National Conference on Mechanical Engineering towards Industry 4.0 (MEI4.0-2023)

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Preface

In the rapidly evolving landscape of Industry, navigating the challenges presented by the digital era has become not just a choice but a necessity. It is in this spirit of adaptation and innovation that Department of Mechanical Engineering, Asansol Engineering College, took the initiative to organize the National Conference on Mechanical Engineering towards Industry 4.0 (MEI4.0-2023) on September 2023. This one day event brought together academics, professionals, and researchers from various corners of the country, fostering an environment for intellectual exchange and exploration. The Proceedings of National Conference on Mechanical Engineering towards Industry 4.0 (MEI4.0-2023) is a testament to the scholarly endeavor that transpired during the conference. It serves as a compendium of thought-provoking contributions from the conference's participants, offering insights into the multifaceted dimensions of Engineering in an increasingly digitalized world. The conference, held on the 1st September, 2023, provided a platform for numerous researchers to share their findings, experiences, and innovative approaches to Industry 4.0. Of these, 52 articles were selected to be included in the proceedings, reflecting the depth and breadth of the discussions that took place.

The success of the conference and this proceeding would not have been possible without the dedication and hard work of the organizing committee. Their commitment to ensuring the highest standards of academic exchange and the support of the Management of Asansol Engineering College were instrumental in making this event a reality. We hope that the insights and knowledge shared in the proceedings will serve as a valuable resource for academics, researchers, professionals, and student’s alike, inspiring further exploration and innovation in the ever-evolving landscape of Mechanical Engineering.

Editors

Dr. Debasish Sarkar

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About the Conference

The Department of Mechanical Engineering (NBA Accredited), Asansol Engineering College has organized a National Conference on “Mechanical Engineering towards Industry 4.0” (MEI4.0-2023) on 1st September 2023. The Conference brings the avid Students, Alumni, Scholars, Academicians and Industry experts on a single platform to cater the novel paradigms and focus on the pertinent research problems in the area of the academicians, researchers, students and representatives from the industry to deliberate on key research of Science and Technology that are relevant in the changing global environment. Industry 4.0 refers to the “smart” and connected production systems that are designed to sense, predict, and interact with the physical world, so as to make decisions that support production in real-time. In manufacturing, it can increase productivity, energy efficiency, and sustainability. It helps to manage and optimize all aspects of manufacturing processes and supply chain. It gives technological facility to assist humans in decision-making and problem solving and the ability to help humans with difficult tasks. The conference aims to expand your knowledge in the field of Mechanical Engineering towards Industry 4.0, receiving exposure and to develop an interest in research, connecting with other researchers and scholars in the same field. The important objective of the conference is to expose and attract young researchers to this growing area.

About The Institute

Asansol Engineering College, a self-financing institute was established in 1998 under the society of The Academy of Engineers (India). The College is approved by AICTE, New Delhi and Dept. of Higher Education, Govt. of West Bengal and affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West. The college is a joint venture between the JIS Group and the Techno India Group. It is situated at Asansol, Paschim Burdwan, West Bengal which is one of the largest Industrial belts of Eastern India. AEC offers various B. Tech programme & M. Tech programme along with BCA, BBA, and MCA in various disciplines. The institute has state of art laboratories, individual computing facility for all faculty members. All departments are active in research and various funded projects.

Managing Director’s Message

Welcome to the proceedings of National Conference on “Mechanical Engineering towards Industry 4.0 (MEI4.0-2023)”. The success of publishing the proceedings requires the commitment and contributions of many faculty members, student committee and staff of Mechanical Engineering Department, Asansol Engineering College, Asansol. I would like to take this opportunity to express my deep appreciation for the efforts of the all the members who provided the technical reviews and necessary discussions for the submitted research papers as well as all other committees and authors without whom this edited proceedings would not have been published.

Best Wishes!

Mr. Taranjit Singh

Managing Director

Director's Message

It is my immense pleasure that you are going through the proceedings of National Conference on "Mechanical Engineering towards Industry 4.0 (MEI4.0-2023)". The dedication and efforts of numerous academic members, student committee, and the faculty members of the Mechanical Engineering Department of Asansol Engineering College, Asansol, are necessary for the publication of the edited proceedings. I would like to take this opportunity to express my sincere thanks for the efforts of all the committee members, authors, and other contributors without whom this edited proceedings would not have been published.

Best Wishes!

Mr. T.K. Ghosh

Director

Principal's Message

I am thrilled to extend my heartfelt congratulations on the publication of the proceedings of National Conference on "Mechanical Engineering towards Industry 4.0 (MEI4.0-2023)". This accomplishment is a testament to the intellectual rigor, dedication, and unwavering pursuit of knowledge.

The proceeding is not only showcases the expertise of the contributor in the Mechanical Engineering domain but also contributes significantly to the broader academic community. Research works published here in the proceedings will undoubtedly leave a lasting impact on the field and inspire future generations of practitioners, educators, and scholars.

Warmest regards,

Prof. (Dr.) Avijit Bhowmick

Principal

Asansol Engineering College, Asansol

Vice-Principal's Message

On behalf of the entire AEC family, I want to extend my warmest congratulations on the publication of the proceedings entitled National Conference on "Mechanical Engineering towards Industry 4.0 (MEI4.0-2023)". This is an achievement which is testament to talent, dedication, and passion for Editors and contributors.

Such creativity and hard work have not only enriched our institute but will also inspire countless researchers who have the privilege of reading this work.

Warm regards,

Dr. Gouri Sankar Panda

Vice-Principal

Asansol Engineering College, Asansol

Contents

Chapter - 1

Study and Review of Inventory Optimization towards Industry 4.0

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Chapter - 1

Study and Review of Inventory Optimization towards Industry 4.0

Pravanjan Bera, Debabrata Das and Nirmal Baran Hui

Abstract

With the advent of modern science technologies like artificial intelligence, cloud computing, smart sensors, virtual reality, IoT, etc., industries have become capable of running in autonomous mode, where each machinery in operation interact with each other and corresponding data, analysis and even predictions are instantly available at the fingertips of management to take best decisions for the organization. All of these contribute to smart manufacturing which is the key to Industry 4.0. As competition and volatility of market demands are in the increasing trend, technologies pertaining to industry 4.0 can play a major role in increasing the margins in businesses. Inventory is a major contributor towards profitability for all supply chains and a big concern for supply chain managers. This work presents a brief review of studies in the field of inventory management and optimization with the aid of Industry 4.0 and further scopes of research in the field. Research works based on computations towards inventory systems optimization have also been reviewed as these can contribute to inventory cost minimization or profit maximization through big data analytics and cloud computing, and thus aid in improving the performance of the supply chain. Conclusion has been drawn summarizing the findings in the reviewed papers and areas open for research towards role of industry 4.0 on inventory systems and optimization.

Keywords: Industry 4.0, optimization, inventory, supply chain, manufacturing, system.

1. Introduction

While third industrial revolution was marked by computing systems, electronic gadgets and information technology, fourth industrial revolution, widely popular as Industry 4.0 has evolved and gained popularity since the early twenty first century. Industry 4.0 in present date is not only limited to industry sector, but covers every aspect of human life. Digitalization of each and every component of any business model through tools pertaining to industry 4.0 have led to simplification of complex problems by enabling management to access real time data and all related information and take decisions accordingly.

Inventory is linked to all members of any supply chin, be it raw material, semi-finished or finished product inventory. Most of the time, inventory holding costs become essential to avoid stock out situations and losing business and customer relations. At the same time, this leads to increasing costs of supply chain. Challenges that contribute to this major component of variable cost is the high volatility of demand and disruptions in desired lead times. A lot of research work was conducted in the field of inventory optimization and many are underway. Objective of this paper is to assess the importance and utility of Industry 4.0 technologies over modernizing inventory tracking processes, subsequently leading to better optimization of inventory than presently used conventional methods.

Proceedings of this paper are sequenced as follows. Publications in reputed conference and journals have been reviewed in the next section. For each of the research papers, content analysis has been performed related specifically to the applications of Industry 4.0 tools towards better inventory control and optimization. Next section deals with general discussion on the findings perceived. Concluding remarks are finally summarized along with scope of future works in the area.

2. Literature Review

Towards role of Industry 4.0 in optimization of inventory systems, Yuan (2020) proposed a model for inventory systems which integrates suppliers and customers through orders, feedbacks, products and services. Inventory is the residue whenever any transaction occurs between subsequent stages of a supply chain. In this buy and sell environment, prior information on customer demand and reliability of the suppliers are extremely vital as control over these factors should minimize inventory cost. Factors that control demand of any product are customer behavior, product pricing and nevertheless quality of product. With these data available, precise forecasting of customer demand can be done through data analytics coupled with market intelligence. Similarly, factors that attribute to the suppliers are their performance, quality of supply, reliability, delivery mode, responsiveness and flexibility to adapt to crisis situations. With availability of large scale data of such system parameters and customer demand, in place of conventional sequential approach, optimization problems can be formulated and solved, thus resulting efficient and effective inventory control in order to generate maximum revenue with least cost and maximum service levels.

In the process of generating a finished product, maintenance, repair and operations (MRO) plays a very important role. Extensive research works have been carried out in the field of MRO parts inventory management and different ways of clustering the MRO parts based on demand pattern for effective control over same. Chen *et al.* (2019) proposed clustering based additionally on usage frequency of the part, detailed item description, price, approximate lead time and usability over different plants using the same part. This work further proposes the utilization of Industry 4.0 tools in effective management of MRO parts inventory after clustering as follows:

1) **Items with usage in definite known frequent pattern:** Use of such tools may not be cost effective, most common forecasting methods such as exponential smoothing and moving averages are sufficient to remain cost effective.
2) **Parts with sudden and non-uniform usage:** Historical consumption patterns do not indicate upcoming usage probability. Linking of such MRO's with mother assets and their scheduled maintenance intervals, reliability and continuous performance monitoring with the aid of IoT, Big Data, Machine Learning enables preventive maintenance. With breakdown predictions, the parts can be ordered in advance in right quantities.
3) **High cost long lead time and non-frequently purchased items:** Lead times can be improved with the aid of additive manufacturing like 3D printing which generates high quality precision items at low costs.
4) **Parts with high variation in demand:** Smart mobility models can aid dealing with this category of products.

Unmanned Aerial Vehicle (UAV) is another technology pertaining to Industry 4.0 over which extensive research work has been carried out. These are capable of performing regular repeated and tedious tasks, some of which are not safe or cost efficient enough to be done manually. Fernandez-Carames *et al.* (2018) designed a system based on UAV to automate tracking and traceability of inventory. They performed real life analysis of the efficiency of the system by operating a drone with radio frequency receiving facility in a sample warehouse. Data capturing time is reduced by nearly 80%. Inventory data (such as location, condition of SKU, etc.) collected by the UAV has further been incorporated in block chains after validation and checking for authenticity. Block chains are another areas of interest in present industrial revolution that enables data to be decentralized and supplied to specific desired parties only maintaining cyber security. Manual operation of the UAV had been performed in the case and may be extended to prefixed paths which shall further increase the efficiency of the system.

Logistics play a vital role in the management of inventory. Logistics systems must be capable of adapting to changes to be simplest, cheapest, fastest and most efficient. Antoniuket *et al.* (2021) researched on developing a tool for the emerging digital technologies of Industry 4.0 that enables a digital twin of the logistics system to accurately capture data and control logistics for an industrial environment. The digital twin of the production house records all real time data through installed RFID’s and smart sensors. Al machinery/ vehicle movement are tracked right from trolleys running on magnetic strip tracks for inter shop transfer of material to tractors carrying inventory from suppliers to shop. It also enables a simulation of the logistics traffic which is practically not possible with physical machinery and other components. A detailed 3-D model of the working space is also generated where managers get a better insight over the whole system. With constant data capturing of the spare parts on the move, it becomes easier to control their stocks and thus optimize inventory better through technologies such as Just in Time concept (JIT).

A digital twin of a production system allows collective information of data, shortening and streamlining of production cycle, identify shortcomings of present systems and minimization of new product introduction times. Morhac *et al.* (2017) simulated a digital twin model for a production line of manufacturing of pneumatic cylinders. Their work comprised data obtained from various stages of the physical process being incorporated into the digital twin through mapping each and every step involved in the manufacturing process. Optimization of the production system as per production plan was conducted through simulation of the digital twin. Sensitivity of different parameters of the production line could be deciphered at the same time. Material flow in the system could thus be predicted aiding better management of inventory.

Trstenjac *et al.* (2017) studied the differences of conventional process planning with the ideas of Industry 4.0 and introduced the concept of ‘product planning’ software as a new approach towards sequencing, process planning and scheduling. In the era of Industry 4.0, industrial products have been referred as ‘smart products’, capable of capturing feedback from the customers to enable the software to decide upon the production parameters. Idea behind design of such software is to connect same with ERP systems, such that automatic process plans can be created with proper scheduling and sequencing. Advanced Industry 4.0 tools such as data mining and decision support systems can be used to make best optimal decisions. With the production plan being fixed through the software, tools like machine learning are expected to generate best solutions towards optimum utilization of inventory storage spaces thus minimizing inventory.

Das *et al.* (2018) aimed research towards optimization of stochastic multi product supply chain facing stochastic demand and following continuous review inventory policy. They prepared a mathematical model for solving the non-linear multiple constrained optimization problem. While objective function for optimization comprises inventory holding cost of different members of the supply chain, constraints include space limitations for holding inventory at different levels. Optimum order quantities and reorder intervals have been derived through extensive calculations to minimize inventory and subsequently total cost of the system. Solution has been generated for a fixed number of installations and products in the illustrated model considered for the study. With the advances in Industry 4.0 technologies, it is very well possible to integrate such data through big data/ data analytics tools, generate solutions through cloud computing and disclose result data to relevant management personnel through specific block chains maintaining cyber security.

Leite *et al.* (2019) formulated an algorithm for real time simultaneous optimization of planning and scheduling problem. Proposed algorithm was based on metaheuristic approach and tested with various instances. For every delay in any job process, penalties arise due to idling of resources and early/ late processing times. Objective of their work was to minimize the cumulative of these losses. In addition to conventional planning and scheduling jobs, the algorithm was based on the following four decision making *viz.*

i) Rescheduling a job from one time to another.

ii) Swapping of jobs with respect to scheduled time.

iii) Swapping of two lists of jobs.

iv) Swapping of jobs between different machines.

With the aid of this variable neighborhood descent algorithm, competitive results were achieved for situations with large number of jobs and lesser number of machines in fractions of seconds towards Industry 4.0 context.

Bagalagel *et al.* (2020) presented the impact of the arising concepts of Industry 4.0 on recycling based supply chains. As a contribution towards green earth, majority of the components of any product ought to be recycled after completion of the product lifetime. A supply chain manufacturing a specific product was considered for formulating the algorithm and find out optimal proportions of components that are to be recycled to gain maximum outputs and subsequently profits. Results indicate maximum profits for cases where proportion of demand to be fulfilled by remanufactured products are not defined as compared to the cases where the proportions have been fixed.In the context of Industry 4.0, model proposed in the research work makes use of real time data centrally collected regarding collection, inspection for reusability of the components and dismantling of assemblies to decide upon the product mix that optimizes inventory as well as operation costs.

There has been significant work on scheduling optimization towards utilization of available machinery of a shop and reduction of inventory. Li *et al.* (2020) established a tradeoff between delays in conventional scheduling and rescheduling frequency by integration of Machine learning (ML) with optimization algorithms. In their approach, ML tool has been used to identify rescheduling patterns for a particular shop environment through real data capturing. Their work suggests that the developed model can also be applied for non-industrial applications such as scheduling of staffs in workplaces to bring a balance to services offered.

3. Results and Discussion

Extensive research work is evident from the literature review in the field of inventory optimization towards Industry 4.0. With majority of the industries having already adapted to this revolution, researches are underway to combine more number of elements of Industry 4.0 technologies to keep up with the pace of the developing world. Present study was intended to cover all possible research works that establish incorporation of various tools like big data, data analytics, smart sensors, cloud computing, machine learning, block-chains, Internet of things, virtual reality, digital twins and cyber security into industries, products and systems to convert them into smart industries, smart products and smart systems. It also focuses on how industry 4.0 has changed the way the conventional methods of inventory optimization have been taken over or raised to another higher level with emerging technologies, thus benefiting businesses in all aspects.

4. Conclusions

Despite several works in the area of role of Industry 4.0 towards inventory optimization, there remains several gaps that paves way for future research opportunities. Future scope in this field can be summarized as:

- High level of automation is the essence of present smart industry scenario. This results in change of human resources, both in quantity and quality. Skill and man management must be areas of concern for future work.
- Application of artificial intelligence to further enhance industry performance.
- Experiment based results of application of Industry 4.0 tools on inventory optimization are scarce. Most of the works in this field have been found to be theoretical. More real life based experimental works and subsequent validation are areas open for research.
- Carbon emissions are detrimental for the future world and one of the ways to reduce same is recycling of products. Future research may be based on building complex networks and optimizing both inventory and business costs for closed loop supply chains enabling maximum recycling.

Conflict of Interest: The authors declare no conflict of interest.

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Chapter - 2

Investigation of Contact Stress along with Deformation in FEM at Active Contacts in Stator and Rotor of Orbit Motor

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Chapter - 2

Investigation of Contact Stress along with Deformation in FEM at Active Contacts in Stator and Rotor of Orbit Motor

Vivek Kumar Singh and Abhijit Nag

Abstract

The Orbit motor is a hydrostatic machine element consisting of several roller around the inside diameter of a stator. The rotor is made to rotate by creating the pressure difference of fluid flow. These orbit motors are based on internal gearing feature with smaller gear having one less teeth compared to outer gear. These motors are having many applications owing to their compact size, robustness, better performance index. Fig-1 shows a ORBIT motor with shaft and valve [1].

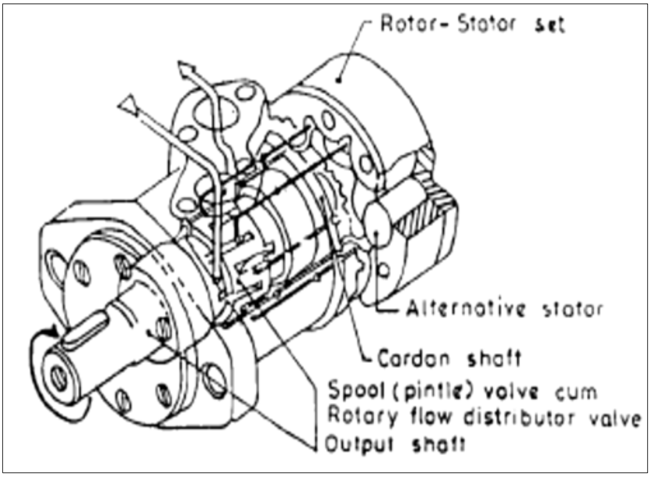

Fig 1: ORBIT Motor with the distributor valve integrated with the transmission shaft

The kinematics of this motor, star is allowed to rotate in orbital manner whereas ring is fixed. During operation there will be some deformation and stress will develop at contact location. In this motor, the rotor is having multiple contact with stator and these contact positions are inaccessible for any physical measurement by installation of measuring instruments or probe. Also in theoretical estimation, the problem faced is statically indeterminate condition of the equations due to multiple contacts. Thus, the estimation of stress at contact position is required for any pressure. To overcome this problem, the model is made with stepwise improvement for accurate and more realistic boundary condition and loading condition. Model is developed by using FEM in Ansys for estimation of stress at contact along with the gap and deformation. Scope of this present investigation is limited to estimation of the stress at contact along with gap and deformation in static condition.

Keywords: Orbit motor, contact stress, deformation and gap.

1. Introduction

The fundamental design features of orbit motor is the cycloidal internal gear with one teeth difference. The tooth of gears at contact are geometrically form-closed with the many contact position at any instant. The rotor-stator with geometrically form closed contacts constitute the chambers. The envelop lobes are either integrated with ring or as a rollers placed in the partial bush of ring.

In the working process the fluid which is already pressurized is forced into the chamber which is under expansion stage and fills it which leads to pressure increase of input chambers. Due to this increase of pressure the rotor which is having active contacts with stator will experience force and moment. The rotor being in a free float condition will start rotation about its own center and revolve around the center of stator. Thus there is change of volume in the chambers. This volume change is because of expansion and contraction of inplane form closed area between two successive active contacts during rotation. Also after some angle of rotation, the chamber in compression stage will begin to expand and the chamber in expansion stage will enters the compression stage. This expansion and compression phase repeats with the rotation of shaft. This expansion and contraction causes the motoring and pumping action. Also among these active contacts there will be two active contacts which separates the lower pressure zone to high pressure zone.

Most of the investigation of epitrochoid based gear profile done earlier was mainly on study of the gerotor or gerollor. Maithi and Sinha [2] in 1988 has presented the kinematic analysis to investigate the nature at active contact regions. L Ivanovic *et al.* [3] carried out in detail study of force and moment analysis between gears in contact with gerotor pump. The author considers two separate cases as mentioned below.

i) There is no pressure variation due to fluid flow

ii) It is considering that the chamber volume variation is having influence in the pressure variation and pump load distribution.

The deformation and gap estimation by debanshu roy *et al.* [4] presents the deformation and gap at active contacts presented with graph indicating the variation of deformation and gap w r.t the shaft angle rotation. Earlier with FEM approach the stress estimation in components and gap in active contacts by NAG *et al.* [5] by considering all geometric, kinematics and operational feature is established targeting the accurate estimation of leakage losses, pressure drop in the chambers and there by steady state characteristics at starting and slow speed range. The present paper provides the variation of contact stress at all contact position with the rotation for one complete cycle of expansion and compression phase.

As the kinematics of these motors w.r.t gerotor or gerolor is different. In the kinematics of orbit motor the stator is not a rotating part with reference to the axis to rotation of rotor as happens in other internal gear type machines. The stator is a fixed member in orbit motors. Thus the behavior at contact position for deformation and stress will be different for orbit motor. In this present investigation, it is studied and estimated the stress at contacts between stator and rotor by FEM approach for the orbit motor along with gap and deformation.

2. Analysis of Contact stress along with gap and deformation at active contacts

2.1. Geometric Model

The model considered for this investigation is having star or rotor as inner gear and stator or ring as fixed ring gear. The model of star- ring made for this investigation is presented in fig-2. The stator has 7 lobes and ring is having one less 6 lobes, thus creating 7 chambers in between the active contacts represented a C1 to C7. There are 07 active contacts points as marked in figure-1 and among these active contacts, there will be two contact points which will separate the chambers by there pressure zone i.e higher pressure side to lower pressure side. These contacts seperating the HPZ to LPZ are also referred as transition contacts. In this present case Contact points at 1 & 4 are transition contacts as presented in fig-3.

In orbit motor the fluid which is already pressurized condition is forced into a chamber in expanding stage thus making the inner member, star to rotate on its own axis and to revolve around the center axis of ring. After rotation to certain angle the adjacent chambers which was in compression mode earlier will be expanding due to flow of pressurized fluid. The expanding chamber, once reaches the maximum volume, will enter into compression mode. The change of phase will be repeated with the rotation of shaft. The kinematics of orbit motor, the outer member ring is fixed and star is allowed to rotate in orbital fashion.

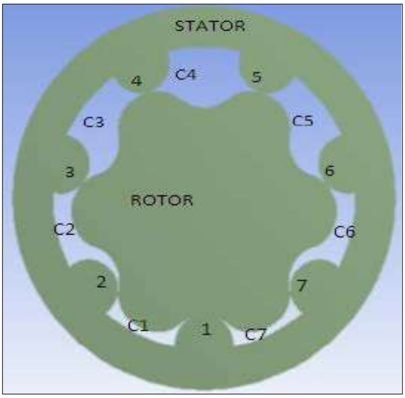

Fig 2: Stator and Rotor with integral lobes.

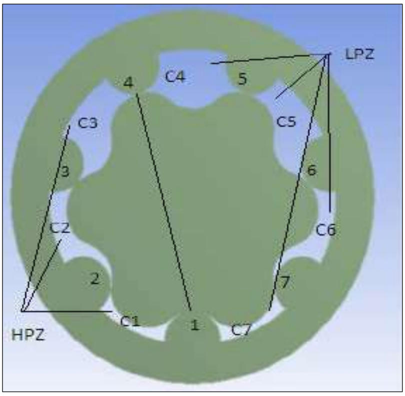

Fig 3: Star and Ring with Transition Contact Points

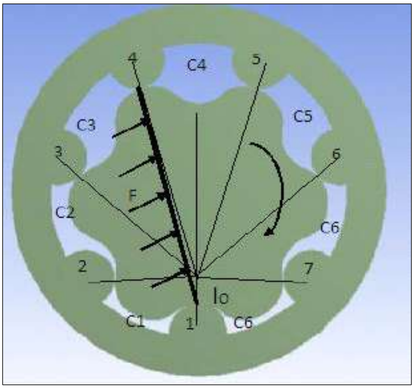

Fig 4: Force through Imaginary line separating

2.2. Working action of orbit motor

The motor in one complete rotation of shafts will experience Z(Z-1) times action of expansion and compression. This is because each chamber will experience expansion and compression for rotation of each rotor lobe in between stator lobes. Thus one cycle of expansion and compression will be of 2 $\pi/Z(Z-1)$ degree of rotation of shaft. Thus a chamber will experience expansion and compression both in $2\pi/Z(Z-1)$ degree of shaft rotation. Also the chambers will be in expanding mode or in compression mode for the half of this angle of rotation of shaft i.e for $\pi/Z(Z-1)$ degree of shaft rotation and the phase of expansion will change to compression and vise versa after π/Z(Z-1) degree of shaft rotation. This angle is called as phase angle.

According to figure-2, the one chamber which is in TDC position let us assume it as the last chamber of the in this orbit motor out of totat 7 chambers and mark it as C7 and accordingly all chambers are marked. Now in this condition C7 is in TDC means in the chamber C1, compression phase has been completed and it is going for expansion phase. Here let us consider two condition:

1) Shaft angle position just before TDC of C7:- Before reaching the TDC position at C7 the chamber C1 was in compression phase which started shaft angle rotation of π/Z(Z-1) degree before the TDC of C7. In this condition the active contact at position 1 and position 4 are the transition active contacts. The chambers in high pressure zone is in expanding mode and others will go through compression phase. This difference in pressure in HPZ and LPZ will exert force which will be acting through this imaginary plane as seen in figure -3. This imaginary plane is formed by joining the transition active contacts.

2) Shaft angle position just after TDC of C7:-In this case the transition contact will change and the new transition contacts are 1 and 5. The HPZ chambers are C5, C6 & C7 whereas LPZ chambers are C1, C2, C3 & C4. Here also the difference in pressure in HPZ and LPZ will exert force which will be acting through this imaginary plane.

At $\xi = 4.2857$ there is a change in transition contact from C1-C4 toC1-C5 thus making a shift in chambers phase also.

The chambers wise phase in complete cycle is represented in Table 1.

Table 1: The chambers wise phase in complete cycle

Orbit motor, Z=7, Chambers phase with rotation from 0 to 8.571 degree.		
ROTATION	Compression Phase	Expansion Phase
$0 \le \xi < 4.2857$ degree, 0 to π/Z(Z-1)deg	C1, C2 & C3	C4, C5, C6 & C7
$4.2857 < \xi \le 8.571$ degree, π/Z(Z-1) to 2π/Z(Z-1) deg	C1, C2, C3 & C4	C5, C6 & C7

As represented in Fig-4, The pressure force is acting through the imaginary plane made by joining the transition contact. The star is having the floating axis, because of the force generated by pressure difference it will experience torque also. This torque will be acting through the instantaneous centre of rotation, IO. Thus for the balancing of these forces there will be reaction forces at the contacts.

Considering the pressure is HPZ (high pressure zone) as Pi and LPZ (low pressure zone) as Po.

Difference in pressure is = δP = Pi-Po

Length of line between active transition contact = L

Breadth of the plane (Width of star & ring) = b, Consequently the area of imaginary plane, $A = Lb$

Force acting through this plane, $\mathrm{F} = \delta\mathrm{PLb}$ -----------------(1)

This force is transferred to ring through the active contacts. For equilibrium of these force

$\mathrm{F} = \sum_{n=1}^{z} F_{rn}$ ------------------------------(2)

Where F_{rn} is the reaction forces at the nth active contact.

Also the star due to its floating axis, will experience torque generated by this force F which will be acting through the instantaneous center of rotation, IO. Thus, Mi = ri X Fi Where ri is the position vector from mid-point of L to IO. These above equation for multiple contact is a statically indeterminate condition. Thus, the FEA is opted to estimate the contact stress.

3. Modelling and Analysis In ANSYS

The rotor and stator of orbit motor is developed in ANSYS for estimation of contact stress. It is very difficult to model the profile and position of rotor and stator in ANSYS, thus the rotor and stator coordinated are obtained by coding and imported in ANSYS workbench for static structure analysis. The final model is developed by considering the boundary conditions and loading patterns. In the geometric model it is considered that ideal profile for star and ring and neglected the manufacturing tolerances and also the fit is considered idle means there is no interference between star and ring and all active contact exists even at no load conditions.

2.3.1. Modelling

The detail geometry of star and ring that is taken presently for analysis and also the properties of material used during FEM modelling and analysis is presented in Table-2 below. Ideal fit is considered for this analysis i.e. all the active contacts is there even when there is no load. Although in reality this is very difficult to achieve due to manufacturing tolerance. In modelling, python is used by us for coding to generate the data point and same is inserted in Ansys.

Table 2: Model Details

Description of parameter	Value
Lobes on envelop (Number)	7
Radius of roller (in mm)	2
Breadth of rotor-stator (in mm)	10
Friction coefficient in contacts	0.15
Young modulus (In Pa),	7.1e+010

2.3.2. Mesh Generation

Once the model is developed, mesh is generated. The 3-D hex dominant structured mesh and having variable fineness is used in this model. Detail of mesh is mentioned in Table 3.

Table 3: Mesh generated details for model @ = 0º

Defaults	Physics preference	Mechanical
	Relevance	10
Size	Used advanced size function	Curvature
	Relevance center	Medium
	smoothing	High
	Transition	Slow
	Span angle center	Coarse
Mesh Control	Method	Hex dominant
	Behaviour	Soft

2.3.3. Load detail and boundary condition

Once the model is created the proper load is required to be defined for analysis. Also as required, considered that surfaces are not penetrating each other as they are constrained to do so. Next the force is applied in terms of pressure. The detail of boundary condition as mentioned in Table 4 below.

Table 4: Load applied details along with the boundary condition for simulation model

Contacts	**Types**	**Frictional**
	Formulation	Augmented lagrange
	Detection method	PC (Programme Controlled)
	Stiffness Details	PC
Geometric modifications	Interface treatment	Adjust to touch
Pressure	Mpa	5

In Ansys Formulation used is Augmented Lagrange as the surfaces in contact are constrained from penetration to other surfaces.

2.4. Computation

Once the loading is completed and other parameters are defined, FEM analysis in ansys is done by rotating the star position from 0^{o} to 8.571^{o}. This rotation makes one complete cycle of expansion and compression. To carry out the analysis, pressure force due to fluid flow is applied. This force is acting in the imaginary plane formed across the rotor by line combining the active transition contacts having area equal to L X b.

In this present analysis the rotor is rotated from 0 to 8.571 degree i.e one phase angle for finding the contact stress in all the contact points. To measure the contact stress, a stress probe is mounted at each of the stator contact surface. Also, the deformation probe is mounted to measure the deformation at the same surface. As the chambers will change the phase from expansion to compression after rotation of rotor ε_{ι}=4.2857. Thus, for more accurate analysis and better results, two close value is considered near to this position. One point just before and other just after ε_{ι}=4.2857.

Result and Discussion

The variation of contact stress w.r.t the rotation angle for all contact point is represented in Fig-5 and Fig-5.1. There is sudden variation at transition point of ε_{ι}=4.2857. Due to the change in phase at transition the variation of contact stress also changes accordingly. At few contact points it increases and also at some contact point it decreases.

Stress in all the active contacts at HPZ is represented in Fig-6 and at LPZ is represented in Fig- 7 respectively. It is seen in the graph that there is sudden drift in contact stress at 4.2857 where the phage is changed from compression phase to expansion phase and conversely for all the chambers. This is more clearly visible in the Fig 6.1 and Fig 7.1 representing contact stress w.r.t angle of rotation from 3 to 5 degree. As the contacts at P1 and P4 forms the transition contact from 0 to 4.2857 of rotation, it is revealed from the Fig-5 and Fig-7 that there is sudden reduction in contact stress at P1 during transition and increase in contact stress at P4. The same fashion of variation is seen in deformation at P1 and P4 where the deformation at lobe 1 (D1) decreases at transition where as it increases at P4 (D4). From 4.2857 to 8.57 degree of rotation the active contact is at P1 and P5. The contact stress at P5 decreases at transition and then it increases.

The variation of contact stress makes the same pattern as that of deformation for all contact points. There is sudden shift in deformation and contact stress at transition for all contact points. Also, the change in deformation and contact stress are in same direction i.e. the contact stress reduces vertically at contact points wherever the deformation decreases and conversely. The change in contact stress with the phase change is more clearly represented in Fig-5.1.

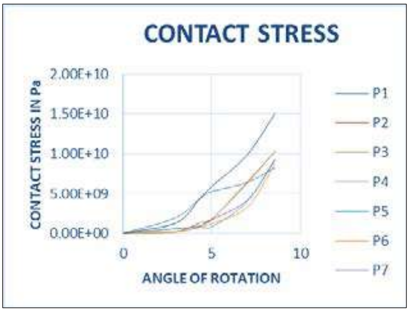

Fig 5

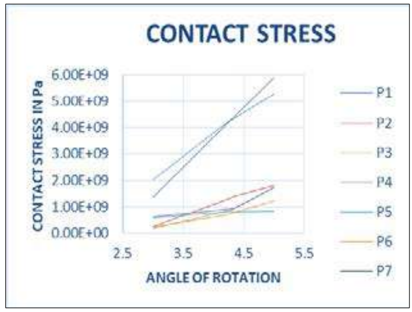

Fig 5.1

At angle ε_c =4.2857, when there is change in stage from compression to expansion and vice versa in all the chambers there in a fluctuation in contact stress also at all contact points. This fluctuation in contact stress is due to change in deformation i.e. sudden increase or decrease in gap and deformation. The variation of gap or deformation with respect to angle of rotation for all contact point is represented in Fig-6. The change in deformation with change in phase is more clearly represented in Fig-6.1.

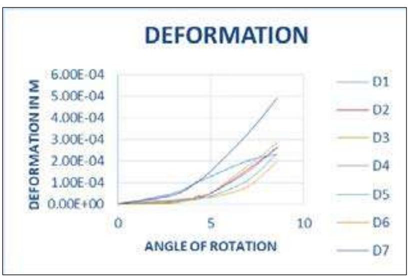

Fig 6

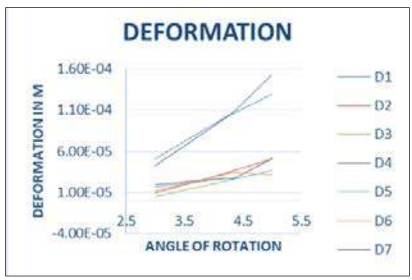

Fig 6.1

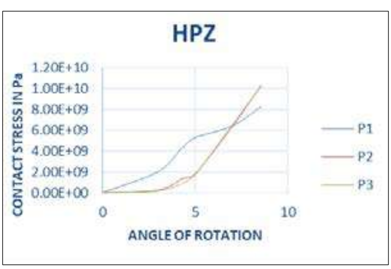

Fig 7: Stress at contact point in HPZ

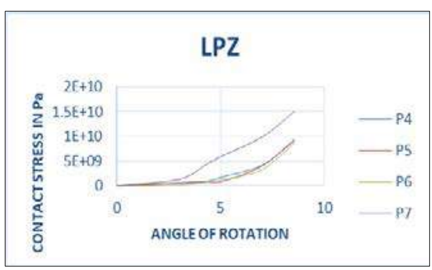

Fig 8: Stress at contact points in LPZ

The variation of contact stress and deformation for each contact position is presented in Fig -9 below

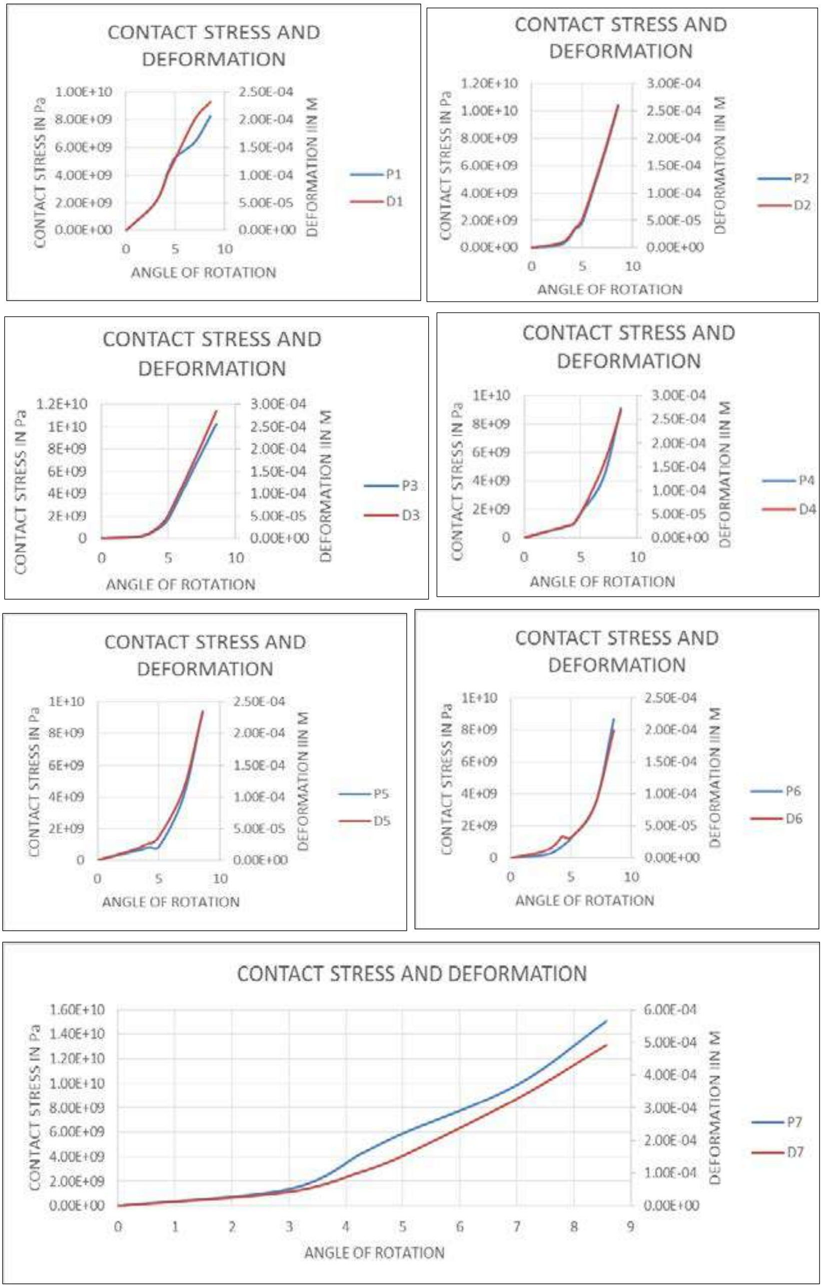

Fig 9

Conclusion

For estimation of stress at the contact surface of the active contact of rotor-stator, we have used the FEA technique. In this investigation, the gap and deformation variation is also studied along with the variation in contact stress for one complete cycle of expansion and compression. However, there are inter chamber and other leakages, the affect of these leakages will also be there which is not considered in this investigation. The stress at contact positions depends on many parameters like material, load applied, working condition of rotor-stator, coefficient of friction are few, thus checking the result for particular pressure is advisable.

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Chapter - 3
A Review of Particle Swarm Optimization Algorithm and Its Developments

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Chapter - 3

A Review of Particle Swarm Optimization Algorithm and Its Developments

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Abstract

Particle Swarm Optimization (PSO) is a stochastic optimization technique that was inspired by natural occurrences like fish schools and bird flocks. The study demonstrates how PSO has changed since its debut in 1995, with researchers continuously improving and modifying the algorithm to satisfy various needs and applications. Starting with its history and inception, the paper discusses a number of PSO-related topics. The article looks at the current state of PSO research and applications, focusing on a number of issues including algorithm structure, parameter selection, topology structure, discrete PSO, parallel PSO, multi-objective optimization PSO, and engineering applications. This comprehensive analysis showcases the versatility of PSO and its wide-ranging applicability across different domains. Overall, this paper appears to be a valuable resource for understanding the history, theory, and current state of PSO.

Keywords: Particle swarm optimization, discrete swarm optimization, multi-objective optimization PSO

1. Introduction

Russell C. Eberhart and James Kennedy (1995) developed a methodology that is inspired from nature. This methodology known as particle swarm optimization in which algorithm imitates animal social behaviours, including those of insects, herds, birds, and fish. These group of swarms cooperates for their survival, and each swarm member adapts how they search food in light of their own and the experiences of other swarm members. The PSO algorithm's basic design base is influenced with two studies: first one is similar to evolutionary algorithms in which PSO operates in a swarm mode, and the second one is to allow it to look at a sizable amount of the solution region for the better function of the objective.

Five key components for developing swarm's virtual life networks with automated agreeable behaviours have been discovered by millions using artificial life theory to analyse social animal behaviours:

1) **Proximity:** It should be possible for the swarms to do easy space and time mathematical calculations.
2) **Quality:** The swarm ought to be able to recognize and react to changes in its perception of its surroundings.
3) **Diverse response:** The swarm's strategy to gather resources should not be limited to a small range.
4) **Stability:** The swarm's behavioural mode should not change.
5) **Adaptability:** When justified, the swarm must alter its behavioural mode.

PSO particles can move consistently through the search space while modifying their path pattern in response to changes in the environmental signal. Particle swarm systems thus meet the aforementioned five requirements.

Its optimization properties are based on this simple idea and two fundamental concepts:

- The problem might be solved by allowing a single particle to evaluate "how good" its current location is.
- Each particle moves through regions of the challenging space with unidentified names, due to a random component in its velocity. Due to this attribute, a complete in-depth analysis of this problem is made feasible, increasing the possibility that the best solutions will be found soon. Additionally, it ensures that the swarm is initially distributed evenly.

2. How does it function?

Additional versions of PSO have been developed since its initial release. In this article, we will provide a detailed explanation of the original operation, along with two alternative option, so before describing the two alternatives, let's first take a look at how the first one works. Since it's initial release, PSO went through additional growth. We will give a thorough description of the original procedure with two different choices in this write-up. According to this particular approach, the position and velocity of each particle are updated regularly. Although PSO has proven to be an effective algorithm with positive outcomes, it does not guarantee that the optimal solution will be found because it depends on visiting and assessing problem space positions. Despite the fact that there are several varieties, most all have a fitness purpose. We will simply refer to this function as f(xi), which is short for f(xi,0,..., f(xi,d)), as its definition relies on the issue being optimized. (Especially with regard to its Dimensions). In a multi-dimensional space, the positioning of the "I" particle relative to the intended outcome is critical. This function demonstrates how well this is achieved. When dealing with an optimization problem in one of the D dimensions, the weights and constraints are used to optimize them. Since the method is multi-dimensional, the locations and velocities of the particles must have d components. Therefore, we have positions as xi(xi,0,..., xi,d) and velocities as vi(vi,0,..., vi,d).

3. Global Best

As a result, with this strategy, we get a completely connected swarm, in which all the particles share information and each particle knows the optimal location that every other particle in the swarm has ever visited. For each particle, place (1) and velocity (2) are computed as follows:

$$X_{i,d}(it +1) = x_{i,d}(it) + v_{i,d}(it ++1) \qquad (1)$$

$$V_{i,d}(it+1) = v_{i,d}(it) + C1 * Rnd(0, 1) * [pb_{i,d}(it) - x_{i,d}(it)] + C2 * Rnd(0,1) * [gb_{d}(it) - x_{i,d}(it)] \qquad (2)$$

Where:

i = a particle's index or identifier

d = the dimension of a particle, which includes its position and velocity;

it = the current iteration number of the algorithm;

xi,d = the position of particle i in dimension d

vi,d = the velocity of particle i in dimension d

C1 = the constant for the cognitive component used to adjust particle velocity

Rnd = a random value between 0 and 1 used as a metaheuristic component of the algorithm

Pbi,d = the location in dimension d with the best fitness among all visited locations of particle i;

C2 = the constant for the social component used to adjust particle velocity;

gb,d = the location in dimension d with the best fitness among all visited locations of all particles in the swarm.

It should be observed that the velocity update (equation 2) is the consequence of the combination of multiple components, each of which has a specific significance, the momentum is the previous velocity, which can be located in line one. The second line contains a cognitive component, and it mostly depends on how close the particle is right now to being in its ideal location. The third line shows particle's proximity to its best position within the swarm determines how socially active it is. Since this modified feature are iterative in a manner that they require past knowledge of velocity and positioning values, it is essential to comprehend how these variables are initialized.

The fundamental PSO method's pseudo-code is shown in algorithm 2. We offer a straightforward solution to number of issues that weren't completely covered in the first PSO presentation, but there are many other options available, each of which has a distinct effect on the algorithm's performance [3]. These components include the halting condition of the genuine PSO algorithm and the setup of the particle locations and velocities in algorithm 1.

When the Local version techniques was first introduced, the same author identified it as a method of preventing particles from leaving the search space for both versions [1]. The essential parameterization needed for this technique has to do with the highest velocity and the acceleration multipliers. As you may have seen, in addition to the algorithm's parameters, you must also define the limits of the search areas and the algorithm's maximum number of iterations. For any important figure given in the literature, such as the modified PSO [6], the overall quantity of iterations can be easily determined. However, it is best to directly obtain these parameters from the described problem.

4. Local Best

The new method reduces the distance between particles for data transfer, compared to the original one. The Swarm is segmented into communities where particles only communicating with their closest communities to share their best values, instead of each particle having the global best value. However, for optimal convergence on a global level, neighbourhoods must overlap. Due to this difference, this approach takes longer to find a solution but explores more search space and is less likely to get stuck in local minima [1]. In the context of Particle Swarm Optimization (PSO), covering a wider search space will increase the chances of finding the best solution, but this may come at the rate of a slower rate of convergence. Consequently, finding a solution may require more iterations than the initial attempt.

Here are two computationally costly methods for creating neighbourhoods: dynamic by geographic distance or static by particle index. Social network topologies that determine particle distributions in neighbourhoods affect the algorithm's performance [3].

5. Weight of Inertia

By balancing the two inclinations of PSO, this algorithm seeks to optimize solutions by utilizing existing areas or exploring new ones. This variant achieves this by concentrating on the momentum section of equation 2 for the particle's velocity. You'll see that removing this element causes the particle's movement to lose track of its prior path and cause it to always explore near to a solution. If the velocity component is used, or even increased by a "inertial weight" factor, the significance of the component is balanced. Due to its restrictions, the swarms will unavoidably explore new regions of the search space swiftly modify its pace in towards one of the best answers.

It must "counteract" first. It allows for the exploration of new ideas while maintaining the pace already attained locations where the "time spent" "counteracts" the impetus from earlier. This version is created by adding a weight to the previous velocity component, worth, w. The author's observations have shown that the w value should be as high as it can be, around [0.9, 1.2], to get a proper balance between performance gain and the algorithm's capability to discover the appropriate resolution. The situation under testing had a linear fall, yet additional research shows the value of a variable w considerably improved this ratio [6].

6. Future Aims

To effectively apply the technique and understand its limitations, to find any algorithmic weaknesses, more investigation is necessary. To find any algorithmic weaknesses, more investigation is necessary. More analysis is required to identify any algorithmic flaws, is with basic uni-modal functions, where regrouping is unnecessary as particles can accurately and quickly approximate the global minimizer without identifying a better minimizer. Although the regrouping mechanism has been demonstrated to be helpful when using the conventional best PSO method, it may also be utilized as a foundation for another search strategy to further improve performance. For example, it could be used with a better local minimizer such as GCPSO. There are much of potential in developing of novel Particle Swarm Optimization methods because there hasn't been enough systematic study on heterogeneity in PSO algorithms.

7. Algorithm

1. Initialize

```
for each particle i in S do
for each dimension d in D do
    //initialize all particles' position and velocity
    X_{i,d} = Rnd(x_min, x_max)
        V_{i,d}= Rnd(−v_max/3, v_max/3)
end for

        //initialize particle's best position
Pb_i= x_i
        //update the global best position
if f(pb_i) < f(gb) then
gb = pb_i
   end if
end for
```

7.1 Algorithm 2 (For Global Best)

```
//initialize all particles
Initialize
  repeat
     for each particle i in S do
    //update the particle's best position
     if f(x_i) < f(pb_i) then
        pb_i= x_i
 end if
     //update the global best position
     if f(pb_i) < f(gb) then
```

$gb = pb_i$

end if

end for

//update particle's velocity and position

for each particle i in *S* **do**

for each dimension d in D **do**

$v_{i,d} = v_{i,d} + C1 * Rnd(0, 1) * [pb_{i,d} - x_{i,d}] + C2 * Rnd(0, 1) * [gbd - x_{i,d}]$

$x_{i,d} = x_{i,d} + v_{i,d}$

end for

end for

//advance iteration

it = it + 1

until it < MAX IT ERAT ION

8. Conclusion

Social psychologist J. Kennedy and electrical engineer Russell C. Eberhart built Particle Swarm Optimization (PSO) sing the idea of swarm intelligence. The method emulates the swarming behaviour of animals to optimize solutions. PSO involves particles moving through a problem space, with their positions evaluated using a fitness-measuring function, and adjusting their velocities based on their own experiences and those of the swarm. The global best version of the algorithm makes sure that all particles communicate information on the best solutions found, whereas the local best version limits sharing to particular particle zones. The weight of inertia in PSO balances exploration and exploitation. The method's flexibility, variations, and parameter settings contribute to its effectiveness while resolving problems with optimization. Ongoing research aims to address its limitations and develop new techniques.

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Chapter - 4
A Review on Design and Development of High-Performance Heat Exchangers

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Chapter - 4

A Review on Design and Development of High-Performance Heat Exchangers

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Abstract

A heat exchangers is a system used to transfer heat between a source and a working liquid. A device in which two mediums do not mix. It is Used In different types of industries and applications to efficiently transfer heat from liquids, gases or solids. The goal may be to remove heat from the liquid or to add heat to the liquid. In this article, we discuss the research done by many researchers to enhance the efficiency of electronic devices. This paper shows that there is an early expectation in the high performance of the heat Swapper, which has a wide market, and after a detailed analysis, we found that the heat Swapper with Channelled plate has the best heat Swapper.

Keywords: Channelled plate heat Swapper, parallel flow, counter flow, LMTD, CFD, heat transfer efficiency.

1. Introduction

Heat exchanger is a device for transferring heat from one liquid to another without allowing them to mix. Heat is transferred from a hot liquid to a cold liquid by convection. The rate of the liquid of heat transfer is determined by the position of the heat Swapper. Heat Swappers are categorized into two main types toast Swappers and regenerators. A recuperator is a heat exchanger that maintains distinct channels for each liquid within its structure, ensuring that heat is transferred by means of the walls that separate these liquid pathways. Automotive radiators, oil painting coolers, condensers, superheaters, and prodigals are all exemplifications of heat Swappers. A heat accumulator is a heat Swapper that uses a medium to store heat. The hot liquid passes through the medium and heats it. The cooled liquid also passes through the medium and absorbs the heat. These are categorized as three types of circular contact heat Swappers tubular, expanded face and plate. Tube heat Swappers are the simplest circular contact heat Swappers. They've a series of pipes through which hot and cold- water overflows. Expanded face heat Swappers have fins or other projections on the pipes to transfer heat to other structure areas. The plate heat Swapper consists of a series of plates separated by gaskets. Hot and cold- water flows through the plates, which give ample space for the transfer of electricity. Plate heat Swappers are the most effective type of heat Swapper. Thus, they're the most extensively used energy products in diligence similar as food processing, medicinal and electricity. Channelled plate heat Swapper is a Channelled plate heat Swapper. Channelled cardboard increases the heat transfer area, thereby adding the effectiveness of electrical outfit. Channelled plate heat Swappers are generally used in operations taking high heat transfer.

2. Literature Review

Channelled plate heat Swappers are more structured than conventional plate heat Swappers. CFD can to be used forecast the performance of Channelled plate heat Swappers during the design phase without actually building them. This saves time and money and helps keep the heat Swapper efficient. CFD simulation starts by creating a Prototype of the heat Swapper geometry. The model is then split into a mesh of smaller particles. The liquid flow and heat transfer equations are applied to these concepts to solve for velocity, pressure and temperature in the heat Swapper. The Outcomes of the CFD simulation can to be used forecast the performance of electronic components. CFD can be Employed to enhance the design of the Channelled plate heat Swapper by examining the impact of design changes. This lets you to adjust the electronics design to meet the application's specifications. Overall, CFD is a powerful tool that can to be used improve the design and performance of Channelled plate heat Swappers. Using CFD, engineers can create better and more efficient electronics. Some additional points to add in the summary are: Channelled plate heat Swappers have a higher heat transfer degrees than plate heat Swappers, which makes them more efficient. CFD can to be used forecast flow patterns in a Channelled plate heat Swapper, which can identify critical areas and areas containing mixed water. CFD can also to be used estimate the drop of pressure of the Channelled plate heat Swapper, which is important for determining the power of the pump. CFD is an essential tool for the design and optimization of Channelled plate heat Swappers.

3. Experimental Studies on Channelled Plate Heat exchanger

Muhammed and Abed conducted a numerical Swotting on heat transfer laminar forced convection and liquid flow characteristics in Channelled channels. The channel walls are kept at a higher temperature than the temperature of the liquid. The effects of wave angle and Reynolds number on liquid flow and heat transfer were investigated. The solutions were found to have a Reynolds number between 500 and 2500, an angle between 0degrees and 60degrees, and a Prandtl number of 0.7. The Outcomes show that when the undulation angle is 40degrees, the best heat transfer and shock are higher than that of the plan channel, respectively. In other words, the Channelled duct has higher electrical transfer and shock efficiency than the 40degrees angled planned duct. This is because the Channelled channel creates more turbulence in the liquid flow, which increases heat transfer and pressure drop. The findings show that Channelled ducts can perform better heat transfer than planned in some applications. However, it is worth nothing that the ideal corrugation angle for heat treatment may vary on the application.

Khan and Kumar studied the performance and performance of Channelled plate heat Swappers under combined current and counter current. The plate has a 45degrees angled sinusoidal Channelled surface. The heat Swapper has three channels, hot liquid flows through the central channel and cold liquid flows through the outer channel. The temperature of hot water is in 40 degrees to 60 degrees, and the Reynolds number of hot and cold water is in the range of 900 to 1300. The Outcomes show the efficiency or performance of the regulated Channelled plate heat Swapper. At counter current, it is higher than Channelled plate heat Swapper arranged in parallel. This is because the counterflow arrangement provides a greater heat driving force for heat transfer. The exergy loss in counter current arrangement is also lower than in concurrent arrangement. This is because the heat Swapper is more efficient at transferring heat from the hot liquid to the cold liquid. Overall, the findings show that Channelled plate heat Swappers are much more in counterflow arrangements than in parallel flow arrangements. This is because the temperature of the driver is higher and the heat transfer is better in the counterflow process.

Rao *et al.* conducted a Swotting on three types of Channelled plate heat Swappers. The heat Swapper is 30cm long and 10cm wide and has 30degrees, 40degrees and 50degrees bend angles. Water is used as the heating liquid. The wall temperature was measured at seven different locations along the length of the heat Swapper using thermocouples.

The outlet temperatures of the measuring liquid and the thermal liquid are also measured using thermocouples. This Swotting investigates the impact of crimp angle on heat transfer. The Outcomes show that the heat transfer of the 50degrees slotted angle is higher than the 30 degrees and 40 degrees slotted angle. This is because more fluctuation angles create more turbulence in the liquid flow, which increases the rate of heat transfer. The Outcomes of the Swotting showed that Channelled plate heat Swapper with larger trough angle is more efficient in heat transfer than Channelled plate heat Swapper with lower trough angle.

However, it is worth nothing that the best gouging angle to improve heat transfer will vary on the application. Some additional details that can be added to the CV are:

- This Swotting was conducted at constant temperature and constant temperature.
- Research Outcomes only apply to certain electrical and liquid applications.
- This Swotting did not identify shock or cost.

More research is needed on the effect of flute angle on heat transfer in other types of water and heat Swappers.

Kumar *et al.* conducted an experimental Swotting on the plate heat Swapper to forecast the heat dissipation performance and heat transfer properties of Channelled plates. The effects of various functions on shock, exergy energy, friction degrees, exergy losses, usability and dimensionless exergy losses are discussed. The Outcomes showed that the efficiency of the heat transfer plate increases with the number of changes (NTU). The exergy loss of the Channelled plate heat Swapper increases with increasing Reynolds number of cold water and hot side, increasing hot water inlet temperature and decreasing cold water inlet temperature. This swotting also shows that the dimensionless exergy loss increases with the degrees of friction and the number of transfer units (NTU).

Rao *et al.* used a Channelled plate heat Swapper with trough angles of 30degrees, 40degrees and 50degrees. Water was chosen as the heating medium and glycerin was chosen as the liquid. Thermocouples are used to measure the inlet and outlet temperatures of thermal and test liquids.

Experimental Outcomes show that the 50degrees angle improves heat transfer.

3.1. CFD for heat Swapper design and optimization

Zena *et al.* conducted a CFD (Computational Liquid Dynamics) Swotting. The objective of this Swotting is to determine the heat exchange between finned tube heat Swappers and finless tube heat Swappers. The heat Swapper consists of an eight-channel copper tube coil. Air flows through the pipes and water flows through the pipes. CFD studies have shown that the heat transfer degrees of finned tube heat Swappers is higher than that of finless tube heat

Swappers.

Giurgiua *et al.* carried out numerical studies on the design of two different plate heat Swappers. Plate geometry has been shown to have a significant effect on heat transfer. The 60 degrees angled mini-channel model has a higher temperature variation than the 30 degrees angled mini-channel model. This is because the 60degrees angle causes more heat, which improves heat transfer.

Ruoxu *et al.* studied counterflow parallel heat Swappers using numerical simulation. It is used to calculate a representative recycler of many alternating current generators containing cold and hot lines separated by plates. Simulation of oil-water heat Swapper using COMSOL. Use oil and water as liquids. With low-speed inlets, oil and water are used at low temperatures. Calculate the Reynolds number for hot and cold-water using properties such as specific heat, viscosity, thermal conductivity, and density of water at 25degreesC and oil at 40degreesC. Reynolds numbers were found to be 224 and 6. The simulation Outcomes show that the hot oil enters the hot channel with an average outlet temperature of 330 K and exits the channel with an average exit temperature of 323.7 K. Channel. The average temperature of the channel is 310 K. The measured cold aisle pressure drop is zero. 0763 Pa, the temperature channel is 68.0 Pa. The average temperature drop corresponding to the cold line and the hot line is 10.5 K and 6.3 K, respectively. In order to increase the temperature and decrease the pressure in the hot line without increasing the pressure in the cold line, the oil rate of flow is increased to 0.02 m/s and the water to 0.05 m/s.

Abdur and Jameel have designed a successful chambered tube heat Swapper. They performed simulations using different dividing angles, specifically 0 degrees, 10 degrees and 20 degrees. They analyzed the flow patterns and temperature using the commercial software tool STAR CCM+ v6.06. Computational fluid dynamics (CFD) simulation Outcomes conclude that the tube heat Swapper with 20 degrees inclined sections outperforms the 10 degrees and 0 degrees inclined sections. The maximum inclination angle of the best partition was determined to be 20degrees. Beyond this angle, midline support is insufficient.

Melvinraj *et al.* While designing the fin-tube heat Swapper and performing numerical tests, they conducted a Swotting on the stability of the heat Swapper. Pro-e and ANSYS 14.5 are used in the design and analysis phase. The performance of the two generators was compared using (CFD). Finned heat Swappers have better performance than different heat Swappers.

3.2. CFD with validation

Thawkar and Farkade performed experimental and (CFD) studies on a bent elliptical heat Swapper to investigate the effect of geometry on the heat Swapper. The purpose of this Swotting is to determine the possibility of using twisted elliptical tubing in applications such as car radiators, air conditioners or other multi-channel applications. The test specimen contains a bent elliptical tube with major and minor diameters of 18 mm and 12 mm, respectively. The tube is made of pure copper and has a strength of 60mm. The Reynolds number for the turbulent region ranges from 50,000 to 350,000. Use different body of water E.g. 0.055 kg/h, 0.147 kg/h, 0.095 kg/s and 0.2 kg/s. The CFD model has been validated with the experimental model and the Outcomes are in good agreement. CFD Outcomes show that the temperature difference decreases when the mass rate of flow increases. The overall heat transfer degrees increase with increasing Reynolds number. The shock also increases with the Reynolds number. This Swotting concluded that twisted elliptical tubes can be used in alternating current applications. The bent geometry creates more turbulence, which improves heat transfer. This Swotting also showed that shock can be controlled by adjusting the Reynolds number. Different heat sources that can use different temperatures on the surface and sinks of ocean thermal energy (OTEC) have been investigated. Plate heat Swappers are less useful in OTEC applications. Experiments and numerical simulations have been made using herringbone heat Swapper to determine the heat Swapper that can provide better performance in OTEC. The Outcomes show that the heat transfer performance of the herringbone heat Swapper is better than the plate heat Swapper.

4. Conclusion

Much experiments have been done in electronics, and traditional methods are often costly and time consuming. The advent of Computational fluid Dynamics (CFD) provided researchers with an invaluable resource. With CFD, efficiency, power transfer and complexity can be determined effectively. Among the various types of heat Swappers, Channelled heat Swappers with the highest rate of heat transfer stand out in particular.

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Chapter - 5
A Review on Thermal Management of High Heat Flux System

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Chapter - 5

A Review on Thermal Management of High Heat Flux System

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Abstract

Rapid technological advances in various miniature heating systems and high-power devices e.g. diode laser, dissipate more heat. Therefore, miniature cooling elements such as mini- and micro-channels, as well as nanofluids, are used to achieve a better cooling effect. An effective heat removal strategy has become even more important. This study numerically simulates the fluid flow and thermal characteristics of a microchannel cooling cell of a high heat generating device. Simulations explore different channel geometries and cooling strategies is a proactive approach to ensure that a diode laser operates at lower temperatures with a uniform distribution. This enhances its performance and also enhance its operational lifetime, reducing maintenance and replacement costs. The comparison of hydrodynamic and thermal behaviour of the cooling plates shows that among all the geometries, the sinusoidal structure gives the best thermal efficiency. Even though the system pressure drop increases by 18%, this configuration increases diode life by 44%. This study also provides a review highlighting the synthesis, characterization and thermophysical properties of hybrid and conventional nanofluids.

Keyword: Heat Sink, MCHS, MAMC, Nano fluid

1. Introduction

Above the two decennary, the implementation of miniaturization devices in the field of science and Engineering increases more pre-dominantly causes the overwhelming of heat release rate. The HT plays the essential role to cool the miniature devices, the conventional fluids with the dispersed micro scaled particles, enriched thermo physical properties were used as coolant in HT applications. The main challenges in micro scaled fluids were agglomeration, coagulation and clogging. To overcome the setbacks in fore said problem the nanoparticles were dispersed in base fluids called 'nanofluids' that provides stability because of the greater increase in surface area to its volume. Nanofluids were used as a HT fluids in MAMCHS of modified design to improve its HT characteristics was made possible by its higher rheological properties. The design of micro-channel and mini-channel heat sinks takes advantage of the heat transfer principles related to hydraulic diameter. Smaller hydraulic diameters lead to increased heat transfer rates, making these heat sinks valuable in a variety of applications where effective cooling is required. Hydrothermal properties of mini-channel heat sinks were studied by Ghasemi *et al.* (2017) for different hydraulic diameters. The findings indicate that a mini-channel heat sink with a smaller hydraulic diameter can provide better thermal performance with less thermal resistance and, in some cases, lower pressure drop compared to a micro-channel heat sink. These results are valuable for optimizing the cooling of electronic components and other systems where efficient thermal management is crucial. According to the study of Lei *et al.* (2016), multilayer heat sinks are a preferred choice for achieving high heat flux and effective cooling. The increased surface area provided by the multilayer structure results in higher heat transfer coefficients, making them well-suited for applications where heat dissipation is critical.

Beni *et al.* (2017) a numerical analysis of the hydrodynamic and thermodynamic behavior of heat sinks with three different channel geometries (zigzag, curved and sinusoidal) was conducted. The sinusoidal structure provides best thermal performance, even though the pressure drop increased by 18% and the lifetime of diode increased by 44%. The flow field is shown in Fig. 1, with a maximum flow velocity of 3.7m/s and an average velocity of 1.14m/s. Reducing the sharp angles of the zigzag geometries by replacing them with smooth, sinusoidal curves resulted in a pressure drop of approximately 17.6kPa, which is lower than the zigzag pressure drop and only 18% greater than the curved channel pressure drop. In this case, almost 64% of this pressure drop occurs within the microchannels of the heat sink. The temperature distribution within the MCHS active region of the sinusoidal channels can be seen in Fig. 2, with temperatures of 324.9kPa, 322.6kPa and 316.8kPa.

The sinusoidal microchannel configuration has a low value of thermal resistance compared to other channel configurations, leading to potential benefits in heat dissipation. This, in turn, is expected to increase the life expectancy of a diode laser based on Arrhenius' Law, which correlates the temperature of a system with its expected lifespan. The specifics of these findings would be relevant in the design and optimization of thermal management for electronic devices like diode lasers.

The results of modelling for the system performance and its predicted lifetime for each case are presented in Table 1.

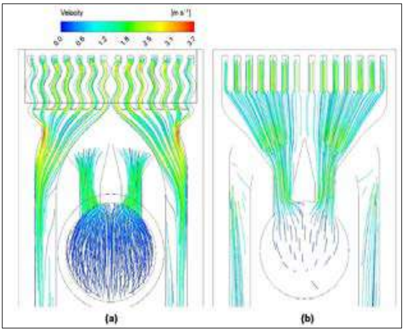


Fig 1: Flow streamlines at the top and bottom microchannels (a) at x = 0.9 mm and (b) at x = 0.6 mm. Beni *et al.* (2017)

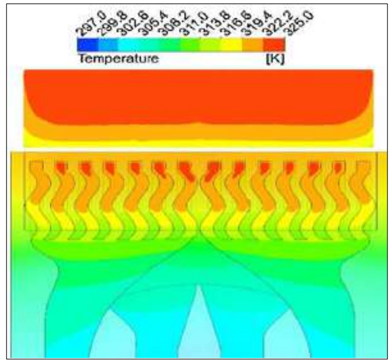


Fig 2: Temperature distribution at the active region of the MCHS with sinusoidal microchannels. Beni *et al.* (2017)

The cooling performance of a micro channel heat sink with copper-water and diamond-water nano fluid as coolants was numerically analysed by Jang and Choi (2006) and stated that the thermal performance was higher by 10% if diamond-water nanofluid was used in place of H_2O as a coolant.

The numerical investigation of these specific nanofluids underlines the importance of considering both theoretical models and computational simulations to understand and optimize the thermal performance of nanofluid systems. Such studies contribute to the ongoing efforts to develop efficient and tailored nanofluid solutions for diverse engineering applications.

Table 1: Computational fluid dynamic result comparison, Beni *et al.* (2017)

Computational fluid dynamic result comparison.

Case	Straight	Curved	Zigzag	**Sinusoidal**
Maximum Temperature at Heat Input Region)	331.3	330.8	329.1	**324.9**
Mean Temperature at Heat Input Region)	328.2	328	326.3	**322.6**
Temperature Uniformity (T_{Max}-T_{Min})	10.3	9.6	9.5	**8.1**
Thermal Resistance of MCHS [K/W]	0.34	0.33	0.32	**0.28**
Lifetime Improvement when compared to the base model	–	About 1%	14%	**44%**
Pressure drop [kPa]	14.8	16.7	18.6	**17.6**
Mean fluid velocity [m/s]	1.08	1.1	1.17	**1.14**

It is observed that cooling performance of the microchannel heat sink is enhanced when using nanofluids, specifically using water-based nanofluids containing diamond nanoparticles at a concentration of 1 volume percentage and a size of 2 nm, the cooling performance is improved by around 10% compared to using pure water. Nanofluids also making heat transfer more efficient by reducing thermal resistance and decrease the temperature difference between the heated microchannel wall and the coolant, implying better temperature regulation.

Ahmed *et al.* (2013) anticipated a new design of aluminum rectangular and triangular double layered MCHS with $Al2O3 - H2O$ and $SiO2 - H2O$ nanofluids. Their results specified that the $Al2O3 - H2O$ nanofluid offered the best performance with triangular double-layered MCHS. The TDLMCHS design has 27.4% reduction in wall temperature compare to RDLMCHS and also better temperature uniformity across the channel length. It is also observed that pressure drop revealed no significant differences between the two designs as more channels and smaller fin thickness led to reduce thermal resistance, without solely increasing pumping power. Higher nanoparticle concentrations in the nanofluids showed better thermal stability compared to pure water. Al2O3–H2O nanofluid with a concentration of 0.9 volume% demonstrated the best performance with a temperature difference of 1.6 °C and lowest thermal resistance of 0.13 °C/W.

Roshani *et al.* (2015) Miniature Plate Pin-Finned Micro chipped Heat Sink (MCHS) Prepared in volume concentrations of 0.5, 1, 1.5, and 2% Water is used as base fluid. Pressure difference between the heat sink entrance and exit Hydrodynamic performance Nano fluids prepared in volume concentration Al2O3 - water TiO2 - water Pumping power increases by 15% and increases by 30% for volume concentration of 2% Average value of heat transfer coefficient increases by 16% and decreases by 14% respectively. Thermal resistance decreases by 17% and 14% for each nano fluid.

Figure 4 shows that nanofluids containing 40 nm and 20 nm nanoparticles, particularly Al2O3–H_2O and TiO2–H2O, exhibit improved heat transfer performance. The combination of superior thermophysical properties, increased Reynolds numbers, and effective dispersion of nanoparticles through Brownian motion collectively contribute to the improved heat transfer capabilities of nanofluids. Understanding these mechanisms is crucial for the development and optimization of nanofluid-based solutions in various engineering applications.

From Fig 5(a), (b) the effects of Reynolds number and the volume concentration of NFs on the thermal resistance of Al2O3- H_2O and TiO2- H_2O nanofluids are depicted respectively. Obviously, thermal resistance decreases when the volume concentration of NFs and Reynolds number increases also this reduction in thermal resistance implies enhanced heat transfer performance Fig. 6(a),(b). On comparing Al2O3- H_2O and TiO2-water nanofluids at a 2% volume concentration, the thermal resistance is reduced by approximately 17% and 14%, respectively. It indicates that using these nanofluids in 2% volume concentration is associated with enhanced heat transfer performance compared to using the base fluid alone.

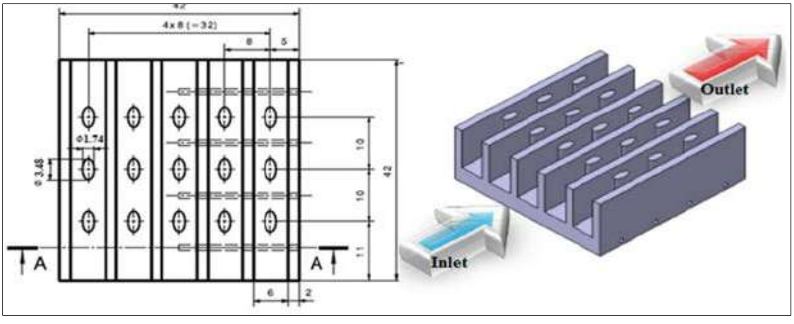


Fig 3: Geometric configuration of the miniature PPFHS, Roshani *et al.* (2015)

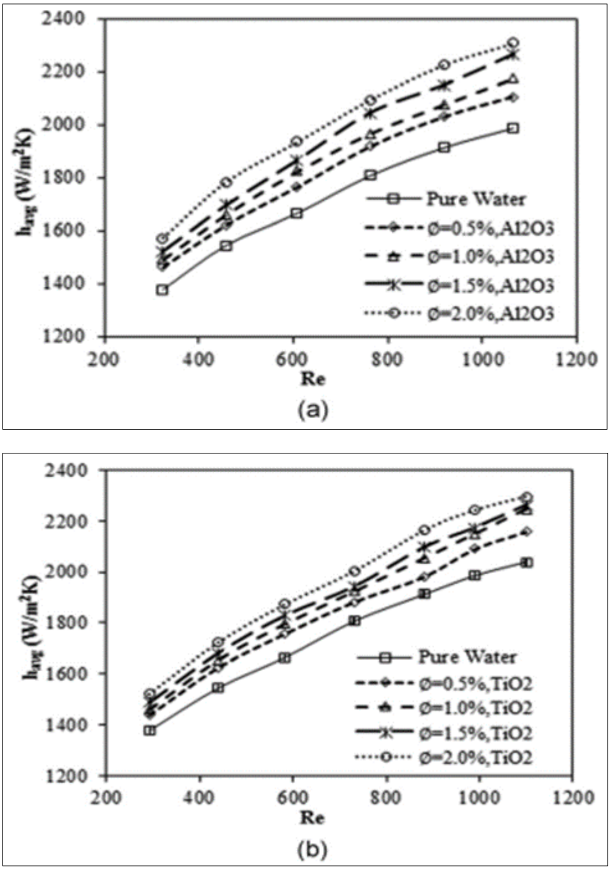


Fig 4: The effect of volume fraction and Re Number on average convective heat transfer coefficient: (a) Al2O3– H2O nanofluids and (b) TiO2– H2O nanofluids, Roshani *et al.* (2015)

Figures 6(a) and (b) shows the average Nusselt number Vs Reynold number, for different volume concentrations of Al2O3–H2O and TiO2–H2O nanofluids and it is observed that for volume concentration of 2%, Nusselt number increases by 11.5% and 10.6% for Al2O3– H2O and TiO2– H2O, respectively.

Figure 6 shows the higher Nusselt number for Al2O3–water by 0.9% compared to TiO2– H2O. The use of nanofluids in conjunction with turbulent flow regimes, such as those created by pins in heat sinks, can be an effective strategy for optimizing convective heat transfer and improving cooling efficiency in a wide range of engineering applications.

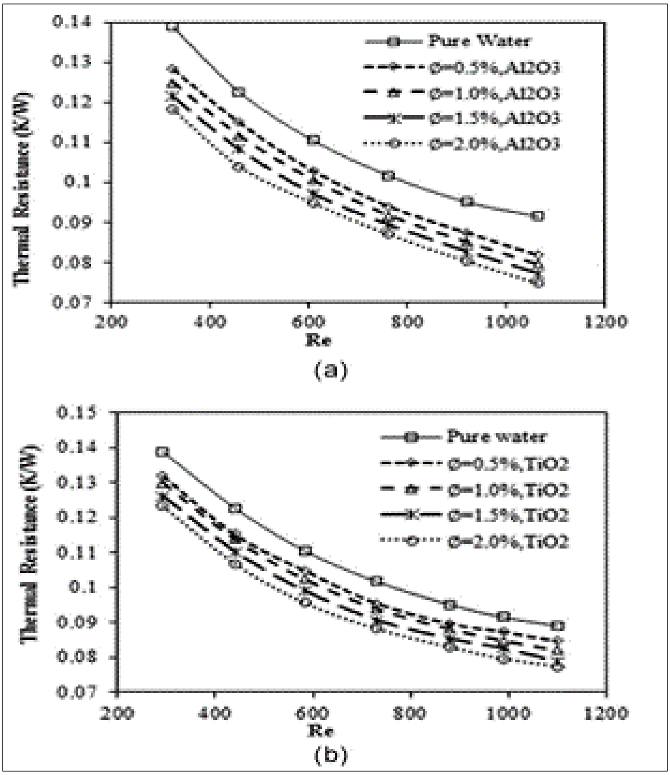
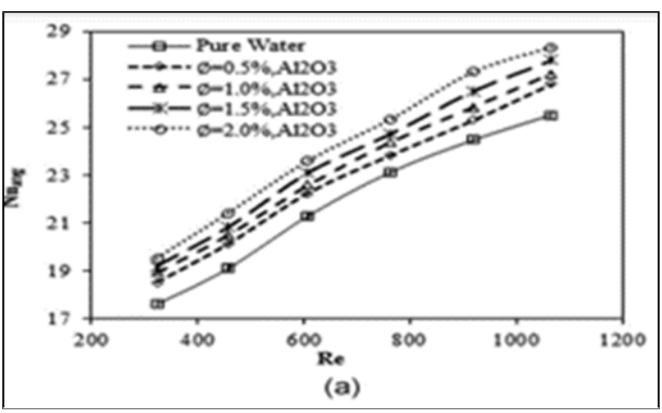


Fig 5: The effect of the volume fraction and Reynolds number on the thermal resistance: (a) Al2O3–water nanofluids and (b) TiO_2–water nanofluids, Roshani *et al.* (2015)



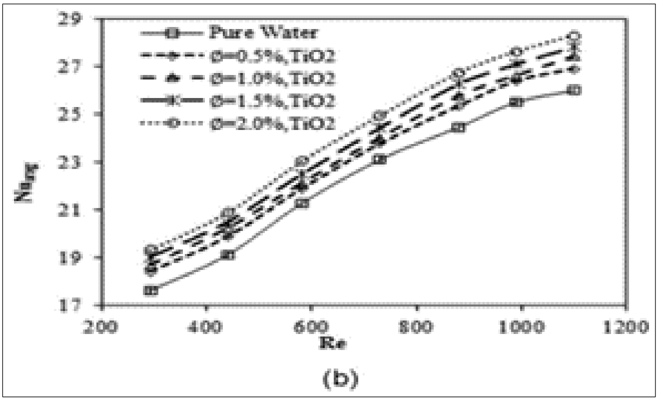


Fig 6: The influence of the volume fraction and Reynold number on Nusselt number: (a) Al2O3–water nanofluids and (b) TiO2– water nanofluids

2. Thermo Physical Properties of Conventional and Hybrid Nanofluids

The spherical particles added in base fluid were able to get scattered by evading the interactions that existed among the particles. To put it simply, the Maxwell equation seems to be an approximation of the first order. Therefore, it can only be used to describe poor particle mixture with diminishing volume concentrations. Since Maxwell's first investigations, the Maxwell equation has been subjected to a great deal of refinement in the form of several modifications. Depending on particle size, these additional modification provide a wide variety of parameters that enhance thermal conductivity, Particle concentration, PH value, particle shapes base fluid, temperature and viscosity. Many methods were incorporated to evaluate the tremendous augmentation in TC of Nano fluids based on the TC, liquid interfacial, clustering of particles and Thermophoresis.

Masuda *et al.* (2006) investigated on TC of TiO2, SiO2 and Al2O3-water Nano fluids. From experimental findings, it was observed TC of Al2O3-Water Nano fluids showed maximum enhancement in TC. Pak *et al.* (2020) investigated the TC of titanium-water Nano fluids having particle size of 27 Nm. The results showed the TC of Nano fluids were augmented based on Particle size, volume concentration and temperature.

3. Overview of thermal conductivity (TC) enhancement of conventional Nano fluids

Based on reviewed literature, stability, temperature, concentration, morphology of nanoparticles are essential to increase of TC. The two-step method was widely used in Nano fluid preparation. The research that has been done so far indicates that the financial cost of overcoming the technological barriers involved in Nano fluid preparation methodologies is high and It requires significant research in order to advance the stage for the economical preparation of the Nano fluid. An overview of TC enhancement using metal oxide based conventional Nano fluids are detailed in table 2.

Table 2: Thermal conductivity enhancement using metal oxide based conventional Nano fluids

Base fluid with conductivity	Nano particles, average diameter and concentration	Method used for synthesis	Max. thermal conductivity ratio
Water 0.613	Al_2O_3, <50 nm, up to 4.3 vol%	2-step	1.08
Water 0.613	CuO, < 50 nm, up to 3.4 vol%	2-step	1.10
Water 0.613	C-MWNT 50 nm, 5 um 3 urn, 0.6 vol%	2-step	1.38
EG 0.252	Fe, <10 nm, 6.0 vol %	2-step	1.18
Water 0.613	TiO_2, 15 nm, < 5.0 vol %	2-step	1.30
Water 0.613	Cu, 18 nm, up to 5.0 vol%	1-step	1.60
Thiolate	Au, 10-20 nm, 0.1 vol %	2-step	1.09
Cirate	Ag, 6-80 nm, 0.1 vol %	2-step	1.85
α- Olephin	CNT, 25x50000 nm, 1.0 vol %	2-step	2.50
EG 0.252	Al_2O_3, <50 nm, up to 5.0vol%	2-step	1.18

An enhancement in TC of hybrid Nano fluids deeply discussed in number of different research works. Jana *et al.* (2007) examined TC of different conventional nanoparticles like CuO, CNT, Gold and hybrid nanoparticles such as carbon nanotubes and copper, carbon nanotubes and gold and found copper nanoparticles exhibit higher TC than other base fluid but the hybrid Nano fluids has no effect in their thermal conductivity. Jha *et al.* (2021) investigated experimentally on TC of hybrid nano composite (copper and MWCNTs). The result showed the copper oxide/multi walled nanotubes showed higher TC compared to base fluids (H2O and EG). Ho *et al.* (2017) investigated TC of Al2O3 -water Nano fluids and MECPM. As a consequence of this, the TC of PCM is amplified by the dispersion of alumina nanoparticles. Suresh *et al.* (2023) revealed experimentally on TC of alumina and copper/ DIW based Nano fluids. The result showed TC of hybrid Nano fluids enhanced to 12.11% at 2 vol%.

4. Conclusions

The conclusions which can be observed after review:

1) Nanofluids represent an excellent prospect for the progress of new devices to cool electronics. The principal advantage of applying nanofluids as a cooling agent in electronics compared to standard liquids is reducing working temperature and decreasing the size of cooling devices.
2) Nanofluids, which are engineered colloidal suspensions of nanoparticles in a base fluid (such as water, oil, or ethylene glycol), have demonstrated improved thermal properties compared to the base fluid alone. This enhancement in thermal conductivity is attributed to the high surface area and unique thermal characteristics of nanoparticles.
3) The use of nanofluids containing Al2O3 and TiO2 nanoparticles at specific volume concentrations resulted in high convective heat transfer coefficients and Nusselt numbers compared to pure water. This indicates enhanced heat transfer performance with nanofluids under the described conditions.
4) An attractive technique to enhance heat transfer and fluid flow into micro channels is the variations of thermal sink parameters, i.e. fin numbers, shape, channel number, aspect ratio, grooved channel, inlet or outlet location, ribs and baffles within each channel.
5) The thermal performance of Sinusoidal MCHS is the best followed by a ZMCHS, wavy, curvy and step types.

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Chapter - 6

A Review on Thermal Management of Electronic Component

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Chapter - 6

A Review on Thermal Management of Electronic Component

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Abstract

With the rapid advancement of microelectronics, effective cooling of electronic devices has become essential due to increased chip density and current-voltage capacity, resulting in significant heat generation. This excess heat can hinder thermal transfer, damage IC chip performance, and lead to electrical breakdown. Researchers have focused on electronic cooling systems, particularly micro/mini-channel heat sinks, as high-performance solutions for heat dissipation. To enhance cooling efficiency in compact applications, the use of specialized Nano-fluids has gained prominence. This study explores electronic component cooling using nanofluids, emphasizing the role of nanoparticles in improving thermal behaviour. Researchers have made notable progress through hybrid nanoparticles, rough surface enhancements, modified channels, and other innovations. The study covers thermophysical properties, behaviours, performance, challenges, applications, limitations, and future prospects of nanofluids in electronic components, highlighting their potential for addressing the thermal management needs of high-performance electronics.

Keyword: Heat sink, MCHS, micro/mini-channel heat sink, hybrid nanofluids

1. Introduction

In the era of rapidly evolving microelectronics, the efficient cool down of electronic component stands as a pivotal imperative to ensure their performance, longevity, and reliability. As chip density and current-voltage capabilities surge forward, the consequential heat generated within these devices can impede thermal transfer, impair IC chip function, and even lead to irreversible damage. Recent years have witnessed an upsurge in research dedicated to electronic cooling systems, driven by the escalating demand for small, high-performance devices across diverse formats. Among the array of cooling methods, micro/mini-channel heat sinks have emerged as high performance solutions to alleviate heat fluxes from electronic components. As the pursuit of enhanced electronic performance within compact dimensions intensifies, researchers have ventured into the usage of tailored nanofluids, departing from traditional coolants. These nanofluids hold the potential to revolutionize thermal behaviour in micro/mini channel heat sinks, with their efficacy intricately tied to the thermophysical properties of nanoparticles. The present study delves into the realm of cooling electronics using nanofluids in micro/mini channels, dissecting the multifaceted aspects of this approach. The exploration encompasses diverse facets, including the impact of distinctive nanoparticle properties, the strides made in cooling electronics with hybrid nanoparticles and surface modifications, and the uncharted territories of modified channel designs.

Addressing the formidable challenges in this domain is pivotal for successful thermal management of mini/micro heat sinks. The challenges encompass issues such as limited surface area, high heat flux density, thermal resistance, fluid dynamics intricacies, manufacturability constraints, thermal cycling durability, and the pursuit of effective thermal interface materials. Striking a delicate balance between performance and size trade-offs remains a perpetual concern.

2. Problem Statements

Limited surface area: Shrinking heat sink size reduces heat dissipation area, causing potential overheating issues.

High heat flux density: Modern electronics generate intense heat, demanding innovative designs to enhance cooling efficiency.

Resistance: Compact heat sinks suffer from higher resistance, leading to uneven cooling and hotspots.

Fluid dynamics and Pressure drop: Smaller heat sinks complicate fluid interactions, causing inefficiencies and pressure drops.

Manufacturability and Materials: Creating intricate small-scale heat sinks with suitable materials is complex and costly.

Thermal cycling and Reliability: Frequent temperature changes stress mini/micro heat sinks, affecting their durability.

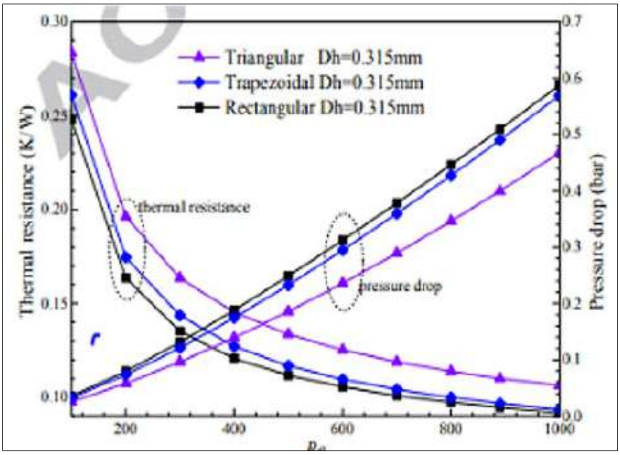
Cooling techniques: Standard methods could not be very efficient at smaller scales, prompting exploration of new cooling methods.

Thermal Interface Materials (TIMs): Ensuring efficient heat transfer with proper TIMs in limited space remains a hurdle.

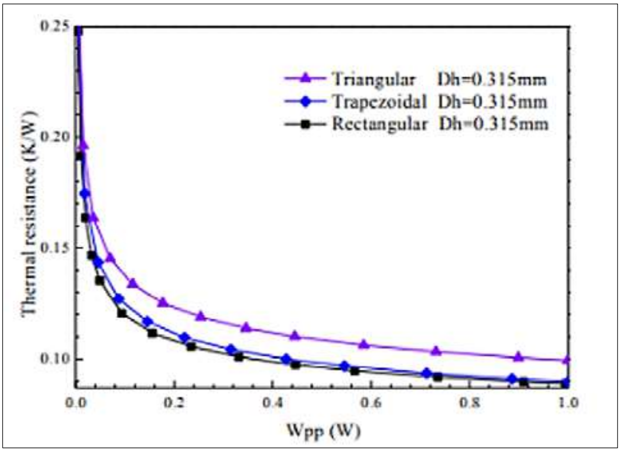
Performance size trade-off: Achieving effective cooling while maintaining device size requires continuous balance.

Baby and Balaji (2012) experimentally investigated the thermal enhancement of phase change materials (PCM) based finned heat sinks having 33, 72 and 120 fins and concluded that the maximum number of fins for a certain limit would not necessarily increase the heat dissipation rate. They used a special material that is adaptive from solid to liquid when gets hot (called "n-eicosane") and put it inside a block of metal made of Aluminium. This fluid helps aluminium to carry heat and spread out surrounding. They have done tests using these metal blocks with and without fins. The fins help make the block cool down better. They put a hot plate on the metal block to make it produce heat like a computer chip would. The metal block they used was like a small brick with a base of 80*62 mm and a height of 25mm. They used a smaller metal plate (60*42 mm and 2 mm thick) to make heat like a computer chip they also tried different kinds of fins and different amounts of heat from 2 to 7 watts. They looked at how long the metal block could work without get too hot and how long it took for the special material to turn from solid to liquid when heating it up. The findings recommended use of fins with the special material in the metal block could make electronic devices work better, last longer without getting too hot, and harm it. In simple terms, they observed adding these special materials and fins to the metal block helped electronic devices stay cooler and work longer without any problems.

