the effects brought about by changing the position of split in the outer triangle of the structure. TSS with the same structure parameters but different angles between the two splits is simulated and analyzed in terms of scattering parameters, to verify the controllability of its resonant frequency. Fig. 3 shows the angular variations, angle 1 shows the positive angle between the centre of inner triangle and split in the outer triangle and angle 2 represents the negative angle between them. The structure is simulated for all the variations of angles, 25, 29, 33 and 37 degree in the negative direction that is, moving left from the centre and 25, 29, 33 and 37 degrees in the positive direction, moving right from the centre split.

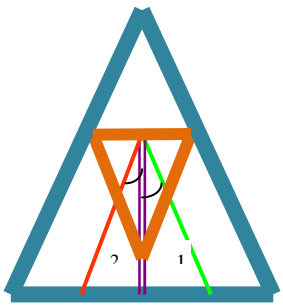

Fig. 3 Angle1 shows the positive angle between the centre of inner triangle and split in the outer triangle and angle 2 represents the negative angle between them.

A. Simulated Results of structures with varying angle

The LH pass band frequency (i.e. the negative refractive index regime) is essentially determined by the ω_m of periodic SRR structures [12]. The change of ω_m can be brought with the change in geometrical parameters, that is, the split width, gap between inner and outer rings, metal width, feeding points and additional capacitances. Fig. 4(a) to 4(c) shows the results of transmission and reflection coefficients magnitude and phases for the structure which has angular separation of 33 degree in the left hand side. Fig. 5(a), 5(b) shows the results for positive 37 degree variation. The red color line indicates S_{11} parameter and blue color line indicates S_{21} parameter for magnitude and phase

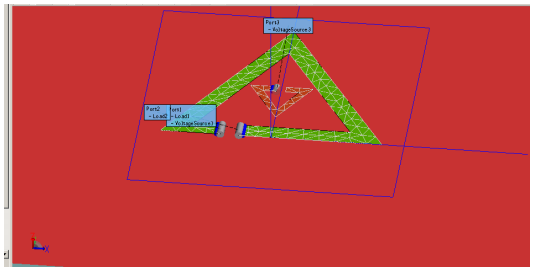

Fig. 4(a) Triangular Structure with negative variation

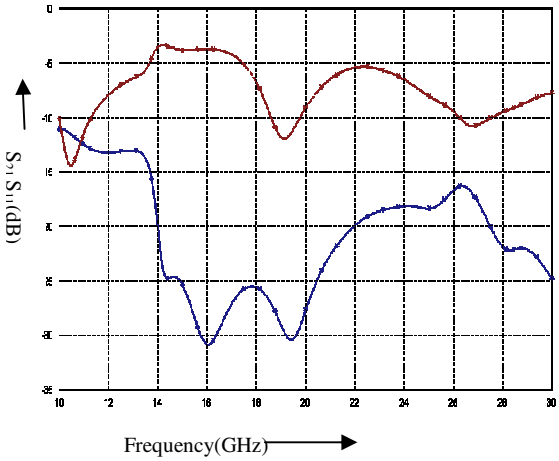

Fig. 4(b) S_{11} and S_{21} magnitude of negative 33 degree variation.

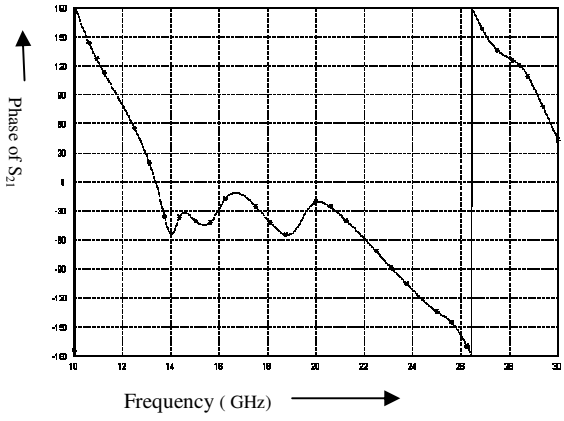

Fig .4(c) S_{21} phase of negative 33-degree angular variation

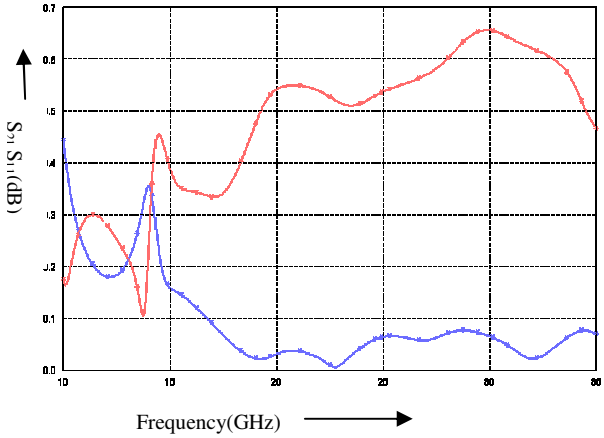

Fig. 5(a) S_{11} and S_{21} magnitude of positive 37 degree variation.

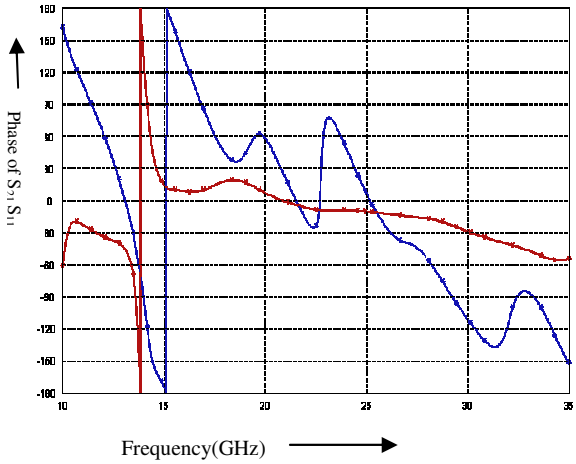

Fig. 5(b) S_{11} and S_{21} phase of positive37 degree variation

B . Comparison of various parameters

Authors have simulated the structure by bringing the variation in the split in the outer triangle, and checked for various s-paramters, resonant frequency and negative permeability. Due to space constraint the simulated results and their respective graphs are depicted only for two structures, one with positive variation and one with negative variation.The results for all the variations are consolidated in the Table 1.

The resonant frequency of the TSS varies as the split from the center shifts towards the end of the outer triangle base. In the positive angular variation, increasing the angle between the inner triangle and outer triangle split increases the resonance frequency as shown in Fig. 6, accounting to decrease in the capacitance of the system [13]. Because of the unsymmetrical orientation of the rings, the mutual capacitance between the inner and outer rings is very small, and the induced charges along both the rings have the same sign and similar magnitude[14].

TABLE 1. Consolidated results for varying angle

Angle (Negative variation)	Resonating Frequency (GHz)	Angle (Positive Variation)	Resonating Frequency (GHz)
37^0	**10.11**	37^0	**14.4**
33^0	**10.46**	33^0	**13.7**
29^0	**26.2**	29^0	**10.14**
25^0	**22.3**	25^0	**5.5**

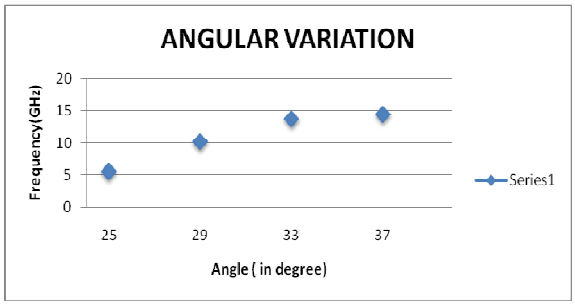

Fig. 6 Change in Resonance frequency with the change in the angular variation in TSS

IV. CONCLUSION

This paper lays stress on controlling the resonance frequency by bringing the variation in the physical parameters of the metamaterial structure. The design of a planar metamaterial in microwave regime, has triangular shape. With the variation in geometrical parameters and design it is possible to change the resonance frequency of TSS structures, and therefore the LH or negative refractive index region of LHMs[15]. Since the frequency ranges where TSS structures possess negative values of permeability are not broad, one may need to tune the magnetic resonance frequency of TSSs in order to obtain LHMs working at desired frequencies. The structure is showing real part of permeability negative and imaginary part as positive which is around 14.8 GHz which is in compliance with the metamaterial properties.

The work done in this direction is of practical application in designing controllable magnetic metamaterials and NIMs. Our novel MTMs open up new arena providing novel ways to design, characterize, and manufacture MTMs in the microwave, millimeter wave, and optical frequency regions. All these structures can be used to construct modified functional devices[16].Once the controllability has been achieved, and verified by the simulation results, the key issue is practical implementation. A tentative implementation approach is to realize the controllability by means of MEMEs switches.

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Analysis Variation of Drying Parameters of Corn Seeds Processed in Microwave Field. Thermal Field Analysis

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***Abstract*: The present research has the objective to analyze the drying characteristics of the corn seeds in the microwave field. During the experiment is being followed the germination of the seeds and the distribution of temperature in the dielectric.**
***Keywords*: corn, microwave energy, dielectric properties, thermal distribution**

I. INTRODUCTION

The development of microwave industrial applications started around 1930s. The most important first applications were for potato chips, pre-cooking of poultry and bacon, tempering of frozen food and drying of pasta [1].

The process of drying food materials was studied by Hall in 1963, Fanslow and Saul in 1971, Bhartia et.al. in 1973 and Shivhare et.al. in 1991 [2].

The use of drying grains in the microwave field has become nowadays very important due to the necessity of reducing field losses, time needed to prepare for the next crop and better utilization [3].

II. MATERIAL AND METHODS

The purpose of drying seeds in the microwave field is to reduce the humidity of grains for a better storage. When drying grains there has to be taken into consideration the quality parameters, that could be affected during the heating process.

The achievement of the drying process of grains consists in an apropriate level of humidity, for a better storage, a high percetage of the germination and a good quality of the grains. So the next step after treating the seeds in the microwave field is studying the germination rate, which is than compared with the rate of the witness sample.

At the end of the treating process of the seeds in the microwave field the germination of the seeds was done using germinators of type Linhard [4]. Due to the fact that there were no fresh harvested seeds, the dielectric was pre wetted [5].

The stand within the Laboratory of Microwave Technologies from Faculty of Electrical Engineering and Information Technology, University of Oradea was used to determine the influence that microwave power has on the granular material.

The microwave installation is designed so that the microwave power, the generated power can be controlled, and the reflected and absorbed power are being measured continuosly.

By controlling the direct and reflected power of the microwaves, we can monitore the way that the seeds are absorbing the microwave power.

By measuring the output air humidity we can study the influence that microwaves without or with air stream has on the humidity of the seeds. When using the air stream is being noticed that the humidity content of the dielectric material decreases significantly, without affecting the structure of the seeds.

We monitored the drying parameters of the seeds every 30 seconds.

The relation given below between the initial mass of the seeds , m_i, and the final weight of the material m_u results in the humidity of the dielectric [6] :

$$U\,[\text{Humidity}] = \frac{m_i - m_u}{m_u} \times 100[\%] \qquad (1)$$

As mentioned before our study followed every 30 seconds the absorbed and reflected power of the microwaves, the temperature measured in the seed bed the temperature and humidity at the applicator exit, the content of humidity evaporated from the dielectric material.

As a conclusion of the experiment the rate of germination was calculated and compared with the witness percentage in order to point out the achievement or not of the study.

There was also measured the initial and final humidity of the seeds, using multigrain handheld

moisture tester (mini Grain Analysis Computers), Dickey-John Corporation.

During our research we used corn seeds, type Kornelius KWS, that were dried using:

1. 0.1W/g/ 10 minutes without air stream;
2. 0.1W/g/ 10 minutes with cold air stream;
3. 0.1W/g/ 10 minutes with hot air stream.

1. For the first sample we used an initial mass of seeds of 100 g, after the process of drying we obtained 96g of dried grains. The initial humidity of the seeds, is U_{init}=20.6% and the final humidity, U_{fin}=16%. The humidity eliminated from the seed bed is U=4.16%.

During the heating process, the variation of the direct power was constant, with no significant changes, as it is shown in fig. 1. The output air humidity had a significant growth in minute 3.5, from 68.4% to 90.8%, but than it was kept at constant variations (see Fig.2).

The temperature measured in the seed bed riched a high value of 90.2^{0}C, in minute 4, as we can see in fig.4, but than got stabilized and had a constant increased till the end of the drying process.

During our testing the output air temperature had a constant variation (see fig.3). The germination of the seeds, after drying was G=97%, a good percentage, the witness sample having the germination rate of 95%.

This sample is a succesful one, because of the rate of germination and also the final humidity of the seeds, U_{fin}=16%, a value apropriate for a better storage.

2. For the next experiment we used the same constant power of the microwaves, 0.1W/g with cold air stream, and we observed the variation of the drying parameters. After 10 minutes of drying, the final mass of the seeds was 97 g of dried grains, the humidity eliminated from the seed bed being U=3.09%.

The initial humidity of the seeds, measured before drying was U_{init}=23.4% and after the drying process it was U_{fin}=17.3%. The value of the final humidity is not apropriate for a good percentage, it should be lower, like in the previous case.

The variation of the direct power showed higher values only in minute 2 and 6, but than kept stabilized (see fig.1).

The reflected power for all samples was kept constant at the value of 0W. The output air humidity decreased during the process of drying from 58% to 18.7%, as it is shown in fig.2.

The output air temperature had a constant increased, with no significant changes, from 20.1^{0}C to 43.9^{0}C and the seed bed temperature had also a constant growth from 22^{0}C to 74.4^{0}C (see fig.3 and 4).

The germination percentage is better than on the previous sample, is G=98%. This high value is the response to the constant variation of the drying parameters that didn't affect the structure of the seeds during the drying process.

3. The final sample was dried using the same power of the microwaves but with hot air stream and so we expect to have a lower final mass of the seeds.

After we finished the drying process, the final mass of the seeds was 95g, the humidity eliminated from the seed bed being : U=5.26%.

The initial humidity of the grains was U_{init}=20.4% and the final humidity, U_{fin}=15%, which represents a good value of the humidity for an optimum storage.

The variation of the direct power was constant, only in minute 7 presented increasing, but was kept constant until the end of the experiment (see fig.1).

As we may see in fig.2, the output air humidity had a constant decreased, from 31.4% to 13.1%, the same situation was for the output air temperature and the temperature measured in the seed bed, having a constant growth, with no important changes (see fig.3 and 4).

The germination percentage is sample is G=88%.

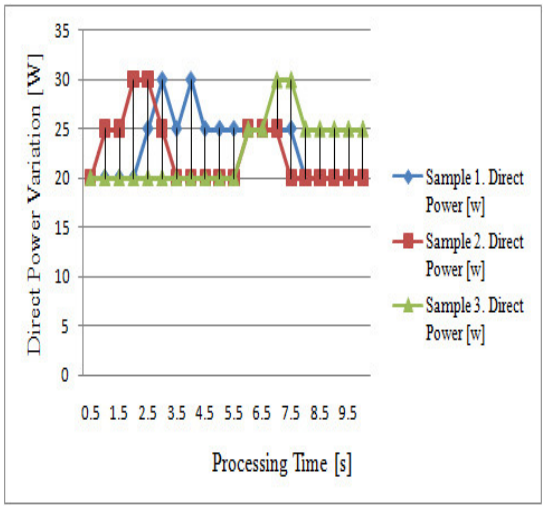

Fig.1 Direct Power Variation

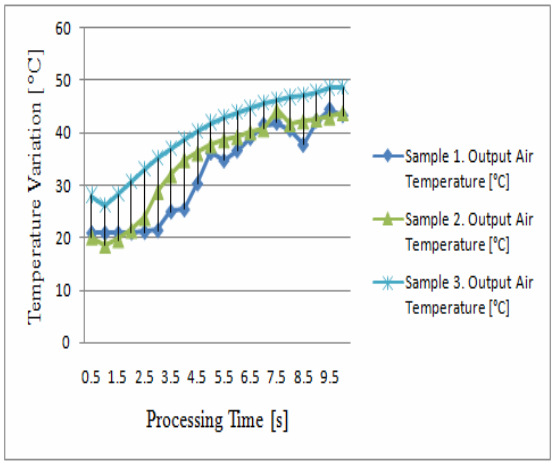

Fig.3. Temperature Variation

III. THERMAL FIELD ANALYSIS

The dielectric properties of materials are very important in undestanding the interaction of microwave energy with those materials [7].

These parameters are dielectric constant (ε'), and the dielectric loss factor (ε''), that are a part of the next relation:

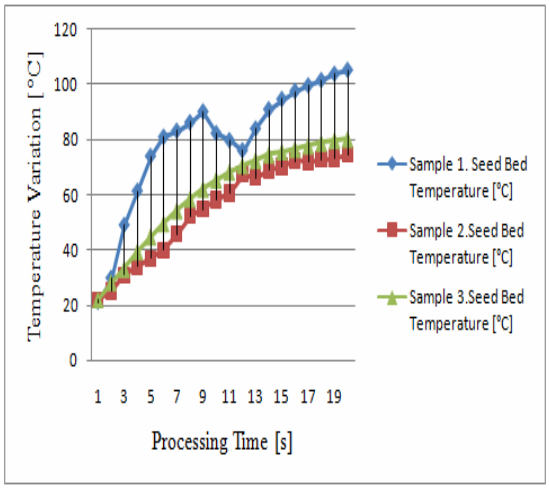

Fig.4. Temperature Variation

$$\underline{\varepsilon} = \varepsilon' - j\varepsilon'' \quad (2)$$

where $\underline{\varepsilon}$ represents the complex permittivity.

The relation between the dielectric loss factor and the dielectric constant is the loss tangent:

$$\tan\delta = \frac{\varepsilon''}{\varepsilon'} \quad (3)$$

The dielectric constant, ε', determines the energy absorbed by the dielectric material, whereas the loss tangent $\tan\delta$ is the ability of the dielectric material to convert the absorbed energy into heat [8].

The penetration depth of the microwave energy depends on the dielectric properties of the material and it is being defined as the depth in the material where the microwave energy is 1/e (e=2.71) or 36.8% of its transmitted value [9] :

$$d_p = \frac{\lambda_0 \sqrt{\varepsilon'}}{2\pi\varepsilon''} \quad (4)$$

where λ_0 represents the free space microwave wavelength.

Figure 5 presents the thermal field distribution over the seed bed for the witness sample.

Figure 6 presents the thermal field distribution on the seed bed surface at the end of the drying process for sample 1, using a constant power of the microwaves of 0.1W/g without air stream.

Figure 7 presents the thermal field distribution on the seed bed surface at the end of the drying for sample 2.

Figure 8 presents the thermal field distribution on the seed bed surface at the end of the drying for sample 3.

III. CONCLUSIONS

Analyzing the results obtained during the drying process of the seeds, an important conclusion was brought out: the temperature ditribution in the material has to be uniform, without any hot spots that could harm the structure of the seeds.

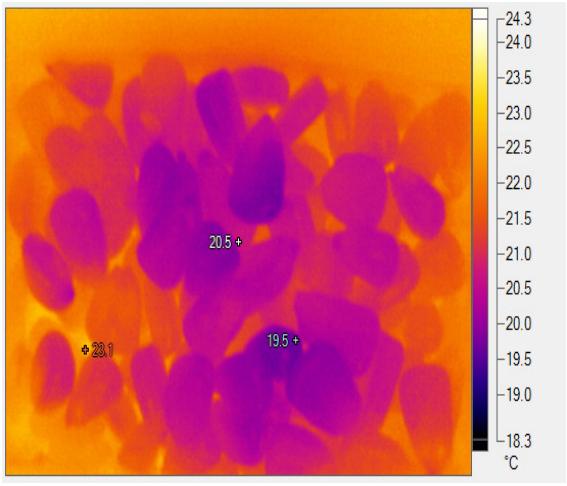

Fig. 5 Thermal Field Distribution

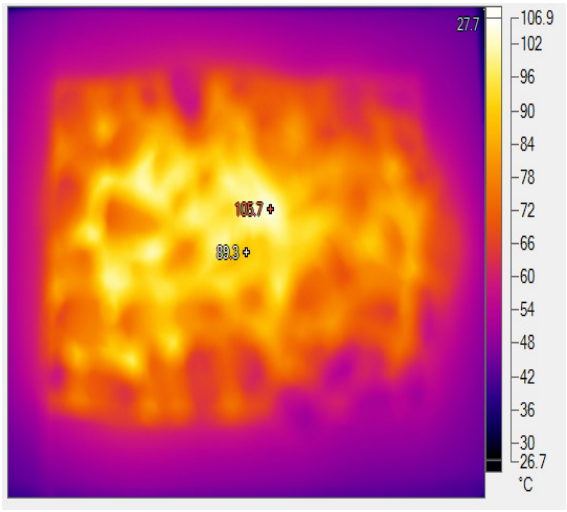

Fig.6 Thermal Field Distribution

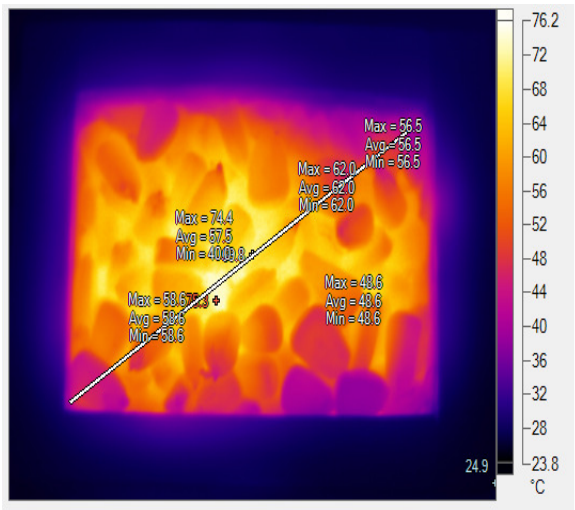

Fig. 7 Thermal Field Distribution

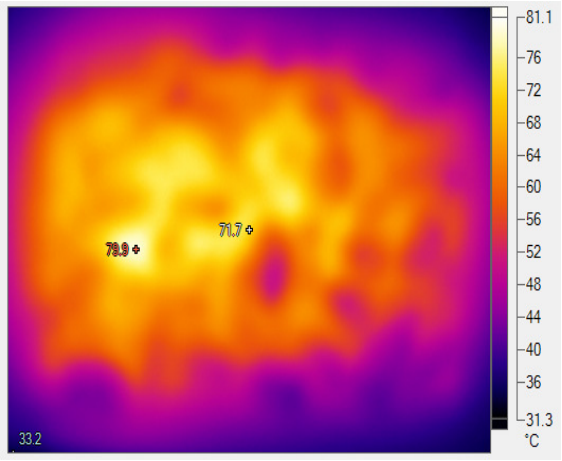

Fig. 8 Thermal Field Distribution

From the results obtained during our research we could say that it is important to use air stream, so there is an optimum distribution of the temperature in the mass of the seeds, to avoid the hot spots, like in the case of the first sample. Using cold air stream lead us to a good rate of germination and a good percentage of the humdity eliminated from the seed bed.

In our future research we will center on finding out the best value of the power to dry grains and to achieve a good rate of germination and also a high percentage of the humidity eliminated from the seed bed, for optimum conditions of storage.

The images taken with the Thermographic Camera show us the neomogenous distribution of the temperature in the seed bed, in some areas the values are greater than in other, that leads to high temperature areas that can destroy the seeds and the rate of germination.

ACKNOWLEDGEMENTS

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Aspects of Numerical Modeling of the Induction Heating Process of Non-Ferromagnetic Parts

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***Abstract* – The paper presents the numerical modeling of the volume induction heating process for non-ferromagnetic semi-products with rectangular (or cylindrical) cross-section. We analyze the couplet electromagnetic and thermal phenomena (variation of temperature, frequency, power consumption, etc.). Numerical modeling can offer precise information about several interdependent linear and non-linear parameters that can influence the transient and final thermal conditions of the semi-product, and how to optimize the design of induction heating systems in order to grow the efficiency of the heating process and to obtain the wanted temperature profile.**

***Keywords:* process; induction heating; numerical modeling; frequency.**

I. INTRODUCTION

Computer added numerical modeling is an important factor in the design of induction heating systems, [6]. Induction heating is a complex combination of electromagnetic phenomena, heat transfer that involve many elements and parameters. The electromagnetic phenomena and the heat transfer are non-linear and coupled due to the fact that the physical properties of the heated materials largely depend on temperature and the intensity of the magnetic field, [2].

Specialists in the field of induction heating use numerical methods for modeling and simulation which apply the finite elements method, the finite difference method, the edge elements method, the finite volume method and also combinations of these methods, [1]. Each of these techniques have advantages and disadvantages, and can be used alone or in combination with other methods. There is no universal computation method that is best fit for all types of applications.

The finite elements method (FEM) became the favorite method for numerical modeling of many engineering applications, very efficient, but it's not an ideal method for all induction heating applications. In many cases a combination of several methods is more efficient.

The finite difference method (FDM) can be used when the modeled domain has a simple geometry, like cylindrical or rectangular, [7]. The mesh divides the domain in a finite number of nodes. FDM is not a suitable method to simulate inductive heating systems that have a complex boundary configuration. In this case FEM has a great advantage over FDM. The computation of the electromagnetic field in the external domain of the geometry (air) is a disadvantage for both methods.

Another method is the boundary elements method (BEM), it takes into account only the boundaries of the electrically conductive parts of the induction system. This simplifies one of the major time consuming steps in the setup of a numerical modeling comparing to FEM and FDM and greatly reduces the computation time.

II. GENERAL ASPECTS

The singularity of induction heating is the heat generation inside the piece. When applying an alternative magnetic field on a conductor, eddy currents are induced in the conductor. The eddy currents tend to cancel the magnetic field inside the conductor, thus raising the actual resistance of the conductor to the current flux and the magnetic field penetration. This is materialized in the skin effect, which plays a major role in the induction heating systems, [8]. The eddy currents can also be induced into a conductor when it moves in the presence of a stationary magnetic field. The Maxwell equation of the magnetic field inside the conducting material can be written:

$$rot\,\bar{E} = -\frac{\partial \bar{B}}{\partial t} + rot(\bar{v} \times \bar{B})$$

where:
E is the intensity of the electric field;
B is the magnetic flux density;
v is the velocity of the conductor.

The mathematical model is based on the Maxwell equations that describe the electromagnetic field and for the thermal part we use the Fourier equation. The methods to obtain the solutions for the electromagnetic phenomenon analysis depend on the way that the

Maxwell equation is solved for a certain domain/region, taking into account the geometry, material properties and boundary conditions. According to the mathematical theory of the field, the magnetic flux density can be described using the specific terms of the magnetic potential vector: A as $\overline{B} = rot\,\overline{A}$ and $div\,\overline{A} = 0$. The boundary conditions for that certain region are chosen so that the gradient of the magnetic potential vector can be neglected along the boundary in comparison with its value in other parts of the region (Neumann condition $\partial A/\partial n$). The volume density of the Joule heat generated by the eddy currents is obtained by solving the electromagnetic field problem. The thermal field is formed by overlapping several effects: equalization of temperature through thermal conduction, distribution of Joule heat losses and heat losses at the surface of the piece. Generally, the transitive process of heat transfer into the piece can be described by the Fourier equation:

$$\gamma C \frac{\partial T}{\partial t} = \mathrm{div}(\lambda\ \mathrm{grad T}) = \mathrm{p}$$

where:

T is the temperature;

γC is the specific heat;

λ is the thermal conductivity;

p is the volume density of the Joule heat losses.

The boundary conditions can be written like this:

$$-\lambda \frac{\partial T}{\partial n} = \alpha(T_s - T_m) + \varepsilon(T_s^4 - T_m^4)$$

where:

$\partial T/\partial n$ is the temperature gradient on the direction normal to the surface,

α is the heat transfer coefficient on the convective surface;

ε is the radiation heat loss coefficient;

T_s is the surface temperature;

T_m is the environment temperature;

n is the vector normal to the boundary surface.

III. PROPOSED PROBLEM. RESULTS

The material properties largely depend on temperature. This dependence has to be taken into account when analyzing the coupled electromagnetic and thermal fields, [4]. The Joule heat, generated by the magnetic field, starts the temperature increase inside the piece. However, the thermal process generates the temperature distribution inside the piece through thermal conduction in the material and heat losses at the surface. Both thermo-physical properties and the heat losses also depend on the temperature. The coupled solving of the electromagnetic and thermal problems can be done using iterative loops. The Joule heat obtained from the analysis of the electromagnetic phenomenon is used for the thermal computation, [3, 5], and the thermal distribution thus obtained is used to correct the specific resistance of the material for the electromagnetic analysis in the next iteration. The non-linear behavior of the simulated system implies the use of a coupled model based on numerical modeling techniques.

Non-ferromagnetic semi-products (aluminum), with 23 mm diameter and L_p = 270 mm length, are heated in order to be processed at a temperature of 550-560 ^{0}C, and for the extrusion process to a temperature of 500 ^{0}C, figure 1.

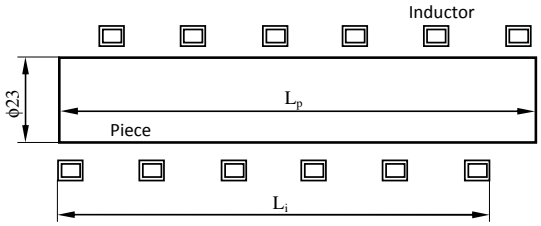

Figure 1. The geometry of the inductor-piece system.

It is very important that during the extrusion process the temperature distribution along the piece and in the profile section has to be constant. Using numerical modeling we can determine the constructive and power source parameters of the copper inductor in order to obtain the desired results. In the figures that follow we present the results obtained by numerical modeling of three cases where we used different types of inductors and different numbers of windings. For each case, the frequency varies until we reach the desired objective of heating the piece to a temperature fit for further processing (stamping, forging).