Wang *et al.* (2016) Wang *et al.* (2016) investigated the impact of Geometrical factors on the flow and heat transfer behavior of microchannel heat sinks of rectangular, trapezoidal, and triangular shapes and made several observations. They found that microchannel heat sinks with a high aspect ratio (indicating narrow and tall channels) tend to have lower thermal resistance due to the enhanced heat-transfer surface area. However, this advantage is counter balanced by higher fluid friction, resulting in elevated pressure drop. High aspect ratios also lead to longer wetted perimeters, enhancing heat transfer but contributing to increased fluid friction. Furthermore, the small hydraulic diameter in such microchannels exacerbates frictional losses, further raising pressure drop. Additionally, the study noted that increasing the number of channels in microchannel heat sinks boosts heat dissipation capacity and lowers thermal resistance by enabling more direct contact between the heat sink surface and cooling fluid, benefiting component cooling. Nevertheless, this also leads to heightened pressure drop within the heat sink, as each additional channel introduces friction. In essence, while high aspect ratios and greater channel numbers enhance heat transfer, they are accompanied by increased pressure drop due to heightened fluid friction, necessitating careful consideration in heat sink design for optimal performance. As the fluid flows through it, and with more channels, the cumulative frictional losses become more pronounced. High-pressure drops can also lead to higher pumping power requirements and potentially affecting the energy efficiency of the cooling system. While designing a heat sink designer must found the right balance between thermal performance and decrease in pressure. In other words, the channel number must be optimal for the same power usage. Additionally, it was shown that among all microchannel shapes, rectangular ones performed the best. At ratio of 8.904-11.442. An optimal aspect ratio can promote favourable flow conditions, allowing for efficient reducing pressure drop while maximizing heat transfer.



a) Thermal resistance and pressure drop



b) Thermal resistance vs. pumping power

Fig 1: Comparison of triangular, trapezoidal, and rectangular MCHS under the same hydraulic diameter (Dh=0.315mm) in terms of flow and heat transmission properties

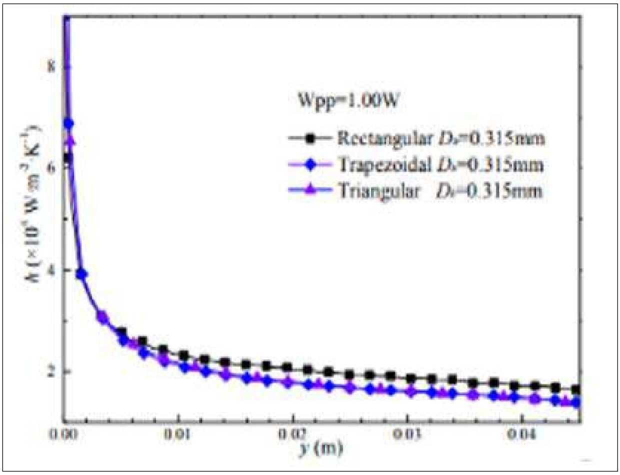


Fig 2: Trapezoidal channel has the greatest temperature, indicating that it is less successful at removing heat compared to the other geometries, while rectangular channel has the highest value of heat transfer coefficient compared to triangular

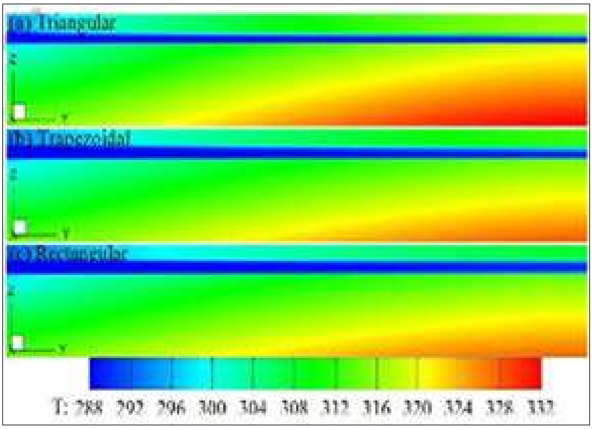


Fig 3: Similar temperature distributions are seen in trapezoidal and rectangular microchannels, with the efficiency of the former closely approaching that of the latter. The rectangular channel therefore has the best heat transfer properties

Fig. 1 A comparison of the heat resistance and pressure drop for triangular, trapezoidal, and rectangular channels with the same hydraulic diameter (Dh = 0.315 mm) is shown in Figures 2a and 2b of Figure 1. Triangular and trapezoidal heat sinks have higher thermal resistance than rectangular heat sinks for pumping power Wpp=1.0 W, by 11.82% and 1.01%, respectively. Triangular microchannel heat sinks, on the other hand, have the lowest pressure drop but the greatest thermal resistance.

Navin R Kuppusamy *et al.* (2013) studied how heat is managed in a special kind of small channel that looks like a trapezoid. They used tiny particles called "Nanofluids" to help with heat transfer. They used a method called the finite volume method to figure out how the heat and energy move around in this channel. They changed the shape and size of the trapezoidal channel and looked at how it affected how well it managed heat. They ried different types of tiny particles of different size and volume fraction and the liquid they were mixed with. They tested this at different speeds of the liquid flow. They found that making the top of the trapezoidal channel wider and the bottom narrower gave the best way to manage heat. This means a shape that's like a triangle works better than a rectangle. They also found that a mix of tiny particles called Al_2O_3 with water worked the best, with 0.04 parts of particles in 1 part of water and the particles being 25 nanometres in size. In simple words, they found that changing the shape of the channel to look like a triangle and using tiny Al_2O_3 particles mixed with water helped manage heat the best in their experiments. The thermal conductivity (knf) of Al_2O_3 –H_2O was much higher compared to Al_2O_3 –engine oil and Al_2O_3 –ethylene glycol. It is because the thermal conductivity of water is much higher compared to ethylene glycol and engine oil. In fact, knf of Al_2O_3 –engine oil and Al_2O_3 –ethylene glycol was lower than pure water. This fact explains the extreme small value of their Nunf/Nu H_2O. The fnf /f H_2O of Al_2O_3 –ethylene glycol and Al_2O_3 –engine oil are increased largely due to their high viscosity and density than Al_2O_3 – H_2O.

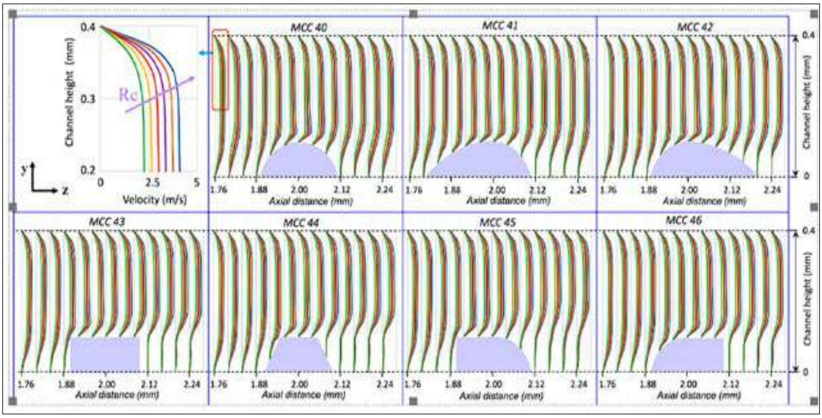


Fig 4: Variation of velocity profile across the bottom wall ribs in YZ plane

Rajalingam *et al.* (2022) studies a microchannel heat sink (MCHS) with special structures inside, like rectangular, trapezoidal, and triangular. He studies on a small, thin passage (0.4 mm wide, 0.4 mm tall, and 50 mm long) on a piece of copper (0.7 mm wide, 0.7 mm tall, and 50 mm long). They did the study in three steps. First, they found that adding tiny ribs at the bottom of the passage made the fluid flow better and improved heat transfer. This setup reduced pressure and made less waste heat. The shape of these tiny ribs they added that making them like airplane wings (called "aerofoil "and "reversed aerofoil") worked best. Aerofoil ribs improve heat transfer, and reversed aerofoil ribs reduced pressure. Based on these findings, they combined both types of ribs. They put 12 ribs in the start and 12 reversed ribs at the end. This new design makes the heat sink work twice than plain one for the same temperature.

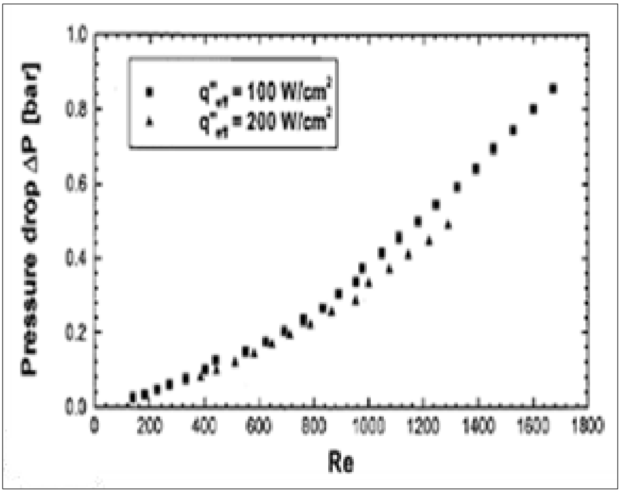
Hussein M. Maghrabie *et al.* (2022) studied the ways to prevent areas of excessive heat (hot spots) in electronic devices. They explored how liquids flow, how heat moves, and how well devices stay cool. To make high-powered electronic devices, smaller and more efficient they used nanofluids instead of water. These nanofluids can help transfer heat more effectively. They also discussed about different types of particles led to improvements in cooling, like using mixed particles, dealing with rough surfaces, using materials that change from solid to liquid (phase change material), changing the shape of the channels, and other effects. They also talked about the properties of these tiny particles, how they behave, how well they work, the challenges they face, where they can be used, their limits, and what might come in the future

Ping Cheng *et al.* (2003) have done a review on how heat transfers and pressure changes when water flows through 13 different narrow channels with a trapezoid shape made of silicon. They found out that the Nusselt number and the apparent friction constant are influenced by the way these channels are shaped. The Nusselt number and the apparent friction constant get bigger when the channel's surface is rougher and more water-attracting (hydrophilic). This effect is more pronounced when the water is flowing faster (higher Reynolds numbers). They saw at low speeds (Reynolds number below 100), the Nusselt number grows in a steady way with the speed, but at higher speeds, the increase isn't as quick. They gathered data from 168 experiments and came up with mathematical formulas that describe how the Nusselt number and the apparent friction constant change in these trapezoidal channels with different shapes, surface roughness, and water attracting properties. Lastly, they calculated how much heat these channels can handle for the energy used to pump the water through them and the temperature difference across them.

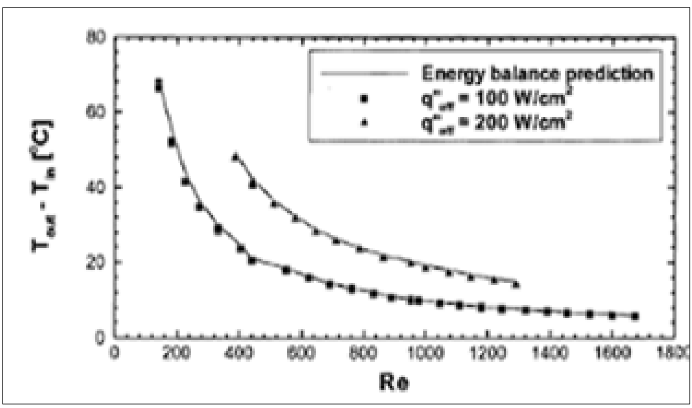
Qu *et al.* (2002) studied the rectangular MCHS by both experimentally and numerically with a channel width of 231 μm and a channel height of 713 μm for two heat flux q’’eff = 100 W/cm2 and q’’eff =200 W/cm2 with deionized water and found high Reynolds numbers were found to be beneficial for improving the thermal performance at the expense of a large pressure drop. In addition, a numerical model using the conventional Navier–Stokes and energy equations proposed by Qu *et al.* accurately predicted the conjugate heat transfer in an MCHS, which was further verified by Wang *et al.*

Fig. 5 (a) shows the measured pressure drop increasing with increasing Reynolds number. The largest pressure drop of 0.86 bar was measured at q’’ eff = 100 W/cm2 and Re = 1672.

For the same Reynolds number, the pressure drop is lower for q’’ eff = 200 W/cm2 because the higher water temperature at this condition decreases water viscosity.



(a)



(b)

Fig 5: (a) Variation of measured pressure drop with Reynolds number. Qu *et al.* (2002) (b) Variation of water temperature rise from heat sink inlet to outlet with Reynolds number. Qu *et al.* (2002)

3. Conclusion

The researchers studied heat sinks with different channel geometry and insertion of fins / ribs in the channel and improved heat transfer performance was reported but the pressure drop also increased which required more pumping power. Few studies reported the performance of the heat sink by including both the heat transfer and the pressure drop parameters in a single indicator, which will reflect the overall performance improvement of the heat sink. Most of the studies reported on the complicated channel configuration and channels with ribs were bases on numerical investigation. The fabrication of complex geometry micro-channels, particularly for bigger size heat sink is still challenging. Hence, the straight rectangular patterns are the most employed owing to their favourable thermo-hydraulic characteristics and low manufacturing costs. The fabrication of a heat sink with different internal channel configuration and study the performance can provide the solution for efficient dissipation of heat from high heat flux diode systems. Air cooling is mostly employed cooling methods for heat sink due to ease of operation. But the air cooling method has been unable to meet the high-density heat dissipation systems like high heat flux diode cooling system in fibre laser, creating the barrier for up scaling of the laser. Hence, study the performance of heat sink with liquid cooling will allow increasing the power of diode laser systems. Air cooling is mostly employed cooling methods for heat sink due to ease of operation.

But the air cooling method has been unable to meet the high-density heat dissipation systems like high heat flux diode cooling system in fibre laser, creating the barrier for up scaling of the laser. Hence, study the performance of heat sink with liquid cooling will allow increasing the power of diode laser systems.

Therefore, it can be concluded that still there is enormous scope of improving the heat transfer performance of heat sink for high heat flux applications by selecting optimum design heat sink with different design parameters.

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Chapter - 7
Algae Biofuel as an Alternative Fuel for Diesel Engine: A Review

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Chapter - 7

Algae Biofuel as an Alternative Fuel for Diesel Engine: A Review

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Abstract

Despite rising prices for energy, rigid contamination constraints, the dwindling supply of petroleum-based fuels, and the prohibitive price of petroleum-based products in the nation of India, it seems imperative to capitalize on substitute fuels, such as diesel. Algae-based petroleum products have also been recognized as overwhelmingly reliable, cost-beneficial, and beneficial to the environment in order to address the issue of climate change and the sustainability of food, in addition to being the sole viable energy produced from renewable sources distributed geared towards accomplishing a long-term global consumption of fuel. The performance, together with emissions traits associated with diesel-powered vehicles using polished algae biofuel, algae biofuel and diesel formulations, alongside contaminants employed on algae biofuel as fuels, are reviewed in this article.

Keywords: Algae biofuel, engine performance, engine emission, CI engine.

1. Introduction

Fossil fuel price is rising day by day and there is a highly growing demand visible among the world, as the source is limited and using the fossil fuel is harmful for the environment, the world needs some renewable source of energies [1].

Greenhouse gases which emit from the burning of fossil fuels, are majorly responsible for climate change. According to a report, emission of greenhouse gases from human activities has increased to almost 43 percent from 1990 to 2015.A recent report has given a data that the amount of total fossil fuel is depleting fast thus newer sources of energies should be on use to fulfill the demand of energies coming in future.

Biofuel is an excellent option. Biofuels are the fuels which are renewable and can be produced from waste plastics, vegetables, fats and microalgae. The best part about the biofuel is, it produces lesser amount of emission and it's renewable. Unlike fossil fuels we can generate a continuous supply of bio fuels.

It has been gone through by the reports of several researchers about their studies of running a diesel engine by different kinds of biodiesels. If it has been compared algae with any other corps which are land-based then as a result it was found that the algae grows faster than the other land-based corps. A process named Transesterification which is essential for producing Biodiesel from the microalgae [2]. A biodiesel which will be produced by blending the oil derived from algae and diesel can replace the fuels which are used in transportation and are petroleum based.

2. Fuel Properties

Table 1: Fuel Properties of Diesel Fuel and blends of different biofuel with diesel fuel

Ref No.	Bio Diesel	Blending ratio	Density (kg/m^3)	Viscosity (mm2/s)	Calorific value (MJ/ kg)	Cetane No.	Flash point (°C)
[3], [4], [5], [6], [7], [8], [9], [13]	Diesel	-	810-850	1.9-4.7	42-45.5	45–55	50-169
[3]	Spirulina Microalgae	SMB1 (20% SMD + 80% Diesel)	836.5	3.26	42.2	48.88	86.4
		SMB2 (40% SMD + 60% Diesel)	842.7	3.67	41.88	49.7	96.8
		SMB3 (60% SMD + 40% Diesel)	848.9	4.2	41.58	50.5	107.3
		SMB4 (80% SMD + 20% Diesel)	855.1	4.67	41.28	51.4	117.7
		SMB5 (100% SMD)	861	5.26	41	52.2	> 128
[4]	Salvinia molesta oil	B10 (10% SM+ 90% Diesel)	829	3.2	40.39	-	98
		B20 (20% SM+ 80% Diesel)	834	3.467	39.58	-	105
		B30 (30% SM+ 70% Diesel)	838	3.9	37.8	-	109
		B100 (100% SM)	870	5.013	36.9	-	194
[5]	S. marginatum Macro algae	B20 (20% SMMA+ 80% Diesel)	830	4.7	43.66	54	179
		B50 (50% SMMA+ 50% Diesel)	830	5.6	45.89	53	180
		B75 (75% SMMA+ 25% Diesel)	830	5.6	45.76	51	179

		B100 (100% SMMA)	830	5.3	43.2	51	182
[6]	Azolla pinnata algae	A20 (20% APA+ 80% Diesel)	803	4.27	39.67	-	49
		A100 (100% APA)	880	5.58	30.88	-	46
[7]	plastic oil and B20 algae biodiesel blend	B20AOME (20% AOME + 80% Diesel)	854.2	2.75	41.78	54	69
		B20AOME10WPO (10% WPO +90% B20AOME)	852.28	2.73	42.04	53	66
[8]	Algae Oil and Algae Biodiesel	Algae Biodiesel	864	4.41	37.5	-	115
		Algae oil	897	33.74	35.8	-	220
[9]	Algae biodiesel blends	B10 (10% AB+ 90% Diesel)	838	3.76	43.24	45.7	65
		B20 (20% AB+ 80% Diesel)	853	4.27	39.67	46.5	71
[10]	Al2O3 and C18H34O2 with Kappaphycus Alvarezil-Brown algae biodiesel	B5	844	2.5	-	48.2	-
		B5-10 ppm	845	2.7	-	48.8	-
		B5-20 ppm	846	2.8	-	49.4	-
		B5-50 ppm	846	2.8	-	49.9	-
[11], [12]	CuO2 nanoparticles added neochlorisoleo abundans biodiesel	B20	832	4.71	43.59	58	175
		B20+ 25ppm CuO2	831.9	5.1776	44.606	54.75	175.5
		B20+ 50ppm CuO2	831.8	5.6451	45.623	51.5	176
		B20+ 75ppm CuO2	831.7	5.6669	45.921	51.75	176.5
		B20+ 100ppm CuO2	831.6	5.6888	46.219	52	177
[13]	Biodiesel fuels	B10	840.5	3.31	40.017	56	83
		B20	843.8	4.8	37.866	70	90

3. Engine Performance and Emission Analysis

Many researchers had analyzed the engine performance and emission characteristics by varying the blending ratio of bio-diesel fuel and had found best optimal results. Upendra Rajak *et al.* [3] investigated the effects of the spirulina microalgae biodiesel (SMB) blends (20,40,60 and 80%) on engine performance and emissions characteristics. He found that for SMB5 the amount of NOx emission is less at 100% load and BSFC increased when the proportion of biodiesel added to diesel is increased. M. Mubarak *et al.* [4] conducted the experiment to find the best optimal result of engine performance and emission characteristic of CI engine when S. molesta biodiesel blend (B10, B20 and B30) were used as a fuel and he got the best result of BTE

(29.51%), BSFC(0.3081kg/kWh), NOx emission (12.86%) and CO emission (14%) for B20 blend. S. Karthikeyan *et al.* [5] had used S. marginatum micro algae biodiesel blend (B20, B50,B75, B100) for his experiment under varied loading condition and concluded that B20 blend gives the best result for BTE(31.15%), BSFC(0.379kg/kWh) and EGT(381.77°).In the evaluation of the combustion, performance, and emission characteristics of CI engines powered by blended Azolla pinnata algae (10,20,30,40,100%), Mohankumar Subramaniam *et al.* [6] discovered that the A10 blend produced the best BTE and BSFC while the A40 blend produced the lowest EGT and the NOx emission reduced as the blending proportion increased. According to D. K. Ramesha *et al.* [7] investigation onto the engine performance as well as the emission characteristics of diesel engines powered by plastic oil and a B20 algae biodiesel blend, EGT (333.2°) and NOx (1007.5 ppm) emission are lower for B20AOME (20% AOME + 80% Diesel), whereas the addition of WPO (10%) increased the percentage of BTE (36.47%) and reduced CO emission (0.29%). A. Prabhu *et al.* [14] carried out a performance analysis of a single cylinder CI engine fueled with fresh water algae biodiesel blend (B10, B20) under varied compression ratio (CR15, CR16, CR17) and obtained the minimum BSFC(0.3kg/kWh) at CR15 for all the variants. But BTE (25.07%) was maximum for B10 blend at CR17. Sushant. S. Satputaley *et al.*[8] had studied on the comparative analysis of engine performance combustion and exhaust emission characteristics of diesel engine operated with algae oil and algae biodiesel separately and had got the minimum NOx and CO emission for algae oil.S. Pravakaran *et al.*[9] had tested the performance and emission characteristics of VCR diesel engine at different compression ratio (CR17, CR18) fueled with algae biodiesel blends (B10, B20) and concluded that the BSFC and CO emission were reduced and BTE, NOX emission increased with the enhancement of compression ratio. Maximum BTE was found for B20 blend at CR18.Abed *et al.*[13] had used different blends of biodiesel fuels to analyze the effect on the emission characteristics of CI engine with B10 and B20 blend obtained minimum CO emission(4.47%) for B20 blend but slight increase in NOX emission (200.66ppm).

Researchers have found that with the addition of nano particles in diesel,biodiesel as well as their blends improve their fuel properties and decrease the engine emissions [15]. Karthikeyan *et al.*[10] analyzed the performance of CI engine charged with kappaphycusalvarezin brown algae with varied proportion of nano additives Al2O3 and C18H34O2 (10 ppm, 20 ppm, 50 ppm) at different engine speedand found the minimum BSFC for B5(50ppm) at 2500 RPM. K. Kalaimurugan *et al.* [11-12] investigated the performance and emission characteristics of diesel engine fueled with blended neochlorisoleoabundans biodiesel (B20) and diversified proportion of CeO_2 nanoparticles (25 ppm, 50 ppm, 75 ppm, 100ppm) at different engine load concluded that the enhancement of CeO_2 level in biodiesel blendincreased the percentage of BTE, NOx emissions and reduced BSFC, CO emissions.

Table 2: Comparison of Engine Performance and Emission analysis of different blends of Biofuels and diesel fuel with neat diesel fuel

Ref No.	Biodiesel	Blend	Brake thermal efficiency at 100% load	Brake specific fuel consumption (g/kWh) at 100% load	Exhaust gas temperature (° C) at 100% load	Carbon monoxide (CO) emission at 100% load	Nitrogen oxides (NOX) emission at 100% load (ppm)	Remarks
[3]	Spirulina Microalgae	SMB1 (20% SMD + 80% Diesel)	↓	↑	↓		↓	A blend of SMB2 (40% SMD + 60% Diesel) provides the optimum results.
		SMB2 (40% SMD + 60% Diesel)	↓	↑	↓		↓	
		SMB3 (60% SMD + 40% Diesel)	↓	↑	↓		↓	
		SMB4 (80% SMD + 20% Diesel)	↓	↑	↓		↓	
		SMB5 (100% SMD)	↓	↑	↓		↓	
[4]	Salvinia molesta oil	B10 (10% SM+ 90% Diesel)	↓	↑	↓	↓	↓	The optimum results can be obtained for a blend of B20 (20% SM+ 80% Diesel).
		B20 (20% SM+ 80% Diesel)	↓	↑	↓	↓	↓	
		B30 (30% SM+ 70% Diesel)	↓	↑	↓	↓	↓	
[5]	S. marginatum	B20 (20% SMMA+ 80%	↑	↓	↑			The blend of B20

	Macro algae	Diesel)						(20% SMMA+ 80% Diesel) gives the optimum results.
		B50 (50% SMMA+ 50% Diesel)	↓	↓	↑			
		B75 (75% SMMA+ 25% Diesel)	↓	↓	↑			
		B100 (100% SMMA)	↓	↓	↑			
[6]	Azolla pinnata algae	A10 (10% APA+ 90% Diesel)	↓	↓	↓	↓	↓	The blend of A100 (100% APA) give the optimum results
		A20 (20% APA+ 80% Diesel)	↓	↓	↓	↓	↓	
		A30 (30% APA+ 70% Diesel)	↓	↓	↓	↑	↓	
		A40 (40% APA+ 60% Diesel)	↓	↓	↓	↑	↓	
		A100 (100% APA)	↓	↓	↓	↓	↓	
[7]	Plastic oil and B20 algae biodiesel blend	B20AOME (20% AOME + 80% Diesel)	↑		↓	↓	↓	Optimum results can be obtained for a blend of B20AOME (20% AOME + 80% Diesel)
		B20AOME10WPO (10% WPO +90% B20AOME)	↑		↑	↓	↑	
[8]	Algae Oil and Algae Biodiesel	Algae Biodiesel	↓	↑	↓	↓	↓	Algae oil provides the optimum result
		Algae oil	↓	↑	↓	↓	↓	
[9]	Algae biodiesel blends	B10 (10% AB+ 90% Diesel)	↓	↑			↑	Not optimum, Still best results could be obtained by the blend of B10 (10% AB+ 90% Diesel)
		B20 (20% AB+ 80% Diesel)	↓	↑			↑	

[10]	Al2O3 and C18H34O2 with Kappaphycu sAlvarezil-Brown algae biodiesel	B5		↓				Optimum results are obtained from a blend of B5-50ppm
		B5-10ppm		↓				
		B5-20ppm		↓				
		B5-50ppm		↓				
[11], [12]	CuO2 nanoparticles added neochlorisole oabundans biodiesel	B20+ 25ppm CuO2	↑	↓	↑	↓	↑	A favourable result can be obtained from a blend of B20+ 100ppm CuO_2
		B20+ 50ppm CuO2	↑	↓	↑	↓	↑	
		B20+ 75ppm CuO2	↑	↓	↑	↓	↑	
		B20+ 100ppm CuO2	↑	↓	↑	↓	↑	
[13]	biodiesel fuels	B10				↓	↑	The best results are obtained for B20
		B20				↓	↑	

Note: ↑ denotes increase in parameter with respect to diesel ↓ denotes decrease in parameter with respect to diesel

4. Conclusion

After thorough comparison of different algae biofuels and their blends with diesel researched by different researchers, the conclusion met is, the overall engine performance is the most favorable for Neochloris Oleoabundans Biodiesel [12] with a blend of B20+ 100ppm CuO2 and overall emission characteristics is favorable for Biodiesel Fuels with a blend of B20 [13]. But for overall performance regarding both engine performance and emission characteristics, Plastic Oil and B20 Algae Biodiesel Blend [7] is the most favorable for a blend of B20AOME10WPO (10% WPO +90% B20AOME).

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Chapter - 8
An Efficient House Price Prediction Mechanism Using Machine Learning

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Chapter - 8

An Efficient House Price Prediction Mechanism Using Machine Learning

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Abstract

Machine Learning has emerged as a rapidly growing and highly influential technology in recent years, with numerous applications and evolving algorithms. House price prediction is one of the many applications that has grown significantly in popularity and has been thoroughly examined in numerous research. The cost of a home is closely related to people's lives and is affected by a wide range of variables, including location, square footage, the number of bedrooms, and bathrooms. As house prices continue to rise annually, prospective buyers have become increasingly cautious, carefully considering their budgets and market strategies. As a result, there is a critical need to create models that can estimate housing prices accurately and offer people useful information for making decisions. In this study, we concentrate on developing a model that accounts for all the important factors that influence how much a property costs. In order to do this, we make use of three well-known machine learning algorithms: Ridge Regression, Lasso Regression, and Linear Regression. Through our experiments, we have observed that the Ridge Regression technique yields the lowest error and highest accuracy compared to the other employed algorithms. Thus, Ridge Regression exhibits slightly superior efficiency in house price prediction. The data set we utilize for our study is obtained from the Kaggle platform. The outcomes of our research hold tremendous value, particularly for housing developers and researchers, as they provide valuable insights into the most significant attributes influencing house prices. By understanding these influential factors, stakeholders can enhance their decision-making processes and strategies related to the housing market.

Keywords: Accuracy, house price prediction, machine learning, regression.

1. Introduction

In the present era, data has emerged as an invaluable asset. In our everyday lives, we encounter an immense volume of data, and as a result, data has become the central driving force behind technological innovations. Utilizing this data to achieve desired outcomes has become feasible through the aid of predictive models. Machine learning (ML) plays a vital role in this paradigm, as it enables software applications to learn from data and enhance their accuracy in predicting outcomes autonomously, without human intervention. In essence, ML empowers machines to comprehend the significance of specific events within a broader system based on their pre loaded data, thereby enabling accurate predictions. This transformative approach finds widespread application in diverse fields, including but not limited to predicting stock prices, anticipating seismic activity, forecasting company sales, diagnosing heart disease, and providing personalized recommendations based on user preferences and interests. The potential applications of ML are virtually limitless [19]. One of the most basic needs in human life is a place to live. Although some people buy homes as investments or as real estate, the majority of people purchase homes for habitation or as a means of support. The issue of fluctuating house prices has long been a concern for homeowners, the construction industry, and the real estate sector, as highlighted in [10]. Additionally, [4] points out that housing affordability has become a pressing problem, with significant price surges observed in numerous countries within the housing market. According to preliminary research, there are two criteria for determining the price of a house that are legitimate in transactions for both purchasing and selling a home: the price based on the developer (market selling price) and the price based on the Value of Selling Tax Object. Lim et.al. [12] claim that a developer’s primary challenge is figuring out how much to charge for a home. Because property prices nearly never decrease in the long or short term, the developer must carefully calculate and choose the best approach for deciding the price of a home [8]. Multiple prediction methods, including Support Vector Machine, Artificial Neural Network, and others, can be used to predict house prices. The house-price model offers various advantages to property speculators, home buyers, and home builders [7]. To accurately anticipate the price of a home using our model, we used regression algorithms like Linear Regression, Lasso Regression, and Ridge Regression. Home purchasers, real estate investors, and home builders would benefit greatly from this model’s wealth of knowledge and information, including its assessment of current market house values, which will aid them in setting house pricing. In the meantime, this model can assist potential buyers in selecting the features of a home that fit within their price range. Finally, our data set's experimental findings demonstrate that the Ridge Regression and Lasso Regression each get the maximum R2 and MSE values. It suggests that Ridge Regression performs well at predicting home prices as well as Lasso Regression.

2. Methods & Materials

2.1 Literature survey

These days, one of the main areas of research is house price forecasting. Numerous research proposals examine the computational techniques for predicting home prices. Varma *et al.*, [21] made predictions about home values using real-time pricing data and machine learning to imitate real-world mapping systems. To gain more precision, they supplemented this strategy by using the multiple regression weighted average method. They have made use of a diverse, verified data set in order to accurately forecast results under all circumstances [1]. They concluded that a succession of algorithms, as opposed to a single method, produces better outcomes after analysing for numerous test runs. Based on each parameter's significance in deciding the price, they awarded each one a weight. At first, they combined neural networks with 3 different machine learning techniques [23], including linear regression, forest regression, and boosted regression. The introduction of neural networks has significantly increased the algorithm's efficiency.

A prediction model for appraising the price of a house based on characteristics [3] that determine the price was attempted by Manasa J *et al.* [15]. For the prediction analysis, they used machine learning techniques [17]. The methodology can be used to estimate the financial worth of homes in large cities like Bangalore. To obtain an accurate conclusion, they took into account a number of variables, including the location, the size of the land, and its closeness to parks, hospitals, schools, and power plants. They looked at the ordinary least squares model, the Lasso and Ridge regression models, the SVR (Support Vector Regression) model, and the XGBoost (Extreme Gradient Boosting) regression model as five prediction models. They have utilised the OLS (Ordinary Least Squares) least squares method to create multiple regression models [18]. They used a variety of metrics, including the coefficient of determination R2, adjusted R2, RMSE (Root Mean Square Error), and RMLSE (Root Mean Squared Logarithmic Error).

Using the machine learning paradigm, S. B. Gubbala *et al.* [9] established a property price projection model that is based on the city of Bangalore, India. Predicting individual house prices require information other than the HPI (House Price Index). They have taken into account certain significant aspects of properties such as location, region, and population. After eliminating all null values from the data set and keeping in mind that the performance of a machine learning (ML) model is solely related to the quality of the data [11], they gathered a data set with information on 13320 instances and nine characteristics, including area type, availability, location, size, society, total sq.ft., bath, balcony, and price. They initially pre-processed the data and after preprocessing the data, they develop a model that accurately predicts the outcome using a variety of techniques.

Hujia Yu *et al.* [24] worked on a study where house values were forecasted using explanatory factors that took into account a variety of attributes of residential properties. Their project's primary goal is to develop classification and regression models that can precisely predict the cost of a house based on the provided features. For continuous house price prediction, they used regression techniques like Lasso, Ridge, SVM, and Random Forest. For individual price range prediction, they used classification techniques like Naive Bayes, logistic regression, SVM classification, and Random Forest classification. They have additionally used PCA to raise prediction accuracy.

Houses are among the most basic necessities for human life, along with food and water, and demand for homes increased over time as people's standards of living improved. For this purpose various hybrid models also proposed. [13]. By contrasting the errors of several algorithms (such as linear regression, decision tree regression, and lasso regression), E. V. Priya Darshini *et al.* [5] sought to determine the exact pricing of the house.

2.2 Method

A machine learning project's journey is a difficult one [6]. To develop a fantastic machine learning-driven product, you need a solid understanding of data science and statistical methods as well as the ability to collaborate with research, engineering, and product teams. Data collecting is the first step in our process. After then, clean data is produced by preprocessing the data. After that, the data is split into training and testing data. The algorithms are used, and the training data is used to train the model. The system is tested using test data to determine the accuracy of the system. We will examine every fundamental framework needed to deliver any machine learning project. A machine learning model's typical operational process is shown in Figure 1.

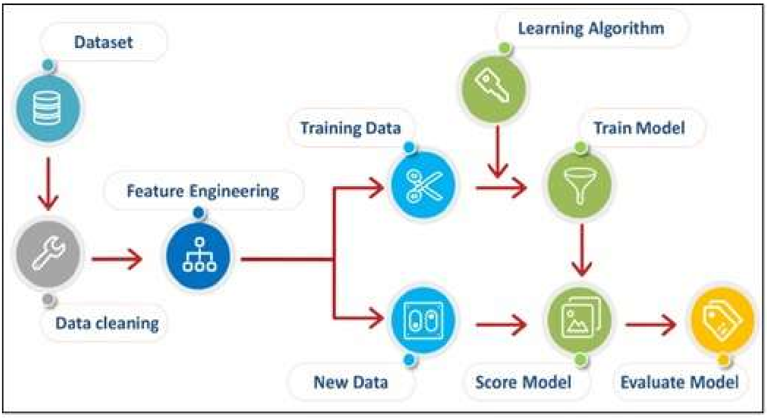
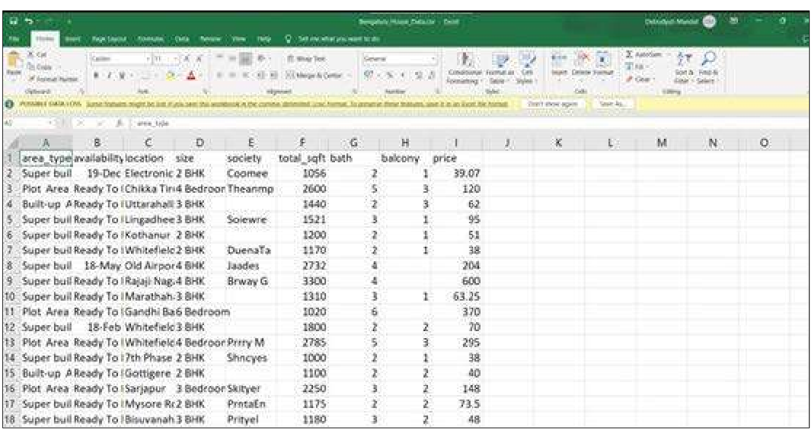


Fig 1: General working procedure of a machine learning model

2.3 Project Initiation: Idea, Requirements, and Data Collection

Understanding the issue, finding a solution, and producing a result that satisfies one's needs are the initial steps in creating a machine learning project successfully. Before starting our project, we must understand the problem, data, and context. We also need to know the goal and how it aligns with what's possible using machine learning techniques. We know in our project, our goal is to predict the price of the house as much as possible accurately so that it can benefit the house dealers, buyers and property investors to forecast house prices accordingly as per their requirements and possibility. In this paper we are dealing with the data set which is collected from the Kaggle platform. Sample data set that are collected from Kaggle platform are shown in Figure 2.



area_type	availability	location	size	society	total_sqft	bath	balcony	price
Super buil	19-Dec	Electronic	2 BHK	Coomee	1056	2	1	39.07
Plot Area	Ready To I	Chikka Tir	4 Bedroor	Theanmp	2600	5	3	120
Built-up A	Ready To I	Uttarahall	3 BHK		1440	2	3	62
Super buil	Ready To I	Lingadhee	3 BHK	Soiewre	1521	3	1	95
Super buil	Ready To I	Kothanur	2 BHK		1200	2	1	51
Super buil	Ready To I	Whitefielc	2 BHK	DuenaTa	1170	2	1	38
Super buil	18-May	Old Airpor	4 BHK	Jaades	2732	4		204
Super buil	Ready To I	Rajaji Nag	4 BHK	Brway G	3300	4		600
Super buil	Ready To I	Marathah	3 BHK		1310	3	1	63.25
Plot Area	Ready To I	Gandhi Ba	6 Bedroom		1020	6		370
Super buil	18-Feb	Whitefielc	3 BHK		1800	2	2	70
Plot Area	Ready To I	Whitefielc	4 Bedroor	Prrry M	2785	5	3	295
Super buil	Ready To I	7th Phase	2 BHK	Shncyes	1000	2	1	38
Built-up A	Ready To I	Gottigere	2 BHK		1100	2	2	40
Plot Area	Ready To I	Sarjapur	3 Bedroor	Skityer	2250	3	2	148
Super buil	Ready To I	Mysore Rc	2 BHK	PrntaEn	1175	2	2	73.5
Super buil	Ready To I	Bisuvanah	3 BHK	Prityel	1180	3	2	48

Fig 2: Sample data set collected from Kaggle platform

2.4 Data exploration

Data exploration is examining data to identify patterns and make sense of them in the context of one's problem. This is often called a "true data science" stage because it's where we get down to business by looking at the raw facts and figures without any preconceived notions about what they might mean. The step involves looking at the available data in different ways, for example, by adding new variables or changing existing ones and then seeing if there are any interesting relationships between those variables. By looking into our data set, we have analyzed many things such as, our data set which is extracted from Kaggle, initially has 13320 records and 9 attributes. There is only one categorical column present in this and other columns are in the form of numeric value. To reach at our goal the price column is considered the dependent variable from our data set. The rest of the columns fall under the independent variable.

2.5 Data processing and Feature selection

Understanding the issue, finding a solution, and producing a result that satisfies one's needs are the initial steps in creating a machine learning project successfully. Data cleaning also falls under data preprocessing, which is very crucial because often we get the data set that has irrelevant values or missing values and that's why our data needs to be cleaned before fitting into a ML model. There are several ways to pre-process data. It may include one or more of the following steps and Figure 3 depicts different stages of data pre-processing.

Fig 3: Stages of data pre-processing

In our data set there were a total 13320 records and 9 attributes present initially. Among these 9 attributes we are only considering 7 attributes and the rest of the columns were dropped as they are irrelevant in respect to our task. We are dealing with “total-sqft”, “size”, “location”, “BHK”, “bath” columns as independent variable (X) in our whole project and “price” attribute as the dependent variable (y) in our project. We have to fill those missing value and in our data set there are a total of 6201 null values or missing values present, and that needs to be dealt with. The null values were replaced by the values that had maximum value count in their respective columns. For this, the null values of the categorical column ‘location’ are removed. ‘location’ attribute has only one null value present, that is replaced by the second most occurring location in our data set. Similarly, the 16 null values present in the ‘size’ column has been filled with ‘2 BHK’ which is the most occurring size in our data set. Finally, the 73 null values of the ‘bath’ column has been replaced with the median of the values present in ‘bath’ column. In the ‘total-sq.ft.’ column, there are some values in the format of range, e.g., ’684 - 810’, which has to converted into numerical values because during model building, we cannot deal with categorical values. After that, this function has been applied to the values of ‘total-sqft’ column. As a result, some null values have been generated in the ‘total-sqft’ column. Next, these null values have been filled with the most occurring value in the ‘total-sqft’ column. Finally, we have removed all the null values. For outlier removal, a new column has been created as ’price-per-sqft’. Here, we observed that ‘price-per-sqft’ column has an extreme value ‘176470.588’ which is behaving like an outlier in our data set and the outliers from the ‘BHK’ column have been removed with the help of the following function. To transform categorical variables into numerical variables (or vice versa) we consider only one categorical column, i.e., location. We transformed this categorical column by the use of One-HotEncoder preprocessing technique.

2.5.1 Model Development

It’s now time to build the model. There are many algorithms and methods available open-source that we may use for the said problem. However, it is often wise to start with something simple and then reiterate. But first, we must divide the data set into two sections in order to simulate how a model might function with fresh or previously undiscovered data. As a result, the method Train Test Split is utilised in this module. Therefore, we divided the known data set so that 80% of it could be used as training data and 20% could be utilised as test data. Using the training set Decision Tree Classifier model is constructed and tested with test data to identify the accuracy level of the model. In this paper our aim is to predict the price of the house which is a numeric value that's why in our project we are mainly dealing with 3 regression techniques namely Linear, Lasso and Ridge Regression.

2.6 Applying linear regression in the proposed mechanism

Regression analysis in mathematical statistics is used in the statistical analysis method known as linear regression [14] to confirm the quantitative association between two or more variables. It's commonly employed.

It is exhibited in the following form,

$$\boldsymbol{y} = \boldsymbol{\omega}'\boldsymbol{x} + \boldsymbol{e}\ (\mathbf{1})$$

where the error follows a mean of zero in a normal distribution called e. There is only one dependent variable and one independent variable, and their connection can roughly be described by a straight line. Unary linear regression analysis is the name given to this type of analysis.

2.7 Applying lasso regression in the proposed mechanism

A regularisation method is lasso regression. For a more accurate forecast, it is preferred over regression techniques. Shrinkage is used in this model. When data values shrink towards the mean, this is referred to as shrinkage. Models with fewer parameters are encouraged by the lasso technique since they are straightforward and sparse. When a model exhibits significant levels of multicollinearity or when you wish to automate specific steps in the model selection process, such as variable selection and parameter elimination, this particular sort of regression is well-suited.

2.8 Applying ridge regression in the proposed mechanism

The Ridge Regression tool is used to analyse multiple regression on multicollinear (mcl) data [2]. The presence of nearly linear connections between variables that are independent is known as multicollinearity (mcl). As in equation 2 and equation 3, Ridge regression adds a particular kind of condition on the parameters: Bridge was selected to minimise the sum of the squares in accuracy. The equations for these are stated below.

$$\sum_{a=1}^{n}(y_a - \sum_{b=1}^{p} x_{a,b} \cdot \beta_b^2) + \lambda \sum_{b=1}^{p} \beta_b^2\ (2)$$

Which is equivalent to,

$$\sum_{a=1}^{n}(y_a - sum_{a,b}\beta_b)^2\ (3)$$

Subject to the for some $c \geq 0$ and $\sum_{b=1}^{p} \beta_b^2 < c$ (4)

i.e., constraining the sum of the squared coefficients.

2.9 Model Evaluation

After the model has been trained, it is crucial to assess it and comprehend how to interpret the outcomes. The measures utilised in our study to assess model performance were MSE (Mean Squared Error), RMSE (Root Mean Squared Error), MAE (Mean Absolute Error), and R2. Testing the samples in the data set is at the heart of MSE, RMSE, and MAE. The more closely a sample matches the model, the more accurate the model is. Since the sum of all test samples will be impacted by the sample size, these three metrics use the average distance instead. The metrics' calculation is done by the following equation 5, equation 6, equation 7, and equation 8.

$$MSE = \frac{1}{m}\sum_{i=1}^{m}\left(y_{test}^{(i)} - y_{test}^{\sim(i)}\right)^2 \quad (5)$$

$$RMSE = \sqrt{\frac{1}{m}\sum_{i=1}^{m}\left(y_{test}^{(i)} - y_{test}^{\sim(i)}\right)^2} \quad (6)$$

$$MAE = \frac{1}{m}\sum_{i=1}^{m}\left|y_{test}^{(i)} - y_{test}^{\sim(i)}\right| \quad (7)$$

$$R^2 = \frac{1 - \sum_i (\tilde{y} - y)^2}{\sum_i (\tilde{y} - y)^2} \quad (8)$$

3. Results and Discussion

Table 1 describes the R2 scores for all the aforementioned metrics in respect to Linear Regression, Lasso Regression, and Ridge Regression and Table 2 represents the accuracy values (%) while applying the said three different Regression models. Therefore, our study shows that, Ridge Regression displayed the best performance for this data set and can be used for deploying purposes. Linear Regression and Lasso Regression are far behind, so cannot be recommended for further deployment purposes. Figure 4, 5, and 6 illustrate Bar plot comparison of linear regression, lasso regression and ridge regression algorithm for RMSE, MSE, and MAE respectively. Table 3 characterizes different observation metrics in respect to accuracy for various existing papers and shows the comparative calculations (%) in respect to accuracy for the proposed model with the existing work(s). From the said table we can see the noticeable improvement in evaluating accuracy factors. The percentages of improvement are 13.45%, 1.45%, 24.4%, and 5.09% in respect to the existing works at [3] [15] [9] [5] respectively.

Table 1: Descriptive Statics table for error calculation.

Regression	**RMSE**	**MSE**	**MAE**	**R^2 - Score**
Linear	29.81	888.73	17.58	0.8596
Lasso	30.68	941.18	18.63	0.8513
Ridge	29.76	885.99	17.55	0.8600

Table 2: Table for accuracy calculation

Model Used	**Accuracy**
Linear Regression	85.96
Lasso Regression	85.13
Ridge Regression	86.00

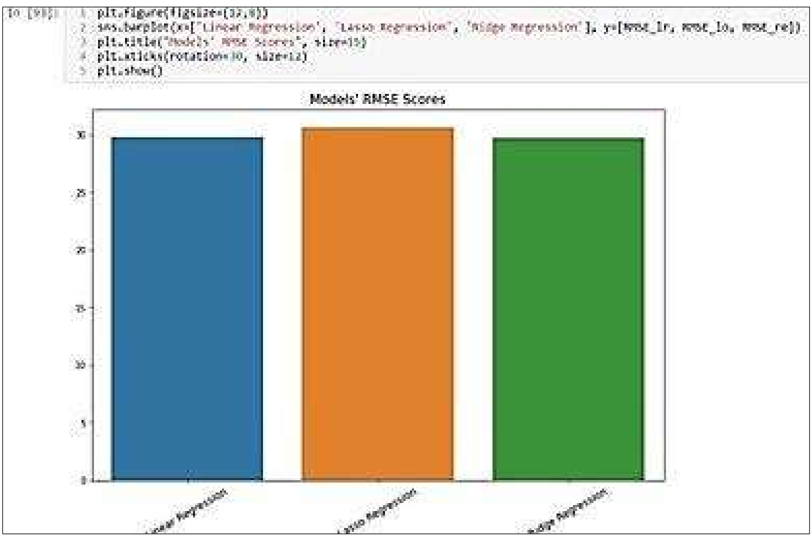


Fig 4: Bar plot comparison of linear regression, lasso regression and ridge regression algorithm for RMSE.

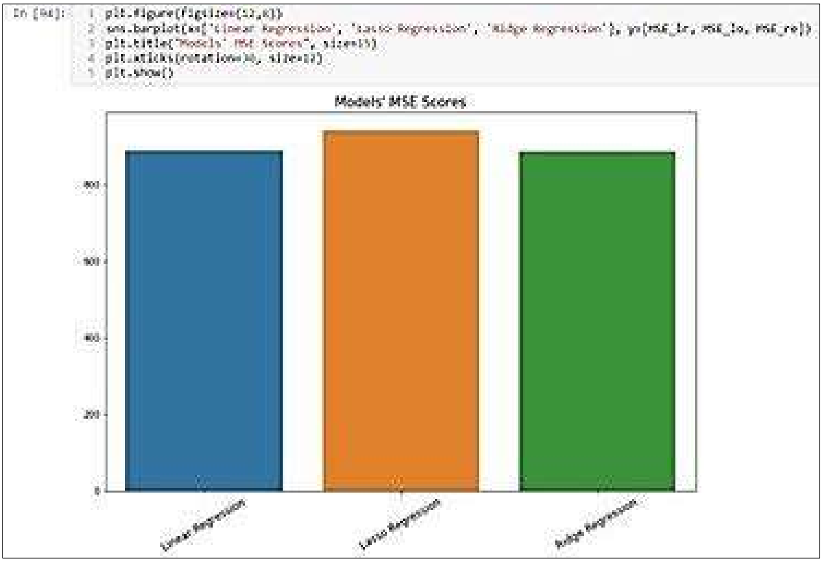


Fig 5: Bar plot comparison of linear regression, lasso regression and ridge regression algorithm for MSE.

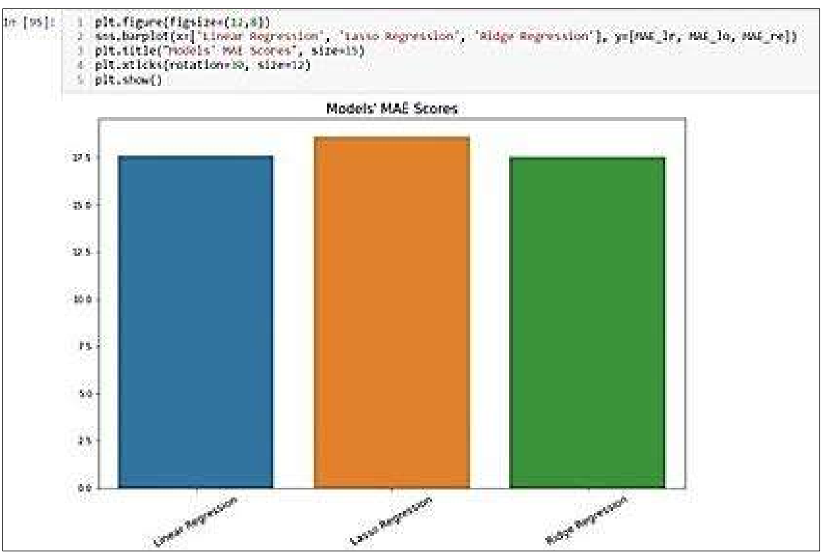


Fig 6: Bar plot comparison of linear regression, lasso regression and ridge regression algorithm for MAE.

Existing Work(s)	Accuracy	% Improvements
Machine Learning Based house price prediction using	75.84%	13.45

Predicting regression techniques [15]		
House price estimation using Data Science and ML [9]	84.77%	1.45
Real Estate price prediction with regression and classification [24]	86.00%	24.4

4. Conclusions

In our research-based project, we conducted a comprehensive examination and analysis of existing studiespertaining to the significant attributes influencing house prices, as well as the data mining techniques employed for predicting house prices. It has been observed that houses with a strategic location, offering easy access to amenities like shopping malls and other facilities, tend to command higher prices compared to houses situated in rural areas with limited amenities. Developing an accurate prediction model holds immense value for investors and prospective house buyers, enabling them to determine realistic house prices, while also assisting house developers in setting appropriate pricing. Our research focuses on the attributes identified by previous researchers as influential in forecasting house prices, employing various prediction models and employing evaluation metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and R squared (R2) to assess model performance. Through our investigation, we have established that house prices are influenced by numerous factors and machine learning methods prove effective in predicting house prices. Specifically, this article centres on comparing different machine learning algorithms [22] [20], namely Linear Regression, Ridge Regression, and LASSO Regression, for house price prediction analysis. Based on our experimental results, the Ridge Regression algorithm demonstrated superior accuracy compared to the other algorithms in predicting house prices. This finding highlights the effectiveness of Ridge Regression as a valuable tool in house price prediction. However, the accuracy of the system can be improved. More cites can be included in the system if the size and computational power of the system increases. Furthermore, we can integrate different UI/UX methodology for better visualization of the results in a more interacting way. Also, a learning system can be integrated alongside the feedback form which will gather users' history so that the system can display the most suitable results to the user according to his preferences. Our research is currently working on appropriate model building to obtain the overall good performance and accuracy for prediction. This research is also in other sectors as well as other countries or cities, is yet to be explored. A major future update could be the addition of larger cities to the database, which will allow our users to explore more houses, get more accuracy and thus come to a proper decision.

In the future, we can adopt more learning methods based on machine learning and deep learning as well, collect more data sets related to house prices, better train models, and take local policy factors into account to further forecast house prices and can integrate many other technologies to get the full flavour of the project.

Deceleration

Availability of data and material the authors have used the data available in Kaggle data set for the above work. Competing interests, the authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' contributions

All authors contributed to the study conception and design. Debodyuti Mandal helps in Conceptualization, Methodology and Writing- Original draft preparation. Srijita Dhar helps in Methodology, Visualization. Shiu Mahata gives her contribution in validation and Writing- Original draft preparation. Arpan Chakraborty helps in Conceptualization and Visualization. Sagarika Chowdhury and Prianka Dey help in Supervision, Writing- Reviewing and Editing.

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Chapter - 9
An Overview of Metal Additive Manufacturing Process

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Chapter - 9

An Overview of Metal Additive Manufacturing Process

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Abstract

Additive manufacturing is a layer by layer-based manufacturing process which build parts directly from 3D model. This technology is widely used nowadays in manufacturing field because it reduces costs and time. This paper provides a review on metal additive manufacturing and their types. Different types of Metal additive manufacturing that are generally used are Wire arc additive manufacturing (WAAM), Electron beam melting (EBM), Direct metal laser sintering (DMLS). These papers also give a review on the challenges, advantages and limitations of these Additive manufacturing process.

Keywords: Additive manufacturing, WAAM, EBM, DMLS.

1. Introduction

Additive manufacturing (AM), also known as 3D printing, is a layer-by-layer addition of materials to form a solid object by using CAD model, typically by laying down and bonding a large number of successive thin layers of materials [Mo. YA, 2018]. The general concept and procedure of 3D printing was first described by Murray Leinster in 1945 [W.E. frazier, 2014]. A continuous inkjet metal material device with removable fabrication on a reusable surface was invented by Johannes F. Gottwald in 1971. It can be used right away or saved and remelted to print again.. This appears to be first patent describing 3D printing with rapid prototyping . The metal 3D printing was first came into picture in 1994, when EOS first introduced its EOSINT M250 machine, this machine is based on direct metal laser sintering machine (DMLS) in which metal powder are partially melted and fused together to create metal parts. Now the modern DMLS machines are able to fully melt metal powders. The various types of Additive manufacturing processes can be classified into following categories:

1) According to base metal, such as polymers, ceramics, plastics, metal.

2) Indirect and direct process

3) According to state of raw material input such as liquid, molten, powder solid layer process [Mo. YA,2018].

This paper presents an overview of various metal AM process such as wire arc additive manufacturing (WAAM), Electron beam melting (EBM), Direct metal laser sintering (DMLS) and their benefits and challenges. This paper also highlights the applications of these additive manufacturing.

2. Classification of metal Additive manufacturing

We are going to discuss the three types metal additive manufacturing process which are mostly used in industries that are 1) WAAM 2) EBM 3) DMLS.

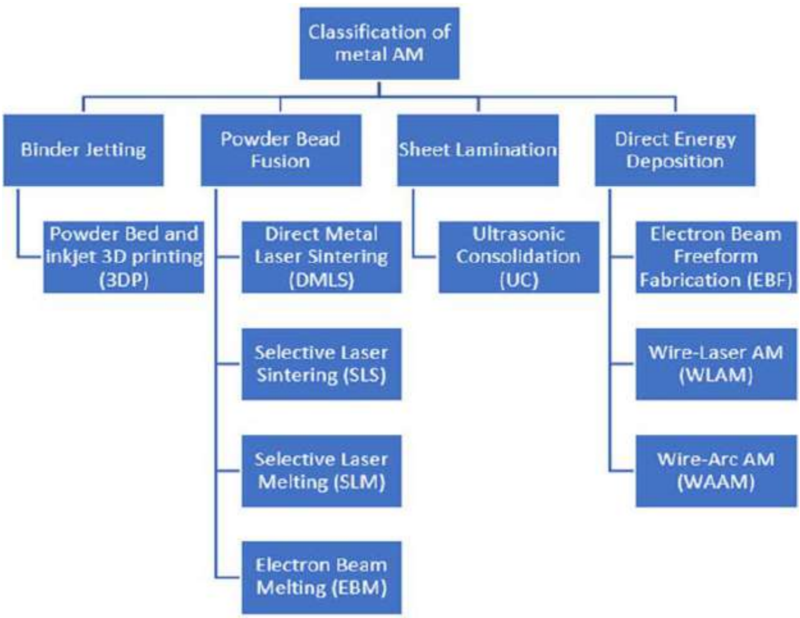

Fig 1: [Mo. YA,2018]. Classification of metal Additive manufacturing

WAAM

Although the initial patent was filed in 1925, WAAM, the combination of an electric arc as a heat source and wire as a feedstock, has been studied for AM uses since the 1990s. WAAM hardware currently makes use of common, off-the-shelf welding tools, including wire feeding systems, torches, and welding power sources. Motion can be provided by robotic system or numerically controlled computer [S.William, 2016]. Metal inert gas (MIG), tungsten inert gas (TIG), and plasma arc welding (PAW) are the three heat sources used in WAAM technology. Nickel, aluminum, titanium alloys are generally used as feed stock .

Working

1) An electric arc is generated between the electrode and the workpiece.
2) The electric arc produces intense heat which melts the metal wire and the workpiece at the point of contact.
3) As the wire melts, it is deposited layer by layer on the workpiece which is controlled by CNC machine.
4) As the molten layer is deposited, the molten metals quickly cools and solidifies to form a solid layer. This layer adheres to the previous layer creating a strong bond. After the part is build fully it may under go post processing such as machining.

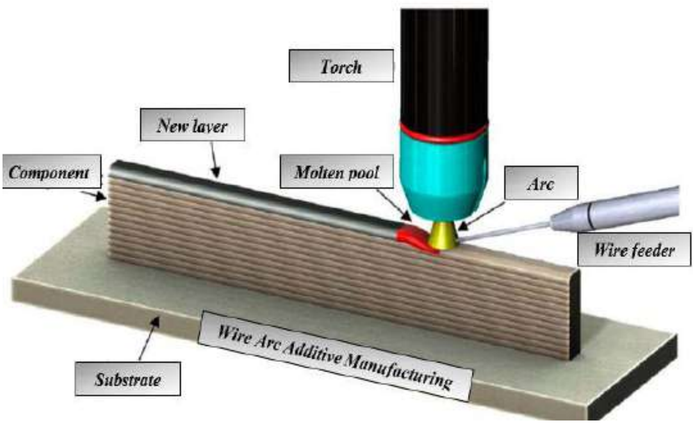

Fig 2: WAAM [S.W.William, 2016]

Advantages

1) For large parts or components, WAAM may be more economical than conventional production techniques. It minimizes material waste and enables the use of raw materials in wire form that are less expensive.
2) This technology allows for flexible material selection based on the needs of the application and is suitable with a variety of metal materials, including steel, aluminum, titanium, and their alloys .
3) Complex geometries and elaborate designs that would be challenging or impossible to produce using conventional manufacturing methods are now possible due to WAAM.

Limitations

1) There exists residual stresses and distortion due to its high heat input [S.W.williams,2016].

2) The majority of WAAM-produced components have straightforward geometries, however geometrical accuracy may not be as great as with other AM technologies.[J.L.Z.Li,2018]

Applications

1) In the aerospace sector, WAAM is utilized to create structural elements like wings, fuselage sections, and engine parts. Large, intricate components can be produced using WAAM with great precision, potentially reducing the requirement for assembly and welding. Additionally, WAAM can restore and repair airplane parts, saving money and time .

2) Engine parts, exhaust systems, and other components requiring high strength and durability are produced in the automobile sector using WAAM. BMW has invested in a WAAM machine for its Additive Manufacturing Campus in Munich because it believes in the technology.

EBM

Electron Beam Melting (EBM) is an advanced additive manufacturing technology used to produce complex metal parts layer by layer. It falls under the broader category of 3D printing and is particularly well-suited for manufacturing high-quality, intricate, and functional metal components. In EBM, the process begins with a bed of metal powder. An electron beam, generated by an electron gun, is then directed onto specific areas of the powder bed. The focused electron beam generates enough heat to melt the metal particles it interacts with, causing them to fuse together. The melted material solidifies rapidly upon cooling, forming a solid layer. The build platform is then lowered, and a new layer of powder is spread over the previous one. The process is repeated, layer by layer, until the entire object is formed. [X.Gong,2012]

Working of EBM

A scanning electron microscope's operating principle is very similar to this one. In the upper column, a heated tungsten filament releases collimated, accelerated electrons with a kinetic energy of roughly 60 KeV. Two magnetic coils located in the lowest column regulate the electron beam. A magnetic lens in the first one concentrates the beam to the desired diameter, and a beam deflector in the second one directs the concentrated beam to the desired place on a build platform. There are no moving mechanical components within the stationary electron-beam gun that could cause beam deflections.. The beam current is controlled in the range 1 to 50 mA and the beam diameter can be focused down to about 0.1 mm. The raw materials used in EBAM are metallic powders and the characteristics and quality of powders strongly affect the process performance. In general, fine powders, with a diameter between 45 and 100 μm, are used.[X.Gong, 2012]

Advantages

1) 1)Highly complex and incarnate geometry design can be made by this process which is difficult to achieve using traditional manufacturing process.
2) They also typically have high density (over 99%). It also has residual stresses due to its preheating of bed, reducing the need for support structure.
3) EBM produces less waste because the majority of the powder that isn't used may be recycled for later use. This is especially advantageous given the high cost of the materials used in EBM.
4) EBM melts the material using a concentrated electron beam, resulting in a minimal heat affected zone (HAZ). Compared to conventional heat-based production techniques, this localized heating produces a smaller heat impacted zone, limiting the danger of distortion, residual stress, and material deterioration

Limitations

1) The range of materials is limited compared to other additive manufacturing processes.
2) The surface finish is rough compared to other techniques.
3) High maintenance and capital cost is required.

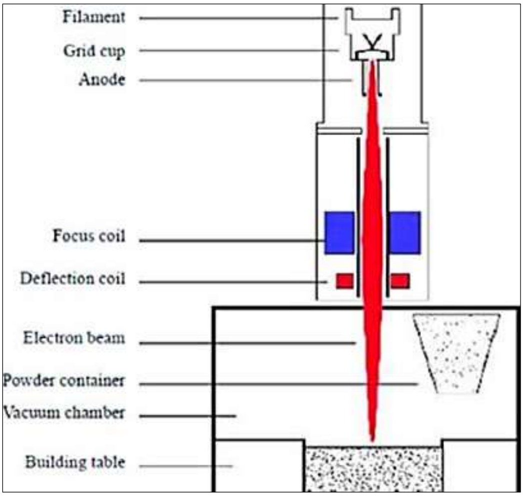

Fig 3: [B.S,2010] EBM

Applications

1) EBM is used in the aerospace industry to produce intricate, lightweight components with exact geometry [X.Gong, 2012]. Turbine blades, fuel nozzles, and structural elements for aviation and spacecraft are frequently produced using it.

2) The electron beam has a high enough energy density to melt a wide range of metals and alloys. EBAM methods have the capacity to work with a wide range of material classes, including superalloys based on cobalt, stool steel (H13), and aluminum alloys. [X.Gong, 2012]

3) Specific net-shaped parts for use in the aerospace and medical implant industries have been created using EBM. [X.Gong, 2012]

DMLS

In DMLS, a high-powered laser is used to selectively fuse or sinter metal powder particles together, layer by layer, to build up a three-dimensional object. The process is computer-controlled and highly precise. A thin layer of metal powder is spread across a build platform. The laser is then directed onto specific points in the powder bed, melting and fusing the powder particles. After each layer is completed, a new layer of powder is spread, and the process is repeated until the final object is formed.

Advantages

1) The primary benefit of DMLS is that it produces products that have

a low percentage of internal defects and residual stresses, which are common in traditionally fabricated metal components. [A. Gangadhar, 2021]

2) Intricate features and cavities can be freely designed with DMLS, which also lowers the quantity of distinct components that must be constructed and assembled for a given product, thereby simplifying its manufacturing process. [A.Gangadhar, 2021]
3) The technology saves time and effort because it does not require CAD-developed support structures.[A.Gangadhar, 2021]

Disadvantages

1) The system needs enough of space to store it, and more space is needed for the storage tanks for the inert gases utilized during each build. [A.Gangadhar, 2021]
2) Due to the high wattage of the laser, which is an integral component of the DMLS process, the system uses a lot of power. [A. Gangadhar, 2021]

Materials used

1) Aluminum (AlSi10Mg)
2) Stainless Steel (316L)
3) Titanium (Ti6Al4V)
4) Inconel 718
5) Maraging Steel
6) Cobalt Chrome [J.Nandy,2019]

Applications

1) Using DMLS, it is possible to design heat sinks and other parts with intricate interior geometries, enhancing thermal performance in electronic devices and other applications.
2) DMLS is used to produce specialty parts for military purposes, including as light, strong parts for vehicles, equipment, and aircraft.
3) NASA, SpaceX, and other aerospace companies have also employed DMLS technology to print precise components for their designs.

Discussions

1) General Electric (GE) Aviation successfully developed 3D printed fuel nozzle for their LEAP engine.
2) SuperDraco rocket engines made by SpaceX using additive

manufacturing are used in their Crew Dragon spaceship using Inconel, a high-performance nickel-chromium alloy.

3) BMW has been researching 3D printing for automobile components aggressively. They created a "Additive Manufacturing Center," a 3D-printed electric car component, in partnership with HP that is lighter and more effective than conventionally manufactured components.

3. Conclusions

This paper aimed to review three types of metal additive manufacturing WAAM, EBM, DMLS with their advantages, limitations and applications. The automotive, aerospace, medical, and dental sectors are the industry leaders for metal additive manufacturing. Other industries, including oil and gas, electronics, construction, and railway, have been paying close attention to metal additive manufacturing (AM) in recent years as a way to make substantial advancements in the design and production of innovative components . As a result, metal additive printing represents an important change in the way we create, think about, and design metal parts and components. Although there are still issues, the technology has the potential to transform industries, spur innovation, and improve sustainability, making it an important field of research for scientists, engineers, and manufacturers alike. Metal additive manufacturing is positioned to play a more significant role in determining the direction of manufacturing and production as research and development initiatives proceed [Mo. YA, 2018].

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Chapter - 10
An Overview of Automated Solar Grass Cutter: Harnessing the Solar Energy

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Chapter - 10

An Overview of Automated Solar Grass Cutter: Harnessing the Solar Energy

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Abstract

The History of automated solar grass cutters traces back to the early 2000s when the world began recognizing the significance of renewable energy and sustainable practices. The concept of integrating solar power with lawn maintenance emerged as a response to the environmental impact caused by traditional gas-powered mowers. It is designed to efficiently maintain lawns and green spaces. The autonomous System aims to promote sustainable and eco-friendly practises by integrating solar energy and advanced robotic technology.

The automated solar grass cutter uses the solar panel to harness renewable energy, eliminating the need for fossil fuels and also reducing the carbon emissions. It's highly intelligent navigation system uses the sensors and algorithms to detect obstacles. It works silently, without emitting harmful gases making it an eco-conscious alternative to traditional gasoline powered mowers, while its autonomous capabilities offer convenience and time saving benefits for property owners. Overall, the automated solar grass cutter is modern, efficient and green solution to keep lawns well-maintained contributing to a greener and cleaner future. In this paper we are trying to describe technologies present in automated solar grass cutter by rundown different research done over time.

Keywords: Solar energy, grass cutter, sensors, renewable energy.

1. Introduction

In now days Pollution is the major threat, for all living beings in the universe and also it is very harmful for environment. In case of gas-powered Traditional lawn mowers or grass cutters because of the emission of the harmful gases it is responsible for pollution, also the fuel cost is increasing day by day hence it is not efficient for future uses. So, solar power automated grass cutters are a revolutionary alternative of traditional grass cutters, because they are pollution free, eco-friendly and also because they are automated, they are easy to use (Tyagi *et al.*, 2018). The first lawn mower was invented by an English engineer named Edwin beard budding in 1830. He primarily designed the mower to cut the grass on the sports grounds and extensive gardens, because it was a superior alternative to the scythe, and later the budding's mower was granted a British patent. Later in 1995 the first fully solar powered automatic robotic mower became available (Yadav *et al.*, 2017). This automated solar grass cutter combines robotics, artificial intelligence, and clean energy technology to provide a hands-free solution for keeping lawns perfectly manicured. The automated solar grass cutter is equipped with advanced robotics that enable it to navigate lawns with remarkable precision. Using sensors, cameras, and mapping technology, the device can detect obstacles, uneven terrain, and boundaries, ensuring a smooth and even cut across the entire lawn. Solar panels located on the device's body collect and store energy during the day, allowing the grass cutter to operate for extended periods without relying on conventional electricity sources. This eco-friendly approach reduces both energy costs and carbon emissions.

In this review we are goanna briefly discuss about 'automated solar grass cutter' and its advantage and limitations with its impact on our environment.

2. Problem statement

The technology is emerging day by day and with it the pollution rate is also increasing. But the awareness for the environment in the consumers are also growing day by day. The consumers are also looking to reduce the carbon footprints and finding the ways to contribute to the relief of the environment.in our daily life pollution can be seen everywhere because it is purely made by human beings. For reference 90% of the homes in U.S uses gas powered lawnmowers, which created 5% of the total U.S pollution (Tyagi *et al.*,2018). Governments and many cooperate business are already adapting the green technology initiatives, so it's also our responsibility to reduce the pollution as much as possible from our end.

To reduce the pollution and to relieve the consumers from the manual work of lawn mowing the automated solar grass cutter is an effective and innovative creation for human beings and also for the environment.

3. Literature review

3.1 Grass cutting machine by solar energy power

E. Naresh *et al.* Author Described that "the automated solar grass cutters represent a significant stride towards efficient and eco-friendly lawn maintenance. Emerging from the convergence of robotics, artificial intelligence, and solar technology, these devices have evolved to liberate homeowners from the tedious task of mowing lawns. The solar grass cutter has an Arrangement of solar panel in such a way that it can receive the highly intensive solar radiation from the sun, Then the solar panels convert the solar energy into electrical energy. This electrical energy is stored in the batteries".

3.2 Automated solar grass cutter

Pushpendra Tyagi *et al.* In this Paper the author briefly describes the motor and all the electrical components of the automated solar grass cutter get its power from the battery. The brain of the automated solar grass cutter is the Microcontroller which controls all the components of this machine from the wheels to the cutters to the sensors. If any type of obstacles come in front of the grass cutter the Ultrasonic sensor sense it and gives the signal to the microcontroller to change its direction until the obstacle is removed or stop the grass cutter altogether. The cutting mechanism is consisting of rotating blades, which are positioned under the grass cutter. As the grass cutter moves along its path the mechanism of the blades is engaged, trimming the grass to a consistent height which is adjustable.

3.3 Automated solar grass cutter

Yadav Rutuja A *et al.* in this paper the author highlights key points in the evolution of lawn mowers, from Edwin Budding's invention in 1830 to modern solar-powered robotic models. Budding's mower aimed to replace scythes, receiving a patent in 1830. In 1995, the first solar-powered robotic mower emerged, using radio frequencies or guide wires to find its charging station, eliminating wear patterns on lawns. These autonomous mowers rely on boundary wires to navigate and recharge. They maintain up to 20,000 square meters of grass, often with rain sensors. By 2012, their sales growth outpaced traditional models.

The authors successfully completed their solar-powered grass cutter project, highlighting its eco-friendly benefits, potential for day and night operation, and room for improvement in mechanical efficiency and materials. The project aims to offer an affordable grass-cutting solution, potentially inspiring further innovations in the field.

3.4 Fully automated solar grass cutter

Karthik *et al.* The Writer Fabricated and discusses the development of a fully automated solar-powered grass cutter (FAGC) as an eco-friendly and efficient solution for maintaining gardens and yards. It highlights the limitations of manual grass cutting in terms of accuracy and efficiency, making the case for automated devices. The FAGC was developed as a green technology initiative that uses solar energy to power its motor and blades. By utilizing renewable energy, the FAGC aligns with the growing need for sustainable solutions and reduces the drawbacks associated with fuel-based grass cutters, such as non-renewable fuel consumption and the need for regular maintenance. The major components of the FAGC model include a solar panel for energy collection, batteries for energy storage, a microcontroller for program control, sensors for obstacle detection, a motor driver for controlling the movement, and DC motors for both vehicle propulsion and blade rotation. The design emphasizes efficiency, accuracy, eco-friendliness, durability, and low cost. The literature review underscores the significance of the FAGC's innovation, particularly its reliance on solar energy and its ability to provide automated, precise grass cutting while minimizing environmental impact.

3.5 Grass cutting machine using solar energy

T. Karthick *et al.* in this paper author describes the growing significance of alternate fuels, particularly solar energy, due to the depletion of fossil fuels. It introduces the historical context of grass cutting technology, with Edwin Budding's invention in 1830 serving as the foundation. His initial mower, designed for sports grounds and gardens, resembled modern counterparts in many ways. The paper addresses the challenges posed by conventional grass cutters powered by engines, highlighting inconveniences, noise pollution, and maintenance requirements. Electric options, while more environmentally friendly, also present limitations, especially with corded designs. The paper's objective is to create a solar-powered grass cutting system, offering a sustainable and efficient solution. The solar grass cutter's simplicity and versatility make it suitable for various applications, including maintaining lawns in different settings. By focusing on pollution control, ease of operation, and cost reduction, the solar grass cutter emerges as a valuable innovation.

3.6 Fabrication of solar grass cutter

Pankaj Malviya *et al.* author manually constructed a grass cutter with the ability to be powered by a solar panel or an external power supply. A controllable DC motor is integrated to alter the cutter's direction as needed. The incorporation of a modern regulator prevents battery overcharging and discharging, thereby extending battery life.

Considering the escalating demand for electricity due to industrialization and various devices, solar energy emerges as an optimal alternative. The fabrication of the grass cutter involves essential components: solar panel, battery, DC motor, and solar charger. The design emphasizes minimal moving parts, translating to reduced maintenance requirements. This grass cutter not only provides the operator with physical exercise but also ensures easy handling.

3.7 Modification of solar grass cutting machine

Praful P. Ulhe *et al.* in this paper they underscore the challenges associated with traditional grass cutting methods, particularly in the context of noise pollution and air pollution generated by engine-powered grass cutters. It highlights the inconvenience of maintenance, including engine oil changes, and acknowledges the environmental friendliness of solar-powered alternatives. However, it also notes potential inconveniences with solar-powered models. The introduction of remote-control operation for ease of use and the incorporation of solar panels for charging indicate efforts to address these issues. They further mention the inclusion of an AC charging option and a spiral cutting blade to enhance cutting efficiency. The design's dual functionality-manual and motor-driven with remote control-demonstrates versatility, while the addition of a collecting box for gathered grass clippings aims to improve lawn aesthetics. Overall, the text reflects a proactive approach to overcome the limitations of traditional and solar-powered grass cutters.

3.8 Solar powered vision based robotic lawn mower

Dipin.A *et al.* in this paper authors suggests a solar-powered robotic mower that charges from sunlight and mains. It simplifies mowing with preset patterns, differentiating from complex GPS and wire-based systems. Sensors, including ultrasonic and humidity, enhance safety and efficiency. The research aims to develop a device reducing pollution, human effort, and enhancing lawn design. MATLAB aids image processing and pattern selection, alongside safety sensor arrays. The study envisions a green replacement for gas mowers, benefitting both environment and users.

3.9 Fabrication of automated solar grass cutting machine

Prof. Mohd Attalique Rabbani *et al.* In this paper, the author describes the design of a machine that utilizes solar energy generated by a solar panel to power the grass cutter motor. All hardware components have been integrated and designed for optimal functionality. The generated torque efficiently drives the cutting head mechanism for grass cutting. The complete setup is mounted on a wooden base, connected to a bicycle frame, and equipped with a wheel arrangement. This portable lawn mower is versatile, suitable for maintaining and trimming grass in gardens, homes, schools, or yards.

3.10 Review paper on agricultural solar grass cutter

Mahendra Kalaskar *et al.* in this paper the author discusses the need for an efficient grass-cutting solution, considering labour costs and environmental impact. It proposes a solar-powered machine for farms and lawns, using batteries and solar panels for power. The project aims to offer adjustable blade height and dual blades for increased coverage. The focus is on environmentally friendly technology and safety. The objective is to create a solar-powered grass cutting system that addresses labour, fuel costs, and emissions.

4. Conclusion

In our brief discussion, we have understood that the automated solar grass cutter is a highly innovative and eco-friendly invention for all of mankind. Its lightweight design, reduced manpower requirement, cost-effectiveness, user-friendly operation, ease of maintenance, and minimal noise emission make it an exceptionally effective creation. The robot's size can be easily modified to suit our specific requirements. The necessary parts are readily available and affordable. It serves as an excellent alternative to fuel and electricity-based machines. However, it does have some limitations. For instance, the machine's battery requires a longer time to reach a full charge, and it faces challenges operating during rainy seasons. Certain components like sensors and solar panels are susceptible to damage in minor incidents. Nevertheless, the cost of these components or the machine itself is much lower compared to other non-solar grass cutting machines. The implementation of the automated solar grass cutter, utilizing this technology, proves to be genuinely effective and advantageous. The demand and necessity for this automated solar grass cutter are expected to increase in the future.

Acknowledgment: We take this opportunity to express our regrets and sincere thanks to our advisor and guide Mr Kaushal Kishor. HIs constant encouragement and moral support gave us the motivation to carry out the project successfully.

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Chapter - 11
Analysis of Gender Specific Human Genetics Disease at Different Ages

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Chapter - 11

Analysis of Gender Specific Human Genetics Disease at Different Ages

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Abstract

Now-a-days genetic diseases are one of the most challenging health problems for people all around the world. In order to invent and prescribe proper treatment of different genetic diseases, it is very important to find out the common genetic diseases among men and women of different age groups. This study cultivates the risk factor for different diseases and targets the prevention and treatment of the same for seriously diseased people. The authors focus on finding out most likely diseased age group with respect to gender and screening as well as smoothness of treatment availability to be patients.

Keywords: Health, genetic diseases, age groups, preventions, treatment

1. Introduction

Genetic diseases have emerged as complex and challenging health problem affecting people all over the world. The interaction between genes and health has led to intense research to uncover root causes, improve treatment and prevention strategies. To convey proper traetment of genetic diseases, it is important to understand the prevalence, presentation and development of age and sex. This comprehensive analysis aims to uncover gender-specific genetic influences on humans at all stages of life. This study aims to identify the genetic disorders across the ages identifying risk factors, promoting prevention and improving treatment for diseased.

Recently genetic researches have made remarkable progress towardsmaking signbificant insight in the complex mechanisms underlying many diseases. Understanding how genes influence disease, development and therapeutic responses is crucial to advancing personalized medicine. Genetic diseases usually occur in different ways according to the gender and age of the person, causing differences in treatment and results. Treatment decisions for these changes can improve patient outcomes and quality of life.

2. Materials & Methods

2.1 Data sources

Analyses were made using statistical data from the National Center for Biotechnology Information (NCBI)to understand gender-specific genetic diseases at different ages.

Qi Yan *et al.* (2021) discovered a valuable opportunity to delve deeper into the interaction between genetic and gender-specific factors. Wang *et al.* (2021) provides unique insights into the genesis of genetic diseases, reducing genetic diseases between sex and age. Using their findings together, the authors have supported their research with a deeper understanding of how genetic diseases evolve over time and between the sexes.

2.2 Data collection and Summary

In pursuit of a comprehensive analysis, data were collectd from the work of Yan *et al.* (2021) and extract professional information with targeted data scraping efforts. The result is a carefully compiled database with enormous potential to advance our understanding of gender-specific genetic diseases across the ages.

Table 1: Summary of Data Set of genes inherited

Patient Id	Patient Age	Genes in mother's side	Inherited from father	Maternal gene
PID0x4175	6	No	Yes	No
PID0x21f5	10	Yes	No	No
PID0x49b8	5	No	Yes	No
PID0x2d97	13	No	Yes	Yes
PID0x58da	5	No	Yes	Yes
PID0x96b6	9	No	No	Yes
PID0x399	4	Yes	No	No
PID0x6819	5	Yes	No	Yes
PID0x9697	12	No	Yes	No
PID0x628a	3	No	Yes	No

Table 2: Summary of Data Set gender

Blood cell count (mcL)	Status	Gender
4.981654852	Alive	Male
5.118889519	Alive	Male
4.876203914	Dead	Ambiguous
4.687766889	Alive	Ambiguous

5.152361728	Dead	Female
4.942383866	Alive	mbiguous
5.113778493	Alive	Tansgender
4.635095714	Alive	Ambiguous
5.175134761	Alive	Ambiguous
4.778253316	Alive	Male

To facilitate the integration of this data into our analysis, the CSV (Comma Separated Values) format has been carefully created . This format not only facilitates access, but combines with the needs of machine learning algorithms to enable us to use the power of artificial intelligence to understand information more deeply.The CSV file shows the content of the work of Yan *et al.* (2021) and insights from our data collection program. Each column in the CSV corresponds to a specific data entry, carefully constructed to reflect the differences and characteristics of sex-specific genetics. Parameters such as sample size, age group, gender and genetics are criteria used for general monitoring.

Table 3: Summary of web scraping

Data Source	Sample Size	Age Groups	Gender	Genetic Variants
Web Scraping	12,500	Children, Adults	Female	18,746,901
			Male	19,305,782

2.3 Methods

In conducting this research, a careful investigation is being undertaken to assess the effectiveness of four different machine learning methods,each of which plays an important role in uncovering gender-specific genealogy complexity. To do this research, The power of various Python libraries was utilized and combined for visual analysis.The"pandas" library has become an essential tool for managing and organizing good files. It provides functionality to convert curated raw data from web scraping into a structured and manageable CSV format. This not only simplifies the processing of the data, but also provides a means for subsequent analysis.Leveraging the versatility of "matplotlib", began on a visualization journey to map complex patterns in datasets. The library's ability to create detailed information and visualizations allows us to gather insights from the complexity of the data.In search of analytics, it turn to the extensive collection of Data Science libraries. This arsenal is augmented by the power of Pandas, allowing us to clean and refine datasets, providing a good foundation for future machine learning.The main focus of our research is educational supervision.In this area, examine many machine learning algorithms such as logistic regression, decision tree and random forest. Building on the power of the "numpy" and "scipy" libraries, these algorithms help extract meaningful patterns and predictive models from data.Our journey begins with the process of beautifying the website using "beautifulsoup". This allows us to collect information from the website and form the basis of our analysis. Then use 'pandas' to import the appropriate data into the data frame ready for full analysis.Along with this process, research is turning to analytics, where the combined power of machine learning algorithms and data science libraries come together. Throughout this complex process, matplotlib continues to increase our understanding through visual presentation.

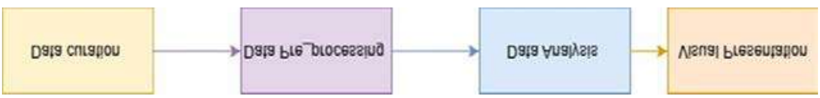

Fig 1: Step-by-Step Data Analysis: Turning Data into Visual Presentation

In summary, our approach integrates different Python libraries to provide unified data collection, organization and analysis. Widespread use of this technology has led to a better understanding of compatibility, gender-specific genetics, and increased our understanding of this complex.

3. Results

In our results, a description was found of the relationship between patient age and disease outcome. Specifically, The diseases have been divided into five groups.:

Table 4: Diseases into five groups

Disease 1	Age-Related Macular Degeneration
Disease 2	Cardiovascular Disease
Disease 3	Genetic Disorders Affecting Tissues
Disease 4	Inflammation
Disease 5	Miscellaneous Disease

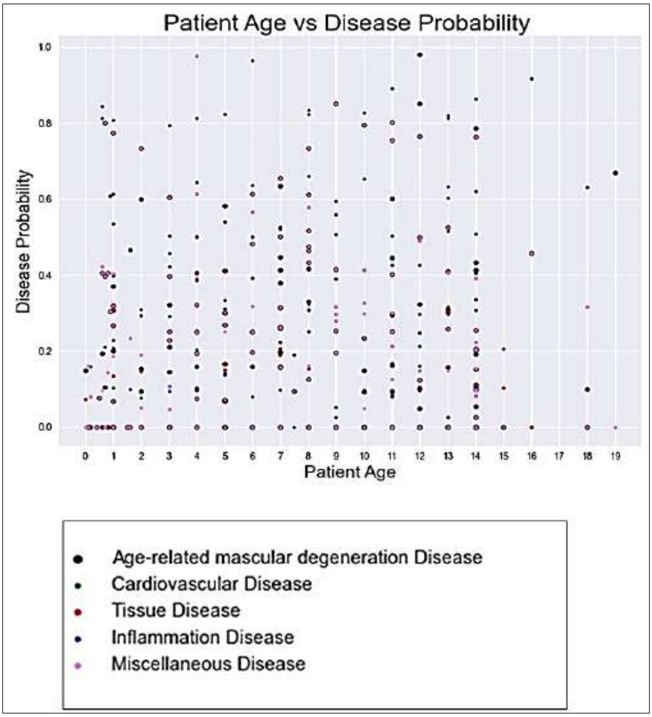

Fig 2: Relationship between patient age and disease outcome

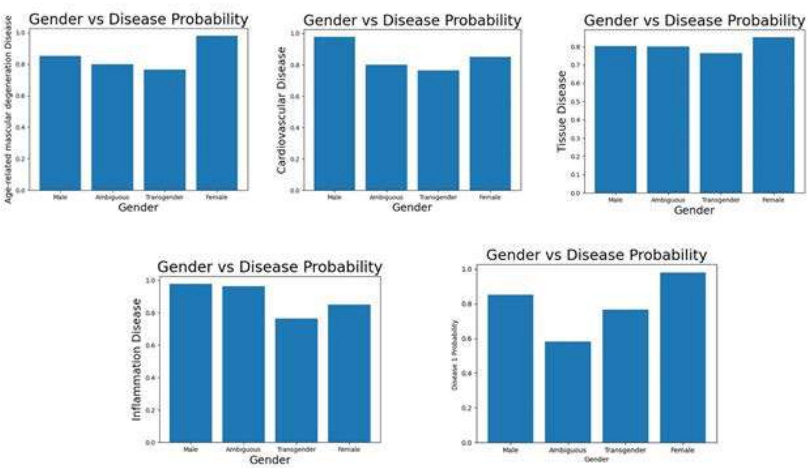

Fig 3: Gender-Disease Plot

"In Figure 2, comprehensively visualize all five diseases, distinctly highlighting their correlation with gender. This visualization offers a comprehensive understanding of each disease's gender-specific patterns."

4. Conclusions

This study identified gender-specific human genetic diseases in different age groups. These findings provide insight into the changes and factors associated with these conditions.

5. Future aspect

This study explores the complexity of gender-specific human genetic diseases in different age groups. By studying various diseases, we gain a better understanding of how these diseases affect men and women differently at different stages of life. The analysis revealed different patterns in disease prevalence, symptom severity, and age of onset by gender, highlighting the importance of considering gender in clinical practice. These findings point to the need to tailor therapy to address the specific genetic predispositions and predispositions of men and women. Finally, this research leads to a deeper understanding of sex-specific genetics, leading to better treatment and improved quality of life for people affected by the disease.

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Chapter - 12
A Review on Experimental Investigation on Evacuated Tube Solar Collector for Water Heating Purpose

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Chapter - 12

A Review on Experimental Investigation on Evacuated Tube Solar Collector for Water Heating Purpose

Pradipta Das, Indrajit Chand, Shrijoy Choudhury, Soumyajit Ghosh, Sourav Das and Arindam Chatterjee

Abstract

An experimental examination on an evacuated tube solar collector utilised for water heating is presented here. The study intends to evaluate, how well the collector uses solar energy and how well it heats water for diverse applications. To examine the efficiency, heat transfer abilities, and overall thermal performance of the collector, studies are being run under various conditions. The most effective operating parameters for maximising the energy absorption and the water heating efficiency will be found through the analysis of the data gathered throughout the studies and experiments. The study's conclusions can provide important information for the creation of solar heating systems for both home and commercial water heating that are more effective and sustainable. Evacuated tube solar collectors have been meticulously used to complete needs both individuals and industry in terms of heat. Different design innovations have been taken into consideration for the creation of novel technologies to capture the most solar radiation as useful heat. Greater results have been produced recently by new technological innovations including the combination of Phase Change Materials (PCM) and Evacuated Tube Solar Collectors (ETSC). As a result, various methods for including PCM in the collector cavity are now being tested. For better performance, several PCM have been used as thermal energy storage (TES). It was discovered that increasing the contact surface area between the PCM and the absorber plate significantly improved the outflow temperatures. The focus of the current work is on an experimental analysis of evacuated tube solar collectors, their manufacture, uses, and limits.

Keywords: Evacuated tube solar collector, solar radiation, ETSC, PCM, TES, absorber plate.

1. Introduction

Uses of Sustainable energy are increasing around globe is increasing with huge demands, solar energy is mostly common energy in all those Renewable energy source. Of because solar power is unlimited for Earth to get energy, human being can use this energy with a very useful manner. Now a days solar energy use in office, hotels, education institute, industries, domestic house-holds & even in automotive systems also (The McGraw-Hill Companies, 2010). There are several kinds of uses of solar energies e.g., to get electricity and water heating purpose. To reduce the prolusion this renewable energy source is very useful to use in everywhere when other geo-energy sources like coal and oil base industries are emitting poisonous gases and damage the environments eco system. Now India is the third engaging energy consuming country after Japan, China, UK, and USA (Kumar ET OL, 2016). According to Indian Govt. 30% energy imports from outer countries. To overcome this dependency of outer countries researches is now going on. There are many types like Wind energy, Geo-thermal energy, Hydropower, Solar energy, Biomass etc. Only biomass generate more amount of CO_2 than other and solar energy generate lower amount of carbon. In solar power solar thermal collector collects heats from sunlight, solar collectors are mainly referring to a solar hot water heating such as solar tower, solar cooker, and solar air heater (Norton ET OL 2013-10-11).

2. Materials descriptions & it uses

2.1 Diagram & Materials used

Materials and its dimensions of the diagram is given below,

(Pic 1 - Full view)

(Pic 2 - Side view)

Fig 1: Solar water heater (Drawn by Group with using SolidWorks)

Name of Materials	Length	Diameter
Evacuated outer tube	1832.68mm	Outer Diameter – 58mm, Inner Diameter – 30mm
Inner Glass Tube	1800mm	Outer Diameter – 30mm Inner Diameter – 28mm
Pipe Container	1330mm	Diameter – 477.4mm Hole Diameter – 62mm
Container form plate	-	Diameter – 481mnm
Base Profile	1220mm	Hole Diameter – 45mm
Aluminium Profile 1	433mm	-
Aluminium Profile 2	1800mm	-
Tube Nipple	-	Diameter – 36mm
Copper Tubing Welded	1800mm	Diameter – 28mm

2.2 Use of evacuated tubes

Solar desalination is the best option to obtain the portable water. Researchers developed the different distillation systems to distillate the water and increase the productivity of the still, but as per several researches and experiment the efficiency is the major use is found. Evacuated tube is very important part for solar heater as a substitute this in major applications in domestics and industrials e.g., in desalination, solar cooker, solar pond etc. (Kabeel *et al.* 2019). (Mehta & Rane, 2013) used the evacuated tube collector for desiccant cooling air conditioning system for regenerating of liquid. The COP obtain with this system is more higher than conventional system which reduce and the losses and increase the efficiencies.

2.3 Using of PCM inside the collectors

The most popular and high effective evacuated tube solar collector is the employment of PCM inside ETCS tubes (Bay Y *et al.*) that has been patented by Zakhidov *et al.* in 2015. This type of compact design has advantage of no other external thermal energy storage units (Felinski P, Sekret R, 2016). Heat absorption and storage co-occur inside the ETSC unit. And the main disadvantage is the storage volume inside is limited, and there is less flexibility for designing the thermal energy storage part of the system (Felinski P, Sekret R, 2016).

2.3 Performance comparison of evacuated U-tube solar collector

Evacuated U-tube solar collector is an alternative solar thermal utilization device for achieving medium discharge temp. (60-150 degree C), due to cost effective, operational flexibility and energy efficient features (Sabhia MA *et al.*, 2015). Several investigators have experimented the performance of Evacuated U-tube solar collector by employing numerical models and by performing experimental studies. With the help of U-tube solar collector from the one side the cold/normal water came and in the other side the hot water goes.

2.5 Manifold channel

Manifold is most important channel in Evacuated tube water heater. It consists two square pipes. Outer pipe is made of stainless steel and inner pipe is made of mild steel. At the surface of outer square pipe, a polyurethane insulator preventing transfer manifold channel to the atmosphere. The inner square pipe passing through the outer square pipe with one end closed. Several holes are made of to attach the evacuated tubes in the manifold. It provides the air flow direction into the evacuated tubes.

3. Discussion

From studying the several articles and several researches of scientist and researchers now we have a discussion on this topic.

- Firstly, we got know that the solar energy uses not only for water heating purpose but also in several works like storage of solar energy in form of electricity for several work done.
- The best solar collector for low and medium temperatures is the evacuated tube collector. levels as a result of the very reduced thermal losses.
- The design of the collector, the op-onal properties of the absorber tubes, and the working fluid inside the tube are the three key determinants of the evacuated tube solar collector's efficiency.
- Analysis of the optimum evacuated tube diameter and thickness for various designs. You can carry out this analysis for many working fluids.

- The working fluids inside evacuated pipe move at slow speed as the fluid boundary layer is close to the pipe wall, so that reason the heat passes coefficient in heat exchangers is limited.
- The integration of PCMs with tube collectors is very effective for improving the collector performance.

4. Conclusions

The articles of recent studies on Experimental investigation on evacuate collector for water heating purpose has revealed that this collector can be very efficient to use in industries, residential and agricultural fields. It can in water different works like solar cooker, air conditioning, drying agricultural products and for many other purposes. A evacuate is highly recommending for higher temperature applications as it has ability to gain higher temperature easily and has potential to prevent heat when outside weather is cold. To improve the efficiency now researchers have mainly focused on several structural changes. As per future prediction of Solar energies after few years the uses of non-conventional energy will be in high demands in market then recent huge production and large-scale implementation of tube collectors have proven this technology as matured with 3 years payback period with any subsidies.

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Chapter - 13
A Detailed Review on Hydraulic Machine Health Monitoring System Using Soft Computing Techniques

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Chapter - 13

A Detailed Review on Hydraulic Machine Health Monitoring System Using Soft Computing Techniques

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Abstract

Health of hydraulic machines plays a vital role in the industry and our daily life. If the condition of various hydraulic machines is not checked regularly then it may cause economic loss of the industry. Therefore, health monitoring of hydraulic machines is an essential task for hydraulic engineer and researchers. There are several methods to monitor the health of fluid machines. This paper presents a detailed review of health monitoring of hydraulic machines. The main outcome addressed is the comparing different techniques *viz.* Convolutional Neural Network (CNN), Genetic Algorithm (GA), Particle Swarm Optimisation (PSO) technique, for the prediction of the hydraulic conditions. It is found that using CNN for the health monitoring is much efficient as compare to using other techniques.

Keywords: Convolutional Neural Network, Health monitoring, Hydraulic machines.

1. Introduction

Hydraulic systems are significant because of their numerous uses in the industry, particularly in the aeronautics, aerospace, and energy industries. (Hossain & Muhammad, 2016). These systems are often made up of a number of networked machinery, equipment and sensors. Their problems may occur at random over time, and if preventative actions are not taken, these devices may fail to function correctly or perform abnormally. Maintenance techniques are frequently periodic and do not depend on machine circumstances. This aspect is becoming increasingly important in terms of system security, reliability, and performance requirements, as well as the provision of fair and accurate information or feedback on the system's health conditions in order to forecast any failures, breakdowns, or abnormalities. Furthermore, in an increasingly competitive market, Industry 4.0 must adapt to new profit, gain maximization, mass, or specialized manufacturing difficulties or possibilities.

These difficulties are driven by technical imperatives (e.g., minimizing machine downtime and maximizing component lifetime), which have an influence on economic issues such as output potential and maintenance cost reduction (Wilhelm *et al.*, 2021). As the design tasks in the hydraulic design process get increasingly complex, to obtain credible findings in a competitive time and cost, hydraulic machine designers rely more than ever on engineering simulation tools, particularly computational fluid dynamics (Thum & Schilling, 2005). It is the most challenging task to determine how to automatically improve the performance of a hydraulic system *viz*. spinning blade and core component such as a turbine runner which is made up of several blades. To meet the criteria of hydraulic performance, the blade shape of hydraulic equipment such as Francis turbine runners and mixed-flow pump impellers typically has sculptural surfaces. Hydraulic optimization design for blades is a complex undertaking process which comprises of a variety of objectives and limitations derived from hydraulics, construction, and geometry (Semenova *et al.*, 2014). In spite of the fact that designers have already used CFD software to evaluate their hydraulic designs, more tightly integrating CFD studies into the design procedure is required by employing efficient optimization approaches to obtain more dependable designs (Schilling *et al.*, 2002). Now a days soft computing techniques are useful for monitoring the health of hydraulic machines. There are lot of soft computing techniques which are useful for the monitoring system (Fig.1). In this article health monitoring, using soft computing techniques are discussed. Monitoring of hydraulic system consist of neural network model plays a vital role in the industry (Tang, Zhu and Yuan, 2021). Not only neural network, Genetic Algorithm (GA) is also used for getting precise result in the health monitoring of hydraulic devices (Lai *et al.*, 2016).

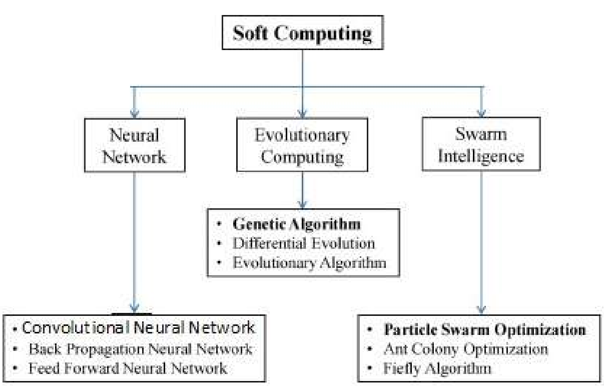

Fig 1: Soft computing techniques (Falcone, Lima, & Martinelli, 2020)

2. Various methods for health monitoring of hydraulic machines

Keleko *et al.*, 2023 showed the framework for condition monitoring using hydraulic systems and multi-sensor data. For the maintenance operations, the system is used as a decision-making support tool. For diagnosis and prognosis, this decision-making support tool plays a vital role. This method also reduces the manufacturing cost of industries. This technique can predict the health of different hydraulic system *viz*. hydraulic accumulator, coolers, leakage in internal pump etc. The Prediction of the hydraulic conditions and an explanation of the model's development are the key findings of the method.

Tang, Zhu and Yuan, 2022 showed, that the hydraulic piston pumps play an important role in many cutting-edge sectors as an integral component of hydraulic gearbox systems. It is critical to execute accurate and effective hydraulic piston pump failure diagnostics. Deep models have lot of interest for both the academics and industry. Tuning the hyper parameters (HP) is required and difficult when building a deep model with high performance. In a hydraulic piston pump, Bayesian optimisation is used for adaptive HP learning, and an enhanced convolutional neural network is constructed for fault feature extraction and classification.

Tang, Zhu and Yuan, 2021 showed, that the hydraulic piston pump is an important component of hydraulic gearbox systems and is used in many modern industries. Convolutional neural network (CNN), a prominent deep learning model, has been shown to be powerful and successful in picture categorization. In this study, an enhanced intelligent approach for defect detection of a hydraulic piston pump is built using CNN and an adaptive learning rate. First, three raw data, comprising a vibration signal, a pressure signal, and a sound signal, are transformed into two-dimensional time-frequency pictures using the continuous wavelet transform. Second, an enhanced deep CNN model with an adjustable learning rate technique is created to detect the various defect kinds.

Lai *et al.*, 2016 showed the procedure to test a variety of design possibilities and quick estimation of hydraulic performance of the blade system. Here an approximate model is capable to substitute the original inner optimisation loop that is used in the hydraulic optimisation of the blade using function approximation. Because the approximation model is built using database samples comprising a set of blade geometries and their resulting hydraulic performances, it may assure that the real blade's performances anticipated by the original model are accurately imitated. The technique is based on the collaboration of a genetic algorithm (GA), a database, and user-defined goal functions and constraints, which include hydraulic, structural, and geometric constraint functions.

Another study shows a supervised machine learning model for monitoring the hydraulic pump health. In this method, effect of induced noise on feature extraction and classification of multivariate time-series data prediction are inspected (Medishetty *et al.*, 2021).

Zhu *et al.*, 2021 showed that the hydraulic axial piston pump is the powerhouse of hydraulic gearbox systems in aerospace and industrial applications. Its stable functioning will have a direct impact on the overall safety and dependability of the equipment. The kernel size and kernel number are enhanced, and batch normalisation layers are added to the network design based on the standard LeNet-5 model. Based on the improve-LeNet-5 model, the recognition accuracy is chosen as the fitness function's target value, and the improve-LeNet-5 model's hyper parameters, including the learning rate, the number of convolution kernels, batch size, and the number of neurons in the fully connected layer, are automatically optimised via particle swarm optimisation (PSO). According to that, the PSO-Improve-CNN diagnostic model is then built.

3. Discussion

Outlines of the mentioned techniques are as shown below:

1) For complex hydraulic system using Deep Neural Network, the decision-making support tool can predict the health of different hydraulic system *viz.* hydraulic accumulator, coolers, leakage in internal pump etc.
2) Convolutional Neural Network (CNN) for fault diagnosis of hydraulic piston pump is much efficient and consumes less time.
3) An enhanced deep CNN model with an adjustable learning rate technique is created to detect the various defect kinds in hydraulic machine.
4) Supervised machine learning model for monitoring the hydraulic pump health.
5) Genetic Alogorithm based model can be used for quick estimation of the hydraulic machine performance.
6) PSO-Improve-CNN diagnostic model also used for hydraulic system health monitoring.

4. Conclusions

In this article various methods for hydraulic machines health monitoring are discussed. It is necessary that monitoring of machines is crucial for smooth functioning of industry or plant. From the research it is found that using convolutional neural network (CNN) is quite satisfactory. Though for testing of design possibilities and quick estimation of hydraulic performance, GA based model plays a key role but CNN model is much efficient and provides precise result for the health observation of hydraulic systems.

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Chapter - 14
Computational Intelligence-Based Fault Monitoring Techniques in Hydraulic Machines - A Review

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Chapter - 14

Computational Intelligence-Based Fault Monitoring Techniques in Hydraulic Machines - A Review

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Abstract

Fault monitoring is an essential part for the hydraulic engineers. It is also challenging works to the researcher because failure of hydraulic machine causes economic loss as well as primary concern of human life. There are various computational intelligence-based fault monitoring system which are applicable to monitor health of hydraulic machine. Genetic Algorithm (GA), Artificial Neural Network (ANN), Fuzzy logic method, Particle Swarm Optimization (PSO) etc. are useful to find fault in various hydraulic machines. The objective of this paper is to review on different computational intelligence-based health monitoring in those machines. The various approaches discussed in the research, introduces important features and advantages of using GA, ANN, Fuzzy logy, PSO, for monitoring the health of hydraulic machines. From analysis it is found GA based diagnostic method is able to detect faults precisely as compared to other monitoring methods. The result confirms the reliability and robustness of GA optimization when dealing with multivariable problem.

Keywords: Fault monitoring, genetic algorithm, hydraulic machine

1. Introduction

Fault monitoring in a hydraulic machine is an essential task for the engineers and researchers. It is crucial to find fault in a stipulated time in order to reduce human life risk and economic loss of industry. According to fourth industrial revolution or Industry 4.0 (Ghobakhloo, 2020), engineers can monitor data of multiple conditions which are available in the cloud to detect cases with abnormalities in production processes, manufacturing equipment, etc. The set of discernment, diagnostic and prognostic tasks is mostly mentioned in Prognostics and Health Management (Zio, and Compare, 2013). Now a days advanced mechanical equipment which are both highly integrated and intellectual mechanical equipment, gives benefits to human. However, there are significant certainty risks and economic losses due to equipment failures. Sensors are also used to observe health condition of equipment in real time, authorize engineers to detect errors and maintain in time to decrease downtime losses and other effects. Prognostic health management (Sutharssan *et al.*, 2015) is an advanced technology which uses intelligent industrial data to minimize maintenance costs while maximizing operational availability and utilization of critical systems. Nowadays, prognostic health management (PHM) is widely used in industries in the manufacturing of various key constituents and equipments such as gearboxes, bearings, hydraulic pumps, engines, etc. because of its efficiency. PHM also made a significant progress in the field of development of intelligent algorithms such as ANN, CNN, etc. and other machine learning methods. Various types of complex engineering optimization problems like fault monitoring in hydraulic machines could be solved by using various optimization techniques. In this research, different computational intelligence based fault monitoring system using GA, ANN, PSO etc. are discussed.

2. Various optimization methods

2.1 Genetic Algorithm (GA)

Genetic Algorithm contains the principle of genetics and natural selection which was introduced by Holland (1975) and also developed by Goldberg (1989). GA is a non-traditional enhance or optimization algorithm extensively utilized due to its ability in reaching the global optimal solutions. It is found on the idea of a Darwinian type fitness for development which is used to generate better individuals for designed problems, as several feasible solutions stand against and match with each other. It is basically a structure of optimization, which is used in difficult functions. GA has a correspondence with chromosomes, in that separate terms are represented by behalf of a linear string. GA starts its method by initiating separate populations i.e chromosomes where they would be calculated & assess individually founded on fitness & then it is ranked according to the upper fitness based on the top survival individuals. GA has two major operators, that is to say crossover and mutation, which will lead to a new generation of individials by replacing the unsuitable individuals with new good ones. The idea of changing GAs is not new in and of itself. Different scholars have already suggested certain improvements for specific jobs and applications. In order to achieve better final results, we attempt to optimize common GA operators in this work to fit our framework. There has been progression in the following causes:

1) Not each altered chromosome is better than unmutated ones,

according to the selection operator. As a result, we choose the best chromosomes from the most recent and previous generations.

2) Crossover operator: rather than using a fixed value, the adaptive crossover probability is employed.

3) Reduced danger of losing beneficial genes due to mutation operator.

Ugly *et al.* 2023, shows an automatic optimization of one-dimensional CNN architecture fault diagnosis of a hydraulic piston pump using GA. In this article a model is proposed which can evaluate raw of sound signal dataset of a hydraulic piston pump. From the result it has been observed that the method performance well as compared to various deep learning models. Li, 2017, shows a most effective condition monitoring technique of gas turbine using GA. From this research it is found that the GA based method is able to quantify the power setting sensor fault. This type of method can be used for analysis of aero turbofan engine. Singh, 2011, shows a design of barrages based embedded simulation optimization approach using GA (Fig.1). The results obtained in this article shows drastic cost savings at the nonlinear optimization formulation, conventional method and hydrological conditions over all the cost of design of barrages.

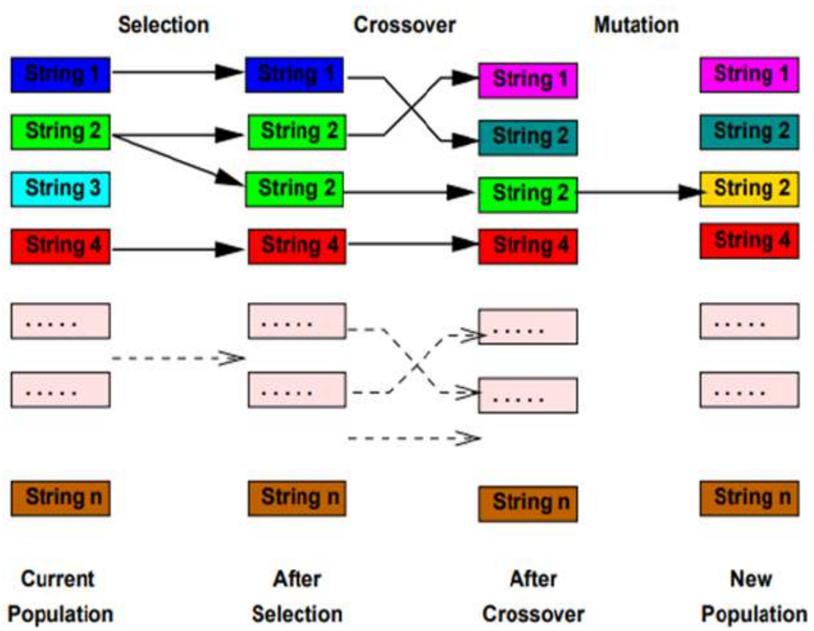

Fig 1: GA operations (Mathew, 2012)

2.2 Artificial Neural Network (ANN)

The Artificial Neural Network (ANN) is a computationally fast method which works on the principle of useful predictive tools and model complex optimization system and was first introduced by McCulloch and Pitts (1943). This method describes the physical behaviour of human brain while solving various intricate mathematical models. It is basically a structure of optimization, the generalization capability to handle the unseen data after the learning process. ANN has been applied in numerous real-world applications like image recognition, speech recognition, medical diagnosis, machine translation and also used for fault monitoring in hydraulic machine. Muqdad Al-Juboori 2021 have meticulously examined the ANN models to measure the productiveness and inevitability of the models by using training data. The successfully trained substitute models are used as an approximate seepage simulator and predictive model to determine the exact particular seepage attribute in case of limited features and conditions. The results of ANN method states material properties and physical boundary conditions very precisely.

2.3 Convolutional Neural Network (CNN)

The idea which improved the process of identifying numbers on postal cards was the idea of CNN and was first coined by LeCun. This method helps in any detection of fault in a hydraulic machine. CNN helps in various computer vision tasks, which includes object detection, facial recognition, image classification, style transfer, semantic segmentation, etc... CNN has the ability to learn automatically and can extract applicable features from raw pixel data has significantly advanced in image analysis and computer vision thus becoming an important tool in modern day AI. Later in 2012, CNN was a next level of a newly precise computational way of image recognition with the invention of Alex Net. CNN is a form of ANN which is specialized in detection and explanation of pattern which helps CNN in image detection. CNN consists of layers which helps it in performing various tasks on the basis of the given data. H. Zhiyi. 2020, has proposed an adaptive model of CNN for the problems regarding vibration monitoring for rotor-bearing system, which diagnose fault and reduces the dependence on large labelled samples.

2.4 Fuzzy logic method

The term Fuzzy means something which is slightly unclear. The architecture of fuzzy logic has been categorised into four major parts. They are rules, de fuzzifier, intelligence, fuzzifier. Implementation of fuzzy logic is in different fields like medical, transportation system, industries, defence, naval control. This Method helps us to control machines effectively while dealing efficiently with uncertainty and Complex issues in engineering as we can easily find the middle ground also its structure is Exceptionally easy and understandable. Wang, 2011, this paper introducing fuzzy logic into a parallel hybrid hydraulic excavator for a better energy placement and to achieve a higher fuel efficiency. A mathematical model of a parallel hybrid hydraulic excavator is presented in a detailed manner, and the components and universal system's parameters are analysed and listed. The fuzzy logic controller is then built to handle energy management and distribution. To achieve a better fuel consumption equivalent. The control effects are evaluated by comparing different control strategies. The results Specify that Hybridization with the proposed strategy can make better fuel economy for the excavator Without sacrificing system performance. Adzic, 2009, explains the application of fuzzy logic to control the speed of an induction generator in a wind turbine. The fundamental goal of a fuzzy controller is to determine the amount of usable wind power should be supplied to the grid. A completely controlled wind turbine consists of an induction generator and a back-to-back converter is underestimate. The electrical torque can be fully controlled by this configuration, complete control over speed, and also help in receptive power compensation and operation under grid disturbances. A fuzzy logic control algorithm has been experimented and the authentication was verified through a detailed simulation in MATLAB.

2.5 Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a metaheuristic optimization algorithm which depicts the social behaviour of flocking of birds and the fish schooling (Jain *et al.*, 2022). At its core, PSO involves simulating a collection of potential solutions to a problem, where each potential solution is put into light by a "particle." These particles move through the solution space, searching for the optimal solution by following the collective information shared by the swarm. The algorithm's behaviour is influenced by social interactions, such as collaboration and competition within the swarm. PSO offers numerous advantages, considering simplicity, easy implementation, and effectiveness in handling complex optimization landscapes. It is suitable for both continuous and discrete optimization problems. Moreover, PSO is parallelizable, making it amenable to high-performance computing environments. PSO is dominant and widely used technique to solve complex optimization problems in various fields, including engineering, economics, and artificial intelligence. Each and every particle has its position and velocity vectors, which are updated iteratively. The particle's position represents a candidate solution to the optimization problem, while the velocity vector indicates its movement direction in the search space. The motive is to adjust the particle's position and velocity in a way that guides it towards the most favourable solution while also considering the best solutions discovered by the other particles. The behaviour and presentation of PSO depend on various parameters, like the count of particles, inertia weight, acceleration coefficients, and termination conditions. Finding the suitable values for the mentioned parameters is essential to achieve effective convergence and accurate solutions. Particle Swarm Optimization is an influential optimization algorithm shown by the collective behaviour of particles in a swarm.

3. Discussion

Outlines of the mentioned techniques are as shown below:

- From this research we observed that the GA based method is able to quantify the power setting sensor fault. This type of method is used for analysis of aero turbofan engine.
- Using GA, drastic cost savings at the nonlinear optimization formulation is possible.
- ANN is mainly used for a range of applications, including image recognition, speech recognition, machine translation, and medical diagnosis and also for fault monitoring in hydraulic machine.
- GA can also optimize their hyper parameters for a fault monitoring of an axial hydraulic piston pump.
- Fuzzy controller is also used to establish maximum power distribution to the grid from accessible wind power.
- PSO is suitable for both continuous and discrete optimization problems.
- It is also found that PSO offers several advantages, including simplicity, easy implementation, and effectiveness in handling complex optimization landscapes.

4. Conclusions

Here is the article, computational intelligence based various techniques for hydraulic machine health condition monitoring are discussed. The machine’s monitoring is essential for appropriate functioning of industry. From the study it is pointed out that using GA for the health checking of machines is adequate. Though for a vast range of applications, involving image & speech recognition, machine translation, Medical diagnosis, and health monitoring of hydraulic machines, Artificial Neural Network (ANN) method is used but using GA is much efficient and provides precise result for the health observation of hydraulic systems.

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Chapter - 15
Smart and Portable Ventilation System

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Chapter - 15

Smart and Portable Ventilation System

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Abstract

Portable Smart Healthcare with automated external ventilation support is important for rural needy people and medical camp where need continuous monitoring that can't be provided outside a hospital and a nursing home. It is also important in villages and rural areas where nearby doctor's clinics can communicate with city hospitals and know the health status of their patients by sharing the health reports. This work demonstrates an intelligent health monitoring system that uses biomedical sensors to check patient conditions and uses the Internet to notify affected persons. The biomedical sensor here connects to his Arduino NANO controller to read data and then to an LCD display/serial monitor to see the output. Here used a voice system for novice people to understand their health conditions. And an online platform is used to see the ECG graph of the patients and print a copy for prescribe. The data is uploaded and stored on the server and converted into JSON links for viewing on smartphones. And all the previous patients reports are saved individually to compare the present condition of the patients for prescribe the best result. An Android application has been developed to allow easy viewing of patient information from doctors and family members.

Keywords: Healthcare, monitoring, biomedical sensors, patient.

1. Introduction

Health not only signifies the absence of disease but also a balance of complete physical, mental, and social well-being. Health is a fundamental part of people's quest for a better life. Unfortunately, certain factors such as poor health care, the existence of large disparities between rural and urban areas, and the unavailability of doctors and nurses during the most difficult times create dilemmas. increase. Connected. IoT has networked all objects internally in the last decade and is considered the next technological revolution. Smart health monitoring mechanisms [1, 2], smart parking [3], smart homes [4], smart cities [5], smart climate [6], industrialized land [7], agricultural sector [8], and IoT is part of Split. application. The largest use case for IoT is healthcare, providing the ability to track health and environmental conditions. IoT is nothing more than connecting computers to the Internet through sensors and networks [9, 10]. These connected components can be used in health monitoring devices. The sensors are used to transmit information to remote locations such as machines for computers, machines for humans, handhelds, or M2M such as smartphones [11]. It's a simple, energy-efficient, much smarter, scalable, and interoperable way to track and optimize healthcare. Today, modern systems offer flexible interfaces [12], tools [13], and mental health management [14] to guide people's mental lives. Heart rate and body temperature are the two most important indicators of human health. Heart rate is the number of heartbeats per minute, commonly known as pulse rate. Increased blood flow can be used to measure pulse rate by calculating pulse rate. A normal heart rate for a healthy person is 60 to 100 beats per minute. A typical resting heart rate for an adult male is approximately 70 beats per minute and for an adult female is 75 beats per minute [15]. Women over the age of 12 typically have higher heart rates than men. Human body temperature is just body temperature, and the total amount of heat emitted by the body is scientifically determined. The average person's body temperature depends on many factors, including ambient temperature, gender, and diet. In a healthy adult, he ranges from 36.5°C (97.8°F) to 37.2°C (99°F). Various factors can lead to changes in body temperature, such as B. Influenza, hypothermia, and other illnesses. Fever is the classic indicator of almost all illnesses [16]. There are various methods of determining heart rate and body temperature invasively and non-invasively. For consumers, non-invasive approaches have proven accurate and convenient for some time [17]. It has been suggested that medical facilities should provide good room conditions to support patients [18]. Several measurements determine the ambient quality of a room, such as the humidity of the room and the content of all gases such as CO and CO_2. Toxic gases and constant humidity are extremely harmful to patients. Indoor humidity should be between 30% and 65% for optimal comfort. Some studies [19, 20] have been done only for smart homes, not specifically for healthcare. There are several fatal diseases such as heart disease [21], diabetes [22], breast cancer [23, 24], and liver disease [25]. However, the main concern of the system we have developed is to monitor the basic symptoms and hospital room environment of all types of patients. This white paper proposes a custom healthcare system that monitors a patient's pulse and temperature, humidity, CO, and CO_2 gas levels in a hospital room.

2. Materials Required

i) Arduino Nano

ii) Node MCU

iii) 20X4 LCD display

iv) iv. Blood Oxygen Sensor

v) ECG Sensor

vi) Temperature Probe

vii) Servo attached with hitting hammer

viii) Humidity Sensor

ix) 9V battery

3. Methodology

The Arduino NANO being the heart of the complete system, controls all the coupled biomedical sensors and the servo motor to run the ventilation system. The complete system is powered by a 5v supply. The sensors connected to the Arduino produce analog serial values that are displayed on the LCD and depending on those values, the servo controls the intensity of ventilation. The ECG sensor is connected to the NodeMCU which, based on the sensor data displays the real-time graph in the mobile phone using Blynk IoT.

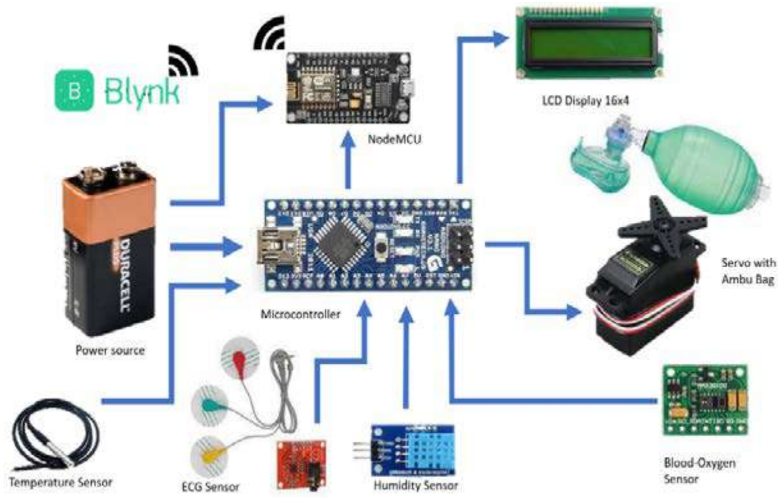

Fig 1: Schematic Diagram of Smart and Portable Ventilation System

Below is the complete circuit diagram of our project divided into two parts.

Scheme I

This part of the circuit contains the sensors that manifest analog serial data which are directly displayed to the LCD display using the Arduino NANO.

Sensors Involved: Blood-O2, Temperature, Humidity, and the servo-ventilation system.

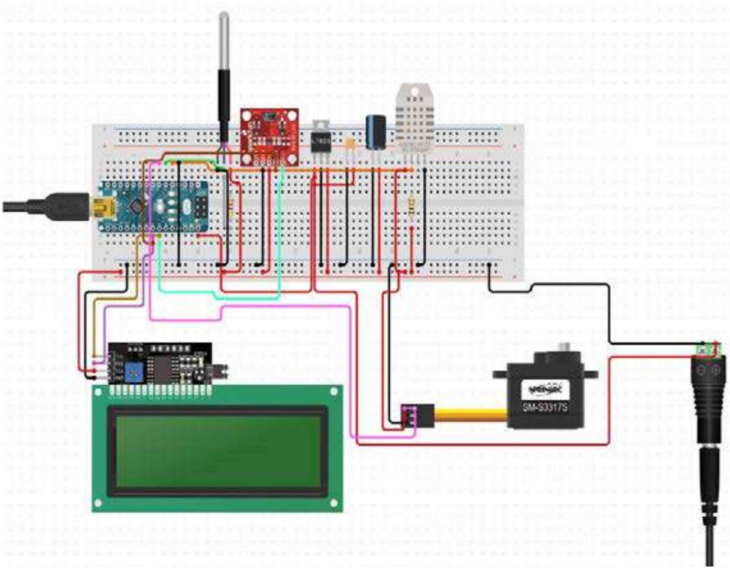

Fig 2: Circuit diagram of ventilation system

Scheme II

This part of the circuit contains the sensors that manifest data which are directly displayed to the mobile or computer screen via NodeMCU using Blynk IoT.

Sensors involved: ECG Sensor, OLED Display.

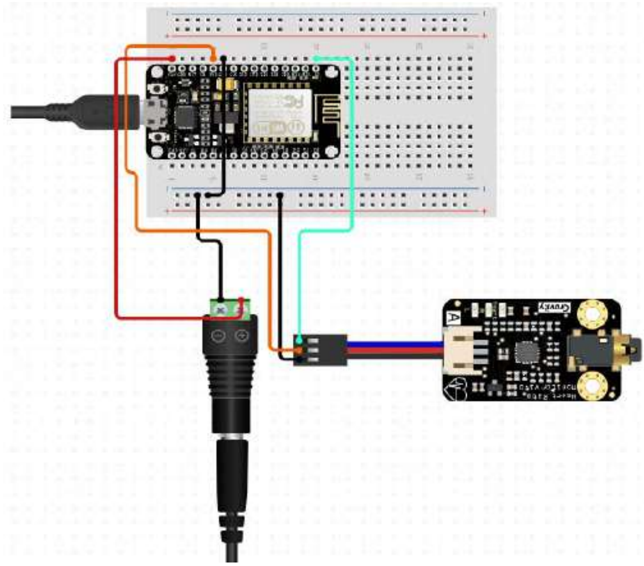

Fig 3: Circuit diagram of ECG sensor circuit

Fig 4: Prototype of smart and portable ventilation system

4. Results

The design has been finished with success with the utmost satisfaction. The constraints measured met and triumphed over with achievement. The system nominated is intended as find it infectious was set within the layout section. The design gives a clever plan for growing a full-fledged mileage fulfilling the person's needs. The device is extremely protean. This law encompasses an easy display screen that lets the person apply without any vexation. confirmation assessments iatrogenic have mainly dropped crimes. vittles are created to ameliorate the law. It has been examined with live records and has supplied a prosperous result. Thence the law has tested to determine expeditiously. The device created met its objects, with the aid of using being veracious to apply. This law is advanced with measurability in mind. farther modules can be different as soon as necessary. The law is advanced with a popular approach. All modules inside the device are examined with licit records and invalid records and the wholeness oils with achievement. still, there's nevertheless plenitude of compass for unborn development and accessories in practicality. A wide variety of the most bones being cell mileage enhancement for extraordinary cell software program package. It's displaying live videotape footage to the controlling person’s device and the stir of the quadcopter is likewise great.

4.1 Observation Table1

SpO2 Level	Servo for ventilation system	
	Input voltage	Time delay
95%	5 V	20 ms
92%	5 V	18 ms
89%	5 V	14 ms
86%	5 V	12 ms
83%	5 V	10 ms
80%	5 V	8 ms

Table 2: Observation Table for researched data

S. No.	Subject	Gender/age	Body temp.	Heart_rate (bpm)	Spo2_level (%)
1.	CASE1	MALE /22	97.8°F/ 36°C	94-96 BPM	98%
2.	CASE2	FEMALE/22	98.3°F/ 37°C	88-90 BPM	99%
3.	CASE3	MALE/19	98.1°F/ 37°C	95-99 BPM	99%
4.	CASE4	FEMALE/19	97.7°F/ 36°C	90-94 BPM	99%

5. Future Scope

- The could be reduced into a wearable gadget excluding the ventilation and to a mini backpack with ventilation for sudden on-the-way emergencies.
- This could be advanced with voice AI support with native language to help novice people handle this machine during an emergency.
- It could to fed with preset data for every illness and would work accordingly in automatic as well as manual mode of a particular patient.

6. Conclusions

The Smart and Portable Ventilation System with monitoring system offers a comprehensive solution for maintaining individual health. Our system reduces the risk of death for less ventilation system. Smart and Portable ventilation system provides emergency ventilation support to people in any places without proper medical infrastructure.

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Chapter - 16
Awareness and Adoption of Green Banking Practices by Customer

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Chapter - 16

Awareness and Adoption of Green Banking Practices by Customer

Priyanka Kanjilal, Durba Mukherjee and Sayan Mondal

Abstract

Sustainable change in enterprises is required to protect the environment. In the present scenario, one of the inclusive factors of climate change is global warming. All economic activities create a direct or indirect and positive or negative effect on environment. Researchers have been conducted continuously all over the world to find innovative ways to attain the goal of sustainability. Due to pressure of public and government the corporate adopts various green movement policies. Green finance, green economy is the new model for economic development. Bank as a financial institution play a vital role in green banking practices. Green banking nothing but an environment friendly practice tries to reduces carbon footprint by change the clints habit in banking activities. Green banking activities focus on two approaches like environment friendly approaches and green transformation of internal banking activities. This green banking practices same as traditional banking activities only physical branches and physical activities are reduces and increase digital practices like online banking instead of branch banking. The clints of the bank must positively accepted and participate on these digital banking services. Green banking is a new concept try to modify its activity on continuous basis. Effect of these practices effected consumers in a different way. This study is tries to cover the areas of green banking strategies adopted by banks in India and impact of this activities towards the customer how much customers were aware about these practices and comfortable to adopt.

Keywords: Green bank, sustainability, eco-friendly banking, green banking strategies, customer's awareness, customers adoption.

1. Introduction

The word GREEN is very popular in now a days. Green management is a notion in flux, where firms are encouraged to consider how their projects and programs will affect the environment. Organizations consider the sustainable development aim of a healthier and cleaner environment while offering their main services (Garg and Sharma 2017; Loknath and Azeem 2017; Ghosh and Chowdhury 2018).

Increasing rate of carbon foot print due to green house gas grenerated by commercial action. According to the Report At COP27 India is one of the highest contributor. In 2022, China and the European Union (EU) are estimated to decreased their emissions by .9 percent and .8 percent, while India's emissions are to increase by 6 percent and the US's by 1.5 percent. For the rest of the countries was estemated 1.7 percent. In 2008 a circuler issued by The Reserve Bank of India (RBI) to boost up the understanding of Corporate Social Responsibility, sustainable development and non-financing reports. Business Responsibility Reporting (BRR), a requisite for the top 100 companies, introduced by the Securities and Exchange Board of India (SEBI). From 2016, near about 500 to 1000 Indian companies matched with the BRR requirements. According to the Indian Banks Association, a "Green Bank" is one that "functions like a regular bank while also taking into account social and environmental factors for the protection of natural resources." The goal of green banking, according to the RBI, is to minimize the negative effects that internal bank procedures, physical infrastructure, and information technology have on the environment. According to the UNEP-FI, a sustainable bank takes into account how its operations, diverse products, and services will affect both the present and future generations. After Covid19 understanding for ESG expanded its activities .Banks are facing huge transition . Due to the credit crisis, traditional banking's operation and viability are in doubt, necessitating a thorough integration of ethical ideals and principles into banking processes (San-Jose *et al.,* 2009). Green banks use financing, not grants also focus on that market which have potential payback. Bank are not able to ignore brown asset that helps to attracts profit also requirements to give more focus on financing green projects is also a responsibility. Banks are facing challenges to attracting and maintaining foreign investor and increase fencing in green bond .Another challenge for bank is to provide Green Taxonomy to provide a clear picture that what exactly called environmentally sustainable investment is. green banking tiring to find intersection between financial risk capacity with climate physical, transition, and liability risks (NGFS Report on Climate Change and Credit Ratings, 2022 ecological balance disturb due to unequal business activity and show holocaust resulted in natural and industrial (Rehman *et al.*, 2021). Sustainability today is an "emerging mega-trend" (Lubin & Esty, 2020). Green banking practices not only align with the principles of corporate social responsibility but also offer potential financial benefits. By embracing sustainability, banks can play a crucial role in addressing environmental challenges, supporting green projects, and fostering a more sustainable and equitable economy for future generations. Financial goods and services that support sustainability and environmental responsibility are referred to as "green banking products" by banks and other financial organizations. These goods are made to aid in the advancement of green projects and efforts, assist in lowering carbon footprints, and solve climate change issues. Here are a few typical categories of green banking products: Green Loans, Green Mortgages, Green Investment Funds, Green Bonds, Green Credit Cards.Banks provide specialist financial services, such as financing for energy-efficient equipment or green supply chain management, for companies wishing to incorporate sustainable practices into their operations. ESG stands for environmental, social, and governance. Investments that have been carefully screened: Some banks offer investment options that take governance, social, and environmental concerns into account. These goods are designed to support investments in businesses with robust sustainability policies.

2. Objective of the study

- To research the level of customer awareness and implementation of green banking.
- To research the relationship between educational attainment and the adoption of green banking.

3. Literature Review

To decrease the impact of development activities, significant investment is required to green the energy sector. This can be accomplished through reducing emissions and fostering green finance. Green finance is primarily financial services for ecologically friendly initiatives, claim Chowdhury, Datta, and Mohajan (2013). Thus, if environmental projects can be sustained over the long term by both people and the environment, investments in them should be made. Green growth, which prioritizes economic progress while preventing climate change, energy shortages, and financial crises, is the goal of green finance, according to Chowdhury, Datta, and Mohajan (2013). A banking sector initiative called "green financing" attempts to preserve the environment and promote green economic development. By providing financial services for sustainable and environmentally friendly initiatives, banks effectively bridge the gap between the economy and the environment in industrialized countries (Arumugam and Chirute 2018). According to Asian Development Bank (ADB 2019), financial institutions give preference to traditional projects that use outmoded energy technology, such as fossil fuels, because the initial return on investment for renewable technologies may be lower. To ensure that the economy grows sustainably, new policies must be developed that focus on greening "business as usual" (Khan *et al.*, 2016; ADB 2017, ABD 2019). To avoid serious environmental disasters, the finance sector must include the Sustainable Development Goals into investment and development plans (Sachs *et al.* 2019; Loknath and Azeem 2017). Online and mobile banking, branchless banking, paperless banking, green ATMs, green marketing, and solar-powered green buildings are a few techniques that reduce internal environmental impact (Meena 2013; Garg 2015; Khan *et al.*, 2016; Herath and Herath 2020). The potential to minimize increased pollution and environmental harm is present in each of these procedures and actions, which all help the bank achieve better environmental performance (Shaumya and Arulrajah, 2017). Whether or not the existing system implements green banking practices depends on customers, consumers, the community, and management (Bukhari, Fathyah, and Azlan 2019). The adoption of new technology-focused services is significantly influenced by gender. Women support and advocate for sustainable development that is kind to the environment. Women are reportedly more likely than men to use mobile banking, according to Karjaluoto, Riquelme, and Rios (2010). A study by Glavee-Geo, Shaikh, and Karjaluoto (2017) found that social norms, attitudes, and behavior play a significant role in determining whether or not consumers choose to use mobile banking. Through education and environmental awareness, customers are persuaded to use digital green banking practices, which promote sustainable development and growth (Ahuja 2015). Noman *et al.* (2015) recommend that Bangladeshi banks adopt green practices to encourage sustainable economic growth. In Pakistan, a growing nation with environmental constraints, the banking industry might be able to minimize environmental issues. Customer education and awareness are just as important as the deployment of green initiatives (Khan and Szegedi 2019). International banks already employ environmental measures like fast loans, resource conservation, and research in contrast to Indian banks like SBI and ICICI (Tara, Singh, and Kumar 2015). According to Ghosh, Ghosh, and Chowdhury (2018) and Javeria, Siddiqui, and Rasheed (2019), Pakistan's banking sector is in risk due to behavioral factors such a lack of understanding, illiteracy in environmental issues, inadequate infrastructure, and a lack of resources.

4. Statement of Problem

In the international efforts to raise the standard of living on Earth, banks have a substantial and crucial role to play. As essential technology implementers, banks may adopt eco-friendly practices and lead this global movement. Thanks to product innovation and technology leveraging, banks now are able to help the environment by using fewer resources, like paper. Numerous recommendations are made by the Reserve Bank of India to help banks become environmentally friendly and protect the environment. By serving as financiers, banks may ensure that businesses adopt environmentally responsible practices. Green banking is one method for ensuring sustainable development, in which economic activity does not have a negative impact on the environment. Green banking is all about going above and above to keep the world habitable without seriously harming it. Banks in India are playing a significant role in the advancement of sustainable practices by embracing several green banking practices. Customers that practice these green banking practices will save natural resources such as paper, gasoline, and electricity. Through the use of stationery, power, lighting, air conditioning, paper, and other materials during normal business activities, banks significantly contribute to carbon emissions. Due to the banking sector's rapid expansion, banks today have a far more direct relationship with the environment. In order to make sure that the economy is composed of investments that are both socially and environmentally responsible, banks, as a large source of capital, can be very crucial. It is best for banks to adopt green banking in order to reduce the aforementioned hazards related to the banking sector.

5. Hypothesis

H0: There is no significant relation between educational attainment level and adoption of green banking practices by customer

H1: There is a significant relation between educational attainment level and adoption of green banking practices by customer

6. Research methodology

Area of study: The study was conducted to ascertain the customers' perception of green banking practices in the Asansol area.

Sample size: The sample size was 41.

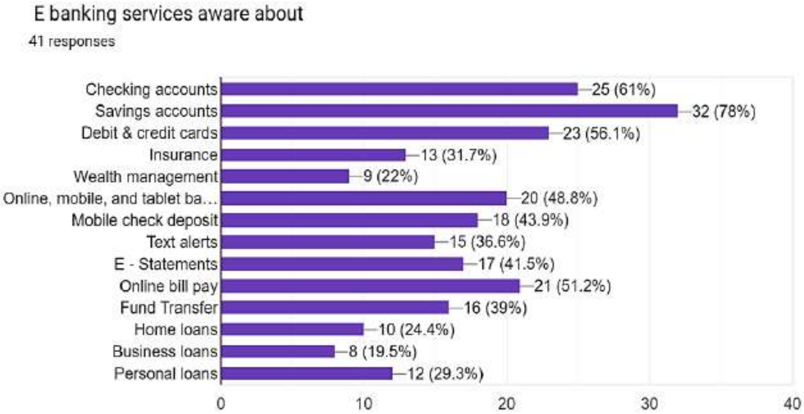
Sources of Data: The study used both primary data as well as secondary data. The data was collected from consumers by questionnaire method.

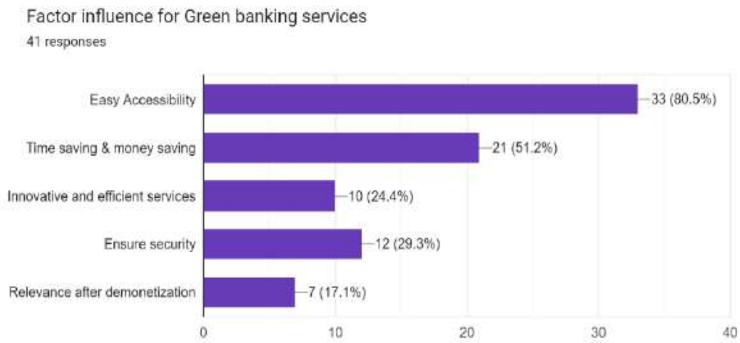
Tools for analysis: statistical tools were used in this study Chi-square Analysis.

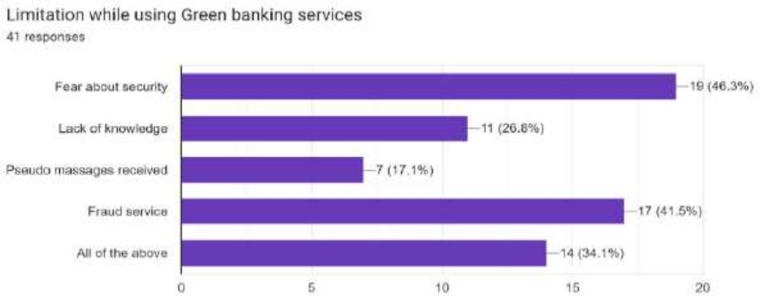
7. Analysis and Interpretation

Table 1: Demographic profile of the respondents

Gender	Male Female	20 21	48.78 51.21
Age	Below 20 20-40 40-60 60 and above	19 14 9 0	46.34 34.14 21.95 0
Educational levels	Upto Secondary Higher Secondary Graduate Post graduate other	0 13 19 9 0	0 31.70 46.34 21.95 0
Occupation	Govt employee Privet Employee Self-Employee Other	4 11 7 19	9.75 26.82 17.07 46.43
Annual income (Rs.)	Below 1 lakh 1lakh to 3 lakh 3 to 5 lakh 5 lakh and above	22 8 3 8	53.65 19.51 7.31 19.51
Marital status	Married Unmarried	18 23	43.90 56.09







8. Testing of Hypothesis

Chi Square Test

H0 - There is no significance relation between educational attainment level and adoption of green banking practices by customer

Table 2: Education and Adoption of Green Banking

Education Level		Hihger Secondary	Graduation	Post-Graduation	Total
Adoption of Green banking Practices	Yes	9	21	8	38
	NO	2	1	0	3
Total		11	22	8	41

X2 = (O-E) 2 /E

Level of significance = 0.05

Degree of freedom= (r-1) *(c-1)

(2-1) *(3-1) =2 Table value = 5.99

Calculated value = 2.53

Calculated value is less than table value. H0 accepted.

There is no association between education and adoption of green banking.

Findings

It is observed that green banking practices is very new as a concept many bank adopted this as a practices but still lack ness is there as customer of banks are not very much aware about the word Green. Digital banking procedure is adopted by people it was been popular during Covid 19 situation. This study represents that people are adopted no of digital banking practices. Most popular practice according to my study is Online bill payment, bank balance checking and fund transfer. But this study also find that there is no signification relation between educational level of a customer and green banking practices.

9. Conclusion and Future Scope of Study

Banks are aiming to create a low-carbon economy since India has committed to lowering its carbon intensity. Green banking has advanced in recent years and is predicted to continue to grow as a competitive strategy driver for banks. Intangible benefits of green banking for banks include improved client base, improved reputation, favorable environmental effects, and simplified banking procedures. A paradigm shift in how people view business, money, and economics is necessary for green banking. In terms of green banking, Indian banks are lagging behind, and it is urgent that they consider it seriously for the country's sustainable growth. Green banking opens new channels and markets for the goods differentiation. Green Banking will benefit both parties.to the businesses, the economy, and the banks. Going Green will guarantee that industries become greener and better the banks' asset quality. Government should participate play a key role in developing green policy standards, and monetary reward for going green. proper instruction and banks' educational initiatives for green causes will truly lead to the success of green banking. The progress of our nation in India can be significantly impacted by the continued importance of green banking. As Indian banks and financial institutions have begun to take initiative, albeit at a low level. As they play a crucial role in ensuring the sustainability of their country's economy, banks and other financial institutions in India must work harder than large overseas banks in order to continue the development of their economy. While making their branches and buildings environmentally friendly and monitoring the projects of their clients to whom they have provided loans, some banks and financial institutions, like State Bank of India, Financial

Information Network and Operations (FINO), have taken initiatives under the umbrella of "green banking." It is required to boost visibility by using the bank's website communicate information via the media and educate people with e-learning programmers so that more people were aware about green banking.

10. Limitations of the study

The information was not gathered based on location; it is Asansol.

There are just 41 people in the data sample; it may be expanded to determine if the results would hold true for a bigger sample size and across different places.

The public is unaware of the green banking program.

The study is based on 3 week of study only if it take more time will produced better result.

A larger sample size might potentially provide further insight into these findings. Future studies on the state of green banking regulations' adoption and their efficacy can be

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Chapter - 17
An Approach to Design Dental Implantation Robot

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Chapter - 17

An Approach to Design Dental Implantation Robot

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Abstract

The strongest part of the human body is the teeth because it contains the strongest material called enamel, so taking good care is quite important as tooth decay is one of the most painful feeling. During tooth implantation surgery the most important thing that is needed to be taken care by the surgeon is accuracy and precision. The human hand has tremors which may lead to huge risks while drilling into the jaw during surgery procedure, so in order to address this problem our proposed instrument Remote Controlled Dental Implantation Robot (REDIRO). This device mainly can be used for teeth or oral implantation surgery along with other improvisation like tooth cleansing. The REDIRO is packed with IR camera (Infrared Radiation), IR distance sensor, Bluetooth module, Rotary Potentiometer and motion sensor for image capturing of the oral cavity, distance feed backing, angulation maintaining and motion sensing. The distance sensor is primarily used to determine how deeply the drill should be drilled into the bone, so that there is a feedback mechanism. As the drill gets closer to a predetermined depth, the motor slows down and stops thus providing feedback. The IR camera is used to continuously monitor the surgery. If the robotic arm is unable to stop the drill, it can be manually halted. Motion sensing is used to detect the movement of the patient's mouth and alter the movement of the arm for an angular dental implantation for the premolars and molars allowing us to know the angle and set the motors to be steady at that specific angle, which is indeed predefined.

Keywords: Infrared radiation, rotary, Bluetooth.

1. Introduction

Dental implantation is a vital area that has altered the way people regain oral functioning and aesthetics. Dental implantation techniques entail the exact placement of artificial tooth roots into the jawbone, which serves as a secure basis for prosthetic teeth. Researchers and engineers have focused on robots and automation to improve the precision, efficiency, and patient outcomes of such treatments. This research goes into a cutting-edge method to building a dental implantation robot that has the potential to revolutionise implant treatments. By merging the knowledge of dentists with robotics, this strategy intends to overcome various issues that traditional manual implantation procedures can provide, such as variability in placement precision, surgeon fatigue, and lengthy process timeframes. The incorporation of robotic technologies into dental implantation aims not only to improve the overall success rates of these procedures, but also to optimise the patient experience and minimise post-operative discomfort. The primary parts and functions of the dental implantation robot are examined in this study, along with the robotic arm's architecture, real-time feedback mechanisms, and the role played by the dental surgeon in directing and supervising the robotic procedure. We also examine the potential benefits and considerations of using such an approach, such as greater placement accuracy, shorter surgical durations, and the significance of preserving the human touch in clinical decision-making during automated procedures. In addition, ethical and legal issues surrounding the use of dental implant robots are investigated, addressing issues with patient safety, professional oversight, and the changing role of the dental professional in this technologically enhanced environment. Finding the correct balance is crucial to provide the best possible patient care as the lines between human expertise and technology continue to blur. This paper's conclusion highlights how a novel approach to dental implantation robots has the potential to revolutionise contemporary dentistry. The envisioned dental implantation robot has the potential to raise the bar for care in implant procedures by fusing the accuracy of robotics with the dexterity of dental expertise, charting a new course for the future of oral healthcare.

2. Materials & Methods

2.1 Component used

- Arduino Nano 6 10, Arduino LilyPad
- 3*Mega servo motor MG995(180 rotation)
- 3*Micro servo motor SG90(180 rotation)
- MPU 6050 (6-Axis Accelerometer)
- Rotary Potentiometer 3 4- posh pop switch
- Proximity Sensor
- 9V DC Power source
- IR sensing camera

- Motion Sensor
- HC05 Bluetooth Module
- Adafruit PCA9685 16-Channel Servo Driver

2.2 Methodology

A remote-controlled dental implantation surgery robot. In this robotic hand we have used a number of sensors. The proximity sensor is primarily used to determine the drill's threshold limit. As the drill gets closer to a predetermined depth inside the teeth, the motor slows down and stops, providing feedback mechanism. We have also used a camera which will be used to continuously monitor the dental process. The robotic hand can also be manually halted. We have also used a motion sensor to detect the movement of the patient's mouth as its natural for any human being to move during the process so for the safety of the patient we will use a motion sensor so that it detects the movement and move the drill accordingly. And this motion sensor will also allows us to know the angle and set the motors to be steady at that specific angle, which is indeed predefined.

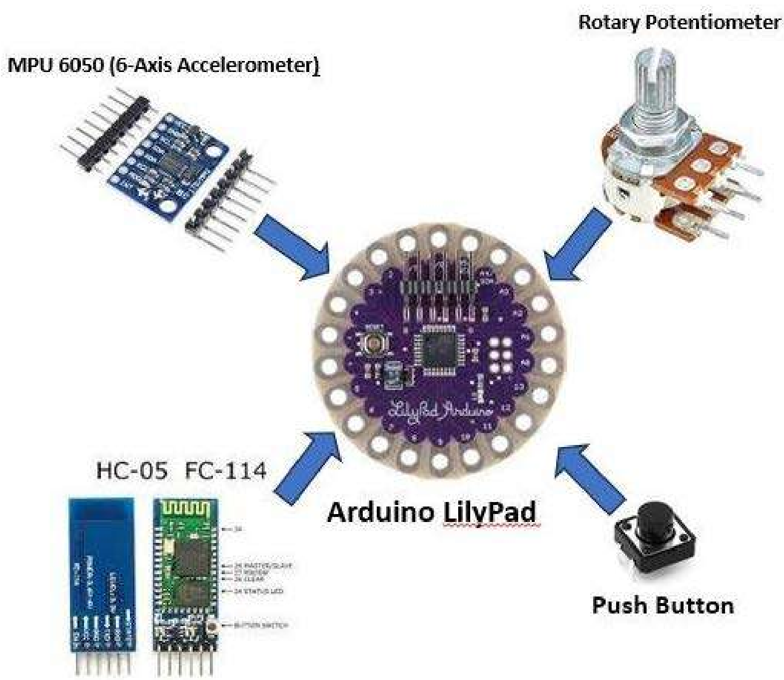

Fig 1: Schematic diagram of the master hand that will control the robotic ARM

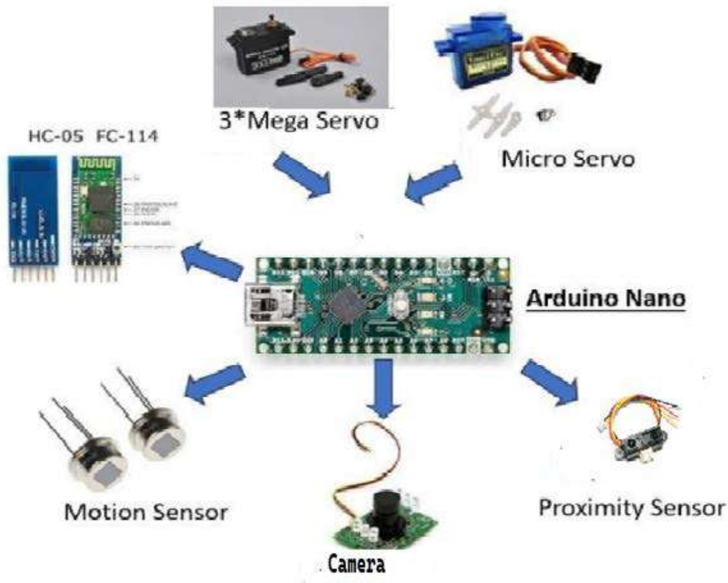

Fig 2: Schematic diagram of the robotic hand that will be used to mount dental implantation tool

3. Results and Discussion

3.1 Results

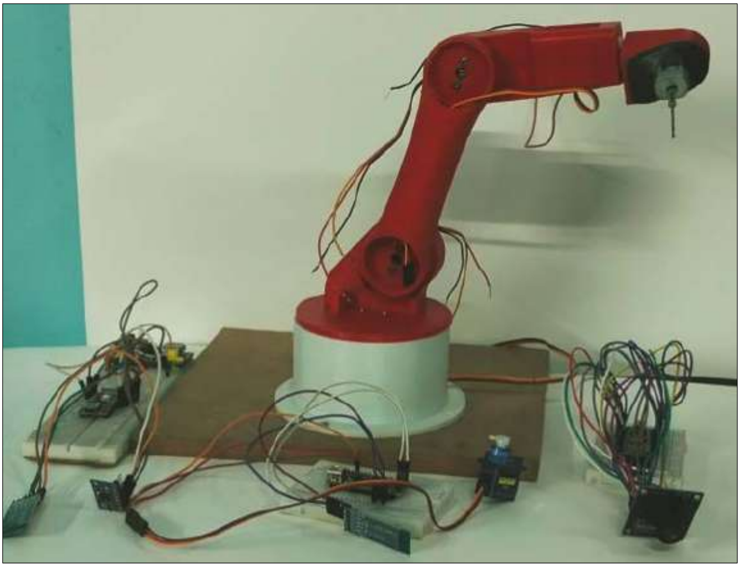

Fig 3: Robotic Hand with the Circuitry of Camera, Master and Slave CIRCUITS

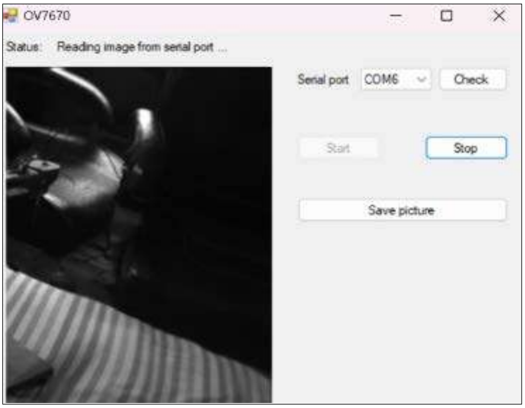

Fig 4: Camera test footage-1

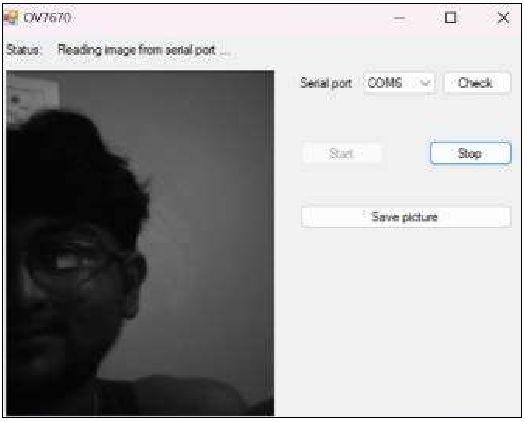

Fig 5: Camera Test Footage-2

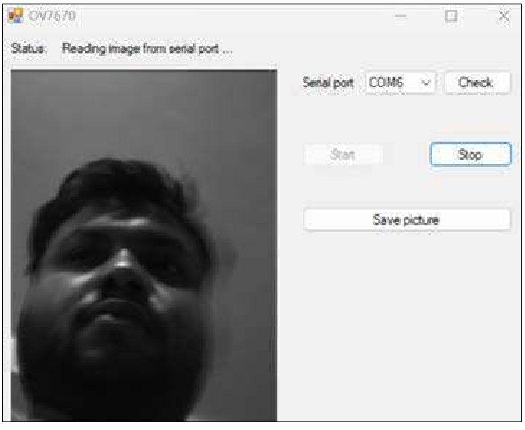

Fig 6: Camera Test Footage-3

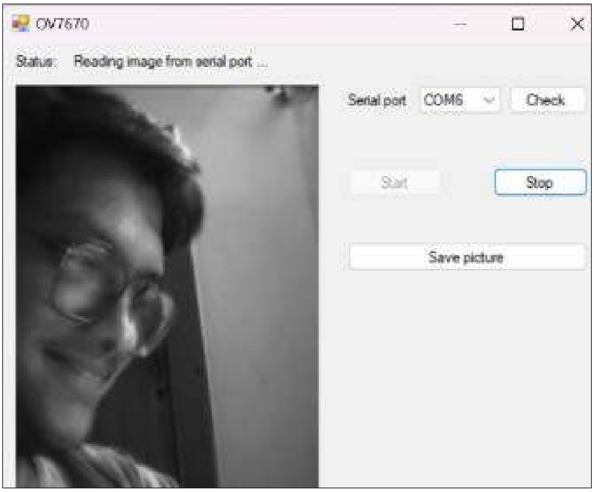

Fig 7: Camera Test Footage-4

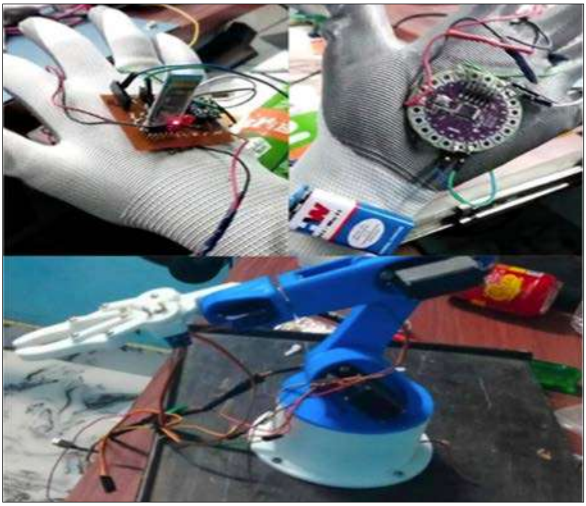

Fig 8: Hand glove to control the robotic arm

4. Future Scope

- By enabling precise and effective dental implant surgeries, this cutting-edge technology could revolutionize dental procedures.
- Dental professionals would have better control and accuracy with a remote-controlled robot, which would improve patient outcomes.
- This proposed system can further more can be used in orthopedic surgery also.

- Moreover the presence of all these sensors can be used to perform more complicated works.

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Chapter - 18
Smart Home Automation using Simulation Software

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Chapter - 18

Smart Home Automation using Simulation Software

Soumyadip Pal, Sayandeep Kundu and Maharghya Hazra

Abstract

The Smart Home Automation project aims to create an intelligent living environment that enhances comfort, convenience, energy efficiency, and security for homeowners. It focuses on building continuous network infrastructure, optimizing energy consumption, and increasing home security through advanced technologies. The project's main goals include connectivity and integration, energy efficiency, home security, automation and artificial intelligence, user experience, and future scalability.

Connectivity and integration are key aspects of the design, enabling central control and data exchange between different smart devices. Also, circuit simulation can be integrated through different sensory mechanisms. Energy efficiency is highlighted through the integration of smart lighting systems, thermostats, and appliances, while home security is enhanced through advanced surveillance cameras, motion sensors, and smart locks. Automation and AI are at the heart of the design, leveraging AI and machine learning algorithms to learn from user preferences and adapt to routine tasks.

The project can be rooftop integrated with sensors for natural sunlight and an outside hanger for rain detection. An integrated solar system is used as a backup energy source. The user experience is key, with an intuitive interface and voice assistants for seamless interaction. Future scalability allows for easy integration of new technologies and ensures the system remains flexible and relevant as new smart devices and standards emerge.

The Smart Home Automation project has the potential to revolutionize the way people interact with living spaces, transforming homes into living beings that respond to occupants' needs and desires. The wall can withstand proper ventilation and support small plants and gardening.

Keywords: Home security, energy efficiency, integration, home automation, sensory mechanisms, circuit simulation.

1. Introduction

Home automation refers to the concept of network devices in the home, such as lighting, security systems, and appliances. These systems provide energy efficiency, improve security, and increase user comfort and convenience. Automation is a technique that reduces human involvement and is becoming increasingly popular in the construction industry. The energy crisis in the country is a major concern, and people often neglect to use available energy. Home automation systems can help solve these problems by detecting human objects and automatically switching on or off electrical equipment. The design focuses on connectivity, integration, energy effectiveness, home security, automation, artificial intelligence, user experience, and scalability. Connectivity and integration are crucial aspects of the design, enabling central control and data exchange between different smart devices. Energy effectiveness is stressed through the integration of smart lighting systems, thermostats, and appliances, while home security is enhanced through advanced surveillance cameras, stir detectors, and smart cinches. Automation and AI are at the core of the design, using algorithms to learn from users' preferences and adapt to routine tasks. The Smart Home System or Intelligent Home aims to make life easier and more comfortable for users.

1.1 Literature Review

This paper presents a smart home automation controller using IoT to convert appliances into intelligent devices, using Node MCU, IFTTT, Adafruit (A library that support MQTT), and Arduino IDE [1]. It uses Google Assistant and a web-based application [2]. This paper presents a smart home system using IoT for home automation, security, and camera functionality. The Android app converts smartphones into remotes for appliances, and motion sensors detect movement at home entrances. The system uses Raspberry Pi as a server. [3] This paper proposes optimizing home power consumption using PLC and Zigbee for easy access, using ACS and DDEM algorithms for intelligent distribution, and addressing variable sensor network topologies. [4] This paper proposes a system to reduce computation overhead in smart home solutions using encryption technologies like AES, ECHD, and hybrid. It uses temperature sensors and a real-time broker cloud for automation and security. [5] The paper presents a vision-based machine intelligence system for sensing the state of common home appliances, enabling a novel home automation system. The system uses Raspberry Pi and Intel Galileo Gen 2 boards, UDP protocol, and a Pi Cam and USB Logitech camera to detect appliance operation. Privacy concerns are addressed with an

SPDT switch on Raspberry Pi. [6] This paper presents a low-cost Home Automation System (HAS) using Wireless Fidelity (Wi-Fi) for monitoring and controlling environmental, safety, and electrical parameters in smart interconnected homes. The system uses a smartphone application and Android Studio for flexible control. [7] The paper presents a voice-based home automation system using Internet of Things, AI, and NLP for cost-effective, efficient integration with home appliances. The prototype uses Arduino MK1000 for seamless communication.

1.2 Our Aim behind this work

Our aim of this work is remote access for the home appliances, user comfort, convenience, increases home safety system and also develop the energy efficiency such as reducing the power usage as well as saving the electric bills.

2. Different methods

Home Automation can be done by the following processes-

2.1 Using simulation software

We can make different circuit simulations (using Multisim, Psim, PSpice, TinkerCAD, Matlab-Simulink, Proteus etc.) for different types of home automation system (like automatic calling bell system simulation, temperature based fan speed control simulation, emergency circuit simulation, etc.).

2.2 Using IOT devices and Electronic components

We can do home automation using IOT devices[1] and Electronic Components also (like using Arduino, Bluetooth module, Wi-fi module, PLC, Smart phone, Sensors etc.).[4]

2.3 By Computer programming

We can use different programming languages (like using C, Python, Java, Scala, Matlab etc.) for home automation. [7]

2.4 By Virtual designing

We can make different virtual home automation designs (Electrical & Civil) using different software (like AutoCAD, Catia, ETAP etc.).

3. Our study works

3.1 Automatic door bell system

The Automatic Doorbell Ringer is a useful and interesting circuit that detects a visitor's presence behind the door. It uses an object detection circuit to sense their presence and rings the doorbell. The circuit uses an IR-LED transmitter and photo-transistor receiver module to detect the person and turn the doorbell on automatically if they are in front of the door.[2]

In this circuit, when the IR-Led falls on the base of the photo-transistor, the photo-Transistor goes into active region. It causes charging the capacitor and generate trigger pulse. This pulse goes to the trigger port of the IC 555 timer and the timer turned ON. It causes the buzzer or calling bell to ringing. In the figure 2.a the upper graph is of buzzer, when the trigger turn on the IC 555 timer, it takes a peak and turn on the buzzer and the bulb. The figure 2.b shows the bulb turning on graph.

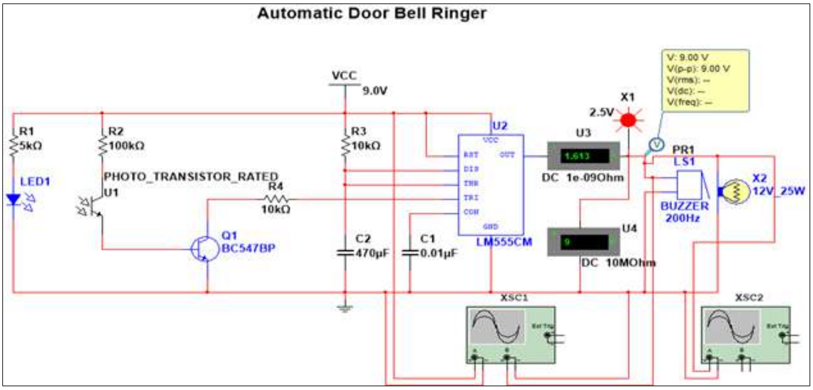

Fig 1: Automatic door bell ringer circuit simulation

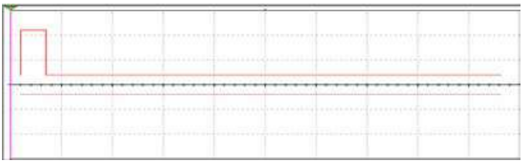

Fig 2.a: Buzzer Simulation Graph

Fig 2.b: Bulb Simulation Graph

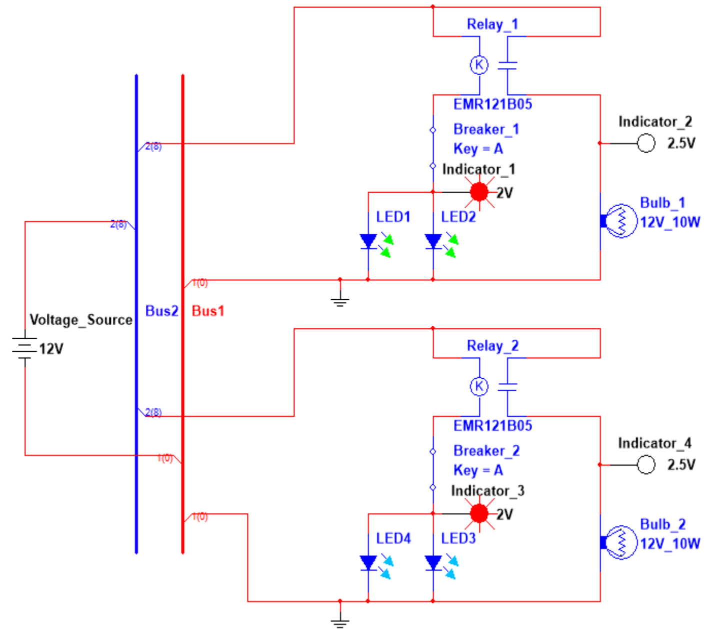

Fig 3.a: Circuit in normal condition

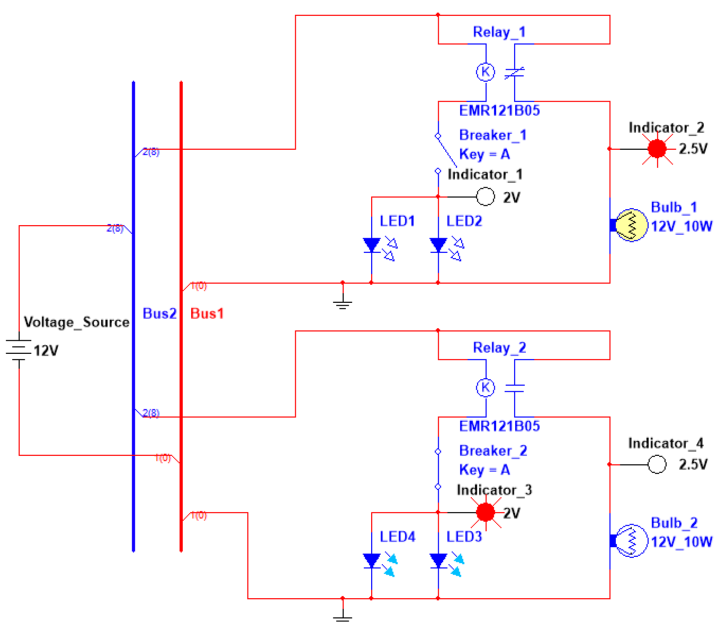

Fig 3.b: Circuit in fault condition (at first floor)

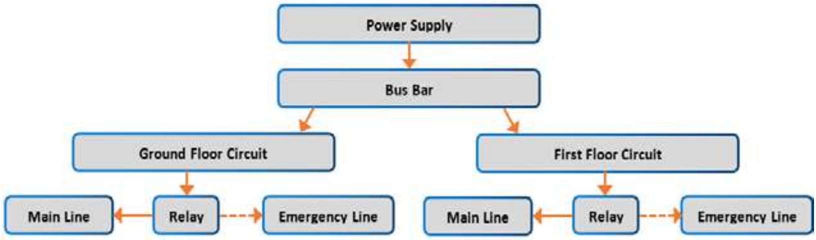

Fig 4: Block Diagram of Emergency Circuit System

3.2 Emergency circuit system

In emergency circuit system, there is only one source but two alternative circuits. One is main circuit and another is emergency circuit. If the main circuit gets short-circuited then the main circuit is disconnected by the MCB and using the relay the emergency circuit get activated automatically. This circuit is needed where the undisrupted power supply is required. If one circuit is failed, then another circuit get activated automatically. In the figure 3.a and 3.b there are two-storey circuits are shown. Both of them have separate main and emergency circuit.

3.3 Temperature based fan speed control simulation circuit system

In the temperature based fan speed control simulation circuit, there is a temperature sensor which measure the temperature and send the data to Arduino.[11] And based on the programming logic in the Arduino, the Arduino control the speed of the fan (motor) using PWM control and show the temperature and fan speed value in the LCD monitor. And based on the temperature, the different color LED lights are glow.[9] As the temperature increases, the speed of the fan also increases (shown in the Table 1 and in Figure 6 graph).

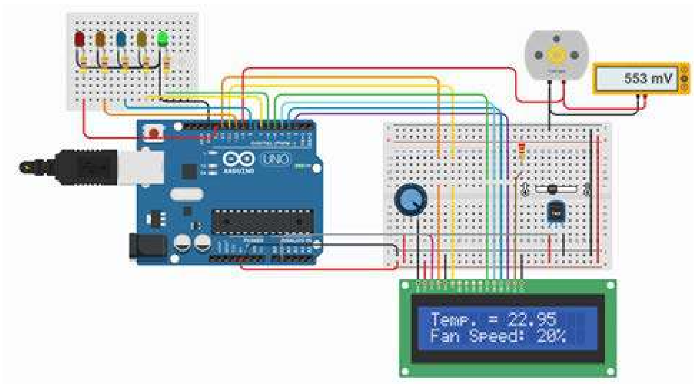

Fig 5.a: Low Temp. low fan speed (20%)

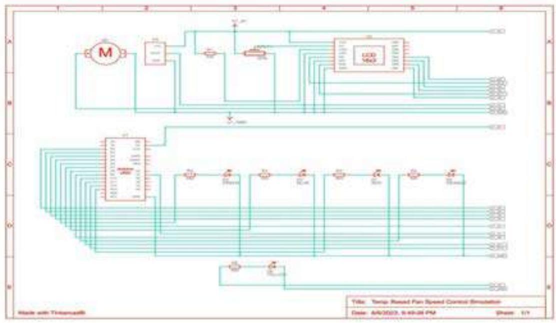

Fig 5.b: Circuit diagram

Table 1: Different Temperature and Fan speed Readings

Temperature Limit	Fan Speed	Color of LED
Temp.<= 20°C	Fan Off	LED Off
Temp.>20°C & Temp.<=25°C	20%	Green
Temp.>25°C & Temp.<=30°C	40%	Yellow
Temp.>30°C & Temp.<=35°C	60%	Blue
Temp.>35°C & Temp.<=40°C	80%	Orange
Temp.>40°C	100%	Red

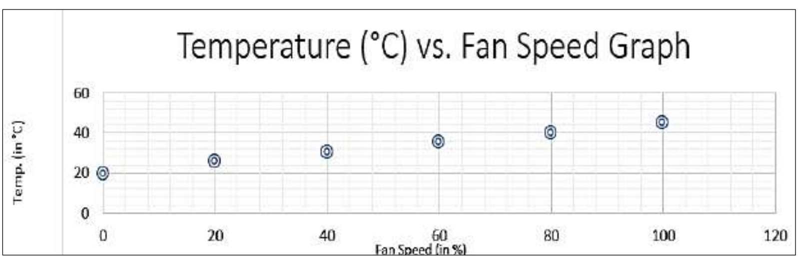

Fig 6: Temperature vs. Fan Speed graph

3.4 Automatic light and Fan on-off control simulation circuit system

In this simulation circuit we use one PIR (Passive Infrared) sensor, one LDR (Light Dependent Resistor) and one Temperature sensor. Here we give three logic to the Arduino to run the circuit properly. First PIR sensor checks if there are any movement of any person or not. If there are any movement in the range of PIR sensor, then it checks if the light in the room is sufficient or not and if the temperature is high or not. If room light is not sufficient, then it turns on the light and if the temperature is more than the limit, it also turns on the fan (motor). Using this circuit, we can save electrical energy if there is no person in the room.[12] Here we have not to worry about fan and light on-off, it's done automatically based on the programming logic.

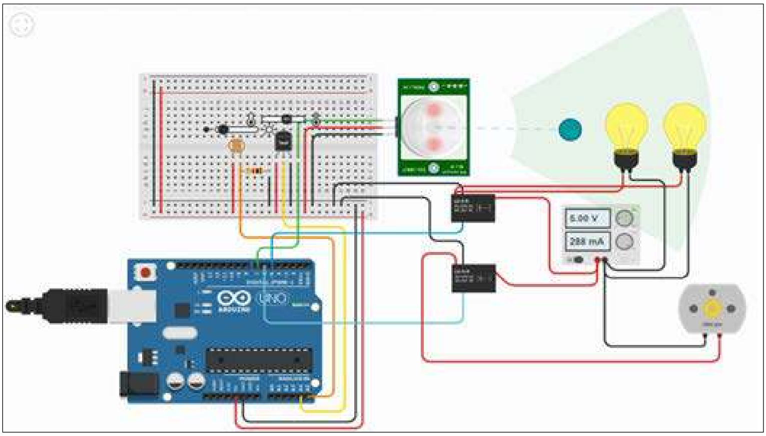

Fig 7.a: PIR sensor sense the movement and light fan ON

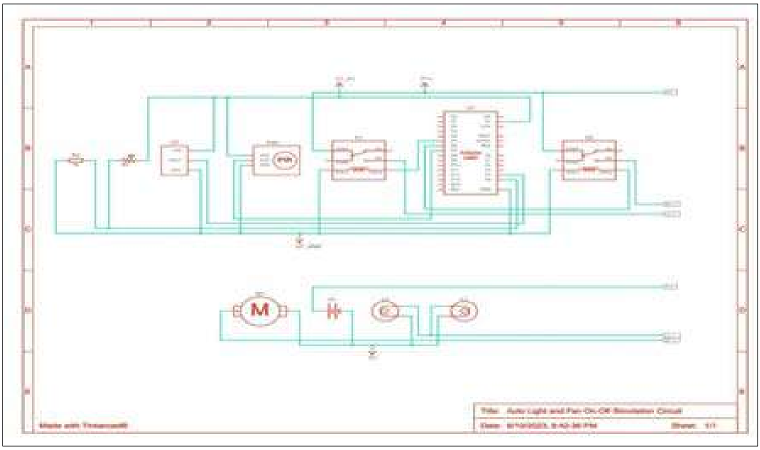

Fig 7.b: Circuit Diagram

3.5 Battery management system using the combination of x-or and x-nor gate (feedback control)

To remain Battery long-lasting, we have to control charging and discharging of battery. In this simulation, 0-0 in the battery state, indicates 20% or less charge, similarly 0-1 means 20% to 50% (suppose 40%), 1-0 means 50% to 80%(suppose 60%) and 1-1 means 80% or above. Here, the charging state-1 means charging and charging state-0 means discharging. Also, output-1 means changing the state of output from discharging to charging and vice versa and output-0 means remaining in the state as it is. So, the automation process can be achieved by changing the charging state from 20% to 80% and vice versa without interference of human-beings.

The circuit have three parts. Main circuit, automation circuit and control circuit. The automation circuit informs about the filling and emptying of the tank. The control circuitry always maintains an average output level regardless of the input level and can also detect errors (to ensure safety and security).

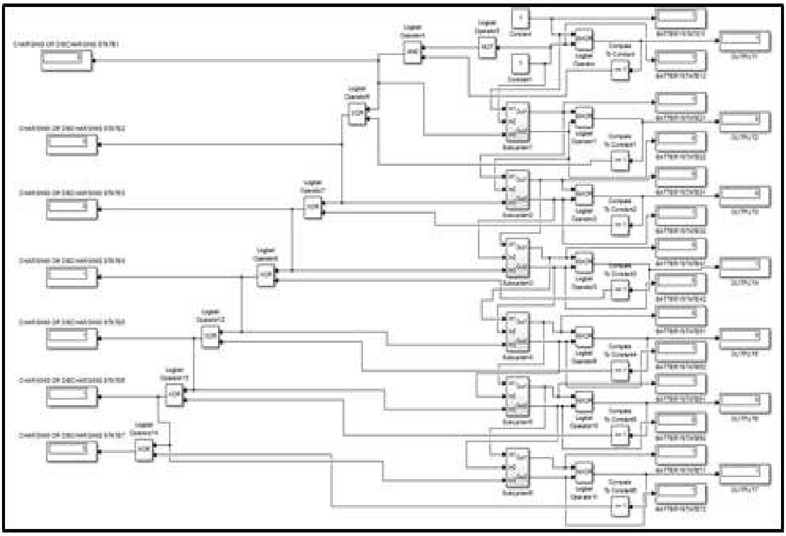

Fig 8.a: Main Circuit Diagram

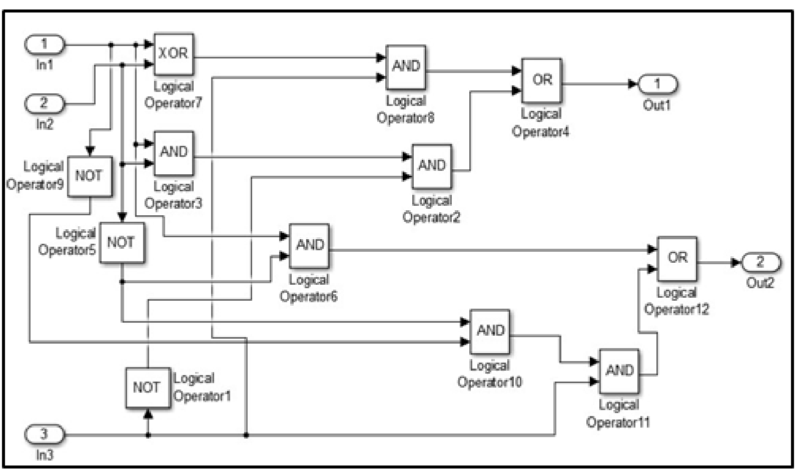

Fig 8.b: Subsystem Circuit Diagram

Table 2: Battery Charging Logic

Battery State		Charging State	Output	
A	B	C	Y1	Y2
0	0	1	0	1
0	1	0	0	0
0	1	1	1	0
1	0	0	0	1
1	0	1	1	1
1	1	0	1	0

	A'B'	A'B	AB'	AB
C'				1
C		1	1	

	A'B'	A'B	AB'	AB
C'			1	
C	1		1	

Fig 9: a. K-map for Y1 [Y1 = C(A xor B) + ABC'] Figure 9.b. K-map for Y2 [Y2 = AB' + A'B'C]

3.6 Water level control simulation system (State control)

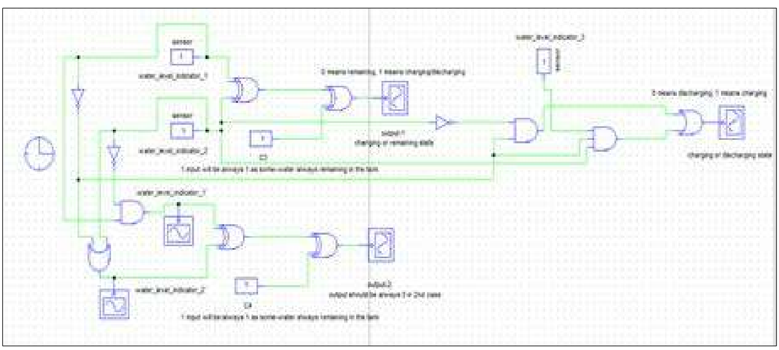

Fig 10a: Water level controller circuit diagram

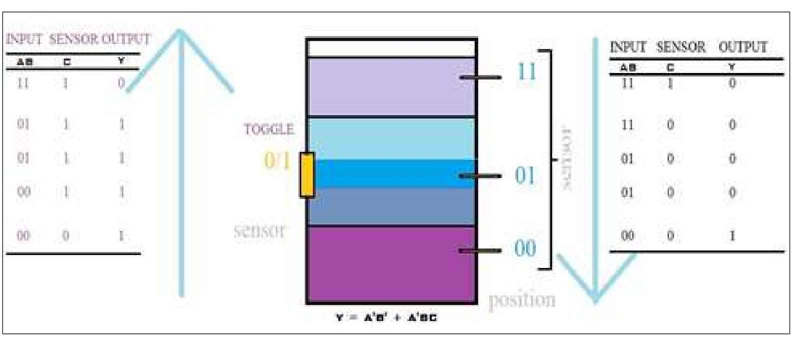

Fig 10b: Logic of Automation

4. Results and Discussion

4.1 Results

Hence, Home Automation can be achieved by Automatic door bell system, Emergency circuit system, Temperature based fan speed control system, Automatic light and fan on-off system, Battery management system using gate etc. [8]

4.2 Discussions

4.2.1 Uniqueness of our work

Uniqueness of our work is we use various simulation software such as Multisim, MATLAB - Simulink, Tinkercad rather than IOT (Internet of Things). In using this simulation software our work is more efficient and advanced in nature than IOT.

4.2.2 Future Aspects

In future our model can be also implemented with gesture control system, voice command. Here we can also able to implement robotics for our convenience in future.[10] Also in future AI will help our smart home do more tasks that humans used to do.[3][5]

5. Conclusions

This paper discusses home automation systems using simulation software, a device that controls and monitors home appliances without extra effort. It discusses the methodology, components, and applications of this system, and the potential for future advancements in simulation technology. The device is compact, low-cost, has more capacity, long life, and has distant signal receivers. The research aims to create a device that saves electricity, improves human lifestyle, and reduces electricity bills, ultimately improving the overall home automation experience.

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Conflict of interest: The authors declare no conflict of interest.

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Chapter - 19
IoT-Based Virtual Health Checkup Robot (AIDO-BOT)

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Chapter - 19

IoT-Based Virtual Health Checkup Robot (AIDO-BOT)

Avrajit Singh, Asibur Rahman, Aadieti Sinha, Sneha and Soumen Sen

Abstract

AIDO Bot offers comprehensive virtual health checkups, empowering users with self-assessments from home. Controlled through a user-friendly mobile app, patients can schedule checkups, communicate with healthcare providers, and receive real-time visual feedback via the robot's high-definition camera. This feature facilitates remote examinations and professional guidance, fostering a holistic remote healthcare experience. Leveraging machine learning, AIDO Bot analyzes collected health data to detect patterns, identify risks, and offer personalized recommendations. Artificial intelligence ensures continuous adaptation based on individual data, refining accuracy and relevance. The deployment of AIDO Bot benefits healthcare providers and patients alike. As an efficient telemedicine tool, it enables real-time remote diagnosis and monitoring, alleviating healthcare facilities' strain. Its scalability and cost-effectiveness make it particularly valuable in densely populated regions. In summary, the IoT-Based Virtual Health Check-up Robot, AIDO Bot, represents a ground breaking fusion of IoT, robotics, and AI in remote health assessment. By providing accessible, efficient, and personalized healthcare, AIDO Bot bridges gaps, connects healthcare stakeholders, and contributes to a healthier society.

Keywords: AIDO-BOT, Health check-up, IoT.

1. Introduction

In recent years, the rapid advancements in the field of Internet of Things (IoT) have revolutionized various industries, including healthcare. IoT-based systems have demonstrated their potential in enhancing healthcare services, particularly through the integration of robotics and telemedicine. This paper presents the design, development, and evaluation of an IoT-based Virtual Health Checkup Robot, termed AIDO-BOT. The AIDO-BOT is a novel solution that aims to provide remote health monitoring and checkup services, thereby addressing the challenges posed by geographical barriers and limited access to healthcare resources. This paper outlines the materials, methods, and results involved in the creation and assessment of AIDO-BOT, shedding light on its potential to transform the landscape of healthcare delivery.

2. Materials & Methods

2.1 Component Used

Geared Motor

A geared motor is a mechanical device combining a motor and gearbox, designed to deliver controlled motion and torque in various robotic and automation applications.

ESP32-CAM

ESP32-CAM is a compact development board that integrates the ESP32 module with a camera, enabling real-time image and video streaming over Wi-Fi, suitable for IoT projects and surveillance systems.

ESP8266

ESP8266 is a versatile Wi-Fi module renowned for its low power consumption and connectivity capabilities, often used for building Internet of Things (IoT) devices.

MAX30100

The MAX30100 is a pulse oximeter and heart-rate sensor module, capable of non-invasive measureme

2.2 Methodology

A block illustration and flowchart were used as attendants to fantasize the arrangement of way to be followed throughout the system operation process. Circuit plates were employed for the planning, development, and support of electrical and electronic gears. The complete system includes the following factors; The system makes use of a robotic vehicle with 4- wheel drive for easy navigation. The robot also includes a regulator box for circuitry of remote- controlled vehicle and a mounting to establish a platform containing the needed detectors to measure the health parameters. It consists of Esp32 Camera which is used to see the real time situation.. Robot is controlled by croaker by covering on the screen using Esp32 camera. The robot having four bus is controlled using an IOT grounded panel to give commands by which it can move around the cases. The control commands transferred online are entered by the robot regulator. The robot regulator operates over Wi- Fi internet. The entered commands are entered in real time and the robot motors are operated to achieve the asked movement commands. IOT case monitoring has 3 detectors. The first one is a temperature detector, the second is the twinkle and SPO2 detector and the third bone is a moisture detector. This design is veritably useful since the croaker can cover patient health parameters just by visiting a website or URL. Working with IOT is related to the bedded world as the detectors use electronic data signals. originally, bias similar as detectors, sensors, observers and microcontroller are connected altogether for synchronization. The detectors and sensors descry the signals in analog form, which needs to be farther converted into digital form. The inbuilt analog to digital conversion is performed through the microcontroller to get data in proper digital format The ESP module continuously reads input from these 3 senses. After the conversion of data, storehouse of data is performed. The data are being transferred to the pall or garçon. In this design, a original garçon is used, which shows the variations of the values or the readings measured contemporaneously. druggies can see the measured value through a mobile operation, and contemporaneously, druggies can see the value through the device's TV display.