In case I, the inductor is powered with a current of 1000A and has an interior diameter of 30 mm, length L_i = 280 mm, and it's made out of a round pipe with the external diameter of 14 mm, with wall thickness of 1,5 mm, with 20 windings and a source frequency that can be chosen anywhere between 500 and 8500 Hz.

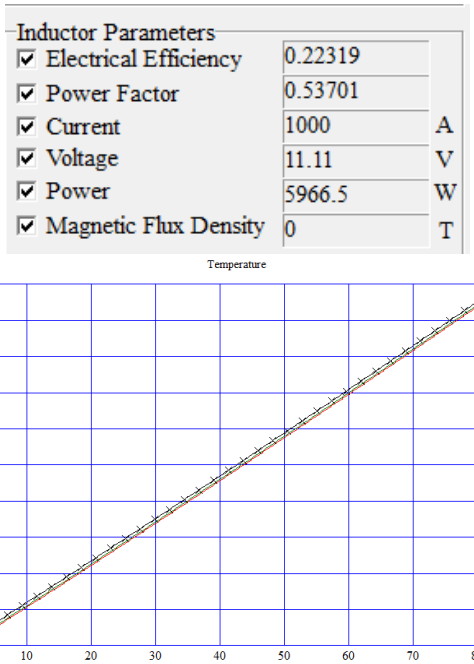

Figure 2. Inductor parameters and temperature variation for a frequency of 500 Hz.

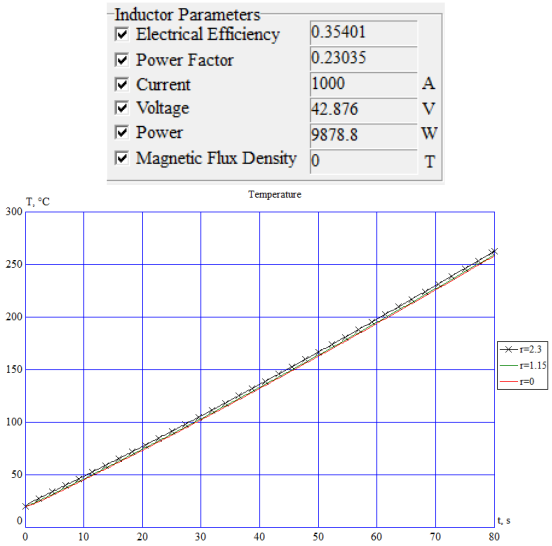

Figure 3. Inductor parameters and temperature variation for a frequency of 2500 Hz.

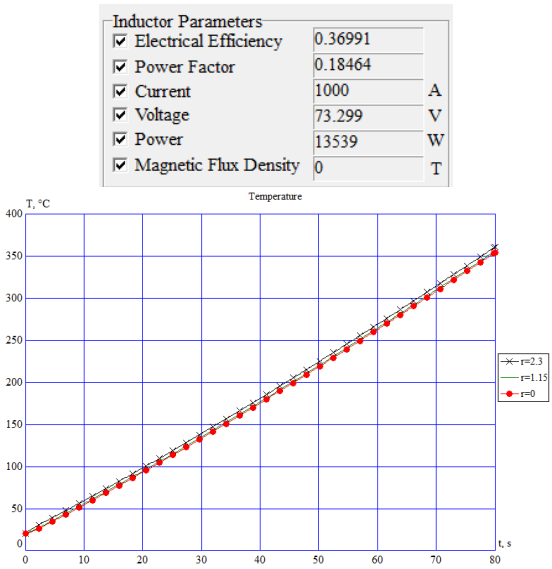

Figure 4. Inductor parameters and temperature variation for a frequency of 4500 Hz.

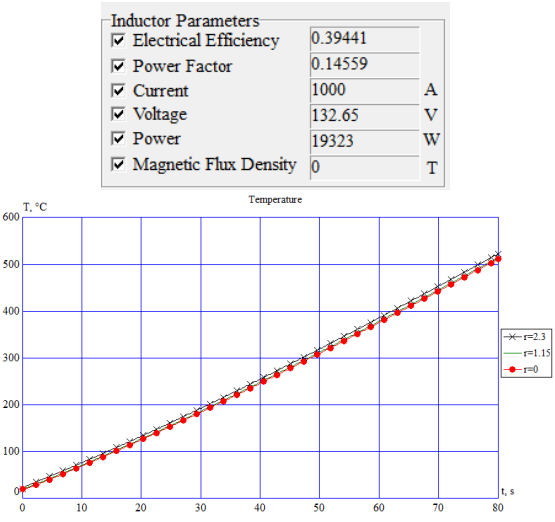

Figure 5. Inductor parameters and temperature variation for a frequency of 8500Hz.

Analyzing the obtained results for this type of inductor we notice that for a frequency ranging between 500 and 4500 Hz the temperature of the piece does not reach the value of 550 ^{o}C (at t=80 sec.), only for a frequency f=8500Hz / t = 80 sec. the temperature reaches the value T=530 ^{o}C. In this case the value of the consumed power oscillates between P_c = 5,99 and 19,32 KW, due to some technological constraints the use of this type of inductor for volume heating of aluminum semi-products is not recommended.

In case II, the inductor is powered with a current of 1000A and has an interior diameter of 30 mm, length L_i = 280 mm, and it's made out of a rectangular pipe of 5x15 mm, with wall thickness of 1,0 mm, with 35 windings and a source frequency that can be chosen anywhere between 500 and 4500 Hz.

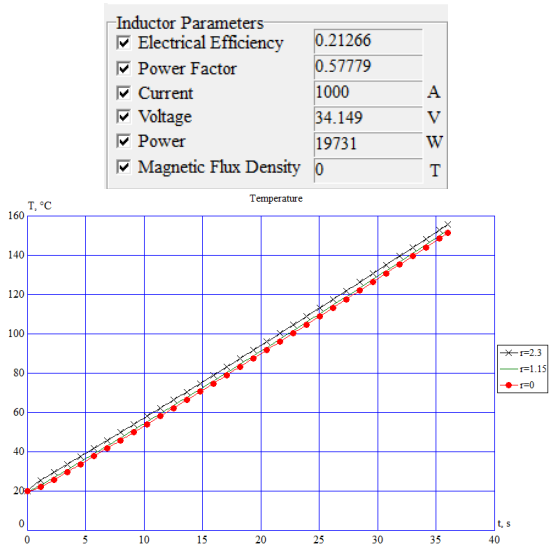

Figure 6. Inductor parameters and temperature variation for a frequency of 500Hz.

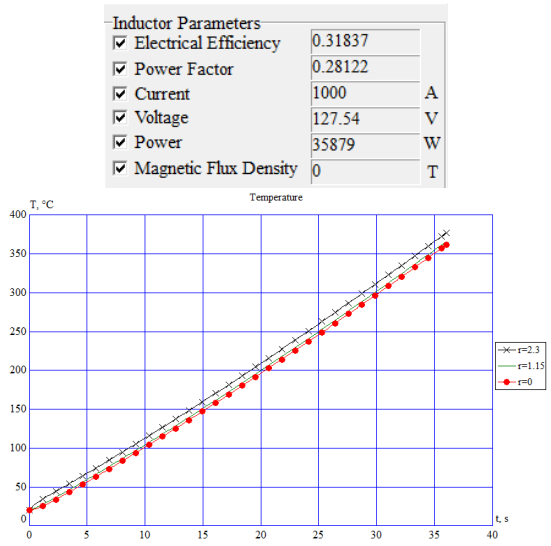

Figure 7. Inductor parameters and temperature variation for a frequency of 2500 Hz.

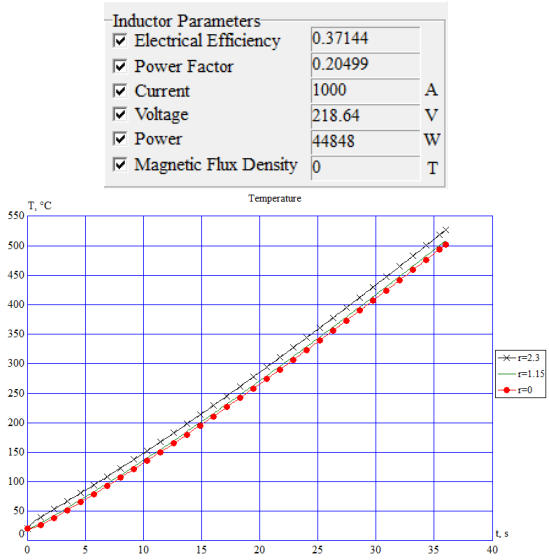

Figure 8. Inductor parameters and temperature variation for a frequency of 4500 Hz.

The results presented for this type of inductor underline the fact that for a frequency f=4500 HZ we reach the desired temperature for further processing inside the 80 sec. time frame. In this case, the value of the consumed power varies between P_c= 19,73 and 44,85 KW. This solution is not economical because of the high value of the power consumption although the heating time is half in comparison with the first case.

In case III, the inductor is powered with a current of 700A and has an interior diameter of 30 mm, length L_i = 280 mm, and it's made out of a rectangular pipe of 5x15 mm, with wall thickness of 1,0 mm, with 35 windings and a source frequency that can be chosen anywhere between 500 and 4500 Hz.

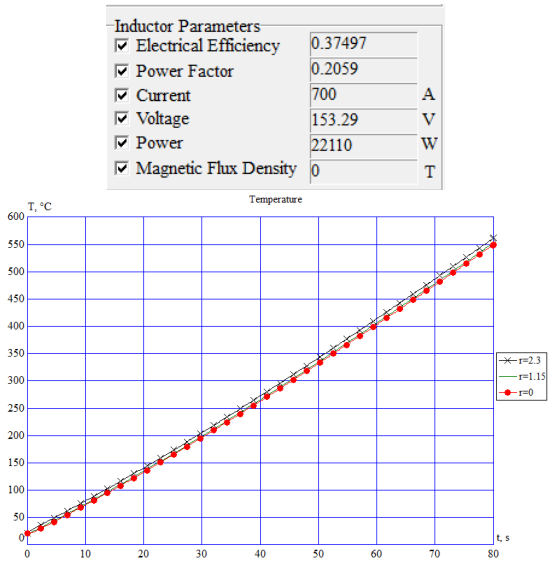

Figure 9. Inductor parameters and temperature variation for a frequency of 4500Hz.

The third constructive solution for the inductor is one of the most favorable ones that reach the desired parameters for further heat processing of the aluminum semi-product: f=4500 HZ, P_c=22,1 KW and t=80 sec.

IV. CONCLUSIONS

Numerical modeling is a modern tool for simulation and control of certain real electro-thermal processes in a short time-frame, with minimal resources and results that offer the designer a preliminary image of the equipment he is designing. From the analysis of the obtained results, we draw the following conclusions:

- By increasing the frequency, in the same time-frame, the final temperature of the piece is higher (at the same time the consumed power grows too);
- By increasing the number of windings (using rectangular cross-section pipes) we obtain a better heating. Thus, we can reduce the heating time (in case II we both the time and the frequency to half and we obtained the same thermal effect) or we can reduce the power source current by a third and the frequency to half (case III).

Due to the possibility of optimization of certain parameters according to the necessities of the technological process, the designer can chose the most economical solution.

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Morphologically Motivated Language Modeling for Slovak Continuous Speech Recognition

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Abstract* – Slovak language belongs to a group of the highly inflective languages, which are characterized by a relatively free order of words in sentences, rich morphology, growing vocabulary and insufficient text data resources. In large vocabulary continuous speech recognition and language modeling using n-grams, this phenomenon forms the problem of data sparsity. Elimination of this problem requires the utilization of morphologically motivated language models by using morphological rules contained in the given language by modeling of the language for example by using classes of words. In the case of the Slovak language, morphology is mainly concentrated at the end of an inflected word form. The proposed morphological rules for automatic identification and segmentation of the inflected word forms into stems and endings we used to derive the classes of words. This idea was then applied in the modeling of the Slovak language by using stem-based and suffix-based classes. We compared the proposed approach with standard word-based and class-based language models, where words are clustered into classes according to their word lemmas or part-of-speech tags. Preliminary speech recognition experiments detailed in this article show satisfactory results in the Slovak broadcast news transcription task.

Keywords:* class-based models; language modeling; morphological classes; speech recognition.

I. INTRODUCTION

The main problem in the statistical modeling of the highly inflective or agglutinative languages is sparsity of the text data used in the training, especially in the languages such as Slovak that usually suffer from the lack of audio databases or linguistic resources. Besides rich morphology that generates a large number of inflective word forms in vocabulary, relatively free order of words in the sentences results in the decreasing of the predictive ability of standard *n*-gram models for these languages. Because the increased number of words in the vocabulary causes that many word contexts are infrequent and produce a large number of higher-order *n*-grams, the model perplexity and number of out-of-vocabulary (OOV) words arise and estimating conditional probability for these *n*-grams is usually not reliable. Therefore, it is necessary to focus on the more sophisticated techniques that eliminate mentioned insufficiencies of *n*-gram models and introduce into the statistical modeling additional syntactical or semantical dependencies between words that came from the morphology of the given language. One of the possible solutions is to cluster words into classes.

Class-based language models are widely used in many applications oriented on the speech recognition and natural language processing. In contrast to the standard *n*-gram models, class-based models overcome the data sparsity problem by grouping words into classes and thus reduce the number of model parameters [1] for effective smoothing and language model size reduction. Then all words in a given class share certain common dependencies considering their surrounding context.

A number of possible ways how to group words into classes were designed. Earlier approaches considered the syntactical, semantical or morphological word classes or classes induced directly from the data [2]. These classes were derived usually from lemmas or part-of-speech (POS) tags that were assigned to the words by using morphological analyzers adjusted to the given language.

Contemporary language modeling using classes of words is oriented to the application of straightforward word clustering methods and algorithms without the need of any complex algorithm for word disambiguation. In [3], authors proposed an efficient distributed word clustering algorithm in machine translation for obtaining word classes directly from the data, based on the well-known maximum-likelihood optimization criterion with number of improvements. Class-based models using term clustering were also used in question answering to improve the sentence retrieval performance [4]. In the both cases, class models were interpolated with standard word-based models to improve the quality of the system. In the large vocabulary continuous speech recognition (LVCSR), classes of words were applied in the modeling of agglutinative Estonian language using classes of stems and endings obtained by using an unsupervised morpheme segmentation of words [5]. For the highly inflective Arabic language, proposed morphological rules were used to put different words into a class from their stem [2]. Novel affix-augmented

morph-based approach was proposed to extent a stem-based language model (LM) for the inflectional Persian language [6].

In this article, we introduce a morphologically motivated approach for word clustering and modeling of the Slovak language using stem-based and suffix-based classes that were obtained from the morphological rules for segmentation words into stems and endings. The proposed approach is compared with the standard word- and class-based models, where words are grouped into classes according to their word lemmas and POS tags. For assigning words into classes, we used two morphological analyzers: Czech morphological tagger Morče [7] and our suffix-based HMM POS tagger [8].

This article is organized as follows. The next section introduces *n*-gram models as the base in the language modeling, advantages of the class-based modeling in highly inflectional languages, part-of-speech tagging in Slovak as well and the proposed approach for clustering words into classes according to their morphological features derived from the stem and ending of a word. In Section III, we describe our speech recognition setup that has been used in experiments. Section IV presents the experimental results comparing with conventional word-based and class-based models, where words are clustered into classes according to their lemmas or part-of-speech tags. Section V concludes this article.

II. LANGUAGE MODELING

A. N-gram Models

In general, LM in LVCSR determines the probability $P(W)$ of sequence of words $w_1 w_2 ... w_n$ what helps the decoder to find the most probable word sequence corresponding to the acoustic information pronounced by the user. Contemporary language modeling is based on the use *n*-grams, which mainly consider the statistical dependencies between *n* individual words as follows:

$$P(W) = \prod_{i=1}^{n} P(w_i \mid w_{i-n+1} ... w_{i-1}), \qquad (1)$$

where $P(\cdot \mid \cdot)$ is the conditional probability of word w_i conditioned by its history $w_{i-n+1} ... w_{i-1}$ that is given by $n-1$ preceding words. As it was said before, the main problem of *n*-gram LMs is that the training data are too sparse to reliably estimate all conditional probabilities $P(\cdot \mid \cdot)$. Therefore, class-based models were proposed to help to overcome this data sparsity problem.

B. Class-based Models

Class-based models group words into equivalent classes and model the language as the product of two conditional probabilities:

$$P_{CL}(W) = \sum_{c_i \in C} P(w_i \mid c_i) P(c_i \mid c_{i-n+1} ... c_{i-1}), \qquad (2)$$

where $P(w_i \mid c_i)$ is the probability that word w_i belongs into the class c_i and $P(c_i \mid c_{i-n+1} ... c_{i-1})$ is the *n*-gram conditional probability between classes of words. Using this approach we can effectively reduce the number of model parameters (*n*-grams) in LM, because the number of classes is still smaller than the number of distinct words and the probability of words that have similar features is accumulated in the equivalent class.

C. Part-of-Speech Tagging in Slovak

As it was said before, we used two morphological analyzers for assigning words into equivalent classes. First, Czech morphological tagger Morče that use a statistical method based on the combination of a hidden Markov model (HMM), which transform a sequence of words into a sequence of morphological tags with the averaged perceptron algorithm for estimating transition weights between HMM states [7]. It uses a set of about 19 features for estimating parameters of the perceptron. This POS tagger has been later modified for the purpose of the Slovak language with the Slovak tagset by the Slovak National Corpus (SNC). Second, the suffix-based HMM POS tagger for the Slovak language has been developed in our laboratory and is the extension of rule-based POS tagger described in [8]. There are used 2 HMMs for better word clustering. HMMs are trained on the trigram statistics obtained from morphologically annotated corpus from SNC [9]. For estimating of the best sequence of tags, standard Viterbi algorithm has been used. Training of the tagger is delimited not only by the sequence of possible tags but also using grammatical features obtained from the suffix of the preceding word.

D. From Morphs to the Classes of Words

The inflection in the Slovak language usually occurs on the border of stem end ending. This knowledge can help with the modeling of the language using morph-based models. We have decided to use these sub-word units for clustering words into classes according to their stem or ending. Using this approach we can effectively and easily group words into classes without laborious disambiguation as it is in case of lemmatization or POS tagging. This approach then ensures that each word in the training corpus is inserted only into one class (satisfies IBM clustering criterion) [1].

The proposed rules for morphological identification and segmentation words into stems and endings for the Slovak can be summarized into following steps:

1) morphological segmentation into stems and endings satisfies rules for automatic segmentation words into syllables for Slovak, described in [10], where each suffix agrees with last syllable of a word;
2) only words than have more than two syllables or 7 characters are segmented;
3) each suffix has length between 2 and 4 characters;
4) remaining words with length less than two syllables or 7 characters are not segmented;
5) segmentation was constrained by the lexicon, which contains about 1 mil. grammatically correct words.

These rules were then used for clustering of words to the corresponding classes. Non-segmented words then appear in the dictionary as single word in one class.

TABLE 1. Statistics and performance of the class-based models of the Slovak language

ID	number of				size [MB]			OOVs	2-gram		3-gram	
	words	1-grams	2-grams	3-grams	dict	2-g	3-g	[%]	PPL	WER [%]	PPL	WER [%]
reference												
25k	25 046	25 046	10 448 110	11 926 759	0.9	266	650	13.42	495.88	31.80	395.90	30.69
50k	50 140	50 140	14 647 391	14 208 553	1.8	378	845	8.59	589.54	23.37	465.25	22.24
75k	75 230	75 230	16 964 041	15 220 704	2.7	441	946	6.73	637.80	20.28	501.00	19.31
100k	100 293	100 293	18 438 264	15 771 964	3.6	481	1008	5.78	667.30	18.77	523.54	17.84
125k	125 601	125 601	19 466 441	16 110 118	4.6	510	1050	5.19	691.04	17.90	542.16	16.95
150k	151 981	151 981	20 232 779	16 337 114	5.6	531	1080	4.79	709.00	17.30	556.44	16.31
Morče lemmatization												
25k	25 038	8 762	6 423 854	12 317 554	1.8	166	555	9.29	387.72	34.20	298.90	35.14
50k	50 123	15 715	8 744 039	14 004 940	3.6	227	676	6.08	426.21	27.15	324.34	26.04
75k	75 099	22 262	9 946 892	14 672 965	5.5	260	733	4.95	447.20	24.35	339.71	23.20
100k	100 289	28 735	10 712 485	15 024 887	7.4	280	768	4.32	459.92	23.03	349.10	21.77
125k	125 873	34 915	11 218 327	15 225 721	9.3	294	790	3.88	470.02	22.05	356.71	20.85
150k	152 600	41 195	11 583 160	15 357 963	12	304	804	3.65	475.89	21.48	361.15	20.31
stem-based classes of words												
25k	25 027	16 265	10 116 595	13 241 250	1.7	239	641	9.20	494.79	31.06	382.86	29.81
50k	50 103	29 653	13 510 699	15 215 817	3.5	322	791	5.07	567.78	22.36	434.45	21.21
75k	75 322	42 702	15 329 118	16 069 378	5.3	367	865	3.55	604.53	19.56	461.62	18.51
100k	100 704	55 534	16 465 344	16 528 774	7.1	395	911	2.69	624.99	18.02	476.38	16.86
125k	126 320	68 011	17 222 162	16 805 118	9.0	414	938	2.20	641.53	17.11	488.45	16.01
150k	150 456	76 431	17 635 907	16 940 330	11	425	955	1.97	650.20	16.71	495.08	15.55
Morče POS tagger												
25k	25 030	698	197 798	2 044 236	1.7	4.3	59	0.46	76.68	41.47	70.61	41.39
50k	50 110	820	225 673	2 142 625	3.4	4.9	63	0.20	75.62	31.57	69.48	31.00
75k	75 023	881	235 064	2 165 494	5.1	5.1	63	0.16	74.84	27.92	68.74	27.22
100k	100 003	927	240 552	2 177 163	6.9	5.2	64	0.13	74.32	25.90	68.23	25.33
125k	125 833	961	244 307	2 183 768	8.7	5.3	64	0.13	73.91	24.61	67.86	23.88
150k	151 865	1 004	247 632	2 189 237	11	5.4	64	0.12	73.68	23.60	67.65	22.88
suffix-based HMM POS tagger												
25k	25 016	842	200 243	2 298 505	1.7	4.6	70	0.45	85.47	37.86	79.93	37.33
50k	50 035	970	224 660	2 381 232	3.5	5.2	73	0.26	87.80	28.23	81.99	27.77
75k	75 371	1 033	233 027	2 402 723	5.3	5.4	74	0.20	87.89	24.32	82.04	23.75
100k	100 564	1 085	239 061	2 414 019	7.2	5.5	74	0.17	87.49	22.30	81.66	21.44
125k	125 923	1 118	242 194	2 419 433	9.1	5.6	74	0.16	87.29	21.39	81.48	20.48
150k	151 540	1 148	244 927	2 424 014	11	5.7	75	0.14	87.05	20.45	81.26	19.74
suffix-based classes of words												
25k	25 000	9 830	4 916 168	12 797 644	1.7	104	442	3.52	300.98	30.77	240.20	29.52
50k	50 133	16 538	6 034 804	13 579 290	3.4	128	490	2.19	315.52	22.17	250.91	20.97
75k	75 336	22 794	6 615 068	13 887 128	5.1	141	512	1.72	321.29	19.24	255.07	18.13
100k	100 720	28 945	6 985 999	14 055 042	6.8	149	525	1.44	324.90	17.62	257.74	16.43
125k	126 337	35 088	7 246 875	14 159 824	8.6	155	535	1.28	327.56	16.83	259.61	15.59
150k	150 474	38 075	7 347 131	14 194 938	10	157	537	1.23	328.48	16.24	260.38	14.95

III. LVCSR SETUP

Experiments have been performed with bigram and trigram LMs created with the SRILM Toolkit [11] and vocabulary sizes from 25*k* up to 150*k* (with step 25*k*) of the most frequent words conditioned by their POS tag, lemma, stem or ending (see Table 1). For both bigram and trigram LMs the Witten-Bell back-off scheme for smoothing has been used. LMs have been trained on a newspaper text corpus size of about 180 mil. of tokens, gathered from the newspaper webpages written in the Slovak from 2007 to 2011 year by using our system for text gathering and processing called webAgent [12].

The triphone context-dependent acoustic model (AM) based on the HMMs have been used, where each state have been modeled by 32 Gaussian mixtures. The model has been generated from feature vectors containing 39 mel-frequency cepstral coefficients. It has been trained using about 60 hours of readings by professionally trained speakers recorded from the Slovak broadcast news database from 2007 to 2009 year. The acoustic database is characterized by gender balanced speakers and contains read and spontaneous speech. For modeling rare triphones the effective triphone mapping algorithm has been used [13].

For decoding, we have used the LVCSR engine Julius based on two-pass strategy, where input data are processed in the first pass with bigram LM and the final search for reverse *n*-gram is performed again using the result of the first pass to narrow the search space [14].

Test data were represented by 240 min. of speech recordings obtained from randomly selected segments from the Slovak broadcast news acoustic database [13]. These segments were not used in the training of AM and contain 40 656 words in 4 343 sentences.

For evaluation, the word error rate (WER) and perplexity (PPL) were used. WER is a standard extrinsic measure of performance the LVCSR system, computed by comparing the reference text read by a speaker against the recognized results and it takes into the account insertion, deletion and substitution errors. For intrinsic evaluation of LMs the perplexity has been used,

which is defined as the reciprocal of the geometric probability assigned by the LM to each word in the test set.

IV. EXPERIMENTAL RESULTS

Experiments have been oriented on the evaluation of PPL and WER on the test data set to discover the effect of the proposed techniques in the language modeling on the overall precision of our LVCSR system, as well as the size and the number of OOVs in resultant LMs for Slovak broadcast news transcription task. As we can see in the Table 1, in the case of lemmatization we observed decrease of the accuracy, relatively about 18.5% WER in the average, in comparison to the reference LMs. For POS tagging, we have reached another increase in WER, 37.2% for Morče and 20.8% for our suffix-based HMM POS tagger, which groups words in training corpus into classes more precisely as Czech POS tagger modified to the rules and tagset designed for the Slovak language. By contrast, the proposed method for identifying and clustering words into classes according to their stems and endings improve recognition accuracy about 4% and 5.7%, respectively. Regarding PPL, we have observed only slight decrease for lemma- and stem-based LMs. Significant decrease in PPL values we have reached with modeling using POS classes. Note that these values are evaluated only between classes (classes were not expanded into words). Similar results were examined for the size of the resultant LMs that are caused by reducing number of *n*-grams in LM, which has the positive effect on the memory requirements of the LVCSR system in a practical application. As a certain compromise for lemma- or stem-based modeling and modeling language using POS classes is suffix-based approach. In this case we observed satisfactory improvement in WER, but also average values in other parameters of the LMs against another presented approaches. Therefore, it is suitable to focus our future research in modeling of the Slovak language on the suffix-based classes, what worked well in other similar highly inflective languages.

V. CONCLUSION

In this paper a morphologically motivated approach for modeling the Slovak language based on the categorization words into classes according to their stems and endings have been introduced. Classification of words into classes came from a set of morphological rules for automatic segmentation of Slovak words into stems and endings that we proposed. We have observed that the stem- and suffix-based classes of words can bring a possible improvement in the quality of a LM and in performance of the LVCSR system as a whole against conventional lemma-based or POS-based classes. This problem will be subject for further research.

ACKNOWLEDGEMENTS

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Analysis of Inductive Heating and Current Density in Cylindrical Pieces Submitted Cleating Process at a Frequency of 1500Hz

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***Abstract* – The topic of the paper is focused on a study which refers to the distribution of the electromagnetic field in structures made of two materials subject to the process of heating by inductive methods. The study presented in the paper is meant to be a first stage of a more complex one with regard to the use of inductive heating of the structures made up of varied materials.**

***Keywords:* cleating electromagnetic field; inductive heating,; heating process bimetallic components**

I. INTRODUCTION

The study and the conception of the heating by induction equipments require evaluating the evolution of the process of important measures such as induced power, the fields of temperature and power density or determining the energetic indicators. These elements cannot be determined with sufficient accuracy but by the numerical analysis of the phenomenon so that the magnetic non-linearity or the electro-magnetic and termic coupling due to the dependency of the physical properties or certain characteristics to be taken into account.

Basically, the electromagnetic field can be considered, conceptually, as being a physical form of existence of the matter, made up of two component parts, namely electric and magnetic field. The electric field is produced by electrized bodies or by the variation in time of the magnetic field and is characterized by the intensity measures of the electric field, E and electrical induction D. The magnetic field appears in magnetized bodies, around the electrized bodies in movement or at the time variation of the electric field, this being characterized by the intensity measures of the magnetic field, H and magnetic induction, B.

Knowing the electric and magnetic field, their spatial distribution, constitutes the premise of a calculation of the global performances in any functioning regime.

In order to understand, analyse and command the complex systems, it is necessary to obtain quantitative mathematical models of these. It is necessary the analysis of the quantitative relations between the system variables and obtaining the mathematical model. Since the systms are dynamic by their very nature, the mathematical equations are usually differential equations. [1]

In practice, the complexity of the systems, as well as the impossibility of knowing the system in detail imposes the formulation of simplifying hypotheses referring to the functioning of the systems. Out of this reason, in most cases simplifying hypotheses are made. Further on, using the physical laws governing the equivalent system, a lot of differential equations are obtained. This approach is applied to an equal extent to the mechanic, electric, termo-dynamic, etc. systems. [4]

Through the nummerical modelling of the processes there can be estimated with sufficient precision the values of the field measures further to imposing certain conditions with regard to the geometrical form of the device taken into study, of the materials used, there can be determined the response of the equipment to the variation of certain parameters: of power supply, of material, etc.

All these data are of great use in projection, provided that the errors among the values calculated on the model and those measured on a real system to be sufficiently small, and the model to be validated experimentally.