2.3 Preparing Figures, Schemes and Tables

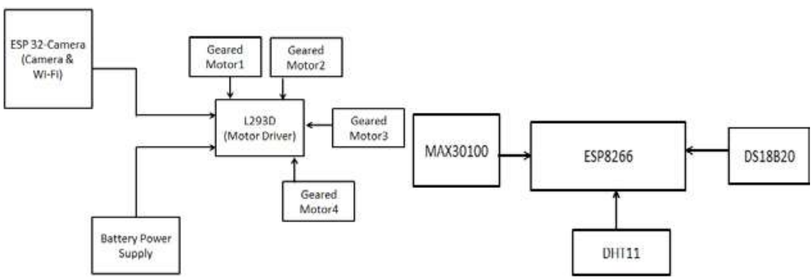

Fig: (a): Serviellence Car Fig.(b): Health Monitoring

2.3.1 Citation in text

Throughout the paper, citations are employed to acknowledge and support the research by referencing existing studies, previous research, and relevant sources. In-text citations are critical for substantiating claims, giving credit to prior work, and contextualizing the contributions of AIDO-BOT. The citations are provided in the form of numerical references enclosed in square brackets, and a corresponding list of references is provided at the end of the paper.

When discussing the foundational concepts of IoT and telemedicine:

"The integration of IoT and telemedicine has been widely recognized for its potential to revolutionize healthcare delivery."

When describing the utilization of sensors for health monitoring:

"AIDO-BOT's health monitoring functionalities are facilitated by an array of sensors, including temperature, blood pressure, and heart rate sensors."

When citing a previous study on the challenges of telemedicine platforms:

"Comparative analysis of telemedicine platforms has highlighted issues related to audio and video quality, which AIDO-BOT aims to address."

When acknowledging prior work on IoT-enabled healthcare solutions:

"Previous research in the field of IoT-enabled healthcare solutions has laid the foundation for AIDO-BOT's design and functionalities."

When discussing ethical considerations in healthcare robotics:

"Ethical concerns surrounding data security and patient privacy have been prominent in healthcare robotics, prompting the need for comprehensive solutions."

When referencing a specific guideline for data security:

"To ensure compliance with healthcare data security standards, AIDO-BOT's design adheres to guidelines set forth by the Health Insurance Portability and Accountability Act (HIPAA)."

When discussing potential AI-driven enhancements for AIDO-BOT:

"Future iterations of AIDO-BOT could leverage AI algorithms for predictive health analysis, offering personalized health recommendations based on historical data."

These examples demonstrate how in-text citations are integrated within the narrative to give credit to prior research, validate claims, and provide readers with the means to explore the referenced sources in more detail.

2.3.2 Web references

In this section, we provide web references to online resources, repositories, and technical documentation that played a pivotal role in shaping the development and implementation of AIDO-BOT.

ESP-32 CAM Official Documentation – URL:https://www.espressif.com/sites/default/files/documentation/esp32-wrover-e_esp32-wroverie_datasheet_en.pdfThe official documentation provided insights into the technical specifications of ESP-32 CAM and offered guidance on setting up the hardware components.

ESP 8266 Official Documentation – URL:https://www.espressif.com/sites/default/files/documentation/ESP8266 DevKitC_getting_started_guide_EN.pdfThe official documentation provided insights into the technical specifications of ESP 8266 and offered guidance on setting up the hardware components.

MAX30100 Technical Documentation –URL: https://www.analog.com/media/en/technical-documentation/data-sheets/MAX30100.pdfThe official documentation provided insights into the technical specifications of MAX30100 and offered guidance on setting up the hardware components.

DHT11 Technical Datasheet –URL:https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdfThe official documentation provided insights into the technical specifications of DHT11 and offered guidance on setting up the hardware components.

L293D Technical Datasheet –URL:https://www.ti.com/document-viewer/L293D/datasheet/pin_configuration_and_functions#SLRS0085560The official documentation provided insights into the technical specifications of L293D and offered guidance on setting up the hardware components.

DS18B20 Official Datasheet –URL: https://www.analog.com/media/en/technical-documentation/data-sheets/DS18B20.pdfThe official documentation provided insights into the technical specifications of DS18B20 and offered guidance on setting up the hardware components.

Python Programming Documentation - URL: https://docs.python.org/3/Python documentation was invaluable in implementing data processing algorithms and programming functionalities for AIDO-BOT.

3. Results and Discussion

3.1 Results

The performance evaluation of AIDO-BOT yielded noteworthy outcomes in both autonomous and telemedicine modes. In the autonomous mode, the robot effectively conducted routine health checks by interfacing with various sensors. The recorded data, including temperature, blood pressure, and heart rate measurements, demonstrated a high degree of accuracy when compared to established medical devices. The camera module facilitated real-time visual assessments, enabling the detection of visible anomalies. User feedback revealed a seamless and intuitive user interface, promoting ease of interaction.

In the telemedicine mode, AIDO-BOT enabled remote consultations with healthcare professionals. The microphone-speaker setup facilitated clear audio communication, and the camera module transmitted high-quality video for visual examinations. User satisfaction surveys indicated positive experiences, with patients expressing comfort and convenience during virtual consultations. The integration of AIDO-BOT with existing healthcare infrastructure showcased its potential in enhancing remote patient care and reducing the burden on traditional clinics.

3.2 Discussions

The results obtained from the AIDO-BOT's evaluation open up avenues for comprehensive discussions. The accurate sensor readings in autonomous mode underscore AIDO-BOT's potential for reliable remote health monitoring. The close alignment of its measurements with established medical devices suggests its viability for routine checkups. However, considerations such as sensor calibration and potential environmental factors need further exploration to ensure sustained accuracy.In the telemedicine mode, the successful execution of remote consultations highlights AIDO-BOT's role in bridging geographical barriers to healthcare access. The clear audio and video transmission capabilities enhance doctor-patient interactions, although network stability remains a crucial factor influencing the quality of remote consultations. Moreover, AIDO-BOT's implementation raises ethical concerns related to data security, patient confidentiality, and the liability of autonomous health assessment. Addressing these concerns will be pivotal to ensure widespread adoption and regulatory compliance. The integration of AIDO-BOT with the healthcare ecosystem merits attention. Collaborative efforts with medical institutions, insurance companies, and regulatory bodies will be essential to integrate AIDO-BOT into mainstream healthcare practices. Additionally, future iterations could explore AI-driven predictive health analysis to offer proactive suggestions based on collected data. In conclusion, AIDO-BOT holds the potential to reshape healthcare delivery by expanding accessibility and enhancing patient-centric care. Its successful implementation and promising outcomes in both modes set the stage for further refinements and broader deployment. However, interdisciplinary collaboration and a holistic approach are indispensable to address technical, ethical, and practical challenges for realizing the full potential of AIDO-BOT in revolutionizing healthcare.

4. Conclusions

The conclusion segment synthesizes the key findings of the research, underlining the significance of AIDO-BOT as a pioneering IoT-based solution for virtual health checkups. It underscores the potential of AIDO-BOT to bridge geographical healthcare disparities, enhance accessibility to medical services, and contribute to the paradigm shift in healthcare delivery. The conclusion also offers insights into the avenues for future development, expansion, and refinement of AIDO-BOT.

Future Scope

- As AIDO-BOT sets the stage for transforming healthcare delivery, numerous avenues for further development and expansion present themselves:
- AI-Driven Health Predictions:Integrating AI algorithms for predictive health analysis could enable AIDO-BOT to offer personalized health suggestions based on continuous monitoring and historical data.
- Remote Surgical Consultations:Expanding AIDO-BOT's capabilities to facilitate remote surgical consultations could redefine the landscape of surgical expertise and training.
- Long-Term Health Monitoring:Exploring the feasibility of AIDO-BOT for continuous long-term health monitoring could support early detection of chronic conditions and improve disease management.
- Collaborative Healthcare Ecosystems:Partnering with healthcare institutions, insurance companies, and policy makers would be instrumental in integrating AIDO-BOT into the broader healthcare ecosystem.

In conclusion, the IoT-based Virtual Health Checkup Robot, AIDO-BOT, presents a tangible step towards bridging healthcare accessibility gaps. While its success showcases its potential, addressing ethical concerns, optimizing network reliability, and exploring innovative avenues are pivotal for realizing AIDO-BOT's full potential. The convergence of technology and healthcare remains a dynamic landscape, and AIDO-BOT's journey exemplifies the transformative impact it can have on patient care.

Acknowledgements

The authors express their gratitude to Asansol Engineering College for their unwavering support, provision of resources, and guidance throughout the research endeavor. A special note of appreciation is extended to ECE Dept for their invaluable contributions and insights that enriched the project.

Conflict of interest

The authors affirm the absence of any conflicts of interest that could potentially influence the objectivity of the research or its outcomes.

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Chapter - 20
Prediction of Pressure Drop for the Flow of High Concentration Coal-Water Slurry through a Horizontal Pipe

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Chapter - 20

Prediction of Pressure Drop for the Flow of High Concentration Coal-Water Slurry through a Horizontal Pipe

Rahul Mishra and Amarnath Mullick

Abstract

Since the last century, the coal-water slurry pipeline system has been in various stages of development and has presented some special features. Key options include transportation, water demand, cost and end use. It has been found that conventional coarse slurries are best for long distance applications, while conventional fine coal slurries can be transported over longer distances. Another advantage of coal water slurry is that it can be transfer by pipelines over long distances. For this form of transport actions, reductions in the flow resistance of the transmitted medium are very important. Many researchers have performed physical and numerical simulations of shock and erosion problems in pipes, fittings and surfaces. Since the 1990s, computational fluid dynamics (CFD) has been widely used to solve the shock loading and corrosion prediction problems of components in curved pipelines. In this study, ANSYS Fluent14.0 with a volume ratio of 0.11, 0.14, 0.18, 0.21 and 0.25 was used to measure the rheological properties of the coal-water slurry and calculate the pressure drop for particle size of 70.5µm, 83.6µm, 187.9µm and 275.7µm and numerical results of data were analyzed. A grid independence study was also conducted to develop an appropriate grid for this study. The Euler multiphase method was used to simulate the flow of coal-water slurry in horizontal pipelines. The RNG k-ε turbulence model is included in the governing equations to simulate turbulent flow with strong particle-particle interactions. For these input data, the pressure drop and the relationship between the pressure drop and the volume ratio were calculated. It was observed that as the volume fraction increases the pressure drop also increases. The pressure drop is maximum for the finest particle size, which is mainly due to the increase in viscosity for non-uniformity in size of the fine particles and as a result the pressure drop also increases. Again, for high volume fraction the non-uniformity in size may reduce, which in turn reduces

the viscosity as well as pressure drop.

Keywords: Rheological parameters, Pressure drop, Grid independence test, Volume fraction, Particle size distribution, Reynolds Number, Euler's Number.

Nomenclature

C_{ov}	Coefficient of variance
d	Particle diameter
D	Pipe Diameter
g	Acceleration due to gravity
L	Length of test section
ΔP	Pressure drop due to flow of solid liquid mixture
V_m	Mean suspension velocity
X_V	Volume fraction of solids
μ_L	Viscosity of liquid
ρ	Density of Liquid
ρ_s	Density of Solid

1. Introduction

Solid particle transportation through pipes is now an industrial reality. As far as the information collected from the literatures, the earliest industrial solid particle transportation through pipeline is date back to 1884 – when in USA the anthracitic culm used to pump through pipes into the workout portion of a mine for extinguishing the mine fire [1]. A comprehensive theory of solid-liquid system inevitably requires the quantitative knowledge of interrelationships and interaction of the many variables involved in the process. The major variables are particle properties like, shape, size distribution, density, transporting medium properties like viscosity and density, pipeline properties such as length, diameter, slope and material, roughness, slurry characteristics such as concentration and rheology, and flow characteristics such as mean and local velocities of both phases. Pipeline transport is considered economical and environment friendly as compared to other mode of transport. To delineate the entire facilities, designers need meticulous information regarding pressure drop, erosion zone, accumulation of solid particles, etc. at the early design phase. They also need to know the critical velocity so that one can adjust the slurry flow to have a minimum pressure drop to ensure minimum operating cost. Such complex flows are very explored very less, so the present effort has been performed in order to predict with an objective to reduce the same for saving the energy. The rheological characteristic of coal water slurry is carried out, which is having more complex rheological behavior because the fine particle of coal is non- uniform in size. High flow velocities or high viscosities result in a larger pressure drop across a section of pipe or any pipeline spatial. The multi-phase pipeline flow may consist of wide particle size distribution, which creates lots of complexities because large particle reduces the viscosity if it is having uniform shape but if shape is not uniform the viscosity increases. Subsequently it increases the pressure drop also if volume fraction increases the formation of eddies increases the pressure drop. In this study, the capability of Computational Fluid Dynamics (CFD) is explored to model the solid liquid slurry flow in pipeline. It has been found that the commercial CFD software ANSYS Fluent is capable to model the solid liquid interactions in slurry flow and the pressure drop is in good agreement with the experimental and analytical data.

Purohit and Roy [2] studied a large number of suspensions up to of different solids. They showed that the solid could be classified into two main groups depending on the variation of viscosity with the particle size. One type showed a decrease in viscosity with decrease in particle size and another type exhibited an increase in viscosity with a decrease in particle size. Sonia [3] presented a heuristic approach in dense phase flow to predict head loss as a function of slurry velocity. The author also developed an equation, which further reported good agreement of the model predictions with their pilot plant studies. Doron and Barnea [7] studied hydraulic transport of coarse particles in Plexiglas pipe and developed a theoretical model for the prediction of flow characteristics of solid-liquid flow. It predicted the pressure drop and flow patterns from the slurry flow rate, input concentration, conduit geometry and solid-fluid properties as the input parameters. The predicted results were compared with the experimental result and with various and widely used correlations. It gives a good agreement among the results obtained in different methods. Ghanta [8] studied the mathematical formulations related to the apparent viscosity of suspension to solids concentration that put forwarded by Einstein. Ghanta studied the viscosity of suspension of glass spheres in liquid for high concentration of solids up to 50% by volume and proposed the relationship valid in the relative fluidity range of 1.00 to 0.005. The author also developed an empirical formula for calculation of pressure drop in solid-liquid two-phase flow.

Li *et al.* [10] compared yield stress, thixotropy and rheological characteristics of coal water slurry and coal sludge slurry. They observed that as the shear rate increases the shear stress of coal water slurry increases continuously but the shear stress of coal sludge slurry increases to certain shear rate (0.138 s^{-1}) and then decreases. They also concluded that as the sewage sludge combines with coal particles inside slurries, the spatial structure can be formed and the rheological differences between coal water slurry and coal sludge slurry can be explained by the colloidal properties of sewage sludge. Chen *et al.* [11] have depicted the slip flow of coal water slurry by using set of steel pipes of different diameters in laminar flow regime. Experimental results were compared with a new numerical technique, which has been introduced to diagnose the hydrodynamic study and wall slip velocities of the coal water slurry. Kaushal *et al.* [12] did the numerical simulation of concentration profile and pressure drop at all efflux concentrations and flow velocities of the particles of uniform size in a dispersed phase through horizontal bed by using Eulerian two phase (k-ε) model. They have concluded that because of secondary flows the maximum solid particles gets switched uniformly along the downstream of the bend and at bend inlet, the concentration profile was very much similar as that in the upstream side.

2. Numerical Anaysis Methods

Numerical calculations performed using a commercial computational fluid dynamic code ANSYS Fluent with the intention of predicting the pressure drop of coal-water slurry flow through a pipe. The problem deals with a 1000mm length of the circular pipe line with a 40mm internal diameter, which has been modeled and meshed to develop a 3D geometry. It is modeled to inspect the hydrodynamics and pressure drop of the flow. The realm is modeled with ANSYS 14.0 design modeler and meshed using ANSYS meshing tool. All the cases included in this study involve turbulent, three dimensional and transient flow. The pressure drop is calculated for different volume fractions and different particle sizes for coal water slurry and the result presented in a graphical form. The grid independent test is performed to fix the grid size and number of nodes for proper meshing of the whole domain. The mesh developed is presented in Figure. 1.

In this numerical simulation, the RNG k-ε turbulent model was taken with the Eulerian model to deal with the granular multiphase flow problem. The constants and functions in the RNG model are derived rigorously from first principles with less number of approximations. Near wall behaviour of the flow, when important, can be resolved without the use of wall functions. The RNG method is applicable to scale invariant phenomena lacking externally imposed length and time scales. For turbulence, this signifies that the method can describe the small scales, which should be statistically independent of the external initial conditions, and dynamical forces that create them through different instability phenomena. The RNG method gives a theory of the Kolmogorov equilibrium range of turbulence, comprising the so-called inertial range of small- scale eddies.

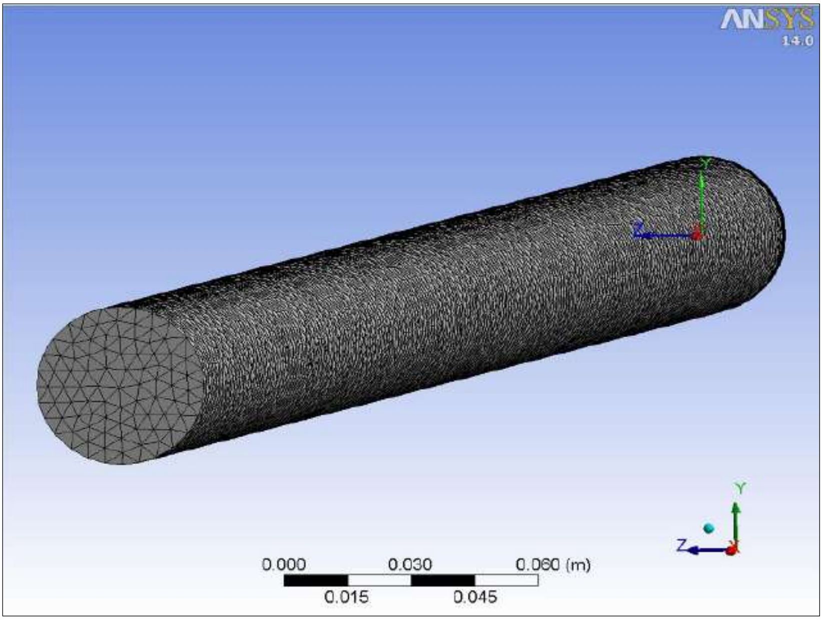


Fig 1: Mesh obtained for the test geometry

2.1 Grid Independence Study

The grid optimization helps in arbitrating the corrected grid size with a trade-off between computational cost and desired accuracy. Mesh the area with a coarse mesh and run the case until the solution converges to the convergence criteria. The method chosen is the pressure drop in the pipes. After many studies, the appropriate meshing is selected. Figure 2 corroborates the same.

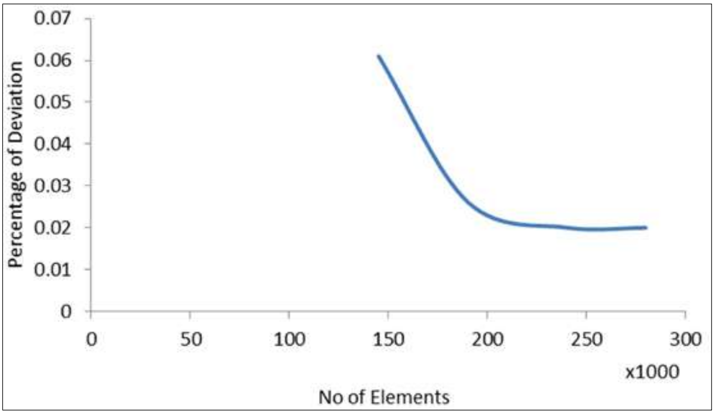


Fig 2: Percentage Deviation of Pressure Drop with respect to the number of elements

From the Figure 2, the grid size is selected such that the total number of cells considered throughout the entire analysis is 190424.The boundary conditions and input details are given in Table 1 and Table 2.

Table 1: Boundary Conditions

S. No.	Part	Type of boundary condition
1	Inlet	mixture phase, velocity inlet type
2	Outlet	mixture phase, pressure outlet type
3	Pipe wall	Slip flow

Table 2: Input details of Coal water slurry

Slurry	Details		Other input
Coal water slurry	Particle size (d)	70.5, 83.6, 187.9, 275.7 (micron/mm)	Inlet velocity = 5m/s Hydraulic Diameter=10mm
	Volume fraction of solids (X_V)	0.11, 0.14, 0.18, 0.21, 0.25	

3. Results and discussion

The computed pressure drop was investigated for a fully turbulent flow with coal water slurry. For coal water slurry, the particle size are taken as 70.5µm, 83.6 µm, 187.9 µm, and 275.7 µm and for each particle diameters, five different volume fractions 0.11, 0.14, 0.18, 0.21, 0.25 are taken. The intent is to develop a correlation between pressure drop- volume fractions, which is illustrated in Figure 3. Since a very wide particle size distribution has been taken, so a correlation between coarse and fine particles in context of the above mentioned properties have been attempted, and the relative variation in results has been analyzed and the causes of all the above have been concluded. The detailed descriptions of all comparative analysis are mentioned below:

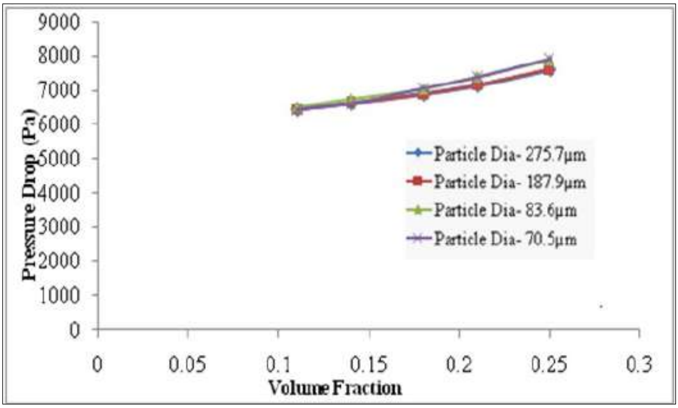


Fig 3: Pressure drop versus volume fraction

Figure 3 shows that for all particle diameters, as the volume fraction increases as the pressure drop also increases.

This is mainly because as the volume increases, turbulence and eddy flow increase and increase as a result of friction, and then the coefficient of friction also increases, and as we know from Darcy's work, coefficient of friction and pressure drop go hand in hand. Therefore, the observations in Figure 3 are sufficient evidence that when the volume increases, the pressure also increases. Figure 3 also shows that the shock is greatest for the smallest particle size (70.5 µm) because coarse coal particles have a similar shape compared to small particles.

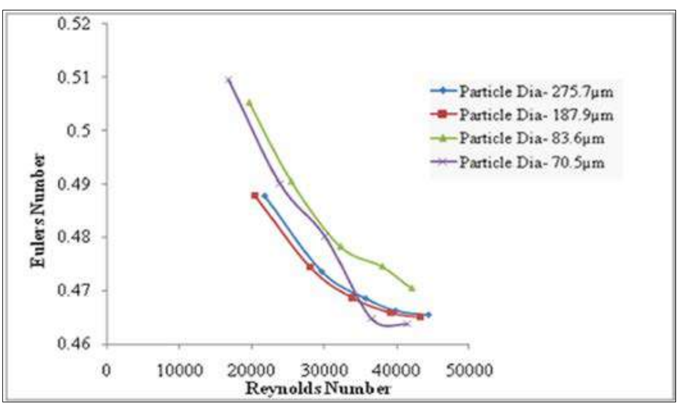


Fig 4: Variation of Euler’s Number with Reynolds Number

Figure 4 depicts that the Euler's Number decreases with the increases in Reynolds Number for all coal particles considered in this study. It is also evident from the figure that for 70.5μm particle diameter, the Euler's Number decreases suddenly, it has occurred because the coal particles are of fine sized and may be of irregular in shape. Moreover, the above mentioned result can be validated by Reynolds Number equation and Euler's Number equation, because by seeing the equation it can be very well seen that as the velocity increases the Reynolds Number increases but the Euler's Number decreases, it means Reynolds Number and Euler's Number are inversely proportional which corroborate the Figure 4.

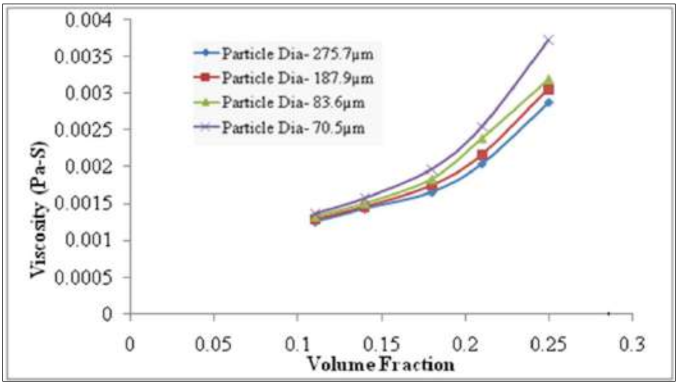


Fig 5: Variation of Viscosity with Volume Fraction

From Figure 5, it may be concluded that for all particle diameters, as the volume fraction increases the absolute viscosity also increases. It is also evident from the figure that among all particle diameters considered for the study, the absolute viscosity is observed to be maximum for minimum diameter of particle (70.5μm).

In this work the numerically calculated value of pressure drop is validated with a correlation developed for coal-water slurry by through an experimental work Ghanta [8] which is given as:

$$\frac{D\,\Delta P_m}{{}^1\!/_2\,\rho\,V_m^2\,L} = 1.272\left(\frac{D\,V_m\,\rho}{\mu_L}\right) - 1.241\left(\frac{d}{D}\right) - 0.211\left[\frac{(\rho_s - \rho)g\,D}{\rho\,V_m^2}\right]^{1.311} .X_v^{0.108}.C_{ov}^{-1.841}$$

The value of pressure gradient ΔP_m calculated for Coal water slurry for all particle diameter and volume fraction by using the above correlation. After comparing the pressure difference with the simulated pressure difference, an approximate error percentage of 8% has been obtained. It clearly shows that computed results are in good agreement with the experimental result.

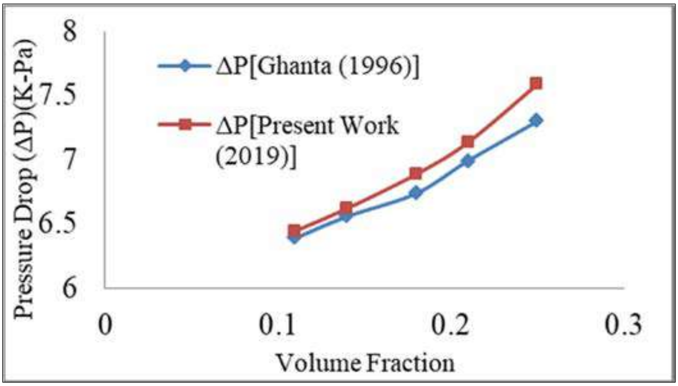
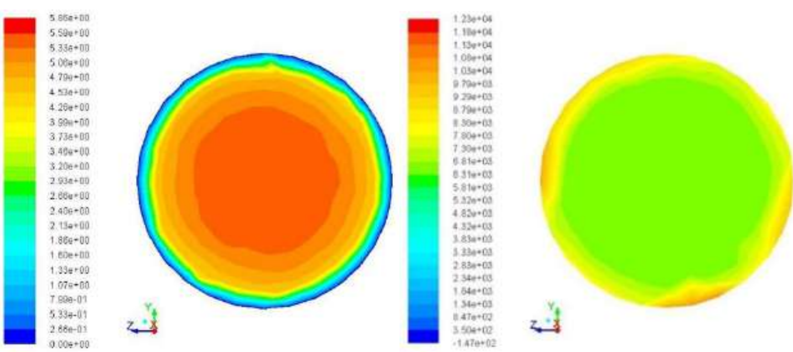


Fig 6: Pressure drop versus Volume Fraction

The graph shown in Figure 6, showing the pressure drop values for 275.7μm particle diameter with volume fraction of 0.11, 0.14, 0.18, 0.21, and 0.25 to compare the results obtained by Ghanta (1996) and the present work for validation of the prediction model. It is noticeable that the pressure drop obtained by using the empirical formula proposed by Ghanta[8] is in good qualitative agreement with the value obtained through numerical simulation for present work and also corroborate the validation of the present work.

It can be seen from Figure 7(a) that the pressure at the center of the pipe is the least and the pressure at the pipe wall is the highest; Figure 7(b) shows the central velocityof the pipe is maximum and the velocity of the pipe wall is the smallest.From Figures 7(a) and (b), it can be concluded that the head loss along the pipe axis gradually increases compared to the pressure at the pipe inlet.



(a) **(b)**

Fig 7: Contours at the mid-section along the axial direction

4. Conclusion

The current task is to select CWS of different size and volume to estimat e the pressure drop along the flow direction after validating the existing mod el. The following conclusions can be drawn from the present investigation:

- For all particle sizes the Reynolds number raises with depletion of Euler's number.
- For all particle sizes, as the volume fraction increases the drop in pressure rises, as a result the absolute viscosity rises. It is noticeable that absolute viscosity is maximum for smallest particle of coal (70.5μm), because as the volume fraction increases the density also increases which in turn increases the viscosity.
- For all particle sizes as the viscosity and volume fraction increases the Reynolds number decreases. It can also be seen that among all particle size the Reynolds number is minimum for the smallest particle of coal (70.5μm). This is because the fact that as the particle size reduces it makes the slurry dense which further increases the viscosity and reduces the velocity as a result the Reynolds number reduces.
- Viscosity, volume fraction and pressure drop are proportional to each other and all these varies inversely proportional with Reynolds Number.

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Chapter - 21
Engine Performance and Emission Analysis by using Lemon Peel Oil in Compression Ignition Engine: A Review

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Chapter - 21

Engine Performance and Emission Analysis by using Lemon Peel Oil in Compression Ignition Engine: A Review

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Abstract

Consumption of hydrocarbon fuels has increased rapidly in recent years, contributing to air pollution and a variety of health hazards. A new biofuel is therefore required as a result, that is less costly, renewable, and more effective than diesel. Researchers were interested to discover a substitute energy source in order to reduce emissions from CI engines. Biodiesel is added to diesel fuel to substitute it. The study comprises numerous ways for extracting essential oils and bioactive substances from lemon peels. These extracted chemicals are then combined in various amounts with regular diesel fuel to produce diesel-lemon peel combinations. Lemon peel oil is thus suitable for blending since it has some characteristics or features with diesel fuel. The main purpose is to provide a clean atmosphere by reducing pollutants such as HC, CO, CO_2, and NO_x produced by diesel engines. This review has documented how lemon peel oil affects performance and how much emissions are decreased when added to diesel fuel.

Keywords: CI Engine, Lemon Peel Oil, Engine Performance, Emission Analysis, Bio Fuel.

1. Introduction

In assessment, while fossil fuels have played an essential role in fueling contemporary society as well as ensuring a lucrative industry, their consumption has additionally culminated in an array of ecological, health, and societal issues. Because of the negative impacts of fossil fuels, there might be a greater focus on switching to higher ecological sensitivity and renewable energy sources. The transition to less polluted, more energy sources that are ecologically friendly is crucial for lessening these adverse impacts, including dealing with the acute annoyance of environmental variations. To be able to meet consumer demand, fuels made from petroleum have been served as a primary source of energy. Nevertheless, fossil fuels need to be supplanted because of shortages of resources, greater emissions of greenhouse gases, and their low reliability. Condensed consumption of fossil fuels and the growth of sources of clean energy may contribute to addressing demand for energy [1]. Among the most widespread exhaust contaminants from diesel engines are hydrocarbons such as CO, CO_2, SO_2, NO_x, and particulate matter (PM). These jeopardise both people and the ecosystem. Interestingly, because of elevated emissions of discharged gases from diesel engines, another source of fuel must be found for diesel engines [2].

Plenty of studies have reported that the physical characteristics of LPO (Lemon Peel Oil) are associated with these qualities of diesel, so LPO could potentially be employed in combination with diesel fuel in diesel engines, either in its native form or blended with diesel. The current review concentrates on the consumption of LPO as an energy source and describes its emission characteristics and performance as they have been implemented in diesel engines.

2. Materials & Methods

2.1 Production of Lemon Peel Oil (LPO) Biofuel

The oil can be derived from the peel of a lemon in two different ways. LPO gets separated from the dried lemon rinds by steam distillation method. Steam distillation has long been employed to obtain oils that are essential [3]. Freshwater can be situated at the base of the main chamber, which is additionally referred to as the steam distillation chamber. The water in the distillation chamber gets transformed into steam by receiving heat from the bottom edges of the container. The surface of the grid that included the peels of the lemon is entirely covered with the peels as the steam vapour warms inside the steam chamber. To bring the temperature down, the vapours generated by the distillation chamber, which include steam and lemon essence, are sent to a condenser container. The watery liquid and LPO mixture is subsequently gathered within a receiving container, wherein variations in density contribute to LPO being separated on top of the tank from the water that lies at the bottom. The LPO is meticulously drained out of the receiving container, combined with a few contaminants, and combined with a tiny quantity of ether. Following that, the blend will be set over a bath of water, where the intense heat of the water within bath enables using ether evaporate and reveal nothing but the purest LPO. This eliminates the oil's volatile element [4]. After that, the oil undergoes filtering employing 40-m filtration paper so as to get rid of any particulate matter [3].

Another method of oil extraction from lemon peel is known as Cold Pressing where the maximum peels have been chopped into tiny fragments ranging in measurement from 1.0 to 3.0 cm. These peels have been inserted into a screw-pressing instrument (a vegetable juicer) that is employed in the household for extracting both fruit and vegetable juices. Both the water and oil mixtures were separated and then retrieved by centrifugation at 3 thousand rotations per minute for a period of ten minutes. After segregating the oil from the solution of water, it was dried in the anhydrous solution sodium sulphate.

Table 1: Properties of LPO and its combination with diesel fuel

Fuel/Fuel Blend	**Calorific Value (kJ/kg)**	**Density (kg/m^3)**	**Kinematic Viscosity (mm^2/s)**	**Flash Point (°C)**	**Refs**
DIESEL	41924 - 42700	820 - 833	3.05 – 3.62	54 - 66	[3], [4], [5], [6], [7], [8], [9]
LPO100	30000 - 41510	842 - 853	1.06 – 1.51	54 - 75	[3], [4], [5], [6], [7], [8], [9]
LPOME 10	42450	840	3.55	58	[3]
LPOME 20	42400	841	4.05	60	[3]
LPOME30	42350	842	4.55	62	[3]
Orange peel oil	38880	871	9.8	140	[3]
LPO20	42059	843	2.5		[4]
LPO40	42380	836.9	2.08		[4]
LPO50	42140	835.8	1.86		[4]
LMPE10	41634	836	3.825	65.3	[5]
LMPE20	41345	842	4.13	76.6	[5]
LMPE30	41055	849	4.43	87.9	[5]
LMPE40	40765	855	4.74	99.2	[5]
20D80LPO	42059	843	2.5	62.8	[6]
LPOE2	39067	852	1.393	57	[7]
LPOE4	39289	867	1.386	59	[7]
LPOE1	29000	871	2.35	93	[8]
LPOE2	31000	867	2.4	87	[8]
10WLPO		856	1.92	62	[9]
20WLPO		867	2.42	68	[9]
20WLPOE		869	2.48	69	[9]

3. Engine performance and Emission analysis

Alternative energy sources or additional hydrocarbons used in engines are assessed on a case by case basis based on engine performance as well as their impact on the environment. In order to satisfy the rigorous ecological standards, researchers keep searching ways to enhance performance of engines while lessening emissions. This research will include an in-depth review of various variables and attributes, such as energy consumption, thermal efficiency, and emissions of pollutants.

3.1 Engine performance analysis

A. Aruna Kumari *et al.* [3] conducted an experiment on the Kirloskar model TV1 and discovered that the Brake Thermal Efficiency (BTE) for the LPOME 20 biodiesel mixture 2.3% less when a diesel engine is used at full load. LPOME 20 generated modified BTE and reduced Brake Specific Fuel Consumption (BSFC) across all load situations due to the lower energy value of lemon peel oil biodiesel when compared to prior LPOME mixturesagain when the Kirloskar TAF1 Single cylinder, four stroke, air cooled, direct injection diesel engine was fully loaded, B. Ashok *et al.* [4] observed that the diesel engine running on 100% lemon peel oil had a 12% more substantial BTE and a 9% inferior BSFC when compared to regular petroleum diesel fuel.A.Naresh Kumar *et al.* [5] reported that, with the probable exception of LPME10, every combination outperformed diesel in terms of values. In terms of BTE, the LPME20 outperformed all other combinations. Because LPME20 contains more oxygen than diesel, its BSFC was lower across the board. An increase in EGR rate at each load resulted in an overall reduction in BTE for the LPME20. Nonetheless, when compared to diesel, LPME20 with 20% EGR demonstrated better BTE. As reported by B. Ashok *et al.* [6], a 20% by volume blend of LPO with conventional diesel has been identified as a viable fuel to address this idling issue. The decreasing heating value of biofuels resulted in a 10.18% decline in BTE and a 21.24% increase in special fuel use.When the single cylinder, four-stroke, water-cooled type, naturally aspirated, direct injection (DI) diesel engine is fully loaded, Ashok Bragadeshwara *et al.* [7] found that pure LPO has a BTE of 36.11%, LPOE2 is 32.41%, LPOE4 is 33.5%, and diesel fuel has a BTE of 34.81%. For all engine operating circumstances, the BSFC values of the suitable emulsified fuels are raised.

Kumara Subramanian Ramar *et al.* [8] used test fuel samples with greater BTE than diesel. As a consequence, the sample produces more power as contrasted with diesel. The amount of fuel consumed when compared to diesel related with brake power improves by 1.5%.Suresh Vellaiyan [9] used neat LPO along with 10% (LPOW10) and 20% (LPOW20) water in LPO in order to determine overall engine performance and emission features, and as an outcome he found that the BTE of LPO and LPOW10 raises 8.3% and 5%, as compared to neat diesel. He also observed that introducing 2 Ethylhexyl nitrate (EHN) to LPOW20 boosts BTE by 9.7% when compared to apparent diesel and significantly reduces BSFC when comparing with LPOW20.

3.2 Engine emission analysis

A. Aruna Kumari *et al.* [3] determined that a 20% blend of biodiesel created through lemon peels lowers engine exhaust emissions by 25%, 25.6%, and 15.44% for CO, HC, and smoke, respectively, in comparison to conventional diesel. As contrasting with diesel fuel, nonetheless just slight rises in NO_x emissions have been observed.B. Ashoket *et al.* [4] noted that significant reductions in CO, HC, and smoke emissions while analyzing the Kirloskar TAF1 Single cylinder, four stroke, air cooled, direct injection diesel engine employing 100% LPO in a diesel engine without any alterations. He also observed that, using 100% LPO at the full load brought up NO_x emissions by 55%.A.Naresh Kumar *et al.* [5] described that as a result it contains more oxygen in the LPME20, there are less HC emissions and more NO_x emissions under all loads. Because the other blends had a lower calorific value, the HC for those blends was slightly higher. They also observed that LPME20 displayed greater amount of heat release at the maximum load.B. Ashok *et al.* [6] found that employing LPO resulted in a 16% reduction in CO emissions and a 42.1% reduction in smoke levels while running at full performance in a Mahindra Jeeto, single cylinder, four-stroke, naturally aspirated, direct injection, and water-cooled diesel engine. Although it completely burns diesel and elevates CO_2 levels by 5.25% while lowers CO levels, organically oxygenated biofuel is presumed to be the root cause of this reduction in emission levels. Due to the fact that LPO encompasses a substantial amount of long-chain cyclic hydrocarbon molecules, it releases additional HC, as seen by the 65.02% increase in HC levels in the exhaust manifold. Greater Mean Gas Temperature, In-Cylinder Peak Pressure, and Heat Release Rate all lead to slightly higher emissions of NO_x.In the study conducted by Ashok Bragadeshwaran *et al.* [7], in comparison to pure LPO, emulsified LPO generates more HC and CO emissions when tested on a single cylinder, four-stroke, water-cooled type, naturally aspirated, direct injection (DI) diesel engine. The substantial amount of water in the fuel samples, which minimises the propensity of evaporated form, has culminated in incomplete combustion and greater amounts of HC and CO emissions. These emulsified samples of LPOE2 and LPOE4, lessen NO_x emissions significantly despite generating substantial performance loss.

Kumarasubramanian Ramar *et al.* [8] observed that contrasting LPO to diesel reduces CO_2 emissions approximately 17.4%. HC emissions have dropped by 1% as contrasted with diesel. Additionally, there was a 12.6% diminution in NO_X emissions while compared to conventional diesel. The largest amount of greenhouse gases will be dropped due to a decreased level in emissions of NO_x.Suresh Vellaiyan [9] discovered that oxygenated LPO reduces HC and CO generation by 38.6% and 37.6%, respectively. When using LPOW10 emulsion fuel instead of regular LPO, these emissions are reduced by 18.6% and 33.2%. Even though LPOW20 is now having an adverse impact, water and EHN combined improve combustion quality and reduce HC and CO output by 6.3% and 17%, respectively, in contrast to LPOW20. Because of the reduced combustion flame temperature and 10.2% higher NO_x generation in low viscosity LPO compared to diesel, 10% water in LPO reduces NO_x by 20.5%. The extended ignition delay of LPOW20 emulsion fuel results in a 15.2% increase in NO_x.Suresh Vellaiyan [9] found that LPO and LPOW10 possessed fewer HC and CO levels than diesel fuel, and that the combined impact of ethane and water on LPO improves combustion quality and reduces HC and CO generation. Due to it's greater combustion temperature and low viscosity, LPO produces more NOx. Two reverse incidents have been observed when 10% and 20% water were incorporated into LPO. Because of the reduced combustion flame temperature, LPOW10 induces less NO_x than diesel fuel, however LPOW20 releases more NO_x owing to the longer ignition delay time.

4. Conclusion

With a declining supply of petroleum fuel and several environmental challenges, the usage of alternative fuels has become critical. Many engine parameters, such as BTE and BSFC, were greatly improved by the application of LPO in this work. While several papers have recognized the reduction in emissions such as HC, CO, and NO_X. Other factors, such as the extraction process and engine modification, must be examined for a more in-depth study.

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Chapter - 22
Effectiveness of Steady State Natural Convection for Different Fin Structures

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Chapter - 22

Effectiveness of Steady State Natural Convection for Different Fin Structures

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Abstract

The effectiveness of fin structures for heat dissipation has discussed in this research work. The work has been done in two phases. At first, the heat dissipation has analyzed for rectangular, conical, and cylindrical fin structures having the same overall surface area and atmosphere. In the first phase of the work, it has observed that the rectangular fin structure has the best heat dissipation capability followed by the conical structure, and the cylindrical fin structure has the least heat dissipation capabilities. In phase two of the work, the effectiveness of the cylindrical fin structure has been done by cutting a groove in the cylindrical fin so as to increase its surface area and in turn the heat dissipation. Grooves has cut at different locations on the cylindrical fin structures. Names of the new cylindrical fin structures has given on the basis of the groove location as cylindrical fins grooved fully, cylindrical fin with half grooved from the bottom, and cylindrical fin with half grooved from the top. After this modification in the fin design, it has analyzed and the result has found to be quite interesting. It has noted that after the grooves on the cylindrical fin structure, the effectiveness of heat dissipation has increased but the efficiency of the cylindrical fin had a downfall.

Keywords: Steady state free convection, rectangular fin, conical fin, cylindrical fin, heat dissipation, grooves.

1. Introduction

In order to prevent overheating during operation, different mechanical, electrical, or electronic appliances incorporate extended components known as 'fins' to effectively dissipate thermal energy. Fins play a crucial role in promoting heat loss from the surface of these appliances. This process occurs first through conduction across the core cross-section and later through convection to the surrounding air, resulting in improved heat dissipation. Fins are elongated surfaces that are affixed to both electronic and mechanical devices. These fins find applications in various devices such as computers, laptops, I.C. engines, motors, transformers, heat exchangers, compressors, and more. As the fins do not generate heat themselves, the rate of heat loss from and heat gain into the fin remains equal. Several studies have explored the use of fins in the field of heat transfer over recent decades. Cuce and Cuce (2013) have delved into this topic, while Dubey *et al.* (2014) compared the 1-D and 2-D heat flows in longitudinal and annular fin assemblies. Grebenişan and Anton (2014) employed the analytical solution of the 3D heat equation to analyze a plate fin heat sink operating under thermally steady-state conditions. Heggs and Stones (1980) took advantage of ANSYS software for their simulations. Joneidi *et al.* (2009) conducted an optimization study of a heat sink, analyzing its thermal performance using ANSYS software under thermally steady-state conditions. They investigated various factors, including total surface area, maximum surface temperature, and material, while also comparing different geometrical features. On a similar note, Khaled (2010) investigated heat exchangers under thermally steady-state conditions for various applications. In this study, the focus was also on fins operating under thermally steady-state conditions. Mohankumarem *et al.* (2021) employed various approaches to investigate fins with temperature-dependent thermal conductivity, analyzing both fin efficiency and fin effectiveness. Similarly, Mokheimer (2003) utilized different methods to study fins with temperature-dependent thermal conductivity. He solely analyzed the fins based on fin efficiency, whereas in our study, we discussed the fins' performance considering both fin efficiency and effectiveness. Mueller *et al.* (2020) conducted an analytical investigation to determine the optimal dimensions of cylindrical pin fins and rectangular fins, accounting for temperature-dependent heat transfer coefficient. On the other hand, Nagarani *et al.* (2014) analyzed multiple fins exposed to variable heat transfer coefficients under natural convection, while our research deals with fins subjected to a constant heat transfer coefficient. Purwadi and Pratama (2019) studied heat transfer from different fins under natural convection and performed thermal optimization of fins in heat sinks, which involved fins with variable thickness and fin thickness varying in the direction of the flow. Xianghui and Shuo (2010) investigated the use of porous fins, demonstrating superior thermal performance compared to conventional solid fins of equal weight. Wood *et al.* (1995) made modifications to bar fins, introducing stepped fins and stepped fins with indentation. Their analysis revealed that extended surfaces with larger surface areas exhibit higher heat transfer rates.

The current study involves a thorough examination of the efficiency and effectiveness of different geometric variants of fins. Comparative analyses were conducted to assess the performance of both standard and geometrically modified designs of fins, operating under a constant heat flux and free convection in a thermally steady state. The research includes the modeling, investigation, and study of various extended surface geometries, such as rectangular fins, cylindrical fins, conical fins, fully grooved cylindrical fins, bottom half grooved cylindrical fins, and top half grooved cylindrical fins.

2. Materials & Methods

Figure 1 illustrates six distinct fins used in this study: rectangular fins, cylindrical fins, conical fins, fully grooved cylindrical fins, bottom half grooved cylindrical fins, and top half grooved cylindrical fins. The dimensions of these fins are presented in Table 1. The rectangular fins, cylindrical fins, and conical fins have been adjusted to have the same total surface area, specifically 8200mm^2, to facilitate a performance comparison. The cylindrical fins have a height equal to 10 times their radius, while the conical fins have a height equal to 6 times their radius. This adjustment ensures that the conical and cylindrical fins share the same surface area dimensions. As part of a design modification, half cylindrical grooves with a radius of 2mm have been cut into the cylindrical fins. These grooves enhance the total surface area based on their length and location. Consequently, three types of fins are created: fully grooved cylindrical fins, bottom half grooved cylindrical fins, and top half grooved cylindrical fins. Despite the modifications, the volume of all three grooved fins remains the same since an equal amount of material is removed from the cylindrical fins in all three cases. To accommodate these fins, they are all mounted on a square base with sides measuring 80 mm and a width of 10 mm. The 3D models of these fins have been generated using the NX-12.0 modelling software.

Table 1: Dimensions of various fin geometrics

Fin Geometry	**Rectangular**	**Cylindrical**	**Conical**	**Fully Grooved Cylindrical**	**Bottom Half Grooved Cylindrical**	**Top Half Grooved Cylindrical**
Dimensions (mm)	51×71×5	10.895 (radius), 109.92 (height)	19.19 (base radius), 115.18 (height)	10.892 (radius) 108.92 (height)	10.892 (radius) 108.92 (height)	10.892 (radius) 108.92 (height)
Number of grooves				4	8	8
Groove Dimensions (mm)				2 (radius), 108.92 (height)	2 (radius), 54.46 (height)	2 (radius), 54.46 (height)
Total Surface Area (mm^2)	8462	8462	8462	19875.30	19925.57	19925.57
Volume (mm^3)	18105	40975	44409	37860.5	37860.5	37860.5
Material	Aluminium 6061					

Table 2: Physical Properties of Aluminium 6061

Desnity	2710 Kg/m^3
Thermal Conductivity	152-202 W/mK
Specific Heat Capacity	897 J/KgK
Tensile Yield Strength	276 MPa
Shear Strength	207 MPa
Fatigue Strength	96.5 MPa
Specific Graviety	2.7

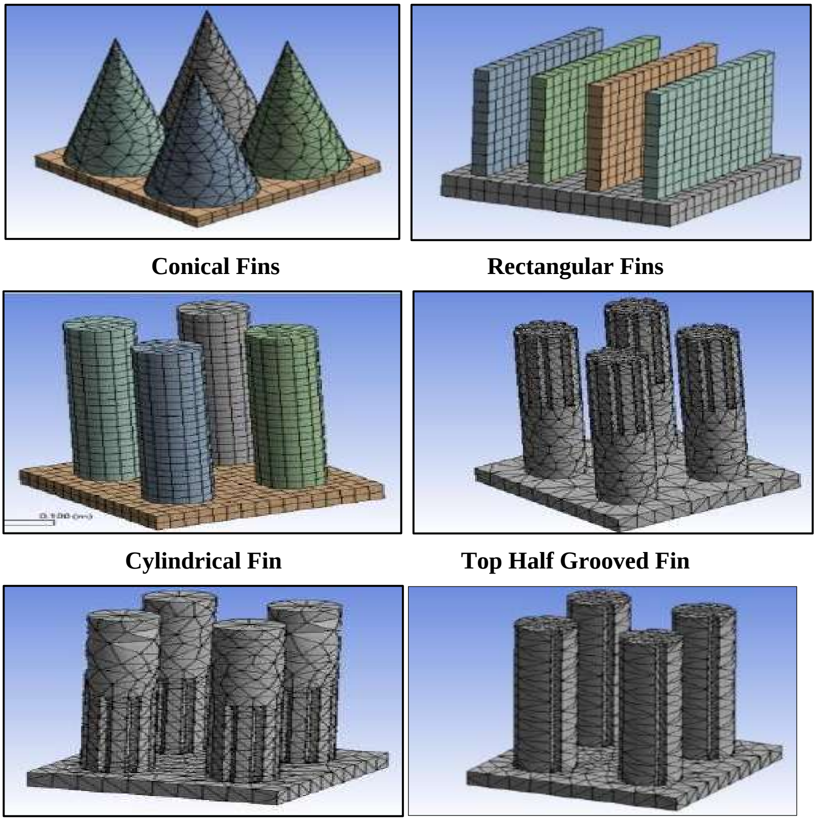

Fig 1: Various fin geometries along with meshing

Table 2 presents the physical properties of Aluminum 6061, an alloy composed mainly of 97.9% aluminum, 0.6% silicon, 1.0% magnesium, 0.2% chromium, and 0.28% copper. This alloy finds extensive applications in welding assemblies, electronic components, marine frames, heat exchangers, and heat sinks due to its outstanding attributes, including remarkable corrosion resistance, weld ability, machinability, and strength. The convective heat transfer coefficient (h) remains constant across the entire surface, and the thermal conductivity (k) of the material is also constant.

3. Modeling and Analysis

Finite Element Method (FEM) is employed with the assistance of ANSYS. In FEM, the entire domain is discretized into numerous small elements. The grooving equation is integrated element by element for the domain using a weak integral form. This leads to the derivation and separation of algebraic equations for each node within the domain. These algebraic equations are then organized into a matrix format. In the matrix format, boundary conditions are incorporated for the corresponding nodes located on the geometry's boundary surface. Solving the matrix system of equations yields the temperature values for all nodes within the domain. By interpolating the nodal temperature values, the temperature at any point in the domain can be determined, thus achieving a temperature profile. The entire process of Finite Element Method, including meshing (discretization into small elements), application of boundary conditions, and obtaining the temperature profile, is automatically performed by ANSYS. After importing the geometries into ANSYS, meshing is carried out, followed by the application of boundary conditions on selected faces of the geometries. By solving the system, the temperature profile is obtained using ANSYS Mechanical. It's important to note that finer meshing (smaller element size and more nodes and elements) leads to more accurate results in ANSYS, as it enables a more detailed representation of the domain.

The study of the differential element involves the consideration of the following assumptions:

- In the analysis, we assume 1D conduction, meaning that the temperature variation occurs solely along the longitudinal axis (x-axis). As a result, the temperature distribution remains uniform across the cross-section.
- The analysis assumes steady-state conduction, which means that the temperature remains constant and does not vary with time.
- There is no heat radiation from the surface, implying that there are no losses due to radiation to the surroundings. Furthermore, there is no heat generation within the differential element.

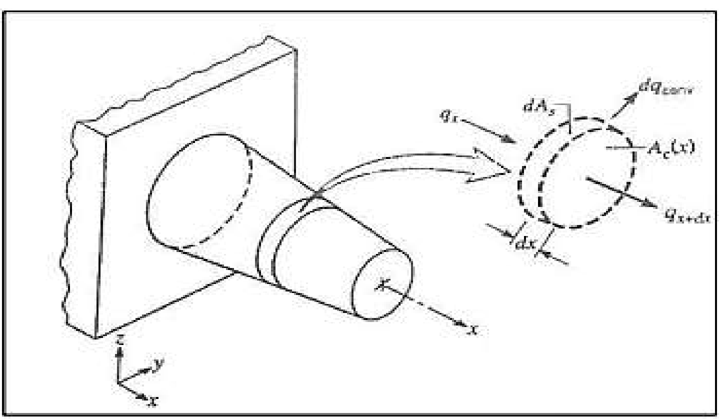

Fig 2: Diagram representing the fin and the differential element

3.1 Governing equation

1 D equation for energy balance is as:

$$\frac{d^2T}{dx^2} + \left(\frac{1}{Ac}\,\frac{dAc}{dx}\right)\frac{dT}{dx} - \frac{hP}{kAc}\,(T - T_a) = 0 \text{.............} \quad (1)$$

Where T_a = Ambient Temperature, k = Thermal Conductivity, h = Heat Transfer Coefficient, P = Perimeter, Ac = Cross section area, T = Temperature

3.2 Boundary conditions

For the analysis in ANSYS, the domain is subjected to the following boundary conditions:

- Heat flux at the base's bottom, q = 10 kW/m^2
- Free convection occurs on all surfaces of the geometry except the bottom of the base.
- Ambient temperature of air = T_a = 25°C and Air Velocity = 0
- Body’s thermal conductivity = k = 170 W/mK
- Coefficient of convective heat transfer = h = 30 W/Km^2

4. Result and Discussion

The temperature profile for the domains is achieved by interpolating the nodal temperature values, which are obtained through the solution of the matrix equation using ANSYS (Figure 3). The nodal temperature values are directly derived from the weak integral form of the governing equation, making them highly accurate. However, for points in the domain that are not nodes, the temperature values are estimated by interpolating the nodal temperatures, and thus, they may not be as precise. The accuracy of temperature values improves with a finer mesh, as it increases the number of nodes and leads to a more accurate temperature profile

Table 3: Calculations of efficiency and effectiveness of fins

Fin Geometry	**As (Total area through which convection takes place) (mm^2)**	**Base Temperature**	**Tip Temperature**	**ΔT (Base temperature - Tip temperature)**	**η (Efficiency)**	**ε (Effectiveness)**
Rectangular	39600	88.93	71.60	17.33	0.84	5.21
Cylindrical	39418.0378	98.26	66.27	31.98	0.73	4.55
Conical	33137.8755	97.46	75.33	22.12	0.88	4.60
Fully grooved cylindrical	42746.3677	95.20	61.81	33.38	0.71	4.74
Bottom half grooved cylindrical	43132.8086	94.22	61.36	32.86	0.71	4.81
Top half grooved cylindrical	42746.3677	95.00	61.89	33.19	0.71	4.76

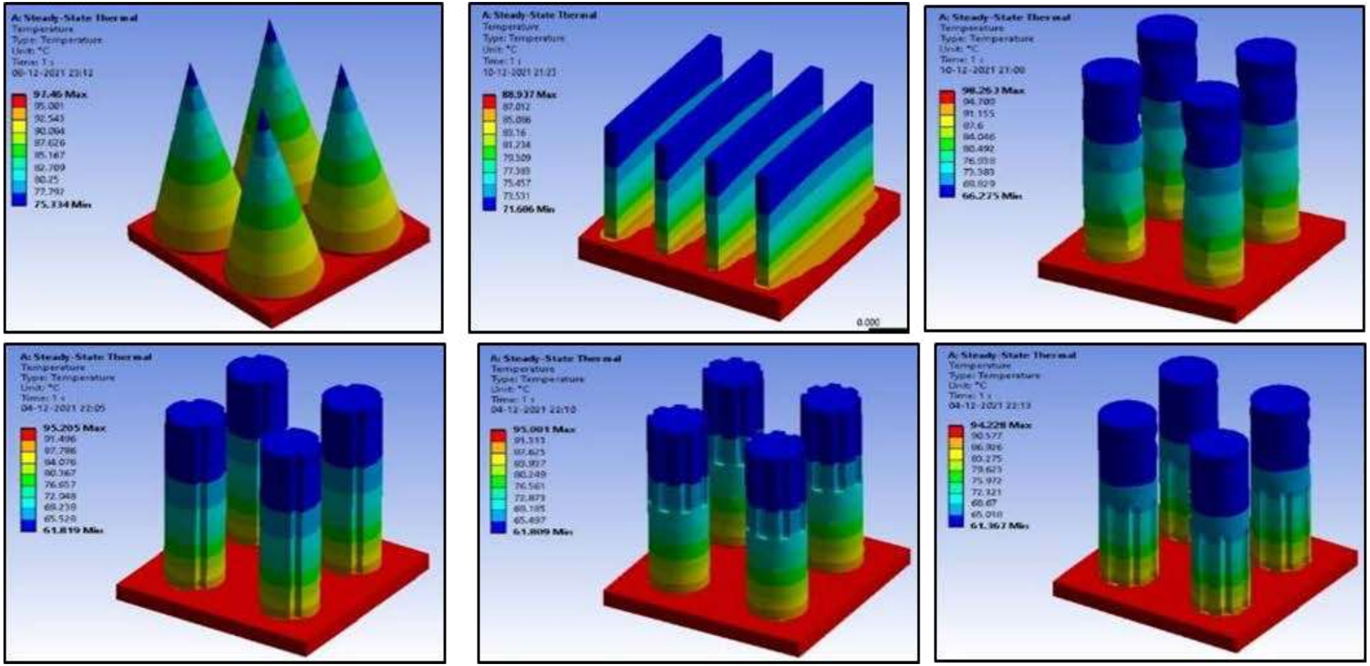

Fig 3: Temperature contours at different fins

5. Conclusion

The conical fin demonstrated the highest efficiency (84.3%) due to its exceptional heat dissipation capacity. On the other hand, the rectangular fin emerged as the most effective (effectiveness: 5.213), as it minimizes heat loss from the surface, with its temperature aligning closely with the base temperature when attached. Despite an increase in surface area through groove cutting, this technique does not significantly lower the base temperature to enhance efficiency, thus reducing its effectiveness. Consequently, groove cutting leads to decreased efficiency. The efficiency of fully grooved cylindrical fins, bottom half grooved cylindrical fins, and top half grooved cylindrical fins is notably lower compared to plain cylindrical fins due to the negative impact of groove cutting on efficiency. Conversely, three grooved cylindrical fins outperform plain cylindrical fins in terms of efficiency. Top half grooved cylindrical fins also exhibit higher effectiveness than plain cylindrical fins.

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Chapter - 23
Application of Geneva Mechanism in Automated Paper Cutting Machine

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Chapter - 23

Application of Geneva Mechanism in Automated Paper Cutting Machine

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Abstract

Industry 4.0 marks the advent of the fourth industrial revolution, characterized by the digitization and intellectualization of the manufacturing domain. This transformation entails a shift from conventional mass production to more specialized manufacturing techniques, leveraging technological advancements to enhance overall productivity. In the exploration of various mechanical systems, the Geneva mechanism has emerged as a pivotal component in the realm of automation, particularly in the context of Industry 4.0. Its applications span diverse industries including packaging, production and assembly lines, liquid filling equipment, coal handling, steel plants, bottling plants, and more. This paper offers insights into both the theoretical underpinnings and practical implementations of the Geneva mechanism model. The Geneva mechanism represents a prime example of an intermediary device adept at converting continuous rotational motion into intermittent rotary movement. Its operation encompasses alternating cycles of motion and rest. Among the mechanisms commonly employed are gear mechanisms, cam-wheel mechanisms, and intermediate gear mechanisms. While the inflated mechanism exhibits elevated noise levels and diminished accuracy, the cam-wheel mechanism excels in precision, accommodating a range of motion profiles; however, it necessitates meticulous processing. The intermediate gear mechanism, while impactful, mandates lighter loads. The primary objective of this project revolves around constructing an automated paper-cutting apparatus. The Geneva drive, an indexing mechanism, plays a pivotal role in effectuating the transition from continuous motion to intermittent motion, thereby enabling equidistant paper cuts. This innovation serves to curtail the reliance on manual paper cutting, resulting in considerable time savings. With far-reaching implications for the paper cutting industry, this automated machine stands to mitigate human labour and associated errors.

Keywords: Geneva mechanism, industry 4.0, intermittent motion, production, manufacturing.

1. Introduction

Mechanisms stand as foundational elements within the physical realm, forming the intricate scaffolds that orchestrate the operation of myriad objects and systems. These mechanisms function as elaborate frameworks, responsible for the transmission, conversion, and regulation of motion, energy, and forces. Ranging from the uncomplicated gears found within clocks to the intricate biomechanical systems within human bodies, these mechanisms occupy an indispensable role in influencing our interactions with and comprehension of the cosmos.

Across the annals of time, humanity has harnessed the potential of mechanisms to amplify efficiency, propel inventive leaps, and facilitate advancement across diverse domains encompassing engineering, physics, biology, and even philosophy. The exploration of mechanisms not only unveils the underlying tenets governing object behaviour but also constructs a bridge connecting theoretical constructs with pragmatic applications in the tangible world.

Within this voyage through the realm of mechanisms, we will immerse ourselves in the heterogeneous domain of mechanical systems, traversing the spectrum from elegantly simplistic to astonishingly intricate. We shall dissect the governing principles underpinning their functionality, unravel the ingenuity woven into their designs, and acknowledge the profound reverberations they impart upon contemporary technology and society at large. Through the comprehension of mechanisms, we attain profound insights into the inner machinations of our reality, thereby bestowing upon ourselves the capacity to forge, innovate, and mold the path ahead.

2. Literature review and Findings

We have studied different mechanisms with their advantages and limitations and are summarized as follows

2.1 Ratchet wheel mechanism

a) **Fundamental purpose:** The ratchet wheel mechanism serves as a pivotal tool for the conversion of continuous circular motion into intermittent unidirectional movement. Its core components encompass a toothed wheel and a pawl, harmonizing to facilitate rotation exclusively in one direction while obstructing any reverse motion.

b) **Merits:** Characterized by its uncomplicated configuration, economical production, and proficiency in scenarios necessitating sporadic movement restricted to a solitary direction.

c) **Confinements:** The scope of its functionality remains confined to unidirectional motion, rendering it less adept in comparison to alternative mechanisms in terms of precision. Moreover, its prolonged use may generate escalated levels of noise and wear over the passage of time.

2.2 Geneva wheel mechanism

a) **Fundamental role:** The Geneva wheel mechanism assumes a fundamental role in the transformation of ceaseless rotary motion into intermittent motion characterized by a consistent angular shift. This mechanism comprises a driving wheel harmonizing with a Geneva cross, the latter encompassing a revolving pin or plate etched with slots.

b) **Benefits:** Eminent for its exceptional precision, the Geneva wheel mechanism facilitates meticulous positioning, seamless motion, and accommodates scenarios necessitating exact indexing and intermittent movement.

c) **Constraints:** Constrained by its adherence to a set angular displacement, the Geneva wheel mechanism may not be universally suitable for all applications. Its optimal operation demands meticulous deliberation in design and alignment.

2.3 Cam wheel mechanism

a) **Fundamental role:** The cam wheel mechanism serves as a pivotal medium for transforming rotational motion into reciprocating or oscillatory motion. This process hinges on the utilization of a cam-an intricately shaped rotating disk-and a follower-a component maintaining contact with the cam-to facilitate the intended motion.

b) **Merits:** Renowned for its adaptability, the cam wheel mechanism boasts the capacity to generate diverse and intricate motion profiles. It proves invaluable for scenarios necessitating a broad spectrum of motion patterns.

c) **Limitations:** Notably, the adoption of this mechanism might introduce augmented mechanical intricacies and escalated manufacturing expenditures. Furthermore, contingent upon the specific design, wear and deterioration could manifest due to the sliding interaction between the cam and the follower.

2.4 Intermittent gear mechanism

a) **Core purpose:** The intermittent gear mechanism assumes a fundamental role in the conversion of uninterrupted rotary motion into intermittent motion through the utilization of gears featuring one or more notches or gaps in their teeth. This configuration facilitates meticulous indexing and regulated intermittent motion.

b) **Benefits:** Renowned for its exceptional precision, the intermittent gear mechanism is adept at achieving a diverse array of intermittent motion patterns. It stands as a fitting choice for myriad applications that hinge on accurate positioning.

c) **Constraints:** Notably, the design complexity associated with this mechanism surpasses that of its counterparts, possibly resulting in elevated intricacies during manufacturing and assembly processes.

2.5 Summary of study

- The ratchet wheel mechanism, while characterized by simplicity and cost-effectiveness, remains confined to unidirectional intermittent motion.
- The Geneva wheel mechanism, distinguished by its exceptional precision, is particularly well-suited for scenarios necessitating fixed angular displacement and meticulous indexing.
- The cam wheel mechanism, known for its capacity to generate a multitude of motion profiles, introduces the potential for heightened complexity.
- The intermittent gear mechanism, heralded for its precise indexing and intermittent motion capabilities, could entail greater intricacies in both design and manufacturing processes.

Table 1: Comparison of the four mechanisms

Name of mechanism	Structure and motion characteristics	Representative mechanism
Ratchet wheel mechanism	The structure is simple that is convenient to adjust the rotation angle; there exists a large impact and noise; the precision is poor	Shaper table horizontal feeding mechanism, one-way clutch, or overrunning clutch
Geneva wheel mechanism	The structure is simple, the size is small, the mechanical efficiency is high and it can be stable and intermittent for transposition. However, the changes in the acceleration rate in the process of motion are large and there exists a flexible impact,	Film feeding device of film projector Automatic transmission chain device

	which is not applicable to the high speed	
Cam wheel mechanism	The structure is simple, the operation is reliable and the transmission is stable. The rigid impact and the flexible impact can be avoided. The additional positioning device is not required. The processing and the assembly have high requirements	Cog zipper machine Match packing machine
Intermittent gear mechanism	The variation range of the time angle is large and the design is flexible. The process is complex, the impact is large and it is suitable for light load with low speed	Intermittent transposition and counting mechanism of the multi-station, multi-process automatic machine, and semi-automatic machine working table

2.5.1 Geneva mechanism

In scenarios where intermittent motion is a requisite, the Geneva mechanism stands out as a frequently adopted indexing solution. Moreover, when a situation demands the wheel's rotation to align with the crank's direction, the Inverse Geneva mechanism, a variant of the standard Geneva mechanism, comes into play. To facilitate the locking mechanism, a circular segment affixed to the crank engages by interacting with a raised rim positioned on the outer periphery of the wheel. This approach optimizes radial space utilization. The components comprising a traditional Geneva mechanism feature exclusively straight lines and circular arcs, a characteristic that contributes to straightforward and budget-friendly design and manufacturing processes. However, the conventional Geneva mechanism is not without its drawbacks. Specifically, a notable challenge arises when the driving crank makes contact with or disengages from the wheel slot, resulting in a considerable impact due to the abrupt acceleration changes at the initiation and culmination points of the motion.

The application of the Geneva Mechanism assumes a pivotal role in its categorization. This encompasses a variety of Geneva Mechanism types, including:

- The External Geneva Mechanism
- The Internal Geneva Mechanism
- The Spherical Geneva Mechanism

2.5.1.1 Applications & uses

i) To facilitate swift film fast-forwarding, modern film projectors often integrate an electronically controlled indexing system or a stepper motor.

ii) Geneva wheels, bearing the resemblance of the driven wheel, once found their place within mechanical clocks. However, these wheels were not utilized for propulsion purposes; rather, they served the role of regulating the tension in the spring. This regulation allowed the spring to operate within a narrow span, wherein its elastic force showcased near-linearity.

iii) The application scope of the Geneva drive extends to encompass automated sample devices, plotters, and mechanisms responsible for altering pens.

iv) The utility of indexing tables spans multiple domains, including assembly lines and CNC machine tool changers, among others.

v) The Iron Ring Clock employs a Geneva mechanism to orchestrate the intermittent movement of one of its rings.

2.5.1.2 Advantages of geneva mechanism

i) Among intermittent motion devices, the Geneva mechanism often stands out for its uncomplicated nature and cost-effectiveness.

ii) Their availability encompasses an extensive array of sizes, spanning from those suitable for machines and instruments to index spindle carriers that exhibit considerable tonnage.

iii) Despite superior motion curve attributes compared to ratchets, Geneva mechanisms exhibit a more pronounced "jerk," indicating an abrupt acceleration transition, in contrast to more sophisticated cam systems.

iv) The Geneva mechanism incorporates locking ring surfaces, ensuring consistent control over its load under varied circumstances.

2.5.1.3 Disadvantages of the geneva mechanism

i) The Geneva process exhibits limited versatility.

ii) Once the count of dwells per revolution is determined, the ratio between the dwell period and motion is defined.

iii) Every Geneva acceleration curve is demarcated by finite acceleration and deceleration, signifying the initiation and culmination points.

iv) Consequently, they engender abrupt accelerations, commonly referred to as "jerks."

3. Geneva mechanism in the paper-cutting machine

3.1 The primary components utilized in the fabrication of the model include

a) **Geneva wheel:** Incorporating a four-slot driven wheel, this component facilitates a 90-degree step movement for each rotation of the drive wheel. As a result, the intermittent motion covers 90 degrees out of the total 360 degrees. The mechanism converts continuous rotation into intermittent motion through the interaction of an intermittent gear. The drive wheel's pin enters the slot of the driven wheel, advancing it by one step, while a raised circular blocking disc secures it in place between steps.

b) **Sprocket:** A sprocket is a toothed wheel featuring a specific pattern of closely spaced teeth that mesh with the teeth of a chain. Employing a roller chain, sprockets serve the purpose of transferring power between two shafts. The sprocket operates as a toothed wheel with perforations designed to engage with chains or similar components. This contrasts with a smooth pulley, as sprockets lack the seamless fit of gears. Sprockets find application in scenarios where gears might not be feasible, such as bicycles, motorcycles, cars, tracked vehicles, and machinery, enabling the transmission of circular or linear motion between shafts or tracks.

c) **Roller chain:** To facilitate the transfer of power from the motor to the mechanism, we've employed a simplex chain in our model. Chain drives serve as positive drives, ensuring a mechanical transmission system that precludes slippage during power transmission. The chain's length in our model is 20 inches.

d) **Paper cutter or cutting blade:** This component encompasses a machine designed for the purpose of cutting paper using straight-edge paper cutters. The paper cutter serves as an oscillator in a 4-bar wrench and switch structure. The measurement units "Pounds per Square Inch" (PSI) and "Kilopound per Square Inch" (KSI) have been abbreviated as PSI and KSI respectively in the provided table.

e) **Motor:** An electric motor assumes the role of generating motion through the utilization of electric power supply.

3.2 Working

In this undertaking, we introduce a conceptualized paper-cutting apparatus designed to surmount the limitations inherent in existing systems. Our proposal revolves around a model machine that capitalizes on the foundational principle of the Geneva mechanism. The operational sequence commences with the rotational motion of a sprocket, a key initiator of the mechanism. This initiation prompts the conveyance of paper into the machine while concurrently activating a cutting tool linked to a distinct cam. This cutting tool effectuates the paper-cutting process.

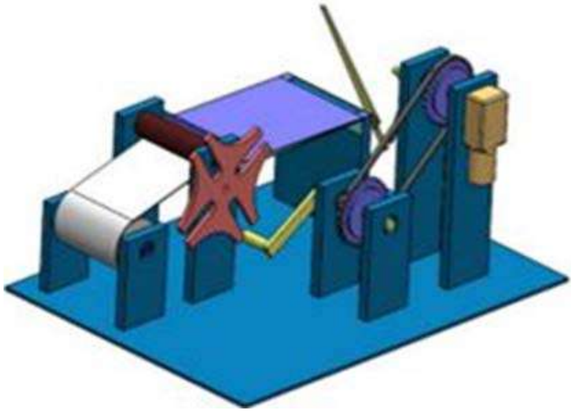

Fig 1: Comprehensive view of the model, showcasing its assembled configuration

The visual representation of our model is depicted in Figure 1. The core construction encompasses a solitary chain drive, intricately connected to a Geneva mechanism. A pivotal connection links the driven plate to the cam, orchestrating the movement of paper from a roll. The operational sequence functions as follows: upon manual rotation of the hand lever, the connected pin experiences motion, in turn driving the driven plate. The driven plate's connection to the conveyor facilitates the controlled unrolling of the paper, while a spring-driven knife executes precise paper cutting. The driven plate, notable for its four slots, ensures regulated intervals for the paper-cutting procedure.

Conclusion

The application of paper-cutting devices utilizing the Geneva mechanism holds significant promise, especially for small-scale companies. Presently, existing paper-cutting machines bear several limitations, including their substantial size, high costs, dependence on manual labor, and the need for electrical power input. Our proposed solution, however, offers a remedy to these shortcomings through its compact size, affordability, and minimal reliance on specialized labour. This innovative machine addresses the aforementioned drawbacks by capitalizing on its small-scale design, cost-effectiveness, and reduced dependence on skilled operators. Notably, the objectives underpinning this equipment encompass expediting the processes of paper marking and cutting.

For small-scale enterprises, embracing the design and analysis of paper-cutting devices grounded in the Geneva mechanism proves especially advantageous. The current landscape may feature larger and costlier machines that necessitate extensive manual effort and electrical consumption. Yet, our machine emerges as a transformative solution, characterized by its compact form, economic viability, and diminished need for professional labour. The pivotal aims driving the development of this apparatus revolve around accelerating both the marking and cutting phases of paper-related operations.

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Chapter - 24

Design and Implementation of a Smart Garbage Bin for Solid Waste Management using Computer Vision and Internet of Things

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Chapter - 24

Design and Implementation of a Smart Garbage Bin for Solid Waste Management using Computer Vision and Internet of Things

Subhadeep Pal, Barish Moitra and Pralay Mudi

Abstract

The increasing global population and urbanization have led to a significant rise in solid waste generation, posing serious environmental challenges. Proper waste management and efficient waste segregation are crucial to reducing the environmental impact and promoting sustainable living. The majority of the waste is not recycled correctly due to faulty waste segregation, and this research paper presents the design, development and implementation of a Smart Garbage Bin (SGB) equipped with computer vision and sensors for automatic solid waste segregation. The proposed SGB employs computer vision algorithms to identify and classify different types of solid waste, including organic waste, metal waste, plastic and other waste. The research outlines the methodology used for the development of the SGB, which involved the integration of cameras and sensors to create an automated waste segregation system. Advanced algorithms are utilized to train the computer vision model, enabling accurate waste classification and minimizing false positives. The results demonstrate the effectiveness of the Smart Garbage Bin in segregating solid waste, promoting recycling efforts, and reducing the burden on conventional waste management systems. By employing this technology, communities can significantly improve waste sorting accuracy and lower the environmental impact of mismanaged waste. The Smart Garbage Bin's ability to automatically segregate solid waste marks a significant advancement in waste management practices, fostering sustainability and paving the way for more intelligent and greener cities.

Keywords: Computer vision, waste management, internet of things, smart garbage bin, customizability.

1. Introduction

Solid waste management is a crucial and complex process that involves the collection, transportation, disposal, and recycling of various types of solid waste generated by human activities. As societies continue to grow and urbanize, the generation of solid waste has become a significant environmental and public health challenge. Effective solid waste management is essential to minimize environmental pollution, conserve natural resources, and promote sustainable development. Solid waste encompasses a diverse range of materials, including household waste, industrial byproducts, electronic waste, and more. Improper handling and disposal of these wastes can lead to a variety of adverse impacts, such as soil and water contamination, air pollution, habitat destruction, and the spread of diseases. Over the years, the field of solid waste management has evolved, incorporating innovative techniques and technologies to address these challenges. Modern approaches prioritize waste reduction, reuse, and recycling, aiming to reduce the amount of waste that ends up in landfills or incineration facilities. Recycling solid waste consists of a complicated process to sort out various waste materials such as metal, plastic, organic and other wastes. Proper segregation at source is the first step to stop recyclable items from ending up in landfills (Ortaliz *et al.*, 2020). A modified way of sorting solid waste is to use computer vision (Ramsurrun *et al.*, 2021). The waste product is being classified using computer vision and multiple sensors (Ortaliz *et al.*, 2020). A camera connected to a microcomputer along with other sensors will help in detecting the type of waste after which the bin's internal mechanism will make sure the waste reaches its proper trashcan (Ortaliz *et al.*, 2020) (Suddul *et al.*, 2018). The main pro of this garbage bin is the flexibility and customizability it offers with the variety of wastes it can detect using computer vision. By separating recyclable materials from other waste streams, this garbage bin can significantly increase recycling rates which helps divert more waste from landfills thus reducing the environmental impact of waste disposal.

2. Materials & Methods

2.1 Sensors and Modules used in the mechanism

Orange Pi 5: The Orange Pi 5 is the brain of this garbage bin. It is chosen over the famous Raspberry Pi because of its capability to run the YOLO (You Only Look Once) v5 Algorithm much smoother with a higher fps as compared to the Raspberry Pi as it has a built-in NPU (Neural Processing Unit) with 6 Tops computing power making it much more suitable for AI Applications (Orange Pi 5, 2023).

Camera module: The Camera Module connected to the Orange Pi 5 is used to enable the Orange Pi to make detections using the YOLOv5 algorithm. The Camera Module will have LEDs attached to it which will turn on when the camera module is making detections as it is difficult to make detections in a dark environment.

Servo motors: The motors are used to rotate the Gates (Gate 1, Gate 2, Gate 3) accordingly based on the detections made by the camera module and the sensors to get the waste to the proper trashcan.

Humidity sensor: The Humidity Sensor helps detect any increase in humidity after the trash is introduced in the garbage bin thus helping in the identification of wet wastes. Based on this and the detections made using the camera module it helps in the identification of organic wastes (Das *et al.*, 2021).

Inductive proximity sensor: The Inductive Proximity Sensor helps in detecting metal and thus identifies metal wastes such as metal cans.

Infrared sensor: The Infrared Sensor helps in detecting if a waste is thrown in the bin and thus activates the whole garbage bin. The main purpose of this sensor is to save power thus making the garbage bin power efficient.

2.2 Design of the garbage bin

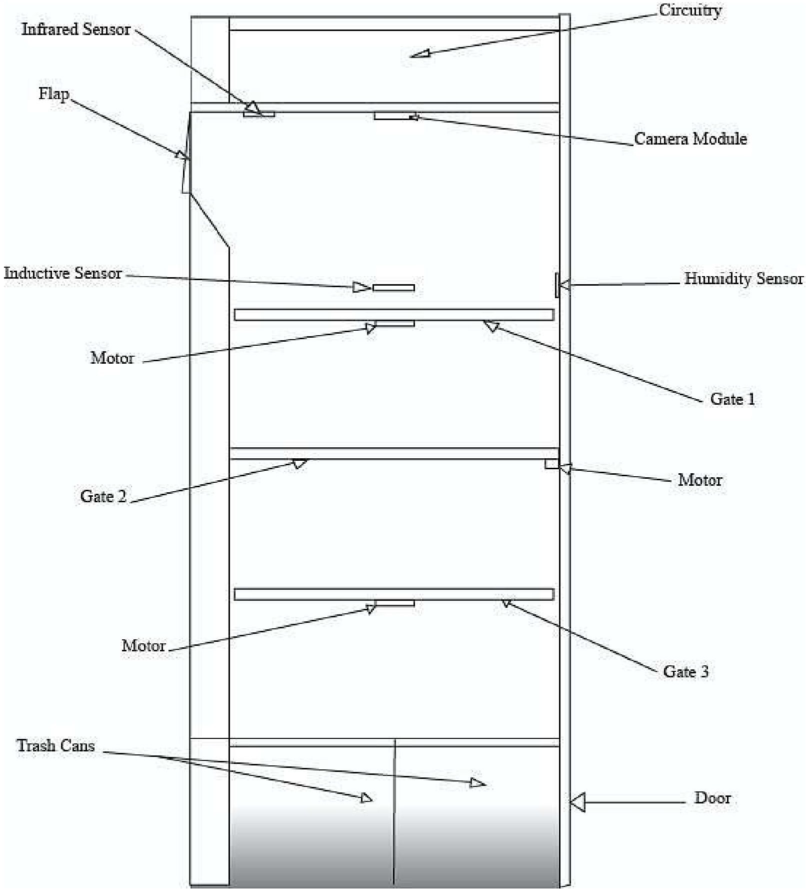
After the waste is thrown in the bin, the infrared sensor senses it and activates the camera and the other sensors. The waste then lands on the first gate (Gate 1) where the detection is made using computer vision and the sensors (humidity sensor and inductive proximity sensor). After the detection is made and the waste is identified as metal, organic, plastic, or other waste, the servo motors rotate the gates accordingly to make sure the waste reaches the proper trashcan (Ortaliz *et al.*, 2020). Figure 1 depicts the diagram of garbage bin of present work.

2.2.1 Design of the gates

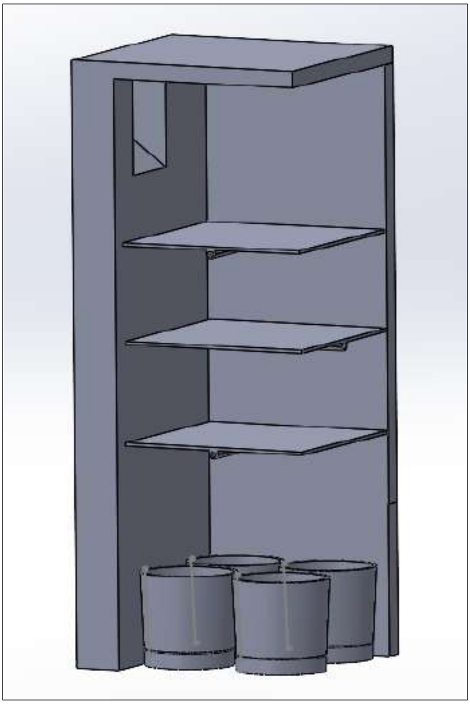
The Gates must be coated with a hydrophobic substance to prevent any wet waste from sticking to them.

2.2.1 Design of the flap

The opening of the garbage bin will be small such that if someone has to throw a plastic bottle, they will have to crush it before throwing it, thus preventing any foul play, i.e., reusing the thrown plastic bottle and selling it instead of proper recycling. The flap will be designed to guard the opening of the garbage bin, preventing any unwanted substances from entering the bin that might damage the mechanism. The user will have to push the flap in order to throw the waste.


Circuitry
Infrared Sensor
Flap
Camera Module
Inductive Sensor
Humidity Sensor
Motor
Gate 1
Gate 2
Motor
Motor
Gate 3
Trash Cans
Door

(a)



(b)

Fig 1: Diagram of the Garbage Bin (a) 2D view, (b) 3D view (NTS)

2.2.2 Accuracy

The accuracy in identifying the type of waste is significantly increased by employing both computer vision and sensors for detections (Ortaliz *et al.*, 2020).

2.2.3 Scope of customization in this garbage bin

The use of computer vision in detecting waste should theoretically give more customization options based on the environment of the garbage bin. For example: Let's consider a hospital environment. Now, obviously, the type of waste generated in a hospital will be different as compared to the waste generated in a shopping mall. Considering this, the YOLOv5 algorithm can be trained on a distinct dataset containing images of items like syringes, bandages, and so on. This will enable the bin to segregate wastes at a higher level based on the environment it is in.

Another modification could be the use of an UV lamp inside the garbage bin, which would be very useful in a lab environment. This slight modification in the garbage bin would be really helpful in a lab environment, as it would help sterilize the wastes thrown in it to prevent the growth of any unwanted microorganisms.

Another slight modification could be the use of an Ultrasonic sensor, which could be used to monitor if the trashcans are overflowing or not and thus alert the person in charge to empty the trashcans.

2.2.5 YOLOv5 Algorithm

The deep learning model selected for training of the waste object detection is the YOLO (You Only Look Once) v5 model which is found to produce best results in object detection (Puthussery *et al.*, 2023). The YOLOv5 Algorithm was trained on a custom dataset (YOLOv5, 2023). A very small dataset was used. All the images in the dataset were collected and manually labelled using "labelImg" (Human signal/ labelImg, 2022), an open-source tool. Then it was trained with an epochs value of 200.

3. The Proposed Algorithm for Waste Segregation

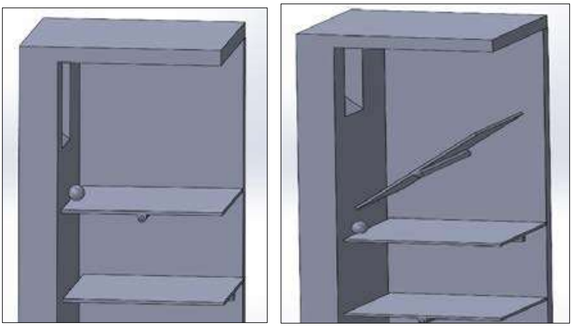
When the user pushes the flap and throws something in the garbage bin the infrared sensor detects it and activates the whole garbage bin.

After the trash is dumped into the garbage bin it lands onto the first gate. Then the camera module using the YOLOv5 algorithm along with the sensors (moisture sensor and inductive proximity sensor) detects the type of waste.

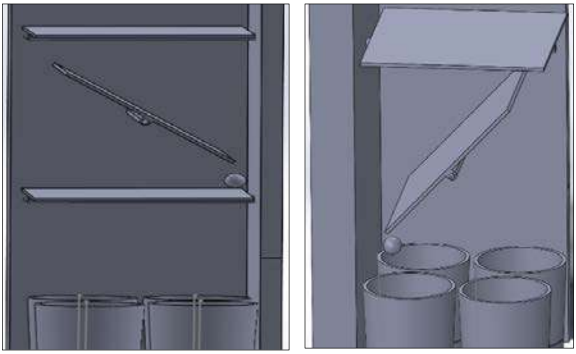
After the detection is made the first gate along with the other gates rotate accordingly to put the waste in the correct trashcan.

3.1 Rotation of the gates

Rotation of gates after throwing garbage in the bin is discussed below and Figure 2 depicts the steps of movement of garbage inside the bin through the gates.



(a) **(b)**



(c) **(d)**

Fig 2: Steps of movement of Garbage inside the Bin

Step 1: Trash lands on the first gate and gets detected and identified through the camera (above) and the sensors (on the sides). (Figure 2a)

Step 2: After trash gets detected and identified the first gate rotates accordingly (allowing the object to quickly get to the second gate) and quickly rotates back to its initial position. (Figure 2b)

Step 3: As the waste has been identified, the motors rotate the gates accordingly to get the trash to its labelled trashcan. (Figure 2c)

Step 4: The trash thus gets collected in the proper trashcan. (Figure 2d)

4. Results and Discussion

The YOLOv5 Algorithm was able to detect the type of wastes although for better results, a much larger dataset with a lot of variations in the data must be used to prevent issues like over fitting.

In the loss function graph, it can be observed that as each training epoch progresses, the loss is diminishing and converging towards a lower value, signifying that the model is undergoing learning. Thus, from the graph it can be observed that the model is learning. Figure 4 is showing the loss function graph.

The results look promising and this algorithm can be trained on a custom dataset to detect a wide variety of wastes generated in various settings thus giving it a lot of customizability.

Fig 3: Detection of Garbage using the YOLOv5 Algorithm

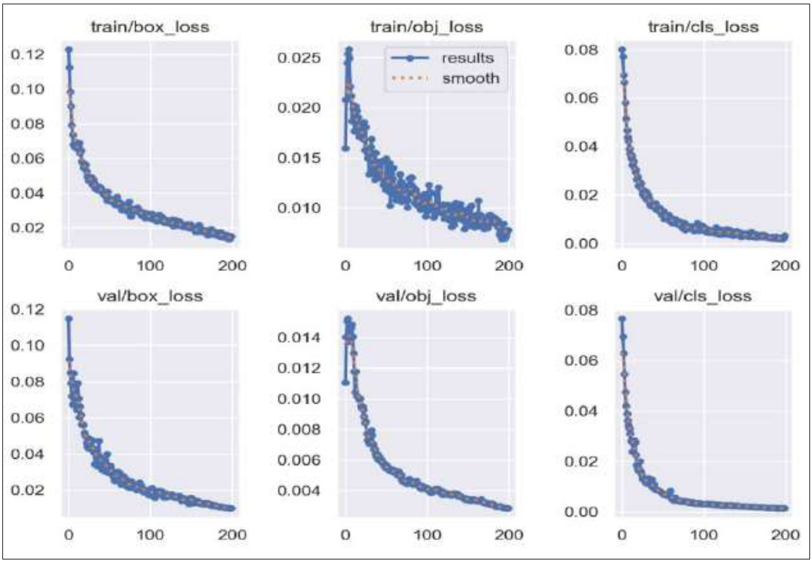


Fig 4: Loss function graph

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Chapter - 25
An Approach to Design Cerebra-Vascular-Haemato-Cardiac Detector Using Artificial Intelligence and Machine Learning

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Chapter - 25

An Approach to Design Cerebra-Vascular-Haemato-Cardiac Detector Using Artificial Intelligence and Machine Learning

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Abstract

Cerebrovascular stroke and heart attack is a leading cause of disability and death worldwide and early detection is crucial for effective treatment. Electroencephalograph (EEG) and Electrocardiograph (ECG) in stroke and cardiac arrest diagnosis needs different systems, which are not wearable due to bulky instruments. To address this problem, a Cerebro-Vascular-Hemato-Cardiac (CVHC) detector is proposed for stroke and cardiac arrest detection. The major components of the CVHC detector are EEG and ECG; apart from these, the oxygen sensor and the blood pressure sensor are also integrated with our proposed CVHC system that will sense the different anomaly levels in the human body. This developed CVHC device detects strokes, cardiac arrests, respiratory problems, and heat strokes while providing immediate emergency alerts using Artificial Intelligence and Machine Learning (AIML). The signals from ECG, EEG, blood pressure sensor, and oxygen sensor are processed by a simulator, Discrete Wavelet Transformation (DWT), and Cerebral Neural Network (CNN) for the convolution, noise reduction, and wavelet differentiation of EEG and ECG signals and ultimately amplifying it to achieve a usable voltage. This developed system will then be used to detect Ischemic Stroke, Hemorrhagic Stroke, and Cardiopulmonary Arrest by comparing the acquired signal to that of predefined normal brain and heart activities.