II. THE ECUATIONS OF THE TERMIC FIELD

Be it the field Ω_0 with the border $\partial\Omega_0$. The field Ω_0 is taken by the di-electric with losses and is included in the calculation domain of the electromagnetic field Ω. The Fourier equation for the stationary regime of the termic field is:[2][3]

$$- div\ \lambda grad\ T = p \qquad (1)$$

where λ is the termic conductibility, and p the volume density of the power which is transformed from the electromagnetic form into heat. The border condition is:

$$-\lambda \frac{\partial T}{\partial n} = \alpha (T - T_e) \quad (2)$$

where α is the termic transfer coeficient at surface, and T_e is the temperature outside the field Ω_θ. Many times one can take $T_e = 0$ and in this case the supra-temperature as to the environment is determined. If in the relation (2) we have $\alpha = 0$, we obtain homogenous Neumann conditions, and if $\lambda = 0$, the Dirichlet border condition results.

Ecuation (1) has a unique solution in the border condition (2).[2]

Indeed, if two termic fields verify the equation (1) and the border condition (2), then the difference field T_d verifies the homogenous form of these relations. We have:

$$-\oint_{\partial\Omega_\theta} T_d \lambda grad T_d \cdot n dS = \oint_{\partial\Omega_\theta} T_d \left(-\lambda \frac{\partial T_d}{\partial n}\right) dS = \oint_{\partial\Omega_\theta} \alpha T_d^2 dS \quad (3)$$

Meanwhile:

$$-\oint_{\partial\Omega_\theta} T_d \lambda grad T_d \cdot n dS = -\int_{\Omega_\theta} \lambda grad^2 T_d dv \quad (4)$$

From the relations (3) and (4) there results:

$$-\oint_{\partial\Omega_\theta} \alpha T_d^2 dS + \int_{\Omega_\theta} \lambda grad^2 T_d dv = 0 \quad (5)$$

wherefrom $T_d = 0$.

III. THE TERMIC DIFFUSION [3]

The diffusion of the termic field is described by the ecuation :

$$-div\lambda gradT + c \frac{\partial T}{\partial t} = p \quad (6)$$

where c is the volume termic capacity. To ecuation (6) there are added the border conditions (2) and the initial condition for the temperature: $T(0) = T_{in}$.

Ecuation (6) has a unique solution in the border condition (2) and with an imposed initial condition.

The relation (3) is valid, but instead the relation (4) we have:

$$-\oint_{\partial\Omega_\theta} T_d \lambda grad T_d \cdot n dS = -\int_{\Omega_\theta} \lambda grad^2 T_d dv - \int_{\Omega_\theta} T_d c \frac{\partial T_d}{\partial t} dv \quad (7)$$

if taken into account that the difference temperature T_d verifies the equation (6). From (3) and(7) there results by integration:[2]

$$\int_0^t \oint_{\partial\Omega_\theta} \alpha T_d^2 dS + \int_0^t \int_{\Omega_\theta} \lambda grad^2 T_d dv d\tau + \int_{\Omega_\theta} c \frac{T_d^2(t)}{2} dv = 0$$

wherefrom $T_d = 0$.

IV. THE STATIONARY REGIME

It is supposed that the border $\partial\Omega_0$ of the fied Ω_θ is formed of 3 surfaces, S_D, where the Dirichlet border conditions are fulfilled: $T = T_e$, Neumann:

$\frac{\partial T}{\partial n} = 0$ and, respectively, mixed $-\lambda \frac{\partial T}{\partial n} = \alpha (T - T_e)$

The first two 2 border conditions are considered particular cases of the mixed conditions, then when λ, = 0 and α = 0, respectively.

From a technical point of view, the Neumann border condition appears on surfaces of symmetry (field surfaces), being always null. Unlike the case of the electromagnetic field, in the case of the termic stationary field the technique of Ritz numerical solving of equation (1) shall be presented.

Be it the functional:

$$\Im(T) = \frac{1}{2}\int_{S_F} \alpha T^2 dA - \int_{S_F} \alpha T T_e dA - \int_{\Omega_\theta} pT dv + \frac{1}{2}\int_{\Omega_\theta} \lambda grad^2 T dv \quad (8)$$

the minimum of which is searched in the multitude of functions which have the Dirichlet border condition imposed.

The solution of equation(1), which verifies the border conditions, minimizes functional (8) and reciprocally, the minimum of functional (8) is given by the (weak) solution of equation (1) which verifies also the Neumann and mixed border conditions.

Be it T_0 the minimum of functional (8) and be it $T = T_o + \gamma\delta T$ a certain temperature but which fulfils the Dirichlet border conditions, with $\gamma \in R$ and δT arbitrary, having $\delta T = 0$ S_D. Replacing in (8), one obtains:

$$\Im(T) = \frac{1}{2}\int_{S_F} \alpha T^2 dS + \frac{\gamma^2}{2}\int_{S_F} \alpha \delta T^2 dS + \gamma\int_{S_F} \alpha T_0 \delta T dS - \int_{S_F} \alpha T_0 T_e dS - \gamma\int_{S_F} \alpha T_0 T_e dS -$$

$$-\int_{\Omega_\theta} pT_0 dv - \gamma\int_{\Omega_\theta} p\delta T dv + \frac{1}{2}\int_{\Omega_\theta} \lambda grad^2 T_0 dv + \frac{\gamma^2}{2}\int_{\Omega_\theta} \lambda grad^2 \delta T dv +$$

$$+\gamma \int_{\Omega_\theta} \lambda grad\ \delta T \cdot gradT_0 dv \quad (9)$$

The last term is integrated by parts:

$$\int_{\Omega_\theta} \lambda grad\delta T \cdot gradT_0 dv =$$

$$\oint_{\partial\Omega_\theta} \lambda \delta T gradT_0 \cdot n dS - \int_{\Omega_\theta} \delta T T div\lambda gradT_0 dv =$$

$$\int_{S_F} \lambda \delta T \frac{\partial T_0}{\partial n} dS = \int_{S_F} \lambda \delta T \frac{\partial T_0}{\partial n} dS + \int_{S_N} \lambda \delta T \frac{\partial T_0}{\partial n} dS -$$

$$-\int_{\Omega_\theta} \delta T div\lambda gradT_0 dv \quad (10)$$

Replacing in (8) and grouping according to the powers of γ, one obtains:

$$\Im(T) - \Im(T_0) = \gamma$$

$$\left\{\int_{S_F}\left(\alpha(T_0 - T_e) + \gamma\frac{\partial T_0}{\partial n}\right)\delta T dS + \int_{S_N} \lambda \delta T \frac{\partial T_0}{\partial n} dS - \int_{\Omega_0} \delta T\left(p + div\lambda grad T_0\right) dv\right\} +$$

$$+\frac{\gamma^2}{2}\left(\int_{S_F} \alpha \delta T^2 dS + \int_{\Omega_0} \lambda grad^2 \delta T dv\right) > 0 \quad (11)$$

If T_0 minimizes the functional 3, then the inequality (11) can take place for any γ if and only if the term which contains γ is nul. Since δT is arbitrary, from the first term of the accolade there results the border condition (2), from the second the Neumann condition, and from the third the equation(1). Reciprocaly, if the two border conditions and the equation (1) are fulfiled, then the term in γ is null, the inequality (11) is fulfilled and T_0 is the minimum of functional 3.

Functional (8) is strictly convex:

$$\Im\left(\frac{T'+T''}{2}\right)<\frac{1}{2}(\Im(T')+\Im(T'')) \quad (12)$$

Using the expression (8), there results, by a few simple calculations:

$$\int_{\Omega_\theta}\gamma(grad(T'-T''))^2 dv>0$$

It is demonstrated that (8) has a single local minimum. Moreover, there results the consistency of the finite elements method: we choose a series of finite dimensional sub-spaces for T: $W_1 \subset W_2 \subset W_3 \subset \ldots \subset W$ where W is the space of the functions defined on Ω, with real values and which fulfil the border condition Dirichlet. The values T_k, are obtained, which minimize (8) and for which:[2][3]

$$\Im_{(V_1)}>\Im_{(V_2)}>\Im_{(V_3)}>\ldots>\Im_{(V)}$$

For the nummerical calculations we write the temperature field T under the form:

$$T=T_D+\sum_{k=1}^{n}\beta_k\varphi_k \quad (13)$$

where φ_k are functions that are lineary independent with null Dirichlet border conditions, and T_D an arbitrary function which fulfils the Dirichlet border condition. It can be placed under the form:

$$D+\sum_{l=1}^{n_D}T_e(P_l)\varphi_l \quad (14)$$

where P_l are the Dirichlet border nodes, φ_l – the nodal elements of these nodes, and n_D the number of nodes on the Dirichlet border. Replacing in (8) and deriving with relation to the unknown a_k, there results the system:

$$\frac{\partial\Im}{\partial\beta_k}=\left[\sum_{j=1}^{n}\beta_j\left(\int_{S_F}\alpha\phi_k\varphi_j dS+\int_{\Omega_\theta}\lambda grad\,\varphi_k\, grad\,\varphi_j dv\right)\right]+$$
$$+\int_{S_F}\alpha\phi_k T_D dS+\int_{\Omega_\theta}\lambda T_D grad\,\varphi_k dv-$$
$$-\int_{S_F}\alpha\phi_k T_e dS-\int_{\Omega_\theta}p\phi_k dS=0,\ k=1,2,\ldots,n \quad (15)$$

or

$$\sum_{i=1}^{N}a_{ki}\beta_i=b_k,\ k=1,2,\ldots,n \quad (16)$$

where:

$$a_{ki}=\int_{\Omega_\theta}\lambda grad\,\varphi_k\cdot grad\,\varphi_i s\Omega+\int_{S_F}\alpha\varphi_k\varphi_j dS \quad (17)$$

$$b_k=-\int_{S_F}\alpha\varphi_k T_D dA-\int_{\Omega_\theta}\lambda T_D grad\,\varphi_k dv+\int_{S_F}\varphi_k T_e dS+\int_{\Omega_\theta}p\varphi_k dv \quad (18)$$

Resolving the system, the coefficients φ are obtained, and thus the temperature in the field.

The brass was chosen for making the study, as a constitutive material for the interior cylindrical structure, having in mind its vast fields of use.[2][5]

The study comprised in the present paper implies the establishing of a series of data of the material, such as the specific heat, rezistivity, etc.[6]

Thus, the following material data were imposed for brass:

- specific heat $\gamma \cdot c = 3{,}45 \cdot 10^6$ J/m^3/°C ;
- rezistivity $\rho = 1{,}9 \cdot 10^8$ Ωm ;
- the relative magnetic permeability of brass $\mu_r = 1$.

V. Border conditions

For the problem of electromagnetic field, the imposed border conditions are presented in Figure 1.[6]

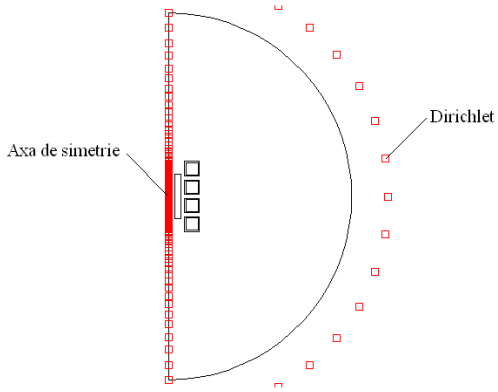

FIGURE 1. Border conditions for the problem of electromagnetic field.

The calculation domain for the termic field is that of the spare part, the border conditions for the problem of termic field are of non-homogenous type, which towards the exterior cedes heat.[6]

In the study carried out, in view of optimizing the process, Fig. 2, 3, 4, 5, the simulation of the process of inductive heating was made for four work frequencies, namely 1500Hz.

Further on, the distribution of the power density induced in the spare part is presented under the form of a coloured map. There are presented the results of the process at the beginning and at the end, 0.4s,30s.

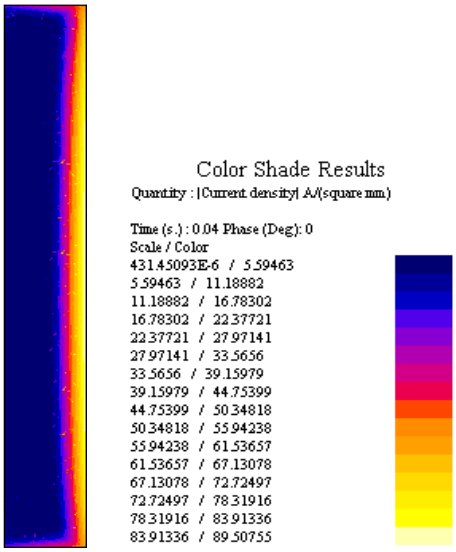

FIGURE 2. The current density in the spare part, at 0,4s and the work frequency of 1500 Hz.

The same as in the studies made at the previous work frequencies, in this case also, the power density induced in the spare part at 0.4s and respectively 30s is analyzed.

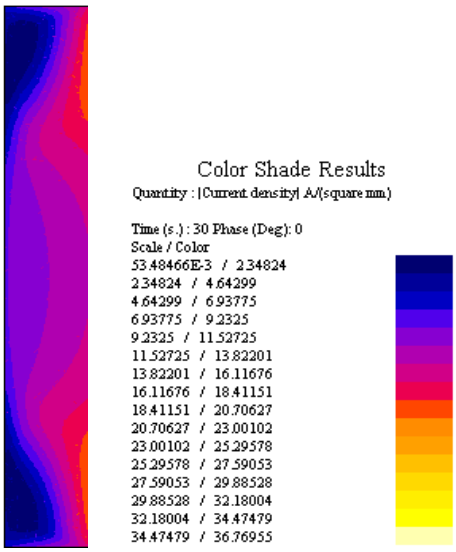

FIGURE 3. The current density in the spare part, at 30 s and the work frequency of 1500 Hz.

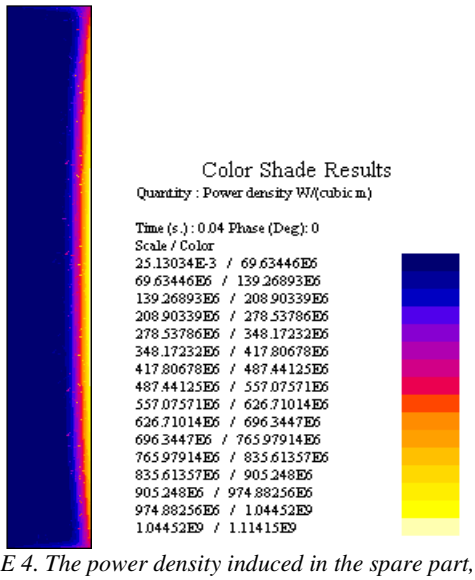

FIGURE 4. The power density induced in the spare part, at 0,4s and the work frequency of 1500 Hz.

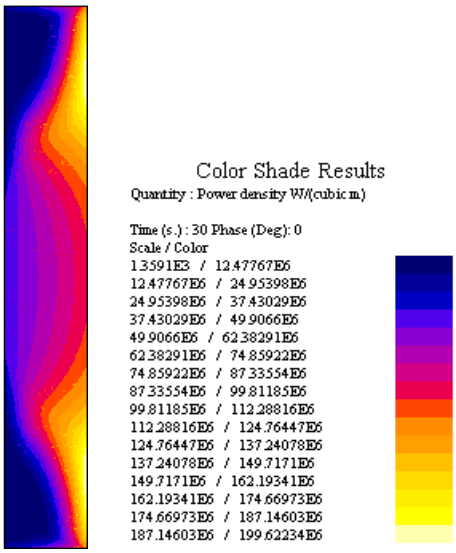

FIGURE 5. The power density in the spare part, at 30s and the work frequency of 1500 Hz.

VI. CONCLUSIONS

In the present paper there have been anaysed the ecuations of the quasi-stationary, electromagnetic field ecuations, there also being analysed the problem of the border conditions. There have been approached aspects related to the quasi-stationary sinusoidal regime, of penetration of the electromagnetic field in cylindrical parts. There are also approached aspects regarding the nummerical sorting out of the problems by turbionary currents by the finite element method.

As a conclusion of the study carried out, for the value of the work frequency of 1500Hz, one can notice a gain in the duration of the process, there being reached the same, the temperature of 803^{o}C within a shorter time, of approximately 30s, comparative with the time of 47s at the work frequency of 500Hz. There was not obtained a significant gain in the distribution of the termic field.

ACKNOWLEDGEMENTS

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Magneto-Thermal Analysis of Reversed Claw-Poles Machine

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***Abstract* – The goal of this paper is to present a magneto-thermal analysis of a permanent magnet based alternator. The present paper is concentrated on the study of a reversed claw-poles machine. Both magnetic and thermal studies are done based on equivalent circuits. In the case of the magnetic analysis, with the goal of determining the flux densities values, an improved magnetic equivalent circuit is implemented. Its results are compared and validated with the ones obtained by the magnetic equivalent circuit developed in previous work. The finite element method analysis is also used as a tool to validate the obtained results. The flux density curves obtained via magnetic equivalent circuit and FEM analysis are compared and discussed. Also the corresponding induced electromotive force wave forms are reconstructed and analyzed.**

In order to perform the thermal analysis, first the losses in the machine must be determined. Knowing the values of the thermal resistances, in Matlab SIMULINK, the corresponding equivalent circuit is built. This model is a complex one – it takes into account the transient process from the beginning of the heating.

Keywords: ***claw-poles machine; Magnetic Equivalent Circui; Finite Element Analysis; induced electromotive force; heating; Thermal Equivalent Circuit.***

I. INTRODUCTION

The claw-poles structure is a special topology for different electrical machines, not a class of electrical machines. Either the stator or rotor core can be built up using claw-poles. Its construction is very simple: all poles use only one winding [1].

The most common application of claw-poles topology is as power source in finite inertia systems like automobiles, aircraft, agricultural applications and wind generation [2].

The claw-pole generator is the oldest type of three-phase electrical machine. The first one was used in the late 19th century to generate electricity. Due to the development of turbo generators and salient poles machines, for a long period of time, they disappeared from the field of interest. In the early 60s, with the development of the automotive industry, this topology has returned in the attention of producers as power supply in vehicles [1].

Most machines that use claw-poles topology are the synchronous ones. In terms of field excitation, during the years, two different types of machines were built: with excitation winding and permanent magnets (PM), respectively [3].

Although the efficiency of these machines is lower compared with others, their large use is due to their high power density, reliability and robustness [3].

Today, the rate of industrial development is very aggressive. To save time and financial resources, before building an experimental model, complex analytical studies are made. These studies are performed using advanced modeling techniques and specialized software [4], [5].

In the field of electrical machine, the trend is to develop analytical models and validate them by finite element analysis (FEM).

This article deals with the magneto-thermal analysis in the main parts of a reversed claw-poles machine. In order to perform it, a magnetic equivalent circuit (MEC) and a thermal equivalent circuit are developed (TEC), respectively.

The goal of MEC is to determine the air-gap's flux density variation curves by analytical means. The obtained results are compared with those obtained from FEM. From the flux densities wave forms the corresponding induced voltage wave forms are reconstructed and analyzed.

The TEC is built with the aim of determining the heat in the alternator. In order to perform this, a complex Matlab SYMULINK model is developed.

II. MACHINE TOPOLOGY

As mentioned in the INTRODUCTION, a reversed claw-poles alternator is proposed to the study. Its topology can be visualized in Fig. 1.

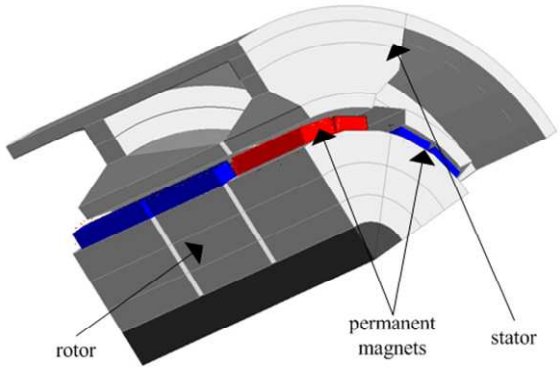


Fig.1. Reversed Claw-Poles Topology

Its construction is simple. The rotor is composed by three identical modules separated by a nonmagnetic material. In order to obtain the proper phase angle of the induced electromotive forces, the modules are shifted from each other by 120°. Each rotor module embeds permanent magnets.

The stator's structure is a special one due to the claw-poles position. The ring type winding is held and fixed by the surrounding claw-poles. The core consists of massive iron.

The machine's clearance gauge is 136 (mm) for the stack length and 148 (mm) for the outer stator. The geometric sizes of the main dimensions are presented in table I. The excitation source is based on 48 NeFeB permanent magnets of parallelepiped form (16 PM per phase). The dimensions of a permanent magnet are the following: a length of 40 (mm), a width of 10 (mm) and a height of 5 (mm), respectively. The alternator is sized to develop a rated output power of 1076 (W). The corresponding efficiency is of 55,4 (%).

III. Magnetic Equivalent Circuit and Fem Analysis

A. Magnetic Equivalent Circuit Presentation

Unlike finite element analysis, magnetic equivalent circuits require less resources and computation time. However, the obtained results are very close to those obtained by FEM. Because of this, the MEC model is often used for performing magnetic analysis of electrical machines [4], [5].

Magnetic equivalent circuits are built up in analogy with electrical circuits. If in the case of electrical circuits, a closed loop is caused by the current flowing through an inductor, in the case of magnetic circuits the closed loop is set up by a magnetic flux. For electrical circuits the path is determined by the conductor and, for magnetic circuits of electrical machines, the path is the machine's core itself, respectively. According to the above presented analogy, the electric resistance is modeled by a magnetic reluctance and the electromotive force is modeled by the magnetomotive force [6].

In the case of the considered machine, the magnetic equivalent circuit is set up following the path: permanent magnet – air gap – claw pole – claw pole flange – stator yoke – claw pole flange – claw pole – air gap – permanent magnet – rotor.

In comparison with the MEC presented in [7], this MEC model is an improved one. The leakage fluxes between two adjacent modules are also taken into account. These leakage fluxes arise between two rotor modules and, also, between the permanent magnets from one phase and the claw-poles from the adjacent phase. Hence, in parallel with the above flux path, a second path, containing the leakage fluxes, is set up.

In Fig. 2 the magnetic equivalent circuit corresponding to the first and second phase is built up. Here: R_{msy} – the magnetic reluctance of the stator yoke, *(A/Wb)*; R_{fl1} – the magnetic reluctance of the stator's exterior flange, *(A/Wb)*; R_{fl2} – the magnetic reluctance of the stator's interior flange, *(A/Wb)*; R_{mp1} – the magnetic reluctance of the claw-pole from the exterior flange, *(A/Wb)*; R_{mp2} – the magnetic reluctance of the claw-pole from the interior flange, *(A/Wb)*; $R_{\delta 1}$ – the magnetic reluctance of the air-gap, *(A/Wb)*; R_{mPM1} – the magnetic reluctance of the first phase's permanent magnet, *(A/Wb)*; R_{mPM2} – the magnetic reluctance of the second's phase's permanent magnet, *(A/Wb)*; R_{ry1}, R_{ry2}, R_{ry3}, R_{ryA}, R_{ryB} – the magnetic reluctance of the rotor yoke, *(A/Wb)*; R_i – the magnetic reluctance of the nonmagnetic material between two phases, *(A/Wb)*; $R_{m\sigma pp}$ – the magnetic reluctance between two claw-poles, *(A/Wb)*; $R_{m\sigma p1}$ – the magnetic reluctance between the permanent magnet and the opposite claw-pole (the claw-pole and the permanent magnet are situated on the same phase), *(A/Wb)*; $R_{m\sigma p2}$ – the magnetic reluctance between the permanent magnet from phase 1 and the opposite claw pole from phase 2, *(A/Wb)*; $R_{\sigma MP1}$ – the magnetic reluctance between the permanent magnets of the same phase, *(A/Wb)*; $R_{\sigma MP2}$ – the magnetic reluctance between the permanent magnets from the two adjacent phases, *(A/Wb)*; $R_{m\sigma r}$ – the magnetic reluctance between two rotor modules, *(A/Wb)*.

More details about MEC's implementation can be found in [1].

TABLE I. Machine's Main Geometrical Dimensions

Name	Value (m.u.)
Stack length	136 (mm)
Outer stator diameter	148 (mm)
Inner stator diameter	84 (mm)
Outer rotor diameter	82 (mm)
Claw pole width	20 (mm)
Claw pole length	46 (mm)
Claw pole's tip	4 (mm)
Claw pole height	12 (mm)
Claw pole width at base	42 (mm)
External claw pole flange length	10 (mm)
Internal claw pole flange length	11.5 (mm)
Coil width	31 (mm)
Coil heingh	12 (mm)

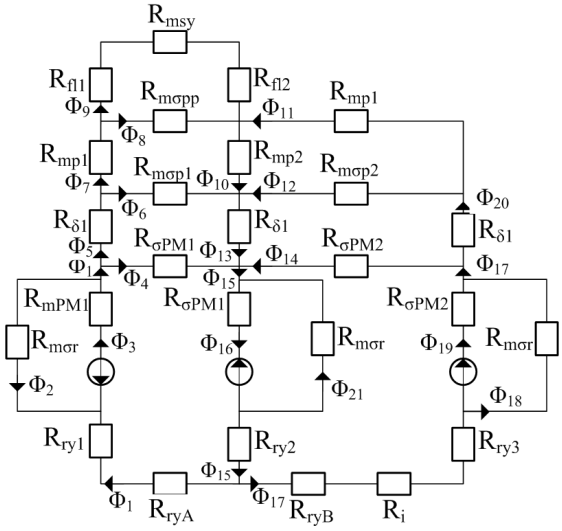


Fig. 2. Magnetic Equivalent Circuit

B. FEM Analysis

The Finite Element Analysis is used as a tool to determine the flux density values in the main parts of the machine and validate the ones obtained by MEC.

Because the flux path in a claw-poles machine is distributed both axial and transversal, the FEM model must be a 3D one. The used software to achieve this is Flux3D provided by CEDRAT.

Because 3D simulations require long computation time, only one quarter of the machine was designed. By respecting the machine's periodicity conditions imposed at the beginning of the simulations, the obtained results are the same as the entire machine have been simulated.

C. MEC and FEM Obtained Results

By solving the system of equations written based on the circuit in Fig. 2, the Φ_1 - Φ_{21} flux values are obtained. Knowing that the flux density is given by the ratio between the flux and the area passed by that flux, the flux densities values in the main parts of the machine are determined.

Table II presents the flux density values in the main parts of the machine obtained by MEC and FEM means. Also, in this table, are presented the values obtained by implementing the MEC presented in [7]. The values corresponding to MEC 1 column were determined as in [7] and the ones corresponding to MEC 2 were determined by using the circuit presented in Fig. 2.

In Fig. 3 the flux density distribution in machine's main parts is presented.

By analyzing the results presented in table II it can be seen that the obtained flux density values are close. The arisen differences are due to the different implementing mode and also to the fact that the equations of MEC 1 and MEC 2 are linear while FEM analysis takes in count both linearities and nonlinearities.

Table II. Obtained Flux Densities Values

	Values		
	MEC 1	**MEC 2**	**FEM**
Air-Gap Flux Density	0,568	0,47	0,56
Stator Yoke Flux Density	0,88	0,67	0,9
Stator Column Surface Flux Density (in the lower part of the flange)	1,74	1,89	1,47
Stator Column Surface Flux Density (in the upper part of the flange)	1,41	1,07	0,86
Rotor Yoke Flux Density	0,38	0,28	0,1
Surface Claw-Pole Flux Density	0,79	0,59	0,675

As mentioned in INTRODUCTION, the MEC is used also as a method to determine the air-gap's flux density wave form. In order to achieve this, the rotor's motion must be considered. Hence, by modifying the permanent magnet's reluctance the other reluctances of the circuit will modify too.

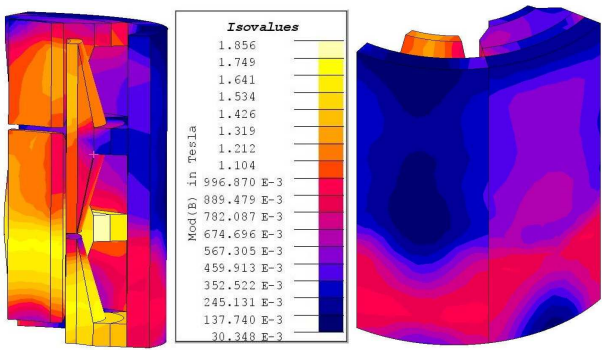
In Fig. 4 the flux density wave forms obtained by implementing the MEC presented in Fig. 2 and FEM analysis are presented. By analyzing this figure it can be seen that the maximum values of the two waves are very close.

In table III are gathered the magnitudes of the air-gap flux density wave forms obtained via MEC and FEM calculations. These were determined by using the Fast Fourier Technique (FFT).

Based on the values presented in table III and knowing that the induced electromotive force is given by the formula (1) the induced electromotive force's wave form can be determined. Here: ω – angular velocity, *(radians/sec)*; Φ – polar flux, *(Wb)*; w_s – number of coils per phase; *f* – frequency, *(Hz)*.

$$E = \omega \cdot \Phi \cdot w_s \cdot \sin(f) \qquad (1)$$

In Fig. 5 the reconstructed induced electromotive force waveforms are plotted. By analyzing them it can be seen that the one obtained via MEC computations is quite similar to the one obtained with FEM.



a) *b)*

Fig. 3. Flux Density Distribution: a) side view; b) top view

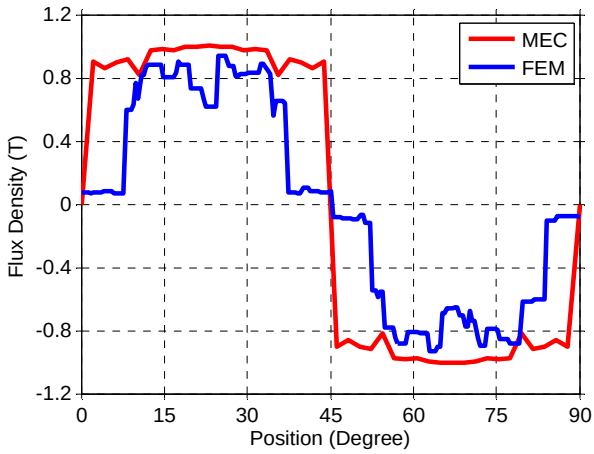


Fig. 4. Air-Gap Flux Density Distribution

Table III. Air-Gap's Flux Densities Magnitudes

Harmonic Order	Flux Density Magnitude (T)	
	MEC	FEM
1	1,21	0,86
2	0,04	0,02
3	0,32	0,02
4	0,04	0,02
5	0,2	0,19
6	0,05	0,09

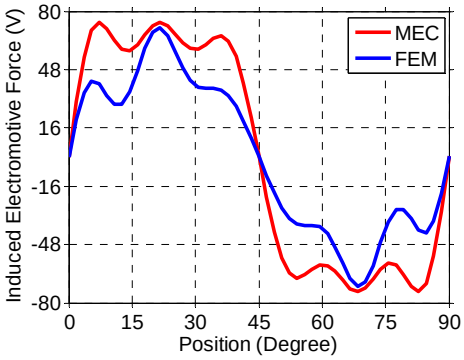


Fig. 5. Reconstructed Induced Electromotive Force

IV. THERMAL ANALYSIS

A. Heat Sources

In the literature there are two different methods of thermal analysis presented. These are: the thermal network and the one based on finite element method. In this article, a thermal equivalent circuit was chosen to perform the thermal analysis. Before detailing the thermal equivalent circuit the machine's heat sources will be characterized. As in any electrical machine, the heat sources are determined by the Joule losses, core losses, the PM losses and stray losses.

1) Joule Losses

The Joule losses are the term often given to the heat produced by electrical currents in the conductors of electrical devices.

Known also as winding losses, these are an undesirable transfer of energy which results from induced currents in adjacent components. In our case, the Joule losses are generated by the induced current in the stator winding. This type of losses is determined by using the formula:

$$P_J = m_1 \cdot R \cdot I_{ph}^2 \qquad (2)$$

Where: m_1 – machine's phase number; R – winding resistance, *(Ω)*; I_{ph} – phase current, *(A)*.

2) Core Losses

Due to the high operating frequency, the core losses calculation is crucial for high speed machines.

They are the dominant power losses component of this kind of alternators. In our case, the core losses are divided into: iron losses in the stator yoke, iron losses in the stator's flange, iron losses in the claw-pole and iron losses in the rotor yoke. All these losses are calculated according to:

$$P_{Fe} = K_{Fnu} \cdot p_{Fe} \cdot m \qquad (3)$$

Where: K_{Fnu} – the coefficient which takes into account the magnetic non-uniformity; p_{Fe} – specific iron losses, *(w/kg)*; m – the mass corresponding to the volume for which the iron losses are calculated, *(kg)*.

3) The Permanent Magnet Losses

The PM losses are determined by using the same principle as in the case of core losses.

4) Stray Losses

Stray losses consist of mechanical and self-ventilation loses. Due to the permanent magnet excitation, these losses are determined only by the bearings friction and self-ventilation losses which appear in the rotor's front rings. These losses are determined according to:

$$P_{mech\_v} = 0{,}8 \cdot 2 \cdot p \cdot \left(\frac{\nu}{40}\right) \cdot \sqrt{\frac{l}{19}} \cdot 10^3 \qquad (4)$$

Where: p – number of pole pairs; υ – peripheral rotor speed, *(m/s)*; l – length of the active rotor's stake, *(m)*.

In table IV are gathered and presented the above determined losses.

B. Thermal Equivalent Circuit Presentation

As in the case of magnetic equivalent circuits, thermal circuits are built up by analogy with electrical circuits. In this case, electrical resistances, currents and electromotive forces are replaced by thermal resistances, heating and losses, respectively [8].

In Fig. 6 the built-up thermal equivalent circuit of the reversed claw-poles alternator can be visualized.

Table IV. Machine's Losses

	Value (W)
Winding Loses	121.3
Stator Yoke Losses	84.58
Stator Flange's Losses	50.833
Claw-Pole Losses	50.31
Rotor Yoke Losses	5.969
Permanent Magnet Losses	0.00477
Mechanical and Self-Ventilation Losses	0.67

Here: R_{T1} – the transmission thermal resistance from the machine's housing to the exterior, radially, *(Δ°C/W);* R_{TYS1}, R_{TYS2} – thermal resistance of the stator yoke in longitudinal and axial direction, respectively, *(Δ°C/W);* R_{iz1} – the transmission thermal resistance from the winding to the stator core in axial direction, *(Δ°C/W);* R_{T2} – the transmission thermal resistance from the winding to the stator core in transversal direction, *(Δ°C/W);* R_{Tfl} – the thermal resistance of the stator flange, *(Δ°C/W);* R_{Tfl_a} – the transmission thermal resistance from the stator flange to the air, *(Δ°C/W);* R_{T3} – the transmission thermal resistance from the stator flange to the air, *(Δ°C/W);* R_{T4} – the transmission thermal resistance from the claw-pole to the air, *(Δ°C/W);* R_{PM_ia} – the transmission thermal resistance from the PM to the air, *(Δ°C/W);* R_{glue} – glue thermal resistance, *(Δ°C/W);* R_{T5} – the transmission thermal resistance from the rotor to the air, radially, *(Δ°C/W);* R_{sh} – shaft thermal resistance, *(Δ°C/W);* R_{T6} – the transmission thermal resistance from the shaft to the air, *(Δ°C/W);* R_{T7} – the transmission thermal resistance from the rotor yoke to the shaft, *(Δ°C/W);* R_{end_sh} – thermal resistance of the shaft's end, *(Δ°C/W);* R_{T8} – the transmission thermal resistance from the machine's housing to the exterior, transversally, *(Δ°C/W);* P_{FeY} – stator yoke losses, *(W);* P_w – winding losses, *(W);* P_{Fefl} – stator flange's losses, *(W);* P_{Fep} – claw-pole losses, *(W);* P_{PM} – PM losses, *(W);* P_{FeR} – rotor yoke losses, *(W);* P_m – mechanical and self-ventilation losses, *(W).*

C. Thermal Equivalent Circuit Implementation

Depending on their type, the thermal equivalent resistances are determined via two distinct paths.

Hence, if the heat is transmitted through the body mass (conductivity), the equivalent thermal resistance is calculated according to:

$$R_\lambda = \frac{\beta}{\lambda \cdot S} \tag{5}$$

Where: β – the thickness of the plate through the heat is transmitted, *(cm);* S – the surface through the heat flows, *(cm^2);* λ – thermal conductivity of the body, *(W/(cm°C)).*

If the heat is transmitted trough the surfaces (radiation and convection), the equivalent thermal resistance is calculated as in (6):

$$R_\alpha = \frac{1}{\alpha S} \tag{6}$$

Where: S – the temperature of the heated surface, through the heat is evacuated, *(cm^2);* α – heat transmission coefficient *(W/(cm^2°C)).*

In order to determine the heating in the machine's main parts, the thermal equivalent circuit presented in Fig. 6 is implemented in Matlab SIMULINK.

D. Obtained Results

The Matlab SIMULINK environment has been chosen as a tool to perform the thermal analysis not only because the TEC is easy to be solved but also because it takes into account the transient process from the beginning of the heating process. This process is taken into account by placing a thermal capacitance in parallel with the core's heat sources [9].

These thermal capacitances are determined according to:

$$C = d \cdot C_s \cdot V \tag{7}$$

Where: d – the density of the material, *(kg/cm^3);* C_s – the specific heat of the material, *(J/(kg• Δ°C));* V – the volume, *(cm^3).*

In Fig. 7 is presented the transient process of the first 100 *(s)* of the machine's operation.

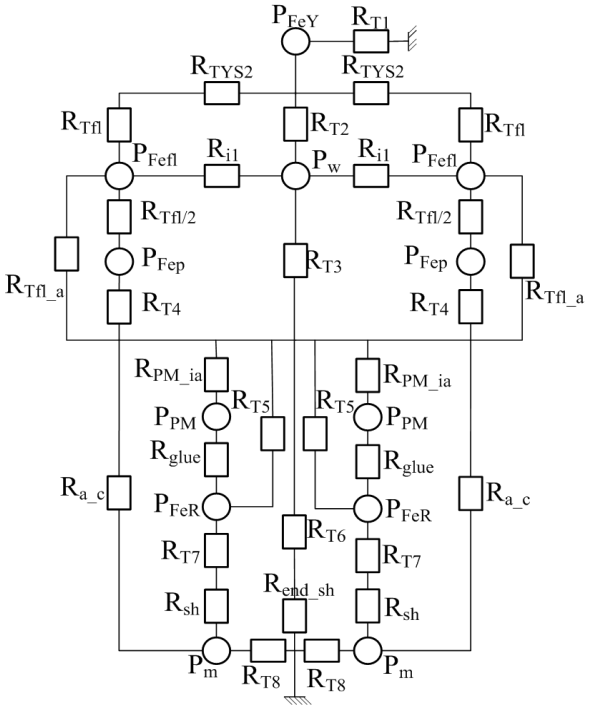


Fig. 6. Thermal Equivalent Circuit

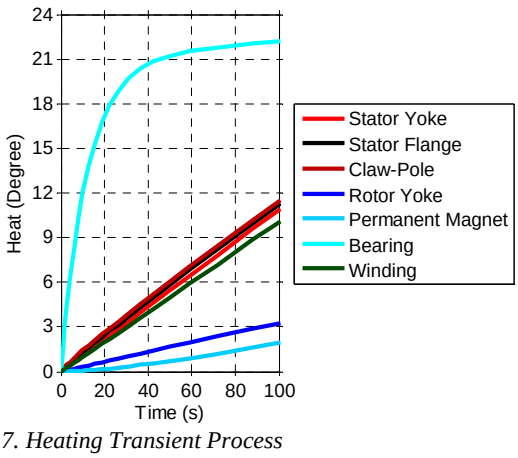


Fig. 7. Heating Transient Process

Table V gathers and presents the temperatures reached in the machine's main parts at 1500 *(rpm)*. It is mentioned that the heating correspond to an ambient temperature of 25 *(°C)*.

By analyzing table V it can be seen that the core's high temperatures causes a proportional heating of the winding. For a regular operation of the machine, the claw-poles alternator must be equipped with a proper cooling system and the winding's insulation must belong to a higher class. The heating in the permanent magnets and in the bearing is normal.

V. CONCLUSIONS

The article presents the magneto-thermal analysis of a reversed claw-poles alternator.

In order to perform the magnetic analysis, two methods are used: a magnetic equivalent circuit and FEM analysis.

Regarding the MEC presented in [7], the one discussed in this paper is an improved one: it takes into account the leakage fluxes between two adjacent phases of the machine. This circuit was developed with the goal of reconstructing the flux density distribution wave through the air-gap by analytical mean. Also the curves of the corresponding induced electromotives forces are studied.

The flux densities values obtained through the new circuit are compared and validated with the ones obtained by using the circuit presented in [7] and the FEM analysis. By analyzing the results presented in table II it can be seen that the flux densities values obtained via the three methods are close.

The flux density distribution wave obtained via analytical and FEM means and the induced electromotive force wave forms reconstructed from these are also compared and analyzed. From the obtained results it observed that the maximum values of the two flux densities distribution waves are very close. Regarding the two reconstructed induced electromotive forces, they are similar.

The thermal analysis was performed by building the thermal equivalent circuit. In order to take into account the transient process from the beginning of the heating, the TEC was implemented in Matlab SIMULINK. Although the core heating is large, by taking the appropriate safety measures, the alternator can operate normally.

Table V. Machine's Heating

Speed *(rpm)* / Heating *(°C)*	1500
Stator Yoke	186,7
Stator Flange	186,1
Claw-Pole	177,3
Rotor-Yoke	53,6
Permanent Magnet	57
Bearing	45,1
Winding	184,8

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An Additive Scaling Factor to Reduce the PAPR of the OFDM Systems

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Abstract **– *The current and future wire line and wireless communications systems use the Orthogonal Frequency Division Multiplexing (OFDM) modulation technique since it has many advantages over the single carrier modulation methods. However, it has a main drawback represented by the high peak to average power ratio (PAPR). To overcome this problem, many techniques have been proposed such as the Selected Mapping (SLM). In this paper, an additive scale factor of zero resultant in the complex plane preceded by the Discrete Fourier Transform (DFT) matrix as a channel coding technique. The PAPR has been reduced significantly (by 3dB) with high reduction in the computational complexity. This is seen in the simulation results where the Bit Error Rate (BER) did not have any effects.***

Keywords: ***OFDM; PAPR; SLM; DFT.***

I. INTRODUCTION

The OFDM system found a lot of fertile ground for sitting and be one of their constituents such as the European Digital Audio Broadcasting (DAB), satellite terrestrial interactive multiservice infrastructure, Terrestrial Digital Video Broadcasting (T-DVB), IEEE802.11a/g/n, and many others [1]. The reasons behind using the OFDM system in these fields are its immunity to noise, Intersymbol Interference (ISI), and combating the multipath fading channels besides its simplicity in implementation compared to the single carrier system. However, it has a problem which can be considered as a main drawback represented by its high-output Peak to Average Power Ratio (PAPR). The PAPR should be reduced to avoid the complication of the system, high weights, and the high cost. So that, many techniques have been suggested to overcome the problem. The main techniques are Amplitude Clipping (AC) [2], coding [3], Tone Reservation (TR) and Tone Injection (TI) [4], Partial Transmit Sequence (PTS) [5], Selected Mapping (SLM) [6], and the Digital All Pass Filter [7]. The simplest technique is the AC method, it is easy to implement and gives the good gain in the PAPR reduction but at the expense of high BER. The second one is the coding method which reduces the PAPR but puts more redundancy bits, which will lead to a reduced bit rate. The PAPR can be reduced to good levels but at the cost of the system's complexity using the TR or the TI methods. The next types of PAPR reduction techniques are the so-called Multiple Signal Representation (MSR) such as the PTS and the SLM techniques which will need high complexity as well as some bits of side information.

In this paper, a novel and simple technique has been proposed to reduce the PAPR problem in the OFDM system based on an adding a complex integer scaling factor of zero resultant to the data vector prior to the Inverse Discrete Fourier Transform (IDFT) (using its fast version IFFT). A channel coding will be needed to diminish the BER, but it must not add more bits as a redundancy to the data vector, so that, the Discrete Fourier Transform (DFT) matrix will be used as a data protector as will be shown in the next section.

The rests of this paper are organized as follows; section II is the basics of OFDM system with a definition of the PAPR problem and simple introduction to the SLM method. The suggested method will be drawn in section III with its computational complexity analysis, section IV will give the simulation results and an extensive discussion, while the conclusions will be written in section V before the references.

II. BASICS OF OFDM MODULATION TECHNIQUE

An OFDM symbol consists of N orthogonal subcarriers, where each subcarrier has been modulated by a randomly generated symbols of M-level Quadrature Amplitude Modulation (M-QAM), $X(k)$, can be expressed as.

$$x(n)=\sum_{k=0}^{N-1} X(k) e^{j2\pi\frac{kn}{N}} \quad (1)$$

Where $X(k)$ is the modulating data and m,n = 0,1…N-1. The produced data, $x(n)$, are statistically independent, which will be added either destructively (which is the required goal) or constructively, this last case will lead to high-output peaks called Peak to Average Power Ratio (PAPR) which can be defined as,

$$PAPR = \frac{\max\left|x(n)\right|^2}{E\left[x(n)^2\right]} \tag{2}$$

The signal at its continuous time version (analog) does not need to do any other operations to capture the high PAPR event's values properly. However, at the discrete time version, it needs to be up-sampled by a factor of $L \geq 4$ before passing it to the IFFT block [8]. Using the Cumulative Complementary Distribution Function (CCDF) of the PAPR, it is possible to capture the events of occurrences of the high PAPR values [8],

$$CCDF(PAPR) = \Pr(PAPR > PAPR_o) \tag{3}$$

Now, it is possible properly see the high peaks of the output signal without need t convert it to analog.

Many techniques have been suggested to reduce the PAPR such as the SLM as mentioned previously. It is simply multiplying the data vector by predefined phase rotation vectors of length equals to the data vector length. The phase rotation vectors indexed as p_1, p_2, … p_U. The resultant rotated data vectors $X_u(n)$, will be converted to the time domain using the IFFT block so that, the SLM-method needs U-IFFT blocks. The produced OFDM symbol ($OFDM_u$) with the minimum PAPR will be sent to the receiver with its corresponding phase rotation vector's index u as side information.

III. SUGGESTED TECHNIQUE

To reduce the probability of high PAPR events, an additive scale will be added to the first four samples of the data vector before the IFFT processes. These additive scaling factors have a resultant equals to zero as explained in Fig. 1. Hence; the real and imaginary parts r□ (□r) = 0 and jr□ (□jr) = 0. This factor must be an integer and less than or equal to 25 ($1 \leq r \leq 25$). More than 25 will cause high BER. So, the new samples after adding these factors will be,

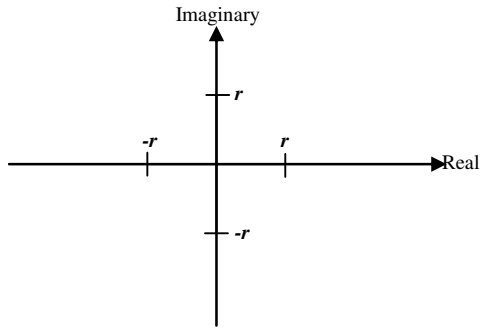

Fig. 1 Explaining the zero resultant scaling factors

$$X_{\text{mod}}(n) = X_{16QAM}(n) + (j)^n r\Big|_{n=0,1,2,3}$$

Hence,

$$X_{new}(n) = X_{\text{mod}} + X_{16QAM}(n) \qquad n = 4,5,...N-1 \tag{4}$$

Although the selected values of r were real and integers, still there is some BER occurs. There are many techniques to do the channel coding to save the samples from any distortion such as [9]. The channel coding methods can be used only when the data are binary or integers but the current case is neither binary nor integers. They are complex values ($\mathbb{C}$); it is needed to protect such data. In fact, our proposed method to reduce the PAPR was suggested originally to ignore any side information with reduced complexity, so that, the conventional channel coding methods cannot be applied to our method. The best way to protect the data is by using the DFT matrix as a channel coding but without the redundancy bits [9]. For this, the data before it modified as in Eq. 4, they will be passed to the DFT (which is implemented using its fast version (FFT)) block,

$$X_{fft} = FFT(X_{16QAM}) \tag{5}$$

Then they will undergo the modification or the addition of the r–factor,

$$X_{\text{mod}}(n) = X_{fft}(n) + (j)^n r\Big|_{n=0,1,2,3} \tag{6}$$

Hence, the final form of the signal will be,

$$X(n) = X_{\text{mod}} + X_{fft}(n)\Big|_{n=4,5,...N-1} \tag{7}$$

Eq. 7 shows the last form for the data vector. It is clearly that $X(n)$ is now differed from the original data $X_{16QAM}(n)$ and the generation of the OFDM symbol can be implemented starting from Eq. 7. At the receiver, the same procedures must be followed.

On the other hand, this novel method needs very low mathematical computations if it compared to the SLM–technique. The reduction in the complexity came from the elimination of the extra U-IFFT blocks required by the SLM method. The suggested technique has only one FFT/IFFT blocks and four operations of addition, so that, the total number of multiplications can be calculated as follows:

$$mul = \left(\frac{N}{2}\log_2 N\right)_{fft} + \left(\frac{N}{2}\log_2 N\right)_{ifft}$$

From which,

$$mul = N\log_2 N \tag{8}$$

While the total numbers of addition operations are (4-for the addition of r–factor, 1–FFT/IFFT),

$$add = (4)_{r-factor} + (N \log_2 N)_{fft} + (N \log_2 N)_{ifft}$$

Then

$$add = 4 + 2N \log_2 N \quad (9)$$

In contrast to the SLM-method, more operations are needed both in multiplications and additions operations as stated in the following equations;

$$mul_{SLM} = U \cdot N\left(1 + \frac{1}{2}\log_2 N\right) \quad (10)$$

$$add_{SLM} = U \cdot N \log_2 N \quad (11)$$

Where U is the total number of phase rotating vectors. For example, let N =512 (as in our simulation), and let U = 8, then, the number of multiplications will be 4608 and 22528 for the suggested and the SLM methods respectively. In other words, an 80% reduction in the number of complex multiplications operations has been gained. Second, the number of addition operations will be 9220 and 36864 respectively for the suggested and the SLM techniques, so, 75% reduction has been gained in the addition operations. It can be concluded that the operation of this method is just changing the probability of high PAPR through the changing of the data distributions, where they will be (some of the samples) transformed from quarter to another in the complex plane as will be shown in the next section.

IV. RESULTS AND DISCUSSION

The simulation parameters were; N = 512, 16QAM mapping, and the scaling factor r will be chosen to be 1 although it did not get much difference if it be higher than 1 in the PAPR reduction. The simulated OFDM symbols will be more than 15600. It can be seen in Table 1 that the original values of the quarter's contents have been changed to get a new location in the complex plane.

Before going deep in the discussion of these results, a simple clarification related to the results in Table 1 and all the other OFDM symbols (more than 15600) must be shown here from the statistics and probability point of view.

From Table 1, it is seen that for the first OFDM symbol, the quarter contents are; for the first quarter ($Q1$) includes 141 samples. The second quarter ($Q2$) contains 127 samples. The third quarter ($Q3$) has 117 samples while the last quarter ($Q4$) filled with 127 samples of the 512 samples of the OFDM symbol with $PAPR_o$ of 13.975 dB. After getting the modification, the quarter contents have been changed to be for the first to fourth quarters ($Qn1$ to $Qn4$); 122, 134, 136, and 120 samples, respectively with reduced $PAPR_n$ of 8.561 dB. Let's see another OFDM symbol, say the fifth in Table 1. There are 117, 123, 141, and 131 for $Q1$ to $Q4$ respectively with $PAPR_o$ equals to 12.469 dB, they changed to 125, 127, 133, and 127 samples for $Qn1$ to $Qn4$ respectively with $PAPR_n$ equal 8.625 dB.

It is clear in Table 1 that the old $PAPR_o$ span between ~14 dB to ~11 dB, while the new $PAPR_n$ span between ~9 dB to ~ 8.5 dB. If the mean value of all the simulated OFDM-symbols calculated, it will be 12.574 dB and 8.573 dB for the original and the new PAPR values respectively; hence, the corresponding variances from these mean values are 0.96 and 0.047 respectively as shown in Fig 2. Fig. 2 is the probability plot for the normal distribution for old and new PAPR values showing the mean and the variance of them.

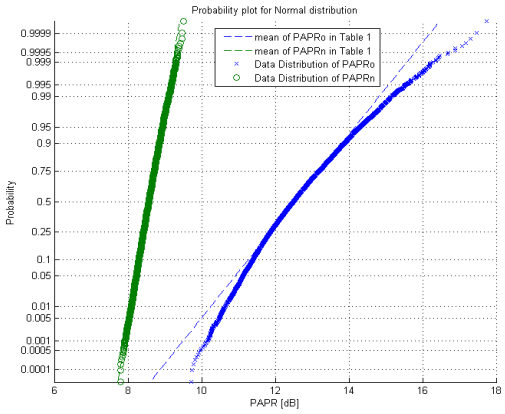

Fig. 2 Mean and variance of the old and the new PAPR versus the PAPR

TABLE 1.Quarter's contents for a sample of 10–OFDM symbols.

#	*Q1*	*Qn1*	*Q2*	*Qn2*	*Q3*	*Qn3*	*Q4*	*Qn4*	$PAPR_o$	$PAPR_n$
1	141	122	127	134	117	136	127	120	13.975	8.5609
2	134	118	120	127	124	139	134	128	13.525	8.9326
3	114	133	114	140	143	124	141	115	11.359	8.5178
4	138	132	122	143	119	125	133	112	12.509	8.4941
5	117	125	123	127	141	133	131	127	12.469	8.6248
6	132	140	131	135	125	118	124	119	13.631	8.8058
7	118	123	124	116	139	135	131	138	14.024	8.5703
8	122	131	129	144	135	126	126	111	12.899	8.4883
9	147	130	130	113	110	128	125	141	11.364	8.6265
10	119	131	136	130	138	126	119	125	13.516	8.5387

The peak values (the numerator of Eq. 2) have been captured also, and their mean was found 4.523 dB and 12.524 dB for the original and the suggested method respectively. The corresponding variances were 1.0097 and 0.00013 respectively. It is concluded that the output PAPR range doesn't span too much away from the mean value which it means a good achievement for the suggested method.

An important test has been done using the new method which is the all zeros or all ones samples where this will lead to a very high PAPR (constructive addition). The suggested method gives an interesting result; the results were reduced from the maximum values of around 20 dB to 12.5 dB (for the peak values not the PAPR) which are approximately near to the mean value of the peaks. This is another achievement in our proposed technique.

Fig. 3 shows the PAPR of the original and the proposed method. It is obvious that the PAPR has been reduced from 12.5 dB to 9.5 dB without put more complicated operations to the system. So that, there is ~3 dB reduction in the PAPR with only 4608 operations of complex multiplications and 9220 operations of additions. On the other hand, the BER was not affected as we have used the DFT matrix as a data protector without the need to the redundancy bits or the decoding algorithms which will add more complexity at the receiver as given in Fig. 4. The two curves are matches each other (the BER of the original and the suggested systems).

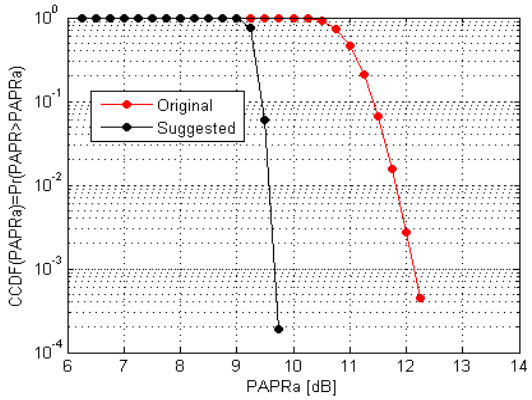

Fig. 3 PAPR comparison of the original and the proposed method

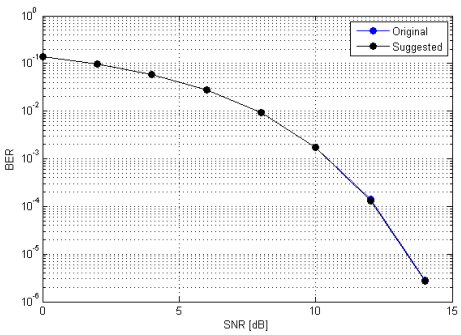

Fig. 4 Bit Error Rate of the two systems.

V. CONCLUSIONS

An additive scale factor (r) of zero resultant has been added at the boundaries of the four axis of the complex plane. The r–factor is to reduce the PAPR; it has been implemented in this work, and it has been shown that 80% and 75% reduction in the total number of multiplications and additions respectively have been achieved. It is known that the change in the minimum distance between the constellation points will reduce the BER performance. A novel suggestion was used in this paper, which is the utilization of the DFT as a coding technique, to get away from the redundancy bits of the conventional channel coding methods. The suggested method (additive scaling factor) does not need side information as in the SLM-method. At the same time, the PAPR has been reduced around 3 dB.

The new method deals with the very high peaks due to the all-zero's or all one's data vectors and reduces them to near the mean value. The computational complexity has been reduced too much compared with the SLM. No restrictions on the type of the mapping techniques in this method, where any mapping such as the M-PSK or M-QAM can be used with no problems.

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Strategic Planning for Effective School Governance in Romania

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Abstract *– In educational setting, learning communities work to enhance curriculum and instruction, and focus on students. Present paper presents the framework for a strategic plan necessary for efficient school governance in Romania. Following a comprehensive analysis of the scholing environment which identifies the determinants of the lack of performance of the romanian students, we formulate strategic objectives and directins necessary for good governance of Romanian school.*
Keywords: *school governance, learning communities*

I. INTRODUCTION

School governance includes all the principles, models and practices that enable a school board to effective direct the working of the school. School governing bodies have taken out more responsibilities and their role has become more important as school have gained increasing autonomy.[1] The governing body complements and enhances school leadership by ensuring that all statutory duties are met, appointing the headteacher and holding them accountable for the impact of the school's work on improving the outcomes for all pupils[2]. School governance means efficiency, a holistic approach people-centered and performance oriented creating sustainable growth and promoting harmonization through informed decision making, accountability and ownership

Starting with the 1970s there has been a plethora of studies focusing on effective school governance and on defining the outcomes desirable in shaping the "concept of school as community" [3]. As Kubiak (2003) shows, more recent literature on communities of learning in education explicitly operates with concepts of strategic management following the framework of strategic planning. [4] Thus, the existing studies shows that effective schools need to conduct an environmental scanning as the schooling environment steers everywhere educational processes influencing the educational governance. School governance implies defining the vision and strategic objective of the school and developing adequate programs necessary to build and effective learning community. All these require that schools leaders and governors make use of the concepts and methodology of strategic management. Moreover adequate managerial skills are required *to optimize* the use of limited resources and produce high quality education opening the school to the civil society.[5]

In what follows I will therefore present a strategic plan necessary to build effective school govrnance in Romania. The environmental scanning identifies the determinants of the lack of performance of romanian students, testing two hypothesis. First hypothesis is that the lack of results is attributable to poor resourses in the system. The second hyphotesis is that the lack of perfromance is attributable to inadeqaute stering mechanisms in the system.

II. THE FRAMEWORK OF STRATEGIC PLANNING

School governance implies defining the vision, specific objectives and strategies, conducting comprehensive analysis of the school's internal and external environment and implementing programs to operationalize the defined strategies. All these are concepts specific to strategic management. Obviously an adequate understanding of the basic model of strategic management and its concepts is necessary in order for the school governors and leaders to apply them in developing and building an effective learning community.