Keywords: ECG, EEG, AI-ML, DWT, CNN.

1. Introduction

A stroke, also known as a brain attack, is an unforeseen and serious medical condition caused by a dislocation in the blood force to a part of the brain, performing in a lack of oxygen and essential nutrients. Strokes can be divided into astronomically two orders. Ischemic stroke1 occurs when a blood clot obstructs a blood vessel, it prevents blood from flowing to a specific region of the brain. Ischemic strokes regard for utmost stroke cases and can be caused by a variety of factors, including atherosclerosis (the accumulation of adipose deposits in blood vessels), embolism (a blood clot that travels from another part of the body), or thrombosis (the conformation of a blood clot within a blood vessel). Hemorrhagic stroke 2, on the other hand, occurs when a blood vessel within the brain ruptures, causing bleeding into the girding brain towel. This type of stroke is less common, but it is frequently more severe because the accumulated blood can put pressure on brain structures and beget fresh damage. Because it weakens blood vessel walls over time, hypertension (high blood pressure) is a significant threat factor for hemorrhagic strokes. MRI and CT checkups are the most habituated styles for neurological stroke opinion, but other studies have shown that bio-signals like brain swells, muscle, and electrocardiograms can also be used to diagnose and help stroke conditions. likewise, ultrasound, echocardiography, cerebral angiography, and single photon emigration reckoned tomography (SPECT) are being used to determine the most common causes of stroke [1], [3], [4]. These though being the most popular imaging fashion for stroke opinion, still have their downsides in examination and opinion due to hypersensitive responses to discrepancy agents, medicine penetration, radiation, and claustrophobia in a confined space[2], [5], [8]. Cardiac arrest is a life-changing medical exigency characterized by the abrupt conclusion of the heart's pumping function. It occurs when the heart's electrical signals come chaotic, leading to an irregular and ineffective twinkle, which can beget blood rotation to stop. Without immediate intervention, cardiac arrest can affect death within twinkles. Cardiac arrest can be caused by several factors, including underpinning heart conditions like coronary roadway complaint, a heart attack (myocardial infarction), arrhythmias (Abnormal heart measures), and certain inheritable conditions. medicine overdose, severe electrolyte imbalances, and traumatic injuries are all possible causes. The heart's normal electrical exertion is disintegrated during cardiac arrest, causing it to shudder (ventricular fibrillation) or stop fully (Asystole). This erratic electrical exertion prevents the heart from effectively pumping blood to the body and brain, performing in unconsciousness and imminent peril. According to the current study, the only way to detect strokes and cardiac arrest is by using a CT scan or MRI scan, or ECG. The amount of time, expense, and money needed to do these checkups might sometimes lead to the death of the patient during emergencies. The instruments used in these are mainly present in hospitals and sometimes they are faulty which may lead to more problems. The instruments are also very much bulky making it somewhat impossible to carry around. As a result of which a profound idea is needed in order to approach this problem. Moreover, the rate of death via both stroke and cardiac-related diseases is increasing day by day so preliminary detection and observation are vital in preventing death and other life-taking symptoms. So, in this paper, we propose a new way of cardiac arrest and stroke detection using EEG (Electroencephalogram) and ECG (Electrocardiogram). Our proposed system can instantly detect the presence of abnormalities in the normal self of the human by comparing it with the pre-existing data of the normal behavior of the human body. By using artificial intelligence and machine learning (AIML) we propose to create an app that will detect and send immediate SOS to the nearby hospital as soon as it detects abnormalities. We use simple electronic devices to make this system as much as portable and wearable. The system uses DWT (Discrete wavelet Transform) for transforming the multi-modal signals acquired from the EEG and ECG. It was also experimentally determined ECG and EEG signals show prominent change during stroke and cardiac arrest thus making the system sustainable. Moreover, the concept of using EEG and ECG together gives us a precise result in stroke and cardiac arrest detection because both the disease factors depend on the prominent abnormalities in the heart and brain. The rest of the sections of this paper is structured in such a way that it discusses the initial advancement of our study and acquires the EEG and ECG signals and creates a database for future comparison with disease signals.

2. Motivation & Objectives

Stroke and Cardiac arrest related disease rate

According to Global Burden of Conditions (GBD), India bore the utmost of the burden of stroke with 68.6% prevalence of stroke, 70.9% stroke deaths, and 77.7% disability acclimated lifetimes (DALYs) lost.

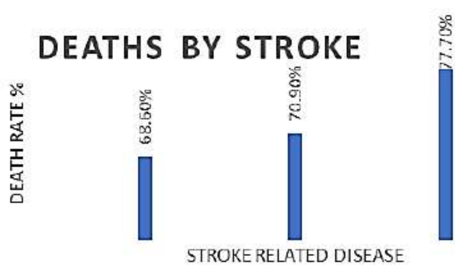

Fig 1: Graphical representation of Stroke and Cardiac arrest related disease Rate

The average age of the SCD (Sudden Cardiac Death) population was 60.8% (35-85 years), with 55.5% being between the ages of 50 and 70. 38%

had coronary artery disease (CAD), and 17% had a documented acute myocardial infarction, but only about 10% had revascularization. In the SCD cohort, 80.6% of subjects had at least one risk factor-diabetes, hypertension, or smoking - and this proportion was similar in subjects over and under the age of 50.

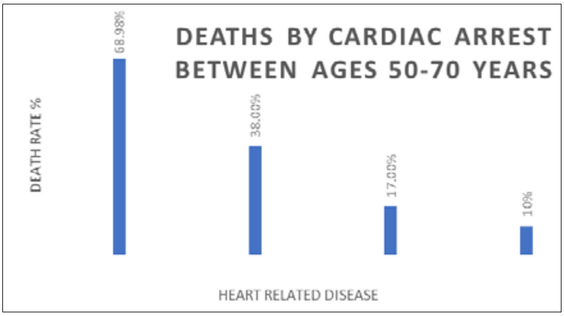

Fig 2: Graphical representation of Pulmonary-related Disease

3. Methodology

We hereby now describe the way to get the signals in the different situations So, in the case of getting all the signals from the brain, we need a high-definition EEG and ECG sensor with the help of which we can catch the electromagnetic waves via the electrodes connected to the different parts of the brain. Here is the overview of the electrode configuration:

There are 12 electrodes connected directly to the skull

1) 4 electrodes in the frontal cortex
2) 4 electrodes in the medulla oblong Ota the neck region
3) 4 electrodes under each ear lobe

And there are 4 electrodes connected directly to the chest.

Figure 3 shows the parts where the electrodes have been placed.

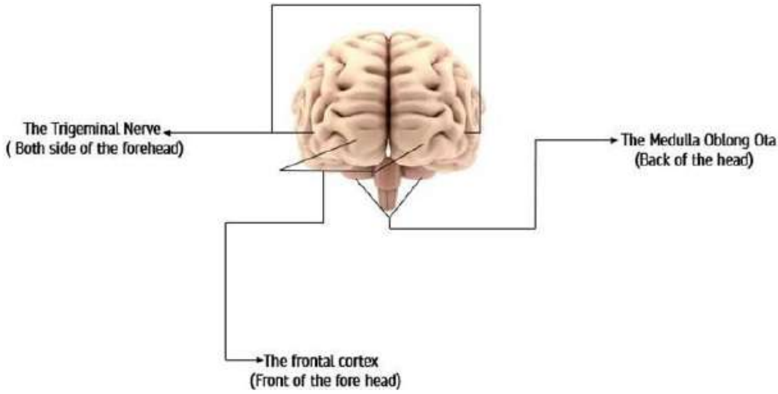

Fig 3: Parts of the brain where electrodes are to be placed

EEG and ECG graph acquiring

So, we use a software known as Brain Bay where we use this to detect the brain signals getting picked up by the EEG and ECG transducer.

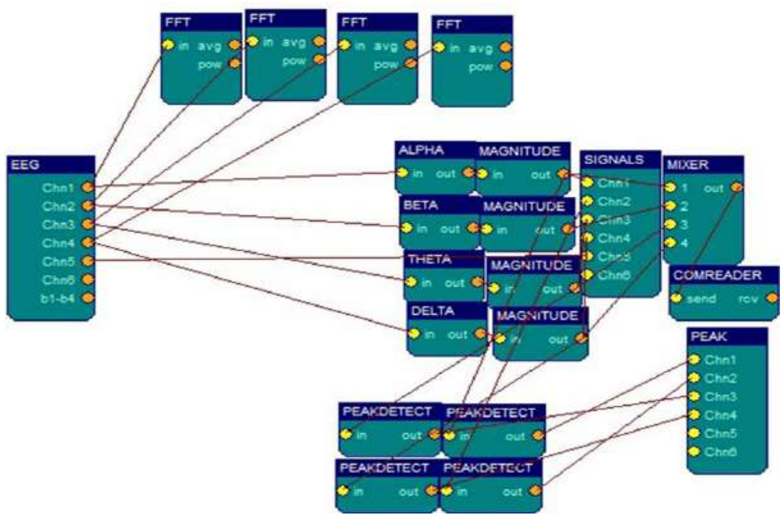

Fig 4: Algorithm of brain signal of brain by the software to detect EEG sensors

Table 1: Different voltage values of the signals collected from the electrodes connected to the three different sections of the brain

Types of signal	Maximum output (µV)	Minimum output (µV)
Frontal Cortex	51.49	0.00
Medulla Oblongata	102.88	0.00
Trigeminal Nerve	133.69	0.00

In order to proceed further we hence forth need to include the Arduino sketch for the EEG & ECG signals in the uno/nano used by the biochip.We use the BIOAMP EXG PILL which is one of the best standalone bionic chips available in the market. It has an inbuilt bandpass filter which helps to get off the excess noise from the signals gained by the electrodes**.** Moreover, by using 4 electrodes mainly in the frontal cortex, medulla oblong Ota, trigeminal nerve, and in the chest gives us the different signal positioning in desired locations. As seen in figure 4, the algorithm uses a 5 channel EEG source with each channel consisting of the same signal that is getting acquired and fed to A0 pin of the nano\uno by the electrodes. After that the signals go to the FFT module (spectrum analyser) which hereby shows the 3d representation of the different wave forms. The channels of the EEG source then pass through the filters with different frequency domain to differentiate between the Alpha, Beta, Delta, Theta wave forms. Furthermore, from these filters the output is taken to the Peak module which thereby shows the peak voltages in the different waveforms. These statements will be further more clear by seeing the visual representation present in Figure 11.

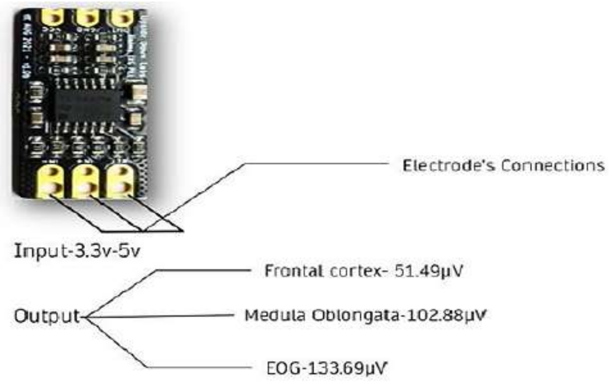

Fig 5: The bionic chip used

Frontal cortex

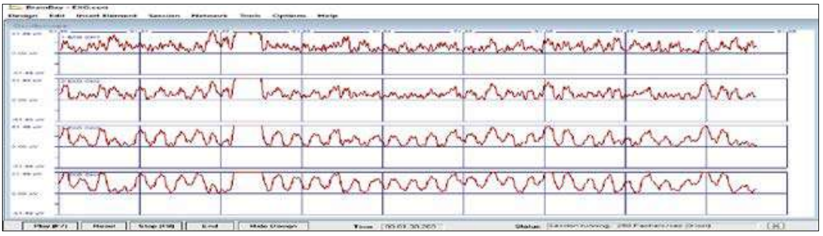

Fig 6: The graph we found in the frontal cortex region

Our frontal cortex has mainly two main nerves:

1) Supraorbital nerve
2) Supratrochlear nerve

This part of the skull gets the highest number of alpha waves as a result so the signal strength of the alpha signal is high. In the figure 6, we can see the maximum voltage output of the signal is 51.49 microvolts. So, this is the pure alpha waves signal. But this above raw signal needs to be filtered through further filtration system thus leading to a better voltage of the alpha wave. If we observe, we can see that the brain signal is quite messy due to the presence of involuntary motions and the muscle movements of the eyes and the other body muscles. As a result, the post-filtration of the signal is necessary.

Medulla oblongata

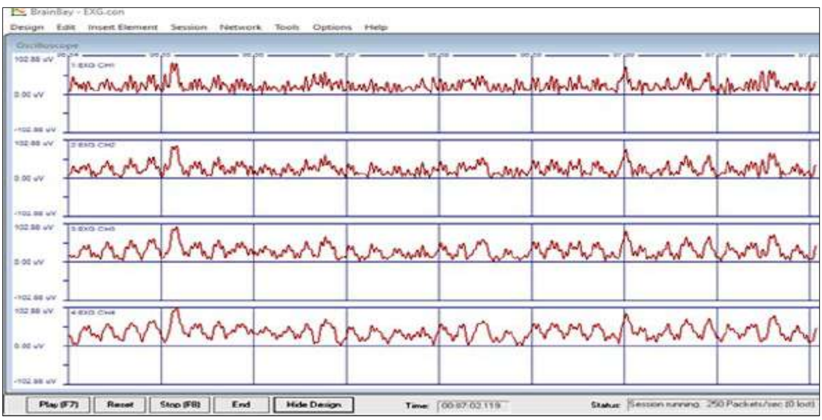

Fig 7: The graph we found in the Medulla Oblongata region

The back of the brain is the most important part because this part controls all the involuntary activities in the brain as a result of which u can find that the signals in the Figure 7 are quite fluctuating. Unlike other parts, this part may contain noise that will be further filtered using MATLAB and LAB VIEW simulations.

Trigeminal nerve

The Trigeminal Nerve is part of the brain which is connected to both sides of the forehead it is also known as the EOG signal. The signals due to changes in eye movement are the biggest issue present in this area which needs to be filtered. U can see the maximum voltage here is 133.69 microvolts because of the presence of spikes in it due to eye muscle movement.

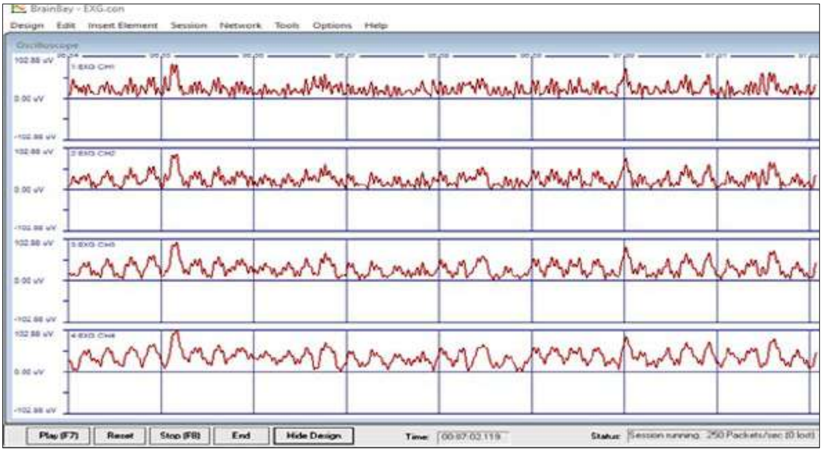

Fig 8: The graph we found in the Trigeminal Nerve region

ECG signal capturing

We use the same concept of capturing EEG signals in the case of ECG as seen in Figure 9. But as we know ECG contains a lot of muscles thus it has a lot of noise so the processing part needs to be very clear of the fact that muscle contraction can lead to anomalies in the signal capturing. The electrodes will be directly placed in the chest to get the signal of the heart as clear as possible.

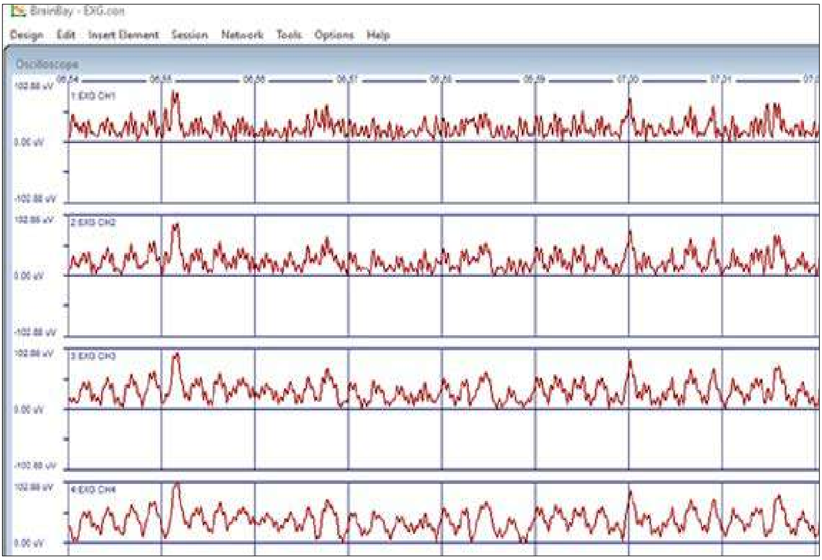

Fig 9: The graph we found in the Chest region

Filtration and Processing

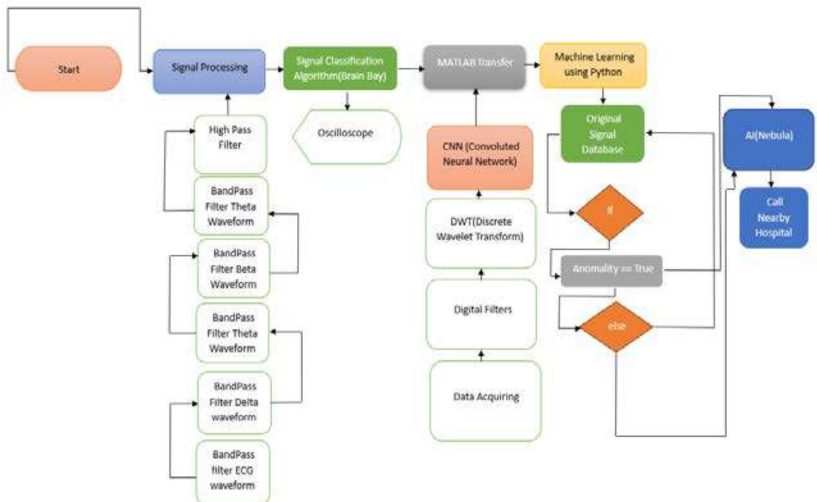

Fig 10: Process Flow Chart

We use the above algorithm to filter the EEG signal and differentiate the following waveform into alpha beta gamma delta theta waveforms from the raw signals.

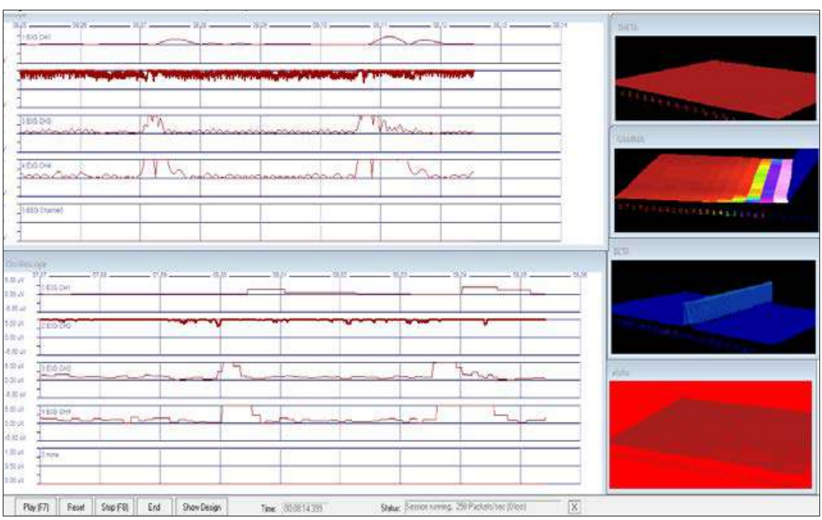

Fig 11: Wavelet Transformation and division using Brain Bay Software

4. Results and Discussions

After this EEG and ECG signals as shown in the above figure needs to be convoluted together using MATLAB. Configuring this will give us a generalized library of the normal brain and heart signals which can be used as a library for Machine Learning. But before that, we need post-process these signals so that more noise can be reduced further leading to a precise convoluted graph. The catch here is taking the peak of the voltage in the convoluted graphs of the normal and the abnormal signals of the brain and heart. After this, the processing of the entire signal will be going to Python programming. In this Python programming, there will also be present some ECG and EEG digital filters which thereby further reduce the noise. After this, the programming flowchart comes to light. Here the signals come to the Python programming using putty software. The programming compares the normal signals to that of the anomaly signal leading. After this, Our Personalized AI uses this as the input and then checks the anomaly and if it increases the normal threshold anomaly level it calls the nearby hospital.

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Chapter - 26
An Approach to Design Fatigue Detection System Based on Behavioural Characteristics of a Driver Using Neural Network

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Chapter - 26

An Approach to Design Fatigue Detection System Based on Behavioural Characteristics of a Driver Using Neural Network

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Abstract

Driver fatigue is a significant factor contributing to road accidents and fatalities worldwide. Traditional fatigue detection systems primarily rely on physiological signals, such as eye movements and heart rate, but they often suffer from accuracy and reliability issues. This paper proposes an innovative approach to driver fatigue detection based on the analysis of behavioural characteristics. This paper introduces an improved fatigue detection system that leverages advanced computer vision techniques and machine learning algorithms to monitor and interpret the behavioural patterns of the driver. Utilizing in-vehicle cameras and maybe surveillance cameras, the system captures real-time facial expressions, head movements, and eye behaviour to assess the driver's level of fatigue. The collected data is then processed through a multi-layered deep learning model trained on a vast dataset of fatigue-related behavioural samples. In critical situations, the system activates visual or auditory alerts to warn the driver about their fatigue level, prompting them to take necessary breaks or rest stops. The paper also addresses concerns related to privacy and data security by implementing strict anonymization protocols for the collected facial data, ensuring compliance with existing data protection regulations. In conclusion, this paper presents a novel and reliable fatigue detection system that enhances road safety by detecting driver fatigue based on behavioural characteristics. The results indicate that leveraging facial expressions, head movements, and eye behaviour provides a promising and accurate alternative to traditional methods. The system's integration into existing vehicle safety systems promises to be a crucial step towards reducing road accidents caused by driver fatigue and ensuring safer roads for all motorists.

Keywords: Fatigue detection, real-time, behavioural patterns, safety, neural network.

1. Introduction

Driver fatigue is a significant contributor to road accidents, posing a severe threat to both drivers and other road users. The consequences of fatigued driving are well documented, ranging from impaired reaction times to compromised decision-making abilities. While various fatigue detection systems have been developed, many rely on physiological indicators that may not comprehensively capture a driver's cognitive state. In response to this challenge, this project paper presents a novel approach to fatigue detection that leverages the behavioural characteristics of drivers. Traditional fatigue detection systems have primarily focused on physiological signals such as eye movement, heart rate variability, and brain activity. However, these indicators can be influenced by factors beyond fatigue, leading to inaccurate assessments. In contrast, behavioural characteristics, encompassing facial expressions, head movements, and hand gestures, offer valuable insights into a driver's alertness and attentiveness. The advantage of using behavioural cues lies in their direct correlation with cognitive state, making them a promising avenue for improving the accuracy of fatigue detection. This project seeks to address the limitations of existing fatigue detection methods by developing an innovative system that captures, processes, and interprets behavioural cues in real-time. By applying advanced machine learning techniques to these cues, the proposed system aims to provide timely and accurate alerts, mitigating the risks associated with fatigued driving. The integration of behavioural characteristics into fatigue detection not only enhances the precision of assessments but also contributes to a more comprehensive understanding of driver behaviour.

2. Motivation behind the project

Fatigue-related accidents have been a longstanding concern, leading to numerous fatalities and injuries each year. Understanding and addressing the factors driving this issue are crucial for the well-being of drivers, passengers, and other road users. Several key motivations underscore the importance of developing an effective fatigue detection system:

Human life preservation: Fatigue-related accidents can have devastating consequences. Lives are lost, families are shattered, and communities are impacted. The primary motivation is to minimize these tragic outcomes by detecting signs of driver fatigue in real-time and prompting timely interventions.

Reducing accident rates: Driver fatigue contributes significantly to the overall accident rate. The development of a fatigue detection system offers a proactive solution to reduce the frequency of accidents caused by drowsy driving, leading to safer roads and fewer injuries.

Public health: Road accidents resulting from driver fatigue burden healthcare systems and resources. Addressing this issue directly contributes to public health initiatives by lowering the number of accident-related hospitalizations and medical costs.

Economic impact: Accidents resulting from driver fatigue lead to substantial economic losses due to property damage, medical expenses, insurance claims, and lost productivity. A fatigue detection system can help alleviate these economic burdens.

Regulatory compliance: Many regions have regulations or guidelines in place to address driver fatigue. Developing a robust fatigue detection system can assist in complying with these regulations, promoting responsible driving practices.

Enhancing driver well-being: Driver fatigue not only jeopardizes the safety of others but also endangers the driver's own well-being. A fatigue detection system serves as a reminder for drivers to prioritize their own health and take breaks when needed.

Behavioural insights: Investigating behavioural characteristics associated with fatigue can offer insights into human cognition, attention, and alertness. This research can contribute to a better understanding of human behaviour in various contexts beyond driving.

Driver experience improvement: Implementing a non-intrusive fatigue detection system enhances the overall driving experience. It provides drivers with a tool to monitor their fatigue levels and make informed decisions to avoid dangerous situations.

3. Behavioural characteristics and their indications

Behavioural characteristics that determine fatigue among drivers can be observed through changes in actions, movements, and overall responsiveness. A comprehensive fatigue detection system should integrate several of the behavioural characteristics alongside physiological and vehicle-based indicators. By combining multiple sources of data, such a system can provide a more accurate assessment of driver fatigue, reducing the risks associated with drowsy driving.

Detecting these characteristics is crucial for identifying fatigued drivers and responding appropriately to ensure road safety. Although these characteristics may depend upon various factors, determination of these marks the first step of fatigue recognition as per general indications.

Blink frequency

- **Detection:** Use cameras or eye-tracking technology to monitor the driver's eye movements and measure blink frequency.
- **Indicators:** Increased frequency of slow or prolonged blinks, extended periods of eye closure.

Eye gaze

- **Detection:** Cameras or eye-tracking technology can analyze the driver's eye gaze and track its steadiness and focus.
- **Indicators:** Fixed or narrow gaze, difficulty maintaining consistent eye movements, lack of focus on the road or mirrors.

Head nodding

- **Detection:** Cameras focused on the driver's face can capture head movements and detect frequent nodding.
- **Indicators:** Repeated head drops followed by jerking back up, indicative of fighting off sleep.

Yawning

- **Detection:** Cameras with facial analysis capabilities can detect yawning episodes.
- **Indicators:** Excessive yawning, especially if it occurs frequently over a short period.

Slower reaction times

- **Detection:** In-vehicle sensors or telematics systems can monitor driver response times to external stimuli (e.g., traffic signals, braking events).
- **Indicators:** Longer-than-usual response times to events on the road.

Drifting within the lane

- **Detection:** Lane departure warning systems or camera-based lane tracking can identify lane deviation.
- **Indicators:** Inconsistent lane position, veering close to the edge of the lane, or unintentional lane crossings.

Reduced alertness

- **Detection:** Analyse driver behaviour using in-vehicle cameras or sensors to detect signs of disengagement.

- **Indicators:** Lack of engagement with the environment, failure to notice signs, vehicles, or hazards.

Changes in speed

- **Detection:** Vehicle speed data from on-board systems or GPS can indicate fluctuations.
- **Indicators:** Unintentional speed changes, particularly abrupt deceleration or inconsistent acceleration.

Decreased conversational engagement

- **Detection:** Cameras or audio analysis can track conversational patterns within the vehicle.
- **Indicators:** Less participation in conversations, delayed or nonspecific responses to passengers.

Restlessness

- **Detection:** Monitoring in-vehicle movements using sensors can reveal restlessness or excessive fidgeting.
- **Indicators:** Frequent seat shifting, restlessness and discomfort.

Slurred speech

- **Detection:** If the vehicle is equipped with a microphone or audio analysis system, it can capture speech patterns.
- **Indicators:** Slower, slurred, or monotonous speech, reflecting cognitive decline due to fatigue.

Delayed or missed signals

- **Detection:** In-vehicle systems can track turn signal usage and other communication gestures.
- **Indicators:** Failure to use turn signals, missed communication cues.

4. Methods for implementing fatigue detection

There are various plausible methods and models used as a way to detect fatigue or drowsiness. These methods aim to monitor physiological, behavioural or vehicle based indicators to identify fatigue signs.

Physiological measures

- **Electroencephalography (EEG):** Monitoring brainwave patterns to detect changes in alertness and cognitive state.

- **Electrooculography (EOG):** Tracking eye movement patterns to identify signs of drowsiness and blinking frequency.
- **Heart Rate Variability (HRV):** Analysing changes in heart rate to assess autonomic nervous system activity, which can indicate fatigue.

Vehicle-based monitoring

- **Steering wheel movement:** Analysing steering patterns for micro-adjustments and irregularities, which can signal reduced attentiveness.
- **Lane departure warning:** Detecting unintentional lane departures or erratic lane changes as potential signs of driver fatigue.
- **Accelerometer data:** Monitoring vehicle acceleration and deceleration patterns to identify abrupt movements that might be indicative of fatigue-related lapses in attention.

Eye tracking

- **Pupil dilation:** Measuring changes in pupil size to gauge cognitive load and drowsiness.
- **Gaze tracking:** Monitoring where the driver is looking and measuring gaze duration on certain areas, like the road or dashboard.

Computer vision techniques

- **Facial Analysis:** Using facial expression recognition to detect signs of fatigue, such as drooping eyelids or changes in facial muscle activity.
- **Head Pose Analysis:** Monitoring head movements and posture to identify nodding or head drooping.
- **Eye Blink Analysis:** Counting the frequency and duration of eye blinks, as prolonged blinking may indicate drowsiness.

Machine learning and Deep learning

- **Classification models:** Training algorithms to classify driver behaviour as alert or fatigued based on input data from sensors, cameras, or physiological measurements.
- **Anomaly detection:** Identifying deviations from normal driving behaviour or physiological patterns as potential indicators of fatigue.

Hybrid systems

- **Integration of multiple sensors:** Combining data from different sources, such as physiological signals, vehicle-based data, and computer vision, to improve accuracy and reduce false positives.

PERCLOS, or 'Percentage of Eye Closure over Time', is a widely used method for detecting driver fatigue based on the analysis of eye closure patterns. Wierwille first established it in 1994 for detecting driver drowsiness. This method relies on monitoring the proportion of time a person's eyes are closed within a specific time frame. PERCLOS is especially effective when used in conjunction with computer vision techniques and cameras pointed at the driver's face. The model applied with Neural Networking and ample eye related datasets, has the ability to identify and detect any form of drowsiness or fatigue among drivers using behavioural characteristics in real time. The general equation of the PERCLOS model is given by:

$$f_{PERCLOS} = \frac{n_{close}}{N_{total}} \times 100\%$$

It is defined as the percentage of time the subject's eyes are more than 80% closed in a specific period. In general, the eyes are said to be closed when they are only about 20% open.

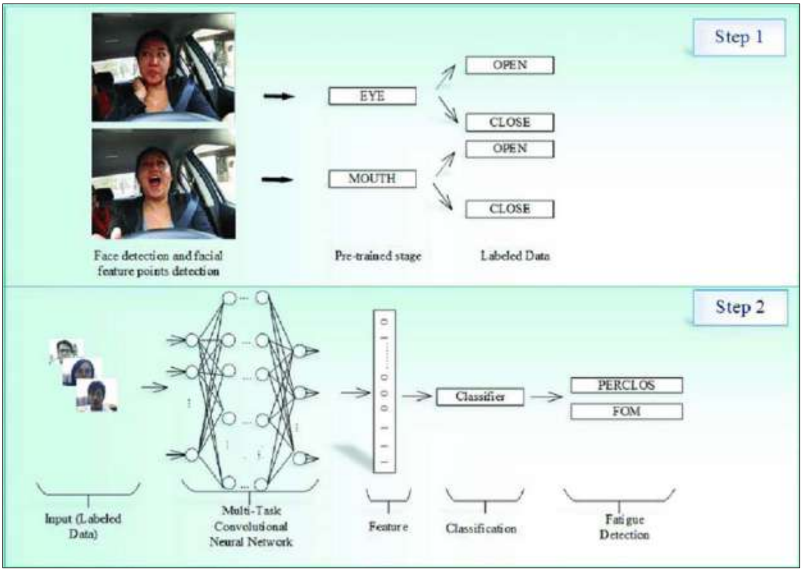

Fig 2: Proposed Model of Driver Fatigue Detection System by Burcu Kir Savaş

5. Method Comparison and Accuracy Involved

Table 1: Comparison of Methods, Datasets and Accuracy used for Fatigue Detection System

Paper Id	Method Used	Datasets/Models	Accuracy
Yin-Cheng Tsai, Peng-Wen Lai, Po-Wei Huang (2020)	Remote Photo plethysmography (rPPG) Signal Method.	ANN1, ANN2, ANN3, ANN4, ANN5	90.13%
A Balasundaram, S Ashok Kumar (2020)	Open CV And Python	-	88%
Gulbadan Sikander and Shahzad Anwar (2020)	Facial Action Units	CNN, Alex Net, Google Net	95.17%
Guanglong Du Tao Li, Chunquan Li (2020)	Integrating heart rate and Facial parameter method	RNN, MFRNN	92.88%
D. Jayanthi, M. Bommy (2018)	EOG Signal Method	-	94%
Gulbadan Sikander, Shahzad Anwar (2018)	Remote Photo plethysmography (rPPG) Signal with RGB camera Method.	HVR, SVM	95%
R.C. Coetzee and G.P. Hancke (2013)	Hypo vigilance method	ANN, SVM, AdaBoost	96.7%
Mens, Kaufmann, Emma Klotz (2020)	-	-	-
Umit Budak, Varun Bajaj, Yaman Akbulut, Orhan Atilla and Abdulkadir Sengur (2019)	Electroencephalogram (EEG), Long-short term memory (LSTM)	Alex Net, VGG16, Deep CNN	94.31%
Marco Javier Flores, José María Armingol, Arturo de la Escalera (2010)	Advance Driver Assistance System (ADAS)	-	94.56%
Koichi Fujiwara, Erika Abe, Keisuke Kamata, Chikao Nakayama, Yoko Suzuki, Toshitaka Yamakawa (2018)	EEG, Heart Rate Variability (HRV)	Auto Regressive model (AR)	88%
Jing-Ming Guo & Herleeyandi Markoni (2018)	CNN, LSTM	ACCV	84.85%
A F M Saifuddin Saif, Zainal Rasyid Mahayuddin (2020)	Pupil Detection using DCNN	Open CV	98.97%
Francesca Trenta, Sabrina Conoci, Francesco Rundo, Sebastiano Battiato (2019)	HRV, Photo plethysmography (PPG)	PPG Signal, CNN, RNN	99%
Zhongke Gao, Xinmin Wang, Yuxuan Yang, Chaoxu Mu, Qing Cai, Weidong Dang, Siyang	ESTCNN with EEG	CNN-B	97.37%

Zuo (2019)			
JianFeng Hu, Jianling min (2018)	GBDT with EEG	-	94%
Yuxuan Yang, Zhongke Gao, Yanli Li, Qing Cai, Norbert Marwan, Jürgen Kurths	CNBLS using EEG	-	99.36%

The table 1 shows the comparison between various models and methods used to detect driver fatigue as proposed by many authors and researchers over many years with the accuracy rating for each of them.

6. Conclusions

Fatigue detection systems among drivers represent a pivotal advancement in road safety technology. These systems address a critical concern, providing real-time monitoring and early warning mechanisms to prevent accidents caused by driver fatigue. The deployment of such systems has the potential to save lives, reduce injuries, and minimize the economic and social burdens associated with fatigue-related accidents. The most effective fatigue detection systems often combine multiple data sources, harnessing the power of machine learning algorithms to interpret complex patterns, offering potential to create robust and accurate systems that adapt to the unique characteristics of individual drivers and varying driving conditions. The continued advancement and implementation of these systems hold the potential to revolutionize the way we approach road safety and make a lasting positive impact on individuals, families and communities.

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Chapter - 27
A Novel Technique for Automatic Moisture Separation of Crystal Silica Granules inside Breather by the IoT Technology

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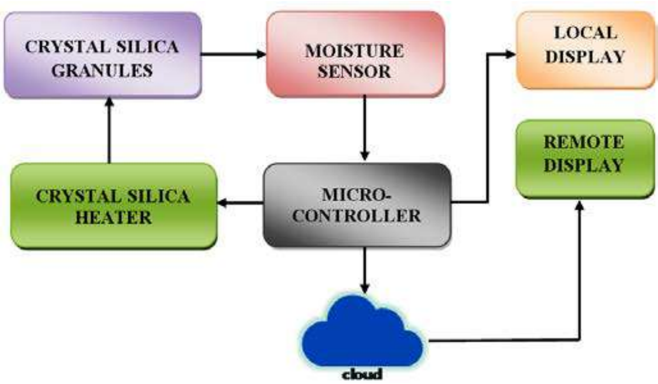
Chapter - 27

A Novel Technique for Automatic Moisture Separation of Crystal Silica Granules inside Breather by the IoT Technology

Debyendu Chakroborty, Bikas Mondal and Subhankar Singha

Abstract



Moisture plays a vital role in degrading equipment life in the process industry. A practical model for evaluating the moisture content of crystal silica granules inside the breather of an onload transformer has been tested. The design of automatic moisture removal from the breather was considered by estimating the real-time dynamic variation of the transformer during its operation. The dynamic variation of the oil temperature changes due to the load change and the natural loading of the transformer leads to the frequent heating and cooling of the low-density transformer oil of the conservator. The absorption of moisture changes the color of silica granules and decreases the efficiency of the breather if not replaced in time. Any discrepancy or overlook of the breather system can deteriorate the efficiency of the load transformer. An experimental setup was developed to monitor the moisture percentage of silica granules inside the breather and its auto-heating process to evaporate moisture from granules. Moreover, the possibility of human error due to time-based monitoring of the breather can be avoided and the timely refill of crystal silica granules gets minimized or restricted. The breather is fabricated with a moisture sensor and a low-power heater and programmed through the microcontroller. The rise of moisture percentage above the desired set point will start the heater and vice-versa. The developed system is validated by the standard input data provided by the manufacturer and experimentally obtained data. The developed model is studied and analyzed using symmetrical relation between the crystal silica granules' moisture concentration and the breather's surrounding condition. The Internet of thing system using a cloud server helps monitor the system status remotely and is more reliable due to its faster communication, no signal loss, optimal performance, good round trip time and economical setup.

Keywords: Crystal silica granules, load transformer, breather, moisture sensor, cloud server, internet of things

1. Introduction

The process industries require power transformers to step-up or step down the voltages for various power control panels. The transformers play a vital role in this operation and maintaining the health of the power factor is one of the prime factors for industrial engineers [1]-[3]. The life cycle of transformers depends upon their various associated accessories, like conservators, radiators, safety relays, lubricating oils, etc. The lubricating oil is one of the prime components for transformer insulation. The increase in the oil's electrical conductivity and reduction in its dielectric strength is the main rival of lubrication oil, mainly caused due to moisture absorption in the transformer oil system. A conservator tank is in direct connection with the breather to limiting the air moisture integration with the transformer oil. The conservator is internally sealed with a rubber material cylindrical bladder to restrict the mixing of ambient air moisture with the low-density transformer oil inside the bladder. Frequent monitoring of the conservator's internal parts is quite difficult and needs transformer isolation. However, during its continuous operational process, the rubber bladder deteriorates its quality due to aging, and ambient air gets mixed up with the lubricating transformer oil. At the secondary stage, the breather containing crystal silica gel granules helps to absorb the moisture and circulate the dry air to the system. The moisture-free crystal silica granules represent a dark blue color and after saturation, their color changed to reddish pink [4].

During the operational period and dynamic load, change will cause the oil temperature to vary, shrinks or swells the volume of transformer oil inside the conservator. Due to the differential pressure inside the conservator, the transformer frequently sucks and discharges the trapped air. Whenever there is an increase in the volume of the oil, the transformer system exhausts the air present above the lubricating oil to the breather by the conservator tank. Due to the pressure and volume variation between the breather air and conservator-trapped air, their temperature remains unequal. Likely, whenever the volume of the oil decreases the moist air tunnel to the conservator tank through the breather and the temperature between the breather air and atmospheric become the same [5].

In the above-said conditions, the crystal silica gel granules inside the breather absorb the moisture in the transformer oil and circulate the dry air to the transformer system, but due to prolong circulation the absorption capability of the silica gel becomes weaker and air-mixed oil gets passes to the system, which in turn decrease the oil break-over voltage and impact the transformer performance. The time-based maintenance of the silica gel granules needs human supervision and may cause errors. In common case studies, it was noticed that the fresh silica granules need replacements within 3 to 4 months of continuous transformer operational condition.

To overcome this situation, in our developed system, a physical model was implemented to predict the failure period of crystal silica granules and its quick recovery method [6], [10].

A bead-type thermistor sensor made up of platinum elements embedded into the ceramic component was fabricated inside the breather. Upon sensing moisture, gradually the temperature of the negative temperature coefficient type thermistor increases and its resistance decreases. The resistance variation depends on the amount of moisture present on the silica crystal granules inside the breather. A 25-watt dc powered heater is installed inside the breather and programmed through a micro-controller unit. Whenever the moisture percentage increases above the set level the heater will start through the relay contact to absorb the moisture of silica crystal granules, it will take 3-4 hours and a maximum of up to 80 °C for its complete drying process [11]. As the silica granules start drying and the moisture percentage comes below the lower set point of the moisture sensor, the heater gets stopped.

The developed system was tested on a fully loaded transformer breather of used crystal silica granules to measure the effectiveness of the drying process. At the time of installation, the color of the crystal silica granules was slightly fed to sky blue. The heater was able to remove the moisture up to 30-35% after one time of successful operation. The output signal from the microcontroller unit was transmitted via Internet of thing communication to the remote station via the think speak platform and another local monitor was installed for manual observation of the operator. The real-time data with good round trip time is continuously fetched by the web server database and displayed online to the remote monitor.

2. Materials & Methods

During the load condition, the temperature of the air inside the conservator and breather can be expressed by the combined gas equation as

$$T_2 = P_2 \times T_1 \times V_2 \times (P^{-1}{}_1 \times V^{-1}{}_1) \tag{1}$$

Where, T_1 is the temperature of the conservator oil in Kelvin

Where, T_2 is the inside temperature of the breather in Kelvin

V_1 and V_2 are the volume of the conservator tank and breather in m3 respectively

P_1 is the pressure of the capillary tube connecting the breather in mm WC

P_2 is the pressure of the capillary tube connecting the breather in mm WC

In the developed system, a negative temperature coefficient type thermistor was fabricated inside the silica breather to measure the change in temperature coefficient in the 1st order system and can be expressed as –

$$\varDelta T = \varDelta R_T / k \times R_T \tag{2}$$

Where, $\varDelta R_T$ is the change in the resistance of bead-type thermistor in ohms

R_T is the internal resistance of the thermistor in ohms at ambient temperature.

K is the temperature coefficient of resistance in the 1st order system

$\varDelta T$ is the change in temperature in Kelvin

The shrinking and swelling of the oil volume of the conservator caused by the temperature and pressure variation of air inside the breather depend on the absorption capacity of the silica granules. The granules consist of innumerable tiny pores. The appropriate distribution of the moisture inside the breather depends on the concentration of silica gel density.

The moist particle absorbed by the silica granules over a period of time reaches its extreme equilibrium condition where its concentration is highest and starts decreasing the temperature due to the start of the heating process. A 25-watt dc heater is installed in the breather to dry the crystal silica granules and minimize moisture by increasing the temperature inside the breather. During this cycle of regeneration, several times heater gets on and off and the corresponding output of the sensor is fed to the microcontroller after proper signal conditioning.

The used thermistor has a negative characteristic that senses the temperature and outputs the change in resistance in inverse curve fitting, i.e. if the temperature raises the resistance decreases and vice-versa. The relation between temperature and resistance can be approximately estimated by the Steinhart-Hart equation and given by the equation [12]-[13].

$$\Delta T = X + Y \log (\Delta R_T) + Z \log (\Delta R_T)^3 \tag{3}$$

Rearranging in terms of Resistance

$$\Delta R_T = e^{\{(\beta-\alpha/2)1/3-(\beta+\alpha/2)1/3\}} \tag{4}$$

Where, $\alpha = (X-1/\Delta T)/Z$ and $\beta = \sqrt{(Y/3Z)^3+\alpha^2/4}$

Where, X, Y, and Z are the Steinhart-Hart parameters

α and β are represented substitutes of the equation (4)

The signal conditioning circuit is used to filter, amplify and convert the resistance signal to voltage signal and expressed by the equation

$$V_{out} = V_{in} \times (\Delta R_T/\Delta R_T+R_s) \times (1+R_f/R_g) \tag{5}$$

where, Vout is the output voltage of the signal conditioning unit in V

Vin is the input voltage of the signal conditioning unit in V

Rs is the series resistance of the signal conditioning circuit

Rf and Rg are the gain resistors in ohms

The temperature of the thermistor provides a gradual change in the resistance which is converted into a voltage signal and boosted by the series resistance R_{sc} and further amplified by the operational amplifier U_1. The operational amplifier U_1 acts as a unit gain amplifier with a lower output impedance and its output signal is fed to the inverting terminal of the operational amplifier U_2. The operational amplifier U_2 is an amplification and filter component, which directly fetches the signal from the thermistor. Figure. 1 below depicts the signal conditioning circuit of the system.

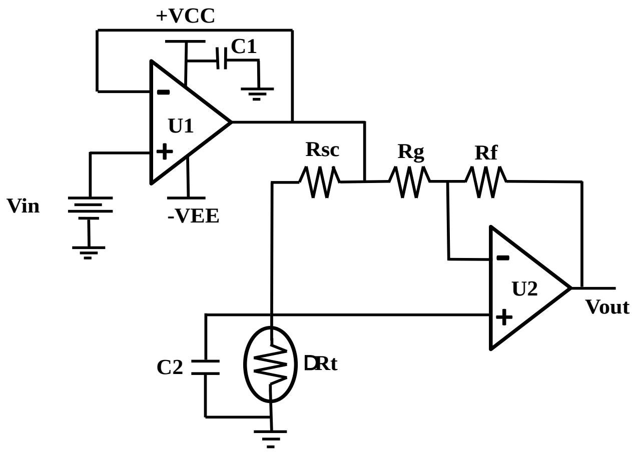


Fig 1: Signal condition circuit for silica granules breather

The output signal of the operational amplifier is next fed to the microprocessor-based Internet of thing module for wireless transmission to the remote server. The micro-controller basically a Node-MCU module receives the data from the sensor and publishes it to the remote server via the think speak cloud system. Node-MCU is an open-source Internet of Thing platform with an integrated ESP8266-12E chip, which supports Wi-Fi communication to the cloud server. Figure 2 below shows the block diagram of the silica granules breather moisture removal system with wireless data communication [14]-[15].

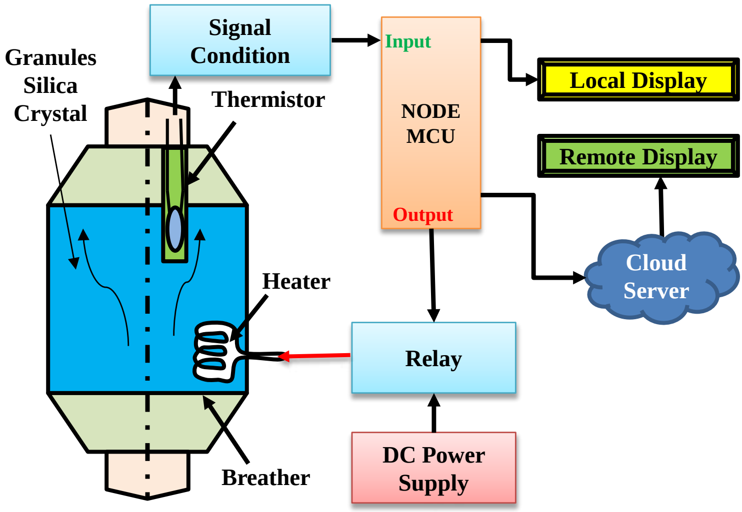


Fig 2: Signal condition circuit for silica granules breather

3. Design and Implementation

The cylindrical breather of the developed system with a volume of 81.43 m^3 was selected for the fabrication of a bead-type thermistor sensor with a negative temperature coefficient. The thermistor dimension of 4mm of bead head and 20mm of total length is selected for the developed system. The thermistor sensor is placed vertically centred on the breather covered by silica granules to acknowledge the maximum air moisture during the operational period. As the sensitivity of the thermistor is very high, a small change (per degree centigrade) in the temperature reflects approximately 60-70 ohms change in the output section. On the left side of the breather a 25 watt 12 volt dc polyimide heater, with a maximum temperature rise of 60°C is selected and connected with a normally open type relay switch. Whenever the moisture level comes below 25°C the heater will start, and the silica granules starts drying. For failsafe operation, the trip setting of the heater is set at 60°C. The designed signal condition circuit amplifies the resistance signal as per the rate of change of the temperature and forwards it to the microcontroller. The logical program written in integrated development environment (IDE) software passes the output command to the relay switch and accordingly the on and off of the heater takes place. The detailed specifications table of the used equipment is shown in the below table 1.

Table 1: Specification table for components used in the developed system

S. No.	Description of component	Specification
1.	Blue Silica Granules	Particle size- approx. 2.5mm, colour-Blue, Absorption capacity = 35% by weight
2.	Bead Type Thermistor	Resistance at 25°C is 10 K, Temperature Range = -55°C to 120°C, Thermal cooling (air) time constant = 25 second
3.	Polyimide Heater	25 Watt, 12-volt DC, Flat Type
4.	Breather	Height = 18.1 cm, Diameter = 23.9 cm, Body – polycarbonate, Top and bottom lead- Aluminium

The microcontroller-based module receives the output signal from the signal condition unit and transmits the signal through Wi-Fi after proper authentication to the client platform. The same authentication key will be provided to the thing speak cloud server to retrieve the real-time sensor data. The delay in data cycling may vary from 2 to 3 seconds and can be minimized by higher round trip time through edge computing (not included in our case).

4. Results and Discussion

The practical development of the mentioned system was implemented on a 2 KVA loaded transformer in the industrial environment. The accuracy of the thermistor sensor and the effectiveness of the absorption factor is crossed checked by manually heating another breather silica granule at the same temperature and then transferring it to the breather. The developed automatic moisture removal system was found much more effective with high response time, while the manual heating silica granules absorb moisture while transferring to a breather in the open environment.

Further, the breather temperature change was compared with a calibrated resistance temperature detector, which acts as a master calibrator and the results found are approximately the same. The static characteristic graph for thermistor temperature change with resistance is plotted in figure.3 as per equation (3). The curve shows a response range of 18.5°C to 60°C for a resistance change of 13.4 Kilo-ohms to 2.4 Kilo-ohms. The static characteristic curve for signal condition output voltage against thermistor resistance has been plotted for different sets of readings as per equation (5) and depicted in figure 4. The curve shows a voltage variation of 0.97 VDC to 4.05 VDC with respect to the resistance change. To determine the relationship curve between temperature and signal condition voltage for various sets of readings is taken and its average static curve fitting is depicted in figure 5. The curve shows a vitiation of temperature from 18.5°C to 60°C for a voltage change of 0.97 VDC to 4.05 VDC respectively. The percentage deviation and standard deviation curve for the silica granules moisture removal system are shown in figure 6 and 7 respectively. The static characteristic curve for IoT is depicted in figure 8 and the Think Speak output graph is shown in figure 9.

Figure.3

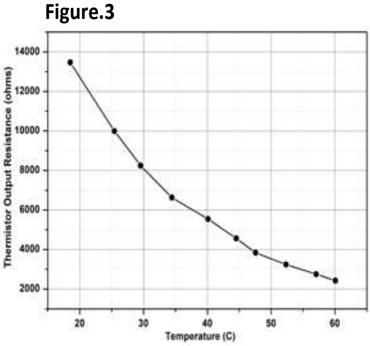


Figure.4

Fig 3 & 4: Static characteristic of Thermistor output resistance with temperature and signal condition voltage

Figure.5

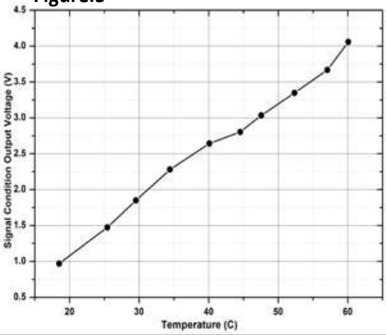


Figure.6

Fig 5 & 6: Static characteristic of signal condition voltage with temperature and percentage error

Figure.7

Figure.8

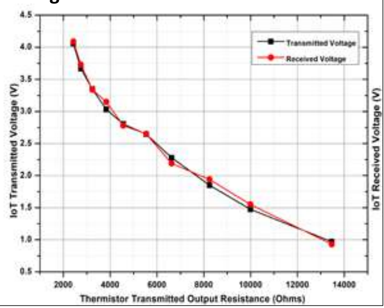


Fig 7 & 8: Standard deviation curve with respect to signal condition voltage and IoT characteristic curve

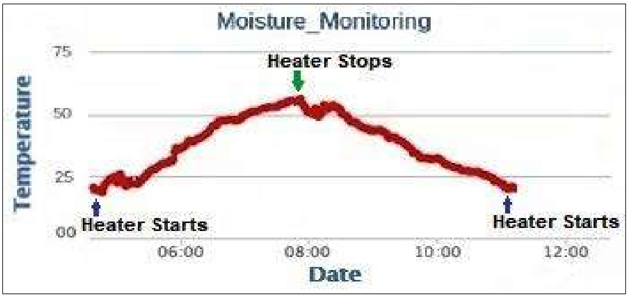


Fig 9: The characteristic curve for Think Speak temperature response with date and time

5. Conclusions

An IoT-based automatic moisture removal system from crystal silica granules from the breather of an operational transformer was developed and implemented in various phases. In the initial phase, case studies were performed to determine the silica granules' discolor time period and thereafter recorded the manual heating time period with various heater temperature ranges.

In the second phase selection of a proper temperature sensor with high sensitivity and accuracy was done and found thermistor with a negative temperature coefficient was highly active for the implementation of said work, subsequently the selection of a failsafe heater with an appropriate relay was selected.

In the third phase, the output resistance change of the thermistor was implemented with proper design of signal condition circuit, as the micro-controller can only accept analog signal below 5 VDC from sensor input.

In the fourth phase, the fabrication of sensors, and heater was done inside the filled silica granules breather with fixation of the relay, signal condition box, and microcontroller unit to a nearby junction box.

In the final phase, the testing and Internet of Thing transmission and its local and remote monitoring were performed on the Think Speak cloud platform. The developed system was kept under observation and its various errors signal were noted, the maximum percentage error was found to be 0.758 percent and the minimum percentage error was -1.576. The standard deviation of the system lies under 0.01 to 0.09 and both the errors system were under the allowable standard.

The developed system was highly reliable, failsafe, requires less human intervention, allows automatic drying, and enhances the transformer oil quality and life. The integrated IoT communication provides in-time alarm and real-time remote monitoring of the system, which makes the overall performance of the system better and can be recommended for industrial applications.

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Conflict of interest: The authors declare no conflict of interest.

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Chapter - 28
Solar Photovoltaic Mathematical Modeling and Simulation using MATLAB/Simulink for a Renewable Energy Solution

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Chapter - 28

Solar Photovoltaic Mathematical Modeling and Simulation using MATLAB/Simulink for a Renewable Energy Solution

Partha Ray, Pallab Roy, Subhajit Mondal, Rahul Dutta, Suman Biswas and Subhajit Pal

Abstract

The solar photovoltaic (PV) which acts a very important to accomplish the power backup of any country during peak load is popular in renewable power generation due to its clean and green energy technology. Mathematical modeling, simulation of PV module and its analysis is so essential, prior to build up a PV system, which helps to realize the performance and characteristics in actual climatic conditions of that location. This article describes step-by step modeling and simulation of single diode based equivalent model PV cell in MATLAB/Simulink. Initially, the I-V and P-V characteristics are mathematically analyzed for a single PV cell, and to end with, it is completed for the PV panel which provides a broad understanding to researchers, manufacturers. The PV cell modeling is done based on five parameters; Open-Circuit voltage, Short-Circuit current of P-V and I-V characteristics, number of series and parallel resistance connected and maximum power at the various for real metrological information - solar irradiance & temperature. The result is verified by the manufacturer data-sheet of BP365TS, BP3230T, SPR-200-WHT-U, MAX-60, PWX 500 and KC200GT solar module and relative error percentage compared with manufacturer values is found less. Further performance of PV module is analyzed to find the effects of weather condition - irradiance and temperature through the year, number of series and parallel resistance connected.

Keywords: Mathematical modelling, PV Cell, I-V characteristics, P-V characteristics, MATLAB/Simulink.

1. Introduction

The rapid increase of use of solar power in renewable energy sector, especially in distributed generation field; the PV power market is rapidly expanded. So, a consistent and flexible tool is necessary to guess the solar cell power generation under different climatic condition. Researchers are continuously updated PV cell mathematical model for a better understanding of the operation (Nguyen *et al.*, 2015). These developd PV models are differed from each other depends on a variety of simulation software, however, most of them used voltage-current retionship of solar cell.

In the study (Walker *et al.*, 2001, Gonzalez-Longatt *et al.*, 2005), author show the effect of temperature, solar irradiation, diode quality factor and series resistance but difficulty of this technique is to require readers programming skills for studey further. Based on solar cell mathematical equations (Villalva *et al.* 2009), (Ishaque *et al.* 2011), and (Mohammed, S.S. 2011), authors simulated PV array in MATLAB/Simulink to study the effect of solar insolation and temperature, diode's quality factor, series and shunt resistance, and saturation current, etc. Due to lack of step-by-step description of the procedure readers faces difficulties in simulation by themselves later. This shortcoming is addresed in by (Savita *et al.* 2010) and (Pandiarajan and Muthu 2011) using user-friendly icons to describe subsystem blocks, however, in these studies effect of partially shading condition on solar PV panel's operation is not considered. The shading effect on PV modules I–V characteristics was investigated by (Ahmed *et al.* 2015) and (Kawamura *et al.*, 2003). A numerical algorithm was proposed by (Quaschning and Hanitsch, 1996) to simulate the complex shading characteristics of the arrays whereby every element (each cell of the module, bypass diode, blocking diode, etc.) was represented by a mathematical expression. The results were good-looking but for larger systems the simulation was noticeably complex, thus increase the operation time.

On a whole, even though having advantages and disadvantages, different methods mentioned above have more or less similar gaps as follows:

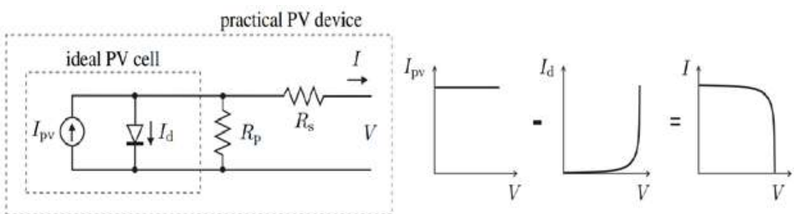
- The proposed models are not enough to study the effect of parameters on P–V & I–V characteristics, including physical parameters such as ideality factor, saturation current, series and shunt resistance, etc. and climatic conditions like solar insolation, temperature and specially shading effect.
- Lack of presenting step-by-step simulation procedure which make readers and researchers difficult to study and do simulation by themselves.

Hence, this study proposes a detailed modeling with MATLAB/ Simulink tools software. In addition, a exclusive step-by-step modeling procedure shown which allows reasearchers to studey and simulate by themselves to do their investigation. The influence of all parameters on PV array performance is also investigated in detail. In this research paper, BP365TS, BP3230T, SPR-200-WHT-U, MAX-60, PWX 500 and KC200GT solar panel are used as a reference model to validate the accuracy of the proposed model. The P-V and I-V characteristic is simulated for different irradiance (200 W/m^2 to 1000 W/m^2) and temperature variation (25°C to 45°C). The output characteristic of the reference model matches with simulated results. The paper is organized as follows: section 2 explains the mathematical equation to describe the equivalent circuit of PV cell; section 3 describes modeling of PV model in MATLAB/Simulink; simulation results are discussed in section 4; section 5 concludes the paper.

2. Modeling of PV Module

2.1 Ideal Model of PV Cell

Considering a single solar cell, the equivalent circuit of PV cell shown in Figure 1, is consist of current source - Photo current (I_{ph}), a diode and two resistors - Series resistance (R_s) and Parallel resistance ($R_{sh}\ or\ R_p$).



(a) (b)

Fig 1: (a) Equivalent circuit of PV cell (b) I-V Characteristic of PV cell

Based on semiconductor theory, the mathemetical equiation (Premkumar *et al.* 2020), (Goyal *et al.* 2020) which describes the I-V characteristic of ideal PV cell is given by the equation (1)

$$I = I_{ph} - \underbrace{I_{rs}\left[exp\left(\frac{qV_{oc}}{nkT}\right) - 1\right]}_{I_d} \tag{1}$$

where I_{ph} is light generated current [A] in solar cell, I_d is Shockley diode equation [A], I_{rs} is reverse saturation current [A] or diode leakage current, q is the electron charge [1.60217646 × 10^{-19} C], k is the Boltzmann constant [1.3806503 × 10^{-23} J/K], T is temparature of p-n junction and n is diode ideality factor. The I-V characteristic of PV cell generated from equation (1) is shown in figure (1).

2.2 Mathematical equivalent modeling of PV module

The PV solar system is an interconnection of number of PV cells/module in series-parallel combination. The power developed by a single diode module is insufficient for large electric load, so such modules are interconnected to build up output for the load. The series interconnection is used to achieve required voltage and parallel interconnection is used to get sufficient value of current. So the equation (1) is modified as follow

$$I = I_{ph} - \underbrace{I_{rs}\left[exp\left(\frac{V+IR_S}{nV_t}\right) - 1\right]}_{I_d} - \underbrace{\frac{V+IR_S}{R_p}}_{I_{sh}} \quad (2)$$

where $V_t = N_s kT/q$ is terminal voltage [V] of the array with N_s is number of PV cells connected is series, R_s is series connected resistance [Ω] and R_p is parallel connected resistance [Ω]. The I_{ph}, sun light generated current [A] of the PV cell depends linearly on the solar irradiation and is also influenced by the temperature according to the following equation

$$I_{ph} = (I_{sc} + K_T \Delta T) \times \frac{G}{G_n} \quad (3)$$

where I_{sc} is the sun light generated current [A] at the standard test condition (STC) - irradiation of 1000 W/m^2 under 25˚C temparature, K_T is short-circuit current coeficient [$1.3 \times 10^{-3} A/°C$, $\Delta T = T - T_n$ (T and T_n the actual and nominal temperatures [K]), G is the irradiation [W/m^2] on the device surface, and G_n is the nominal irradiation. The diode saturation current I_s may be expressed by equation (4)

$$I_s = I_{rs}\left(\frac{T}{T_n}\right)^3 exp\left[\frac{qE_g}{nk}\left(\frac{1}{T_n} - \frac{1}{T}\right)\right] \quad (4)$$

where E_g is the bandgap energy [eV] of the semiconductor and I_{rs} is the nominal reverse saturation current [A] can be expressed by equation (5) and (6) respectively:

$$E_g = E_{g0} - \alpha \frac{T^2}{T+\beta} \quad (5)$$

$$I_{rs} = \frac{I_{sc}}{exp\left(\frac{V_{OC}}{nV_t}\right) - 1} \quad (6)$$

where $E_{g0} = 1.16$ is the bandgap energy at 0 K, $\alpha = 7.02 \times 10^{-4}$ and $\beta = 1108$ is material constant. If N_p number of parallel connected solar PV cells bulit a PV array, the photovoltaic and saturation currents may be expressed as: $I_{ph} = I_{ph}N_p$, $I_{rs} = I_{rs}N_p$, $R_s = R_s \times (N_s/N_p)$. The current output of PV module/array then can be expressed by the equation (7)

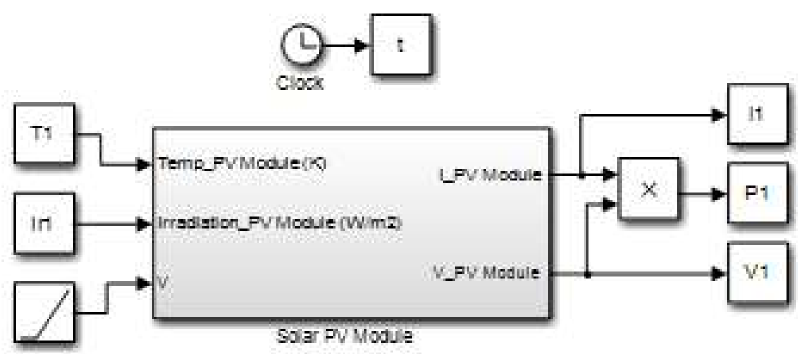
$$I = I_{ph}N_p - \underbrace{I_{rs}N_p\left[exp\left(\frac{V+IR_s\frac{N_s}{N_p}}{nV_t}\right)-1\right]}_{I_d} - \underbrace{\frac{V\frac{N_p}{N_s}+IR_s}{R_p}}_{I_{sh}} \quad (7)$$

3. Simulation model of PV cell in MATLAB/Simulink

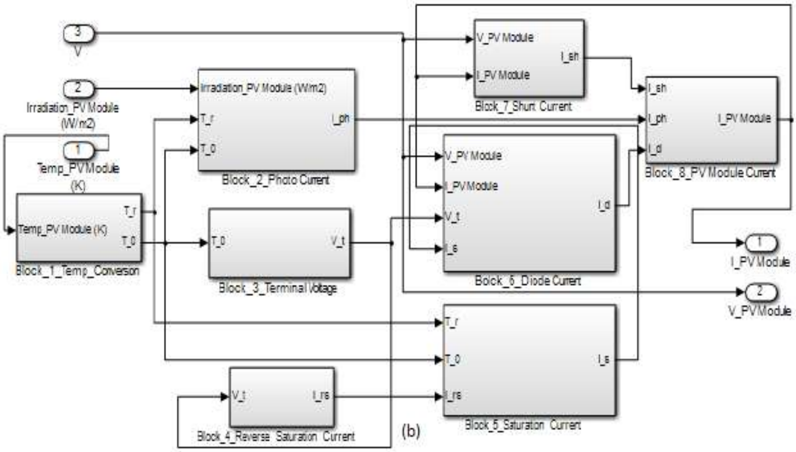
The mathematical model of solar PV cell is developed using the above mentioned equations (1) - (7). The detailed implemention model of complete PV cell is shown in figure (2). For simulation BP365TS, BP3230T, SPR-200-WHT-U, MAX-60, PWX 500 & KC200GT solar module have selested as reference to provide input parameter for simulation. The physical model parameters are tken from the datasheet of the module & are listed in table 1.

Table 1 Electrical reference parameters of PV module.

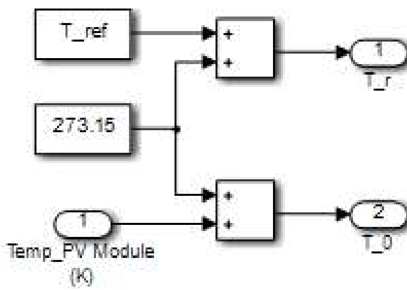
PV module	V_{oc} (V)	I_{sc} (V)	R_s (Ω)	R_p (Ω)	n	N_s	V_{mp} (V)	I_{mp} (A)	P_{mp} (W)
BP365TS	11	8.1	0.13134	49.95	0.9768	32	8.7	7.5	65
BP3230T	36.7	8.4	0.41305	179.89	0.9624	16	29.1	7.9	230
SPR-200-WHT-U	47.8	5.4	0.4427	232.82	0.96675	72	40	5	200
MAX-60	21.1	3.8	0.45	310.0248	1.3	72	17.1	3.5	58
PWX 500	21.6	3.11	0.56	790	1.3	72	17	2.88	49
KC200GT	32.9	8.21	0.221	415.405	1.3	72	26.3	7.61	200.143



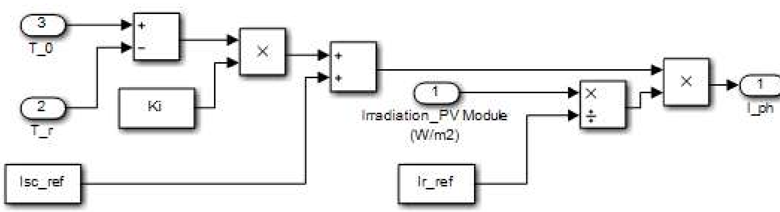
(a)


3
V
2
Irradiation_PV Module (W/m2)
1
Temp_PV Module (K)
Temp_PV Module (K)
T_r
T_0
Block_1_Temp_Conversion
Irradiation_PV Module (W/m2)
T_r
T_0
I_ph
Block_2_Photo Current
T_0
V_t
Block_3_Terminal Voltage
V_t
I_rs
Block_4_Reverse Saturation Current
V_PV Module
I_PV Module
I_sh
Block_7_Shunt Current
V_PV Module
I_PV Module
V_t
I_s
I_d
Block_6_Diode Current
T_r
T_0
I_rs
I_s
Block_5_Saturation Current
I_sh
I_ph
I_d
I_PV Module
Block_8_PV Module Current
1
I_PV Module
2
V_PV Module

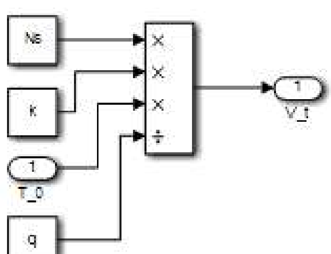
(b)


T_ref
273.15
1
Temp_PV Module
(K)
1
T_r
2
T_0

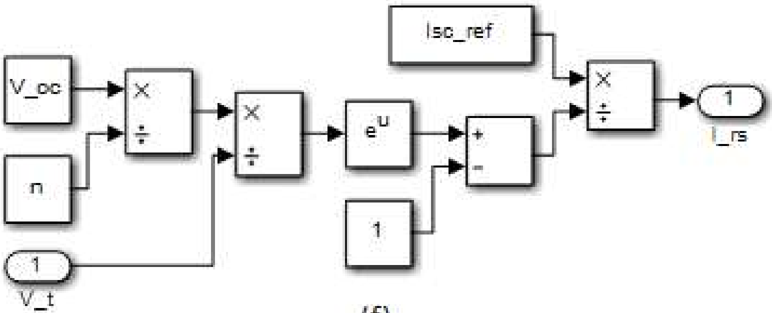
(c)


3
T_0
2
T_r
Ki
Isc_ref
1
Irradiation_PV Module
(W/m2)
Ir_ref
1
I_ph

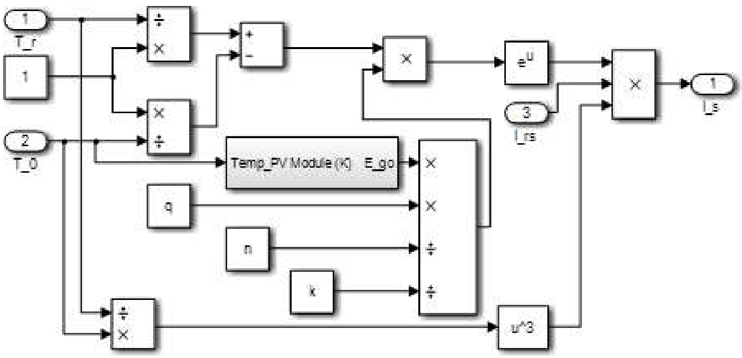
(d)


Ns
k
1
T_0
q
1
V_t

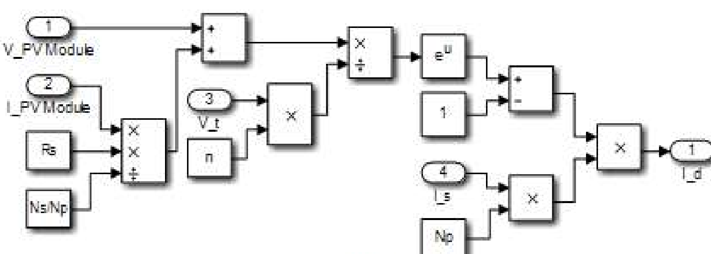
(e)


Isc_ref
V_oc
n
e^u
1
1
I_rs
1
V_t

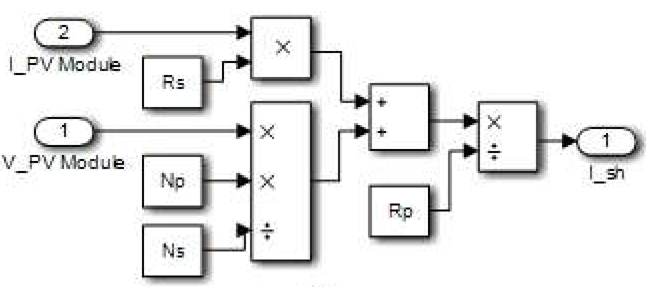
(f)


1
T_r
1
2
T_0
Temp_PV Module (K)
E_go
q
n
k
e^u
3
I_rs
1
I_s
u^3

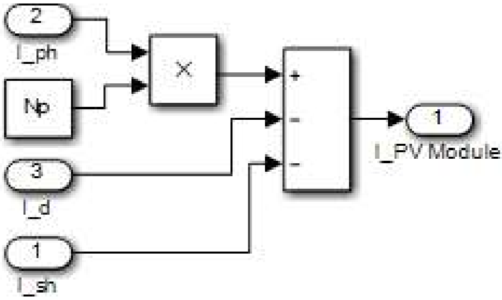
(g)


1
V_PV Module
2
I_PV Module
Rs
Ns/Np
3
V_t
n
e^u
1
4
I_s
Np
1
I_d

(h)


2
I_PV Module
Rs
1
V_PV Module
Np
Ns
Rp
1
I_sh

(i)



(j)

Fig 2: (a) Implementation model PV cell (b) Subsystems of PV cell model (c) Temparature conversion model (Block 1) (d) I_{ph} calculation model (Block 2) (e) V_t calculation model (Block 3) (f) I_{rs} calculation model (Block 4) (g) I_s calculation model (Block 5) (h) I_d calculation model (Block 6) (i) I_{sh} calculation model (Block 7) (j) I_{PV} calculation model (Block 8)

4. Simulation Result and Discussion

All the six PV model are used to validate and evaluated effectiveness of developed PV module in STC. The calculated error between refrence model and simulation model are tabulated in table 2.

Table 2: Electrical reference parameters of PV module

PV Module	V_{mp} (V)	I_{mp} (A)	P_{mp} (W)	V_{mp} (V)	I_{mp} (A)	P_{mp} (W)	V_{mp} (V)	I_{mp} (A)	P_{mp} (W)
	Refrence value			Simulation value			Absolute error (%)		
BP365TS	8.7	7.5	65	8.91	7.4514	66.3920	2.1438	0.6480	2.1415
BP3230T	29.1	7.9	230	36.7	8.3994	223.7223	4.677	7.031	2.7294
SPR-200-WHT-U	40	5	200	41.888	4.7163	197.5551	4.72	5.6746	1.2224
MAX-60	17.1	3.5	58	21.1	3.7945	57.7668	1.2865	2.2227	0.4021
PWX 500	17	2.88	49	17.28	2.8195	48.7208	1.6471	2.1011	0.5698
KC200GT	26.3	7.61	200.143	26.978	7.4988	202.3013	2.5779	1.4619	1.0784

The effect of temparature by varying from 25˚C to 45˚C at constant irradiation 1000 W/m^2 and effect of irradiation by varying intensity from 200 W/m^2 to 1000 W/m^2 at constant 25˚C temparature on solar PV model I-V and P-V characteristics is shown in figure (3) for MSX-60 module. It is observed that, with increase irradiation intensity both the short circuit current and output power value is increased while decrease in temparature the open circuit voltage is decreased.

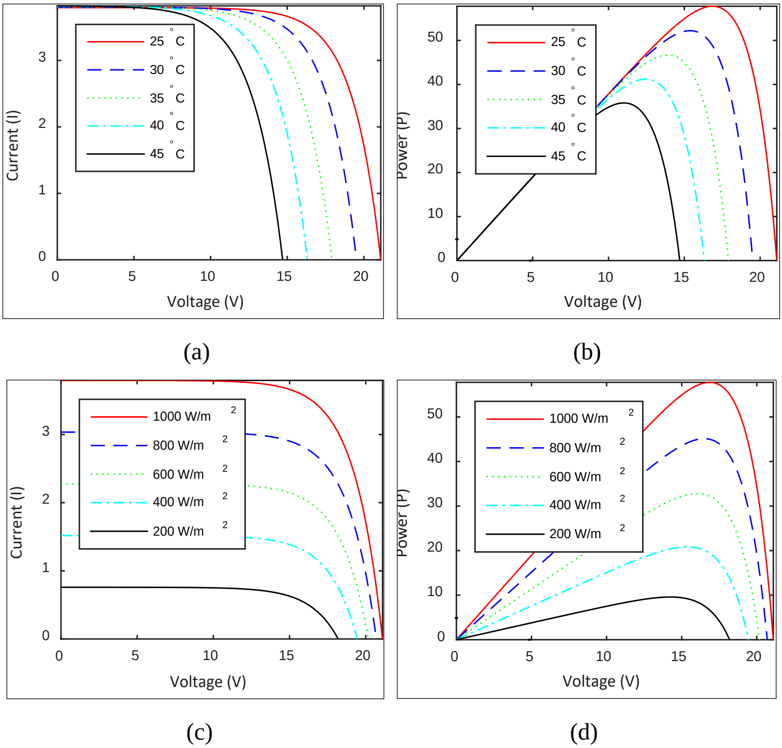


Fig 3: (a) I-V characteristics – varying temparature at constant irradiation (b) P-V characteristics – varying temparature at constant irradiation (c) I-V characteristics – varying irradiation at constant temparature (d) P-V characteristics – varying irradiation at constant temparature

The effect of change in combination of N_s and N_p with irradiation & temperature keep constant at STC is also simulated and shown in figure (4). It has been observed that with the double of N_s, open-circuit voltage is double and with decrease the N_p value half, both the short-circuit current and power is half.

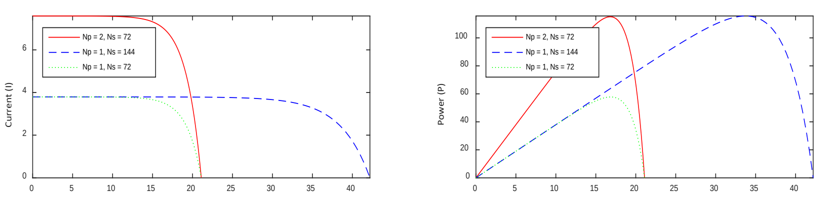


Fig 4: I-V and P-V characteristics for MSX-60 PV panel with different combination of N_p and N_s

The effect of change in combination of R_s and R_p with irradiation & temperature keep constant at STC is also simulated and shown in figure (5). It has been observed that with the decrease of R_p both short-circuit current and maximum power are get decrease and with increase the R_s value, I_{mp} and P_{mp} are decrease.

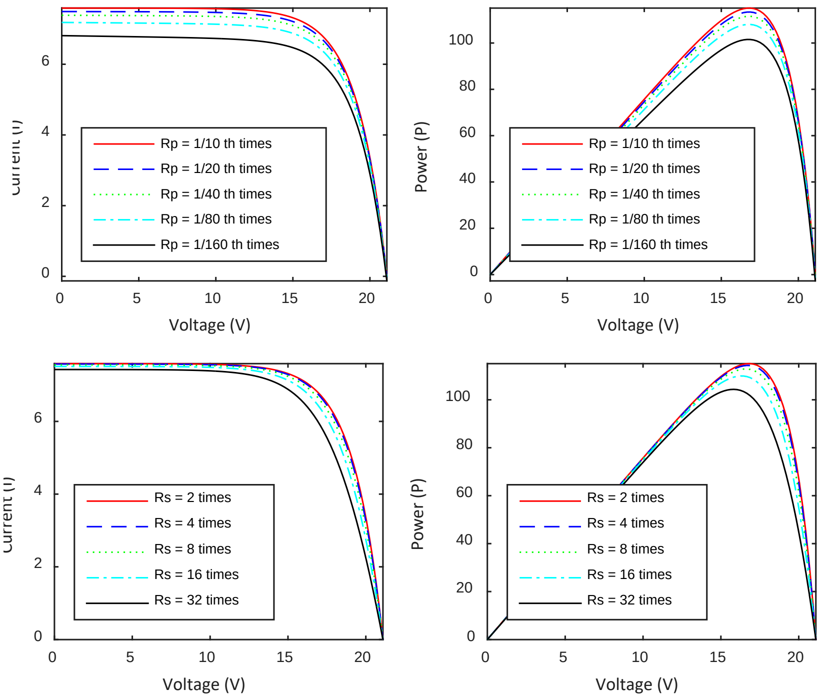


Fig 5: I-V and P-V characteristics for MSX-60 PV panel with different combination of R_s and R_p

5. Conclusions

Stepwise procedure for modelling solar panel and array in MATLAB/Simulink with user-friendly stimulation tool is demonstrate in study, which will help reasearchers for further modelling the solar system and I-V & P-V characteristic. The main highlight of this paper is that the PV model is derived based on the design data from the manufacture's datasheet. Thus, the model produces accurate output than the in-built PV array model in MATLAB software. The derived PV model is flexible for all the PV parameters and P-V and I-V curves for the PV array. The effect of variations of model parameters and effect of different solar irradiation intensity (200 – 1000 W/m^2) and module temparature (25˚C - 45˚C) have been demonstrate. The accuracy and reliability of the PV model are verified systematically by comparing the simulation results with data provided by the manufacturers. The accuracy validation of the model was done through a simulation experiment at different solar irradiation and cell temperature for the different configurations. The I-V and P-V characteristics from the predicted results are consistent for all the PV configurations, and the consistent results show the accuracy and reliability of the PV model.

Conflict of interest: The authors declare no conflict of interest.

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Chapter - 29
Numerical Simulation based Investigation to Improve Efficiency of CdS/CdTe Solar Cells using SCAPS 1D

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Chapter - 29

Numerical Simulation based Investigation to Improve Efficiency of CdS/CdTe Solar Cells using SCAPS 1D

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Abstract

In this study, numerical simulation of cadmium sulphide (CdS) - cadmium telluride (CdTe) based solar cell has been presented using SCAP-1D to improve the efficiency of solar cell. CdTe is familiar for its forbidden direct band gap of 1.5 eV which make absorption coefficient higher; means, just a few microns thickness are enough to absorb the light. Even with the advantages of CdTe PV technology, due to scarcity of Te, CdTe face the challenge. However, it is possible to decrease the CdTe thickness (upto 3μm) without much negotiation in efficiency. Reducing the absorber layer thickness can lower the material cost also. A modified structure of CdS/CdTe base PV solar cell ITO/SnO_2/ZnO/CdTe/NiO has been proposed over the reference structure ZnO/CdS/CdTe/NiO. In this work height conversion efficiency has been found to be as 27.34% using CdTe absorber thickness 3μm.

Keywords: Thin film PV cell, cadmium telluride, numerical simulation, SCAPS-1D

1. Introduction

The thin film photovoltaic (PV) solar cell, due to low cost and high energy conversion efficiency (ECE), has been prefered as most efficient solar cells. The efficiencies of silicon (Si -large crystalline), copper indium gallium selenide (CIGS) and cadmium telluride (CdTe) thin flim solar cell materials are recorded as 25.2±0.7%, 20.3±0.6% and 16.7±0.5% respectively (Green *et al.* 2011). But CdTe-technology is cheaper about 30% more than CIGS-technology and about 40% than Si technology (Swami *et al.* 2012). The maximum efficiency (laboratory experiment) of n-CdS/p-CdTe heterojunction PV solar cell is recorded 20.4% (Kim *et al.* 2014) and theoretical efficiency is predicted to be up to 28–30% (Nykyruy *et al.* 2019). Even though silicon solar cells achieve notable and unparalleled success in the PV industry for its relatively high ECE, but due to being an indirect band gap the thickness more than 100 μm is required for enough absorption of light. The record ECE of

26.7% is achieved with substrate thickness of 165 μm which value is below than its predicted theoretical value of 32.33% (Sharma *et al.* 2021). Due to direct and tunable band gap, CdTe and gallium arsenide gallium arsenide (GaAs), can absorb 90% of the incident light within a few micrometers of the materials (usually, 2-3μm). Though, compared to CdTe, GaAs have high ECE of 29.1% so far but not preferred due to expensive and toxic material. Till now, numerically obtained efficiency of 19.5% has been reported for CdTe thickness of 1μm and experimentaly reached efficiency of 22.1% (Green *et al.* 2011) although the theoretical limit is exceeds 24% in this study.

The present study yielded an wide study about the impact of different parameters on the CdTe/CdS device structure by Solar Cell Capacitance Simulator - SCAPS-1D. Then, a new configuration proposal ITO/SnO_2/ZnO/CdTe/NiO was studied for improving the device performance.

2. Device Modeling and Simulation

The thin film PV solar cell construct with glass substrate as a back-supporting slide, a thin layer film as hole transport layer (HTL) was deposited as back contact on the glass substrate layer, p-type absorber layer was deposited on back contact, a n-type buffer layer and another n-type substrate was used as a window and finally conducting surface front contact layer was used as transparent conducting oxides (TCO) as shown in figure 1 (a). In this study, indium-tin-oxide (ITO) with a thickness of 20 nm was used as conducting surface layer (front contact). The zinc oxide (ZnO) with a thickness of 50nm, CdS with a thickness of 25nm and CdTe with a thickness of 3μm form the n^+-n-p heterojunction sturcture. Nickel oxide (NiO) with a thickness of 100 nm was used as back contact.

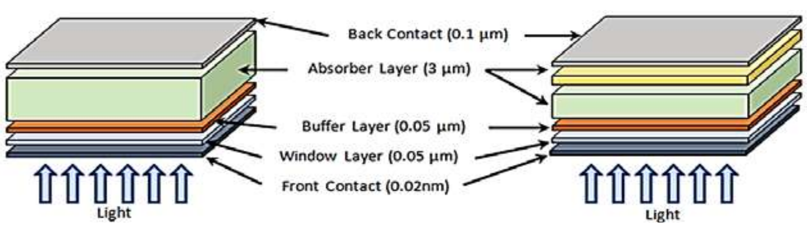


Fig 1: Structures of the CdTe solar cells: a) Reference structure, b) Proposed structure

The material physical parameters used in solar cell simulation are listed in Table 1 (Zyoud *et al.* 2021). The metal work function value used for back contact is 5 and filter value and complement filter value are 0.8 & 0.2. Thermionic emission/surface recombination velocity for electron and holes are used as 10^5 and 10^7 cm/s.

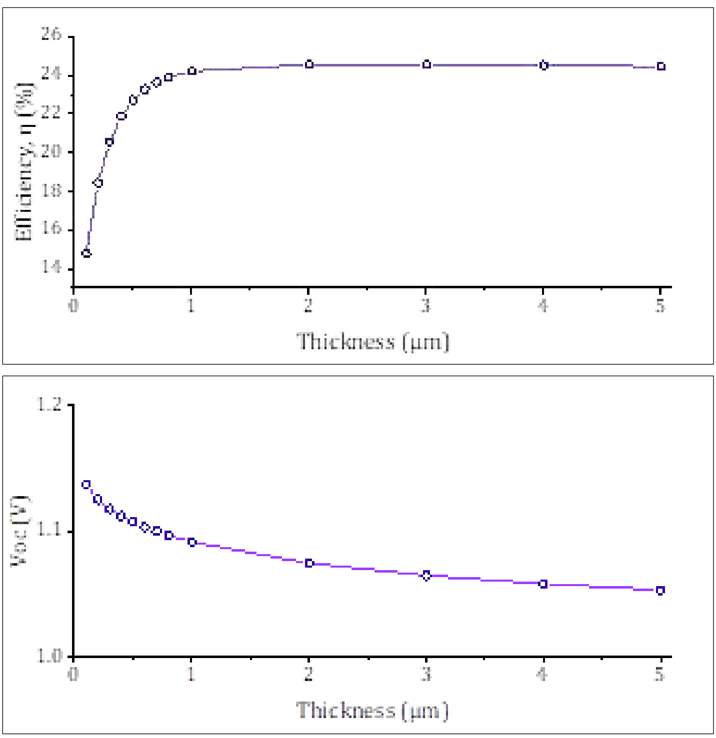
Table 1: Electrical reference parameters of PV module.

Electrical Parameters	HTL		Buffer Layer				Window Layer		TCO
	NiO	p-CdTe	n-CdS	n-ZnS	n-ZnSe	n-In_2S_3	n-ZnO	n-SnO_2	ITO
Bandgap (ev)	3.8	1.5	2.42	3.68	2.9	2.96	3.37	3.6	3.72
Electron affinity (ev)	1.46	3.9	4.3	4.13	4.09	4.2	3.9	4	4.5
Dielectric permittivity (relative)	10	10.3	10	8.8	10	8.4	9	9	9.4
CB effective density of states (cm^{-3})	2.8×10^{19}	9.2×10^{17}	2.2×10^{18}	1.7×10^{18}	1.5×10^{18}	1.8×10^{19}	1.8×10^{19}	2.2×10^{18}	4×10^{19}
VB effective density of states (cm^{-3})	1×10^{19}	5.2×10^{18}	1.8×10^{19}	2.4×10^{19}	1.8×10^{18}	4×10^{18}	2.4×10^{18}	1.8×10^{19}	1×10^{18}
Electron thermal velocity (cm/s)	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}
Hole thermal velocity (cm/s)	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}	1×10^{7}
Electron mobility (cm^2/Vs)	12	700	100	25	50	50	25	100	30
Hole mobility (cm^2/Vs)	2.8	60	25	70	20	15	25	25	50
N_D (cm^{-3})	-	-	1.1×10^{16}	1×10^{19}	1×10^{19}	1×10^{19}	1×10^{19}	1×10^{19}	1×10^{21}
N_A (cm^{-3})	1×10^{18}	1×10^{16}	-	-	-	-	-	-	-
Interface Parameters									
Radiative recombination coefficient (cm^3/s)	2.3×10^{-9}	2.3×10^{-9}	2.3×10^{-9}	2.3×10^{-9}	2.3×10^{-9}	2.3×10^{-9}	2.3×10^{-9}	2.3×10^{-9}	2.3×10^{-9}
Defect type	-	neutral	-	-	-	-	-	-	-
Capture cross section electrons & hole (cm^2)	-	1×10^{16}	-	-	-	-	-	-	-
Reference for defect energy level Et	-	Above eV	-	-	-	-	-	-	-
Energy level with respect to Reference (ev)	-	0.06	-	-	-	-	-	-	-

3. Results and Discussion

The NiO/CdTe/CdS/ZnO solar cells structure was used as reference structure shown in Figure 1(a) has been analyzed initially. The reference cell has shown the highest conversion efficiency of conversion efficiency, η = 24.74% (open circuit voltage, V_{oc} = 1.0669 V, short circuit current density, J_{sc}

= 27.82 mA/cm^2, fill factor, FF = 86.75%). One sun illumination (100 mW/cm^2) and global air mass (AM) 1.5 spectrum at temperature of 300 K were used to simulate the designed solar cell structure. Though, theoretically a 2 μm thick CdTe layer is efficient to absorb 99% of the incident photons, a further numerical analysis has been done to find the optimum thickness of CdTe layers for maximum efficiency for the reduction of materials usages and cell production cost. The CdTe absorber thickness has been varied from 100 nm to 5000 nm for reference cells to explore possibilities of ultra-thin CdTe absorber layer. The simulated results are graphically shown in Figure 2. It is clearly seen that the photovoltaic parameters: η and J_{SC} increase with the increment of the absorber layer thickness whereas V_{oc} and FF decrease. As maximum conversion efficiency occurs at 3 μm, therefore, this thickness has been chosen for further investigation.