There is a consensus in the existing literature that the process of strategic management (known also as strategic planning) consists of the following elements:

- Environmental scanning: The process of strategic management begins with a comprehensive scan of the environment of the organization called strategic diagnosis.
- Mission statement: A mission statement defines the purpose of the organization, succinctly describing why the organization exists.
- Identifying strategic objectives: While mission statement tends to address questions concerning the

organization's reason for being, strategic objectives are broadly defined objectives, which explicitly state the organization's objectives in terms of the results it wants to achieve in the long term

- Defining strategy: Strategy formulation is the development of long-range plans necessary to achieve the desired outcome. The procedural approach to strategy dates back to 1970's. It was this approach which has places the environmental scanning at the beginning of the strategic management process. Thus, environmental scanning is necessary to gradual adjustment of habits and routines to the ongoing changes in the environment that is to identify adequate strategic objectives and relevant strategies to achieve the proposed objectives.
- Strategy Implementation: is the translation of chosen strategy into organizational action so as to achieve strategic objectives. Organizational structure allocates special value developing tasks and roles to the employees and states how these tasks and roles can be correlated in order to maximize competitive the advantage.
- Evaluation, control and feedback: The organizational structure is not sufficient in itself to motivate employees. An organizational control system is also required. This control system equips managers with motivational incentives for employees as well as feedback on employees and organizational performance.

III. STRATEGIC PLAN NECESSARY FOR SCHOOL GOVERNANCE IN ROMANIA

In 2006 OECD has conducted a study for assessing international student attainment (PISA). According to PISA, the perfromance of romanian students is well bellow OECD average, as shown in Table 1.

TABLE 1. Performance of Romanian Educational System

Country	Mean Readings	Mean Mathematics
	Score	Score
Romania	*395.93*	*414.80*
Greece	459.71	459.20
Italy	468.52	461.69
OECD Average	491.79	497.68
Netherlands	506.75	530.65

Source: OECD, PISA, 2006

We will conduct a comprehensive analysis of Romanian environment of educational system, aiming at identiying the determinants of the performance – or lack of performance – of romanain students. According to the literature on strategic management, the environment of Romanian education has two major components: external environment and internal environment. The external environment is the general context of educational system. Analysis of the internal environment of education has to address three broad issues: resources, participation and results of the education.

- Romanian context

The educational attainment depends on the development level of each country. Thereby a rich country can more easily afford to buy more education for its citizens.[6] One way to do this is by the level of direct education expenditure. Public education expenditure per student, public education expenditure as percentage of gross national income or public education expenditure as percentage of total governmental expenditure could therefore influence the characteristics of the educational systems. In order to assess the economic environment of schooling we have also to control for GDP per capita because education is costly and an ambitious educational policy is costly and governments might choose to subsidize education. [7] Besides economic context of schooling, demographic, cultural, religious and ethnic issues as well as increasingly worrying phenomenon such as immigration tend to shape the structure and functioning of educational systems. In addition, EU efforts to create the most competitive economy in the world have shaped the Member states' educational systems. All these influences made up the external environment of schooling. They corroborate to further determine steering and monitoring mechanisms which constitute the internal environment of schooling. We begin our analysis of the external environment of Romanian schooling by analyzing the economic aspects which impact on schooling attainment. There are huge economic discrepancies between Romania and the EU15. Romania has a GDP of 4200 Euro per inhabitant while the GDP per capita is 23000 for EU 27 and 27000 for EU15. At EU level only Bulgaria has a lower real GDP per capita (3500 Euro per inhabitant). General level of development directly determines the level of social exclusion. Romania reports in 2010 the highest relative proportion of people at risk of poverty at EU level (41.5% as compared to 23.4% at EU27 level or 14.4 in Czech Republic, 15.0 in Sweden or 14.9 in Norway). [8]

Political features and policies often corroborate with economic policies to condition education. In particular the existing literature underlines a relationship between type of welfare system and educational policy. Countries with state provision of welfare tended to have also broader goals for compulsory education (SGOLC Report on School Governance). In Romania the government has begun a comprehensive attack on the social state – actual president of the Republic has publicly announced the end of Romanian social state. This ideology has been articulated in economic policies and measures.

The existing literature on school governance underlines the role of religion and cultural diversity in the shaping of national educational systems. Private schools have been traditionally more developed in Catholic and countries that are heterogeneous from a cultural perspective. Romania is an orthodox country with some religious diversity especially in the western

part of the country and this is expected to influence its schooling realities.

Socio-demographic and ethnic issues are also affecting the functioning of any educational system. Population has decreased by over 1 million people from 1992 with a prognosis of almost 2 million decreasing by 2020. According to the Green Book Regarding Demography in Romania (2006) the young population (0- 14 years old) has decreased from 22.7 percent (in 1992) to 15.9 percent (in 2005). It is expected that population would decrease further on, namely by 1.8 million until 2020, especially regarding the young groups of population (10-24 years old). The demographic decline can be explained both through the natural negative surplus and through the negative surplus of the external migration. [9].

Although Romania is facing similar socio-demographic problems to those at European level, there are also issues specific to the actual Romanian context. In particular there has been lately increasing awareness in Romanian mass-media about the downside effects that the partial opening of western labor market to Romanians has on children left at home. Romanian Association for Social Alternatives recognizes that the prolonged absence of one or both parents may be associated with a series of problems, including educational neglect, proposing a methodology aimed at offering children left behind by parents that have chosen to work abroad adequate social, psychological and juridical assistance.

- Internal schooling environment

The economic structures, socio-demographic policies and developments and political ideology and orientation constitute the external environment of schooling, providing the general framework of educational process. Besides external environment, analysis of the school environment has to address the current situation in the educational system. This constitutes the so called internal schooling environment and has three components: resources, the main steering mechanism of good school governance and the current results in educational system.

Although it is generally accepted that education generates social net benefits and consequently governments might choose to simply "buy" more schooling for their citizens, investing more in education, this is not the case in Romania today since, after a general increasing trend reaching in 2007 a maximum of 4.25 percent of the public expenditure on education (as compared to 4.98 at EU27 level or 7.83 for Denmark), situation has deteriorated. Today is estimated that no more than 3 percent of the public expenditures are allocated to education. It is obvious that the ongoing reform of social policies in general and education in particular relies on costs reductions even with the price of shutting down schools and hospitals, regardless of the impact on local communities.

Unfortunately for Romania there is no available data concerning public education expenditure per student, public education expenditure as percentage of gross national income or public education expenditure as percentage of total governmental expenditure. Nevertheless the 2006 OECD PISA study provides an index of the quality of the school's educational resources. A comparative situation is presented in Tables 2 and 3.

TABLE 2. Quality of schools' educational resources

Country	All students	
	Mean Index	S.E.
Greece	-0.03	0.10
Italy	0.18	0.07
Netherlands	0.26	0.08
OECD Average	0.00	0.01
Romania	*-0.74*	*0.09*

Source: OECD, PISA, 2006

TABLE 3. Availability and quality of human resources

Country Name	Mean index	S.E.
Greece	-0.34	0.08
Italy	0.06	0.07
Netherlands	0.13	0.06
OECD Average	0.01	0.01
Romania	*-0.61*	*0.06*

Source: OECD, PISA, 2006

We see that PISA data confirms that Romanian education lacks adequate resources. This was anticipated by the precedent analysis of the general environment of Romanian Educational system. Lacking resources it is hard to get good results. Obviously we can assume that lack of resources do influence the outcome of Romanian educational system. Thereby we have found evidnece supporting the hypothesis that lack of resourses negatively impact the perfromance in the system. We continue the analysis of the determinants of schooling performance with an analysis of the possible impact of steering mechanism of good governance on schooling performance. In Romania centralization and decentralization are two essential pillars of reforming and restructuring the education. In Romania subsidies and transfers do exists even for private schools there by privatization can only partially transfer budgeting issues from national level to local level, alleviating the burden of central budget. The question is whether privatization is associated with schooling outcomes. Table 4 shows the difference in performance between private and public schools in selected countries.

Although data for Romania is not available for this issue, we can see in Table 4 that at OECD level, in average, private schools have obtained poorer results then public ones. This is also true for Netherlands and Greece although Italy seems to be an exception. Being an orthodox country Romania seems to have more in common with Greece. Although we do not have direct data we can infer from above analysis that privatization of Romanian school is not likely to improve

performance. To the contrary it is indirect evidence that shows that privatization will lead to poorer outcomes of Romanian schools.

TABLE 4.Difference in performance between private and public schools

Country Name	Results	
	Dif	S.E.
Greece	-76.28	7.09
Italy	17.72	18.25
Netherlands	-2.95	12.94
OECD Average	-24.93	2.79
Romania	*a*	*a*

Source: OECD, PISA, 2006

School policies and practices are also expected to affect schooling performance. OECD PISA study presents data concerning school admittance policies, assessment policies and practices and approaches to school management. Data on admittance policies is shows that academic record plays a central role in admittance in Romanian schools. From this perspective Romania is far better situated then average OECD countries. Student's residence, parent's endorsement and attendance of other family member of that school also determine the admittance policies but there are no significant differences between Romania and Netherland. The only admittance policy where Romania differs significantly from the other countries is a higher weight of student need or desire for a special program. We can infer that if there is 'a special need of the student 'that particular need has to be proved by existing records not by 'student desire for that program'.

Analysis of PISA databese als reveals that in Romania the responsibility for staffing decision belongs to national or local authorities (96%) whereas the school governing board comes second in importance (38%). We see that from this perspective in Romania the school's governing board plays less important role then in Netherlands (66%) but more important than in OECD (average 33.80%) or Greece (2.16%) or Italy (2.88%). Situation is somewhat similar for budgeting decisions. In Romania the school's governing board plays the most important role in budgeting decisions while local authorities comes second and things are the same for all countries in the analysis.

According to PISA database, in decisions regarding educational content national and regional authorities do have the first word in all the countries in the analysis and this is also true for decisions regarding assessment practices. So it seems that Romania is not different from countries with far better schooling outcomes in terms of those involved in decisions in education.

Yet it might be the case that Romania is different from other in the way decisions are used or, in other words, in terms of the criteria upon which decisions are taken. Indeed, PISA database shows that Romanian authorities have chosen not to report if allocating institutional resources is based on school's performance. Neither they have chosen to report if they use school performance in evaluating the principal's performance Lack of reporting is indirect evidence that resource allocation is not based on school's performance and also the principal is not hold accountable for schooling performance. Yet Romanian authorities are tracking very carefully the schooling performance over time and the information on schooling performance is made public.

IV. CONCLUSIONS

In the light of the previous detailed analysis of Romanian environment of schooling we identify students, parents, teachers, schools' governing bodies and local authorities as the stakeholders which have to be considered in our strategic effort to build good governance. Obviously Romanian schools lack quality resources. Recognizing the strategic importance of education in Romania will lead to finally allocating the financial resources while creating the incentives necessary to increase the quality of human resources in Romanian Education. Simply increasing the funding for education would not resolve the problems of inadequate human resources in the system. Adequate funds and incentive should address targeted toward increasing the quality of teachers in the system. A second strategic direction necessary for good governance of Romanian school should target a better management of the resources allocated to Romanian education. In this respect developing the managerial skills of managers is important although not sufficient. Yet finding the programs that will operationalize this strategy is not the object of present paper.

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Exploration Algorithm for a Mobile Robot Based on Two Infrared Sensors

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***Abstract* – This paper details an exploration algorithm for structured and partially unstructured environments based on two infrared sensors and a typical mobile robot. Simulation results using a mobile robot validate the proposed approach.**

***Keywords:*- mobile robot, infrared sensors, exploration algorithm, behaviors**

I. INTRODUCTION

An autonomous or semi-autonomous mobile robot is an assembly composed of: the basic chassis, locomotion system, object handling system, batteries, sensors, communication system, etc., whose actions are controlled and supervised by a microcontroller. In this way the robot is able to perform a series of actions, such as:

- locomotion on wheels, legs, or wings,
- manipulation with one or several mechanical arms, grippers and hands,
- localization with odometers, sonars, laser, inertial and GPS sensors,
- scene analysis and environment modeling with a vision system.

The most common tasks that can be achieved by mobile robots, are: in industry (painting, welding, loading/unloading heavy components or other assembling parts), in servicing (in a store, a warehouse or a factory for maintaining, surveying, cleaning the area or transporting objects), exploring an unknown natural area, (planetary exploration, building a map with characterized landmarks, extracting samples and setting various measurement devices, assisting a person (in an office, a public area, or at home), performing tele-operated surgical operations, as in the so-called minimal invasive surgery.

The robots are often planned from the outset on the basis of a program which is written in a memory of microcontroller or accessible by them. The microcontroller will do step by step the written instructions in the program. Of course, because the mobile robots are equipped with sensors to detect obstacles or to detect target objects, the microcontroller will take into account, in planning robot actions, the information provided by them.

However a robot action planning is quite complex as compared to other application domains of planning, due mainly the need to handle:

- online input from sensors and/or communication channels;
- heterogeneous models of the robot environment as well as noisy and partial knowledge from information acquired through sensors and communication systems;
- direct integration of planning with acting, sensing, and learning.

There are various forms of robot planning, like: path and motion planning, perception planning, navigation planning, manipulation planning, and domain independent planning [1]. The path planning problem is to find a feasible geometric path in some environment for moving a mobile robot from a starting position to a goal position. A geometric model of the environment with the obstacles and the free space is supposed to be given. A path is feasible if it meets the kinematics constraints of the mobile robot and if it avoids collision with obstacles. The motion planning problem is to find a feasible trajectory, in space and time, and a control law along that path that meets the dynamics constraints (speed and acceleration) of the mobile robot.

From the above forms of planning the perception planning is a younger and much more open area, although some problems of them are well advanced, e.g. the viewpoint selection problem with mathematical programming techniques [2].

There are many mobile-robot applications that require the complete coverage of an structured or unstructured environment. Examples are humanitarian de-mining, floor-cleaning tasks, exploring an unknown area, etc. An exploration algorithm is then used, a path-planning technique that allows the robot to pass over all points in the environment, avoiding unknown obstacles. Different exploring algorithms exist, but they used many type of sensors and sophisticated mobile robots.

In [3] the environment is divides into a finite number of regions called cells, which are free of obstacles. A cell can then be swept by a simple zigzagging pattern of motion in which the robot moves back-and-forth along successive grid lines that sweep across the entire field

from left to right. Two different types of critical points can be found: an IN critical point closes an existing cell and opens two new ones; an OUT critical point closes two existing cells and opens one new cell. Then, the complete coverage of the field is guaranteed by means of an adjacency graph, which assures that every cell is visited.

The outline of the paper is as follows: first, Section 2 describes the exploring algorithm and the type of robot which will be used. Then, Section 3 briefly reviews about the mobile robot Robby RP5 and shows some results obtained after the algorithm was testing. Lastly, Section 4 presents some conclusions.

II. PRESENTATION OF THE ALGORITHM

In the following, an algorithm for displacement of a mobile robot to explore an area will be presented (Fig. 1). It is assumed that the surface is rectangular and this is fenced.

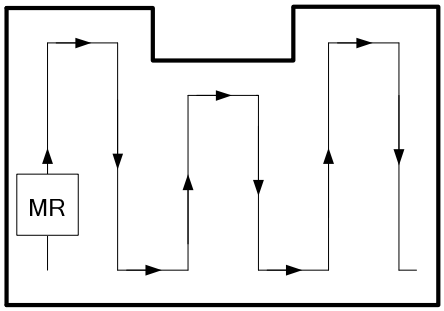

Fig. 1. Exploration mode of the surface.

The mobile robot is equipped with two infrared sensors, mounted in front, to detect the edge of the surface (see Fig. 2). The robot will begin exploring by parallel motion to one of the edge. When that meets the perpendicular wall it will make 90 degree rotation, then a forward movement, then another 90 degree rotation, then it will continue to move ahead. The robot will repeat these operations until it explore all the available space.

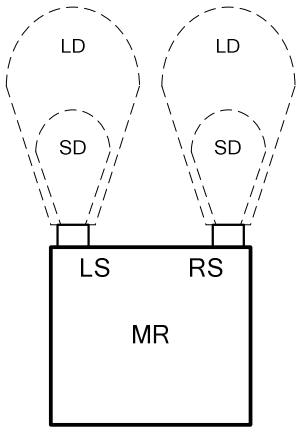

Fig. 2. The position and the area covered by sensors.

The robot will know that it has reached the opposite wall from which the movement has begun, when after the first rotation of 90 degrees, the both sensors will detect an obstacle.

There are situations when only one sensor detects an obstacle; the robot will work around that obstacle. The main actions of the robot in order to explore the surface are presented in Fig. 3.

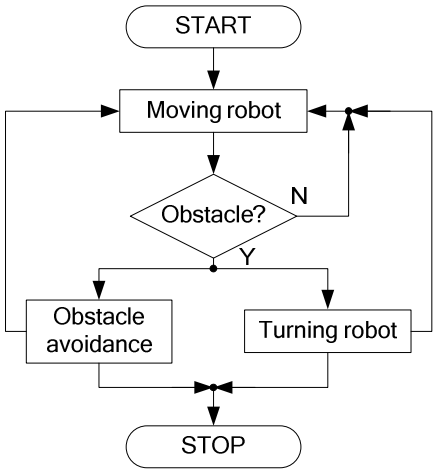

Fig. 3. The main actions of the robot.

For the robot to go through the available space in a short time and at the same time avoiding the edge of the surface or another possible obstacle a variable speed of its is necessary. Its speed must be low (LS – low speed) when it is situated near the edge of surface and fast (HS – high speed) otherwise.

The detailed flowchart from which the robot movement is achieved is shown in Fig. 4. At first the ACS system (Anti Collision System) is set for a long distance (LD) (see Fig. 2). If the robot does not detect any obstacle in front of, then its speed will be set on high speed (PWM setting at high speed). When an obstacle is detected (in this case the edge of the surface) its speed will be set on low speed (PWM setting at low speed). Depending on the position of the obstacle (left - L, right - R or both – R&L) the variable e will be changed to 0 or 1. Further, the ACS system will be set for a short distance (SD) and the robot will continue its slow movement.

The robot can be a rectangular area or a circular area of width/diameter Wr. When the robot detects obstacles in front (the surface edges) it will turn left (TL) or right (TR) 90 degrees depending on the previous rotation (the value “e”). Then it will move forward with a distance Wr and again rotate 90 degrees in the same way. Next the robot will move to the opposite side of the surface. If after the first rotation of 90 degrees or after the movement with “Wr”, the IR sensors detects any obstacle the exploration process will end.

If only one sensor detects an obstacle, $RxL \neq 1$, (a small obstacle or a part of a larger one) then the robot will avoid it then will continue to move.

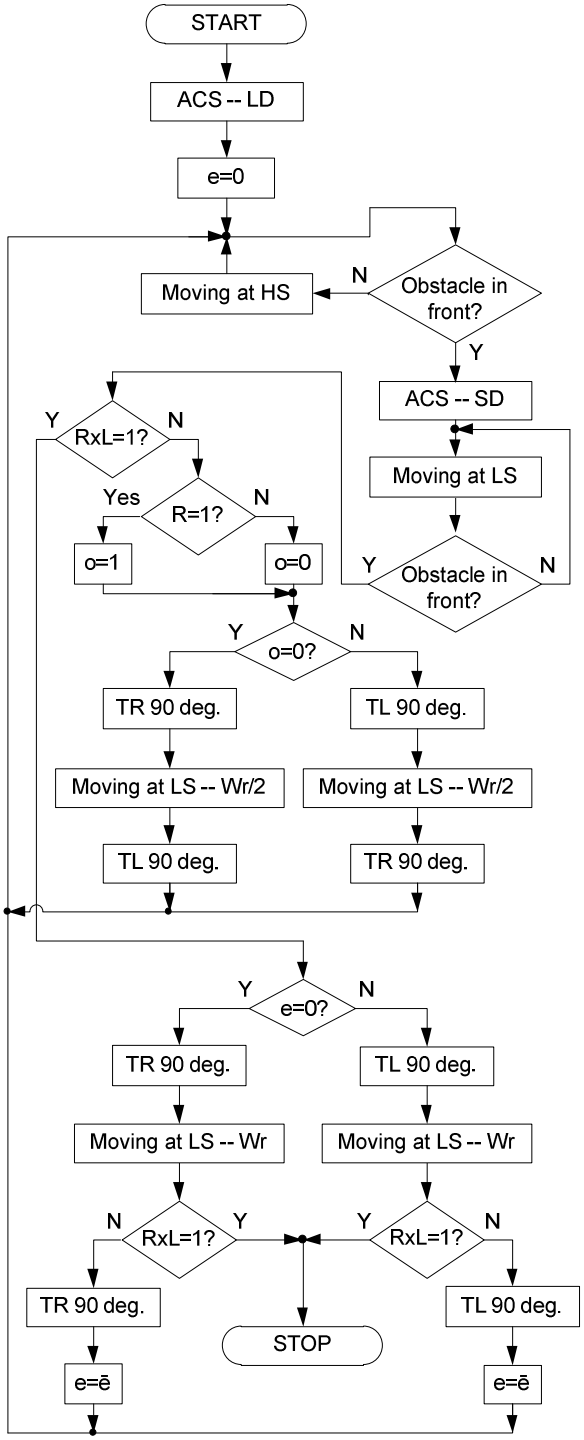

Fig. 4. The movement flowchart of the robot.

The obstacle can located on the right side (o=1) or on the left side (o=0), respectively.

Basically, the robot performs the task of exploring the area based on eight behaviors:

- ACS → LD,
- ACS → SD,
- Moving at HS,
- Moving at LS,
- Moving at LS → Wr,
- Moving at LS → Wr/2,
- TR 90 deg.,
- TL 90 deg.

The mobile robot will activate one of these seven behaviors depending on the presence or absence of obstacles in its path.

Moving behaviours-based of a mobile robot has the advantage of a quick reaction and thus speeds of movement and achieving tasks.

III. TESTING OF THE ALGORITHM

The algorithm proposed in the paper was tested using the miniature mobile robot Robby RP5 (see Fig. 5). The locomotion system of the robot is composed from two symmetrical trays [4]. Both of the DC motors and the spur gear transmissions are integrated therein. The wheel axles and drive shafts are supported in sintered bearings. Two independently controllable electric motors ensure highest mobility of the chassis.

The robot uses the D/A converters, in this case better referred to as PWM outputs, to switch the drive motor voltage, so that, the speed and direction of each track is freely controllable.

As can be seen in Fig. 5 the mobile robot is equipped with two IR sensors, for obstacle detection, each of them composed from an emitter and a receiver [5],[6]. The distance of area covered by the sensors can be set up on three levels: 30, 60 or 100 cm, respectively.

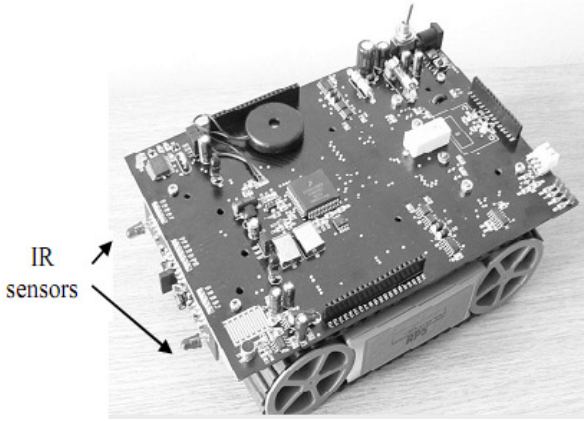

Fig. 5. The mobile robot Robby RP5.

The microcontroller on the robot is a computer of the C-Control series *(M68HC05)*. It allows programming in the BASIC programming language. Through a few lines of BASIC (simplification variant CC-BASIC) source code the computer is able to handle a task like the "brain" of a small autonomous mobile robot.

The signals given by IR sensors (LS and RS), (Fig. 2) are directed to microcontroller inputs and the signals commands are used for speed control of DC motor drive. In the same time these signals can be used to turn the mobile robot with different turning radius.

The developed BASIC program, determining the actions and reactions of the robot, will be translated into

a sequence of command bytes by the compiler. The commands and the related parameters may then be transferred via serial interface to the microcontroller, and stored into the EEPROM memory (24C65). The interface connection between PC and robot is only necessary while uploading the program. When the robot is programmed (the program was transferred or uploaded into robot memory), it may be disconnected before starting the robot.

An example of area exploration in which two obstacles are placed, is presented in Fig. 6. Of course, the obstacles cause the appearance of small areas uncovered and same areas that are covered twice by the robot.

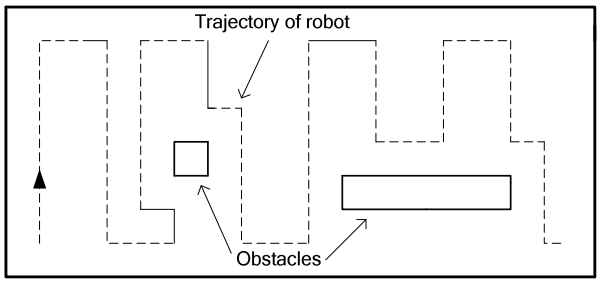

Fig. 6. Example of a surface exploration.

Unfortunately, if robot's rotation is not achieved at 90 degrees (due to surface, that the robot is moving), errors occurring in its displacement (see Fig. 7).

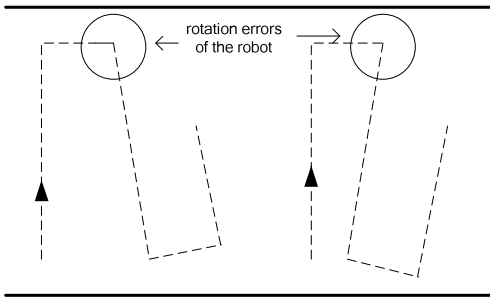

Fig. 7. Displacement errors of the robot.

III. CONCLUSIONS

The environment surface is important to complete safety navigation because the slippage of the robot's wheels can be appearing (especially at 90 degrees rotation). A good positioning of the robot can be obtained if the odometer sensors or other sensors are used.

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An Integrated Framework for Business Process Re-engineering in Multi-agent Systems

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Abstract **– *Multi-agent Systems (MAS) technology provide general architecture for a multilayer feedforward neural network to structure, coordinate and to model nonlinearities common in an integrated social-technical-economical system. The paper proposes to model a re-engineering process in a complex system approached by means of Multi-agent Systems organization. The case study validates the effectiveness and suitability of methodology which evaluates a systems' performance in the multi-domain hierarchical environment encompassing economical, social and technical/operational fields.***

Keywords: ***multi-agent Systems; socio-technical-economical system (STES); real-time constraints; a multilayer feed forward neural network; nonlinear model.***

I. INTRODUCTION

An organization, regarded as an integrated socio-technical-economical system (STES), has to face external and internal market environment changes along with adapting its products/services to the consumers' needs and want, in the context of real-time and resources constraints. A STES, approached with multi-agent paradigm, is a dynamically changing set of autonomous, heterogeneous, collaborative agents.Each component of a complex system can be defined, design and operated as a sequence of interconnected agents. Handling the accumulated information provided by company's internal and external environment analysis, can be commanded and controlled a set of agents that fulfils same well-targeted goal.

The multi-agent abstraction allows the decomposition of complex system in interrelating components each represented by an agent, as self-organized, flexible and autonomous entity. Autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in this environment and by doing so realize a set of goals or tasks for which they are designed [1].

– The integration and cooperation between individual agents according the belief and goal of the agents, defined the collective agents which share the same goal or common task as a multi-agent system, thus:

– multi-agent environments provide an infrastructure specifying communication and interaction protocols;

– multi-agent environments are typically open and have no centralized designer;

– multi-agent environments contain agents that are autonomous and distributed, and may be self-interested or cooperative [4].

In multi-agent systems, the agents can function as intelligent application programs, active information resources, and will be knowledgeable about information resources that are local to them, and cooperate with other agents to provide global view of the particular management information.

Multi agent technology is applied by intelligent systems to solve the problems of analysis of complex systems and intelligent management activities. Intelligent Multi-agent Systems (MAS) based learning combine collection of information from their environment, recognition data, intelligent classification data and prediction future data, storage data, delivery data to knowledge management systems such as Decision Support System (DSS) and Management Information System (MIS) [5].

When adapting agent technology to complex system, the collaboration between agents integrates local knowledge, effective to obtain a broader basis for decision support. The uncertain and incomplete knowledge which comes from the complexity, instability, or unknown factors of the managed system and the dependency between the management components or correlated management events are aspects added to form a global view of the whole system.

II. TAXONOMY

An intelligent agent is a hardware or (more usually) software-based computer system that enjoys the following properties [2, 4, 5]:

– autonomy: agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state;

– social ability: agents interact with other agents (and possibly humans) via some kind of agent

communication language. IA has capability of interacting with other agents for negotiation and/or cooperation to satisfy their design objectives;

– reactivity: agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, or all of these combined), and respond in a timely fashion to changes that occur in it intelligent agents receive information of its environment by its sensors, changes internal design objectives of its structure and has suitable actions with feedback periodically;

– pro-activeness: agents do not simply act in response to their environment, they are able to exhibit goal directed behavour by taking the initiative intelligent agents can show goal directed behavior by taking the initiative, responding to changes in their environment in order to satisfy their design objectives;

– mobility: this refers to the agents' capability of transporting their execution between machines on a network. This form of moving can be physical, where the agent travels between machines on a network, or logical, where an agent which is running on a single machine is remotely accessed from other locations on the Internet;

– collaboration: collaboration among agents underpins the success of an operation or action in a timely manner. This can be achieved by being able to coordinate with other agents by sending and receiving messages using some form of agent communication language, and permits a high degree of collaboration, thus making social activities such as distributed problem solving and negotiation possible. Moreover, it is possible for agents to collaborate without actual communication taking place. The interaction of agents with resources and their environment may lead to the emergence of collaborative or competitive behavior;

– veracity: this refers to the agent's ability to deceive other agents via their messages or behavior. An agent can thus be truthful in failing to intentionally deceive other players. Moreover, an agent that is untruthful may try to deceive other agents, either by providing false information or by acting in a misleading way;

– disposition: this refers to the agent's "attitude" towards other agents, and its willingness to cooperate with them. An agent may always attempt to perform a task when asked to do so (benevolent), or may act in its own interests to collaborate with other agents only when it is convenient to do (self-interested), or it might try to harm other agents or destroy them in some way (malevolent).