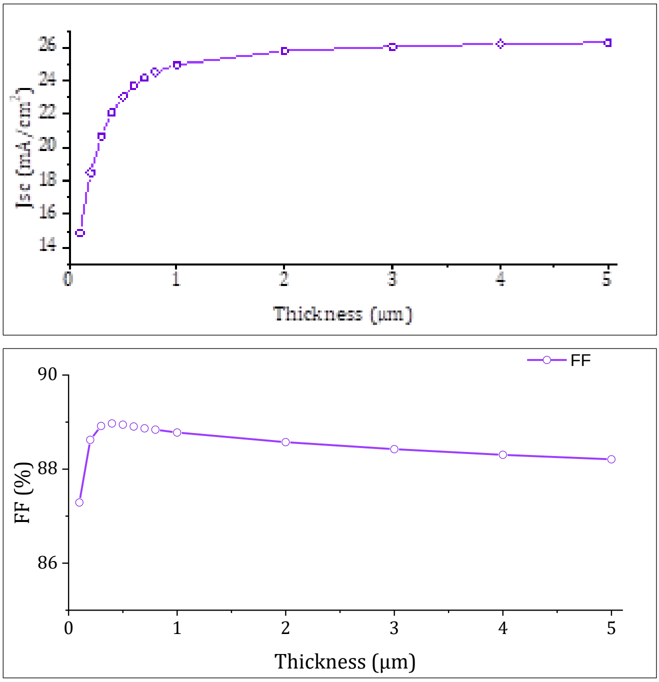
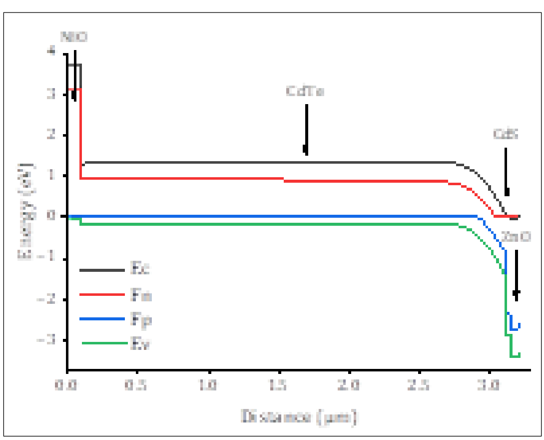
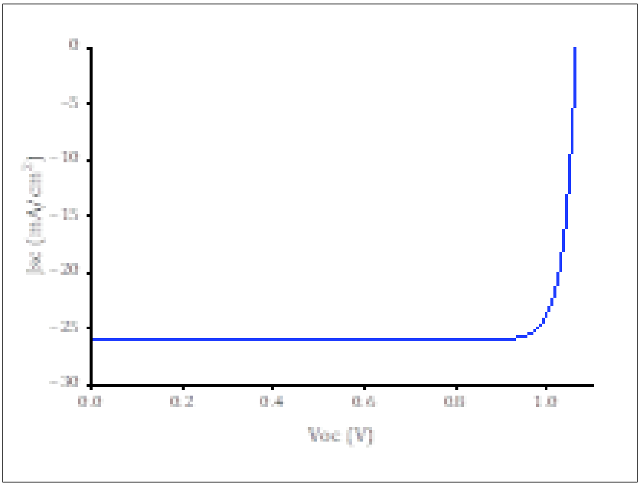


Fig 2: Effect of CdTe thickness layer variation on reference cell photovoltaic parameters

On the other hand, electron affinity of NiO is 1.46 eV and band gap of this semiconductor is 3.8 eV, therefore, this semiconductor also forms a suitable pp+ heterojunction with CdTe when heavily doped as shown in Fig. 3(a) is used for back contact. Figure 3(b) and 3(c) shows the simulated J_{SC} - V_{oc} curves and quantum efficiency (QE) curve.





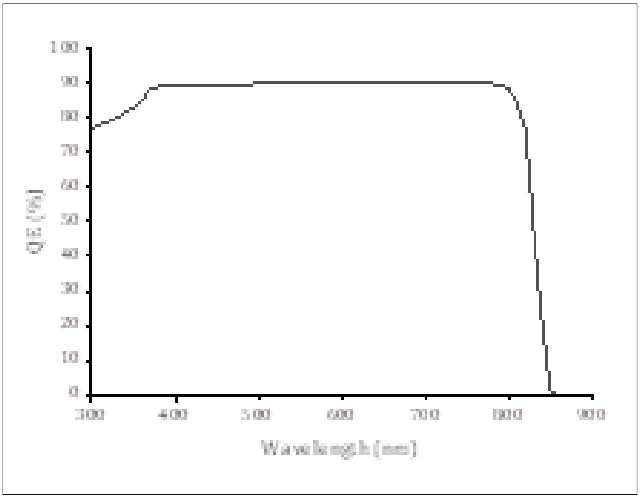


Fig 3: (a) Energy band diagram (b) J-V Characteristic (c) Spectral responce of reference solar cell

3.1 Effect of different window layer on thin film-based solar cell

Zinc oxide (ZnO) and stannic oxide (SnO_2) are most common substrate used as winodw layer in solar cell. The optimal photovoltaic parameters (V_{OC}, J_{SC}, FF and η%) of a CdTe thin film with various window layers are shown in Table 2. It is observed that SnO_2 performs the best as a window layer, obtaining an efficiency of 25.76% with higher J_{sc} (27.82 mA/cm^2) and FF (86.77%) compared to ZnO, so SnO_2 have been recomended as window layer in thin films.

Table 2: Effectiveness of the window layer material (donor) on J–V characteristics.

Buffer Layer	**V_{oc} (V)**	**J_{sc} (mA/cm^2)**	**FF (%)**	**Efficiency (%)**
ZnO	1.0669	27.8161	86.75	24.74
SnO_2	1.0669	27.8287	86.77	25.76

3.2 Effect of different buffer layer on thin film-based solar cell

Cadmium (Cd) is harmful to the environment and humans due to its poison and toxin nature. Other possible buffer layers, such as zinc sulfide (ZnS), zinc selenide (ZnSe), ZnO, zinc stannate (Zn_2SnO_4) and indium sulfide (In_2S_3) have been investigate in this paper. The optimal photovoltaic parameters (V_{OC}, J_{SC}, FF and η%) of a CdTe thin film with various buffer layers with SnO_2 as window layer are shown in Table 3. It shows that ZnO performe as a best buffer layer, obtaining an efficiency of 26.33%. The results also reveal that buffer layers made of ZnSe, ZnS and Zn_2SnO_4 have excellent efficiency 26.30%. While buffer layers based on In_2S_3 had a lower efficiency of 26.24%. So, ZnO may have been proposed as replacements for CdS as a buffer layer in thin films.

Table 3: Effectiveness of the buffer material (donor) on J–V characteristics

Buffer Layer	**V_{oc} (V)**	**J_{sc} (mA/cm^2)**	**FF (%)**	**Efficiency (%)**
CdS	1.0669	27.8287	86.77	25.76
ZnS	1.0666	27.8507	88.54	26.30
ZnSe	1.0666	27.8456	88.56	26.30
ZnO	1.0666	27.8596	88.59	26.33
Zn_2SnO_4	1.0666	27.8398	88.59	26.30
In_2S_3	1.0667	27.8318	88.39	26.24

3.3 Proposed ITO/SnO_2/ZnO/CdTe/NiO Thin film-based solar cell

Based on the simulation results describe above the optimum PV parameters can be achived with an efficiency 27.34% with V_{oc} = 1.0676 V, J_{sc} = 28.9156 mA/cm^2, FF = 88.61%, when thickness and accepter concentration of CdTe are 3 μm and 1 x 10^{16} cm^{-3} respectively, thickness and donor concentration of ZnO are 25 nm and 1 x 10^{19} cm^{-3} respectively, thickness of SnO_2 are 50 nm, thickness of ITO are 0.02 nm. Figure 4 shows the SCAPS solar cell definition panel and J-V characteristics of proposed solar cell.

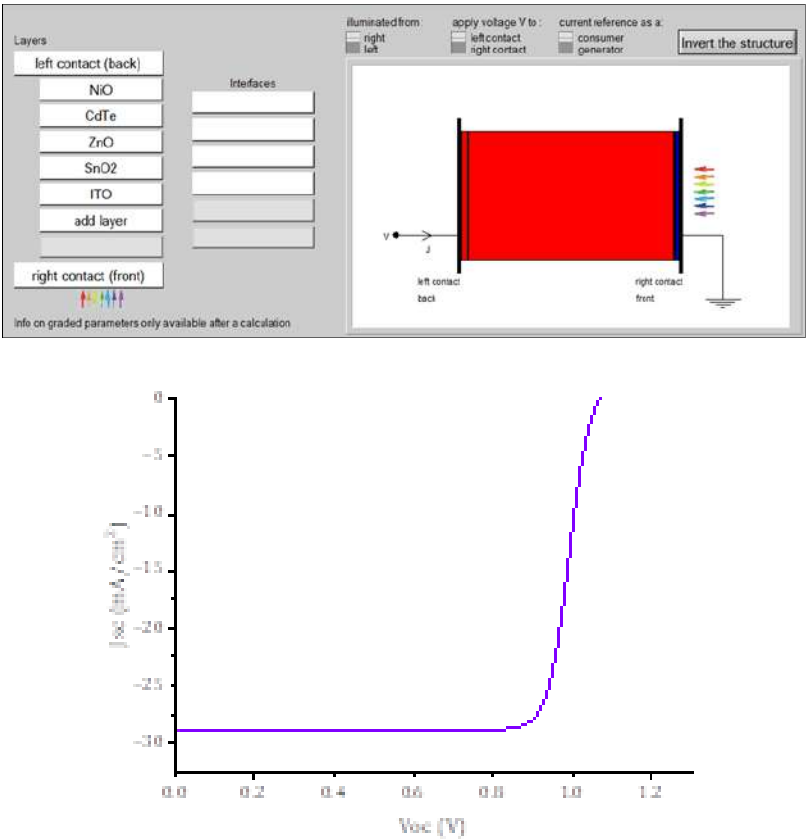


Fig 4: SCAPS solar cell definition panel and J-V characteristics of proposed solar cell

3.4 Comparison between Published Work and Proposed Work

The simulation results of this work were compared with published work. Table 4 shows comparison of simulation results with published work. It shows that the proposed work outperforms recently published studies in terms of four performance of the solar cell.

Table 4: Comparison of simulation results with published work

Buffer Layer	Method	V_{oc} (V)	J_{sc} (mA/cm^2)	FF (%)	Efficiency (%)	Reference
CdS	Experimental	0.69	30.9	72	15.3	Islam *et al.* 2009
	Simulation/SCAPS-1D	0.9113	23.4497	81.41	17.43	Zyoud *et al.* 2021

	Simulation/SCAPS-1D	1.0669	27.8287	86.77	25.76	This work
ZnS	Experimental	0.55	34.4	73	13.6	Ennaoui *et al.* 2003
	Simulation/SCAPS-1D	0.9121	23.2602	74.84	15.88	Zyoud *et al.* 2021
	Simulation/SCAPS-1D	1.0666	27.8507	88.54	26.30	This work
ZnSe	Experimental	0.67	34.9	72.7	14.4	Ennaoui *et al.* 2003
	Simulation/SCAPS-1D	0.9112	23.4840	82.38	17.42	Zyoud *et al.* 2021
	Simulation/SCAPS-1D	1.0666	27.8456	88.56	26.30	This work
ZnO	Experimental	0.835	21.4	75.46	15.19	Kartopu *et al.* 2019
	Simulation/SCAPS-1D	0.9142	23.3039	76.37	16.27	Zyoud *et al.* 2021
	Simulation/SCAPS-1D	1.0666	27.8596	88.59	26.33	This work
In_2S_3	Experimental	0.27	46.8	71.5	12.9	Spiering *et al.* 2004
	Simulation/SCAPS-1D	0.9198	23.1535	66.81	14.23	Zyoud *et al.* 2021
	Simulation/SCAPS-1D	1.0667	27.8318	88.39	26.24	This work

4. Conclusions

To model and analyze a CdS/CdTe thin flim-based solar cell was numerically simulated using SCAPS program. Researchers, engineers and designers will find this work extremely valuable in studying and constructing CdTe-based systems. This study employ a number of buffer layers (CdS, ZnSe, ZnS, In_2S_3, ZnO) from a numerical simulation point of view and the result using SCAPS–1D indicate that ZnO is the best buffer layer which may good option as alternate buffer layers for the CdS of CdTe solar cells. Additionally, the material that is used for the CdS buffer layer must be changed to a more appropriate material. To improve the PV solar cell performance, ITO/SnO2/ZnO/CdTe/NiO thin film-based solar cell is proposed in this work. This work achieved encouraging optimized results with a conversion efficiency is 27.34% with V_{oc} = 1.0676 V, J_{sc} = 28.9156 mA/cm^2, FF = 88.61%. The findings will provide vital information for the predicting high-efficiency thin-film solar cells. The progress of improved numerical modeling performance of solar cells plays a vital role, as evidence by these findings.

Conflict of interest: The authors declare that there are no conflicts of interest in this work.

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Chapter - 30
Effects in Process Parameters with Development of Corner Radius and Rake Surface of the Cutting Tool during Turning Operation under Dry Machining Conditions

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Chapter - 30

Effects in Process Parameters with Development of Corner Radius and Rake Surface of the Cutting Tool During Turning Operation under Dry Machining Conditions

Goutam Paul, Subhadeep Mukherjee and Souma Nandy

Abstract

In machining processes, there has been an increased investigation for methods to reduce the tool wear rate, prolong tool life and optimisation of parameters like cutting, to achieve better machining. Here an experiment and detailed study has been done to analyse the effects on the process parameters, particularly, the temperature of the tool and work piece, and load variation by variation of the corner radius of the tool and by using an array of grooves in the rake surface of the tool. This was done through simulation methods to predict the parameters. The cutting parameters are then compared for the corner radius values used and results are shown for the temperature fall using multi rake surface.

Keywords: Turning, tool wear, tool life, rake surface, cutting edge, energy conservation.

1. Introduction

As we head towards industry in the near future, where the target is to manufacture in a sustainable way, we need to focus more on cleaner ways of manufacturing or green manufacturing. This can be achieved using different methods that are already in our hands; either they are costly or are not industry-ready to be employed directly. But researchers are always keen for more options so as to achieve this target.

As said above, the problem is being worked on throughout the world and research has shown the wastage of heat during the operation, and simultaneously the energy that is being wasted (power consumption), increased efforts in order to cool the system, increased in tool wear rate and reduction in tool life etc. are the key problems.

Development of predictive models and optimization techniques in order to determine the most optimised machining parameters leading to cleaner machining are being done recently using: Response Surface Methodology (RSM), Artificial intelligence (AI), ANN, SVR and machining theories etc. are being found out for a better and detailed machining process [1, 2]. These lead to predicting the temperature, stress-strain, surface roughness, tool wear rate, tool life and power consumed during machining.

Past research shows that the MRR is increased in dry machining conditions as compared to using liquid CO_2 and MQCL conditions, whereas the chip surface and job surface finish is of much more excellent quality than as produced by dry machining [3].

On similar lines, some have done the experiments and prediction simultaneously have arrived at a conclusion that the cutting speed and depth of cut affect cutting force and surface roughness; and if considered only surface roughness and cutting force, then MQL turning is advantageous over wet turning processes [4].

While studies show tool life increases with an increase in the corner radius [5], the thrust forces are also found to be greater for a honed tool or a worn tool [6].

Hence power consumption to an extent can be optimised through studying and development in the tool and was done via simulation by using Deform 3D software. A precise study of the load prediction and temperature generated during cutting in both the tool and work piece, the effect observed in tool life, tool wear rate etc. will provide a detailed analysis.

2. Methodology used

The level setting used for proceeding with the multi-rake surface and corner radius experiments is constant, where

N=1000 rpm; Depth of Cut = 0.5mm and feed rate = 90mm/min. The material of the tool is carbide with 19% cobalt and the job material used is Aluminium Al6061 alloy. For this experiment, three values of corner radius were used; 0.01mm, 0.03mm and 0.05mm being the values of R1, R2 and R3 respectively.

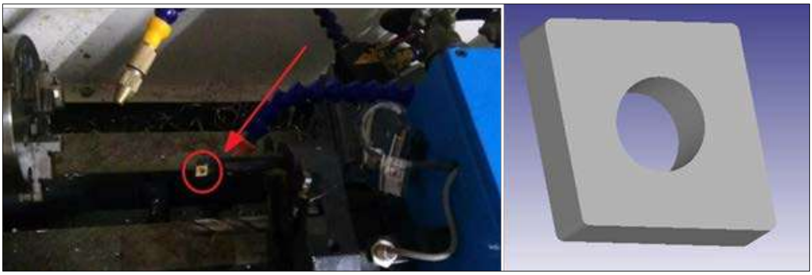

Fig 1: The carbide tool insert- turning operation and the same is used for simulation

3. Design and Generation of the tool

3.1 For variation of corner radius of the tool

The tool was designed using Solid Works and the designing of the work piece or job, and mesh generation of the tool and workpiece were done using DEFORM 3D software. The results of the tool and work pieces generated are shown in the figures below:

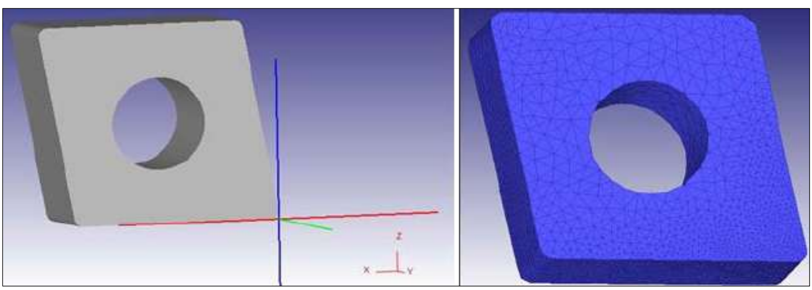

Fig 2: The tool used and its mesh generation

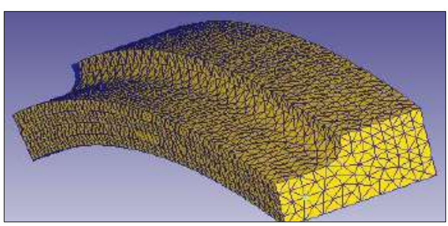

Fig 3: Workpiece (section of the sample) and its mesh generated

Table 1: Composition of the workpiece material

Component	Wt.%
Al	95.8 - 98.6
Cr	0.04 - 0.35
Cu	0.15 - 0.4

Fe	Max 0.7
Mg	0.8 - 1.2
Mn	Max 0.15
Other, each	Max 0.05
Other, total	Max 0.15
Si	0.4 - 0.8
Ti	Max 0.15
Zn	Max 0.25

3.2 For use of an array of grooves in the rake surface of the tool

For this experiment, an array of grooving, for 2, 3, 4, 5 grooves, enhancing multi-rake surface is used, each being 0.75µm in-depth, and the analysis is shown below; and from the graphs, it can be observed easily, the tool and work piece temperature shows an effective variation for a change in the rake surfaces.

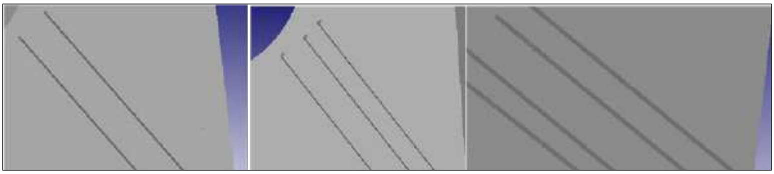

Fig 4: Tool generated with different arrays of micro rake

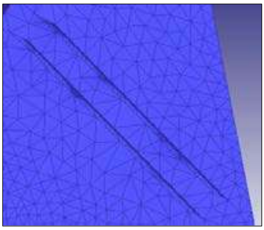

Fig 5: Mesh generation of a tool insert sample with multi rake surface

4. Results

4.1 For variation of corner radius of the tool

For this experiment, three values of corner radius were used; 0.01mm, 0.03mm and 0.05mm being the values of R1, R2 and R3 respectively. The temperature generation for tool and work piece and loads Px, Py and Pz are analysed. The analysis reveals that at with an increase in the radius value, the temperature decreases. For the work piece, the temperature-time plot is shown below, showing the temperature generated at the work piece for the three radius values.

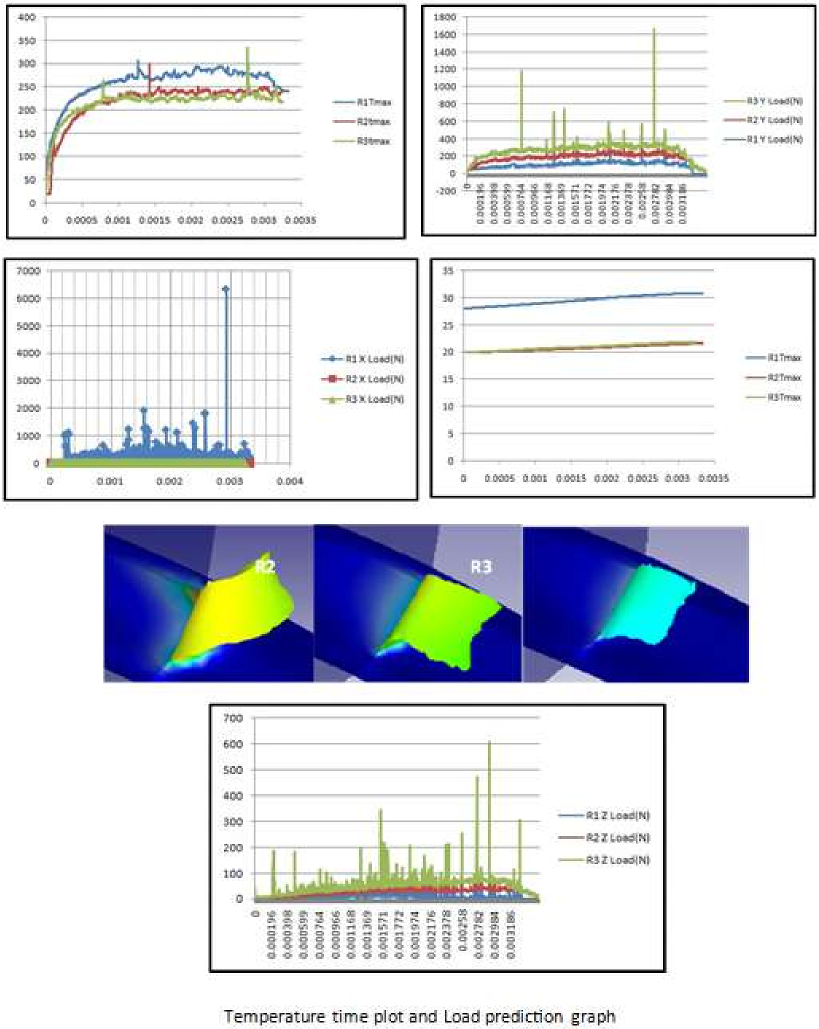

Fig 6: Temperature time plot and load prediction graph

4.2 For use of an array of grooves in the rake surface of the tool

It is observed here, with an increasing number of cutting in the rake surface of the tool, (2, 3, 4 and 5 respectively) and each being 0.75μm in depth; the temperature of the tool decreases, which is found from the graph as shown below:

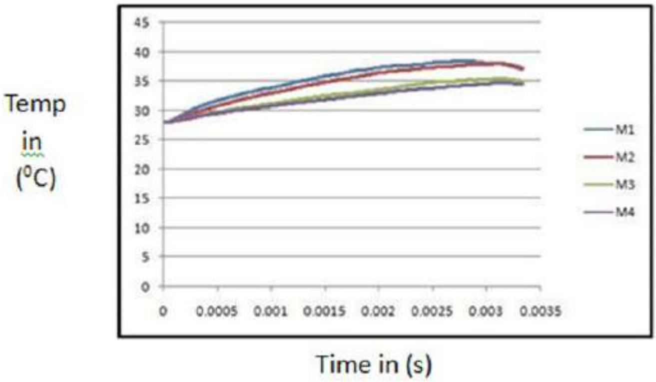

Fig 7: Temperature variation with time for different micro rake surface

5. Conclusion

As can be seen here, as the radius values increase, the tool and workpiece temperature, the load at each of the X, Y and Z axes, decreases, showing that (a) There is less heat generated for the increase in the corner radius value; (b) There is less amount of power consumption, for the machining and also the cooling setup, as the experiments were carried out in dry environments; (c) The effect of the load is less in x and z directions and increases with increase in radius value for the cutting force in the y-direction (cutting force), thereby showing that for a honed edge, the cutting force is more as seen here. (d) With an increase in the number of grooves at the rake surface of the tool, the temperature of the tool decreases, thereby resulting in less power consumption.

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Chapter - 31
Overview on Implementation of the Arduino UNO-based Blind Stick for Visually Impaired People to use in their Daily Lives

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Chapter - 31

Overview on Implementation of the Arduino UNO-based Blind Stick for Visually Impaired People to use in their Daily Lives

Piyasha Bhattacharjee, Anamitra Upadhyay, Tanisha Kumari, Arya Pratap Singh and Debashis Sarkar

Abstract

The technology has advanced itself with the running talent of the emerging generations starting from teaching to industries and the HealthCare Centres, there people observe so many instruments in the hospitals for any kind of check-up or surgery but found no cost-effective device which could help the visually impaired people who permanently lost their sights. So, it almost becomes impossible for an individual to do at least their possible hand-in work. This Smart Blind Stick embedded with various latest technology instruments will help a visually impaired individual to detect obstacles and use various sound buzzers. Here, the buzzer is connected to the Arduino Uno board via a breadboard using male-to-male jumper wires. The Arduino board serves as the control centre, receiving input from the Ultrasonic sensor and transmitting output signals to the buzzer. Upon detecting a person within the specified range, the Arduino board activates the buzzer, generating a distinct sound as the doorbell alerts. So, the person can walk without any tension as well as without fear. This device will be the best solution to overcome their difficulties and to trust wholeheartedly. In this project, there is being used four Ultrasonic Sensors HC-SR04. So now, this smart stick will have to sense distance from any obstacle and three different sound buzzers using which the blind man could recognize the pith holes or bumpers or side obstacles, or front obstacles. Arduino Uno is connected to the four Ultrasonic Sensors HC-SR04, additionally, it demonstrates the versatility of the Arduino Uno board and its ability to interface with various components to perform specific tasks and buzzers using male-to-male, female-to-female, and male-female jump wires along with a breadboard.

Keywords: Ultrasonic sensor, buzzers, arduino uno, blind stick, visually impaired

1. Introduction

'Visually Impaired People' as they can't see anything what's going around them, the slightest they can know their environment is by touching their surroundings. As per statistics The World Health Organization (WHO) says that the important part of human psychology is 83% (2018) of the information they get from their respective environments they belong to [Arvind (2018) *et al.,*]. Not only that but added to it, their mobility gets affected too due to their eye-sight loss. To prevent such obstacles in their lifestyles, technology recently has come up with a SMART BLIND STICK. In fact, Artificial Intelligence as well as IOT (Internet of Things) has come over with many techs not only for blind person, but also for Deaf and Dumb persons [Pratik NK *et al.,*].

The main end of this system is to permit sightless persons to explore autonomously in the outward terrain usual path navigational systems in the outdoor terrain. These people are expansive debit as they regularly don't have the data which is needed for one while passing these obstacles and troubles come in the way.

They usually have little information about data similar to as land jokes, heading and self-velocity information which pivotal for them to explore them from a new terrain. The end of the common system is to give a low cost and effective navigation aid for eyeless which gives a sense of artificial unreality by furnishing information about the environmental script of objects around them. Moment technology is perfecting daily in nonidentical aspects in order to give adjustable and safe motion for people. In this technology-AI-driven world, where people strive to reside singly, this paper proposes a minimum-cost 3D ultrasonic stick for eyeless people to gain particular independence from other people, so that they can remove from one position to another fluently and securely. A movable stick is projected and developed that detects the obstacles in the path of the eyeless utilizing ultrasonic detectors. It consists of these detectors to overlook three nonidentical directions, a microcontroller, buzzer. This study aims to develop a device that can be exercised to descry obstacles for eyeless people. This device also uses the HC- SR04 ultrasonic detector. The system exercised in the manufacture of eyeless assistive prototypes in the shape of sticks utilizing Arduino and Ultrasonic Sensors for eyeless people with the system attained by tackle project ways exercised consists of ATMEGA328 as the main regulator, Ultrasonic detector HS- SR04 as detecting objects, this study has produced a prototype project stick for eyeless people utilizing detector technology to support alert and remove eyeless people who are suitable to descry objects at a minimal distance of 7 centimetres with affair in the shape of sound and vibration.

The purpose of this study is to ameliorate the quality of lifestyle for the visually impaired by restoring their capability to tone-mobility navigation. In this paper describes a compact device that converts visual information into a conspicuous signal. This device, constructed entirely from commercially available corridors, enables the user to receive distant objects via Ultrasonic Sensors. Primary data suggest that this device is useful for object avoidance in surroundings. [B. Manikandan (2022) *et al.*,]. This project highlights the potential of hardware-based projects in implementing automated systems for enhanced convenience and functionality.

2. Proposed Word and Equipments

The stick is embedded with a box inside which Arduino UNO ATMEGA328, 4 different sound buzzers are present, Female-to-Female jump wires, Male-to-Female jump wires, Male-to-Male jump wires and a 4 Mini-Breadboard is present.

Developing this product at a minimal cost and useable becomes the main docket of this project. Three Ultrasonic Sensors are connected to the front and both sides of the stick and one facing towards the ground.

Ultrasonic Sensor HC-SR04

This sensor senses the obstacles within the distance (range) which is provided/provided by the user manually in the system. A pair of eyes can be observed we are basically the Transmitter and the Receiver. The transmitter (here) transmits the pulse signals to the microprocessor (Arduino UNO) with velocity v, and the Receiver receives the transmitted signals from the microprocessor (Arduino UNO) after time t. This is generally known as *TIME OF FLIGHT*. So, the distance can be given by $\frac{v \times t}{2}$.

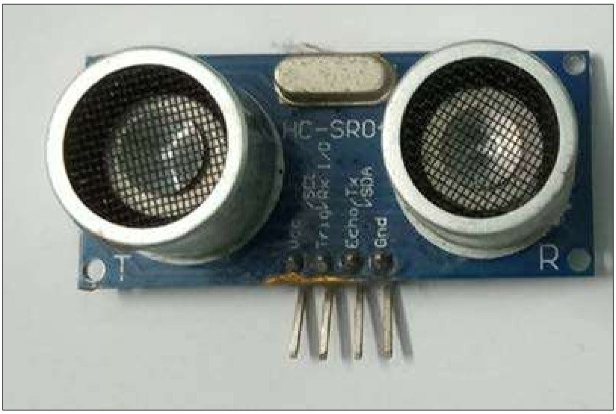

Fig 1: Ultrasonic Sensor HC-SR04

Fig 2: Arduino UNO (Microprocessor: ATMEGA328)

Arduino UNO (Microprocessor: ATMEGA328):

The Arduino UNO board can be built with power pins, analog pins ATMEGA328, ICSP header, power LED, digital pins test led 13, TX/RX pins, USB interface, an external power supply and reset button.

The Arduino UNO power supplies mainly include AC-to-DC adaptor otherwise a battery. The adapter can be connected to the Arduino UNO by plugging into the power jack of the board. Similarly, the battery leads can be connected to V_{in} pin and the GND pin of the power connector. The suggested voltage range will be 7 volts to 12 volts.

The memory of this ATMEGA328 Arduino microcontroller includes flash memory-32 KB for storing code, SRAM-2KB EEPROM-1KB.

The programming in the Arduino UNO was done in Arduino IDE tool which has to get installed in the PC/respective Laptop.

Jump Wires

Here, in this project three types of jump wires and those are: -

Male-to-Male Jump Wires

Male-to-Female Jump Wires

Female-to-Female Jump Wires

These are used to complete the circuit connection to make the product usable.

Buzzers

Different kinds of buzzers (2310E, 3026, 3015, TM-1407B) with different sounds are attached to four different Arduino UNO by these jump wires inside the box so that the person can identify that from where the obstacle is identified.

-2310E **-3026**

-3015 **-TM-1407B**

Fig 3

Breadboard

A breadboard, solderless breadboard, or protoboard is a construction base used to make semi-permanent prototypes of electronic circuits. Unlike a per board or stripboard, breadboards don't bear soldering or destruction of tracks and are hence applicable.

Batteries

9V batteries are also preferred to use for longer time durations. Companies of the batteries may vary.

Modifications needed

The Ultrasonic Sensors HC-SR04 can be attached to a same Arduino UNO.

The Motor can be proposed inside the stick.

LDR and GSM systems can be added so that the GPS navigation of that person could be tracked.

Bluetooth could also get included in this system and certain switches can be attained so that visually impaired could access the calls and messages easily.

Could be made more compatible and a small circuit with the help of fewer components.

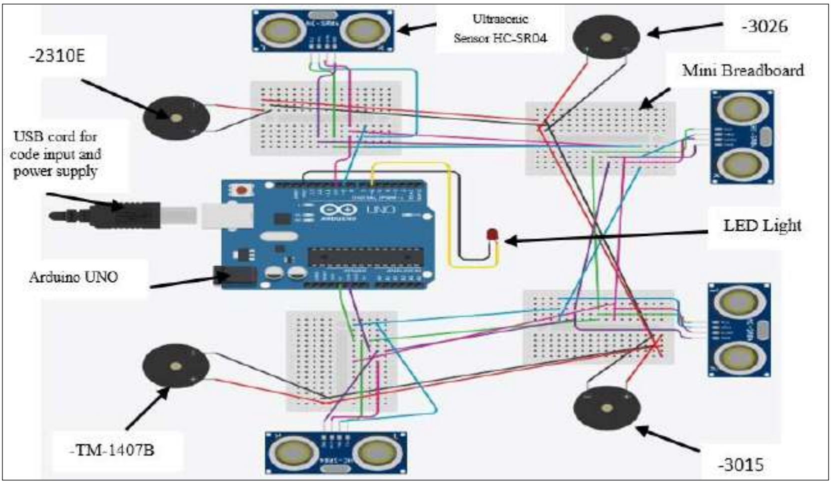

Fig 4: Circuit connection

3. Conclusion

This Stick is being designed so that the Visually Impaired Persons who lost their eyesight either due to any mishap or by birth can use this for their mobility without depending on any other human. This Stick embedded with multisensory components keeps helping the person to detect the obstacle in front or left or right and can also detect the speed breaker or dead end of the road. The aim is to make this model smarter and helpful. The literatures and surveys were reviewed and analysed. Hence, it is effective and affordable.

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Chapter - 32
A Review on Electrical Discharge Machining Process: Diversity of Tool Material and Effect of Process Parameters on Material Removal and Surface Finish

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Chapter - 32

A Review on Electrical Discharge Machining Process: Diversity of Tool Material and Effect of Process Parameters on Material Removal and Surface Finish

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Abstract

Electrical discharge machining (EDM) is one of the popular non-conventional machining processes which is developed approximately 80 years ago. Still, many of its capabilities yet to be exploited. It has become popular as complex 3D objects can be machined with this process. Its limitation is that only conductive materials can be machined. In the present study the authors reviewed different research articles to find out the diversity of EDM process on different materials and effect of different process parameters for improvement of material removal rate (MRR) with better surface finish. In this review diversity of use of different materials as tool in EDM process is considered. Also review of multiple research papers has been conducted to study of effect of different process parameters like current, voltage, spark gap, pulse time on MRR and surface finish.

Keywords: EDM, EDM Tool Material, Spark Gap, current, MRR.

1. Introduction

In the new era of manufacturing many sources of nonconventional energy *viz*. electrical, mechanical, light, ultrasound, electrons, ions etc. Among them Electrical Discharge Machining (EDM) is one of the popular non-conventional machining processes, where cutting force is not required. In this process electro-thermal energy is applied to remove material from the upper surface of the job. Thermal energy is generated from the electrical spart generated at the gap between the tool and the job-piece. Thermal energy erodes the job-piece. The job and tool materials must be electrically conductive. Job piece is submerged into the dielectric fluid and a flow of dielectric fluid is maintained for better erosion. Unwanted material from the upper surface of job piece is done through melting and evaporation. Since last few decades, several researchers explored many paths of improvement machining by optimizing EDM Process parameters on different materials and environment. This paper reviews the research articles of different researchers to find the effect of process parameters of EDM on machining.

2. Electrical Discharge Machining (EDM)

2.1 Theory

Electrical Discharge machining (EDM) is non-traditional machining process used for shaping hard materials that are tough to machine using conventional methods. The process involves the controlled removal of materials by the repeated spark discharge that occur between a tool electrode (also known as tool) and the work piece, submerged in a dielectric fluid. The spark is created in between electrodes which is helped to create heat that melts and vaporizes the material from workpiece and tool to continuous material removal.

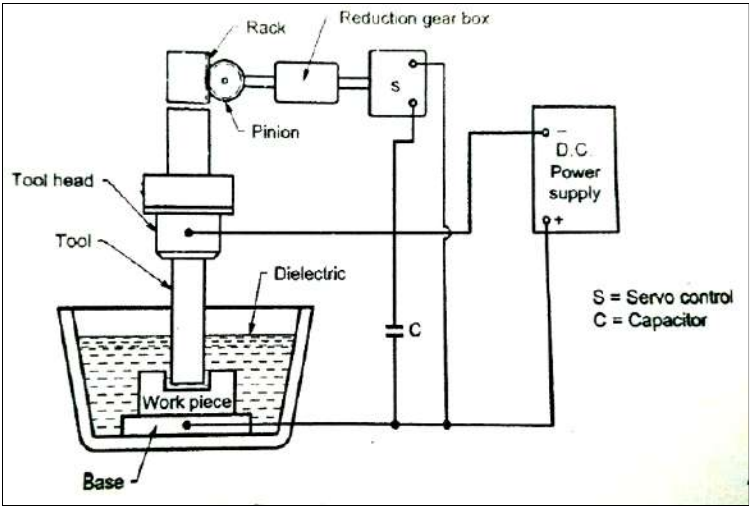

Fig 1: Diagram of EDM machine

2.2 Diversity of tool material

In Electrical Discharge machining (EDM) tool materials are chosen based on their electrical conductivity and wear resistance. Like copper, graphite, tungsten, and brass are common choices. The process parameters, including pulse current duration, gap voltage is mainly influencing the MRR (material removal rate and surface finish. Some tool material which are widely used in industry’s are, carbide, ceramics, high speed steel (HSS), copper.

1) **Carbide:** Carbide tools are largely used for their high hardness ability, which is excellent wear resistant. It is also suitable for high-speed machining and it can handle high temperature
2) **Ceramics:** Ceramic tools also have high hardness ability and can withstand high temperature. It can be used in cast iron and super alloys.
3) **Copper:** Copper is one of the most common tools used in EDM. It has good electrical and thermal conductivity which is suitable for EDM machining.

2.3 Types of Dielectric fluids use on EDM

2.3.1 Water as Dielectric Fluid

The tap water has proven to have the best machining rates, and when utilizing copper tools with negative polarities and machining in water, it is probable to obtain 0% TWR.

In their 1987 performance, Koenig and Joerres added aqueous glycerin solution to water. (Konig, 1993) In comparison to kerosene, the impulsive power of discharge in distilled water is smaller but more consistent, and the Ti-6Al-4V alloy debris size is larger in distilled water.

In 2004, Leao and Pashby looked into the possibility of enhancing the efficiency of demineralized water by adding organic compounds such ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 600, dextrose, and sugar. (Yan *et al.*, 2005).

2.3.2 Powder-Mixed in Dielectric Fluid

Dielectric fluid is blended with EDM powder made of various materials because they increase the likelihood of a discharge and decrease the breakdown strength of the insulating dielectric fluid, the floating particles prevent ignition from happening. This results, MRR, SR, TWR, and sparking effectiveness are all improved. Since conductive particles increase the gap distance and spread the discharges more erratically across the surface (Kansal *et al.*, 2005). The recast layer's thickness is thinner, and microcracks are diminished. As a result, the machined surface's corrosion resistance is significantly increased. H.K. Kansal also came to the conclusion in 2007 that PMEDM holds great promise for the use of EDM, especially in terms of process productivity and workpiece surface quality (Jeswani, 1981). The doping elements mixed with the hydrocarbon's carbon to generate the corresponding carbides. For these applications, the tool electrode was negative and the workpiece was positive. The parameters those affected the doping properties for the same powder concentration were pulse current and pulse length.

Early in 1995, Miyazaki applied steel with a plasma arc created by a nozzle with a tiny diameter (Wong *et al.*, 1998). It was discovered that using negative electrode polarity was crucial for obtaining mirror-finish state.

In the year 2000, Okada set out to increase the modified surface's hardness through an increase in pulse length and powder concentration. (Rehbein *et al.*, 2004)

Additionally, it to be noted that the addition of aromatic hydrocarbons to the dielectric fluid has a significant impact on the ignition and breakdown phase of single discharge (Furutani and Shimizu, 2003)

2.4 Process parameters of (EDM)

2.4.1 Peak current

In EDM, the peak current is essentially one of the most crucial machining parameters. It measured in amps and refers to the power used in EDM. The current rises during each pulse on-time until it reaches a predetermined level, which is designated as the peak current. The maximum amperage in wire-EDM and die sinking procedures is determined on the cut's surface area. Roughing operations and cavities or feature with vast surface areas demand a higher amperage. Higher currents will increase MRR, but at the expenditure of increased tool wear and surface roughness (Ho and Newman, 2003).

2.4.2 Electrode gap

The tool servo-mechanism used in EDM machines serves the purpose of responsively controlling the working gap to the pre-set value. Many of the systems employed are electro-mechanical (DC or stepper motors), and they are typically made to react to average gap voltage. Figuring 7. Gap stability and system reaction speed are fundamental prerequisites for optimal performance; the existence of backlash is particularly undesirable. To react to short circuit or open gap conditions, the reaction time must be swift. Although gap width cannot be measured directly, the average gap voltage (Crookall and Heuvelman, 1971).

2.4.3 Dielectric flushing

The dielectric fluid used in EDM has the following qualities: strong dielectric strength, quick recovery after breakdown, efficient quenching and flushing capabilities, good degree of fluidity, and accessibility. The kind of dielectric and how it is flushed have an impact on TWR and MRR (Wong *et al.*, 1995).

2.4.4 Rotating the work piece

The methods used to apply rotational motion to the sparking process have an impact on the EDM performance in addition to cleansing the dielectric. (Guu and Hocheng, 2001). increased the temperature distribution of the workpiece and the rotary motion of the workpiece to improve the flow of the dielectric fluid in the spark gap, resulting in better MRR and SR. The opposite is true for Kunieda and Masuzawa. (Kunieda and Masuzawa, 1988)

2.4.5 Rotating the electrode

Similar to this, adding a rotational motion to the electrode increases the performance metrics of the EDM process. It acts as a practical gap-flushing method that greatly raises MRR and SR (Kagaya *et al.*, 1990) (Sato *et al.*, 1986) (Soni, 1994). When using rotating electrodes, the same alloying impact of material elements migrating from the workpiece and tool is also seen in connection to the morphology, chemical content, and size distribution of debris (Soni, 1994).

3. Literature Review

One of the research features of the EDM process is the fluctuation in response characteristics caused by the generated pulse's changing form. The average spark energy delivered to the surface is influenced by the discharge pulse form. Since the electrical energy determines the machining properties in the EDM process, the pulse shape affects machining parameters including material removal rate, surface quality, and electrode wear rate.

2.1 Effect of electrical process parameters based on performance criteria

The performance of the die-sinking EDM technique with RC pulse generator explained by Gostimirovic *et al.*, (Gostimirovic *et al.*, 2011). They Found the EDM (Electrical Discharge Machining) process, the rate at which material is removed is indeed influenced by the pulse duration and discharge current. These parameters play a crucial role in determining the efficiency and precision of the machining process. By adjusting the pulse duration and discharge current, manufacturers can optimize the material removal rate to achieve desired results. Mohan *et al.* (Mohan *et al.*, 2002) optimized these EDM process parameters is essential to achieve the desired balance between material removal rate, tool wear, and surface roughness, depending on the specific requirements of the machining application.

Nowicki *et al.* (Nowicki *et al.*, 2009) summarized that, increasing the discharge current in EDM generally leads to higher tool wear and increased

Material Removal Rate. However, finding the optimal balance is crucial to achieve efficient machining with acceptable levels of tool wear for a given application. Researchers and practitioners often conduct experimental studies to understand the specific effects of different parameters and optimize the EDM process for specific materials and applications.

It's worth noting that research findings in EDM are often specific to the materials, tooling, and process conditions used in a particular study. The optimization of parameters such as pulse on time and spark gap is essential for achieving desired outcomes in terms of surface quality and machining efficiency. Kuppan *et al.* investigated with numerical computation and revealed that the pulse on time and spark-gap have potential to influence on surface roughness. They reported on their experimental examination that for small deep-hole drilling by EDM on Inconel 718 workpiece using electrolytic copper tool electrode (Kuppan *et al.*, 2008). Wang *et al.* employed variously shaped copper electrodes, a number of planned studies employing varied process parameters, for example open voltage, pulse duration, and pulse current, have been conducted in H13 steel. Since the edges of electrode quickly wear out, it was being shown that the triangular-shaped electrode shows a very inefficient output. With polycrystalline diamond, a sequence of tests has been conducted to investigate the effect of electrode rotation speed, machining polarity and nominal capacitance over tool and MRR (Wang *et al.*, 2011).

3.2 Observation and EDM process control

Through the machining process, the process parameters of EDM must be monitored in order to manage them and acquire the necessary response parameters. The fundamental goal of process monitoring and control is to watch and measure process variables in order to lessen the variance in performance metrics from the target level.

Yan designed an adaptive control system for the wire electrical discharge machining process that allows for process monitoring, identification, and control. (Yan, 2010). Adjusting has been found to help the pulse interval of each supply pulse cycle has allowed for control of wire breakage.

In order to forecast the surface roughness of machined surfaces produced by the wire EDM process as a function of process factors including open circuit voltage, pulse duration, and wire feed rate. created a model of an adaptive neuro- fuzzy inference system (Caydas *et al.*, 2008).

Yilmaz *et al.* (Yilmaz *et al.*, 2006) conducted experiments with the proposed control system have demonstrated improvements in the surface quality of the EDM process. The development of a user-friendly intelligent system, guided by the expertise of skilled operators, further enhances the efficiency and precision of selecting EDM parameters, specifically for machining AISI 4340 stainless steels. This approach not only benefits experienced operators but also opens up the use of EDM to a wider audience, including novice users, while still ensuring high-quality results. To improve the EDM process performance, Zhou and Han created an adaptive control system that directly and automatically controlled the tool downtime (Zhou and Han, 2009).

On the change of the proportion of normal spark, arc, and short circuit in the total spark, the impacts of pulse interval, machining feed rate, and workpiece have been discussed. According to the experimental findings, the devised control system effectively decreased the arc discharge during the EDM process to ensure stable machining.

Chang's creation of a proportional derivative controller for the spark gap in the EDM process reflects an attempt to tackle the inherent non-linearities associated with EDM. This approach demonstrates a focus on dynamic control to enhance stability and performance in the machining process. (Chang, 2005).

They came to the conclusion that the effective discharge in EDM process had been decreased by this non- linearity. A neuro-fuzzy based gap width controller was proposed by Behrens and Ginzel as a highly effective removal mechanism for the EDM process (Behrens and Ginzel, 2003).

Tong *et al.* created an experimental system with a macro/micro dual feed spindle that used an ultrasonic linear motor as the macro drive and a piezoelectric actuator as the micro feeding mechanism to enhance the machining performance of the servo scanning micro EDM process (Tong *et al.* 2008). A real-time control system based on the LabVIEW software package has been created to coordinately operate the dual-feed spindle driving the tool electrode. With the use of an artificial neural network, Fenggou and Dayong provided a technique for automatically determining and optimizing the process parameters for the EDM sinking process. (Fenggou and Dayong, 2004).

4. Conclusions

After review of several research papers following conclusion may be derived:

- Many of the researchers explored and optimized the effect of EDM process parameters involved in erosion in EDM process.
- EDM process is dependent of pulse duration and current.

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Conflict of interest: The authors declare no conflict of interest.

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Chapter - 33
Analysis of Die Material Surface During Hot Forging

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Chapter - 33

Analysis of Die Material Surface During Hot Forging

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Abstract

This research investigates the wear profile on the die surface for an axisymmetric cross-section during "hot forging" operations, focusing on accurate predictions of die wear and its distribution, the effects of friction on die wear and material flow by presenting numerical die wear profiles in hot forging operations. Here we have used two wear models, and the study finds that higher friction coefficients do not generally increase die wear. To extend die life, increasing surface hardness and wear resistance can help prevent hot forging die failure. The wear process depends on numerous aspects, which makes analysis extremely challenging. Hot forging primarily causes die wear due to abrasive particles, caused by mechanical friction between the die surface and work piece. These particles can damage the die surface with each stroke. The study investigates the impact of friction on die wear and material flow in this forging component. The contact stress and sliding length are utilized to compute the die wear. By considering a model, manufacturers can achieve significant mechanical improvements in hot forging die materials, leading to better performance and durability. This study examines the effects of friction on die wear and material flow by presenting numerical die wear profiles in hot forging operations. The findings demonstrate that neither friction factor nor friction coefficient alters die wear at worn locations, nor does an increase in friction coefficient improve the profile.

Keywords: Hot forging, friction, wear, die, tribology, surface engineering.

1. Introduction

Life of die component has a significant influence in productivity and product quality during forming at higher temperatures. On the basis of a study by researchers [1] around 70% of tool substitutes are brought on by early die erosion. Alternative 5% are brought on by permanent deformation and thermo-mechanical fatigue, while rest 25% are brought on by mechanical fatigue [2]. Therefore, erosion of die is the primary cause of tool failure when replacing forging tools in large production. At the design phase, predicting abrasion of die component is a crucial responsibility. In reality, the lubricant type and die material selections have a significant impact on condition of die wear material throughout the process of designing the optimal die shape [3]. Excessive wear might start an ineffective filling of die cavity. Additionally, it may result in forging flaws on the finished goods that are outside the prescribed dimensional tolerances. Untimely abrasion of die and large worn portion on the die material surface should be avoided by an ideal design. Changing the shape and design of the die, the surface's heat treatment, the material choice of die [4], and the lubricant type are often effective ways to address crucially worn portions of the component. Some foreign particles like abrasive particles can be the primary source of material wear in forging brought primarily by rubbing of two contacting surfaces. Throughout each die stroke, these particles may gradually harm the material surface [5].

2. Model Formulation

MODEL-I

To construct a well-established model to improve hot forging of die materials we introduce

$$d\Delta = \mu_i \left(\frac{d\alpha \times dx}{K} \right) \dots \dots \dots \dots . . (1)$$

Where $d\Delta$ defines the wear volume, $d\alpha$ is contact load for Hot foging, dx is sliding length, K is surface hardness, μ_i is our simulation constant. By finding the numerical simulation we can demonstrate our findings for the influence on abrasion of the element and its material flow in presence of hot forging.

MODEL-II

$$d\Delta = \rho \times d\lambda + C \dots \dots \dots \dots \dots \dots (2)$$

$$d\lambda = \tau \times dA' \times dx \dots \dots \dots \dots . . (3)$$

Where dA' defines area of contact zone and τ denotes the ‘shear stress’ and C is arbitrary constant. The basic difference between Model-I and Model-II is just to find the ‘critical area’ more specifically. The coarse units might be additional hard carbides that have come loose from the ‘die surface’, rough oxides or external contaminants. Material is removed from the die exterior due to foreign particles, causing abrasive wear [6]. The quantity of this material removal dependents on numerous factors which includes sliding length, temperature of die, roughness of die material surface, relative velocity, contact pressure, and lubrication [7]. It is challenging to establish a link among several factors due to complexity of wear characteristics.

Wear Profile Analysis by Numerical Methodology

Modern computers' processing power and recent advancements in the 'finite element method' helps to widely model wear using basic properties of die substantial and process parameters [4].

Here, u indicates sliding velocity, dτ signifies sliding time, and dH is known as depth of wear. Eqn. 1 can be updated by inserting eqn. 3 and dividing two sides by dA'. Here r and t indicate stand for spot and period restrictions respectively.

$$d\Delta = k\ dH \times dA' + C \dots\dots\dots\dots..(4)$$

$$d\alpha = d\rho \times dA' \dots\dots\dots\dots\dots\dots(5)$$

$$dx = v \times d\tau \dots\dots\dots\dots\dots\dots.(6)$$

Here, v defines the relative velocity of 'sliding'

After substituting the wear values, from equation -4 and then running a rigid-thermo-viscos-plastic 'FE' simulation [2], it is possible to assess the scratch of every point at each simulation time step on the face of die module. A spell integral which depends on overall length to find wear at every point was articulated as

$$dH = k\left(\frac{\rho(r,\tau)v(r,\tau)}{h}\right)d\tau \dots\dots\dots\dots\dots..(7)$$

The 'time step' here is called τ, and the overall 'number of time steps' is represented by t. As per the model, the total abrasion on the object exterior in discretized form, Model-II can be shown as follows:

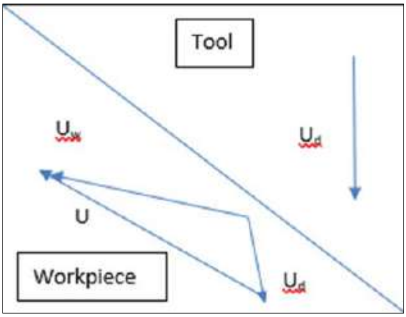

Fig 1: Relation between displacement and boundary nodes, shears stress

According to these models' discretized forms, we need to define an index factor to express the material wear in all over the die's k th points. For instance, this index may be elaborated as follows if C is taken to be constant.

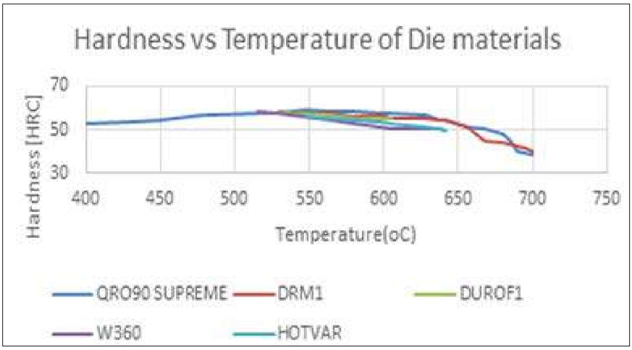

Fig 2: Relation between hardness and temperature ofdie materials

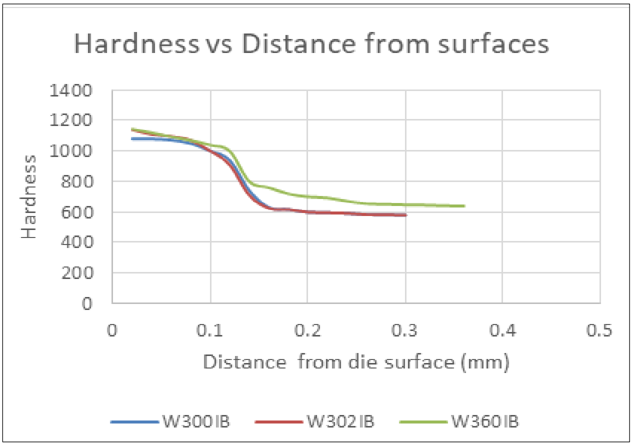

Fig 3: Relation between hardness and distance from material surfaces

These 'indexes' are evaluated at all locations on the die component surface. The crucial worn-out portions of the material face were monitored when they are strategized compared to the die surface radial coordinate. The stress and blow length at the die work-piece interface are required to evaluate the above parameters. To estimate the principal stress, and length of stroke at the die work-piece face, parameters of edge protuberances of the work-piece material is expected to diverse surfaces of die cavities.

Initially 'radial coordinate' values at the different junctions of the boundary of the work-piece is directly connected with the module exteriors are pointed out in ascending order for every time frame of the recreation [2]. After that each die section are established separately then, two boundary nodes around the work-piece are chosen. 'The Euler interpolation' system is used to regulate the erosion parameters at all locations on surface of the die material [8].

3. Discussion of The Model

Here, model validation is carried out using a case study of an axisymmetric cross-section forging component from reference 2. The findings of the investigation described in reference 2 are given here.

The closing phase is where the majority of the worn-out areas from the investigational remarks are described [8]. The regions of the crucial portions visible in this image are well congruent with the experimental findings displayed in fig. 3.

The warm forming of an industrial 'gear blank' using a closed die is the subject of the case study. The forging process is finished by a press of hydraulic in nature [2]. Die and billet combination figure, billet (DIN C43) flow stress, temperature of working condition (billet- 1200 °C and dies- 320 °C), and press speed (0.1 m/sec) make up the starting forging parameters. The only factors affecting the tool and work-piece material shear stress boundary at low compression situations are pressure of the tool (p) and coefficient of friction [5]. However, sometimes at high compression conditions it simply depends on the material's flow stress (e) and shear rubbing aspect (m). The results are required w.r.t. flow of subtract, compression, and 'shear stress' at the die-to-work-piece interface to determine wear index. The wear computation subprogram is then updated to reflect these results [4].

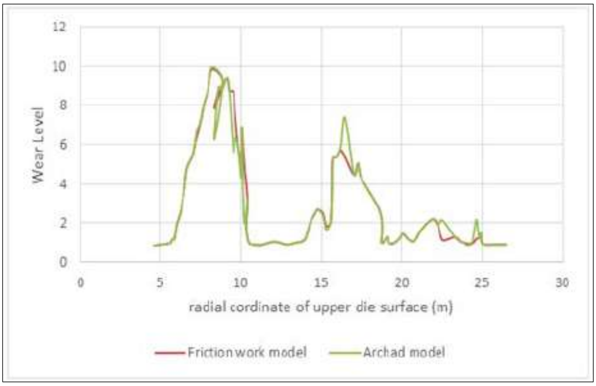

Fig 4: The 'Archard model' and 'friction work approach' are compared to identify the major wear-out areas.

The model displays the die-wear distribution (index) on both halves of the dies using model 2 and various abrasion factors. This number represents there may be a very small wear in the corners of the component. This is because there is little sliding action and material is trapped in these places. Contrary, convex fillets appear to show comparable high wear [2]. It is possible to determine unalike rubbing influences by examining the simulations' outcomes.

For instance, in this component, increasing the rubbing coefficient will alter the flow of material and increase the likelihood that defects will form. This graph illustrates that here is decent promise between the two models in terms of identifying the most eroded sections.

4. Conclusion

This paper presents the numerical findings of the die erosion profile during warm forming. The consequence of abrasion on the rate of die erosion and the flow of material was conferred. Those were detected the volume of abrasion of die at the critical areas is unaffected by variations in the friction factor or coefficient. This study has discovered that both the models reach agreement with one another. They are also in line with the region of the profoundly damaged zones on the die surface, which was predicted. Additionally, it was determined that a higher friction coefficient in general may not improve the die wear contour.

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Chapter - 34
A Review on Effect of Process Parameters on Moulding Sand Properties

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Chapter - 34

A Review on Effect of Process Parameters on Moulding Sand Properties

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Abstract

Sand mould casting is one of the most common and popular technique of casting of ferrous and nonferrous metals. As the raw materials of sand mould preparation are very much cheap, reusable and easily available, sand mould casting become very much popular since ancient age. Mould characteristics *viz*. permeability, compatibility, mould strength etc. depends on the proportion of mixing of raw materials. In present study, the authors reviewed several research papers on the sand mould casting. Review is conducted on the influence of different process parameters *viz*. sand shape and size, moisture content, clay content etc. on the mould strength, permeability etc. The various process parameters on which green sand strength is dependent are moisture content, clay content and type, amount of binder and its type, grain size of sand etc.

Keywords: Moulding sand, permeability, moisture content, binding materials, mechanical.

1. Introduction

Sand Mould casting is one of the widely accepted and popular casting process to the foundrymen. The sand mould can be prepared with very much cheap raw materials *viz*. silica sand, river sand, clay binder, decayed organic components, chopped straw etc. Almost all the raw materials are cheap, easily available and reusable. Mould prepared with sand is having better permeability to permit gas and air from the mould cavity, strength to withstand pressure of molten metal poured in mould cavity. Moulding sand is suitable for casting due to its properties like strength, hardness and permeability (Sadarang *et al.*, 2020). Permeability is dependent on sand grain size and shape, clay content and water content. Strength of mould is dependent on compactibility of moulding sand. Compactibility depends on the proportion of mixing raw materials. As per the increasing demand of casting quality chemical binding materials are mixed during moulding sand preparation. In the present research paper, the authors reviewed various research articles to study the effect of various process parameters i.e. the proportion of mixing raw materials on properties of mouling sand i.e. permeability, compactibility, green and dry strength, surface finish of mould.

2. Moulding and casting Process

Sand moulding is the technique in foundry work for creating complex design metallic parts. Ferrous and nonferrous metal can be casted in the sand mould. There are several steps of moulding process.

Pattern Making: A pattern, made of wood, metal, or plastic, is designed to replicate the final part's shape. It includes allowances for shrinkage and draft angles to aid in mould removal.

Core Preparation: For making internal hollow portion during casting, cores are created separately using sand mixed with binders. Cores are then placed inside the mould to form the hollow portion in cast.

Sand Mixing: High-quality moulding sand is mixed with binders, typically clay and water, to provide strength and cohesion. Sometimes, additives like coal dust are used to improve mould properties.

Mould Box Setup: A two-part mould box, also known as a flask, is prepared to enclose the pattern and sand. It consists of a cope (top) and a drag (bottom) section. First of all, on a clean floor inverted drag box is set. Then the pattern is placed inside the box after that sand is rammed and leveled off. The packed drag box is then turned over and cope box is placed over it. After that, the second half of the pattern is placed exactly over the first half of pattern. Then, the sand is filled and rammed tightly. Now two boxes are opened and pattern is removed with the help of screws. Boxes are again put back into position and clamped with rivets to prevent upper box floating. Gates and sprues are formed to pour the metal. Then, the molten metal is poured into the mould cavity then it is allowed to cool down for some time. After cooling the final cast is taken out. Figure 1 shows the sequence of mould making and casting process.

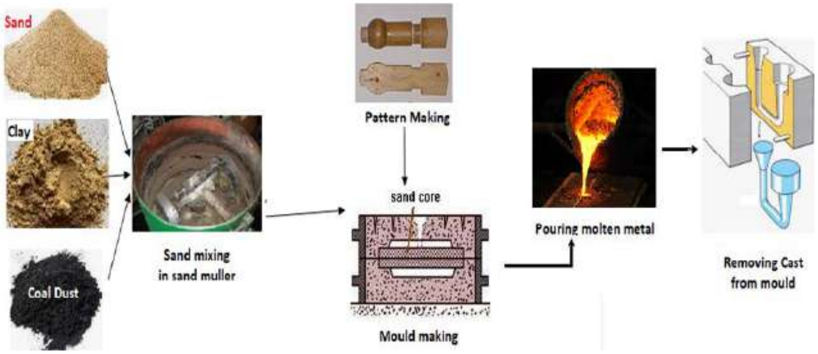

Fig 1: Diagram of moulding and casting process

3. Literature Review

Loto and Adebayo investigated the effect of variation in sodium carbonate, clay and moisture content on the synthetic moulding properties (Loto and Adebayo, 1990). The investigation was aimed to create efficient synthetic moulding sand using Igbokoda pure silica sand. They found that, after adding Na_2CO_3, properties of moulding sand were improved, but collapsibility was affected a little. Igbokoda clay showed promising results as a binder, to provide good strength and improved mechanical properties. They found that Igbokoda's high-purity silica sand (98%) suits for higher refractory uses, like steel moulding. Igbokoda clay-silica bond achieves optimal strengths with 13% clay, 3% water while dry strengths reasonable but lower. Small sodium carbonate (0.5%) upgrades strength, reduces collapsibility, enhances toughness.

Abdullah et al. tested Tailing sand samples from Ex Tin Mines in Perak State, Malaysia (Abdullah *et al.*, 2012). The investigation was performed on the prescribed standard method of American Foundrymen Society (AFS). Permeability and green compression strength were tested for the specimen of Ø50mm×50mm. They prepared the sand mixture by using 4% bentonite clay. Their experimental results showed that permeability and green sand strength was increased gradually with increment in moisture content in 4% bentonite bonded sand samples and after a peak value gradually both started decreasing. They tested various sand samples *viz*. Batu Gajah, Taiping, Tanjung Tualang, Tronoh. Each sample reached peak strength and permeability at varying moisture levels: Batu Gajah (4.86%, 4.10%), Taiping (3.91%), Tanjung Tualang (4.15%, 3.18%), Tronoh (3.24%, 3.47%). They found effective permeability and green compression strength at the range of 3-3.5% of moisture content. Above 4.0% moisture i.e., excessive water reduced clay binding. Due to that strength and permeability become poor, and rendering it unsuitable for mould making.

Azhar *et al.* studied the effect of moisture content and sand grain on green compression strength in greensand casting moulds (Azhar *et al.*, 2022). They found that grain size impacts mould strength and surface finish of the casted products. They also stated that water enhances bentonite clay binding efficiency and improves green compression strength. They prepared samples with three different grain sized sand *viz*. 425 µm, 300 µm and 150 µm. They tested as per AFS guidelines. The samples were prepared of size Ø50 mm×50 mm from varying grain size and moisture content with 5% bentonite. The experimental results showed better green compression strength for the sample prepared with 150 µm grain size and with 3% moisture content. This study found sand grain size impacts green compression strength in greensand casting moulds. Coarser grains reduce strength, 150 µm was stronger than other two samples. 150 µm and 300 µm sizes were found suitable for preparation of green sand mould. Their experimental result shoed that moisture content of 2-5% provide maximum strength (20-80 kN/m2) to the green sand mould.

Sun *et al.* explored influence of chemical binder on foundry sand performance (Sun *et al.*, 2014). They performed experiments to find properties on sand from different origins but with same grain size. They used sand from three different origins *viz*., Weichang sand, Dalin sand and Zhangwu sand. They found that raw sand of same grain size and acid values of different origin have large dissimilarity in mechanical properties and tensile strength. Better grain shape boosts moulding strength, even with higher clay binder. Liquid binder enhances tensile strength in four-screen sand. Solid phenolic resin boosts three-screen sand with good grain shape.

Joshua *et al.* investigated the influence of binders *viz*. bentonite, cassava starch, and yam starch on foundry sand (Joshua *et al.*, 2016). Each binder was mixed separately to River Niger silica sand in different amounts. They conducted experiments as per AFS guidelines to find out dry and green strength, mouldability, moisture content, permeability. Bentonite exhibited superior binding capability than other two binders. They found that Strength and mouldability was improved with addition of higher amount of binder material. Experiments also exhibited that shatter index and permeability become lower with increment of binder quantity. They found that properties of River Niger silica sand (GFN 45) are suitabe for casting the metals *viz*. non-ferrous, malleable iron, and light grey iron. Bentonite binder gave greater value of green/dry compressive strength, than binder by cassava and yam starches. River Niger sand plus binder offers economical, good surface finish.

Munusamy *et al.* analysed the moulding capacity of sand mould using sand with binder as industrial powders and fly ash (Munusamy *et al.*, 2017). They reviewed a number of research articles on Greensand moulding using sand with binder of fly ash. They performed green compression test and permeability test with varying additives to enhance casting efficiency and proper additive ratios. They analyzed green strength and permeability of greensand with fly ash and clay additives. They found from experimental analysis of green sand that compression strength rises with increment in fly ash binder in green sand. It rises up to 14% fly ash. Green sand permeability rises up to 2% with increment of quantity of fly then permeability falls. Optimal values are 2% fly ash and 3% clay.

Sadarang *et al.* performed experiments to find out the effect of binder material and moisture content on sand mould properties *viz.* compactibility and shear strength (Sadarang *et al.*, 2021). They prepared sand by mixing pure silica sand, river bed sand of Madhya Pradesh, India, bentonite clay, coal dust. From the experiment they found that compactability of samples was gradually decreased as quantity of bentonite increase. Optimum shear strength and compactibility was found at 7% of moisture in the prepared sand. They found that prepared sand with 7% moisture and 14% bentonite gives optimal compactibility of 52 and shear strength (0.56 kg/cm2)**.**

Apeh *et al.* analysed the influence of variation of moisture content on properties of moulding sand (Apeh *et al.*, 2022). The sand samples were collected from the river bank of Fori. They performed experiments on the Fori river bank sand as per AFS guidelines to find out its suitability of use in metal casting. Experiments were conducted to find the moulding sand properties *viz.* permeability, strength, mouldability by varying moisture content in sand mix. After analysis of chemical composition of the sample they found Na_2O, K_2O, TiO_2, MgO, Fe_2O_3, CaO other than Silica. They found that in the collected material clay content was 15.32% which is quite higher than the normal. The highest permeability they found 440 at the low moisture content. Green and dry compressive strength showed adequacy as erosion resistant and also withstand the pressure of metallic cast. Hence, they found the sand to be suitable for casting metallic material.

Ihom *et al.* investigated the change in characteristics of Yola natural sand by varying moisture levels (1% to 9%) (Ihom *et al.*, 2011). They have studied the influence of moisture quantity present in sand mix on various mechanical properties. They also studied sand shape, grain size, fineness, clay content, and clay content. They found that optimal value of green strength can be achieved at moisture content of 5% and dry strength peaks at 9% of moisture content. Permeability initially rises with moisture, then decreases at saturation. Bulk density drops with increasing moisture until saturation, after which it increases. They figure out that the moisture content produces a quality casting of aluminum using aluminum alloy scraps.

Saikaew and Wiengwiset optimized the composition of sand for improvement of quality of iron casting (Saikaew and Wiengwiset, 2012). They optimized the ratio of mixing water and bentonite with recycled moulding sand. They analysed experimental data with statistical tools ANOVA and Minitab software. They found the optimized data as mixing proportion of 93.3% mass of single recycled moulding sand with 1.7% mass of water and 5% mass of Bentonite.

Pradana and Ariono investigated the influence of sand grain size on permeability and compressive strength of mould (Pradana and Ariono, 2020). The researchers conducted their experiment on volcanic sand from Mount Semeru for preparation of casting moulds, aiming to improve the mould quality. They found the highest permeability of the sand of size 20 mesh and compressive strength become highest with the sand size of 60 mesh.

From the review of many researchers, it has been observed that a number of research persons have investigated the effect of various sand, sand shape, sand grain size, moisture content, clay content and binders on mechanical properties of sand mix *viz*. permeability, green and dry compressive strength, compactibility, mouldability. The researchers of the reviewed papers worked to improve mouldability of the sand mix in casting process to eliminate the defects arise during casting. Many researchers used local river sand to change in shape and grain size.

4. Conclusions

In present study some research articles of different researchers are reviewed. Researchers conducted various tests to find the influence of different process parameters to achieve better quality moulding sand for casting. They have used various local river sand to prepare sand. Various river sand have different size and shape. They found that mouldability and compactibility depends of different size and shape of the river sand. Clay content and moisture content plays a major role on the green and dry compressive strength, compactibility and mouldability. Increase in clay content, decrease the compactibility and permeability. Increase in moisture content reduce the compressive strength. Besides the various natural components some of the researchers added fly ash to improve permeability and compressive strength. Casting products are being rejected due to various defects depends on mould preparation. This rejection may be reduced by varying the process of sand mixing and proportion of quantity of natural, chemical and other chemical binders mixed sand.

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Chapter - 35
Recent Improvement in Parameters of Electrical Vehicle: An Overview

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Chapter - 35

Recent Improvement in Parameters of Electrical Vehicle: An Overview

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Abstract

Demand of Electrical Vehicles (EV) are exponentially increasing over the last decade due to environmental pollution in various highly traffic congested areas as well as other less traffic areas and also due to price hike and lower availability of fossil fuels. From engineering aspects, for electrical vehicle major parameters are travelling range, battery; type, its life and charging - discharging time, sensors used for monitoring & controlling and load carrying capacity of electrical vehicles. In this paper, an overview of recent developments of EV with respect to battery, its management system, improvement of travel range, development of various sensors used in electrical vehicles for the purpose of safety, security and comfort of the users are discussed in brief. The paper will help the researchers to find the future roadmap for the design, development and fabrication of next generation electrical vehicles.

Keywords: Electrical vehicles, travelling range, battery, sensors, load carrying capacity.

1. Introduction

Global warming and pollution have become two of the world's most irresistible challenges in recent decades and the automotive industry is one of its key drivers. Over the last decade, electrical vehicles (EV) have emerged as a sizeable substitute for conventional internal combustion (IC) engine-powered vehicles, while also playing a vital role in pollution management [Fu et.al., 2018]. EVs have attracted substantial interest as the automotive industry swings towards more sustainable transportation solutions due to their ability to cut emissions and reliance on fossil fuels. In recent years, there have been remarkable advancements in various parameters of electric vehicles, transforming them from niche alternatives to mainstream contenders in the global automotive landscape. From extended driving ranges and advanced battery technologies to enhanced charging infrastructure and improved performance, electric vehicles are reshaping the automotive industry and contributing to a more sustainable and environmentally friendly transportation background [Sriram *et al.*, 2022]. Parameter development for electric vehicles is a thorough process that comprises developing and optimizing different parts of the vehicle to enable efficient and dependable functioning. These improvements have been driven by rapid technological innovation, increased environmental awareness, and the growing demand for sustainable transportation solutions. The battery capacity range for an electric vehicle is about 30 to 100 KWH or more [Ng and others *et al.*, 2009]. This paper aims to provide an overview of some of the noteworthy enhancements in various parameters of electrical vehicle such as the travelling range, battery management system, charging – discharging time, and sensors of electric vehicles.

2. Parameters of Electrical vehicle

Electrical vehicles run primarily or entirely on electric power stored batteries. The main components of electric vehicle include – electric motor, battery pack, power electronics, charging and parts that contribute to the expansion of electrical cars have seen excellent advances The component level enhancements are described in brief in the following sections;

2.1 Development in Battery and Battery Management System

The most important and vital part of electric vehicles are the battery and battery management system (BMS). Battery safety and function are ensured by BMS, which guarantees dependability [Lokhande et. el., 2020].

a) Batteries and their developments

The battery is one of the most crucial components of an electric car, and battery technology has advanced significantly since the invention of electric vehicles. The primary barrier to a widespread adoption of EVs at the moment is the batteries. Users see electric vehicles as a real alternative to internal combustion engine vehicles as a result of the development of better, more affordable, and higher capacity batteries, which will increase vehicle autonomy [Park and Kim *et al.*, 2020]. The EV batteries store and supply the energy required to power the car. In the early 1900s, the earliest electric automobiles were powered by lead-acid batteries, which were heavy, bulky, and had a restricted range. Nickel-metal hydride batteries, which were more efficient than lead-acid batteries but still had a limited range, were created in the 1990s. But in the early 2000s, the introduction of lithium-ion batteries, which changed the electric vehicle sector [C, Weidong, 2018]. Due to their high specific power in kW/tonne, Li-ion batteries are the most popular (Table 1). It further observed that battery cycle life that indicates numbers of charging & discharging cycles before death, has increased more than 2.5 times.

Some of the recent batteries used in EVs with their specifications are designated in Table 1

Table 1: Types and specifications of battery [Xiaoli *et al.*, 2019]

Battery type	**Specific Power (kW/tonne)**	**Cycle life (Hrs)**	**Charge-Discharge efficiency**	**Energy Density (Wh/kg)**
Li-ion	1150	2000	90%	100-250
Bi-polar Pb/SO_4	500	3500	91%	33
NiMH	200	3000	91%	30-80
NaS	90-150	5200	85%	155

b) Development in Charging & Discharging time of EVs

One of the most significant concerns that users have when using an electric vehicle is the lengthy charging period. So, in recent years there have been ongoing developments in reducing the charging time of EVs. Manufacturers and researchers are working on several advancements to resolve this issue. Some of the recent advancements to reduce the charging time of batteries are High- power charging infrastructures, Bidirectional charging, Charging network expansion, Wireless charging, Cooling systems and Software optimization [Jin and others *et al.*, 2022].

c) Battery Management System

A Battery Management System (BMS) (Figure 1) is a crucial component in electric vehicles (EVs) and other battery-powered applications. In most road/highway, rail, air, and sea-based vehicles, storage energy (SE) is used to fully or partially power EVs. ES is currently being added to modern high-tech vehicles like private cars and city buses [Hasan and others *et al.*, 2021]. It plays a vital role in monitoring, controlling, and ensuring the safety, performance, and longevity of the battery pack. It minimizes the risk of battery damage and controls the charging and discharging processes of the battery [Rai Hu, 2011]. Some of its most important functions are- State of Charge (SOC) Estimation, State of Health (SOH) Estimation, Cell Balancing and Thermal Management.

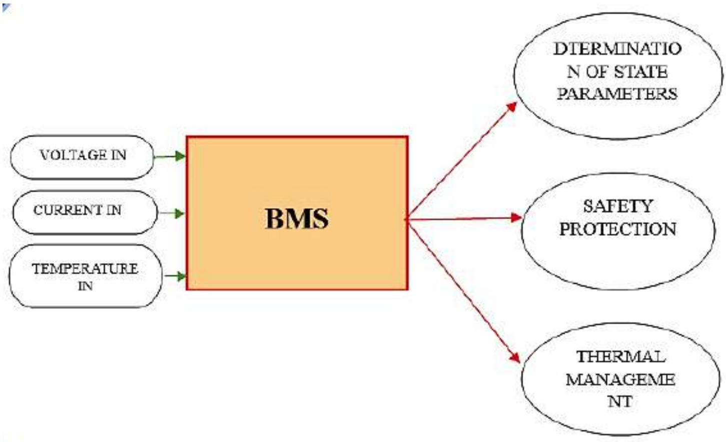

Fig 1: Battery Management System

2.2 Development in range of EVs

When it comes to purchasing an electric vehicle, one of the most important considerations for customers is the driving range. Theoretically, a perfect electric vehicle (EV) might travel 150–200 miles on a single charge, but in reality, there aren't as many charging stations as there are gas stations. From a consumer's perspective, this makes EVs less dependable and convenient, hence a fix is necessary to address this issue [Chandran and Joshi *et al.*, 2016]. The average driving range of new BEVs has been steadily increasing over the last decade. The weighted average range of a new battery electric car in 2020 was around 350 kilometres (km), up from 200 kilometres in 2015. Because China has a higher proportion of tiny urban electric cars, the weighted average range of electric automobiles in the US is higher. The average electric range of PHEVs has remained relatively constant about 50 km over the past few years [Kadav and Asher *et al.*, 2019].

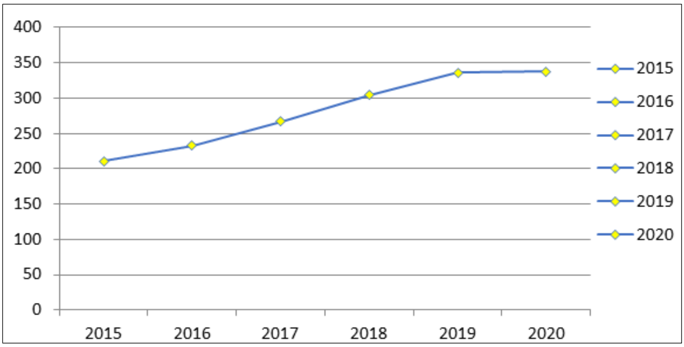

Fig 2: Data of EV range [International Energy Agency, 2022]

2.3 Developments in Effective Load Carrying Capacity of EVs

An electric vehicle's effective load carrying capacity (ELCC) is defined its ability to accommodate greater peak load without increasing the chance of load loss on the grid [Brooks and others *et al.*,2010]. An electric vehicle's ELCC can also be estimated by estimating the amount of existing supply capacity that the source can displace while serving the same load profile and keeping the loss of load probability constant [Chakraborty *et al.* (2012)]. The load-carrying capacity of electric vehicles (EVs) has also seen notable improvements over time. As EVs become more popular and diverse in their applications, manufacturers have been working on enhancing their load-carrying capabilities to cater to various needs, including commercial, industrial, and personal use. Some key developments in their area include: Stronger suspension, High- capacity batteries, Specialized EV models, Electric commercial vehicles and Autonomous and self-driving.

2.4 Development of Sensors: Monitoring and Control

The development of sensors in electric vehicles (EVs) is crucial for enhancing safety, improving driving experience, and enabling advanced driver assistance systems (ADAS) and autonomous driving features [Bhattacharya and others *et al.*, 2019]. Over the years, various types of sensors have seen significant advancements in the EV industry. Here are some key developments:

a) LiDAR (Light Detection and Ranging): LiDAR sensors use laser beams to measure distances and create detailed 3D maps of the vehicle's surroundings. They are essential for autonomous vehicles [Liu and others *et al.*,2018], providing high-resolution data for object detection, localization, and mapping. LiDAR technology has become more compact, affordable, and efficient, enabling its integration into EVs.

b) Cameras: Camera-based systems are integral to ADAS and autonomous driving capabilities. Improvements in camera technology, such as higher resolutions, better image processing algorithms, and increased sensitivity, have enhanced object recognition, lane detection, and driver monitoring systems in EVs.

c) Radar: Radar sensors use radio waves to detect objects and measure their distance and speed. They are especially useful in adverse weather conditions, where visibility may be limited. Advanced radar systems with multiple antennas and beamforming capabilities have improved object detection and tracking in EVs.

d) Ultrasonic Sensors: Ultrasonic sensors are widely used for parking assistance and obstacle detection at low speeds. They have become more accurate and reliable, contributing to better parking assistance and autonomous parking features in EVs.

e) Infrared Sensors: Infrared sensors are used for night vision and pedestrian detection, enhancing safety during low-light conditions. Advancements in infrared technology have made it more viable for EVs, improving their ability to detect and avoid potential hazards.

f) Proximity Sensors: Proximity sensors are employed for various purposes, such as detecting the presence of objects around the vehicle, monitoring blind spots, and providing warnings to the driver. These sensors have become more sophisticated, enabling better situational awareness for drivers.

g) Environmental Sensors: EVs may include environmental sensors to monitor air quality, humidity, temperature, and other factors. These sensors can optimize the vehicle's systems for improved energy efficiency and passenger comfort.

3. Conclusion

This paper's originality comes from its presentation of a minimal set of design parameters derived for the BEV's first development stage. The development of parameters for electric vehicles has led to substantial advancements in technology, infrastructure, and consumer adoption. And all these advancements ultimately resulted in a rise in the number of electric vehicles on the road. Sales of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), which increased in 2020 despite a depressed auto industry due to covid, nearly doubled year over year to 6.6 million in 2021. With this, there are now more than 16.5 million electric vehicles on the road worldwide. Similar to prior years, the majority of the growth (about 70%) was due to BEVs [Das & others *et al.*,2020]. The EV industry is on a trajectory towards increased efficiency, extended range, enhanced performance, and reduced environmental impact. While obstacles remain, the overall trend indicates a promising future for electric mobility. Following a study of existing research on the status of electric cars (EVs), it is believed that creative approaches can be effective in overcoming the barriers to EV development.

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Chapter - 36
A Review on Impact of Industry 4.0 on Supply Chain Network

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Chapter - 36

A Review on Impact of Industry 4.0 on Supply Chain Network

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Abstract

Industry 4.0, the fourth industrial revolution, has brought drastic changes in manufacturing and supply chain practices. This paper explores the impact of Industry 4.0 on inventory systems and supply chain networks. Application of digitalization, automation, and interconnected technologies has significantly changed the businesses process of managing their inventories and orchestrate supply chains.

Firstly, the integration of smart technologies, such as the Internet of Things (IoT) and sensors, has enabled real-time data collection and monitoring of inventory levels. This enhanced visibility leads to more accurate demand forecasting and inventory planning, reducing stockouts and overstocking. Consequently, businesses can optimize inventory carrying costs and can improve operational efficiency.

Secondly, Industry 4.0 technologies enable the implementation of advanced analytics and Artificial Intelligence (AI) algorithms in inventory management. These tools can analyse vast amounts of data, identifying patterns and optimizing inventory replenishment strategies. AI-driven algorithms can predict demand fluctuations, lead times, and supplier performance, leading to better decision-making and reduced supply chain disruptions.

Thirdly, Industry 4.0 facilitates the emergence of interconnected supply chain networks. Through the application of block-chain technology, supply chain partners can maintain clear transactions, trust and traceability among them. Additionally, smart contracts automate agreements and transactions, streamlining processes and reducing administrative inefficiencies.

In conclusion, Industry 4.0 has profoundly impacted inventory systems and supply chain networks. The utilization of smart technologies and AI-

driven analytics has led to improved inventory management, demand forecasting, and operational efficiency. Moreover, interconnected supply chain networks enable enhanced traceability and transparency, fostering trust among supply chain partners. Despite the challenges, embracing Industry 4.0 has become necessary for existence in businesses in the dynamic landscape of modern manufacturing and supply chain network.

Keywords: Supply chain, industry 4.0, inventory management, optimization, manufacturing, network.

1. Introduction

The rapid advancement of technology recently has led to the emergence of the fourth industrial revolution, named as Industry 4.0. This transformational wave is characterized by the colaboration of digitalization, automation, and interconnected smart technologies into various industries. Industry 4.0 has led to profound changes in the supply chain networks and management. Traditional inventory systems and supply chain practices have been revolutionized, presenting new opportunities and challenges for businesses operating in the global market place.

Industry 4.0's impact on inventory systems is carried by the seamless integration of technologies like Internet of Things (IoT), cloud computing, big data analytics, and artificial intelligence (AI). These innovations have unlocked the potential for real-time data collection, analysis, and decision-making, transforming inventory management from a static process into a dynamic and agile one.

One significant advantage of Industry 4.0 on inventory systems is the enhanced visibility it provides. IoT devices and sensors embedded in products, storage facilities, and transportation vehicles enable continuous monitoring of inventory levels, location, and condition. Consequently, businesses gain remarkable insights in real-time status, enabling them to instant response towards fluctuations of demand and supply.

In addition to transforming inventory management, Industry 4.0 has revolutionized the whole supply chain system. Traditional linear and hierarchical supply chain models are being replaced by interconnected and collaborative ecosystems. Block chain technology, which ensures secure and transparent data sharing among supply chain partners, plays a key role in enabling this transformation. Through block chain, stakeholders can track products from their origin to the end-user, ensuring product authenticity and quality while minimizing the risk of counterfeiting and fraud.

Moreover, Industry 4.0 has facilitated the rise of smart contracts, which automate and enforce agreements among supply chain participants. These contracts streamline processes, reduce administrative overhead, and foster trust among partners, ultimately leading to improved supply chain resilience and responsiveness.

Despite these remarkable advancements, the transition to Industry 4.0 is not without challenges. The integration of new technologies requires significant investments in infrastructure and employee up-skilling. Additionally, the reliance on interconnected devices exposes the supply chain network to potential cyber threats, data breaches, and disruptions, demanding robust cyber security measures.

2. Literature Review

Industry 4.0 refers to the integration of advanced digital technologies in industries, *viz*. IoTs, AI, big data analytics, cloud computing, robotics, and automation to create smart and interconnected production systems. The application of Industry 4.0 has significant impacts on supply chain networks, leading to improved efficiency, visibility, and responsiveness.

Here's a literature review summarizing some of the key impacts of Industry 4.0 on supply chain networks:

2.1 Inventory Optimization

Industry 4.0 technologies enable real-time data collection and analysis, which helps in minimizing inventory levels. IoT sensors, coupled with AI algorithms, can monitor inventory, demand, and production processes. This approach of data handling helps in forecasting accurate demand, reducing excess inventory, stock-outs, and associated holding costs.

2.2 Enhanced Visibility and Traceability

With Industry 4.0 technologies, supply chain stakeholders gain enhanced visibility and traceability throughout the entire supply chain. RFID, GPS, and block-chain technologies enable real-time tracking of products, helps in identifying inefficiencies, potential bottlenecks, and discrepancies in the supply chain.

2.3 Agile and Responsive Supply Chains

The integration of Industry 4.0 technologies fosters flexibility and agility in supply chains. Advanced automation and robotics allow for rapid adjustments in production processes to accommodate changing demand patterns. AI-powered predictive analytics can assist in proactive risk management and supply chain disruptions mitigation.

2.4 Collaborative and Integrated Networks

Industry 4.0 promotes collaborative and integrated supply chain networks. Digital platforms and cloud-based solutions enable seamless communication and information exchange between suppliers, manufacturers, and customers. This integrated approach enhances coordination, reduces lead times, and facilitates a more efficient flow of goods.

2.5 Reduced Costs and Waste

By leveraging Industry 4.0 technologies, supply chains can optimize production processes, leading to reduced operational costs and minimized waste. AI-driven predictive maintenance helps in identifying potential equipment failures, reducing downtime, and extending the lifespan of machinery.

2.6 ICTs in Industry 4

Industry 4.0 comprehends the development and integration of information and communication technologies into business processes [11]. The broad vision of Industry 4.0 requires frameworks and/or architectures for connecting physical assets and digital technologies in a cyber-physical system (CPS) [12]. The internet-of-things (IoT) plays a critical part in Industry 4.0 and is also referred to as the industrial IoT (IIoT) [13]. Not just IIoT, but other significant technologies like artificial intelligence, cloud Computing, computer- aided design and manufacturing (CAD/CAM), Intelligent enterprise resource planning (I-ERP), programmable logic controllers (PLCs), Automation/ industrial robots, sensors/actuators, additive manufacturing, simulation and Other innovative models of data exchange play a crucial role in digitalizing supply chains.

2.7 Autonomous Robots in Supply Chain Management

Autonomous robots or self-guided vehicles are key equipment for the development of factories that want to become intelligent. Such devices are incorporated at organizations' operational level. They are usually incorporated into the transport of materials between different points, both internally and externally.