The properties of an agent are summarized in the table 1 [3].

Table 1. Properties of agents

Property	Property	Meaning
Reactive	sensing and acting	responds in a timely fashion to changes in the environment
Autonomous		exercises control over its own actions
Goal-oriented	pro-active, purposeful	does not simply act in response to the environment
Temporally continuous		is a continuously running process
Communicative	socially able	communicates with other agents, perhaps including people
Learning	adaptive	changes its behavior based on its previous experience
Mobile		able to transport itself from one machine to another
Flexible		actions are not scripted
Character		believable "personality" and emotional state

Agents may be usefully classified according to the subset of these properties that they enjoy. Every agent, by our definition, satisfies the first four properties. Adding other properties produces potentially useful classes of agents, for example, mobile, learning agents.

Agent refers to an entity that acts on behalf of other entities or organizations; and Multi-Agent System consists of several agents with capable of common interaction with selforganization. The structure of multi-agent system encompasses [6]:

Actions: Responsing of agent in front of environment events and changes,

Percepts: Accumulating information from the environment,

Events: Processing of updating beliefs and to operate actions,

Goals: Considering objectives of system to accomplish and can be updated,

Beliefs: Handling accumulated information about the environment,

Plans: Using plan library for handling events and achieve goals,

Messages: Necessary for agents to interact,

Protocols: Rules of interaction.

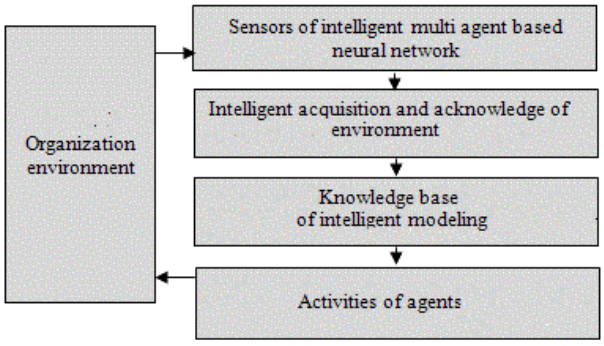

Fig.1. A multi-agent system model

II. STRUCTURE OF MULTI-LAYER NEURAL NETWORK

A generic artificial neural network can be defined as a computational system consisting of a set of highly interconnected processing elements [7]. The inputs

received by a single processing element can be represented as an input vector $\mathbf{A= (a_1, a_2,\dots a_n)}$, where $\mathbf{a_i}$ is the signal from the i*th* input. A *weight* is associated with each connected pair of neurons. Hence weights connected to the j-*th* neuron can be represented as a weight vector of the form $\mathbf{W_j= (w_{1j}, w_{2j}, \dots, w_{nj})}$, where $\mathbf{w_{i\ j}}$ represents the weight associated to the connection between the processing element $\mathbf{a_i}$, and the processing element $\mathbf{a_j}$. A neuron contains a threshold value that regulates its action potential. While action potential of a neuron is determined by the weights associated with the neuron's inputs a threshold modulates the response of a neuron to a particular stimulus confining such response to a pre-defined range of values factor is given by equation 1:

$$SUM = \sum_{i=1}^{n} x_i w_i \tag{1}$$

The output *y* of a neuron as an activation function *f* of the weighted sum of *n+1* inputs. These *n+1* correspond to the *n* incoming signals. The threshold is incorporated into the equation as the input :

$$y = f\left(\sum_{i=0}^{n} x_i w_i \right) \tag{2}$$

$$f(x) = \begin{cases} 1 \; if \; \sum_{i=1}^{n} x_i w_i > 0 \\ 0 \; if \; \sum_{i=1}^{n} x_i w_i \le 0 \end{cases} \tag{3}$$

An artificial network performs in two different modes, learning (or training) and testing. During learning, a set of examples is presented to the network. At the beginning of the training process, the network deducts the output for each example. However, as training goes on, the network modifies internally until it reaches a stable stage at which the provided outputs are satisfactory. Learning is simply an adaptive process during which the weights associated to all the interconnected neurons change in order to provide the best possible response to all the observed stimuli. Neural networks can learn in two ways: supervised or unsupervised. The network is trained using a set of input-output pairs. The goal is to 'teach' the network to identify the given input with the desired output. For each example in the training set, the network receives an input and produces an actual output. After each trial, the network compares the actual with the desired output and corrects any difference by slightly adjusting all the weights in the network until the output produced is similar enough to the desired output, or the network cannot improve its performance any further.

The network is trained using input signals only. In response, the network organises internally to produce outputs that are consistent with a particular stimulus or group of similar stimuli. Inputs form clusters in the input space, where each cluster represents a set of elements of the real world with some common features. In both cases once the network has reached the desired performance, the learning stage is over and the associated weights are *frozen*. The final state of the network is preserved and it can be used to classify new, previously unseen inputs. At the testing stage, the network receives an input processes it to produce an output. If the network has correctly learnt, it should be able to *generalise*, and the actual output produced by the network should be almost as good as the ones produced in the learning stage for similar inputs.

Neural networks are typically arranged in layers. Each layer in a layered network is an array of processing elements or neurons. Information flows through each element in an input-output manner. In other words, each element receives an input signal, manipulates it and forwards an output signal to the other connected elements in the adjacent layer. A common example of such a network is *the Multilayer Perceptron* (MLP) (Fig. 3).

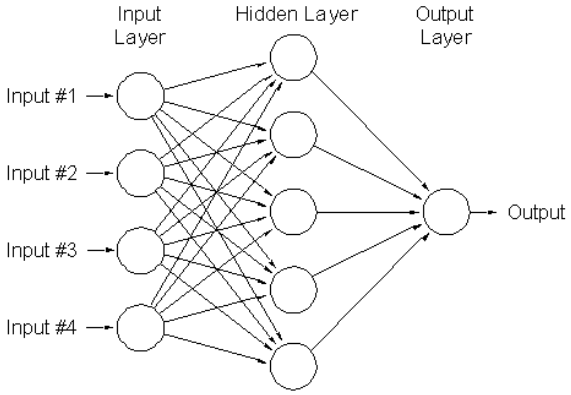

Fig.1. A feedforward artificial neural network model that maps sets of input data onto a set of appropriate output

MLP networks normally have three layers of processing elements with only one hidden layer, but there is no restriction on the number of hidden layers. The only task of the input layer is to receive the external stimuli and to propagate it to the next layer. The hidden layer receives the weighted sum of incoming signals sent by the input units (Eq. 1), and processes it by means of an activation function. The activation functions most commonly used are the sigmoid (Eq. 4):

$$f(x) = \frac{1}{1+e^{-x}} \tag{4}$$

and hyperbolic tangent (Eq. 5) functions

$$f(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}} \tag{5}$$

The hidden units in turn send an output signal towards the neurons in the next layer. This adjacent layer could be either another hidden layer of arranged processing elements or the output layer. The units in the output layer receive the weighted sum of incoming signals and process it using an activation function. Information is propagated *forwards* until the network produces an output. network response to a presented input. The way in which these weights are adapted is specified by the learning rule. The most common rules are generalizations of the Least Mean Square Error (LMS)

rule (Eq. 6) , being the generalised delta rule or backpropagation, the most frequently used for supervised learning in feedforward networks. In supervised learning, a feedforward neural network is trained with pairs of input-output examples. For each input, the network produces an output. The accuracy of the response is measured in terms of an error E defined as the difference between the current o_p and desired t_p output. Weights are changed to minimise the overall output error calculated by equation 7:

$$E = \frac{1}{2}\sum_j \left(t_{pj} - o_{pj}\right)^2 \quad (7)$$

The error E is propagated backwards from the output to the input layer. Appropriate adjustments are made , by slightly changing the weights in the network by a proportion d of the overall error E. After weights have been adjusted, examples are presented all over again. Error is calculated, weights adjusted, and so on, until the current output is satisfactory, or the network cannot improve its performance any further. A summarized mathematical description of the backpropagation learning algorithm extracted from [9] has the following steps:

1. Present the input-output pair p and produce the current output o_p.
2. Calculate the output of the network.
3. Calculate the error d_{pj} for each output unit j for that particular pair p. The error is the difference between the desired t_{pj} and the current output o_{pj} times the derivative of the activation function $f'_j(net_{pj})$, which maps the total input to an output value:

$$\delta_{pj} = \left(t_{pj} - o_{pj}\right) f'\left(net_{pj}\right) \quad (8)$$

4. Calculate the error by the recursive computation of d for each of the hidden units j in the current layer. Where w_{kj} are the weights in the k output connections of the hidden unit j, d_{pk} are the error signals from the k units in the next layer and $f'_j(net_{pj})$ is the derivative of the activation function. Propagate *backwards* the error signal through all the hidden layers until the input layer is reached:

$$\delta_{pj} = \sum_k \delta_{pk} w_{kj} f'\left(net_{pj}\right) \quad (9)$$

II. RE-ENGINEERING PROCESS

Business Process Reengineering is a process-centric thinking attempted by many organizations that are looking for gains from the successful redesign of their processes. Re-engineering their processes, the firms faces the difficulty of integrating processes with management and organizational structures BPR, the high risk, time consuming activity with no guarantee of success. Business Process Reengineering (BPR) is a management approach aiming at improvements by means of elevating efficiency and effectiveness of the processes that exist within and across organizations. It is a fundamental and radical approach by either modifying or eliminating non-value adding activities [10].

Radical redesign means disregarding all existing structures and procedures, and inventing completely new ways of accomplishing work. Reengineering reinvent business, begins with no assumptions and takes nothing for granted.

Business Process Reengineering (BPR) is a management approach aiming at improvements by means of elevating efficiency and effectiveness of the processes that exist within and across organizations. It is a fundamental and radical approach by either modifying or eliminating non-value adding activities [10]. The Radical redesign imply ignoring all existing structures and procedures, and inventing completely new ways of accomplishing work. Reengineering reinvent a business, begins with no assumptions and takes nothing for granted, not looking for marginal or incremental improvements or modification.

Reengineering is driven by open markets and competition. No longer can we enjoy the protection of our own country's borders as we could in the past. Today, in a global economy, worldwide customers are more sophisticated and demanding [11]. Modern industrialization was based on theories of specialization with millions of workers doing dreary, monotonous jobs. It created departments, functions and business units governed by multiple layers of management, the necessary glue to control the fragmented workplace. In order to be successful in the future, the organization will have fewer layers of management and fewer, but more highly skilled workers who do more complex tasks. Information technology, used for the past 50 years to automate manual tasks, will be used to enable new work models. The successful organization will not be "technology driven;" rather it will be "technology enabled" [12].

Reengineering is about radical improvement, not incremental changes having the goal of dramatic improvements in performance. The integrated business process that eliminates wastes and provides real-time management in a complex system has the specific objectives that include:

– Analysis current business processes;
– Identify relationships and deficiencies within the current operating system;
– Develop a business process model that addresses the three key business processes: Front-end Sales, Opportunity Introduction, Order Fulfilment;
– Implement new operating systems and establish monitoring and review of the effectiveness of the business process model.

The methodology has to: explicitly define a business vision; define process objectives; identify processes that cover a high proportion of the business; extensively document and measure processes being redesigned prior to redesign; consider IT as a lever for new processes; have managers highly involved;consider and support employees [14].

To support the organizational, structural, functional and social behavior perspectives [5], requirements modeling process which is decomposed into two main activities:

Requirements definition and Requirements Specification, (fig.2).

The purpose of this model is to represent the different roles found in each sub-organization and to reason about their special relationships. The special relationships between roles can serve to identify the common properties between the roles in order to create a hierarchy of roles using inheritance relationships and the identification of the social behavior relationships between roles in different sub-organizations. In order to obtain a clear view of the models used, each of them is presented as follows. The *Mission Statement* is defined in natural language, with a recommended extension of one or two paragraphs. Since the *Mission Statement* identifies the overall goal within the organization as a whole, it provides us with information about the organizational and functional perspectives. The *Mission Statement* is the root of the *Refinement Tree*.

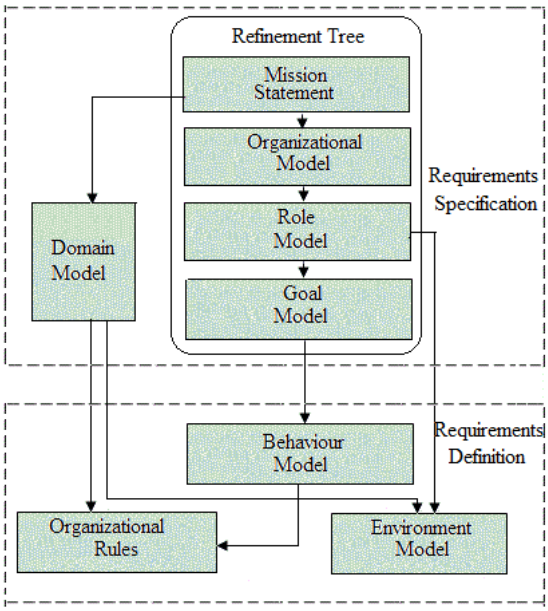

Fig.2. Model of re-engineering process

The first step in the analysis of current business processes is SWOT analysis is a tool used for identifying the company's internal and external environment by focussing on key issues. The SWOT acronym stands for strengths, weaknesses, opportunities, and threats. Strengths and weaknesses are internal factors; opportunities and threats are external factors. The SWOT analysis helps identify relevant internal and external factors regarding a complex system and how to actively improve the company by turning weaknesses into strengths and threats into opportunities. It will make it easier for managers to communicate and share their understanding to stakeholders through the display of the SWOT analysis. This will enable identifying the relevant measures which need to be taken in order to make the company more efficient and effective. SWOT analysis was applied to a firm that want to re-engineering its processes. The firm (Romanian firm) consists of four divisions under a central managing director at the head office The firm has approximately 100 employees. During the 2000's electronic supply industry became market oriented. The firm responded by changing its structure to align itself more with how products were sold rather than the type of product. The firm subsequently split into three strategic business units (SBU's), and later acquired a fourth (Electronics) the company became increasingly inefficient. As the managing director stated "processes do not remain static, and thus inefficiency grows." Within the divisions, profitability was declining and employees were consistently inundated with work The SWOT analysis resulting is summarized in table 2.

Table 2. SWOT analysis

STRENGHTS	High quality products; Continuous improvement process; It has flexible logistics; User friendly website; Social responsible and protecting the environment by reducing wastage; It is an important marketing tool for suppliers; All primary business are listed to the IT system; Includes suppliers in their projects; Employees are self-motivated; Internal solution finding; Experience on the market; Operating deliveries; Guaranteed next day delivery
WEAKNESSES	High prices compared with competitors; High minimal value; High order value; Cannot prove the quality of the products; Concentrated in only 1 market
OPPORTUNITIES	Globalization; New technology; Widening the range of products; Mergers, joint ventures or strategic alliances; Moving into new market segments that offer improved profits; An international market; Free trade
THREATS	Market increases only 1%; New competitors; Only 38% of the population have internet at home; Small percentage use electronic shopping; Price wars with competitors; A competitor has a new, innovative product or service. Competitors have superior access to channels of distribution; Taxation is introduced on products or services; It relies too much on its IT infrastructure

II. CASE STUDY

Supervised Multi-layer Neural Network models need suitable data pre-processing techniques to find input values while pre-training techniques to find desirable weights that in turn will reduce the training process. Without preprocessing, the classification process will be very slow and it may not even complete. Potential Weights Linear Analysis is technique for reducing training process and fast classification in new Supervised Multi-layer Neural Network model with high accuracy. The first Potential Weights Linear Analysis

normalizes input values as data preprocessing and then uses normalized values for pre-training, at last reduces dimension of normalized input values by using their potential weights. Supervised Multi-layer Neural Network models can change to new models by using Potential Weights Linear Analysis [6]. All agents of system can apply the outputs of Potential Weights Linear Analysis technique and new Supervised Multi-layer Neural Network model. first define the decomposition of the system in a hierarchy of sub-organizations, thus representing the Organizational Model. It is successively refined to identify the goals of the system to be represented as leaf nodes in the tree.

VII. CONCLUSIONS

The study shows there is a correlation between increased efficiency and business process re-engineering, suggesting that it is often a combination of initiatives which when implemented alongside business process re-engineering helps to make the real difference. The contributory initiatives identified include: changing organisational structures, improving performance management, improving stakeholder management, replacing IT systems, training and providing guidance to staff.

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Leakage Inductance of Windings used in Electrical Machines with Disc-Type Rotor

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Abstract *– This paper deals with the optimization of leakage inductance of windings used in electrical machines with disc type construction. These machines have short axial length what makes them suitable to use in small wind-power turbines or in-wheel traction drives. Disc type construction of stator offers more possibilities for winding arrangements than are available in classical machines with cylindrical construction. Thus the leakage inductance can be better optimized. To find out the best winding arrangement with the lowest leakage inductance a series of analytical calculations, simulations and experimental measurements were performed.*

Keywords: *electrical machines; axial-flux machines; windings; leakage inductance; optimization.*

I. ELECTRICAL MACHINES WITH DISC-TYPE ROTOR

Disc type electrical machines pose relatively new design approach in electrical machinery. They come out of the concept of axial flux machines, where the magnetic flux flows axially through the air gap. Magnetic field is usually excited by permanent magnets built in the rotor or glued on the rotor ferromagnetic core. Stator can be made from axially layered laminations or cast from SMC (*Soft Magnetic Composite*) materials.

Axial flux machines are being used in electric vehicles and in renewable energy sources like small wind turbines. They occupy lower volume when the ratio of length to diameter of radial flux machines is low (meaning that the machine is short) and when the number of poles is higher. Axial flux machines have generally higher power density in kW/kg, or Nm/kg respectively. They require about 30 % lower volume of PMs than radial flux machines, less electrical steel for manufacturing the iron cores, however the copper consumption is typically higher. This is due to the difficulties of arranging the end-windings in axial flux machines [1].

This paper deals with the comparison of leakage inductance of windings which are most commonly used in axial-flux disc-type electrical machines.

II. WINDING TYPES USED IN DISC-TYPE MACHINES

In comparison with classical cylindrical machines it is possible to use more winding configurations in axial-flux machines. When the machine is designed, it is assumed that in terms of induced back electro-motive force (EMF) all winding types are equivalent, since the back EMF is only a function of length of conductors placed in the stator slots regardless of the way how the end-windings are shaped and placed outside of the stator [2]. Nevertheless, there are differences among the winding types which are not considered in the law of induced EMF (so called *BLi* law).

The coils can be arranged in single or more layers and connected either in series or in parallel. However, parallel connection of coils is not recommended in practical applications, since the back EMF can be different in each coil what can lead to occurrence of circulating currents between coils. In case that the coils are placed in different slots under the same magnetic pole their induced voltages can have different phase. If they would be placed in the same slots under different poles, the amplitude of induced voltage can be different. In this paper the most commonly used winding arrangements are considered. Special types of windings, like printed windings or coreless windings are not considered, since they are used only in very special types of electrical machines.

A. Concentric solenoid windings

Concentric windings are used in disc-type machines with salient poles. The coils are wound as solenoids with concentrated parameters, where each coil has its own ferromagnetic core (Fig. 1). Usually the number of stator poles differ from the number of rotor poles. This is done in order to achieve non-zero starting torque in each position of the rotor and also in order to minimize the torque pulsations [3]. An advantage of this winding type is the modularity of construction, thanks to what each coil can be quickly replaced and repaired when necessary.

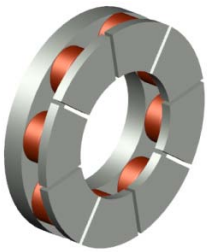


Fig. 1. 8-pole stator of disc-type machine with concentric coils

B. Toroidal windings

Toroidal windings are used exclusively in axial flux machines with internal stator and double rotor surrounding the stator from both sides. They can be wound on a slotted or non-slotted stator core. An illustration of toroidal winding is shown in Fig. 2. Main pros of this winding type are very short end windings, simple motor construction and compact design. The biggest disadvantage of this construction is its mechanical weakness. This is caused by problematic fixation of stator to the motor frame, since the whole stator is covered by windings. The weakness of mechanical construction is actually the main drawback which prevents wider usage of this winding.

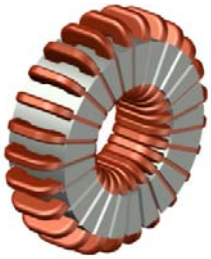


Fig. 2. Stator of axial flux machine with toroidal winding

C. Lap windings

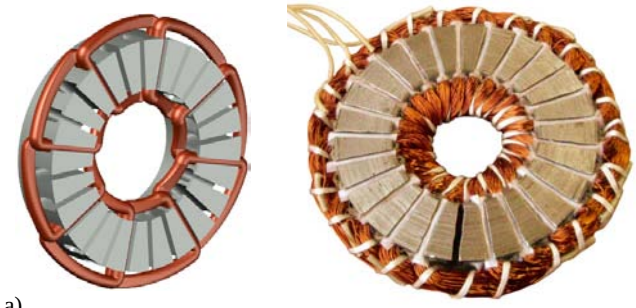
Lap windings represent the most popular way of placing the coils in the stator of axial-flux machine. The distribution of coils is done a very simple way, either in one or in two layers and usually without shortened pitch (Fig. 3, 4). In case of single layer winding there is only one coil side placed in each slot. The coils are wound as pole-pair coils and the number of coils is half of the number of slots. In double layer windings each coil works as single-pole coil. In each slot exactly two coil sides of two different coils are placed. The number of coils per phase equals the number of slots per phase.

D. Wave windings

This type of winding is practically suitable only for disc type machines, since placing of wave coils in the stator of cylindrical machine would be practically impossible. The winding itself consist of single long coil which snakes through the slots of single phase. Unlike in lap winding, in wave winding are the end-windings placed alternatively on inner and outer diameter of stator (see Fig. 5, 6).

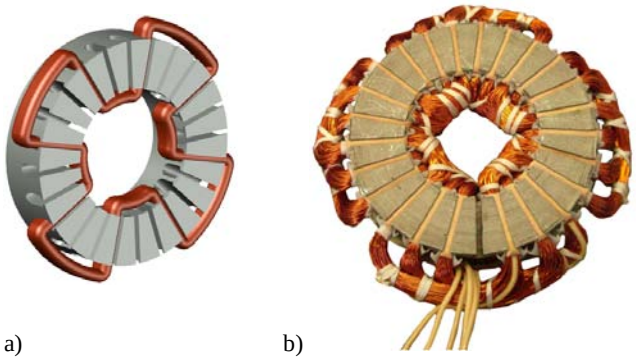
a) b)

Fig. 3. Single-layer lap winding
a) arrangement of end-windings, b) real model



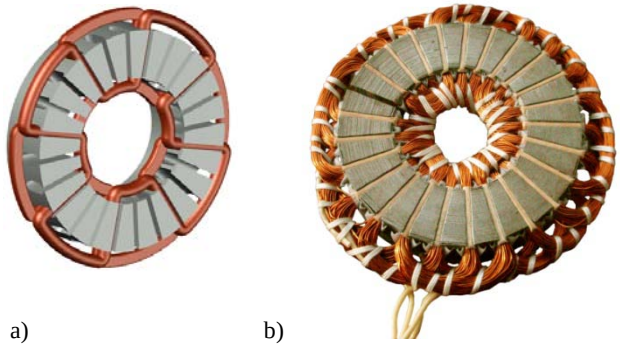
a) b)

Fig. 4. Double-layer lap winding
a) arrangement of end-windings, b) real model



a) b)

Fig. 5. Single-layer wave winding
a) arrangement of end-windings, b) real model



a) b)

Fig. 6. Double-layer wave winding
a) arrangement of end-windings, b) real model

III. ANALYTICAL CALCULATION OF WINDING LEAKAGE INDUCTANCE

At the present time the calculation of electrical parameters of windings used in axial-flux disc-type machines is basically the same for all winding types. Here, only the calculation of winding leakage inductance is presented. Armature reaction inductance does not depend on chosen winding type, therefore it is not of interest [4].

Analytical calculation of leakage inductances is one of the most difficult parts when designing an electrical machine. Leakage inductance depends on many factors like leakage permeances, exact length of coils, distance between coils, differential leakage flux, skin effect, influence of phases on each other, etc. These parameters cannot be exactly evaluated before the machine is really constructed. Therefore three different analytical approaches has been used for calculations. The first one comes out of equations published in [5].

The second approach has been taken out from [2]. However, this approach does not consider differential leakage flux, only slot leakage flux and end-windings leakage.

The most recent and most complex approach on this issue has been published in [4]. From there, the total leakage inductance of single phase can be calculated as:

$$L_\sigma = 2\mu_0 \frac{L_i N_p^2}{pq}\left(\lambda_d + \frac{l_c}{L_i}\lambda_c + \lambda_{dif}\right) \quad (1)$$

where $\mu_0 = 4\pi\cdot 10^{-7}$ is the relative permeability of free space, L_i is the effective length of conductor in slot, l_c is the total length of coil end-windings, p is the number of motor pole pairs, q is the number of slots per pole and phase and N_p denotes the number of turns per phase. Coefficient λ_d stands for specific permeance of slot leakage, λ_c for end-windings leakage and λ_{dif} represents specific permeance of differential leakage caused by the presence of higher harmonics in magnetic field.

The leakage flux within the slot is closing around the conductors through stator iron core and free space in the slot opening. It can be calculated from the slot dimensions using the following equation:

$$\lambda_d = \frac{h_{d1}}{3b_{ds}}k_\beta + \left(\frac{h_{d2}}{b_{ds}} + \frac{3h_{kl}}{b_{ds}+2b_o} + \frac{h_{kz}}{b_o}\right)k_\beta' \quad (2)$$

Coefficients $b_o, b_{ds}, h_{d1}, h_{d2}, h_{kl}, h_{kz}$ represent the dimensions of slot. More detailed description can be found in [6]. Coefficient k_β' includes the influence of shortened pitch. However, in case of full slot pitch is equal to $k_\beta' = 1$.

The leakage flux of end windings is closing around the end winding of coils of one stator phase. It is very hard to obtain exact analytical equation considering the complexity of geometry and influence of phases on each other. Usually the specific permeance is calculated using empiric equations, like the following one taken from [5]:

$$\lambda_c = 0{,}34q\left(1 - \frac{1}{\pi}\frac{\tau_{cout}l_{cin} + \tau_{cin}l_{cout}}{l_{cin}l_{cout}}\right) \quad (3)$$

Coefficients l_{cin} and l_{cout} are the lengths of coil end winding on inner and outer diameter of stator, τ_{cin} and τ_{cout} are the slot pitches on inner and outer diameter.

Differential leakage is caused by upper harmonics which are present in the magnetic field of electrical machine. Specific permeance of differential leakage can be calculated as:

$$\lambda_{dif} = \frac{m_1 q \tau k_v^2}{\pi^2 \delta_c k_c k_{sat}} \sum_{v>1}\left(\frac{k_{vv}}{v}\right)^2 \quad (4)$$

where m_1 is the number of phases, τ is pole pitch, k_v is the winding coefficient, δ_c is the width of air-gap, k_c is Carter's coefficient and k_{sat} is saturation coefficient. Curves of $\tau_{dif} = \frac{1}{k_v^2}\sum_{v>1}\left(\frac{k_{vv}}{v}\right)^2$ depend on the number of slots and pitch shortening. They can be determined from curves published in [6].

IV. CALCULATION OF WINDING INDUCTANCE USING 3D FEM ANALYSIS

From equations for analytical calculations of electrical parameters presented in previous paragraph it is obvious that the leakage inductance of winding does not depend on the chosen arrangement of end windings. In other words, the calculated leakage inductance for all single and double layer lap and wave windings (Fig. 3 - 6) would be the same. It is assumed that the dimensions of windings are the same and that the windings differ only in the arrangement of end-windings.

This fact, however, does not correspond to experimental results (see paragraph *V. Experimental results*). In practice, the end-windings influence each other and the resulting leakage inductance really depends on how they are mutually arranged.

Therefore a 3D Finite Element Method (*FEM*) analysis of leakage fluxes has been performed. In 3D FEM analysis the total leakage inductance is calculated from the current flowing through the coil and from the total magnetic energy W stored in the volume, through which the leakage flux is closing. That involves the volume of air around inner and outer end windings, the volume of winding itself and the volume of air surrounding the winding in the slot [7].

$$L_\sigma = 2\frac{W_{outer\_air} + W_{inner\_air} + W_{winding} + W_{slot\_air}}{i^2} \quad (5)$$

Created 3D computer models (Fig. 3 - 6) came out of dimensions of respective real windings. All computer models had the same length of windings, the same inner and outer diameters and they had modeled complete 3-phase winding. An example of FEM mesh for 2-layer lap winding is shown in Fig. 7. Figures of other final 3D models with 3-phase windings can be found in [8]. In this way it was possible to exactly evaluate the influence of mutual end-winding arrangements on the resulting leakage inductance.

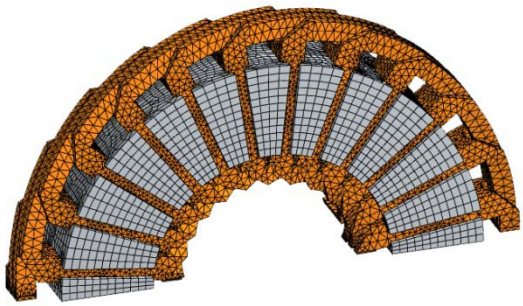


Fig. 7. 3D FEM model of double-layer lap winding

The values of calculated leakage inductances obtained by 3D FEM analyses are listed together with analytically calculated and measured values in Tab. 1.