Simulation and supply chain management: Simulation is used for the development, projection, and analysis of SCM. It is a tool for decision-making [16]. Regarding decision- making, several applications are included in the SCM context, such as simulation of picking, simulation of cross-docking, simulation for inventory optimization, optimization model, among others. While simulation can be used to study any aspect of the supply chain, it is particularly well-suited to studying transportation and logistics systems. By simulating the system, managers can test different configurations and identify the most efficient way to operate the system [17]. In this sense, simulations can be used in activities that require re-planning of layouts and validation of production flows, contributing to logistic planning. In addition, through computational simulation, it is possible to evaluate strategies for the allocation of orders from different clusters and to combine different market scenarios, demonstrating all impacts to members of a supply chain system. Also simulation may be used to study the impact of disruptions on the supply chain. By simulating different types of disruptions, managers can identify the most vulnerable parts of the system and develop contingency plans to minimize the impact of disruptions

3. Discussion

Industry 4.0 technologies offer unprecedented real-time tracking capabilities. For example, sensors in a warehouse can monitor inventory levels and automatically trigger reorder requests when quantities fall below a certain threshold. This ensures that products are always available to meet customer demand, reducing stock-outs and improving customer satisfaction.

This is gradually changing the way we think and carry out our daily operations. Different technologies to support the fourth industrial revolution has been discussed which include big data analytics; 3D printing technology, IoT, AI, and robotics. These technologies are useful to facilitate supply chain operations. There is no doubt that the technologies of the fourth industrial revolution will greatly enhance supply chain design, processes, engineering and management. Considering product delivery aspect, the use of autonomous systems (aerial and ground robots) will facilitate delivery process timely inbound and outbound operations.

4. Results

Numerous industries have witnessed tangible results following the adoption of Industry 4.0 principles in their inventory systems and supply chain networks. For instance, in the automotive sector, companies have reported reduced lead times and enhanced quality control through IoT-enabled production lines. In the consumer electronics industry, real-time demand insights have led to better allocation of resources and reduced excess inventory. Pharmaceutical companies have leveraged Industry 4.0 to ensure regulatory compliance and traceability of products across the supply chain.

Overall, the results from various sectors showcase reduced operational costs, improved customer satisfaction, enhanced efficiency, and increased competitiveness as a direct consequence of embracing Industry 4.0 principles in inventory management and supply chain operations. However, it's important to note that successful implementation requires careful planning, investment, and change management strategies to fully harness the potential benefits of these technologies.

5. Conclusions

The impact of Industry 4.0 on inventory systems and supply chain networks is manifold. The integration of advanced digital technologies has ushered in a new era of efficiency, responsiveness, and collaboration across industries. Industry 4.0's transformative effects have been felt in various dimensions, from inventory optimization to agility and supply chain visibility.

Furthermore, the agility and responsiveness are reshaping supply chain strategies. Companies are now better equipped with market conditions, respond to disruptions, and fine-tune production processes to align with demand fluctuations. This, coupled with the collaborative and integrated networks fostered by digital platforms, has created a more synchronized and efficient flow of goods and information throughout the supply chain.

Industry 4.0 has fundamentally reshaped how businesses approach inventory management and supply chain operations. By embracing these technological advancements and addressing the associated challenges, organizations can position themselves to thrive in an era of rapid technological transformation and seize the opportunities presented by the fourth industrial revolution.

Conflict of interest: The authors declare no conflict of interest.

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Chapter - 37
Solar Energy Conversion, Storage and Utilization for Sustainable Development

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Chapter - 37

Solar Energy Conversion, Storage and Utilization for Sustainable Development

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Abstract

The urgent necessity for sustainable energy has reached a critical point due to the conflict between global energy demand and limited fossil fuel reserves. Among renewable sources, solar energy emerges as a promising solution due to its abundance and environmental friendliness. However, challenges arise from the dispersion and variability of solar radiation. This article explores existing solar energy storage technologies and acknowledges their significance as solar power gains traction in the energy mix. These storage methods are categorized based on their capacity and discharge time, necessitating advancements in chemical engineering and materials science. Additionally, a life cycle assessment is crucial to evaluate the environmental impacts of renewable energy processes, underscoring the importance of sustainable storage solutions. Generating solar electricity through direct conversion using solar cells or thermal energy proves to be a robust competitor in the realm of green electricity. To achieve widespread adoption, continuous improvements in cell efficiency and manufacturing costs are essential. Thin film solar cells offer particular promise, boasting advantages in both production cost and efficiency. The ultimate goal is to leverage renewable energy sources effectively to combat greenhouse gas emissions and surging fuel prices. Although direct solar radiation holds tremendous potential as a global energy source, its large-scale utilization necessitates cost-effective solar energy storage technologies. Phase change materials (PCM) present promising opportunities as storage options, but practical application demands further research and development to overcome challenges.

Keywords: Solar electricity, solar energy conversion, renewable energy process, global energy demand, solar cells, solar radiation.

1. Introduction

Amidst the rising global energy demands and increasing concerns about finite fossil fuel reserves, the urgent pursuit of sustainable alternatives has propelled solar energy into the spotlight. Solar power offers a beacon of hope in the dual challenge of meeting surging energy needs while preserving the environment. Solar energy conversion lies at the heart of this endeavour, capturing and transforming sunlight into usable energy, with photovoltaic technology leading the way. This innovation directly converts sunlight into electricity using semiconductors, capitalizing on the photovoltaic effect, where photons dislodge electrons to generate electric current. Advances in this field have significantly improved the efficiency and cost-effectiveness of photovoltaic systems, making solar-generated electricity increasingly practical.

Moreover, solar energy's potential encompasses storage solutions aimed at mitigating the intermittency of sunlight. Advanced battery and thermal storage technologies capture excess solar energy during peak hours, allowing for its subsequent use during periods of reduced solar radiation. This approach guarantees a steady energy supply and bolsters system resilience, grid stability, while also playing a role in decreasing greenhouse gas emissions.

The impact of solar energy reaches beyond technology, holding promise in addressing societal challenges. Notably, it enhances energy security, a crucial aspect compared to fossil fuels, which are often subject to geopolitical tensions. The universal availability of solar power reduces reliance on energy imports, enhancing energy sovereignty and reducing vulnerability to market fluctuations, increasing global energy demands.

Furthermore, the adoption of solar energy serves as a potent tool in tackling environmental concerns. Fossil fuels contribute to pollution and climate change, while solar power's clean and renewable nature results in minimal emissions, effectively reducing the carbon footprint. Embracing solar energy can thus play a pivotal role in countering climate change, protecting ecosystems, and fostering sustainable coexistence between human societies and the natural world.

2. Solar Energy Conversion Technologies

The field of solar energy conversion technologies is a dynamic and rapidly evolving landscape encompassing a wide range of innovative approaches aimed at harnessing the immense power of the sun. Solar photovoltaic (PV) systems stand at the forefront of these approaches, representing a remarkable achievement in directly converting sunlight into electricity through the photovoltaic effect as shown in figure 1. Semiconducting materials absorb photons from sunlight in this process, generating an electric current. Over the years, relentless advancements in PV efficiency and cost-effectiveness have positioned solar energy as a formidable contender against conventional energy sources (Smith & Taylor, 2020).

Simultaneously, the emergence of concentrating solar power (CSP) systems has become a significant avenue in the pursuit of efficient solar energy conversion. These setups utilize mirrors or lenses to concentrate sunlight onto a specific focal point, often a receiver or collector. The intensified sunlight generates substantial heat, which is then captured to create steam and drive turbines, thereby producing electricity. An important advantage of CSP technology lies in its capacity for incorporating thermal energy storage. Excess heat generated when sunlight is plentiful can be stored for later utilization, guaranteeing uninterrupted power generation during periods of reduced solar radiation, such as overcast days or nighttime. (Al-Sulaiman *et al.*, 2021).

As the push towards sustainable energy intensifies, newer and more innovative technologies continue to be explored. Organic solar cells and perovskite solar cells are two exciting examples of such innovations. Organic solar cells utilize carbon-based materials as the active layer to capture sunlight and convert it into electricity. These materials offer potential for low-cost and flexible solar panels, suitable for various applications, including integration into building materials.

Perovskite solar cells have gained significant attention for their potential to achieve high conversion efficiencies and ease of manufacturing. These cells rely on perovskite materials, which efficiently convert sunlight into electricity. Researchers are actively working to overcome challenges related to stability and scalability to unlock the full potential of perovskite solar cells (Polman & Atwater, 2020).

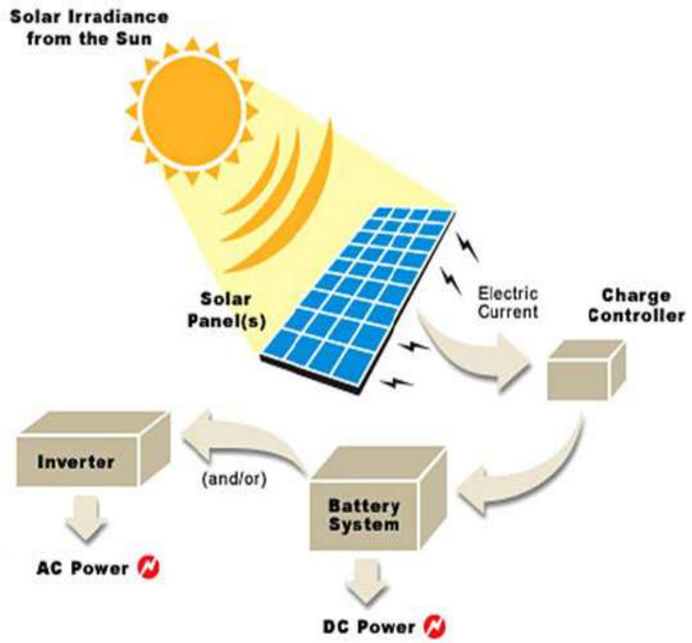

Fig 1: Solar energy conversion process

2.1 Energy Storage for Optimal Solar Utilization

In the realm of solar energy utilization, the crucial role of energy storage mechanisms cannot be overstated. Effective energy storage acts as a bridge between surplus generation and subsequent consumption. In the short term, storage solutions include batteries and supercapacitors, designed to cater to immediate energy needs. Lithium-ion batteries, lead-acid counterparts, and sodium-ion variants have emerged as reliable choices for storing and disbursing energy, ensuring stable power supply chains (Dunn *et al.*, 2011).

Simultaneously, the realm of long-term storage witnesses the rise of pumped hydro storage and compressed air energy storage (CAES), exemplifying grid resilience and adaptability (Zakeri & Syri, 2015). Adding to this narrative, Phase Change Materials (PCMs) emerge as an innovative paradigm for sustained and sustainable energy storage, showing transformative potential (Sharma *et al.*, 2018).

2.2 Phase Change Materials

Phase change materials (PCMs) represent a promising avenue for solar energy storage, boasting remarkable energy density and the ability to absorb and release energy during phase transitions. PCM-based storage systems offer compactness and scalability, making them suitable for applications ranging from residential to industrial domains. However, practical implementation of PCM technology faces challenges such as optimizing thermal conductivity, enhancing cycling stability, and addressing material compatibility concerns. Dedicated research and development efforts are crucial to overcoming these obstacles and unlocking the full potential of PCM-based solar energy storage systems (Dincer *et al.*, 2018).

2.3 The Solar Energy Conversion and Storage Process

The orchestration of solar energy conversion and storage constitutes a complex journey involving various stages that collectively contribute to efficient harnessing, storage, and utilization of solar power. This intricate process encompasses a sequence of steps, starting with the capture of solar energy through photovoltaic cells and culminating in the discharge of stored energy when needed. The integration of energy storage technologies, especially batteries, within grid-connected solar energy systems plays a pivotal role in enhancing overall system performance and efficiency, a concept often exemplified through net metering practices (Sharma *et al.*, 2019).

The complete process of solar energy conversion and storage can be divided into interconnected stages:

i) Solar Energy Capture: The process begins with the installation of photovoltaic (PV) cells, absorbs sunlight and converts it into direct current through the photovoltaic effect. These cells typically use semiconductor materials like silicon to release electrons upon exposure to sunlight.

ii) Inverter conversion: the direct current (DC) electricity produced by PV cells is channelled into an inverter, which then transforms it into the alternating current (AC) electricity commonly utilized in residential and commercial settings.

iii) Energy Consumption and Grid Interaction: The converted AC electricity can be directly consumed on-site. Excess electricity is fed back into the grid, causing the electricity meter to run backward through net metering. This two-way interaction allows surplus power to be supplied to the grid, while grid electricity can be drawn during low solar production.

iv) Energy Storage: To optimize solar energy utilization and overcome sunlight intermittency, energy storage systems, often in the form of batteries, are employed. These batteries store excess energy during sunny periods for use when solar production is reduced, such as during cloudy days or nighttime. Stored energy can also be deployed during peak demand hours to reduce grid strain.

v) Energy Management and Control: Advanced control systems manage electricity flow between solar panels, batteries, and the grid. These systems ensure efficient battery charging and discharging, monitor energy consumption patterns, and make real-time decisions to optimize energy flow based on grid conditions and user preferences.

vi) Discharge and Utilization: When electricity demand exceeds solar production, stored energy from batteries is discharged to maintain a reliable power supply. This reduces reliance on grid electricity during peak demand, contributing to grid stability.

vii) Net Metering and Grid Interaction: The integrated energy storage system optimizes net metering. Property owners with solar installations offset their electricity bills by receiving credits for excess energy fed back into the grid. Surplus energy beyond battery storage requirements can be exported to the grid.

2.4 Multifarious Applications of Solar Energy

- Solar energy's versatility is evident across diverse sectors, weaving a multifaceted tapestry of applications aligned with sustainable development goals (IEA, 2021). Primarily, solar power catalyses electricity generation by harnessing sunlight's potential through photovoltaic and concentrating solar power systems. This not only powers homes and businesses but also extends its reach to remote and off-grid areas, fostering socio-economic growth.
- Beyond electricity, solar energy revolutionizes transportation into an eco-friendly realm. Solar-powered electric vehicles and charging stations offer cleaner, renewable alternatives to traditional fossil fuel-powered vehicles, promoting greener mobility and reduced carbon emissions.
- Furthermore, solar energy provides warmth through thermal solutions. Solar thermal systems convert sunlight into heat for residential and commercial heating, industrial processes, and desalination. This reduces reliance on fossil fuels, mitigating pollution and conserving resources.
- In agriculture, solar energy orchestrates a symphony of benefits. It powers irrigation systems, enhancing water management in arid

regions. Solar-powered sensors and smart technologies optimize crop yields, promoting sustainable farming practices and food security.

2.5 Life Cycle Assessment: Comprehensive Environmental Analysis

The journey towards renewable energy sources demands a comprehensive understanding of their environmental impact. Life cycle assessments (LCAs) emerge as pivotal tools for evaluating the overall environmental performance inherent to renewable energy processes, encompassing energy production and storage. The scope of LCAs encompasses raw material extraction, manufacturing processes, transportation logistics, and ecological consequences of end-of-life disposal. By quantitatively elucidating the environmental footprint associated with solar energy storage technologies, LCAs provide guidance for developing sustainable solutions and facilitating informed decision-making.

3. Conclusion

In conclusion, the urgent need for sustainable energy solutions thrusts solar energy to the forefront as a potent alternative to fossil fuels. Effectively harnessing solar energy and seamlessly integrating it into the energy landscape necessitate innovative design and implementation of energy storage technologies that are both cutting-edge and economically viable. Strides achieved in chemical engineering and materials science hold profound implications for the evolution of efficient storage mechanisms. Additionally, life cycle assessments serve as sentinels, illuminating the ecological implications of renewable energy processes. As the global community grapples with the imperative of reducing greenhouse gas emissions and navigating volatile fuel prices, the practical realization of solar energy storage solutions assumes a pivotal role in fostering a sustainable energy future.

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Chapter - 38
Case Study on National Awards for Films in India: An Application of Multiple Regression Analysis

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Chapter - 38

Case Study on National Awards for Films in India: An Application of Multiple Regression Analysis

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Abstract

National Film Award in India was first presented in 1954. The award has been given since than every year to encourage Indian art and culture and to honour films made across India. Through this case study we tried to know that the films that are getting awards either follow a peculiar trend or not. Hence, we have compared the films nominated and the films which are popular but not nominated, made in the year from 2001 to 2022 with the independent variables like Budget, Language, Screen Time, Number of Songs, Male/Female oriented and Ratings. Stepwise multiple regression method at confidence level of 95% were used for the study. The study reveals the information that not too many variables were effectively giving any impression on the film chances to get nominated for National Film Award. This study further may help to the stakeholders of the films industry to focus on the variables more which is causing maximum in the nomination of films for the national award.

Keywords: Stepwise multiple regression analysis, national award for films.

1. Introduction

Movies: A film-also called a movie, motion picture; moving picture etc. is a work of visual art that simulates experiences of a sequence of consecutive still images recorded in a rapid succession to mirror an illusion of natural movement.

In 1913, Dadasaheb Phalke released Raja Harishchandra in Bombay, the first film made in India. On July 7th 1896 the Lumiere Brothers showcased 6 films at the Watson Hotel in Mumbai (then Bombay) and this mark the birth of Indian cinema. Kisan Kanya was a 1937 Hindi Cinecolor Feature Film which was directed by Moti Gidwani and produced by Ardeshir Irani of imperial pictures. Over 1000 Feature Films are released in India every year.

National Film Awards is the most prominent film award ceremony in India. Which was established in 1954. It has been administered along with the International Film Festival of India and the Indian Panaroma, by the Indian government's Directorate of film festival since 1973.The National Film Awards are presented into two main categories namely Featured Film and Non-Featured Film There are strict criteria as to weather a film is eligible for consideration by jury panels. Over hundred films made across the country are entered in each category (Feature, Non-Feature) for the awards and are deemed eligible each year.

Multiple Regression Analysis

It is a statistical technique that helps in analysing the relationship between two or more variable and uses the information to calculate the estimated values of the dependent variables.

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + \cdots + b_kx_k$$

Y is the dependent variable

X1, X2, X3, …… Xk are the independent variables.

a is the Y-intercept, the value of Y when all the X's are zero.

bj is the net change in Y for each unit change in Xj, holding all other X's constant. j the subscript can assume values between 1 and k, which is the number of independent variables.

Assumptions

- There must exist a linear relationship between dependent and independent variable. It means, in the residual plot (Yactual – Ypredicted), there must not be a random pattern.
- Homoscedasticity that is variation around the regression equation is the same regardless of the value of independent variables.
- The residuals must normally distribute with a mean of 0
- Multicollinearity does not exist (moderate to high collinearity) among the independent variables. It can be measure by Variance Inflation Factor.
- $VIF = \frac{1}{1-R_j^2}$
- Successive residuals should be independent. It means there must not be autocorrelation found.

2. Literature Review

Hardly any research has been in the direction of explaining the success factor of a film in terms of National Award. Some research works are found focused on performance analysis of films in terms of first week collection and social ratings (Bali, 2020; Mudra *et al.,* 2019; Gaikar *et al.,* 2015; Bhave *et al.,* 2015) but either they were conducted outside India or for a very shorter time frame. A high gap is there in this domain where a model is tried to be developed based on more than 20 years data targeting National Award for films as dependent variable. The dependent and independent variables taken for the research are evident from the research works of Swenney et.al. 2008; Visch et.al. 2010; Harris et.al. 2016; Walls and Mckenzie, 2020; Jang et.al. 2021

Varaibles

Award (Dependent Variable): It is categorical, but will be represented as Scaled (As it combines the interval and ratio scale into one, it helps in quantifying any event or another object). They are presented in recognition of excellence in cinematic achievement.

1 is represented as non-Nominated.

2 is represented as Nominated but no wins.

3 is represented as Nominated and win (dependent variable y).

Budget (BUD): Budget is taken as an independent variable represented through 'BUD'. Budget is reflecting the amount of expenditure done for making the movie. It has been compiled from trustable sources as a scale data.

Language (LANG1): (Independent Variable, Catagorical) – 1 is represented as Hindi, 2 is represented as Hindi and others, 3 is represented as only other languages. It is reflecting the methods and conventions of cinema that are used to communicate with the audience.

Rating (RAT): (Independent Variable, scaled) – It represents the score or measurement of how good or popular it is.

Screen Time (SCT): (Time conversion - Into Hrs, Independent Variable, Scaled) – The amount of time devoted to a particular actor, topic, plot line in a film/ movie.

Theme (THEME): (Independent Variable, Nominal) – It defies what the story is, what it is about, at its core. There are various abbreviation's used, they are:

1) Drama/ Family/ others
2) Romance
3) Mystery/ Thriller Crime
4) History/ Politial Drama / Documentary
5) Comedy
6) Action
7) Sports / Adventure

Songs (SONGS): (Independent Variable, Nominal) – For entertainment, songs/ movies are played at intervals. Abbreviations used are: (1) Less than 5, (2) 6-10, (3) 11 or more.

Male and female dominance (MFD): (Independent variable, Nominal) – The overall weight of either male or female and their impact on the movie, and its roles.

Research objective

- To find a model fit between dependent and independent variable
- To test the relationship among the latent variables

Hypothesis

H_{01}: Award (Y) is related with Bud (X_1), Lang 1 (X_2), RAT (X_3), SCT (X_4), THEME (X_5), Songs (X_6) and MFD (X_7)

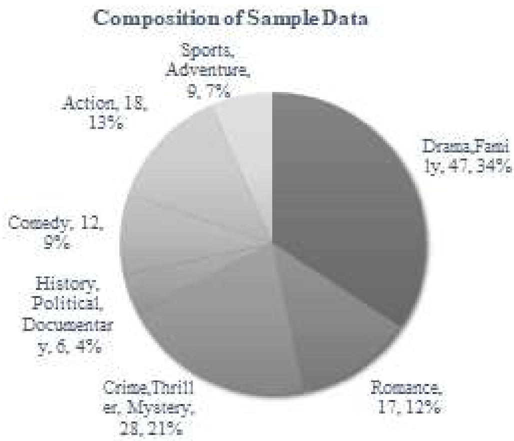
H_{02}: Bud (X_1), Lang 1 (X_2), RAT (X_3), SCT (X_4), THEME (X_5), Songs (X_6) and MFD (X_7) are significantly not related.

3. Research Design

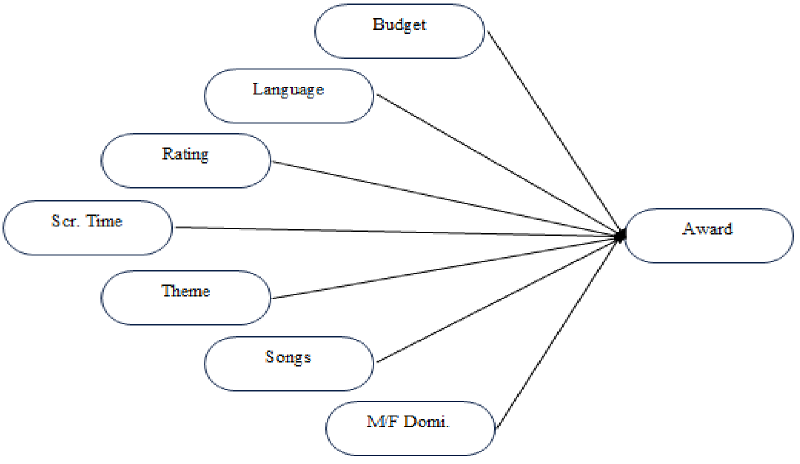
Nature of Research: Exploratory

Data Collection: Secondary (through trusted sources only)

Sampling: Movies from Year 2001 to 2022



Research Model



Multiple Regression Analysis (Output)

Descriptive Statistics

	Mean	Std. Deviation	N
AWARD	1.64	1.056	139
BUD	30.0863	52.91100	139
LANG 1	2.18	.836	139
RAT	7.7626	.56199	139
SCT	2.1529	.56003	139
THEME	3.07	2.045	139
SONGS	1.65	.709	139
MFD	1.81	.391	139

		AWARD	BUD	LANG 1	RAT	SCT	THEME	SONGS	MFD
Pearson Correlation	AWARD	1.000	-.022	.312	-.045	-.158	-.021	-.051	-.024
	BUD	-.022	1.000	.063	.057	.240	.192	.097	.085
	LANG 1	.312	.063	1.000	.093	-.056	-.139	-.053	.104
	RAT	-.045	.057	.093	1.000	.031	.093	.009	.159
	SCT	-.158	.240	-.056	.031	1.000	.152	.016	.057
	THEME	-.021	.192	-.139	.093	.152	1.000	-.023	.089
	SONGS	-.051	.097	-.053	.009	.016	-.023	1.000	.079
	MFD	-.024	.085	.104	.159	.057	.089	.079	1.000

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.312[a]	.097	.091	1.007	.097	14.736	1	137	.000

a. Predictors: (Constant), LANG 1

b. Dependent Variable: AWARD

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	LANG 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: AWARD

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.958	1	14.958	14.736	.000[b]
	Residual	139.057	137	1.015		
	Total	154.014	138			

a. Dependent Variable: AWARD

b. Predictors: (Constant), LANG 1

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	BUD	-.042[b]	-.518	.605	-.044	.996
	RAT	-.074[b]	-.912	.363	-.078	.991
	SCT	-.141[b]	-1.748	.083	-.148	.997
	THEME	.022[b]	.271	.787	.023	.981
	SONGS	-.034[b]	-.422	.674	-.036	.997
	MFD	-.057[b]	-.692	.490	-.059	.989

a. Dependent Variable: AWARD

b. Predictors in the Model: (Constant), LANG 1

Excluded Varables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	BUD	-.042[b]	-.518	.605	-.044	.996
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	SCT	-.141[b]	-1.748	.083	-.148	.997
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	SONGS	-.034[b]	-.422	.674	-.036	.997
	MFD	-.057[b]	-.692	.490	-.059	.989

a. Dependent Variable: AWARD

b. Predictors in the Model: (Constant), LANG 1

4. Conclusion

- None of the horror movies were nominated for National Award since (2001-2022)
- LANG 1 variable for explaining 9% variation in dependent variable where (R^2 = 0.097)
- Only LANG 1 is significantly related with award

$$y = a + b_1x_1 + b_2x_2 + b_3x_3$$

Y = 0.782 + 0.394 LANG 1

- No multicollinearity was found. All the correlation are less than 10%.

Future scope of the study

Though most of the related research works on the determinants for success of movie were done focusing of first week collection of the movie as a dependent variable, our research works were carried out on taking the scope of getting nominated for award as variable. With the research work it could not be evident that which factors works in favour of a film to get nominated. More research works can be carried out taking variables like experience of film director, effect of film actors on audience, patriotism and marketing of film from different platforms before releasing the movie to the theatres. Though award as a dependent variable fails to prove a complex relation among success of a movie and its determinants, probability of success of a movie through logit functions could also open many more doors in realising the real nature of a movie.

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Chapter - 39
Study on Power Generation from Speed Breakers

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Chapter - 39

Study on Power Generation from Speed Breakers

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Abstract

This study introduces a straightforward method of generating electricity by replacing conventional speed breakers with a simple mechanism. The proposed approach utilizes a rack and pinion mechanism, along with high-tension springs, to convert the motion of passing vehicles into electrical energy. This method presents an effective solution for electricity generation, especially in areas experiencing a surge in vehicle numbers. The system can be strategically placed near toll plazas, parking lots, and other high-density vehicle locations. The implementation involves a rack and pinion spring assembly mechanism that transfers the motion from passing vehicles to a DC motor/generator for electricity generation. This cost-effective approach harnesses the mechanical energy produced by dynamic vehicles on roads and efficiently converts it into usable electricity. The system's potential applications include addressing the increasing demand for electricity while capitalizing on the rising number of vehicles on the highways/roads. By tapping into the kinetic energy of moving vehicles, this method offers an environmentally friendly alternative to conventional power generation, reducing the dependence on fossil fuels.

Keywords: Electricity, generation, rack and pinion, mechanism, harvesting.

1. Introduction

The increasing demand for energy and regard about environmental sustainability has led to a growing interest in alternative energy sources. Conventional power generation procedures often rely on fossil fuels, contributing to pollution and climate variation (Sharma.,2003). As a result, researchers are exploring innovative elucidation that can enrich to the energy mix while minimizing adverse environmental impacts. One such solution is harnessing energy from speed breakers, which are omnipresent in built up cities and suburban areas (Mukherjee and Chakraborti., 2005).

This study aims to delve into the intricacies of power generation availing speed breakers and highlight the multifaceted that make this technology a promising avenue for clean energy production. The paper will discuss the underlying principles, working mechanisms, technical challenges, environmental benefits, and potential applications of this technology. Additionally, it will examine real-world case studies and ongoing research efforts in this field, emphasizing the feasibility and scalability of implementing speed breaker power generation systems (Sharma., 2003).

2. Methodology

Power can be prompted using both traditional and unconventional energy sources. In this study, we demonstrate energy reformation from kinetic energy to rotational energy and rotational energy to electrical energy independently. This design demonstrates how speed combers generate power. The process of generating energy from speed swell arrangements is simple but effective.

These automobiles are speeding past many speed combers on the roadway. We wish to substitute these typical speed combers with our contemplated speed swell. It's an electromechanical unit. For power generation and storage, this system employs mechanical and electrical technology. The generation will be commensurable to the business viscosity (Watts and G.; 2004).

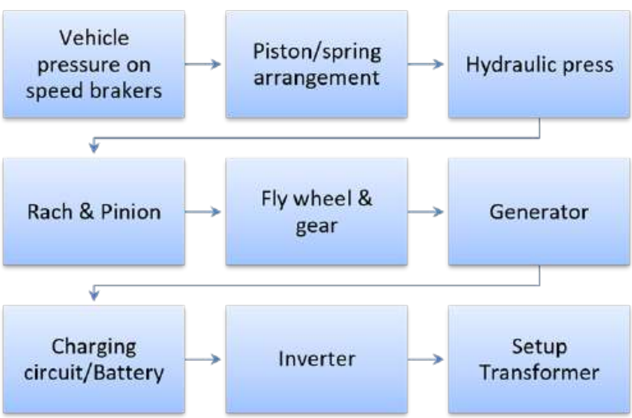

Fig 1: Block Diagram of RPG (Road Power Generation) System

3. Structure Construction & Function

The vehicles waste implicit energy that they retain while moving because of their weight. This kinetic energy can generate power by utilizing a special setting/arrangement called a “power hump.” It's an electro-mechanical unit. It utilizes mechanical and electrical technologies for power generation and its storehouse. Whenever the vehicle is allowed to transit the pate, it gets compacted down. Also, the springs hooked to the pate are compressed, and the rack attached to the bottom of the pate moves over in repaying stir. Since the rack has teeth coupled to gears, there exists a conversion of repaying stir of the rack into rotator stir of gears, but the two gears circumvolve in contrary directions so that shafts will circumvolve with a certain rpm. The shafts are coupled through a set of gears to the pistols, which convert the mechanical energy into electrical energy. The conversion will be commensurable to business viscosity (Brandt and Granlund., 2008). The battery is charged by charging circuit. The inverter circuit changes the DC voltage to alternating voltage current, which is then increased by a step-up motor. A black seeing circuit is accustomed to scent the night and turn on the street light. A hydraulic press, according to this theory, turns pressure of vehicle on the speed swell into rotary energy via rack and pinion.

As a result, this rotary motion rotates the creator, generating electrical power that is reserved in a battery via a charging circuit (Rao *et al.*, 2014). Figure 2 depicts the entire system.

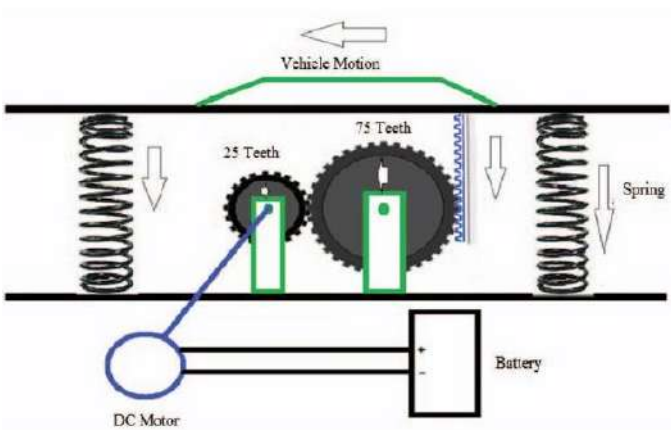

Fig 2: Rack & Pinion Mechanism

The speed swell system is conveyed to rack and pinion arrangements when the vehicle cargo is acted upon. The top section of the speed swell slides downward due to the weight of the vehicle (Pathan *et al.*, 2019). The pressure rod, one end of which is hooked to the bottom of the speed swell and the other to a hydraulic press's little piston.

The hydraulic press multiplies the force from the little piston to the huge piston four times. The huge piston is equipped with three rakes. Each rack is linked by two one-way pinions. The back-and-forth motion of the rack is causing gyrating in the pinions. Every pinion is bended together to a cover wheel, which absorbs energy while demand is low and releases it when needed. The flywheel is linked to a huge gear, which is linked to a small gear, which is linked to a creator. Rotational energy is converted into electrical energy by the maker (Kaur *et al.*, 2013). When the vehicle delivers the speed swell, the springs expand and return the speed swell to its original position, causing the system to rear. A battery is charged by the charging circuit. The inverter circuit converts the DC voltage to alternating current voltage, which is then increased by a step-up motor. A dark sensor circuit detects the presence of darkness and activates the road lights

4. System Design

This mechanism employs rack and pinion, hydraulic presses, speed breakers, spring arrangements, gear combinations, a generator, a battery, a sensor, a switching circuit, an inverter circuit, and step- up transformers.

a) Speed Breaker: The upper half of the system is formed of curved iron. This speed breaker's main duty is to maintain and compress vehicle pressure as a vehicle goes through it.

b) Spring arrangements: A spring is an elastic body that distorts when loaded and returns to its original shape when the weight is removed. It cocoons, absorbs, or manages energy due to shocks or climatic change (Mitsubishi., 2014). Four helical springs beneath the speed swell are compressed when the vehicle applies pressure, restoring the speed swell to its original state.

c) Hydraulic press: A hydraulic press converts a tiny force given to one liquid column into a considerably smaller force that is available to another liquid column. It is a Pascal's law operation. In our proposed system, when the pressure formed on the speed swells utilizing this equation, it turns the force into 4 times from a small piston to a large piston in our proposed system.

$F1= (A1*F2)/A2$

F1= converted to force by hydraulic press.

F2= created force on a small piston by a speed breaker.

A2= area of small piston.

A1 = area of large piston.

a) Rack & Pinion: Rack and pinion devices can change the direction of motion from linear to rotary or vice versa (Anderson and Fouad., 2003). A circular gear is a pinion, and a linear gear is a rack. The rack's applied force is translated into rotation by the pinion. The rotational force is created by converting the mechanical force.

b) Flywheel: The role of a flywheel is primarily that of an energy storage device. It lessens speed peaks and valleys (Padiyar.,1996). It absorbs energy when the demand is low and releases it when it is high.

c) Generator: Generators are machines that transform mechanical energy into electrical energy. Alternating current is created by an AC generator, which is made up of a combination of stationary (the stator) and moving (the rotor) components. The gear is attached to the rotor. The generator's rotor is turned by the torque produced by the gear. The generator's alternating current (AC) output is produced by the stator's windings, which are surrounded by a moving magnetic field created by the rotor (Rao *et al.*, 2014).

d) Charging circuit: The battery is charged with the help of a charging circuit.

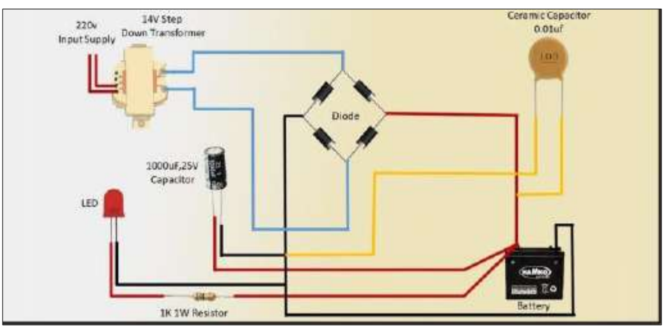

Fig 3: Charging Circuit

a) Inverter circuit & step-up transformer: Inverter converts DC voltage to AC voltage, and a step-up motor is a type of motor that steps up the AC voltage.

b) Dark sensing and switching circuit: When darkness happens, the sensor senses it and switches on the light.

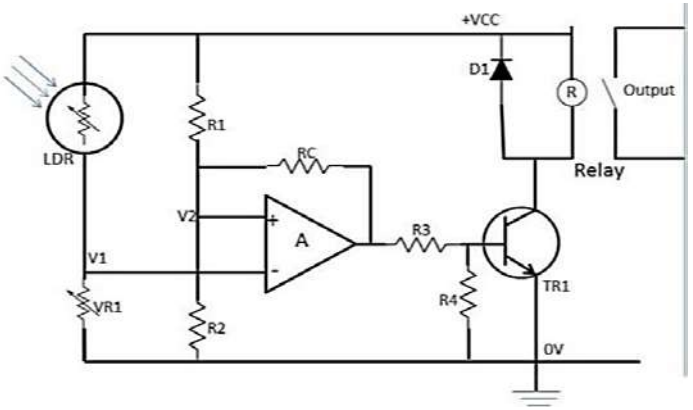

Fig 4: Dark sensing and switching [K.M Ullah, 2016]

5. Calculation

Let,

Normal car mass = 1500kg (Avg.)

Car weight = acceleration due to gravity*Mass

= 1500kg * 9.81 m/s^2=14715N

Speed breaker height = 15cm=0.15m

Work done = Displacement * Force

= 14715*0.15=2207.25Nm

Power = Work done/ time

= 2207.25 /60 = 36.7875W

Power generated in the whole day = 36.7875*24hr*60min

= 56.45KW

If we are using a bulb which is 100W, and in two km 120 numbers bulb needed. The total watt consumed =120*100 =12000W

= 12KW

Since the above calculation shows us, the generated power from moving vehicles is sufficient to power road lights all night.

6. Conclusion

The described system presents a non-conventional and environmentally friendly approach to power generation (Nota *et al.*, 2005).A key advantage of this system is its independence from external energy sources.

By implementing this innovative solution, we can significantly mitigate power crises and alleviate issues with load shedding. The surplus electricity generated can adequately cater to the daily energy demands of street lighting. Furthermore, the system can be harnessed for a variety of applications such as road signals, tollbooth operations, and other valuable tasks. It is evident that this system offers a highly effective means of addressing and reducing power shortages in Bangladesh from multiple perspectives.

Future scope

The prospective expansion of this initiative involves enhancing the eco-friendliness of speed bumps by utilizing diverse materials in their construction. Furthermore, enhancing the power generation infrastructure could encompass incorporating alternative forms of power generators.

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Chapter - 40
Surveillance System of Conveyor Belt's Health - A Review

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Chapter - 40

Surveillance System of Conveyor Belt's Health - A Review

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Abstract

The present study describes a system for monitoring the health of conveyor belts. In coal mines and other manufacturing settings, belt conveyors are a common piece of machinery. This essay will concentrate on a few of the technical elements required for conveyor belt health monitoring. The belt is susceptible to a number of problems, including scuffs, cracks, and general wear and tear. Conveyor belt inspection and fault detection are crucial in both academic research and practical applications. In this study, we review the methods currently in use for conveyor belt rip detection in industrial manufacturing. Before monitoring the belt surface, we first condition the belt. The most common technology used to monitor belt interior or carcass conditions in the case of steel cord belts is conductive monitoring, followed by other approaches of monitoring system. Induction loops and coils in conjunction with external transmitters and receivers are the most widely used belt rip detecting method. Before the laser beam is reflected and captured by the camera, it strikes the surface of a belt carry side. shows the effectiveness of RFID sensors in tracking the orientation of the fracture into the belt. The condition-based approach's basic needs for intelligent monitoring and automated maintenance may be the answer. These techniques can also forecast the last belt life and identify possible conveyor belt failure before it occurs.

Keywords: Health monitoring, conveyor belt, belt rip, surveillance system.

1. Introduction

Coal mines and other manufacturing facilities frequently use belt conveyors, which are mostly made up of a variety of idlers. A conveyor system is absolutely necessary for the operation of a mine or plant, and the conveyor belt is one of the most expensive components of a conveyor machine. A continuous belt that travels between two pulleys and has a take-up pulley in the middle is what makes up a conveyor belt. They work by creating friction between the belt and a pulley's floor, which is pulled by a motor. The separate pulley's purpose is to act as a return for the belt and it typically rotates freely other than when it is being driven. Between the two pulleys, there are intermediate rollers or idlers that serve as both return and training rollers for the belt. Therefore, a series of components, including the tail pulley, the idlers, the belt, the head or power pulley (motor, reducer, bearings, etc.), and others, make up conveyor belts. It has become very important to ensure the safe and environmentally friendly operation of the conveyor systems given the rising cost of mining operations. Any operation could be harmed by belt replacement and unanticipated downtime. As a result, it has become crucial to be able to safeguard conveyor belting and precisely anticipate the last belt life. This will not only prevent unanticipated breakdowns and production interruptions, but it will also force the manufacturer and customer to better prepare for upcoming belt requirements, lowering the amount of necessary inventory and increasing mechanical availability. It is now feasible to monitor the health of conveyor belts more successfully. Conveyor belt systems are now more dependable thanks to data collection, analysis, and corrective measurements. Effective health monitoring of conveyor belts ensures safe and most cost-effective operation of the conveyor system. It also reduces unplanned stoppages due to breakdowns and ensures more accurate stock planning.

The measuring of belt wear and guarding the belt from longitudinal rips are the major areas to concentrate on in order to increase belt life and operational availability. This study will concentrate on a few technical elements that are crucial for conveyor belt health monitoring. Piotr Bortnowski, *et al.* [1] investigated the use of an acoustic camera as a tool for verifying the proper design and operation of each component of a belt conveyor. Using recordings from video digital cameras and measuring microphones, a map of the belt conveyor's sound pressure levels was created. Based on the testing, three noise sources electric motor noise, idler roll bearing noise, and noise on the tail pulley produced by belt misalignment were identified in terms of frequencies and sound pressure levels.

In the paper, Wei Li, Zewen Wang, *et al.*[2] developed a fault diagnosis approach for belt conveyor monitoring, namely the identification of idler defects, integrating wavelet packet decomposition (WPD) and support vector machine (SVM). Following the decomposition of vibration signals by WPD, each frequency band's energy was extracted as a feature, which was then applied to the training of an SVM to identify idler defects.

RFID tags were applied to fabric conveyor belts as carriers of information about conveyor belts (ozone-induced ageing/accelerated thermal ageing, damage to cover layers and the carcass, and igniting) by Daniela Marasova *et al.* [3].

The strain gauges positioned on the roller surface, which monitored the pressing force of the belt against the roller, were used to create a novel belt monitoring system that was discussed in the study by D. Bzinkowski *et al.* The paper examined equipment variation EV calculations, Type A uncertainty estimation, and stability of indications during a 5-day period. The percentage repeatability%EV was determined to be 9.5%, and the expanded uncertainty taken into account for the 95% level of confidence was less than 0.1% of the actual measured value.

Andrejiova, M. *et al.*'s discussion[5] of connections between the occurrence of significant damage to rubber-textile conveyor belts and the chosen parameters (the type of falling material and the impact height) of belt conveyor system, both new and renovated, focused on these two factors. Different machine learning methods, including regression analysis, logistic regression, decision trees, and Naive Bayes classifier, were used to create classification models. The models' quality was confirmed using the training and testing groups as well as three coefficients (general accuracy, Kappa coefficient, and AUC). The examination of the results revealed that the kind of falling material and the height of the impact had a significant impact on the severity of all types of conveyor belt damage.

The application of virtual reality to a test specimen chosen from the damaged conveyor belt for the subsequent analysis was covered in the study by Fedorko, G. [6].

For the conveyor belt's safe operation in the coal mine, Hou, Ch. *et al.* [7] proposed a multispectral visual detection method of conveyor belt longitudinal rip. The precision of longitudinal tearing recognition was over 92.04%, while the accuracy of the suggested approach was over 90.06%.

Semrád, K. [8] addressed impact damage to airport conveyor belts used to haul luggage and proposed a method for estimating the probability of such damage using statistical models to optimize conveyor belt maintenance processes.

Second stage safety diagnostic system for conveyor transport was proposed by Mazurkiewicz, D.[9]. In addition to real-time measurements, the system allowed for a long-term examination of historical data for each joint that makes up the conveyor belt loop, from the point at which it is manufactured until the point of use. With the right inference rules in place, this system would improve decision-making efficiency, reduce decision-making time, and validate created signals.

For belt conveyor idlers, Liu, X. *et al.* [10] showed a simulated framework of integrated maintenance decision making. For precise decision-making, data from condition monitoring, idler reliability estimation, and operational circumstances were combined.

Importance

Reducing revenue losses caused by conveyor system failures, improving awareness of and avoiding predictive maintenance technologies and techniques, including conveyor monitoring, are becoming the focus of the health monitoring market's growth (figure, provided below). Waste reduction, decreased maintenance time and expenses, and improved customer credibility are used to advertise it.

Attractive Opportunities in Conveyor Monitoring Market

- The global conveyor monitoring market is expected to grow from USD 206.3 million in 2018 to USD 253.6 million by 2024.
- Rising adoption of predictive maintenance techniques and growing focus on reducing unbudgeted losses due to conveyor and motor breakdown drive the demand for conveyor monitoring solutions.
- The mining industry held the large market share in 2018 owing to the wide development of conveyor monitoring solutions in mining plants to prevent expensive conveyor shutdowns.

Major players operating in the conveyor monitoring market are NIPL Engineering Pvt. Ltd (India), Fenner Dunlop (Australia), PHOENIX CBS GMBH (Germany), ContiTech Conveyor Belt Group (Germany), SKF (Sweden), Bruel & Kjaer (Denmark), Beltscan Systems Pty Ltd. (Australia), Yellowtec (Australia), Honeywell International Inc. (US), Emerson Electric Co. (US), and Parker Hannifin Corporation (US).

2. Condition Monitoring of Belt

The condition of a conveyor belt is a combination of the conditions of

1) Belt surface that includes top and bottom covers,
2) The belt's interior that includes belt carcass rubber and steel cables or fabric layers, and
3) Conveyor belt splices.

Belt surface monitoring

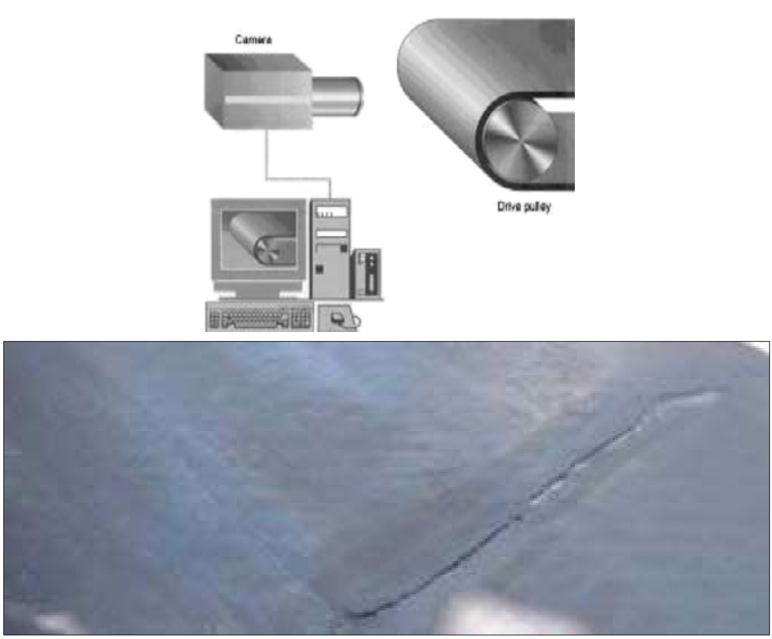

Fig 2: Belt surface monitoring

Cameras are often used to take pictures of items that are being watched. Both an expert and an automated system can analyze the image data. High speed cameras can be utilized for tele-monitoring and pattern recognition with computer systems to automate belt surface monitoring (Conveyor Experts B.V., 2004).

Belt interior monitoring

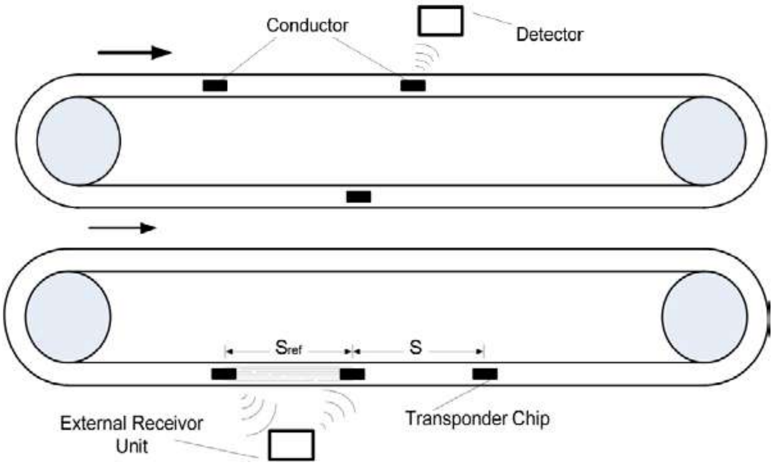

Fig 1: (a) Conductive monitoring Principle; (b) Belt splice monitoring

The most common technology used to check the quality of the carcass or interior of a steel cord belt is conductive monitoring. An embedded conductive monitoring system can be created by embedding conductors into the belt carcass. Conductors in these kinds of applications can be magnets, transponder chips, conductor loops, or circuit coils. Detectors can be powered transmitters and receivers, magnetic sensors, or inductive or conductive couplings. These detectors are situated on the conductors' course of motion and are contactless to the belt (see Figure below). When conductors move through the electrical or magnetic fields produced by the detectors, the detectors pick up signals from the conductors such electrical pulses or induced electromotive force signals. The external transmitter/receiver device determines that there has been a critical change in the length of the splice and takes appropriate action if the spacing S of the transponder chips is greater than a specified amount Serf.

3. Distinctive methodologies of monitoring system

Foreign items like drill steel, rock bolts, steel liner plates, or rock slabs that pierce the belt and become trapped in the impact bed structure or surrounding steel are the main cause of conveyor belts ripping longitudinally. The rip typically happens at the conveyor's loading point or tail, though it can happen anywhere along the conveyor on occasion.

Rip Detection Sensor Loops

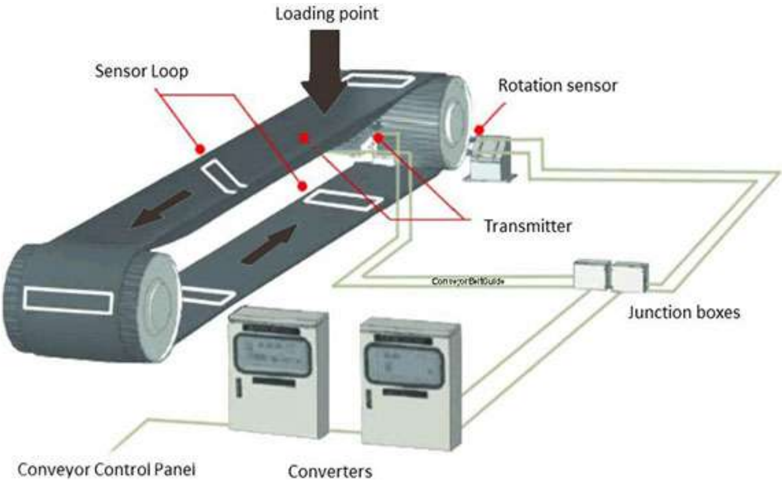

Fig 2: Belt rip detection Sensor loop

Induction loops and coils in conjunction with external transmitters and receivers are the most widely used belt rip detecting method. The loops are fused to the top or bottom cover of the belt. The belt could rip if an object pierces it and becomes impaled on the conveyor system. The receiver sensor does not receive a signal when a sensor loop is broken by this foreign body, and the conveyor drive is turned off as a result.

Sensor loops are delicate components that could cause a false alarm. Additionally, the rip detection system might not function properly if high grade iron ore, such as magnetite, with strong ferromagnetic characteristics, is being transported. By far, sensor loops fall short of the conveyor belt's operating lifetime. Pitch or spacing between two loops is often calculated by multiplying the belt speed by the time it takes to stop the belt, divided by 2. The outcome will likely range from 50 to 200 m.

Laser Rip Detection

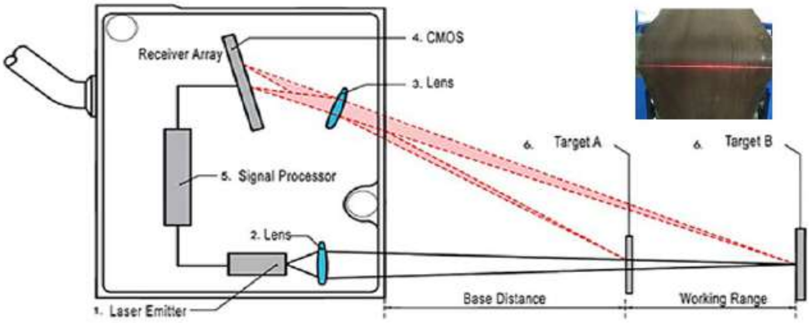

Fig 3: Schematic Diagram of Laser rip detection technique

The surface of a belt carry side is struck by the laser beam before it is reflected and photographed by the camera. By using triangulation, the laser stripe is continuously analyzed to ascertain the extent and depth of the belt's rip or injury. The computer program creates a 3D graphic that shows any possible tearing. The conveyor will automatically stop in the event of a belt rip.

Wire Under Belt

This is an outdated technique where a wire is suspended beneath the belt. The motor will stop if a foreign object enters the belt and moves the wire in the direction that the belt is running. Its origins can be found in the emergency pull-wire that runs along the majority of conveyor systems. To touch and move the string, the invading body must indeed emerge for a sufficient amount of time. The device is unable to respond if the body is caught somewhere and continues to rip the belt, which is typically the case.

RFID technology

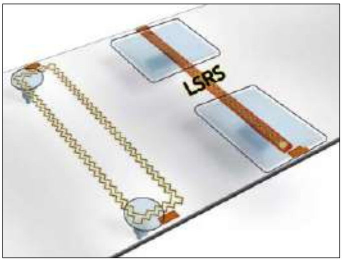

Fig 4: RF tags mounted in the belt

Radio Frequency Identification, sometimes known as RFID, is the wireless transmission of data using electromagnetic fields with the goal of automatically recognizing and tracking things that have identification tags. Magnetic fields generated close to the reader provide electromagnetic induction power for passive tags. Active tags have a power source installed or linked to them. To be read or recognized, RFID tags do not need to be in the reader's line of sight. In the past few years, RFID has been included into sensor loop systems. These tags served primarily as a means of identifying the sensor loops and assisting in pinpointing the site of belt damage.

In place of the more conventional sensor loop, the recently created RFID Rip Detection system uses UHF RFID tags with a single strand antenna extending across the width of the conveyor belt. This results in a significant reduction in antenna size from roughly 400 mm wide to merely 100 mm wide. Because the antenna and RFID tag are less than 3 mm thick and have thinner coverings, they may be inserted inside belting.

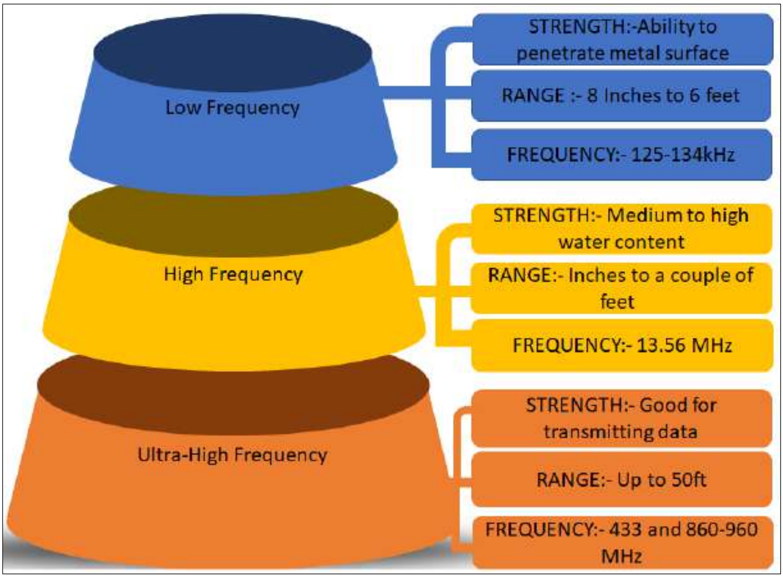

Fig 5: Industry Standard RFID Frequency

Table 1: Industry Standard RFID Frequencies

	STRENGTH	RANGE	FREQUENCY
Low Frequency	Ability to penetrate metal surfaces	8 Inches to 6 feet	125 – 134 kHz
High Frequency	Medium to high water content	Inches to a couple of feet	13.56 MHz
Ultra-High Frequency	Good for transmitting data	Up to 50 ft	433 and 860-960 Mhz

Belt Thickness, Wear Measurement/Monitoring

The measurement of belt thickness at regular intervals in order to ascertain the rate and pattern of wear of any specific belt is another technique for condition monitoring. Through measurement and tracking of the wear, it is reasonably reasonable to ascertain the remaining belt life and spot any unusual wear patterns that could point to malfunctioning or damaged conveyor system components.

It has always taken a lot of time to conduct the measurements and provide a usable report, which is a huge disadvantage.

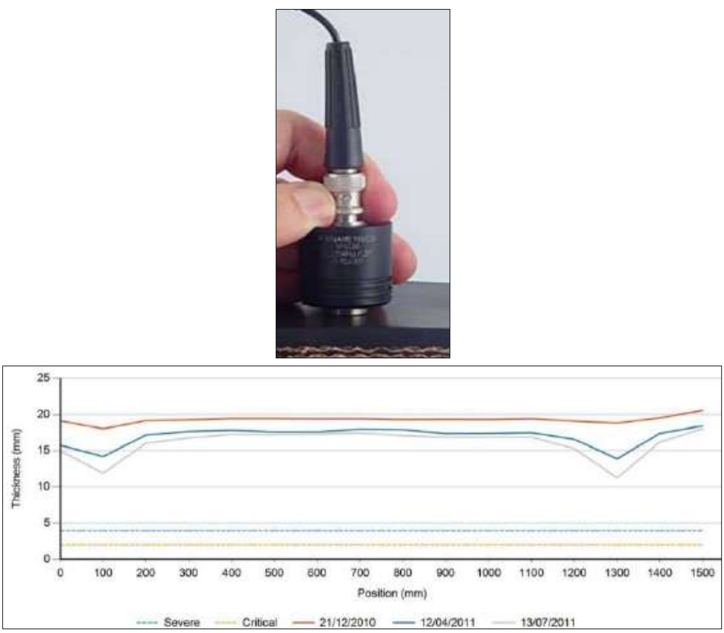

Fig 6: Thickness measurement showing cover damage by skirting rubber

To measure this more precisely, numerous techniques have been created recently. From employing electromechanical methods to lower a measuring unit on the belt to conduct the measurements to using laser modules (Fig. 5).

Fig 7: (a) Laser module; (b) Electromechanical unit

4. Analysis & discussion

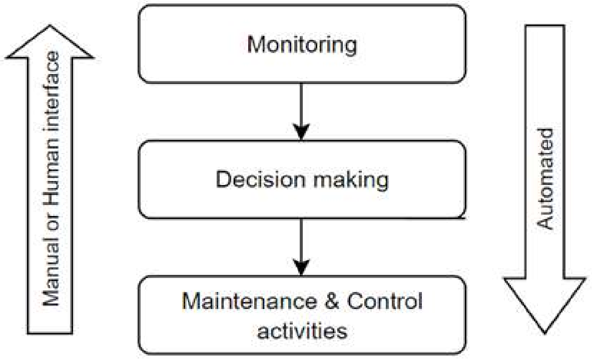

Fig 8: Condition based strategy

The condition-based approach's basic needs for intelligent monitoring and automated maintenance may be the answer. The three control points—monitoring, decision-making, and maintenance and control actions—can be partially or entirely automated or involve human or physical interaction. The following are the four primary phases toward automated maintenance:

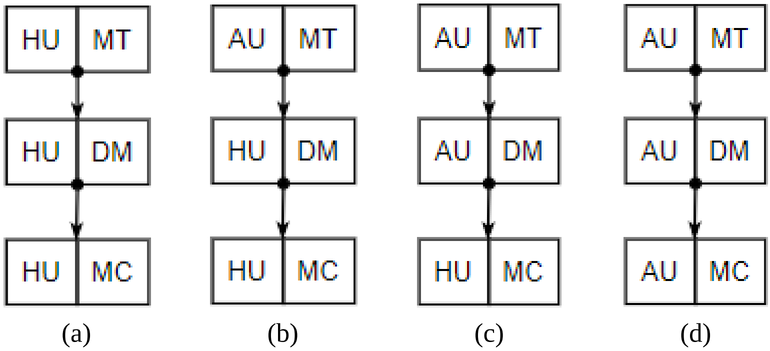

Fig 9: HU: Human or Manual, AU: Automated, MT: Monitoring, DM: Decision making, MC: Maintenance & Control activities

5. Conclusion

This paper discusses several conveyor belt condition monitoring techniques and collects data on the efficient application of cutting-edge technology to identify a variety of failures, including scratches, cracks, and general conveyor belt wear and tear. The extensive technical and/or quantitative study of conveyor belt health monitoring is not done in this paper. The application of artificial intelligence and machine learning algorithms to the safe and effective functioning of conveyor belts will be the subject of more in-depth research in the future.

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Chapter - 41
The Bond Graph: A Comprehensive Review on Its Application in Robotics

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Chapter - 41

The Bond Graph: A Comprehensive Review on Its Application in Robotics

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Abstract

The paper presents the Bond Graph as a powerful modelling and simulation tool that is well-suited for capturing the complex dynamics of robotic systems. It emphasizes the benefits of the Bond Graph's unified framework, which allows for the integration of various components found in robotics, such as mechanical, electrical, and hydraulic systems. Furthermore, the paper acknowledges the growing demand for efficient modeling strategies in the rapidly advancing field of robotics. It also highlights the challenges that may be faced when using the Bond Graph methodology for robotics applications, including issues related to modelling complexity and system integration. By providing recommendations for future research and discussing strategies to overcome challenges, the paper demonstrates a comprehensive approach to exploring the potential of the Bond Graph methodology in robotics. Overall, this review appears to be a valuable contribution to the field of robotics, as it showcases the advantages and limitations of using the Bond Graph methodology and offers insights into its practicality and reliability for real-world robotic applications.

Keywords: Bond graph methodology, robotics system.

1. Introduction

Robots are devices that use electricity and mechanics to perform tasks that might be difficult, dangerous, and repetitive for humans. The use of robots has increased significantly over the past decade. In the field of robotics, bond graphs provide an intuitive and systematic way to represent the dynamic behavior of robotic systems [1]. Bond graphs are graphical representations of the physical components of a system and the way energy moves between them. This representation helps engineers and researchers understand how different parts of the robot interact with each other and how energy is transferred and transformed throughout the system. This method uses the terms effort and flow to describe physical processes. Bond graphs are an influential modeling tool that can be used for simulating the dynamic actions of complicated systems, including robotics systems. Bond graphs provide a model that is not specific to any particular domain, making it simple to capture the behavior of robotic systems that typically incorporate electrical, mechanical, and hydraulic elements [2]. Different approaches have been developed for designing fault detection and isolation (FDI) procedures, depending on the type of knowledge used to describe the detection of faults in robots. Initially, the bond graph tool's causal properties were used to determine the origin of faults from an FDI and supervision perspective [3]. A bond graph model is useful for creating mathematical and graphical representations that can help design monitoring and supervision systems to detect and isolate faults. The bond graph tool has multiple applications which include modeling, robust diagnosis, and sensitivity analysis of residuals. It is used while taking into account parameter uncertainties. With the use of bond graph methodology and an LFT bond graph model, it is possible to effectively acquire physical knowledge of systems and improve their monitoring by determining adaptive thresholds for residuals. This ensures the implementation of sufficient safety measures to detect and prevent faults [3].

2. Bond Graph Terminology

The bond graph technique is a method for modeling dynamic systems using energy as a shared currency between various domains, including mechanical, electrical, fluid, thermal, and acoustic. An effort and a flow are defined for each domain, and every bond between two elements in a bond graph is linked to an effort and a flow. The power transmitted on each bond is calculated by multiplying these two quantities [4].

Table 1: Key quantities in various domains

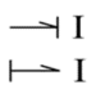
Domain	Effort	Flow	Momentum	Displacement
Mechanical Translation	Force	Velocity	Linear Momentum	Linear Displacement
Mechanical Rotation	Moment	Angular Velocity	Angular Momentum	Angular Displacement
Electrical	Electric Potential (Voltage)	Current	Flux Linkage	Charge
Hydraulic	Pressure	Volumetric Flow	Pressure Momentum	Volume

Bond graphs consist of several components such as energy storage elements, energy dissipation elements, junctions, transformers, gyrators, and sources. These elements have unique descriptions and are utilized in different domains for energy storage and dissipation purposes.

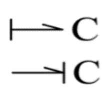
Table 2: Type of Elements in Various Domains

Domain	**Element Type**		
	I	**C**	**R**
Mechanical Translation	Mass	Linear Spring	Damper
Mechanical Rotation	Mass Moment	Torsional Spring	Rotary Damper
Electrical	Inductor	Capacitor	Resistor
Hydraulic	Fluid Inertia	Tank	Pipe Resistance or Orifice

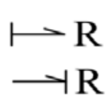
- Inertance: Inertance, an energy storage element, shows a connection between the flow and generalized momentum.



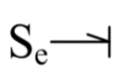
- Compliance: Compliance, the energy storage component, demonstrates a connection between displacement and effort.



- Resistance: Resistance is an element that doesn't store energy but dissipates it. Even though the energy is not destroyed and total energy is conserved, it gets converted into a form that is difficult to recover.

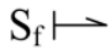


- Source of Effort: When a system is subjected to an external force, torque, pressure or electric potential, it is considered a source of effort. This results in a specific flow of response from the system.

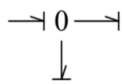


- Source of Flow: A source of flow refers to something that causes movement within a system, and the system responds accordingly.

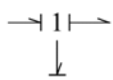
These sources can take many forms, such as linear or angular velocities, volumetric flow of fluids, or electrical currents.



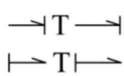
- Common Effort Junction: A "0" junction, which is also called a common effort junction, is a component that doesn't use or preserve power and has the same effort on each bond.



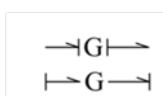
- Common Flow Junction: A "1" junction, also called a common flow junction, is a component that doesn't store or dissipate power. It has an equal flow on every bond.



- Transformer: A transformer is a theoretical device that accurately relates the input force and flow to the output force and flow while conserving energy.



- Gyrator: A gyrator is a theoretical device that conserves energy and links output efforts to input flows, and output flows to input efforts.



3. Different Works on Robotic by Bond Graph Methodology

This report presents a preliminary mathematical model and its results for a gantry robot used in printing circuit applications. Traditional modeling approaches such as Newton-Euler, Kirchoff's law, and the Lagrangian fail to combine electrical and mechanical phenomena. Therefore, this study utilizes algebraic mathematical models developed with Maple software, which are then evaluated in MATLAB by incorporating robot models created in Solidworks.[5]

Bond graphs offer a comprehensive paradigm for designing complex systems and several techniques have been developed accordingly. In this study, slender robotic linkages are represented as a set of finite element beams using a co-rotational formulation. The resulting mathematical model is written as a system of differential-algebraic equations (DAEs) [6].

One advantage of utilizing bond graphs is that the model formulation is based on velocities, resulting in index 2 semi-explicit DAEs that can be easily solved using existing techniques. This approach is applied to two flexible multi-link issues, and simulation results demonstrate exceptional numerical performance. The proposed technique may also be applied to simulate other mechatronics systems with success [7].

A bond graph model of a multidomain physical system, such as a skid-steered mobile, is described. The suggested technique is utilized to characterize the system's dynamics in several physical domains. The resulting dynamic model and controller are modeled in MATLAB using the BG V20 toolbox [8].

This report also includes a lesson on designing models for common robotic parts created in a reusable object-oriented language style. Additionally, employing a bond graph representation in linear fractional transformation (LFT) form, uncertainties can be reduced in the presence of parameter development of fault indicators and residual thresholds [9].

To achieve continuous operation, defects must be discovered and diagnosed in a timely manner. Fault Detection and Diagnosis (FDD) has been studied by researchers for many years. However, only a few surveys have been reported in the research of FDD for robotics, and none have focused on Multi-Robot Systems (MRS). This report discusses different MRS characteristics that present distinct obstacles for FDD. To overcome these issues, several FDD techniques relevant to MRS are examined, and research potential in this subject is discussed [10].

Finally, this report includes a study on the oscillating cylinder mechanism, which is crucial to the robot walking system. The prismatic leg of the robot is powered by two DC motors. The bond graph model is then translated into a Simulink block, which is then utilized for obstacle avoidance. The study includes the construction of a hybrid obstacle avoidance algorithm that combines the advantages of the line following, tangent bug, and wall following algorithms. The algorithm's practicability is evaluated in two situations based on the placements of the obstacles. The algorithm's code is created with the MATLAB program [11].

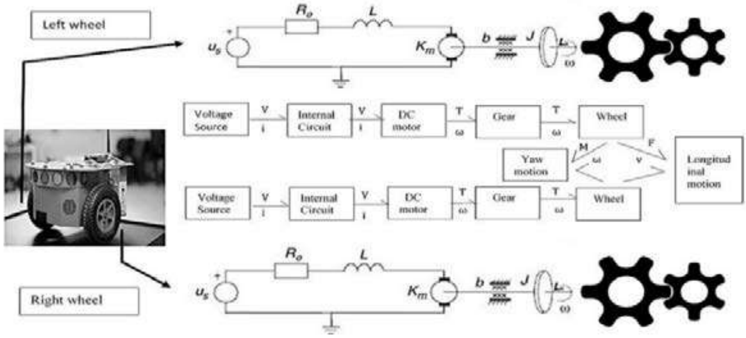


Fig 1: Lay out of the robot

The motion of a two wheel skid mobile robot is powered by DC motor coupled with a gear box. The word bond graph of the robot is the first step towards building bond graph. The components of the robot are defined by lay out as shown in Fig 1 and Bond graph model of the robot is shown in Fig 2 [14].

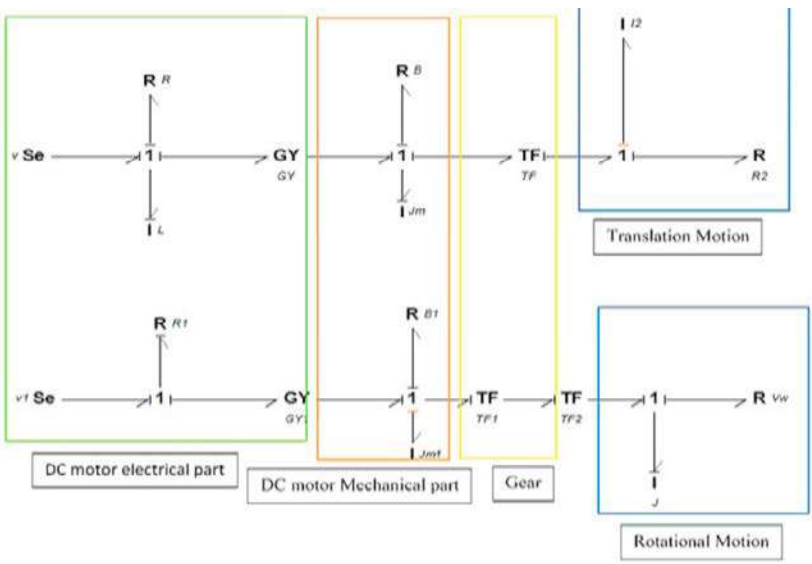


Fig 2: Bond Graph of the Robot

4. Challenges Faced

Robotics is a complex field that involves mechanical, electrical, and control elements. To accurately represent these components and their interactions through bond graphs can be intricate, especially for large and sophisticated robotic systems. Creating precise bond graph models for robots requires a deep understanding of the mechanical and control aspects of the system, and it can be time-consuming and requires domain expertise. Some robotic systems exhibit nonlinear behaviours that can make it challenging to represent and analyze using bond graphs. Linearizing these systems for bond graph analysis might lead to inaccuracies in capturing the system's true behaviour. Integrating multiple disciplines, such as mechanics, electronics, and control theory into a single bond graph model for robotic systems can be complex, and it might require simplifications that impact the accuracy of the model. Validating bond graph models against real-world robotic systems can be challenging due to the complexity and variability of physical environments. It is crucial to ensure that the bond graph model accurately represents the actual system behavior through careful experimental verification.

5. Future Scope

The Bond Graph approach is an effective tool for modeling and simulating complex systems, especially flexible multibody systems. This method involves breaking down the model into smaller components using a top-down approach and using predefined library elements for modeling. To model flexible multibody systems, finite element modeling is used based on Bond Graph 3D ray factors [12]. This method can be used to solve complex control problems in robotics. The Bond Graph model provides a topological architecture for fault isolation using qualitative logic methods, known as the TCG representation. The unique combination of qualitative and quantitative approaches to FDI is effective in parameterized fault isolation and estimating actuator and process faults [13]. This approach is innovative and provides an efficient scheme for fault isolation. Bond graphs are an effective way to conceptualize a system at different levels of abstraction. They are commonly used in soft robotics and could also be systematically employed to calculate equations that govern coupled multi-domain dynamics.

6. Conclusion

In this paper, the Bond Graph is introduced as a valuable tool for modeling and simulating complex robotic systems. The Bond Graph's unified framework enables the seamless integration of various components, including mechanical, electrical, and hydraulic systems. However, challenges may arise in applying the Bond Graph methodology for robotics, such as issues with modeling complexity and system integration. The paper provides recommendations for future research and suggests strategies for overcoming these challenges. Overall, the Bond Graph approach offers an intuitive and systematic means of representing the dynamic behavior of robotic systems. Combining various fields like mechanics, electronics, and control theory into a unified bond graph model for robots can be challenging and may necessitate simplifications that could affect the model's precision.

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Chapter - 42
A Review on the Microstructure and Mechanical Properties of the Heat Treated Additive Manufactured Ti-6Al-4V Alloy Components

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Chapter - 42

A Review on the Microstructure and Mechanical Properties of the Heat Treated Additive Manufactured Ti-6Al-4V Alloy Components

Soumyajyoti Ghanti, Suman Pal, Suraj Yadav, Nikhil Kumar, Shantanu Datta, Sarnendu Paul, Srijan Paul, Kaushal Kishore

Abstract

This study examines how different heat treatments affect the microstructures and mechanical characteristics of components made of the Ti-6Al-4V alloy utilizing additive manufacturing methods. Ti-6Al-4V is a popular titanium alloy known for its high strength-to-weight ratio and resistance to corrosion. The particular microstructural traits and residual stresses brought on by additive manufacturing, however, might have a big influence on the ultimate qualities of these components. It was discovered that annealing increased ductility and toughness while decreasing strength. In contrast, solution treatment was successful in producing a more uniform microstructure by removing undesired phases and precipitates produced during additive manufacturing, resulting in enhanced ductility and machinability. The ageing process has the most effects on mechanical properties. This work emphasizes the need of heat treatment parameter optimization to obtain the required microstructure and mechanical characteristics in Ti-6Al-4V components made utilizing additive manufacturing. Finding the ideal balance between strength, toughness, and other critical attributes is essential. Additional study in this area is essential to expand our knowledge of additive manufacturing and heat treatment techniques for Ti-6Al-4V components.

Keywords: Heat treatment, additive manufacturing, Ti-6Al-4V alloy, annealing, solution treatment.

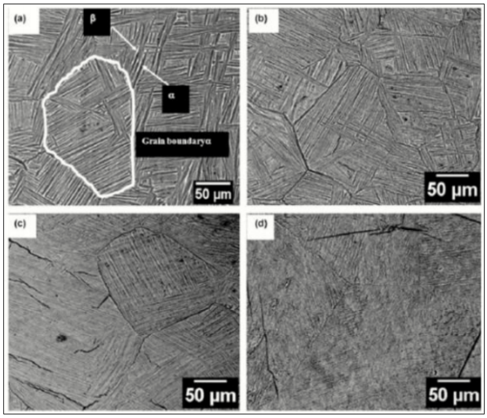
1. Introduction

1.1 Titanium and its alloys

Titanium, being a transition metal, has some distinctive properties that makes it very versatile. It has higher strength-to-weight ratio than steel and other commonly used alloy, low density and excellent resistance to corrosion [1]. Based on their crystal structures, titanium alloys are classified as Alpha (α), Beta (β), and Alpha + Beta (α + β). α Alloys are mostly composed of hexagonal close-packed (HCP) phases, which provide corrosion resistance and ductility without the need for heat treatment. Alloys are based on the body-centred cubic (BCC) phase, which provides strength, heat-treatability, and toughness. Manufacturing alloys is more difficult than manufacturing alloys [2]. α + β alloys have both α and β phases; at room temperature, α is dominant. When correctly treated, they provide a balance of strength and ductility [3]. Notably, Ti-6Al-4V, an α + β alloy with 90% titanium, 6% aluminium, and 4% vanadium included in our study, excels in strength, low density, fracture toughness, and corrosion resistance, making it excellent for aerospace, medical, and marine usage [4].

1.2 Microstructures of Ti-6Al-4V

Rapid cooling at 525° C/s resulted in unstable acicular martensite production in research by TJ Ahmed *et al.* using the Jominy end quench test. Tempering allows this metastable phase to convert to a completely lamellar microstructure (alternating alpha and beta layers), giving strength, ductility, and fracture toughness [5]. Cooling at 410 C/s caused a huge change, switching beta to alpha phase. The block-like appearance of alpha with an internally displaced substructure was observed by transmission electron microscopy (TEM) [6]. Slower cooling formed alpha nucleation sites [5], and very slow cooling produced the Widmanstatten microstructure, in which alpha plates develop in certain orientations controlled by beta structure, creating colonies or basketweave morphology depending on the rate of cooling. Colonies provide strength and low weight for aerospace, whereas basketweave microstructures are suitable for biological applications [7]. Titanium alloy mechanics are heavily influenced by microstructure. Controlling cooling rates during heat treatment results in various microstructures, which vary alloy characteristics. Thus, for customising alloy characteristics to specific applications, analysing and modifying heat treatment procedures based on the microstructure is critical [8].



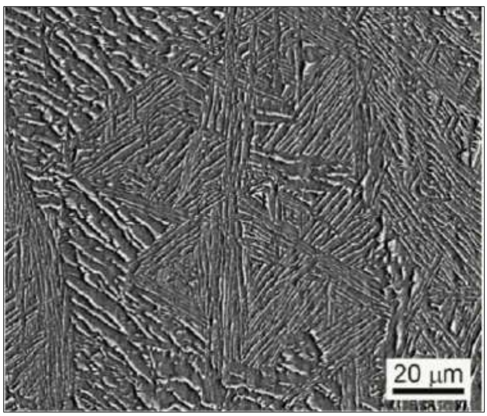


Fig 1.1: Microstructures at various

Cooling rates Fig 1.2. Widmanstatten Microstructure

2. Manufacturing of Ti-6Al-4V

2.1 Traditional method

Depending on the needs of the application, techniques like casting, forging, rolling, extrusion, and machining are used to produce Ti-6Al-4V. Complex shapes work best with casting, whereas great strength is produced by rolling and forging [9]. However, traditional technologies have a high BTF ratio (up to 20:1) and are expensive, which prevents the creation of low-cost, low-waste products. Because of its strength, Ti-64 requires strong forces during machining, which increases tool wear. Work hardening, heat accumulation, and deformation during machining are caused by its low thermal conductivity, elasticity, and chemical characteristics. Unconventional solutions, including additive manufacturing, being developed to address these problems. These methods get around the limitations of conventional production by enabling complex designs, reducing waste, and lowering the BTF ratio [10].

2.2 Additive Manufacturing

Additive manufacturing (AM) involves using 3D model data to create parts by combining materials. The process typically involves adding layers of material rather than using subtractive or formative methods of manufacturing, as defined by ISO/ASTM 52900 terminology standard. ASTM International categorises AM into seven different manufacturing processes [11]. Directed energy deposition is one of the processes, which involves depositing the material in a molten state onto a substrate to build a part. The material can be in the form of a wire or powder [12].

2.3 Wire Arc Additive Manufacturing

Wire Arc Additive Manufacturing (WAAM) is a form of Directed Energy Deposition (DED) technology that uses wires. It uses the heat energy from an electric arc to melt consumable wire electrodes, allowing for the formation of material layers. The wire melts when an electric arc is formed between a consumable wire electrode and the substrate, resulting in the development of a pool of molten material. The continual feeding of the wire into the arc allows for the sequential deposition of material layers onto the substrate, allowing for the precise layer-by-layer creation of complicated three-dimensional forms [13]. One of WAAM's particular benefits is the lower cost of its wire-shaped feedstock when compared to powder feedstock in comparable production techniques. This process has a significantly greater deposition rate of roughly 10 kg/h, which is a significant increase above the deposition rate of around 600 g/h seen in powder-based additive manufacturing techniques. As a result, WAAM is an efficient alternative for the manufacturing of large components. WAAM's fast deposition rate and low-cost wire feedstock make it an interesting solution for large-scale component manufacture, with its potential efficacy underlined by a comparatively low Buy to Fly (BTF) ratio of as little as 1.2 [14].

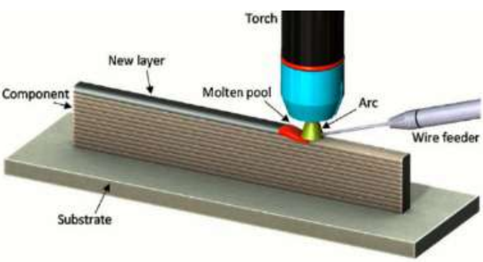


Fig 2.1: WAAM Robot Setup

Cooling rate, solidification duration, and process temperature all influence the microstructure of titanium alloy generated by WAAM. Because of the quicker solidification time, GTAW-based WAAM exhibits columnar prior and Widmanstatten α / β grains. Heat treatment at 600°C for 4 hours or 834°C for 2 hours improves microstructure and results in advantageous lamellar structures. WAAM titanium alloys' tensile characteristics (YS and UTS) are lowered due to lamellae spacing and a high interpass temperature (200°C). On one occasion it had a UTS of 929 MPa, whereas other authors discovered an YS 803 UTS of 918 MPa. Heat treatment (600°C for 4 hours) increases the strength to 972 MPa. YS 861 MPa, UTS 937 MPa for others. Due to fast cooling, the GMAW-based WAAM titanium alloy microstructure exhibits epitaxial columnar development on walls, with the outer layer displaying fine α + β Widmanstatten and the inner layer exhibiting coarse colonies. The process produces small lamellar α + β and acicular α' martensitic grains. Because of the low temperature gradient, the lower wall edge features coarse grains. Heat treatment (900°C, 4 hours; 1200°C, 2 hours) changes the microstructure to a lamellar α + β mixture, which improves the characteristics. YS and UTS of 820 and 960 MPa, respectively was reported. Post-heat treatment (at 900°C for 4 hours), the UTS is reduced to 841 MPa. Because of the constant solidification and temperature gradient, CMT production of titanium alloys results in coarse-columnar grains. The top layer has martensitic and fine phase lamellae. The middle section shows phase growth, whereas the bottom shows lamellae from phase owing to cooling rate. Low cooling rate yields create a grain border before, while larger rate yields inside like a basket wave. Martensitic types are quite common. The fusion border displays coarse columnar from phase. Cooling produces α-lamella and α + β Widmanstatten colonies. Rolling after each layer deposition re-organises the coarse β-columnar structure, improving microstructure and mechanical characteristics. CMT titanium alloys have YS and UTS values of 958 and 1046 MPa, respectively. Post-heat treatment of produced components (710°C, 850°C, and 920°C) boosted yield strength but marginally lowered UTS due to grain rearrangement [15].

WAAM has various advantages, but it also has certain disadvantages, such as anisotropy, residual stresses, porosity, and distortion within the manufactured components [16]. The trade-off between benefits and negatives emphasises the need of carefully considering material qualities and component requirements when choosing the WAAM process.

3. Heat Treatment

In alloys like Ti-6Al-4V, heat treatment is essential for reducing residual manufacturing stresses, optimizing characteristics, and enhancing performance [17]. By lowering defects and somewhat increasing corrosion resistance, hot isostatic pressing (HIP) improves fatigue qualities and is advantageous for additive manufacturing [18]. By altering the width of the alpha lamellae, reducing residual stresses, and fostering uniform stress distribution, annealing helps to increase the ductility of WAAM components [19].

The heat treatment of Ti-6Al-4V involves solution treatment to convert secondary phases into alpha and beta phases, then quick cooling to preserve the microstructure. Precipitates are produced by aging between 535°C and 675°C for 2–8 hours, increasing strength and hardness [20]. Mechanical properties are tailored by optimizing precipitate volume and size. Materials become stronger as they age due to secondary phase precipitation. This happens in titanium alloys below 600 °C, generating Ti3Al (α2). Precipitation is influenced by oxygen content and aluminium concentration. Small initial clusters develop into a network that obstructs movement of dislocations, increasing strength. Fine precipitates increase hardness by pinning dislocations. For the desired mechanical qualities, α2's features are controlled by solution treatment, quenching, and aging [21]. According to research by Callegari *et al.* [22], martensitic morphology hinders α2 precipitation while globular phase morphology promotes it. Phase formation is impacted by thermal treatment of titanium and related alloys, including allotropic alterations. Through the dissolution of interstitial components, solution treatment homogenizes the microstructure, and quick quenching inhibits phase precipitation. Phase creation allows age hardening, which has a range of temperatures and times depending on the alloy and processing history, to strengthen [23]. The appropriate titanium alloy properties require careful tuning.

Table 1 [24]

Sl. No.	Heat Treatment	Condition	Microstructures	Mechanical Properties
1.	Solution Treatment	950-980°C for 1-2 hours	Homogeneous α+β microstructure	High strength and ductility
2.	Aging Treatment	450-500°C for 4-8 hours	Fine α precipitates in β matrix	High strength and hardness

3.	Stress Relief Annealing	550-650°C for 1-2 hours	Homogeneous α+β microstructure	Reduced residual stresses
4.	Annealing	700°C to β transus temperature for 1-2 hours	Fully annealed microstructure	Improved ductility and toughness
5.	Normalizing	Slightly above β transus temperature for 1-2 hours, followed by air cooling	Fine and uniform microstructure	Overall Improved mechanical properties
6.	Double Annealing	First annealing at slightly above β transus temperature, followed by second annealing at lower temperature	Fine α+β microstructure, followed by fully annealed microstructure	Improved ductility and toughness

4. Conclusion

The impact of different heat treatments on the microstructural features and mechanical qualities of additive produced Ti-6Al-4V alloy components has been investigated in this detailed research. Ti-6Al-4V, known for its high strength-to-weight ratio and corrosion resistance, has showed promise in a variety of applications. The study shows that different heat treatments have varying impacts on alloy properties. Annealing increases ductility and toughness while decreasing strength. Solution treatment produces a more homogeneous microstructure, which improves ductility and machinability. Mechanical qualities are strongly influenced by age. The need of optimising heat treatment settings in order to achieve the appropriate microstructure and mechanical properties is emphasized. It is vital to strike the proper balance between strength, toughness, and other critical characteristics. This study emphasizes the significance of additional research in the fields of additive manufacturing and heat treatment for Ti-6Al-4V components, which will contribute to a better knowledge of materials science and engineering applications.

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Chapter - 43
Advanced and Secured Voting System - AADHAR Authenticated

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Chapter - 43

Advanced and Secured Voting System - AADHAR Authenticated

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Abstract

Voting has always taken place under pressure, with many people doubting its sincerity, correctness, and usefulness. Our research seeks to solve this issue by proposing a workable and cost-effective alternative while also minimising personnel requirements and accelerating the procedure. In the traditional voting method, there is no way to verify that, for instance, 100 votes were cast by 100 distinct and legitimate people. But in this process, the voter must scan their biometrics as part of this process, and after the data from the AADHAAR database has been validated, the voter is allowed to cast their ballot, hence verifying the unique voters. According to the Election Commission of India, more than 60% of India's 94.5 crore voters have linked their Aadhaar numbers to their voter IDs as of January 2023. In total, 56,90,83,090 voters are linked to their Aadhaar.

Keywords: Aadhaar, voting, democracy, ballot.

1. Introduction

Voting is a crucial procedure in any democratic democracy, and the government spends a lot of money, human resources, and time to ensure it happen properly. Based on the data, it has been discovered that in many situations, the ballot is tampered with to allow numerous votes in a row. Typically, the Election Commission of India claims that in the existing EVM can record 3840 (now 2000), this when tampered can cause a severe threat to our democracy. Also, if this occurs, that section of the constituency must hold elections again within a few days. This can sometimes turn violent, resulting in fights just to get on the ballot. As a result, we propose an advanced and secure voting method in which the machine is engaged only after the voter validates his identity. With the evolution of technology, where every transaction in daily life is becoming safer, we require a more secure voting system. There are proposed digital voting methods such as online voting and mobile voting, however those technologies appear to be less practical and more expensive to execute. Our solution replaces the old voting mechanism with a security level that ensures biometric verification.

2. Materials & Methods

The project includes an Arduino Nano Board as the primary controller, which controls the entire system, as well as an IIC/I2C Serial Interface Adapter Module for the LCD display module, which uses the PCF8574T IC chip to convert I2C serial data to parallel data for the LCD display. Membrane Switch 4x4 Matrix Keypad for the password module and switching between system modes. The Bluetooth module HC-05 is utilised in the system's future applications to communicate authentication data from the mobile to the system. The LCD 16x2 liquid crystal display is used to display important information such as the current mode and overall vote result. Push buttons are employed for the system's vote input buttons, while LEDs are used to signal which candidate received the vote as well as power and machine status (enabled or not for voting). Connecting cables are used to connect the various hardware components required in the system for the hardware unit to work properly. The specific functions of the components are as follows:

2.1 Fingerprint Module R305

This is used to scan the biometrics of the voter and verify it with the AADHAAR database and then allow the voter to cast his vote. This ensures that a voter can cast only vote. For communicating with the fingerprint module with Arduino we use Adafruit_Fingerprint library, the RX and TX pin of the fingerprint module is connected with the digital input output pins 2 and 3 of the Arduino and Software-Serial library for RX-TX communication between them.

2.2 Arduino Nano

The ATmega328P-based Arduino Nano is a small and versatile microcontroller board. It has 14 digital I/O pins (6 of which can be used for PWM), 8 analogue I/O pins, and a clock speed of 16 MHz. It has enough capacity for programme code and data with 32KB of flash memory and 2KB of SRAM. The Nano has a USB interface for programming and communication, making it user-friendly and simple to use. It supports serial communication, I2C, and SPI protocols, allowing it to communicate with a wide range of sensors, actuators, and external devices. Because of its tiny size and low power consumption, it is appropriate for a wide range of tasks, from prototyping to embedded systems and IoT applications.

2.3 4x4 Matrix Keypad Membrane Switch

This is used to switch between different modes of the voting machine. It has four modes i.e., Display mode, Voting mode, Reset mode and Exit mode. We can also use this keypad module for setting-up passwords for switching between the modes. It is connected with 8 variable resistances of the values 80 Ω, 100 Ω, 150 Ω, 180 Ω, 330 Ω, 380 Ω, 540 Ω, 670 Ω and another resistor of value 590 Ω. It takes input as a matrix with four rows and four columns to the analog pin A1 of the Arduino. We use voltage divider rule for getting different input voltages on the A1 pin, on pressing each button of the keypad.