IV. EXPERIMENTAL RESULTS

In order to obtain a complete evaluation of various winding types from Fig. 4 – 6 a series of experimental measurements was performed. In each experiment the winding was placed in the same stator of permanent magnet axial-flux machine with the following parameters: P_n = 300 W, U_n = 180 V, n_n = 3000 rpm, $2p$ = 8 poles. Phase leakage inductances measured afterwards are listed in Tab. 1.

It is obvious that double layer windings have generally lower leakage inductance, not only because they can be constructed with shorter end-windings, but also because of the fact that the end-windings are more evenly distributed and the mutual influence of phases on each other decreases the leakage inductance.

TABLE 1. Calculated and measured leakage inductances

Phase leakage inductance	Lap winding 1-layer	Lap winding 2-layers	Wave winding 1-layer	Wave winding 2-layers
Measured value	5,51 mH	4,26 mH	5,26 mH	4,80 mH
Analytical calculation [2]	4,21 mH	4,41 mH	3,77 mH	4,18 mH
Analytical calculation [5]	6,14 mH	5,17 mH	6,01 mH	5,19 mH
Analytical calculation [6]	5,87 mH	5,87 mH	5,77 mH	5,86 mH
3D FEM analysis	5,29 mH	4,71 mH	5,16 mH	4,59 mH

Considering the analytically calculated results, the approach from [4] has proved to be the best. However, the analytical approach still doesn't provide accurate results, therefore 3D FEM analysis is recommended.

For all winding types the measured inductance of armature reaction was the same 3,019 mH, what confirmed the fact that the armature reaction inductance is independent of the chosen winding arrangement. Just for comparison, the value calculated by 3D FEM analysis was 3,2 mH.

V. CONCLUSIONS

High leakage inductance of winding can negatively influence the power factor of the machine, so choosing the winding with the lowest value of leakage inductance is prerequisite for optimal operation of the machine.

Analytical calculations provide only approximate results and they do not consider the difference caused by different arrangement of end-windings. Therefore for calculating the leakage inductance in disc-type machines it is recommended to use 3D FEM analysis, where the arrangements of end-windings can be taken into consideration.

From technical point of view the 2-layer lap winding seems to be the best option for axial-flux machines in terms of the lowest leakage inductance. However, when considering also production costs, it is better to use 2-layer wave winding, which can be fabricated faster and with lower labor and material costs.

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Experimental Results of Wheat Seeds Processed in Microwave Field

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***Abstract**: The objective of this work is to analyze the drying characteristics of the wheat seeds in the microwave field. The germination of the seeds, treated in the microwave field, is also studied.*
***Keywords**: wheat, thermal field, microwaves, dielectric properties*

I. INTRODUCTION

Microwaves are electromagnetic waves that occupy the range of frequencies between 300MHz and 30 GHz [1].

The main reason why microwave drying is more convenient than traditional methods is because heat is being generated in the interior of the material through a selective absorption of the electromagnetic energy by the water molecules, creating a transfer of humidity outside the material [2].

The process of drying grains in the microwave field involves simultaneous heat and mass transfer through which the humidity of the dielectric material is being reduced for better storage [3].

Depending on the climate of the country, drying is being made using the solar energy in hot areas and artificial drying in countries with wet climate [3].

II. MATERIAL AND METHODS

The process of drying materials using the microwave energy represents a powerful tool, better than conventional methods, due to the many advantages of it.

There are known the advantages of treating/processing granular materials in the microwave field in front of the conventional drying methods. From these we mention the most important:

- shorter time for processing;
- high quality products;
- the heating process takes place in all the volume of the dielectric material;
- option of controlling the direct power of the microwaves and the temperature measured in the material [4], [11].

The main problem that is being followed is the variation of the drying parameters that should have constant values, in order to not affect the structure of the wheat seeds. The next step after treating the seeds in the microwave field is studying the germination rate, which is than compared with the rate of the witness sample. The final result of our study is given by the germination of the seeds, which was made using Linhard germinators [5]. The seeds used during our experimental data, were pre wetted, in the absence of fresh harvested grains [6].

The studies were made using the stand within the Laboratory of Microwave Technologies, Department of Electrical Engineering, Faculty of Electrical Engineering and Information Technology, University of Oradea (see Fig.1).

The microwave installation that was used during our experiments consist's of a microwave generator with power up to 850 W, a waveguide, an applicator test, dummy load, hot air source with the possibility of controlling the temperature, electrical inter-blockage, stub tuner with some adjusters, directional coupler. The installation is supplied from mains.

The applicator is a monomode type and its interior dimensions are about 109.22×54.6×150mm.

In order to eliminate the water that forms during drying in the seed bed, the applicator was created so that ventilation could enter from downwards to upwards, through some holes. The result of airing the seed bed is the elimination of hot spots in the material and also creating a uniform temperature in the whole volume [7].

The reflected power is being absorbed by the absorbent adapted charge, which is set to be at the end of the equipment. If the seed bed won't absorb all the given microwave energy, a part of the energy could reflect back to the microwave generator which can

produce some damages to the installation without a proper control.

In case the dielectric material does not absorb efficiently the energy of the microwaves, a sizable quantity of energy may be reflected towards the microwave generator.

The microwaves are being directed by the circulator which determines the direction of the energy.

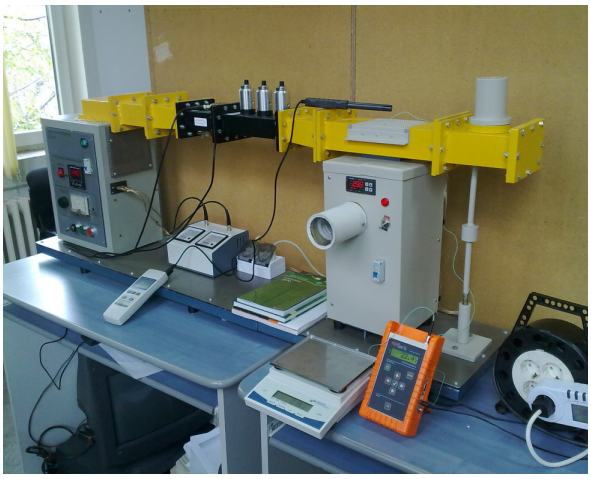


Fig. 1. Test Bench

The measurements were performed every half minute in continuous operating mode at different levels of power starting from 10W up to 40W.

During the experiments we calculated the humidity of the seeds using the weight of it before , m_i, and after drying m_u [8] :

$$U\,[\text{Humidity}] = \frac{m_i - m_u}{m_u} \times 100[\%] \qquad (1)$$

The aim of the testing was to evaluate : the absorbed and reflected power, the output air humidity and temperature characteristics, the temperature measured in the dielectric that in this case are the seeds, the amount of humidity that was estimated using (1) the evaporated water from the seeds and finally the percentage germination.

The initial conditions of the experiments are as it follows:

- using wheat seeds, type Apache×Renan with:
  - 0.1W/g and
  - 0.2W/g processing for ten minutes.

The experiments were performed using only the generated power, without any ventilation in the dielectric material.

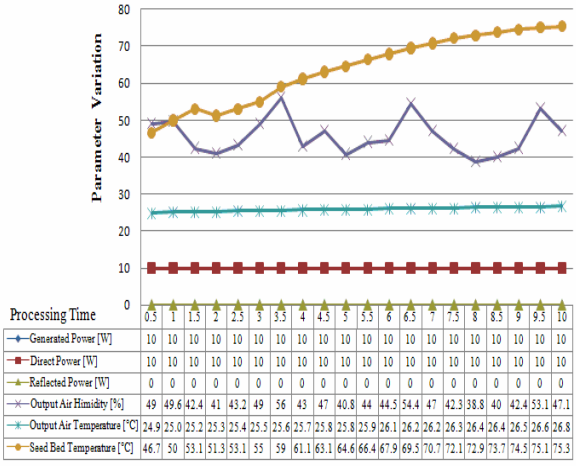
1. In the first case, were dried 100 g of wheat seeds, for 10 minutes, using a constant power of the microwaves of 0.1W/g. The final mass was 99.8 g, 0.2 g of water were evaporated from the seed bed. The humidity eliminated from the seed bed, calculated with formula (1) is U=0.2%, which represents a very low value. The output air humidity presented big variations, due to the fact that we didn't use air stream to eliminate the water that formed at the surface of the seeds. The output air temperature had a constant growth from 24.9^{0}C to 26.8^{0}C ; the seed bed temperature increased from 46.7^{0}C to 75.3^{0}C, having a constant growth during the period of testing (see Fig.2).

The rate of germination achieved for this sample is G=80%, and the witness sample germination is G=95%. If we have used air stream to create homogeneity in the seed bed, and to avoid the hot spots, we would have had better results.

2. For the second sample we increased the power of the microwaves to 0.2W/g and we obtained after drying for 10 minutes, 99.3 g. The difference between the initial and final mass of the seeds is 0.7g of evaporated water from the seed bed.

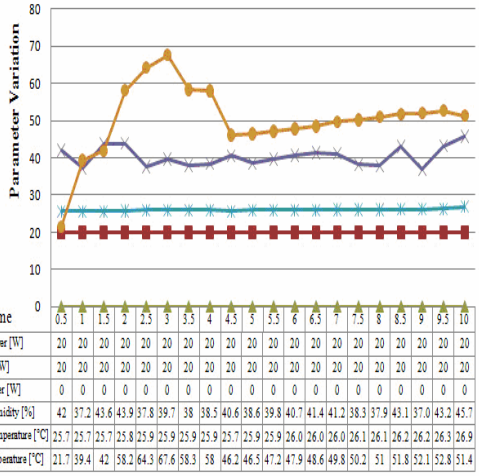
The humidity eliminated from the seed bed is U=0.7%. The output air humidity shows, like in the previous case, variations, because of the absence of airing in the seed bed. The output air temperature had a constant growth from 25.7^0 to 26.9^{0}C (see Fig.3).

In the first 4 minutes, the seed bed temperature had variations and increased from 21.7^{0}C to 67.6^0, but at the end of the testing period got stabilized to the value of 51.4^{0}C. The germination obtained is G=50%. Due to the variations of the seed bed temperature the kernel was affected and resulted in a lower rate of germination.



Processing Time	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
Generated Power [W]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Direct Power [W]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Reflected Power [W]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Output Air Himidity [%]	49	49.6	42.4	41	43.2	49	56	43	47	40.8	44	44.5	54.4	47	42.3	38.8	40	42.4	53.1	47.1
Output Air Temperature [°C]	24.9	25.0	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.8	25.9	26.1	26.2	26.2	26.3	26.4	26.4	26.5	26.6	26.8
Seed Bed Temperature [°C]	46.7	50	53.1	51.3	53.1	55	59	61.1	63.1	64.6	66.4	67.9	69.5	70.7	72.1	72.9	73.7	74.5	75.1	75.3

Fig.2- 0.1W/g/10min, U=0.2%, G=80%



Processing Time	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
Generated Power [W]	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Direct Power [W]	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Reflected Power [W]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Output Air Himidity [%]	42	37.2	43.6	43.9	37.8	39.7	38	38.5	40.6	38.6	39.8	40.7	41.4	41.2	38.3	37.9	43.1	37.0	43.2	45.7
Output Air Temperature [°C]	25.7	25.7	25.7	25.8	25.9	25.9	25.9	25.9	25.7	25.9	25.9	26.0	26.0	26.0	26.1	26.1	26.2	26.2	26.3	26.9
Seed Bed Temperature [°C]	21.7	39.4	42	58.2	64.3	67.6	58.3	58	46.2	46.5	47.2	47.9	48.6	49.8	50.2	51	51.8	52.1	52.8	51.4

Fig.3 - 0.2W/g/10min, U=0.7%, G=50%

III. THERMAL FIELD ANALYSIS

Accordingly to von Hippel, 1952, the dielectric properties of a material are defined by [9]:

$$\varepsilon^* = \left(\varepsilon' - j\varepsilon''\right)\varepsilon_0 \quad (2)$$

Where: ε^* =complex permittivity;
ε'=dielectric constant;
ε''=dielectric loss factor;
ε_0=permittivity of free space;
j=complex operator.

The dielectric constant describes the ability of a dielectric material to store electric energy.

The loss factor describes the energy absorbed from the applied field [9], [10], [11].

The applicator with a parallelepiped shape, made up of aluminum walls is being excited by a magnetron, at a frequency of 2.45 GHz.

Electromagnetic waves transmission from the magnetron to the cavity is being made through a rectangular waveguide, in which prolongation is being placed the applicator.

An important thing to mention is that for the magnetron to transmit the maximum generated power, the port was placed in a maximum of the electromagnetic field, namely λ/4 from the end of the magnetron of the guide.

Our purpose was to analyze the parameter variations that influence the microwave drying of the granular materials, in our case the wheat seeds.The supposed dimensions of the considerate seeds bed are: 103mm length with 70 mm wide.

The rectangular waveguide $TE_{10,}$ having the dimensions : width x=109.22mm, length y=300 mm and height z=54.6 mm. The excitation of the guide is being made on the lateral part, f=2.45GHz.

In order to compare the numerical and experimental data, at the end of the experimental process, the temperature map was captured with a Fluke F32i infrared thermal Camera.

Figure 4 presents the thermal field distribution over the seed bed and also the 3D distribution of the temperature for the witness sample.

Figure 5 presents the thermal field distribution on the seed bed surface at the end of the drying process and also the 3D distribution of the temperature for sample 1, using a constant power of the microwaves of 0.1W/g.

Figure 6 presents the thermal field distribution on the seed bed surface at the end of the drying and also the 3D distribution of the temperature for sample 2, using a constant power of the microwaves of 0.2W/g.

III. CONCLUSIONS

An important issue when drying seeds in the microwave field is keeping the constant temperature in the dielectric material, so in the end a good percentage of the germination would be acomplished.

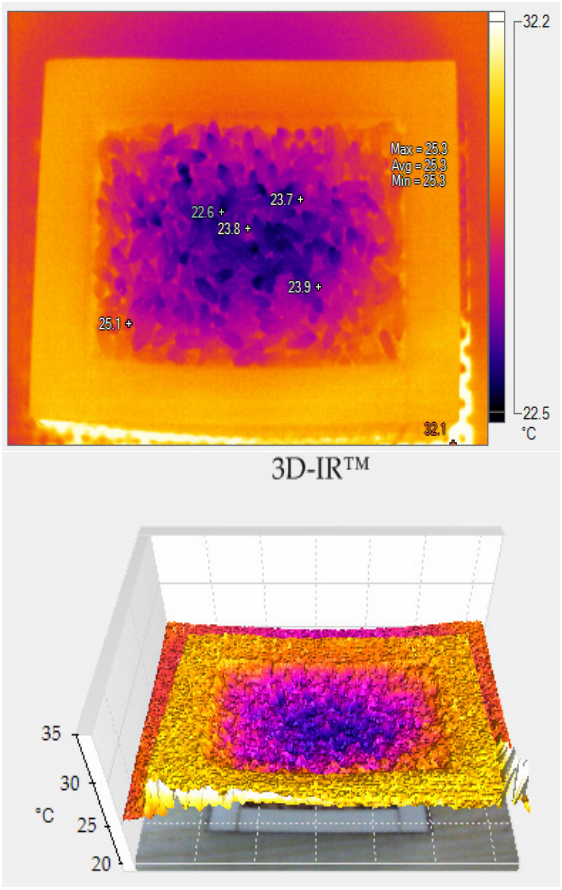


Fig. 4 Thermal Field Distribution

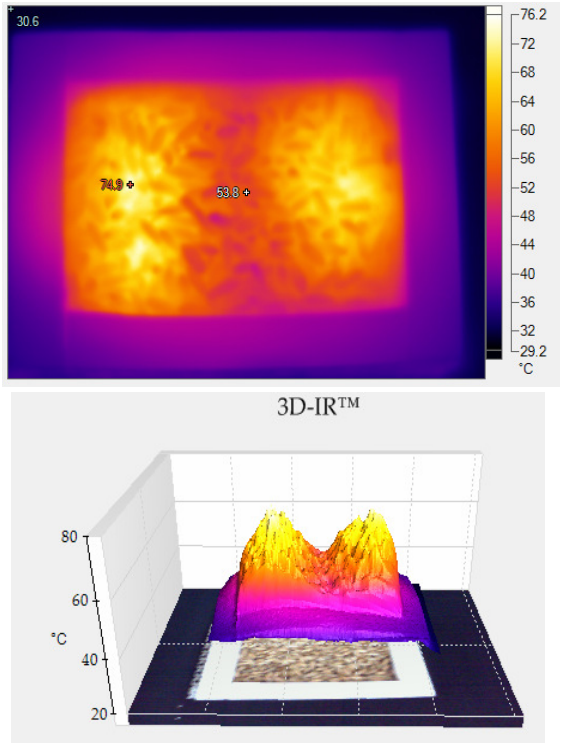


Fig.5 Thermal Field Distribution

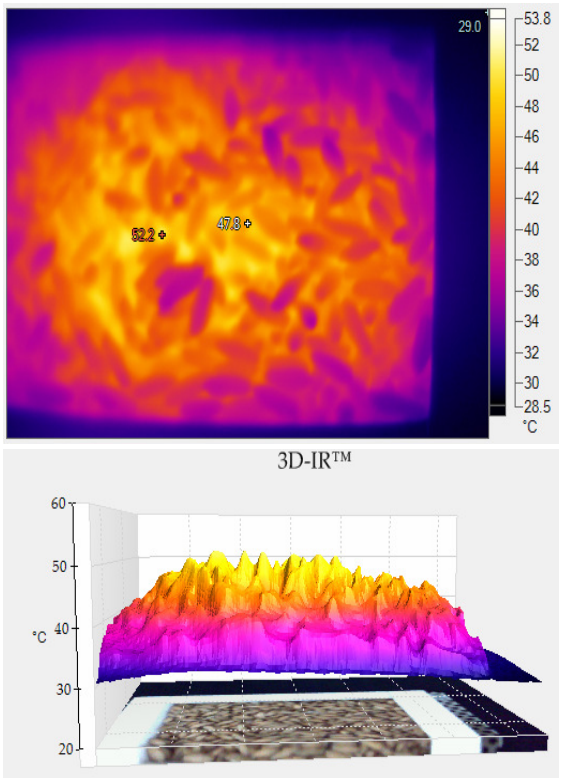


Fig. 6 Thermal Field Distribution

Using the power of the microwaves without air stream, affects the structure of the seeds by increasing the seed bed temperature and worsen the airing of the dielectric material.

From the images taken with the Thermographic Camera we can see the neomogenous distribution of the temperature in the seed bed, in some areas the values are greater than in other, that leads to high temperature areas that can destroy the seeds and the rate of germination. For this reason, we obtained a low rate of germination for the second sample, caused by the thermal instability and by the impossibility of measuring the temperature in each point of the seeds bed.

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Two-Dimensional Linear Subspace Learning Based on Discriminant Analysis of Speech

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***Abstract* – This paper is oriented to an application of linear feature transformation in Slovak phoneme-based large vocabulary continuous speech recognition (LVCSR) task. Specifically, an extension of Linear Discriminant Analysis (LDA) is used in experiments, called Two-dimensional LDA (2DLDA). The performance of 2DLDA is investigated under different conditions and various dimensions of transformation matrices. In all experiments, the state-of-the-art Mel-frequency cepstral coefficients (MFCCs) are treated as reference baseline models. The experiments are evaluated on Slovak speech corpus. As the evaluation parameter of all recognition tasks using Slovak database we chose the accuracy.**

***Keywords:* feature vector; linear transformation; scatter matrix.**

I. INTRODUCTION

The most common acoustic front-ends in automatic speech recognition (ASR) systems are based on the state-of-the-art Mel-Frequency Cepstral Coefficients (MFCCs). It is known that this general technique is a good choice to obtain satisfactory speech representation. In the past few decades, the researchers have made a great effort in order to develop and apply such techniques, which may improve the recognition performance of the conventional MFCCs. One group of mentioned methods is represented by linear feature transformations (also referred as subspace learning or dimensionality reduction methods). They are used to convert the original data set to an alternative and more compact set with retaining of information as much as possible.

The most popular linear transformations used in speech processing are Principal Component Analysis (PCA) [1], [2] and Linear Discriminant Analysis [3]. In order to overcome the limitations of LDA (singularity problem), it was developed an extension of LDA, called Two-dimensional LDA (2DLDA) [4]. In numerous research works it was proven that LDA was successfully applied in ASR to multiple languages. The Slovak speech recognition research group tends to follow this trend. Based on our previous work [5], the main subject of this paper is the application of 2DLDA in Slovak phoneme-based LVCSR task. Several context lengths of basic vectors are used in discriminat analysis and various dimensions of transformation matrices are utilized.

This paper is divided into few basic units. The next section describes 2DLDA, Section III gives the experimental setup. Section IV presents the experiments based on 2DLDA. Section V shows the experimental evaluation and results. Section VI concludes the paper.

II. TWO-DIMENSIONAL LINEAR DISCRIMINANT ANALYSIS

A. Conventional Linear Discriminant Analysis (LDA)

Linear discriminant analysis is a well-known dimensionality reduction and transformation method that maps the N-dimensional input data to p-dimensional ($p<N$) subspace while retaining maximum discrimination information. A general mathematical model of linear transformation can be written as:

$$\mathbf{y} = W^T \mathbf{x} \tag{1}$$

where $\mathbf{y}$ is the output transformed feature set, W is the transformation matrix and $\mathbf{x}$ is the input feature set. The aim of LDA is to find W with respect to optimization criterion. W can be obtained by applying an eigendecomposition to the covariance matrices. The p eigenvectors resulting from decomposition are used to transform the feature vectors to reduced representation.

B. Two-dimensional Linear Discriminant Analysis (2DLDA)

Linear Discriminant Analysis used as a feature extraction or dimension reduction method in applications with high-dimensional data may not perform always optimally. Especially, when the dimension of the data exceeds the number of data points, the scatter matrices can become singular. This is known as the singularity or undersampled problem in LDA, which is its intrinsic limitation.

Two-Dimensional Linear Discriminant Analysis (hereinafter 2DLDA) [4] was primarily designed to overcome the singularity problem in classical LDA. 2DLDA overcomes the singularity problem implicitly. The key difference between LDA and 2DLDA is in the data representation model. While conventional LDA works with vectorized representation of data, the 2DLDA algorithm works with data in matrix representation. Therefore, the data collection is performed as a collection of matrices, instead of a single large data matrix. This concept has been used in [6] for PCA.

It is known that the optimal transformation matrix in LDA can be obtained by applying an eigendecomposition to the scatter matrices. Generally, these matrices can be singular because they are estimated from high-dimensional data. In recent years, several approaches have been developed to solve such problems related to high-dimensional computing [7]. One of these approaches is called PCA+LDA and it is a widely used two-stage algorithm especially in face recognition [8]. All mentioned methods require the computation of eigendecomposition of large matrices, which can lead to degradation of the efficiency.

2DLDA alleviates the difficult computation of the eigendecomposition in methods discussed above. Since it works with matrices instead of high-dimensional supervectors (in LDA), the eigendecomposition in 2DLDA is computed on matrices with much smaller sizes than in LDA. This reduces the processing time and memory costs of 2DLDA compared to LDA.

C. Mathematical description of 2DLDA

Let $A_i \in \Re^{r\times c}, i \in \langle 1;n \rangle$ be the n training speech signals in the corpus. Suppose there are k classes $\Pi_1,...,\Pi_k$, where class Π_i has n_i feature vectors. Let

$$M_i = \frac{1}{n_i}\sum_{X\in\Pi_i} X, \quad i \in \langle 1;k \rangle \tag{2}$$

be the mean of the *i*-th class and

$$M = \frac{1}{n}\sum_{i=1}^{k}\sum_{X\in\Pi_i} X \tag{3}$$

be the global mean. In [4], X originally represents a training image. For speech recognition, X represents the concatenated acoustic vectors (supermatrix) computed on successive speech frames (see equation (13)).

2DLDA considers an $(l_1 \times l_2)$-dimensional space $L \otimes R$, which is a tensor product of spaces L, spanned by vectors $\{u_i\}_{i=1}^{l_1}$ and space R, spanned by vectors $\{v_i\}_{i=1}^{l_2}$. In 2DLDA the speech is considered as a two-dimensional element, transformation matrices L and R are defined as:

$$L = \left[u_1,...,u_{l_1}\right], L \in \Re^{r\times l_1}, \tag{4}$$

$$R = \left[v_1,...,v_{l_2}\right], R \in \Re^{c\times l_2}. \tag{5}$$

These matrices map each $A_i \in \Re^{r\times c}$ to $B_i \in \Re^{l_1\times l_2}$ as:

$$B_i = L^T A_i R. \tag{6}$$

Due to difficult computing of optimal L and R simultaneously, authors in [4] derived an iterative algorithm, which for fixed R computes the optimal L. With computed L, R can be updated. The procedure is several times repeated. As in classical LDA, the scatter matrices are computed similarly, but in two-dimensional concept. Note that in 2DLDA are defined two within-class scatter matrices S_w^R and S_w^L and two between-class scatter matrices S_b^R and S_b^L concurrently. Scatter matrices coupled with R are defined as follows:

$$S_w^R = \sum_{i=1}^{k}\sum_{X\in\Pi_i}\left(X - M_i\right)RR^T\left(X - M_i\right)^T, \tag{7}$$

$$S_b^R = \sum_{i=1}^{k} n_i\left(M_i - M\right)RR^T\left(M_i - M\right)^T. \tag{8}$$

For fixed R, L can be then computed by solving an optimization problem

$$\max_L trace\left((L^T S_w^R L)^{-1}(L^T S_b^R L)\right). \tag{9}$$

This problem can be solved as an eigenvalue problem $S_w^R \mathbf{x} = \lambda S_b^R \mathbf{x}$. L can be obtained by applying an eigendecomposition to matrix $\left(S_w^R\right)^{-1} S_b^R$. Scatter matrices coupled with L are defined as follows:

$$S_w^L = \sum_{i=1}^{k}\sum_{X\in\Pi_i}\left(X - M_i\right)^T LL^T\left(X - M_i\right), \tag{10}$$

$$S_b^L = \sum_{i=1}^{k} n_i\left(M_i - M\right)^T LL^T\left(M_i - M\right). \tag{11}$$

In this way, with obtained L it can be computed the optimal R by solving an optimization problem:

$$\max_R trace\left((R^T S_w^L R)^{-1}(R^T S_b^L R)\right). \tag{12}$$

This problem can be solved as an eigenvalue problem $S_w^L \mathbf{x} = \lambda S_b^L \mathbf{x}$. The optimal R can be then obtained by applying an eigendecomposition to matrix resulting from $\left(S_w^L\right)^{-1} S_b^L$. It should be noted that the sizes of scatter matrices in 2DLDA are much smaller that those in LDA. Specifically, the size of S_w^R and S_b^R is $r \times r$ and the size of S_w^L and S_b^L is $c \times c$.

III. SPEECH CORPUS AND EXPERIMENTAL CONDITIONS

A. Speech corpus

All experiments were evaluated by using a Slovak speech corpus *ParDat1* [9], which contains approx. 100 hours spontaneous parliamentary speech recorded from 120 speakers (90% of men). For acoustic modeling 36917 training utterances were exactly used. For testing purposes another 884 utterances were used.

B. Speech preprocessing

In MFCC feature extraction, the speech signal was preemphasized and windowed using Hamming window. The window size was set to 25ms and the step size was 10ms. Fast Fourier transform was applied to the windowed segments. Mel-filterbank analysis with 26 channels was followed by logarithm application to the linear filter outputs. After DCT, first 12 MFCCs were retained and augmented with the 0-th cepstral coefficient. During the acoustic modeling the first and second order derrivatives were computed and added to the basic vectors. Thus, the final MFCC vectors were 39-dimensional. The MFCC models were treated as reference models.

For 2DLDA-based processing the 13-dimensional MFCC vectors were used as the input. During the acoustic modeling the Δ and $\Delta\Delta$ coefficients were computed. Thus, in order to regular comparison of recognition accuracies, 2DLDA models were trained using 39-dimensional vectors. The number of classes k used in 2DLDA were identical with the number of phonetic classes in acoustic modeling (k=45).

C. Acoustic modeling

Our recognition system used context independent monophones modeled using a three-state left-to-right HMMs. The number of Gaussian mixtures per state was a power of 2, starting from 1 to 256. The phone segmentation of 45 phones was obtained from embedded training and automatic phone alignment. The number of trained monophone models corresponded to the number of phonemes and basic classes for 2DLDA

For testing purposes a word lattice was created from a bigram language model, which was built from the test set. The vocabulary size was 125k. The feature extraction, HMM training and testing by using HTK (Hidden Markov Model) Toolkit [10] were performed.

D. Evaluation

In order to evaluate the experiments we chose the accuracy as the evaluation parameter. Accuracies were computed as the ratio of the number of all word matches (resulting from the recognizer) to the number of the reference words [10].

IV. EXPERIMENTS

In this section we extensively evaluate the performance of 2DLDA at different configurations in LVCSR task and compare with the reference MFCC model. The whole mathematical 2DLDA computing was performed according to equations (2) – (16). The statistical estimations are similar as in conventional LDA. The main difference is that it is necessary to compute two eigendecompositions and we have two transformation matrices; L and R.

2DLDA does not deal with supervectors as in LDA but with supermatrices, which are the basic data elements in 2DLDA (instead of vectors). These supermatrices were created from the basic cepstral vectors by coupling them together. We used 5 different sizes of supermatrices according to the number of contextual vectors (context size J). To build a supervector (supermatrix) of J acoustic vectors (J is typically 3, 5, 7, 9 or 11 frames), the cepstral vector $\mathbf{x}_j$ at the current position j is spliced together with $(J-1)/2$ vectors on the left and right according to:

$$X = \left[\mathbf{x}\left[j - \frac{J-1}{2} \right] \ldots \mathbf{x}[j] \ldots \mathbf{x}\left[j + \frac{J-1}{2} \right] \right]. \quad (13)$$

Thus, the sizes of supermatrices were 13×3, 13×5, 13×7, 13×9 and 13×11. Consequently, the statistical estimators have corresponding sizes according to the current length of context. For example, when the context size was J=7, then 7 cepstral vectors were coupled together to form a supermatrix of size 13×7. Statistical estimators have then the following dimensions:

- class means M_i : 13×7,
- global mean M : 13×7,
- left within-class scatter matrix S_w^L : 7×7,
- left between-class scatter matrix S_b^L : 7×7,
- right within-class scatter matrix S_w^R : 13×13,
- right between-class scatter matrix S_b^R : 13×13,
- left transformation matrix L : 13×13,
- right transformation matrix R : 7×7.

The mathematical computations resulted in the transformations L and R. These matrices were used to transform the whole corpus. In this way, each supermatrix created from the coupled vectors in the recording was transformed to its reduced version. This step was done by choosing the required size of L and R.

In the next step, each transformed supermatrix was re-shaped to vector according to the matrix-to-vector alignment. The specific dimensions used in transformations are listed in the Table 1 (see Section V). Since the mathematical part of 2DLDA is an iteration algorithm, it was necessary to set the number of iterations I. In [4] it is recommended to run the iteration loop only once (I = 1), which significantly reduces the total running time of the algorithm. In our experiments we run the "for loop" three times (I=3).

V. EXPERIMENTAL EVALUATION AND RESULTS

The results of 2DLDA can be divided into three categories related to the number of retained dimension of the 2DLDA transformation matrices. The accuracy levels for these three categories are given in the Table 1.

TABLE 1. Accuracy levels (%) for 2DLDA with different number of retained dimensions compared to reference baseline MFCC model (SupM represnts the full size of the supermatrix).

Mix.	MFCC	2DLDA	Diff.	J	SupM	$L \times R$	I
13 2DLDA coeffs. +Δ+ΔΔ (39-dim.)							
1	82.32	**82.67**	**+0.35**	3	13×3	13×1	3
2	83.26	**84.60**	**+1.34**	3	13×3	13×1	1
4	85.06	**87.07**	**+2.01**	3	13×3	13×1	1
8	87.77	**88.87**	**+1.10**	3	13×3	13×1	1
16	89.53	**90.28**	**+0.75**	3	13×3	13×1	1
32	90.83	**91.16**	**+0.33**	3	13×3	13×1	1
64	91.48	**91.70**	**+0.22**	3	13×3	13×1	1
128	92.37	**92.46**	**+0.09**	3	13×3	13×1	1
256	92.50	**92.82**	**+0.32**	3	13×3	13×1	1
19 2DLDA coeffs. +Δ (38-dim.)							
1	82.32	79.35	-2.97	5	13×5	10×2	3
2	83.26	81.90	-1.36	5	13×5	10×2	1
4	85.06	84.03	-1.03	5	13×5	10×2	1
8	87.77	86.42	-1.35	5	13×5	7×3	3
16	89.53	88.31	-1.22	5	13×5	7×3	1
32	90.83	89.63	-1.20	5	13×5	10×2	1
64	91.48	90.77	-0.71	5	13×5	7×3	2
128	92.37	91.41	-0.96	5	13×5	7×3	1
256	92.50	92.19	-0.31	5	13×5	10×2	1
39 2DLDA coeffs. (39-dim.)							
1	82.32	80.13	-2.19	3	13×3	13×3	1
2	83.26	81.51	-1.75	5	13×5	13×3	3
4	85.06	83.62	-1.44	3	13×3	13×3	1
8	87.77	85.78	-1.99	5	13×5	13×3	3
16	89.53	87.62	-1.91	5	13×5	13×3	3
32	90.83	88.91	-1.92	5	13×5	13×3	1
64	91.48	90.15	-1.33	5	13×5	13×3	1
128	92.37	91.00	-1.37	5	13×5	13×3	1
256	92.50	91.66	-0.84	7	13×7	10×4	1

The first category is represented by transformed 2DLDA vector with dimension 13. The final dimension was set to 39 (13 2DLDA+Δ+ΔΔ coeffs.). As it can be seen from the Table 1, this case resulted in the highest accuracies with context length J = 3. The second category is represented by 2DLDA vector of dimension 19 with final dimension 38 (19 2DLDA+Δ coeffs.). For example in case of supermatrix with dimension 10×2, to obtain a vector with dimension 19, the last coefficient in the matrix-to-vector alignment was ignored. Table 1 shows that 2DLDA at this dimension does not perform successfully. For the third category applies similar conclusions as in previous case. The 2DLDA feature vector dimension was 39 (without Δ and ΔΔ coeffs.).

The maximum improvement achieved by 2DLDA was 2.01% abs. for context length J = 3 and one iteration (I=1) for 4 mixtures with size of retained transformed matrix 13×1.

VI. CONCLUSIONS

Application of 2DLDA to MFCCs leads to an improvement for all numbers of mixtures for case of context length J=3. For higher context sizes 2DLDA did not improved the baseline performance.

In the near future we want to develop an algorithm, which will allow to train 2DLDA in unsupervised way without using the labeling of speech corpus (class label information would be eliminated).

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Acoustic Event Detection Based on MRMR Selected Feature Vectors

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***Abstract* – This paper is focused on the detection of potentially dangerous acoustic events such as gun shots and breaking glass in the urban environment. Various feature extraction methods can be used for representing the sound in the detection system based on Hidden Markov Models of acoustic events. Mel – frequency cepstral coefficients, low - level descriptors defined in MPEG-7 standard and another time and spectral features were considered in the system. For the selection of final subset of features Minimum Redundancy Maximum Relevance algorithm was applied. The results of set of experiments showed that the proposed approach had a positive impact on the accuracy for the acoustic event detection system.**

***Keywords:* feature extraction, feature selection, MRMR, acoustic events, surveillance system.**

I. INTRODUCTION

The events recognition from the audio [1], [2] is one of the challenging tasks for the intelligent surveillance system. This task belongs to the field of pattern recognition, retrieval, audio forensics, etc. These days' intelligent surveillance systems can enhance the ability of the emergency services to protect the public. The value that will be added by intelligent surveillance system is that system would operate with less human intervention, which will lower the level of subjective assessment and the number of human mistakes. The acoustic event recognition is a partial task within INDECT project [3]. The main objective of INDECT is to make monitoring and searching process (and procedures) more automatic. This will allow for more informed decision-making. For example, if some dangerous situation is detected, the system should generate an alert and emergency services receive information that some dangerous situation was detected.

In this work, we are focused on the detection of gun shots and breaking glass in the urban environment. Various feature extraction methods can be used for representing the sound [4], [5], [6], [7], [8], [9], [10] . In the speech recognition tasks Mel-Frequency Cepstral Coefficients (MFCC) [11], [12] are used very often. For non – speech recognition tasks descriptors from the MPEG – 7 standard are commonly used [5], [7].

The research described in this paper is focused on the feature extraction in the cepstral, the spectral and in the time domain. The cepstral domain is represented with Mel-Frequency Cepstral Coefficients (MFCC), spectral domain with Audio Spectrum Envelope (ASE), Audio Spectrum Centroid (ASC), Audio Spectrum Spread (ASS), Audio Spectrum Flatness (ASF), Spectral Flux and Spectral Roll-Off. For the description of time characteristics of acoustic signals Audio Waveform (AW), Skewness, Kurtosis and Zero Crossing Rate (ZCR) were extracted.

The aggregation of all mentioned features, 77 dimensions supervectors were created, then Maximum Relevance Minimum Redundancy (MRMR) selection algorithm was used for the selection of relevant features. MRMR algorithm was primarily created for the selection of relevant genes but we applied it for the selection of relevant features which will optimally describe the nature of acoustic events. This way supervectors with lower dimensions were created. According to MRMR, the reductions of feature vectors had the positive impact to the recognition performances.

In the classification phase the well known Hidden Markov Models (HMM) were used to classify the input sample in to the given sound's classes.

The mentioned approach is applied to the acoustic event detection framework as a partial task in the complex surveillance system.

The rest of the paper has the following structure: section II. presents feature extraction methodology. Section III. gives information about the used feature selection algorithm – MRMR and section IV. describes the classifier. The selection process and performed experiments are presented in section V. Section VI. summarizes the obtained results.

II. FEATURE EXTRACTION

The effective parametric representation of acoustic events is crucial aspect for each detection system, which performance directly depends on the quality of extracted feature vectors. Used extraction methods (in the cepstral,

spectral and time domain) are briefly described in following lines.

A. Cepstral Based Features

The cepstrum is a representation used in homomorphic signal processing. Ear's perception of the frequency components in the audio signal does not follow the linear scale, but rather the Mel-frequency scale, which should be understood as a linear frequency spacing below 1 kHz and logarithmic spacing above 1 kHz.

MFCC coefficients [8], [11] are computed form signal segments, which are divided into the short frames, where the parameters of the signal are constant. The Hamming window method was applied on the frames. Then, they are transformed to the frequency domain via the discrete Fast Fourier Transform (FFT), and then the magnitude spectrum is passed through a bank of triangular shaped filters. The energy output from each filter is then log - compressed and transformed to the cepstral domain via the Discrete Cosine Transform (DCT).

MFCC is often used as a feature vectors for representing the human voice, musical signals, etc.

B. Spectral Based Features

This group of feature extraction methods was mostly inspired by the low-level descriptors, which were defined in the standard MPEG-7, namely it is Audio Spectrum Envelope, Audio Spectrum Centroid, Audio Spectrum Spread, Audio Spectrum Flatness and by the other spectral characteristic such as Spectral Flux and Spectral Roll – Off.

Audio Spectrum Envelope

The audio spectrum envelope (ASE) [8] is obtained by summing the energy of the power spectrum within frequency bands which are logarithmically distributed between lower and higher frequencies. The sum of power coefficients in defined band gives the ASE coefficient for this frequency range. The ASE provides a compact representation of the spectrogram of the input acoustic signal.

Audio Spectrum Centroid

The Audio Spectrum Centroid (ASC) gives information about the centre of gravity of a log-frequency power spectrum [8]. The ASC measure describes the shape of the power spectrum and indicates whether in a power spectrum low or high frequencies are dominated. It is an approximation of the perceptual sharpness of the signal.

Audio Spectrum Spread

The Audio Spectrum Spread (ASS) is a measure of the spectral shape and it is defined as the second central moment of the log-frequency spectrum [8]. ASS is extracted by taking the root-mean-square (RMS) deviation of the spectrum from its centroid ASC. The ASS gives indications about how the spectrum is distributed around its centroid. A low ASS values indicated that the spectrum is concentrated around the centroid, where as a high values reflect a distribution of power across a wider range of frequencies [8].

Audio Spectrum Flatness

The Audio Spectrum Flatness (ASF) reflects the flatness properties of the power spectrum [8]. For a given signal frame, it consists of a series of values, each one expressing the deviation of the signal's power spectrum from a flat shape inside a predefined frequency band. For each band, a spectral flatness is estimated as the ratio between the geometric mean and the arithmetic mean of the spectral power coefficients within this band. High ASF coefficients reflect noisiness whereas a low values may indicate a harmonic structure of the spectrum.

Spectral Flux

Spectral Flux [8] is a measure of how quickly the power spectrum of a signal is changing. It is a measure of the variation of the power spectrum between adjacent frames. Spectral Flux can be used to determine the timbre of an audio signal.

Spectral Roll-Off

Spectral Roll-Off frequency [8] is a measure defining the frequency below which 85% of the accumulated magnitude of the spectrum is resides. The threshold takes values between 0.85 and 0.99. The Roll-Off reflects the "skewness" of the spectral shape.

C. Time Based Features

This domain can be characterized by various parameters e.g. with statistical measures such as Skewness and Kurtosis or by the minimum or maximum values of audio waveform or by the Zero Crossing Rate, etc. These feature extraction methods are described below.

Skewness

Skewness [13] is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. The skewness for a normal distribution is zero and any symmetric data should have a skewness near zero.

Kurtosis

Kurtosis [13] is a measure of the "peakedness" of the probability distribution. The kurtosis for a standard normal distribution is equal to three.

Audio Waveform

Audio Waveform [8] gives information about minimum and maximum values form the acoustic signal. It is the straightforward description of the shape of any audio signal.

Zero-Crossing Rate

Zero-crossing rate (ZCR) [8] is the rate of how often the signal changes its sign within a signal frame, i.e., the rate at which the signal changes from the negative to the positive or vice versa.

III. FEATURE SELECTION

For the selection of relevant features Minimum Redundancy Maximum Relevance – MRMR algorithm was applied [14], [15].

MRMR includes two independent criterions:

- maximal relevance,
- minimal redundancy.

First criteria *maximal relevance*: features are selected according to the highest relevance (dependency) to the target class *c*. Relevance can by interpreted such as correlation or mutual information, which defined dependencies between variables.

For discrete variables, the mutual information *I* of two variables *x* and *y* is based on their joint probabilistic distribution *p(x,y)* and their probabilities *p(x)* and *p(y)*:

$$I(x,y) = \sum_{i,j} p(x_i, y_j) \log \frac{p(x_i, y_j)}{p(x_i) p(y_j)}. \quad (1)$$

The searching according *maximal relevance* criteria chooses the feature with high relevance to the target class *c*, so that these features have strong dependency to this class, therefore *maximal relevance* is associated with maximal *dependency*. *Maximal relevance* (maximal dependency - *maxD*) of feature set *S* with features x_i can be described with formula:

$$maxD(S,c), \qquad D = \frac{1}{|S|^2} \sum_{x_i \in S} I(x_i, c), \quad (2)$$

where *maxD(S,c)* is computed with the mean values of all mutual information values between individual feature x_i and corresponding *c* class.

Features selected by *maximal relevance* usually have rich redundancy (we can say that there is a strong dependency between features). When two features are strongly dependent on each other, their class-discriminant power would not change much if one of them will be removed. For this reasons *minimal redundancy - minR* criteria is applied by formula:

$$minR(S), \qquad R = \frac{1}{|S|^2} \sum_{x_i, x_j \in S} I(x_i, x_j). \quad (3)$$

MRMR combines these two criterions *maximum relevance* and *minimum redundancy* by the operator *Φ (D,R)*, which optimize *D* and *R* simultaneously:

$$max\Phi(D, R), \qquad \Phi = D - R. \quad (4)$$

MRMR feature selection framework were successfully applied to genes selection, where selected genes led to the improving of class prediction on some gene expression data sets such as Lymphoma, Lung, Leukemia, Colon, NCI [14].

It should be noticed that the combination a very effective features with another very effective features does not necessarily lead to the better feature set.

In general for feature selection algorithms, there are these advantages:

- a dimension reduction for reducing the computational cost,
- a reduction of irrelevant features (noise features) for improving the classification accuracy.

IV. CLASSIFIER

Many classifiers are based on statistical approaches for modeling the acoustic signal. One of these ones are based on the Hidden Markov Models (HMMs). A HMM based classifier is a popular approach for various recognition tasks. The goal of acoustic processing is to provide an appropriate method to the determination of the conditional probability *P(O/W)*, which means a probability that a word/event *W* will represent an acoustical vector/observation *O*. Continuous HMMs using PDF (Power Density Function) mixtures from 1 to 1024 were used. In the training process the models with one, two, three and four states were created for acoustic events and background sounds.

V. DESCRIPTION OF EXPERIMENTS AND RESULTS

Experiments performed in this work are focused on the selection of the most relevant groups of coefficients that represent cepstral, spectral and time domain. We extracted mentioned features according to their best settings (in respect of acoustic event sound). Following settings were used:

- MFCC_E coefficients were extracted by 25ms Hamming window and 10ms of frame rate (13 coefficients per frame).
- ASE coefficients with the frame length (hopsize) equal to 20 ms for the frequency band from 1000 to 23000 Hz were extracted, (38 coefficients per frame).
- ASS coefficients with hopsize equal to 5 ms were extracted (1 coefficient per frame).
- ASC coefficients were extracted with the same settings like ASS (1 coefficient per frame).
- ASF coefficients for the frequency band from 1000 to 22000 Hz with hopsize equal to 5 ms were extracted (17 coefficients per frame).
- Spectral Flux, Spectral Roll-off, ZCR, Skewness and Kurtosis were extracted with the frame rate 5 ms and each of them generated only 1 coefficient per frame.
- AW coefficients were extracted with the hopsize parameter equal to 5 ms and generated 2 coefficients per frame.

Features were extracted with different frame lengths, therefore their feature matrices had different sizes. This problem was solved by duplications of each vector of X recording m - times,

$$m = hopSizeX_i / hopSizeX_j, (i > j). \quad (5)$$

Original feature supervectors contained too much different and also redundant information. For these reasons MRMR feature selection algorithm was used for

sorting them from the best to the worst one according to their relevance. Original supervectors contained 13 cepstral, 59 spectral and 5 time domain features (see Fig.1.).

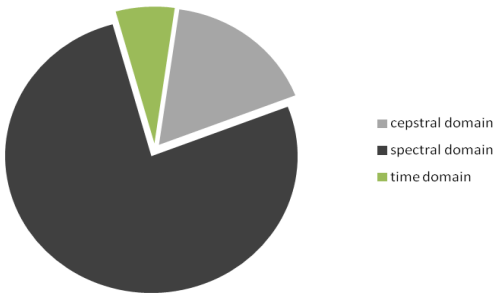

FIGURE 1. The representation of domain dependent features

Full feature supervectors had 77 parameters and their sequence before and after MRMR selection you can see in the Fig. 2.

1	MFCC_1	39	ASE_26	13	MFCC_13	14	ASE_1
2	MFCC_2	40	ASE_27	4	MFCC_4	15	ASE_2
3	MFCC_3	41	ASE_28	2	MFCC_2	16	ASE_3
4	MFCC_4	42	ASE_29	69	ASC	17	ASE_4
5	MFCC_5	43	ASE_30	1	MFCC_1	18	ASE_5
6	MFCC_6	44	ASE_31	3	MFCC_3	19	ASE_6
7	MFCC_7	45	ASE_32	72	Flux	20	ASE_7
8	MFCC_8	46	ASE_33	67	ASF_16	21	ASE_8
9	MFCC_9	47	ASE_34	6	MFCC_6	22	ASE_9
10	MFCC_10	48	ASE_35	70	ASS	23	ASE_10
11	MFCC_11	49	ASE_36	5	MFCC_5	24	ASE_11
12	MFCC_12	50	ASE_37	11	MFCC_11	25	ASE_12
13	MFCC_13	51	ASE_38	7	MFCC_7	26	ASE_13
14	ASE_1	52	ASF_1	8	MFCC_8	27	ASE_14
15	ASE_2	53	ASF_2	68	ASF_17	28	ASE_15
16	ASE_3	54	ASF_3	9	MFCC_9	29	ASE_16
17	ASE_4	55	ASF_4	10	MFCC_10	30	ASE_17
18	ASE_5	56	ASF_5	66	ASF_15	31	ASE_18
19	ASE_6	57	ASF_6	74	Kurtosis	32	ASE_19
20	ASE_7	58	ASF_7	63	ASF_12	33	ASE_20
21	ASE_8	59	ASF_8	65	ASF_14	34	ASE_21
22	ASE_9	60	ASF_9	62	ASF_11	35	ASE_22
23	ASE_10	61	ASF_10	12	MFCC_12	36	ASE_23
24	ASE_11	62	ASF_11	64	ASF_13	37	ASE_24
25	ASE_12	63	ASF_12	61	ASF_10	38	ASE_25
26	ASE_13	64	ASF_13	60	ASF_9	39	ASE_26
27	ASE_14	65	ASF_14	73	Skewness	40	ASE_27
28	ASE_15	66	ASF_15	58	ASF_7	41	ASE_28
29	ASE_16	67	ASF_16	53	ASF_2	42	ASE_29
30	ASE_17	68	ASF_17	59	ASF_8	43	ASE_30
31	ASE_18	69	ASC	55	ASF_4	44	ASE_31
32	ASE_19	70	ASS	76	AW_1	45	ASE_32
33	ASE_20	71	Roll-Off	57	ASF_6	46	ASE_33
34	ASE_21	72	Flux	56	ASF_5	47	ASE_34
35	ASE_22	73	Skewness	54	ASF_3	48	ASE_35
36	ASE_23	74	Kurtosis	77	AW_2	49	ASE_36
37	ASE_24	75	ZCR	52	ASF_1	50	ASE_37
38	ASE_25	76	AW_1	75	ZCR	51	ASE_38
		77	AW_2			71	Roll-Off

FIGURE 2. Original (left side) and new (right side) feature sequence

MRMR selection algorithm proposed new feature order (see Fig. 2 on right side): 13, 4, 2, 69, 1, 3, 72, 67, 6, 70, 5, 11, 7, 8, 68, 9, 10, 66, 74, 63, 65, 62, 12, 64, 61, 60, 73, 58, 53, 59, 55, 76, 57, 56, 54, 77, 52, 75, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 71.

According to the MRMR, smaller subsets of features were chosen. We always selected first *n*-features (*n*=12, 13, 14, 15, 16, 18, **19,** 20, 21, 22, 23, 25, 30, **34,** 35, **36**, 37, **38,** 39 and 77). We are focused on the dimension up to 39 (~ 50% reduction), which is commonly used in many applications [16], [17].

In the new feature order the cepstral coefficients obtained good score and all of 13 MFCC coefficients are concentrated in the first half. On the other hand ASE coefficients and spectral Roll-Off seem to be less important and they are grouped in the second half.

After the selection, continuous Hidden Markov Models (HMM) form 1 to 4 states and from 1 to 1024 Probability Density Functions (PDF) were trained and evaluated.

A. Acoustic event database

The extended acoustic event database JDAE TUKE [18] used in this work involved the gun shot recordings with 463 realizations of shots from commonly used weapons, breaking glass recordings with 150 realizations of broken glass and approximately 53 minutes of background sounds (traffic sounds). The recordings (48 kHz, 16 bits per sample) were cut and manually labeled using Transcriber.

In the testing process 46 gun shots and 13 breaking glass were used. Shots and breaking glass sounds formed one class i.e. the acoustic event class, so they were evaluated together.

B. Evaluation of results

The training and recognition process was done by the Hidden markov model ToolKit - HTK [19]. HTK includes different program tools that were primary developed for speech recognition tasks. HResults tool evaluates the output of HTK decoder with e.g. accuracy measure that is described following:

$$ACC[\%] = \frac{N - D - S - I}{N} \times 100, \qquad (6)$$

where D is the number of deletion errors, S the number of substitution errors, I the number of insertion errors, and N is the total number of labels in the reference transcription files [19]. This measure is not oriented on the particular class (acoustic events), but it informs about overall system performance. The class, which is the most represented in the reference, has the largest impact on the overall results.

Another evaluation approach is based on the confusion matrix (can be obtained form HResults) and several measures can be computed e.g. *precision, recall, F – measure* [20], etc.

This group of measures is more suitable for representing the class dependent results, therefore precision and recall were chosen to describe the detection performance for acoustic events class.

Precision [20] is defined by the following formula:

$$Precision[\%] = \frac{TP}{TP + FP} \times 100. \qquad (7)$$

Recall [20] is defined by the following formula:

$$Recall[\%] = \frac{TP}{TP + FN} \times 100, \qquad (8)$$

where *TP* - true positive is the number of items correctly labeled as belonging to the positive class, *FP* - false positive is the number of items which are incorrectly labeled as belonging to the positive class, *FN* - false negative corresponds to the items which were not labeled as belonging to the positive class but should have been. The results of experiments are depicted in Tab.1.

TABLE 1. Results of experiments for one, two and three state HMMs

		One states HMMs				Two states HMMs				Three states HMMs			
		19	34	36	38	19	34	36	38	19	34	36	38
1	ACC	55,88	3,68	-4,41	-7,35	66,18	11,03	2,94	-11,76	75,74	81,62	76,41	36,76
	Precision	58,00	42,14	39,86	39,33	69,05	44,62	42,65	39,73	76,32	74,32	68,35	48,74
	Recall	98,31	98,33	98,33	96,72	100,00	100,00	100,00	100,00	98,31	90,16	91,53	96,67
2	ACC	62,50	10,29	7,35	7,35	**92,65**	12,50	25,74	13,97	**90,44**	74,26	79,41	47,06
	Precision	62,77	45,04	43,70	44,03	89,23	44,88	48,72	44,96	87,88	68,06	71,62	53,77
	Recall	100,00	100,00	100,00	100,00	100,00	100,00	98,28	98,31	98,31	81,67	89,83	96,61
4	ACC	53,68	20,59	22,79	11,76	**97,79**	66,91	70,59	61,76	78,68	79,41	77,21	70,59
	Precision	78,69	47,97	48,36	45,38	98,28	64,63	65,88	61,96	78,33	71,62	70,83	71,62
	Recall	82,76	100,00	100,00	100,00	100,00	98,15	100,00	100,00	87,04	89,83	85,00	98,15
8	ACC	**91,18**	75,00	71,32	69,85	89,71	85,29	82,35	89,71	85,29	76,47	79,41	**99,26**
	Precision	58,42	68,67	66,67	65,91	89,47	80,28	74,68	83,10	83,05	70,42	73,53	98,33
	Recall	100,00	100,00	100,00	100,00	91,07	100,00	100,00	100,00	84,48	81,97	83,33	100,00
16	ACC	**91,18**	78,68	88,97	**94,12**	81,62	**97,79**	**95,59**	**97,06**	72,79	84,56	80,88	**92,65**
	Precision	89,39	70,51	79,73	92,06	79,31	96,67	93,44	96,67	68,97	81,67	77,97	91,53
	Recall	100,00	91,67	100,00	96,67	79,31	98,31	96,61	100,00	68.97	83,05	77,97	91,53
32	ACC	80,88	**90,44**	**93,38**	89,71	77,94	88,97	86,03	82,35	75,74	78,68	86,03	89,71
	Precision	78,69	88,52	91,67	88,33	75,00	86,67	83,61	80,00	72,41	75,00	83,61	88,14
	Recall	82,76	93,10	93,22	92,98	76,27	88,14	86,44	81,36	72,41	76,27	85,00	88,14
64	ACC	77,21	80,88	**94,12**	79,41	75,00	88,97	71,32	83,82	72,79	72,06	76,47	88,24
	Precision	74,14	72,37	93,22	71,05	70,49	86,67	68,12	81,67	68,97	65,33	68,42	86,44
	Recall	74,14	91,67	93,22	91,53	72,88	88,14	73,44	83,05	68,97	80,33	86,67	86,44
128	ACC	72,79	**91,18**	86,76	77,94	69,12	/	77,94	86,67	/	75,00	76,47	78,68
	Precision	68,97	89,83	83,87	68,83	65,57	/	75,00	83,61	/	71,19	72,88	71,23
	Recall	68,97	89,83	86,67	89,83	65,57	/	76,27	86,44	/	71,19	72,88	86,67

As was mentioned, one, two, three and four states models were trained and evaluated, but only the best results are presented in this work (see Tab.1). Four states HMMs reached worse results than one, two and three states HMMs. In some cases the training process failed too soon, therefore some models with higher PDFs were not successfully trained.

The different dimensions feature sets according to MRMR order were evaluated. Subsets including only the spectral, cepstral and time domain features were evaluated too, but the recognition results were not good. The recognition performance for full set of features (with 77 parameters per frame) was very low and this system worked inaccurate and generated too much false alarms (these results are not presented).

Better results were achieved by the selection according to MRMR. The extraction of MFCC was done in HTK. The spectral and time domain features were computed in Matlab environment. Selections and creations different feature dimension sets were done in Matlab too.

The best recognition result (ACC=99,26%) was achieved by the 38 dimension feature vectors for three states HMM with 8 PDFs. The combination of MFCC coefficients, ASC, Spectral Flux, ASF coefficients, ASS, Kurtosis, Skewness, AW coefficients, ZCR created the best features set. ASE coefficients and Spectral Roll-Off absented in the best feature set.

Results show that also two states models with 16 PDFs seem to be suitable for modeling acoustic events and background sounds. They obtained more balanced results in the comparison of the rest models.

VI. DISCUSION AND CONCLUSIONS

In this work we are focused on the gun shots and breaking glass detection as sounds that are potential dangerous and they are typical sound candidates that can point to the robbery scenario. Acoustic events were detected in the traffic background.

Shots and glass belong to the non-speech sounds so spectral and time features were chosen for describing the sound nature and cepstral features mostly used in the speech recognition try to come near to the human perception. The feature fusion of these different domains led to the complex feature vectors, which were used to build supervectors. The algorithm of sorting the coefficients according to their relevance was applied on them. Then the new sequence of coefficients was given and subsets of superior feature vectors were created and evaluated. The best recognition results were obtained by the three states HMMs with 8 PDFs, i.e. ACC=99,26%.

The interesting application for the intelligent surveillance system is to predict the situation by the detection of several different events evaluated in the context. This challenging task can be very helpful for the impact prediction, so the rescue sources could operate more effectively.

In an ideal case the surveillance system should be based on the information fusion from several information sources. If the dangerous event is detected (e.g. form audio information), the camera should change the coverage area to the side of interest (direction from which this abnormal sound came [21]) and these audio-visual data could be analyzed more precisely by the human, which can make a decision if the event (scenario) was a threat or not.

This process can take a lot of time of the operator so it is very important to reduce the number of false alarms (sound incorrectly detected as an event sound).

Although many aspects can influence these systems (e.g. extreme weather conditions, sound similarity between dangerous and not-dangerous sounds, inappropriate rate of SNR, etc.), they can be very helpful for police investigations and also help to keep a low level of criminal activities, because these systems continuously monitor designated areas therefore they have preventive nature.

In the future we would like to tune the extraction processes of various features, the selection of the "best" ones and also serching for most effective combinations for the optimal feature subsets that should describe the nature of acoustic events.

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