2.4 IIC/I2C Serial Interface Adapter Module

It makes use of the PCF8574T integrated circuit chip, which converts I2C serial data to parallel data for the LCD display. This interface module also makes it easier to connect an Arduino to a 162 Liquid Crystal display by requiring only four cables.

Components

Fig 1a: Components

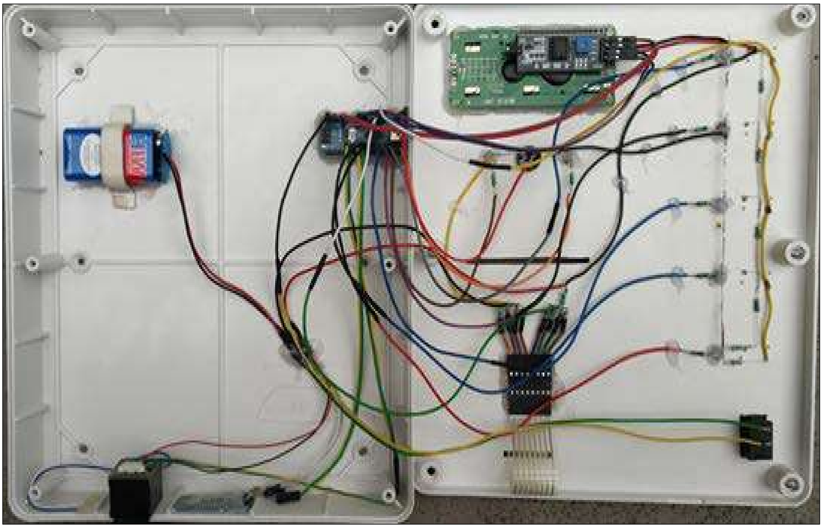
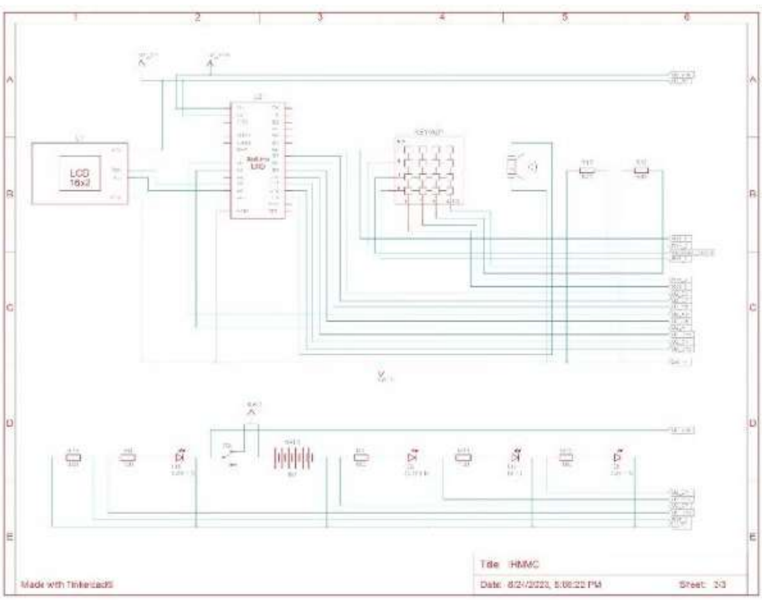


Fig 1b: Components

Circuit Diagram



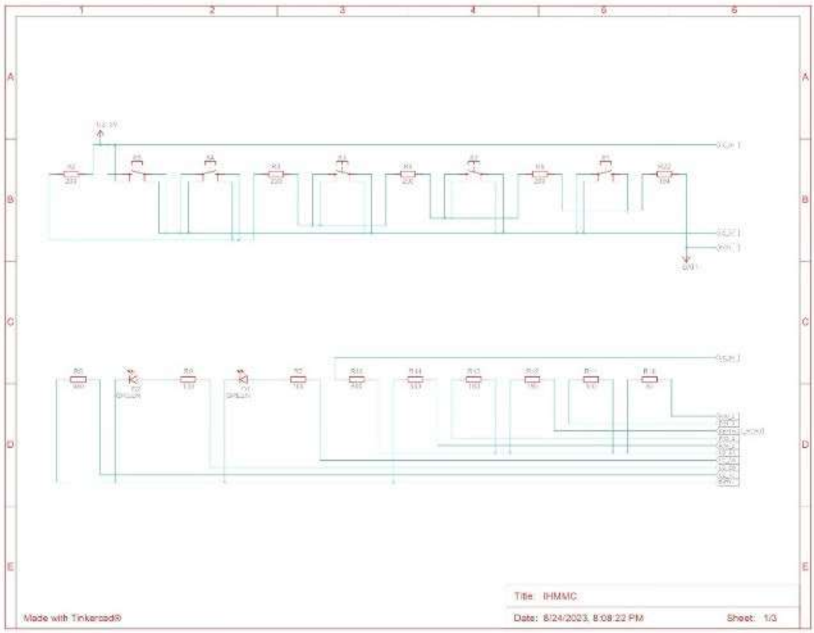


Fig 2: Circuit diagram

3. Conclusion

This project aims to alter the game in the voting system by making it the most trustworthy, affordable, secure, and convenient voting system available. This prototype comprises of a microcontroller that keeps the code and, for the time being, the votes, allowing us to acquire instant election results, making the process faster, smoother, and safer.

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Chapter - 44
Run Time Delay Between Originating and Destination Stations of Express Trains: A Pilot Study in Indian Railway

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Chapter - 44

Run Time Delay Between Originating and Destination Stations of Express Trains: A Pilot Study in Indian Railway

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Abstract

Railway is the constraint motion and one-dimensional type land transport system. Indian Railway is the socio-economical backbone of many countries, particularly India and wide spread over more than 128,305 km track length and running track length of 68,043 km. In maintaining this railway network there is a failsafe system that operate the movement of train safely and securely. To Travel from a particular station to a destination speed of the rolling stock is of prime importance. Low required speed may lead to delay, though delay may be unavoidable for some circumstances. In this paper a pilot study has been carried out to observe the delay of some trains with various priority levels in a particular route. This research highlights running time delay in a particular region between starting and destination stations, this may conclude the reason and or hints of solution of this problem related to the delay of trains.

Keywords: Indian railway, run time, delay, express train.

1. Introduction

Railway systems play a pivotal role across the globe in moving living items, particularly people and things from one location to another. As a result, railways hold a unique place in the cultural, social and economic [Hudoklin and Rozman, 1992] fabric of a country. It has been noted that a nation's ability to move goods efficiently influences its trade and commerce which can be used as a gauge of its social and economic development. Developing and constructing transportation, including roads, trains, rivers and airports in effective and efficient modes, is one of a nation's most crucial and significant goals. Among all modes of transportation, railways have proven to be in the greatest position to meet the continually rising demand for everyday public transportation. They are primarily utilized to transport big and bulky commodities over great distances safely [Saxena & Arora, 2005], affordably, and with the least amount of potential for bad environmental effects, and they are always seen as potential tools for boosting a country's economy [Sarkar et.al. 2010]. On 16th April, 1853 Indian Railway (IR) started its journey by rolling passenger trains over a range of 34 Km. which ran between Bombay and Thane. Since then, Indian Railway runs over 64600 km track length covering 7349 stations. Indian Railway has a total number of 13,169 passenger trains and 8479 freight trains which attend about 23 million passengers and 3 million tons of freight daily. Out of 64600 Km track length 58812 Km has been electrified [Sarkar et al, 2023].

There are several reasons why delay occurs, few of them are: disruptions in the operations flow, accidents, malfunctioning or damaged equipment, construction work, repair work, and severe weather conditions like snow and ice, floods, and landslides [Pradhan et al. 2021] Railways have a stricter order of line resources as compared to road and air transportation that any delay occurring in a scheduled train would affect several trains and cause of delays. The conflicts between various trains over network resources should be eliminated and ideally trains are supposed to run according to a nominal timetable without any ambiguity [Yang et al. 2019]. Another important reason that causes the delay of trains is due to the presence of a huge number of railway gates. Railway gates play a major role in safety mechanisms that prevent pedestrians and vehicles at the rail-road crossing when a train is approaching. Therefore, a gate needs to be closed before a train passes to ensure the safety of rolling stock and road users. The opening and gate closing may lead to delays in a train’s schedule which occurs due to traffic congestion where, especially in urban areas, railway crossings are situated on busy roads. This can cause significant congestion specifically during busiest hours leading to delays of both road users and train passengers. The delay might also be caused due to gate malfunction where a gate may either be stuck in the closed position or is not closing properly; this leads a train to slow down or stop until the problem is resolved.

Primarily rolling stocks are classified as Goods trains [Kulshrestha et.al. 2001] and passenger trains. Further in India trains are categorized into different types based on their speed and purpose. The Indian Railways, which operates one of the world's largest railway networks and serves the country having 1.5 billion population with different economic status, this in turn leads to classify the trains on the basis of their speed so as to reach the destination faster or not . Here are the main kinds of trains in India depending on speed as of most recent information updated in September 2022:

1) Superfast Trains: These trains are meant to travel longer distances in less amounts of time. They are speedier and make fewer stops than

conventional express trains. Trains such as the Rajdhani Express, Shatabdi Express, and Duronto Express are examples of Superfast Trains.

- Rajdhani Express: These are high-end long-distance trains that connect large cities. They are noted for their rapid speeds and short stopping distances. Rajdhani Express trains offer overnight service with amenities like air-conditioned carriages, luxurious berths, and onboard cuisine.
- Shatabdi Express: Shatabdi Express trains are luxury day-travel trains that connect major cities. They provide fast service, comfortable seats, and onboard catering. Air-conditioned and non-air-conditioned chair car coaches are common on Shatabdi Express trains.
- Duronto Express: Duronto Express trains run non-stop or with few stops between major cities. They are built to go great distances swiftly. They provide air-conditioned coaches as well as various levels of accommodation

2) Express Trains: In India, Express trains are one of the most prevalent types of trains. They link many cities and towns and make more stops than ultrafast trains. Express trains provide a variety of accommodations, including sleeper and general unreserved carriages.
3) Local Trains: Trains like this run within cities, linking suburbs and city cores. They are frequently used for commuting and short-distance trips [Express trains in India].

This paper focuses particularly on high-, medium-, and low-priority passenger trains. All priority trains in our pilot study, have been routed from Howrah to Delhi in order to avoid delays caused by weather fluctuations and variation in climatic conditions.

2. Data Collection

The data for this pilot study was gathered via the "Where is my train" application, a popular software for tracking real-time train movements, timetables, distance covered and other relevant information. The application offers users with up-to-date information about train arrivals, departures, delays, and itineraries. Given the application’s popularity and relevance to our study's focus on identifying trains based on speed, it served as a thorough supply of data.

We collected data for each selected train travel using the application’s search and tracking tools. This includes the departure and arrival stations of the train, as well as the scheduled and actual departure and arrival timings, as well as intermediate stops. For this study all priority trains have been chosen which are routed from Horah to New Delhi and Vice-Versa. (Fig.1) represents the intermediate stoppages that has been taken into consideration for this study along with their distances in kilometres with respect to the starting stoppage.

Dynamically, the application 'Where is my train' stores data for consecutive 90 days. In this study, the Rajdhani Express was selected as a high-priority train example, considering both its 'up' and 'down' directions. The relevant data, including scheduled and actual arrival as well as scheduled and actual departure times, was sourced from the 'Where is my train' application, sample of run time delay at respective stations is shown (Table 1). Subsequently, delays were calculated by subtracting the actual departure time from the scheduled departure time for each train journey. For the study, any train arriving after a time period of one-minute within the Indian railway system is considered as undergoing a delay.

Fig 1: Intermediate stoppage representation as shown in "Where is my train" application

Table 1: Run time delay status at various stations, sample for HWH-NDLH Rajdhani Express (12301)

DAYS	Hwh	Asn	Dhn	Pnme	Gaya	Ddu	Pryj	Cnb	NDlh
1	0	3	4	5	3	0	7	0	0
2	0	3	0	2	0	0	31	24	0
3	0	0	0	3	0	0	4	0	12
4	0	0	0	3	3	0	4	0	12
5	0	0	2	7	3	0	14	0	2
6	0	0	0	15	0	0	34	33	16
7	0	0	2	3	27	27	48	32	57
8	0	0	2	9	0	0	23	4	0
9	0	0	2	3	3	0	18	0	8
10	0	0	2	2	0	0	9	0	0

11	0	0	2	2	0	0	9	0	0
12	0	16	6	12	4	5	74	56	79
13	0	11	2	3	6	0	24	3	0
14	0	10	0	5	7	0	7	0	3
15	0	18	13	16	2	0	19	7	0

3. Result and Discussions

Figure 2 represents that the train undergoes the maximum delay at Prayagraj junction almost every day which is located at a distance of 814 kms from its starting station that is Howrah Junction which is around 3 a.m. in the morning. In this graph the trend in delay patterns are displayed at different stoppages taking the source stoppage as Howrah junction and the destination as New Delhi Junction. There might be some exceptional uncontrollable situations due to which day 7 and 12 has experienced an anomaly in the delay therefore they are considered as outliers here.

Figure 3 represents that the train undergoes the maximum delay at Pt. DD Upadhyay junction almost every day which is located at a distance of 787 kms from its starting station that is New Delhi Junction which is around 2 a.m. in the morning. In this graph the trend in delay patterns are displayed at different stoppages taking the source stoppage as New Delhi junction and the destination as Howrah Junction. There might be some exceptional uncontrollable situations due to which day 4 has experienced an anomaly in the delay therefore it is considered as an outliers here.

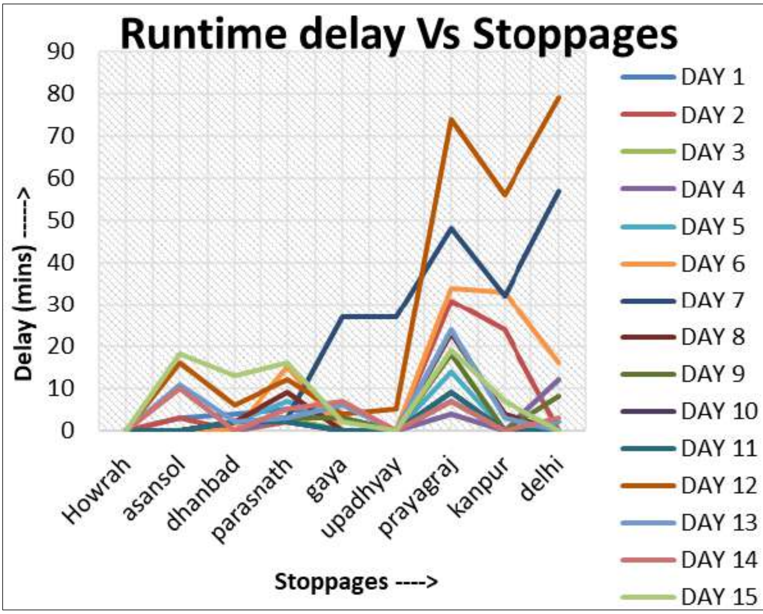

Fig 2: Runtime delay at different station for 12301

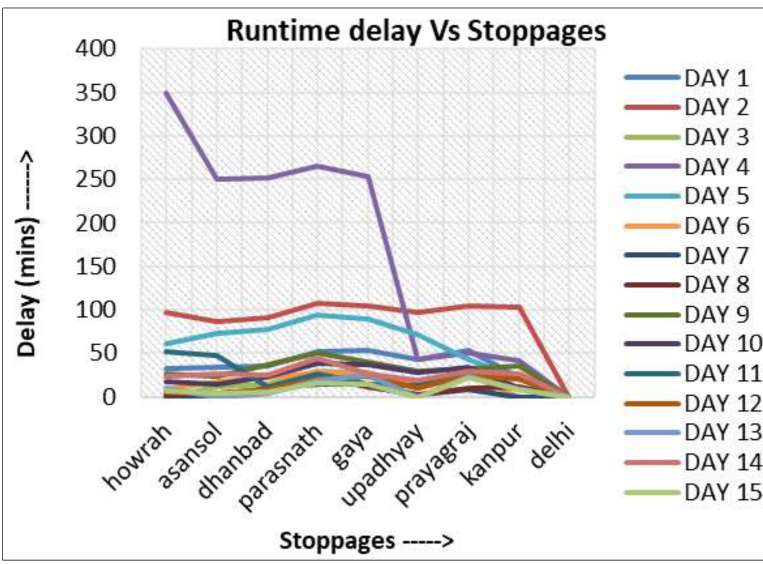

Fig 3: Runtime delay at different station for 12302

Figure 4 represents that the train undergoes the maximum delay at Prayagraj junction almost every day which is located at a distance of 814 kms from its starting station that is Howrah Junction which is around 10 p.m. at night. In this graph the trend in delay patterns are displayed at different stoppages taking the source stoppage as Howrah junction and the destination as New Delhi Junction. There might be some exceptional uncontrollable situations due to which day 8 and 13 has experienced an anomaly in the delay therefore they are considered as outliers here.

Figure 5 represents that the train undergoes the maximum delay at Barh junction almost every day which is located at a distance of 1064 kms from its starting station that is New Delhi Junction which is around 8 a.m. in the morning. In this graph the trend in delay patterns are displayed at different stoppages taking the source stoppage as New Delhi junction and the destination as Howrah Junction. There might be some exceptional uncontrollable situations due to which day 15 has experienced an anomaly in the delay therefore it is considered as an outliers here.

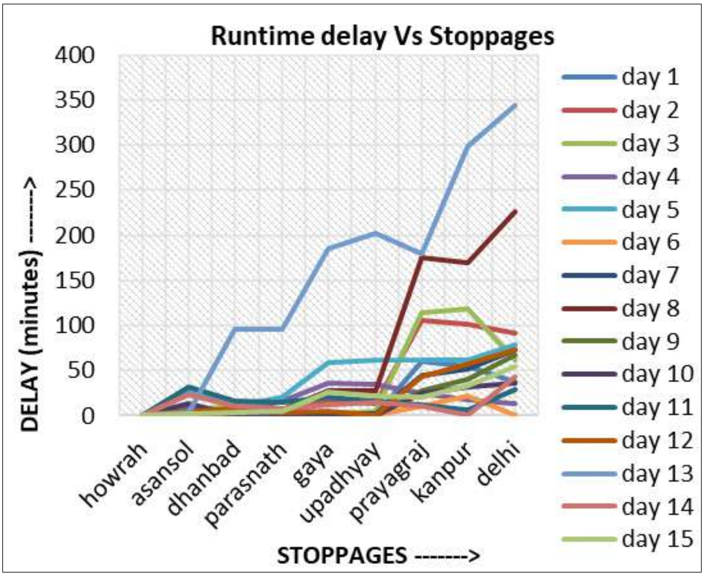

Fig 4: Runtime delay at different station for 12381

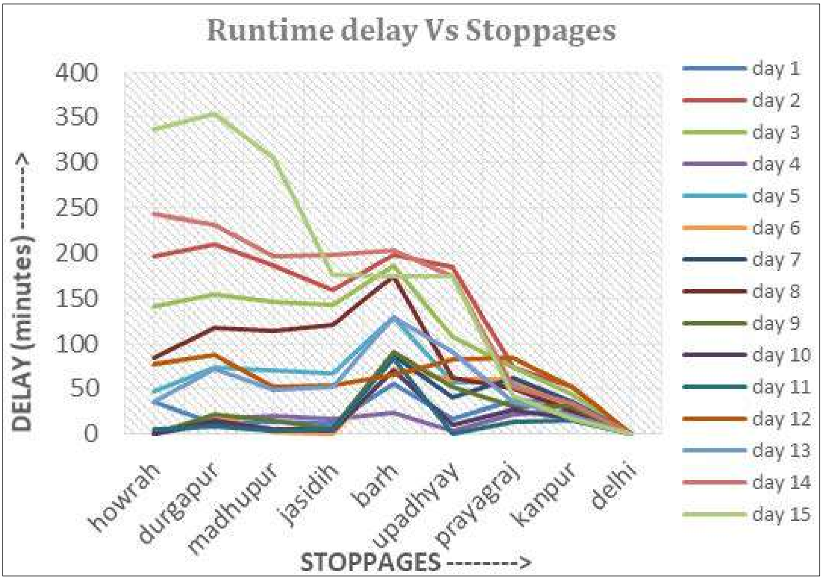

Fig 5: Runtime delay at different station for 12304

Figure 6 represents that the train undergoes the maximum delay at Phapund junction almost every day which is located at a distance of 1094 kms from its starting station that is Howrah Junction which is around 3a.m. at night. In this graph the trend in delay patterns are displayed at different stoppages taking the source stoppage as Howrah junction and the destination as New Delhi Junction. There might be some exceptional uncontrollable situations due to which day 8 and 13 has experienced an anomaly in the delay therefore they are considered as outliers here.

Figure 7 represents that the train undergoes the maximum delay at Phapund junction almost every day which is located at a distance of 352 kms from its starting station that is New Delhi Junction which is around 12 noon. in the morning. In this graph the trend in delay patterns are displayed at different stoppages taking the source stoppage as New Delhi junction and the destination as Howrah Junction. There might be some exceptional uncontrollable situations due to which day 2 and 15 has experienced an anomaly in the delay therefore they are considered as outliers here.

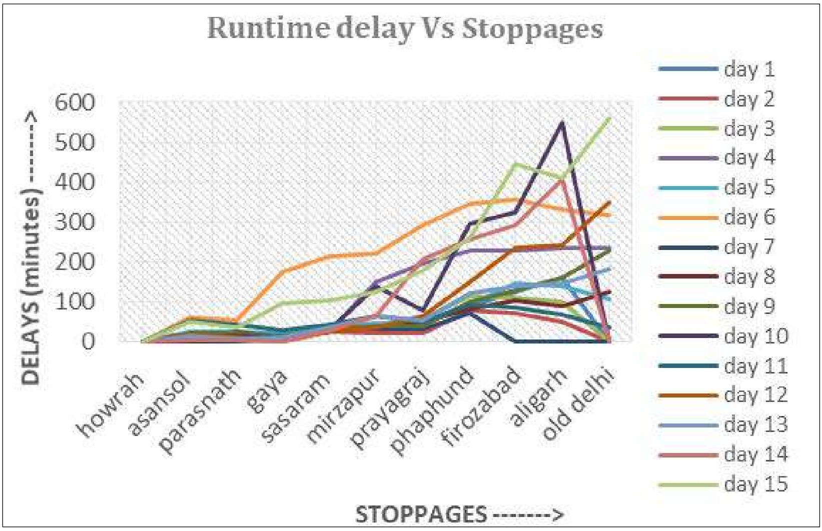

Fig 6: Runtime delay at different station for 12311

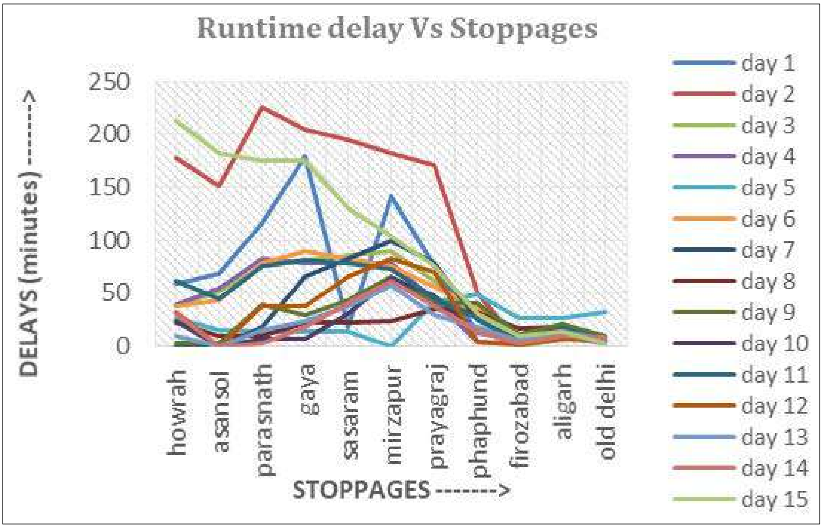

Fig 7: Runtime delay at different station for 12312

The current pilot study examined railway trip data derived from the commonly used "Where is my train" application. This program is well-known for tracking train movements, timetables, distances travelled, and other vital information in real time. The application's popularity and connection with our study emphasis on speed-based train recognition gave a vast dataset as an excellent source of information for our study.

4. Conclusion

The findings of this research highlight the importance of the "Where is my train" application as a repository of real-time rail travel data. We were able to get useful insights into the mechanics of train scheduling and punctuality inside the Indian railway system by focusing on the Rajdhani Express, Poorva Express and Netaji Express on its 'up' and 'down' travels. Our delay study provided insight on the efficiency of train operations by demonstrating the magnitude of deviations from anticipated timetables. This data can help improve both operational efficiency and the passenger experience as a regular delay of a train after a journey of 700 to 800 kms on an increasing pattern is observed. Delays, while unavoidable to some extent, can be handled by railway officials to reduce their impact. However, it is critical to recognize that the breadth of this study is limited because it relied solely on a single application's information and focused on a specific train route. Future study might include a greater selection of trains and itineraries, as well as numerous data sources, to provide a more thorough insight. Finally, the outcomes of this pilot study lay the groundwork for future research into railway travel dynamics. The "Where is my train" application is a great resource, and the study of delays brings up opportunities for operational and service improvements in the Indian railway system. Subsequent research efforts might build on these findings to provide a comprehensive view of railway punctuality and its numerous effects.

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Chapter - 45
Retinal Image Quality Enhancement using Denoising by Filtering

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Chapter - 45

Retinal Image Quality Enhancement using Denoising by Filtering

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Abstract

In this work we plan/implement one image enhancement method by de-noising of retinal related images. The quality of that images mainly affected by various noises/interferences and it can be filtered out and de-noised by proposed structures. This work helps to improve signal to noise ratio in its calculated value. Also, proposed filter had taken for the relative study. The metrics are used to compare the quality of the retinal image for further image processing. In all areas image improvement/enhancement methods doing best analysis to distinguish the diseases. In digital image processing is a area that totally dependent on available datasets. In medical area doctors used retinal images for diagnosis of disease purpose. So these images need to have visual improvement prior to apply a analysis for disease damage detection. Filters results shows the nature of this improvement in a better way.

Keywords: SNR, PSNR, mean SE, filters.

1. Introduction

In image processing areas variation de-noising, also known as total variation regularization or total variation filtering, is a noise removal process (filter). It is defined on the method/rule that image signals with noise, that is, the integral of the absolute image value or magnitude is high. According to this rule, reducing the total noise of the image signals—subject to it being a close match to the actual signal—removes unwanted noise details whilst keeping other important details such as noises permanent. Noise reduction or de-noising is the method of removing noise from an image signal. Noise reduction methods exist for different images. De-noising/Noise reduction processes may change the image signal to some extent. Noise rejection is the ability of a network to isolate an undesired signal component from the desired signal component, as with common-mode rejection ratio.

All signal processing methods, both analog and digital image signals, have variance that makes them acceptable to noise. Noise is always random with an even frequency distribution (white noise), or frequency-dependent noise introduced by some mechanism or signal processing methods.

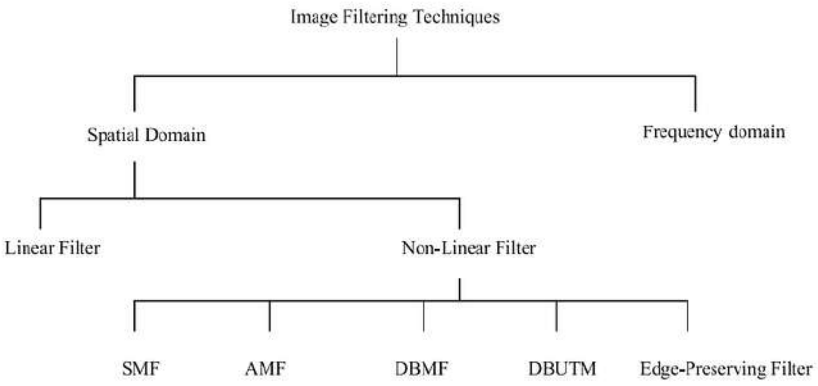
In latest systems, a major type of noise is created by random electron motion due to thermal agitation. These excited electrons very rapidly adjust from the output signal and thus create sufficient noise.

2. Review of Literature

Previously it was introduced a method to filter out of noises in the different images. It shows the real nature for removing unwanted noise called denoising in its technical terms.

This paper focuses to develop a method for identifying the different metrics of retinal images also. These captured images are stored.

3. Types of Existing Filters and its Classifications



a) Sobel filter
b) Winner filter
c) Mean filter
d) Median Filter
e) Average filter
f) Gaussian filter

4. Proposed Flowchart/Algorithm

The proposed method follows the following steps for image quality enhancement. The Figure 1 shows the proposed method:

The fundamental steps of Image Processing are as follows:

1. Image Acquisition

2. Image Enhancement
3. Image Restoration
4. Color Image Processing
5. Wavelets and Multi-Resolution Processing
6. Image Compression
7. Morphological Processing
8. Image Segmentation
9. Representation and Description
10. Object Detection and Recognition
11. Knowledge Base

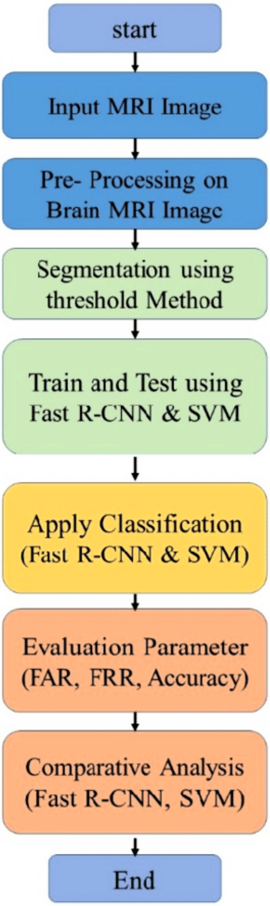
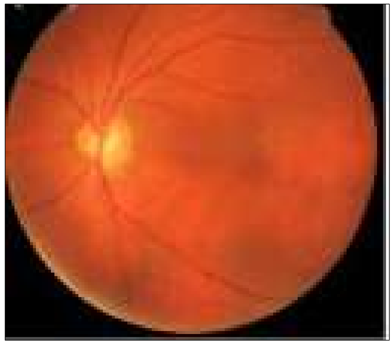


Fig 1: Proposed Method

5. Discussion on Results



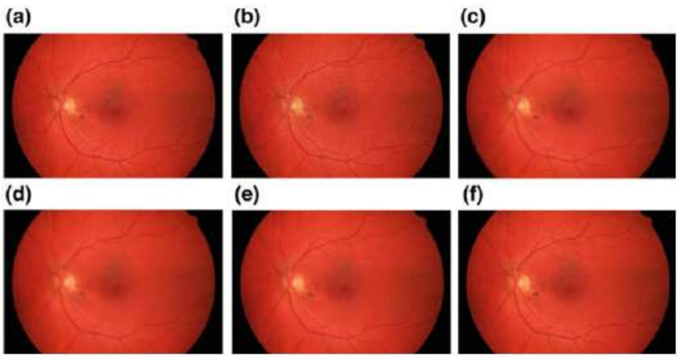


Fig 2: Retinal Image Figure 3. Image De-noised after the process of de-noising

The analysis of proposed method is tested for different retinal images. From the literature survey it does not suitable to eradicate noise. The results show that the defined method removes all types' noise and save the image as per the defined methods. The metric values are calculated and evaluated with the following images. Here, the experimental results are shown for different retinal images in figures. The figure 2 shows the output de-noised images.

Table 1: Image Analysis Retinal Images

S. No.	SNR (Signal to Noise Ratio)	PSNR (Peak signal to Noise Ratio)
1.	7.83	32.98
2.	7.91	32.79
3.	7.56	32.7
4.	7.44	32.58
5.	7.08	32.22
6.	7.12	32.01
7.	7.23	31.98
8.	7.02	31.76

9.	7.24	3.45
10.	7.14	31.25
11.	7.2	31.03
12.	7.78	30.86
13.	7.52	30.7
14.	7.27	30.44
15.	7.04	30.22

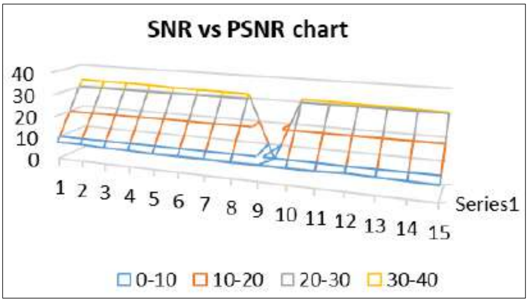


Fig 4: Comparative Graph between PSNR (Peak signal to Noise Ratio) and SNR (Signal to Noise Ratio

6. Conclusion

In this work discussed and defines the method of de-noising and its disadvantages. In this work we plan/implement one image enhancement method by de-noising of retinal related images. The quality of that images mainly affected by various noises/interferences and it can be filtered out and de-noised by proposed structures. This work helps to improve signal to noise ratio in its calculated value. Also, proposed filter had taken for the relative study. The metrics are used to compare the quality of the retinal image for further image processing.

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Chapter - 46
Study of Dimensional Deviation of a PLA Material 3D Printed Square Socket Bar and Socket Assembly using FDM Method

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Chapter - 46

Study of Dimensional Deviation of a PLA Material 3D Printed Square Socket Bar and Socket Assembly using FDM Method

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Abstract

3D printing is becoming more popular nowadays since material wastage is either nil or very negligible. Previously conventional manufacturing technology was used widely, however it consists of lots of material wastage during preparation. Fused deposition modeling (FDM) is a additive manufacturing technique which consists of extrusion of semi liquid polymer material and deposit it in the build platform in the layer by layer manner. Polylactic acid (PLA) is a bioplastic is increased its popularity day by day as FDM method of 3D printing. The objective of the current study is to investigate the dimension accuracy of FDM 3D printed square bar and socket assembly and also it investigate the shrinkage allowance of PLA material under varying condition of printing e.g. raster angle, layer thickness and infill percentage.

Keywords: 3D printing, PLA, square bar & socket assembly.

1. Introduction

Additive manufacturing (AM) technology becoming more popular currently since it can create products with complex, customized and even assembled geometries can be produced with more economical way. Fused Deposition Modelling (FDM) is one the most widely accepted additive manufacturing due to its low cost and versatility. Although FDM process is a slow process and poor surface quality as compared to other AM processes. The quality of the parts depends on several factors. Even though FDM technology increases popularity for manufacturing functional models, prototypes or components in thermoplastic materials having mechanical, thermal and chemical properties. Thermoplastic polymer filament is heated to a temperature close to the point of fusion in FDM technology. the semi molten filament passing through single or multi extruder nozzle and deposit the material in layers on X – Y plane. The layers may vary in thickness along the axis perpendicular to the worktable (Z-axis). Most frequently used thermoplastic materials such as ploythene, plypropylene, polybutadyne, polystyrene, polyvinyl chloride, ABS, ABS-plus, polyamide and PLA. Thermoplastic materials have excellent mechanical, thermal and chemical properties. Thermoplastic materials are more acceptable to industrial applications as it can be easily manageable in pre-fusion phase at low temperature and gradually harden as they cool down at glass transition temperature and finally retained their initial properties. Poly-Lactic Acid (PLA) is one of the most used materials in FDM technology. Manufacturer of commercial 3D printers provide information about to adjust their printer setting, such as layer thickness, density, extrusion speed, nozzle temperature and others. But the quality of the product is not widely discussed by the manufacturers. Little information is available about some other features also, they are repeatability of positioning the extruder, dimensional and geometric precision, surface texture, dimensional and geometric tolerances, surface finish, correct printer setup, functioning and manufacture of prototype. The new possibilities of the manufacturing stage involves new opportunities on the design phase. Additive manufacturing allow more exploring new possibilities. As there are more possibilities, more importance will be in optimization process.

2. Materials & Methods

2.1 Workpiece Preparation, 3D Printer, and Printing Material

In this research, 3Dmodel of socket bar Assembly was created as it can been seen in Figure 2(a). The nominal dimensions can be also found in the same figure. This model was designed in AutoCAD 2013 software (AUTODESK Inc, San Rafael CA, US) and it was extracted in STL format then the STL file was sliced and converted to G-Code with the use of the open source software “UltimakerCura”. Commercially available “CrealityEnder-5 Pro” 3D printer was used for the printing of the two sets of dovetail assembly. A cubic structure is possessed by the Ender-5 Pro, and it is designed with a dual Y-axis, a silent motherboard to avoid noise, and a removable platform to enable uninterrupted printing of 100% filament feed in-out.Some technical specifications of the 3D printer are as follows.

- Build volume: 220 x 220 x 300 mm
- Minimum layer height: 100 microns
- Nozzle size: 0.4 mm

- Nozzle quantity: 1
- Maximum nozzle temperature: 260℃
- Hot bed temperature: 135℃
- PLA can be printed between 40-80 mm/sec

PLA material was the used for printing the material as it has

2.2 Preparing Figures, and Tables

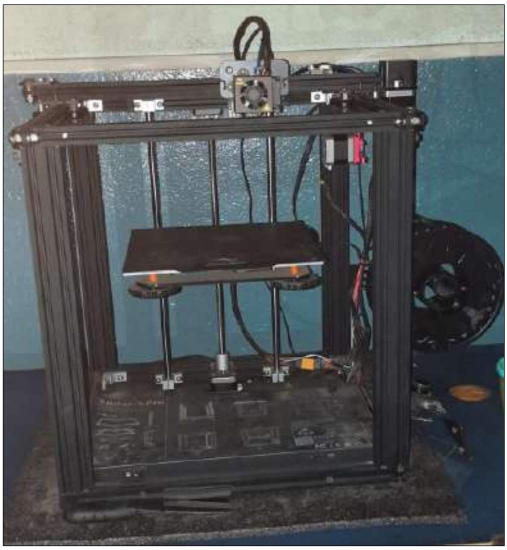
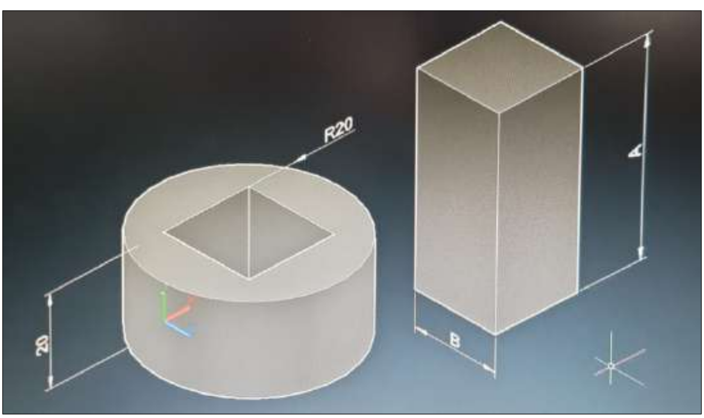
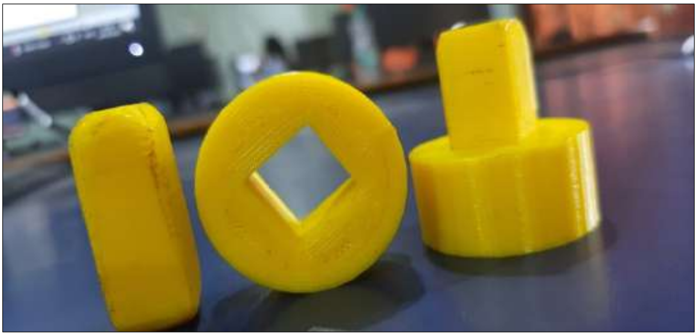


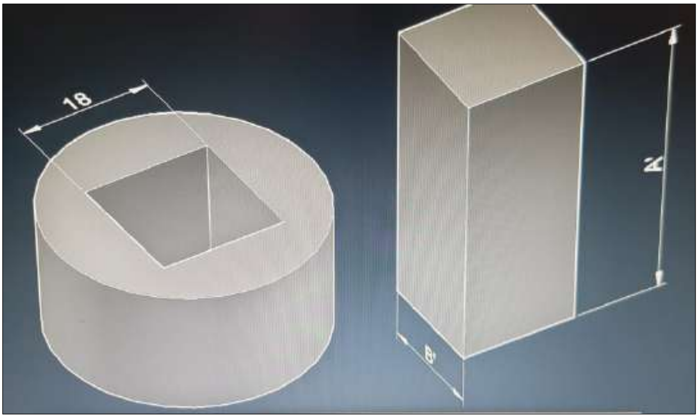
Fig 1: Ender 5 Pro (3D Printer)



(a)



(b)



(c)

Fig 2: a) 3D CAD model of Square bar and Socket assembly, b) assembled and unassembled part of Square bar and Socket assembly

Dimensions of the fabricated samples were measured by Vernier Caliper and the measurement of the fabricated square bar & socket assembly is. Given in Table1 and Table 2. All sides of fabricated model were assigned an alphabet and measured using a Vernier caliper.

Table 1: Measurement of Model

Side	Nominal	Reading 1	Reading 2	Reading 3	Average Reading
A	33.75	41.08	41.24	41.20	41.17
B	13.5	16.10	16.40	16.40	16.3
Circle Thick.	15	15.80	16.08	15.72	15.86
Square Thickness	14.475	16.06	16.06	16.06	16.06

Table 2: Measurement of Model

Side	Nominal	Reading 1	Reading 2	Reading 3	Average Reading
A’	33.75	38.60	38.50	38.52	38.54
B’	13.5	15.60	15.02	14.70	15.10
Circle Thickness	15	19.60	19.60	19.50	19.56
Square Thick	13.5	15.10	15.04	16.18	15.44

3. Results & Discussions

In this experiment, a 3D printed square socket bar fabricated and socket assembly using PLA material in the 3D Printer and studied its dimensional variation in the AutoCAD software. The main objective of this experiment was to study the dimensional variation and determine the shrinkage allowance to achieve better dimensional accuracy. The experiment was conducted by using the Creality Ender 5 Pro FDM 3D Printer machine with PLA (Polylactic acid) filament material. The dimensions of the printed square bar and square socket assembly were measured by using a vernier caliper. The measured dimensions of actual components were compared with the designed dimension which was developed in the AutoCAD software to determine the dimensional variation.

The results showed that the 3D printed square socket bar and socket assembly had some a dimensional variation from the designed dimensions. This indicates that the 3D Printed Square Bar and square socket assembly can achieve good dimensional accuracy for assembly purpose. The dimensional variation can be attributed to the shrinkage of the PLA material during cooling after printing. In conclusion, this experiment demonstrated that 3D Printing technology can be used to fabricate Square Bar and socket assembly with good dimensional accuracy using PLA material. However, it is important to consider the shrinkage of the material during cooling after printing when designing the parts for 3D Printing.

4. Conclusions

It was observed that the dimensional variation causes due to shrinkage of FDM printed material. The shrinkage calculated for both the model i.e. model 1 and model 2, also for both shaft and hole. For model 1 shaft shrinkage in volume observed for shaft is 43.76% and same for the hole determined as 23.17%. Similarly for model 2 the shrinkage percentage for shaft and hole determined as 40% & 33% respectively. This high percentage of deviataion caused may be due to error in designed and printed dimension. In future scope of study the dimensional variation will be thoroughly checked and possibly will reduce.

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Chapter - 47
Experimental Investigation of 3D printed Dove Tail Assembly using PLA Material

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Chapter - 47

Experimental Investigation of 3D Printed Dove Tail Assembly using PLA Material

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Abstract

3D printing is a versatile technology that can create complex and customized shapes with minimal material waste. However, 3D printing also poses some challenges, such as the accuracy, strength, and durability of the printed parts. To check the dimensional accuracy of the printed part dovetail joint has been selected for assembly purpose. Dovetails are geometrically constrained connections that provide high strength and stability without the need for additional fasteners. In this study, the performance of 3D printed ploylactic acid (PLA) material dovetail assembly investigated. PLA being a biodegradable and eco-friendly polymer derived from plant starch was considered to be the material for 3D printing. The dovetail model was developed in AutoCAD software and printed through fused deposition modeling (FDM) printer for different types of dovetail joints. Post printing and assembly different dimensions were measured. Also, the effects of printing parameters, such as layer height, infill density, and print orientation, on the quality and accuracy of the printed parts studied. The results showed that 3D printed dovetail joints using PLA material can achieve good dimensional accuracy. The results also suggested some optimal printing parameter settings and design guidelines for improving the performance of 3D printed dovetail assemblies. This study demonstrates the potential of 3D printing for creating complex and functional structures using interlocking joints and PLA material.

Keywords: 3D Printing, PLA, dovetail joint, assembly.

1. Introduction

The Additive Manufacturing (AM) process known as Fused Deposition Modelling (FDM), often referred to as Fused Filament Fabrication (FFF), Modelling Extrusion (ME), Fused Layer Manufacturing (FLM), or 3D printing, is based on extrusion, with the material being "selectively dispensed through a nozzle or orifice" [1].In these procedures, single or multiple extruders heat polymer filaments nearly to their fusion temperature in order to deposit material in the shape of layers [2].PLA filament was used to manufacture the experiment samples. The study focuses primarily on the usage of PLA material in 3D printed dovetail assemblies as it explores the functionality and properties of these assemblies. A biodegradable and environmentally beneficial polymer made from plant starch is called PLA, or polylactic acid. The study carried out a thorough investigation into the performance and dimensional accuracy of PLA-based 3D printed dovetail joints. The findings demonstrated the excellent dimensional accuracy that these couplings may attain, showing the capability of 3D printing technology to produce complex and useful structures out of eco-friendly materials. The study also offered helpful information on the best printing parameter choices and design principles that can improve the performance of these assemblies. In addition to providing a greener option, the usage of PLA material demonstrates the adaptability and diversity of 3D printing technology. This study shows how 3D printing technology may be used to build intricate, useful buildings out of sustainable materials and interlocking joints. In addition to providing a greener option, the usage of PLA material demonstrates the adaptability and diversity of 3D printing technology. The results of this research have important ramifications for many other areas, including engineering, design, and manufacturing. This study fits into a larger environment that emphasises the demand for eco-friendly materials as well as the rising interest in sustainable production techniques. With PLA as a feasible replacement for conventional polymers, there are now more opportunities to lessen the environmental impact of additive manufacturing procedures. The effective use of interlocking joints in 3D printed structures also emphasises the possibility for producing intricate and useful items without the use of additional fasteners or glue. The FDM printing factors that have a major impact on the quality of FDM produced items were examined by Mohamed *et al.* [3]. Layer thickness was shown to be the key factor influencing surface roughness. Therefore, a thinner layer and a hotter model result in a finer surface finish (lower surface roughness values). Layer thickness and air gap were once more key considerations for dimensional accuracy. The tensile strength, dimension accuracy, and surface roughness of FDM-fabricated parts were examined by Wang *et al.* [4] in relation to the effects of six process factors (layer thickness, deposition angle, support style, deposition orientation in Z direction, deposition orientation in X direction, and build location). The effects of three process parameters (layer thickness, road width) were examined by Anitha *et al.* [5].

2. Materials & Methods

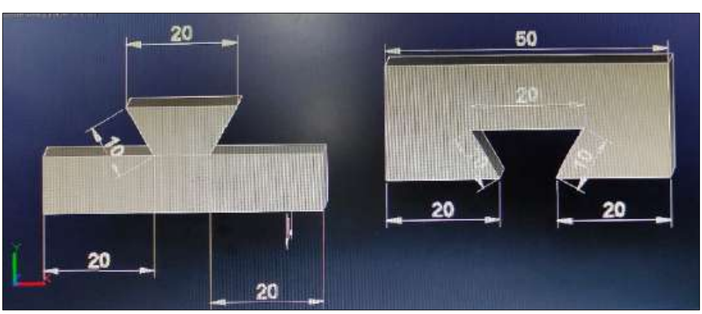
2.1 Workpiece Preparation, 3D Printer, and Printing Material

In this research, 3D model of Dovetail Assembly was created as it can been seen in Figure 2(a). The part's nominal dimensions can be also found in the same figure. This model was designed in AutoCAD 2013 software (AUTODESK Inc., San Rafael CA, US) and it was extracted in STL format then the STL file was sliced and converted to G-Code with the use of the open source software "Ultimaker Cura". Commercially available "Creality Ender-5 Pro" 3D printer was used for the printing of the two sets of dovetail assembly. A cubic structure is possessed by the Ender-5 Pro, and it is designed with a dual Y-axis, a silent motherboard to avoid noise, and a removable platform to enable uninterrupted printing of 100% filament feed in-out. Some technical specifications of the 3D printer are [6].

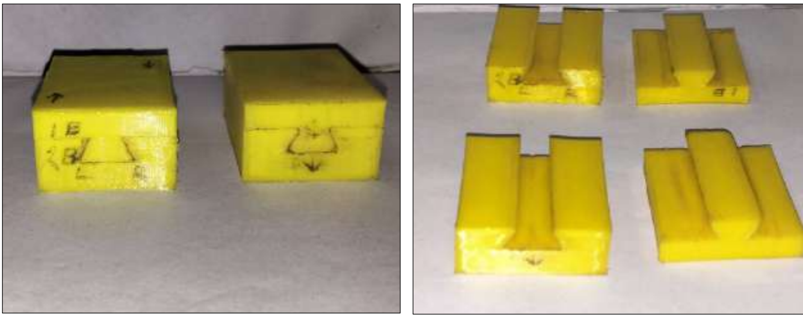
- Build volume: 220 x 220 x 300 mm
- Minimum layer height: 100 microns
- Nozzle size: 0.4 mm
- Nozzle quantity: 1
- Maximum nozzle temperature: 260℃
- Hot bed temperature: 135℃
- PLA can be printed between 40-80 mm/sec
- PLA material was the used for printing the material as it has

2.2 Preparing Figures, and Tables

Dimensions of the fabricated samples were measured by Vernier Caliper and the measurement of the fabricated dovetail assembly is given in Table1 and Table 2. sides of fabricated model were assigned an alphabet as shown in Fig.2 and measured using a Vernier caliper (150x0.02mm)

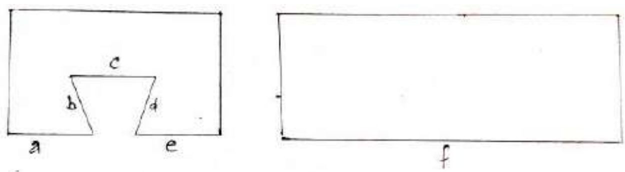


(a)

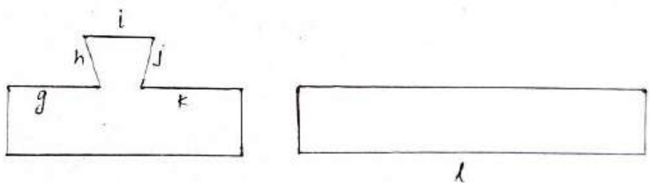


(b) **(c)**

Fig 1: a) 3D CAD model of the Dovetail Assembly, b) assembled part of Dovetail model, c) unassembled part of dovetail model



(a)



(b)

Fig. 2: a) hole assembly, b) shaft assembly

Table 1: Measurement of Model 1

Side	Nominal	Reading 1	Reading 2	Reading 3	Average Reading
1.	14.812	14.32	14.26	14.52	14.366
2.	7.312	h1=7.08	h2=7.2	h3=7.12	7.484
3.	15.187	15.2	15.16	15.8	15.386
4.	7.3125	h1=7.08	h2=7.2	h3=7.12	7.394
5.	14.812	14.44	14.2	14.64	14.426
6.	45	45.8	45.7	46	45.833
7.	15	14.5	14.42	14.4	14.44
8.	7.5	h1=6.64	h2=6.66	h3=6.82	7.73
9.	15	14.22	14.2	14.3	14.24

10.	7.5	h1=6.8	h2=6.7	h3=6.76	7.77
11.	15	15	14.46	14.64	14.7
12.	45	44.62	44.6	44.7	44.64

Table 2: Measurement of Model 2

Side	Nominal	Reading 1	Reading 2	Reading 3	Average Reading
1.	15	14.5	14.46	14.7	14.553
2.	7.5	h1=6.86	h2=6.8	h3=6.7	7.836
3.	15	13.68	13.07	13.34	13.363
4.	7.5	h1=6.86	h2=6.8	h3=6.78	7.866
5.	15	14.06	14.52	14.42	14.333
6.	45	44.9	45.08	45.1	45.027
7.	15	14.19	14.01	14.2	14.133
8.	7.5	h1=6.48	h2=6.72	h3=6.7	7.659
9.	15	13.34	13.64	13.72	13.567
10.	7.5	h1=6.6	h2=6.68	h3=6.66	7.674
11.	15	14.6	14.34	14.58	14.507
12.	45	45.04	45	45.24	45.093

3. Results and Discussion

3.1 Results

The results showed that the 3D printed dovetail assembly had a dimensional variation from the designed dimensions. The experiment aimed to investigate the shrinkage in shaft and hole assemblies of two different models fabricated through Fused Deposition Modelling (FDM) process. The results showed that the shrinkage in the first model was relatively minimal, with a shrinkage of -3.89% in the shaft and 2.029% in the hole assembly. Conversely, the second model experienced a significantly higher level of shrinkage, with a shrinkage of 20.04% in the shaft and 14.46% in the hole assembly.

3.1 Discussions

In this experiment, we fabricated a 3D printed dovetail assembly using PLA material and studied its dimensional variation. The purpose of this experiment was to investigate the dimensional accuracy of the 3D printed dovetail assembly. The experiment was conducted using a 3D printer machine that uses PLA material. The dimensions of the dovetail assembly were measured using a Vernier caliper. The measured dimensions were compared with the designed dimensions to determine the dimensional variation.

The difference in the amount of shrinkage observed between the two models can be attributed to multiple factors, including material selection, environmental conditions, and printing parameters. The study's findings indicate that the FDM process may not be suitable for producing precise parts that require tight tolerances, primarily if material properties and printing conditions are not carefully controlled. Thus, thorough understanding and optimization of the FDM process parameters are crucial to achieving accurate prints.

The findings of study support previous research on the topic, indicating that accurate prints are difficult to achieve without optimizing print parameters. The FDM process may not be appropriate for producing precise parts that require tight tolerances.

4. Conclusions

In conclusion, this experiment demonstrated that 3D printing technology can be used to fabricate dovetail assemblies with good dimensional accuracy using PLA material. However, it is important to consider the shrinkage of the material during cooling after printing when designing parts for 3D printing.

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Chapter - 48
Experimental Study of Material Removal Rate and Tool Wear Rate during Dry-EDM and Die-Sinking EDM of MS Plate and Inconel-825 using Brass Tool

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Chapter - 48

Experimental Study of Material Removal Rate and Tool Wear Rate during Dry-EDM and Die-Sinking EDM of MS Plate and Inconel-825 using Brass Tool

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Abstract

Electro Discharge Machining (EDM) is widely applied unconventional machining process used to remove micro to macro-order material for very hard and conductive work piece. In this research, material removal rate (MRR) and tool wear rate (TWR) of MS (mild steel) plate in Dry-EDM and Die-sinking EDM using Brass tool at various current have been calculated. Further, material removal rate of Inconel-825 at different current in Die-sinking EDM have been experimented. Finally, a comparative study of MRR has been carried out. Experiment result depicts that with increase in current MRR and TWR increases in case of Die-sinking EDM for both MS and Inconel-825. But MRR decreases in case of Dry-EDM of MS plate. It is also witnessed that MRR and TWR are almost equal for MS plate and Inconel-825. This implies, mechanical property of job does not affect MRR and TWR in die-sinking EDM.

Keywords: Dry-EDM, Die-sinking EDM, MRR, TWR, mild steel, inconel-825.

1. Introduction

Electrically conductive but difficult to cut materials can be machined by a non-traditional machining process known as Electro Discharge Machining (EDM). The material is removed from the work piece by melting and vaporizing the chips formed. In EDM, no contact is observed between the work piece and the job, thus no cutting force is generated by using an easily machinable, electrically conductive [Yuan et.al. (2008), Pramanik et.al. (2016), Mouralova et.al. (2019)] softer material as the tool material. This is also known as the spark erosion process where the spark spot temperature can reach 10,000-12,000 °C [Ghosh & Mallik, 1985]. This controlled spark is maintained in die-sinking environment. If air is jet is applied between tool and work piece gap instead of dielectric fluid it is known as Dry-EDM. The commonly used dielectric fluids for die sinking EDM are kerosene [Chen et.al. (1999)], hydrocarbon oils such as spark2[Kane et.al, (2020)] and ipol, and deionized water . The frequently used tools are brass [Ramulu & Taya (1989)], zink and copper [Bhaumik & Maity (2018)].

Several works have been completed with the development of Dry- EDM and Die-sinking EDM processes to compare Material Removal Rate (MRR) and Tool Wear Rate (TWR) [Ho and Newman(2018)] using different types of electrodes. Dongre *et al.* (2023) performed EDM on SS316 using brass as the electrode material and used the Taguchi orthogonal matrix with three levels and three variables to analyze how various process variables affect the rate of material removal, tool wear, and surface roughness. Author found that the MRR drops and then improves with a pulse ON time. TWR increases linearly with increasing current and pulse ON time and reduces linearly with increasing pulse OFF time. Govindan *et al.* (2010) investigated dry-EDM drilling on SS304 using copper electrodes the trials were carried out in a 'quasi-explosion' mode, with the pulse 'off-time' controlled to maximize MRR. It was observed in the morphological study of the dry EDMed surfaces that it indicated the presence of micro-cracks generated by thermal stresses, spherical particle deposition, and trapped gas marks on the machined surface. Tripathy *et al.* (2021) have carried out experimental research on near-dry EDM on mild steel material by employing a copper tubular electrode. The machining responses were the material removal rate and tool wear rate. For both machining responses, ANOVA, regression analysis, and sensitivity analysis were performed. The ROVOP technique was used to optimize the process parameters. Mohanty *et al.* (2014) observed the effects of EDM process variables on Inconel 825 using a pure copper electrode. Using an L9 orthogonal array, peak current (Ip) has a substantial influence on MRR, surface roughness (SR), and radial overcut (ROC), while Tonne has an influence on surface crack density (SCD). Vidya *et al.* (2022) performed micro-holes and channels in EN-24 alloy steel with die-sinking EDM with short electronic pulses and CNC-controlled placement using copper electrode. Results are evaluated using optical microscopy, profile projection, SEM, and EDX analysis. Dikshit *et al.* (2019) developed an empirical mathematical model to investigate the effects of die-sinking electrical discharge machining (EDM) parameters on Inconel 625 using brass alloy electrode. On ANOVA analysis it was observed that the peak current was dominant for MRR and pulse on time for surface roughness.

From the above literature it has been found that least work has been done in comparing tool wear rate and material removal rate against same set of values of current for Inconel and Mild Steel. In this study, TWR and MRR are compared for both die sinking and dry EDM of two different job material i.e. Mild Steel and Inconel 825 using Brass as tool electrode.

2. Experimental Setup

The prepared sample was machined using "Electronica Vector" EDM machine. This machine is a die sinking EDM machine and dielectric fluid is Spark2 EDM oil, a special setup is made so as to work in dry-EDM using same die sinking EDM setup for this purpose a work holding platform is prepared so that a dielectric fluid cannot touch the work piece but it can flow over the sensor that finally dictates ON/OFF of the sparking, shown in [Fig. 1]. For the initiation of sparking in the machine, flow of di-electric fluid over the sensor is mandatory and in this situation if both the tool and the job is sinking in the fluid, it is known as die sinking EDM. Later, the level of the sensor is adjusted in such a way that the dielectric fluid will flow over the sensor but the job and tool will not be submerged in the die electric fluid. Hence dry EDM experiment is achieved. Further an external air jet flow is made to accelerate the particle generated from the spark gap. For the die sinking EDM condition, the dielectric fluid is made to flow above the spark gap between the electrodes.[Fig. 2] shows the setup for the sinker condition. The dielectric fluid used here is Spark2.

Fig 1: Dry- EDM arrangement

Fig 2: Die sinking EDM

3. Result and Discussion

Table 1. Shows TWR and MRR for Brass tool and Mild Steel Plate in a sinking condition at different current. T- ON =95 and T- OFF=5 is maintained throughout all the experiment, machining time-5 min.

Table 1: Die Sinking EDM of MS Plate using Brass Tool

Current (amp)	Initial Tool wt. (gm)	Final Tool wt. (gm)	TWR (gm/min)	Initial Job wt. (gm)	final Job wt. (gm)	MRR (gm/min)
5	58.67	58.6	0.01	133.133	133.064	0.009857
7	58.6	58.5	0.014286	133.064	132.96	0.014857
11	58.5	58.3	0.028571	132.96	132.84	0.017143
15	58.3	58.01	0.041429	132.84	132.71	0.018571

Table 2 represents TWR and MRR on Inconel 825 using brass electrode under same die sinking conditions, machining time-5 min.

Table 2: Die sinking EDM of Inconel 825 using Brass Tool

Current (amp)	Initial Tool wt. (gm)	Final Tool wt. (gm)	TWR (gm/min)	Initial Job wt. (gm)	final Job wt. (gm)	MRR (gm/min)
5	57.87	57.7937	0.00763	75.6347	75.4782	0.01565
7	57.7894	57.6666	0.01228	75.4782	75.285	0.01932
11	57.6528	57.4193	0.02335	75.285	75.1166	0.01684
15	57.4106	57.1068	0.037975	75.1166	74.973	0.01795

In table 3. Dry EDM is experiments done on MS plate where air jet is made to flow towards the spark gap. The same brass tool is used here and machining time-5 min.

Table 3: Dry EDM of MS plate using Brass Tool

Current (amp)	Initial Tool wt. (gm)	Final Tool wt. (gm)	TWR (gm/min)	Initial Job wt. (gm)	final Job wt. (gm)	MRR (gm/min)
5	38.2001	37.8958	0.06086	65.0997	65.0086	0.01822
7	37.8958	37.6352	0.05212	61.1698	61.1428	0.0054
11	38.2742	38.228	0.00924	62.2026	62.2015	0.00022
15	38.228	38.2001	0.00558	62.9938	62.9895	0.00086

The graphical plots are presented below to explain TWR and MRR for both the work piece materials using Brass tool at two different machining environments.

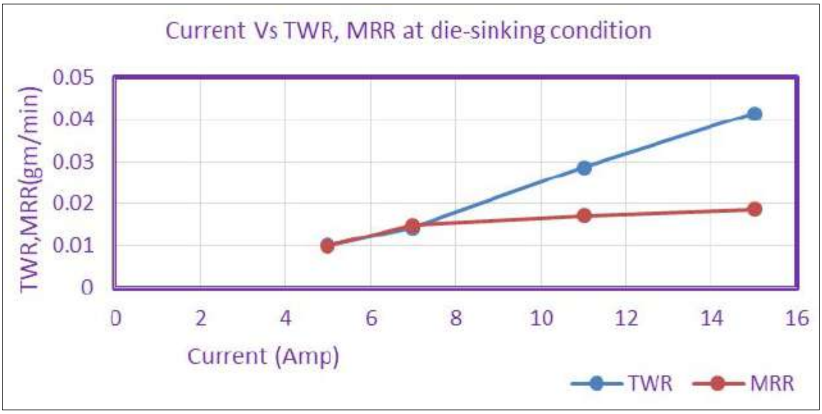

Fig 3: Current Vs TWR, MRR at die-sinking condition for MS plate

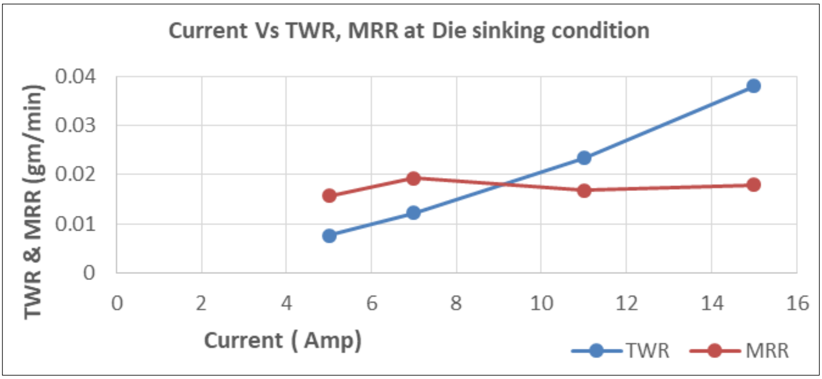

Fig 4: Current Vs TWR, MRR at die-sinking condition for Inconel-825

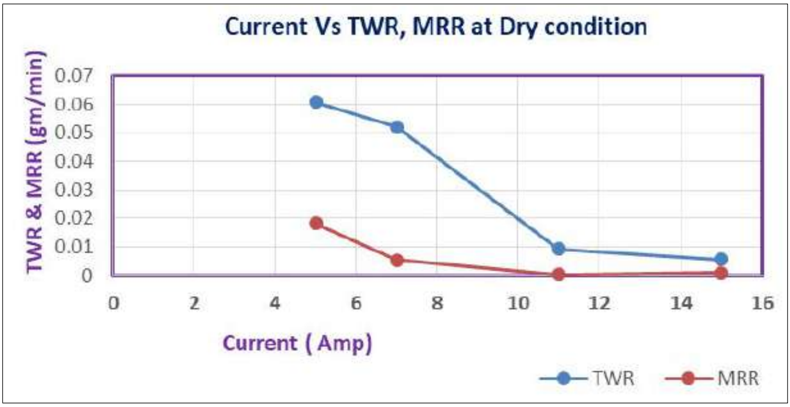

Fig 5: Current Vs TWR, MRR at dry condition for MS plate

Fig. 3 indicates that MRR and TWR are increasing with increase in current but TWR is slower than MRR for die-sinking EDM of MS plate. Similarly Fig. 4 shows that MRR and TWR are increasing with increase in current but TWR is slower than MRR for die-sinking EDM of Inconel-825. Comparing Fig. 3 and Fig. 4 it is observed that at 5 amp current TWR and MRR of MS plate and Inconel-825 are almost equal. On the other hand at maximum experimental current (15amp) TWR and MRR are maximum and values are virtually same. It indicates that applied current has great influence on MRR and TWR but hardness of work material has negligible significance.

Fig. 5 specifies that MRR and TWR are decreasing with increase in current at dry-EDM. It may be due to improper flow away of evaporated work material between the tool& work gap. This vaporized removed material stick to the tool and thus reduce spark generation and spark strength. Further it is observed MRR at 5 amp is more in case of Dry-EDM in compare to die-sinking EDM.

4. Conclusion

From this study following points can be concluded;

a) MRR and TWR rises with the increase in current for both work materials named MS plate and Inconel-825, keeping other parameter constant for the EDM where both tool and work submerged under die-electric fluid and same tool material.

b) For MS plate in dry condition, MRR and TWR reduces with increment of current using brass tool.

c) MRR and TWR are independent of mechanical property of the job for same tool.

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Chapter - 49
A Comparative Study on Mutual Fund Investment and Other Investment

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Chapter - 49

A Comparative Study on Mutual Fund Investment and Other Investment

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Abstract

The study was based on Mutual Fund Investment V/s Other Investment Preference of individual investor based on Asansol location. The objective of the study were to analyse and compare the investment decisions of two gender based on various factor. We have taken the sample of 152 respondents based on Asansol location. We have divided the responses in two gender group (male and female) and again we have taken few factors such as source of Information, risk tolerance, investment preference etc. to get more insights into the topic and fulfil the objective. At the end we have highlighted different findings and according to the findings we have given our recommendations and conclusions, that how individual prefer different types of investment.

Keywords: Mutual fund, investment, risk.

1. Introduction

In this study we have made a comparison between investment in mutual fund and other investment. Mutual fund investment is an investment which pools money from the investor and invest in diversified portfolio. In a country like India, where the awareness regarding the investment option are very poor. Previously the investment in mutual fund presumed to be very risky, but despite of that the total AUM of Mutual fund in India is Rs.46.38 lacs, crore, which is 16% of our GDP (data provided bt AMFI India). The figure seems good but this is very poor compare to the global standard of 73%. The reason behind this is that lots of investment in India are still mobilizing in LIC, FD, PPF, NSC, NPS etc. RBI data indicates that over 103 trillion is currently locked in 24.23 million FDs. This figure surpasses the 18.5 trillion held in current accounts and 59.70 trillion in savings accounts, which, put together, comes to a whopping 181 trillion. For comparison, the Indian GDP in 2021-22 was estimated to be 234 trillion. Whereas LIC India is also in that list, which has settled a total claim of 2.09 lacs crore in FY-2022-23. The total market share in number of policies is 71.76% and total market share in premium is 62.58%. In this study we have compare the same things but based on primary data, just to check the perception of individual investor about mutual fund investment and other investment.

2. Literature Review

Xingting Zhu, Xiang Ma, Faheem Ur Rehma, Bin Liu, (2023), This study shows that although Chinese stock pension funds frequently underperform (outperform) their mutual fund counterparts in growth (value) stock investing, they have similar investment preferences to mutual funds (pensions and mutual funds are handled by the same group of fund managers). This discrepancy is known as the "China Pension Fund Puzzle." They proofed that stocks with low pension fund ownership have taken on large price manipulation risks and should be paid by a risk manipulation premium in order to address this conundrum.

Anand Kumar Mishra, Rohit Bansal, Prince Kumar Maurya (2023), SRI has recently grown significantly in popularity as a means of achieving sustainable development objectives. Retail investors are still ahead, despite the amazing efforts made by institutional investors to direct capital towards socially conscious funds. This study has investigated the factors influencing Indian retail investors' investment decisions in socially responsible equity funds (SREF) using the behavioural reasoning theory (BRT) paradigm. 370 participants were subjected to a structured questionnaire over the course of five months beginning in June 2022 utilising a multi-stage stratified random sampling technique. The disjoint two-stage partial least square-structural equation modelling (PLS-SEM) approach for data analysis is complemented by artificial neural network (ANN) and fuzzy set qualitative comparative analysis (fsQCA) to ensure the robustness of results and offer essential practical insights.

David Hirshleifer, Andrew W. Lo, Ruixun Zhang (2023), In a multi period setting, where investors are more likely to spread their ideas to other investors after experiencing larger payoffs in one of two investment styles with various return distributions, in this study they explore the contagion of investment ideas. It has been demonstrate that different investment approaches can persist over the long term, suggesting more diversity than what conventional theory would suggest. In relation to the distribution of security returns, they define the persistence and attractiveness of fashion trends. Additionally, it show how psychological phenomena like conformist preference can cause oscillations and bubbles in fashion choices. These findings hold true even when endogenous returns and a broad range of replication conditions are used. They make forecasts that can be empirically tested and offer fresh perspectives on the longevity of the diverse set of investment methods utilised by professional portfolio managers, hedge funds, and individual investors.

Xingchun Peng, Baihui Li (2023), This paper studied that, the return on the hazardous asset must be predictable in order for this article to examine the optimal investment, consumption, and life insurance purchase dilemma for a wage earner. While the Vasicek model describes the evolution of the interest rate, we assume that the market price of risk is an affine function made up of an observable and an unobservable factor that follow the O-U processes. By using the filtering technique and the dynamic programming principle approach, the best investment, consumption, and life insurance strategies are determined, along with the related value function. In addition, when a wage earner disregards learning or the randomness of the interest rate, suboptimal tactics and utility losses are offered for comparison examination. The results are then shown with some numerical examples.

Saeed Sazzad, Jeris, Shahriar Frances, Mst Taskia Akter, Majed Alharthi (2023) The degree of uncertainty or unpredictability resulting from governmental policies on issues like taxes, trade, monetary policy, and regulation is known as economic policy uncertainty (EPU). Investigating the link between EPU and insurance rates can shed light on more general economic trends and political choices. Understanding how political and economic events affect insurance rates can help us better understand how policy choices and other external factors may effect the insurance sector and the overall economy. EPU is frequently driven by political and economic events. This study explores the relationship between EPU and insurance premiums in 22 countries from 1996 to 2020 to better understand the effects of EPU. The PMG-ARDL regression and panel cointegration tests are used to discover the periodic (short- and long-term) influence of EPU on insurance premiums. EPU has also shown to have a longer-term impact on insurance premiums than it does in the near term. Additionally, compared to non-life insurance, EPU plays a bigger part in life insurance. When robustness approaches (FMOLS and DOLS) are used, the outcomes are consistent. The government, policymakers, insurance regulators, and other important parties must consider the article's results carefully.

Danilo Cavapozzi, Elisabetta Trevisan, Guglielmo Weber (2012), Life insurance has traditionally been a significant component of household portfolios in the majority of European nations, frequently serving as the first asset ever acquired. In this study, we examine how life insurance investments affect people's attitudes towards investing in stocks and mutual funds by using life history data from a variety of European nations. We demonstrate that life insurance policy buyers are more likely to go on to invest in mutual funds and stocks in the future. These results lend support, on the one hand, to the idea that life insurance policies can educate people about financial investments. On the other hand, they are also consistent with behavioural models, where economic agents are first concerned with avoiding unfavourable scenarios by purchasing low risk investments, like life insurance policies, and then invest in riskier assets, like stocks and mutual funds, in order to obtain higher economic returns.

3. Objectives of the Study

- The study aims to compare the investment preference based on gender, between Mutual Fund and Other Investment.
- The study aims to know what investment preference we choose.
- The study aims to know that how do they purchase the investment, means what medium they choose to investment.
- The study aims to know that which factor and risk tolerance affect most while investing.
- The aims to know that for how much time they prefer while investing.
- The study aims to know that which investment option is safe for them.

4. Research methodology

We have conducted the research based on various data collected through two sources:-

Primary data source

For our study we have collected the data in primary mode by creating an online structured Questionnaire based on our topic and circulated the questionnaires through google form and asked the people to fill this questionnaire for our research purpose. Total 152 responses has been received, of which 80 responses are from male and 72 are from female.

Secondary data source

We have collected different journals, literature reviews, questionnaires from various sources on the internet for our study. They were not directly linked or related to our study. Gave us the knowledge of how to prepare our questionnaire and the way to ask questions in it based on our objectives and to record the raw data and analyse it and preserve it for the future.

Data Analysis

Where do they invest?

Male

Table 1

Area of Investment	Responses
Fixed Deposit	6
life insurance	7
NPS	7
PPF	6
Real Estate	7
Saving Account	8
Share & Stock	6
Mutual Fund	27
Post office NSC	6

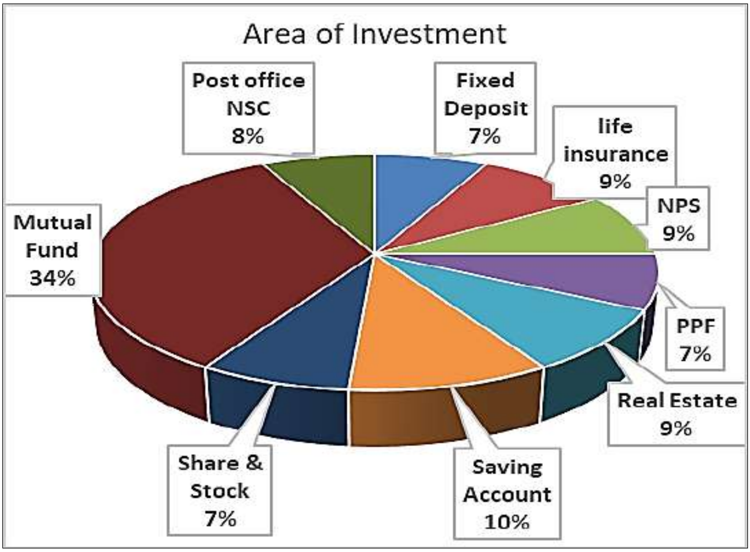

Fig 1

Female

Table 2

Area of Investment	Responses
Fixed Deposit	16
Mutual Fund	13
Savings A/c	11
NPS	6
Life Insurance	6
Share & Stock	5
Real Estate	5
PPF	5
Post office NSC	5

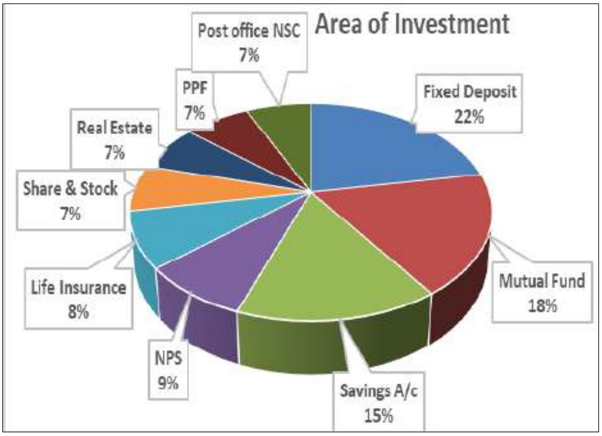

Fig 2

How do they invest?

Male

Table 3

Way of investment	Responses
Demat A/c	9
Direct-by self	15
Post office	7
Through Broker	13
Through Bank	36

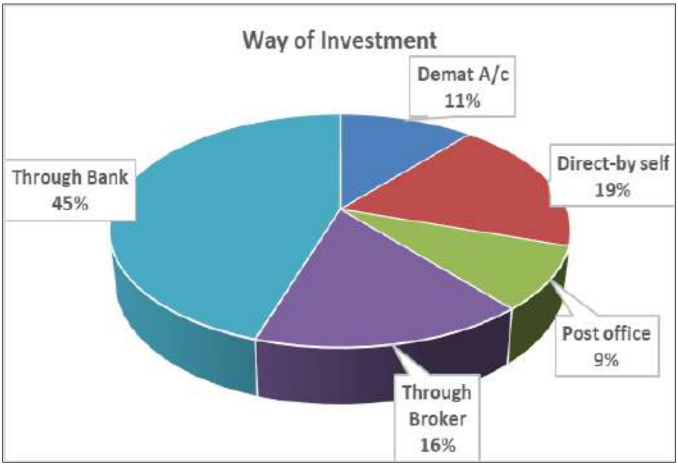

Fig 3

Female

Table 4

Way of investment	Responses
Demat A/c	14
Direct-by self	8
Post office	8
Through Broker	16
Through Bank	26

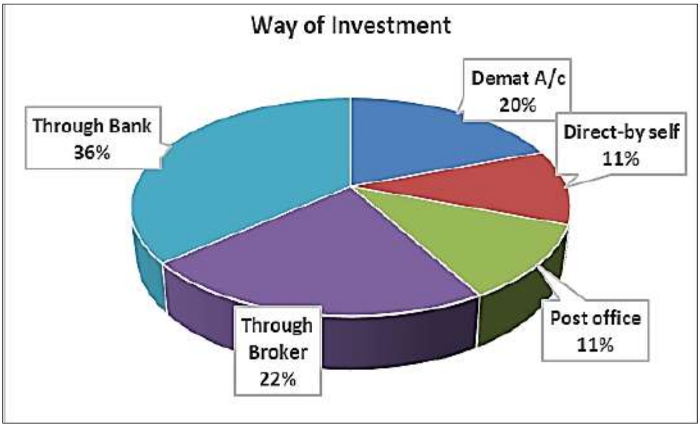

Fig 4

Which factor do they prefer most at the time of investments?

Male

Table 5

Factors	Responses
High Return	22
Liquidity	19
Low Risk	24
Mid Return	15

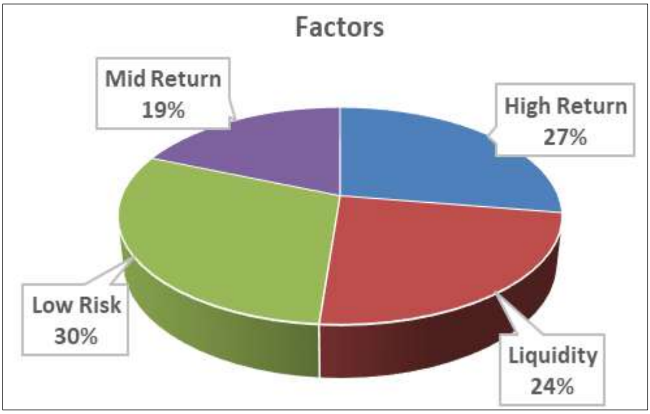

Fig 5

Female

Table 6

Factors	Responses
High Return	22
Liquidity	13
Low Risk	29
Mid Return	8

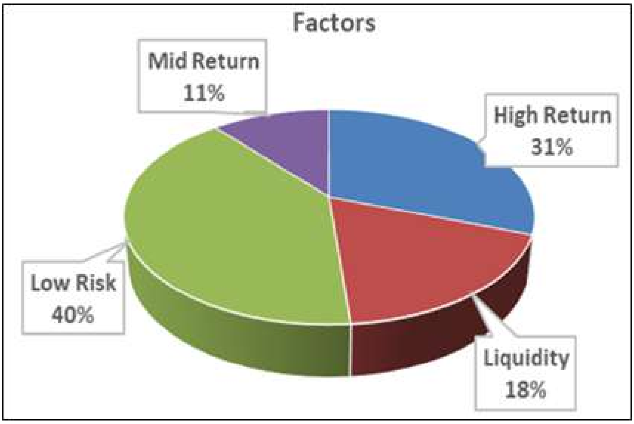

Fig 6:

What duration they prefer

Male

Table 7

Duration	Responses
Long Term	48
Moderate Term	25
Short Term	7

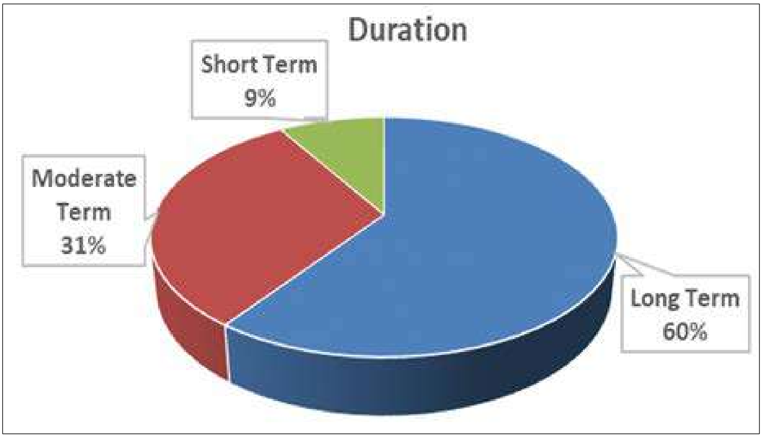

Fig 7:

Female

Table 8

Duration	**Responses**
Long Term	40
Moderate Term	24
Short Term	6

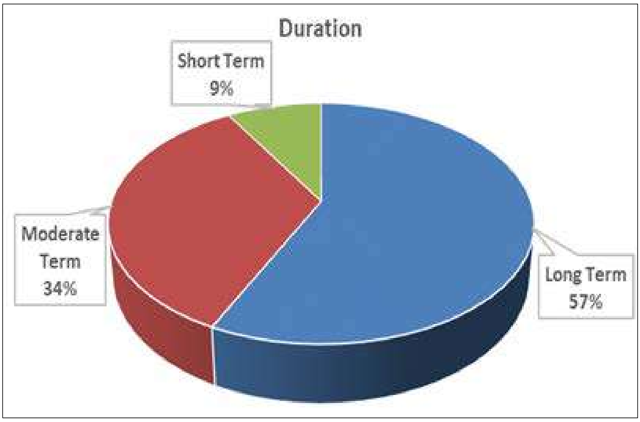

Fig 8

Which is the safe investment option?

Male

Table 9

Types	**Responses**
Mutual Fund	21
Fixed Deposit	11
PPF	10
Life Insurance	8
Savings A/c	7
NPS	6
Post office NSC	6
Real Estate	6
Share & Stock	5

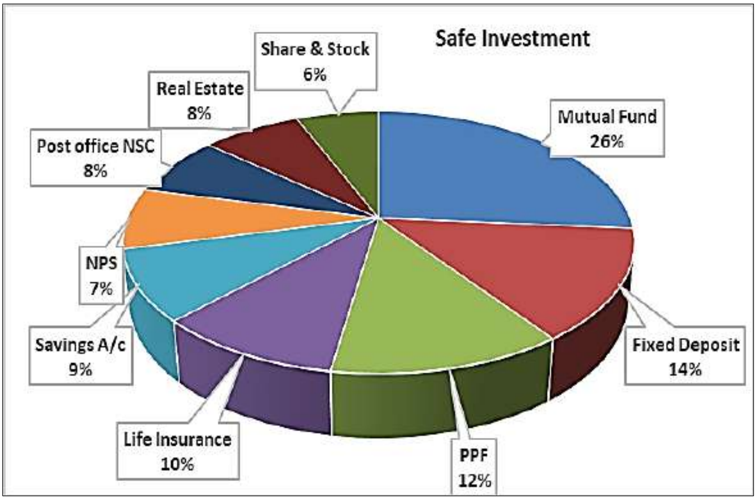

Fig 9

Female

Table 10

Types	Responses
Fixed Deposit	16
life insurance	6
NPS	6
PPF	5
Real Estate	5
Share & Stock	5
Mutual Fund	13
Post office NSC	5
Saving Account	11

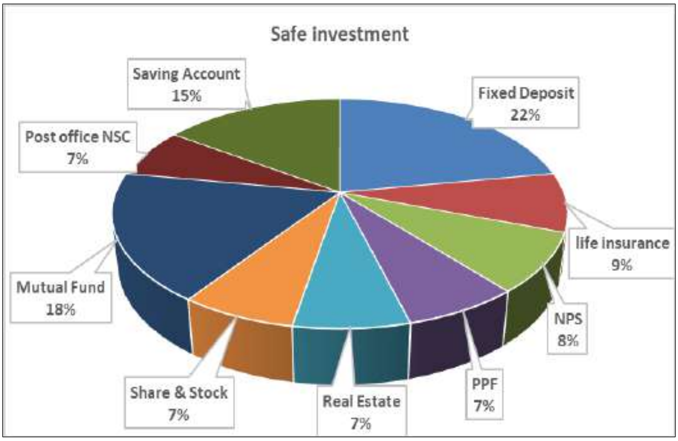

Fig 10

5. Findings

- **Data Collection:** The data was collected through google form (Online). So, only people with internet and people with proper understanding has taken part in it.
- **Investment Preferences by gender:** As per the responses received, approximately 27.34% of the males are investing in mutual fund. Whereas most of the female (approx. 22%) keep their money in Fixed Deposit, then they prefer Mutual Fund and Savings Accounts.
- **How do they invest:** Males and female both are preferring banks more as a medium to invest their funds, because now lots of investment like Mutual Fund, NSC, PPF, FD etc. can be done through bank. But broker and direct-by self-investment is also playing a significant role in investing.
- **Factors of Investment:** When we see the factors considering the investment whether it is male or female, both of them prefers low risk investment and expectation of high risk is at second place. Both of them are not worry about the liquidity, may be this is because of investment preference in FD, PPF, NSC etc.
- **Duration of Investment:** Both male and female are preferring the long term investment proposal, which is very much logical because they are preferring low risk investment.
- **Safe Investment Proposal:** It is quite logical that males are preferring mutual fund more for investment, but we can see that female are preferring FD for their choice.

6. Recommendation

- The data should have been collected in all medium (online, offline). So, more number of people can take part and accuracy will also increase.
- Out of the total 80 responses from male, 41 are excepting for high return and liquidity and 15 responses received who are expecting medium return, but only 27 number of males are investing in mutual fund and 6 number of males are in shares. So my recommendation is if they asking for medium to high return and high liquidity, then they must change perception and invest more in mutual fund or stocks, which can give medium to high return, with a quick liquidity.
- Similarly, out of the total 72 responses from female, 22 are excepting for high return, 13 are expecting for high liquidity and 8 responses received who are expecting medium return, but only 13 are investing in mutual fund and 5 are in shares. So my suggestion is if they are asking for medium to high return and high liquidity, then they must change way of doing investment and should focus on that investment option which provides medium to high return with a quick liquidity like mutual fund or shares.
- Both male and female are largely depends upon banks and broker as a medium of doing investment. A very less number of male and female are doing investment through direct source or by self. So my suggestion is this, both male and female, especially females must be provided with more education for investing their fund by their self, means without any intermediary that will reduce the cost of doing investment and saves time.
- Total 48 out of 80 males and 40 out of 72 females are doing investment in long term purpose mind-set. My recommendation is to them is in a fast changing economic scenarios one should do the investment for low to medium term period.

7. Future Scope

1) We have collected the through online and peoples have given their responses in google form. But we should conducted the study through offline also. Because people with internet facility and with proper education has responded, but if we could go offline then and collect the data then the number of responses could have been improved.

2) **The scope of the study is:** The study is based on the Asansol city only, but in future if we could reach maximum number of city then we can increase the data.

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Chapter - 50

Eye Blink Sensor for Antisleep Alarm: A Review of Technology and Effectiveness

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Chapter - 50

Eye Blink Sensor for Antisleep Alarm: A Review of Technology and Effectiveness

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Abstract

A blink sensor, also known as a blink detector or blink tracker, is a device or technology used detect and track the eye blinking patterns. In various applications it can be used such as human-computer interaction, medical diagnosis and assistive technologies. The eye blink sensor has become a key component in the design of anti-drowsy alarm systems, improving safety in various areas where drowsiness can pose significant risks. This summary provides overview of eye blink sensor technology in sleep disorders, their applications, and their effectiveness in mitigating fatigue-related accidents. Driver fatigue is the leading cause of traffic accidents worldwide, resulting in many deaths and injuries each year. To alleviate this critical problem, researchers and developers have used innovative solutions to like eye blink sensor to create anti-sleep alarm systems. This article presents eye blink sensor review coupled to a sleep disturbance alarm. It focuses on its design, functionality and potential impact on driver safety.

Keywords: Eye blink sensor, security, Driver Fatigue.

1. Introduction

Anticipating the demands and safety of drivers is most important topics in the automotive industry, and the goal is to avoid life-threatening situations. Given the vast number of cases and quot drows and quot; is "sleepy, and quot; indicating tendency to drool. Drowsiness is usually caused by insomnia, various medications and boredom from long car rides. [1] Recent crash analysis reports show that drowsy or drowsy drivers are the leading cause of fatal crashes, serious injuries, and economic losses. Statistics show that more than 1.3 million people die from road accidents every year, while Between 20 and 50 million people are seriously injured and disabled due to road accidents. [2] Vitiable *et al.* suggested employing a fixed light source to create a real-time sleep detector for usage in automobiles. On the instrument panel, the light source emits infrared light with a wavelength of 850 nm. To solve this problem and prevent devastating accidents, driver status must be checked regularly. Methods used for identification fatigue can be separated into three groups: behavioral, physiological, and vehicle-based. The method suggested in this study uses driver behavior and measures; that is, it functions by deciphering the controller and visual cues.

2. Literature Review

The article talks about the creation of image-based driver alertness detection systems that keep track of a driver's eye health using computer vision techniques. However, there are currently no practical or inexpensive solutions for eye detection, as existing algorithms struggle with constantly shifting lighting circumstances and absence of identification and correlation analysis of different visual metrics.

M. Singh and G. Kaur [2] developed a technique using a median screening algorithm for real-time fatigue detection with a camera with a resolution of 640x480. This system uses a 640 x 480 resolution camera to detect eye blinks in actual time with 99% accuracy. In 2011. This system uses hardware technology such as Array of Field Programmable Gates technology and strong methods for processing images that analyze a full 720x576 image in 16.7 microseconds, enabling real-time drowsiness detection. Flores *et al.* [4] introduced an Advanced Technology for Driver Assistance component in 2009 that makes use of algorithms for artificial intelligence for face and eye detection and tracking, and also drowsiness detection. The system works in a variety of lighting conditions and takes into account additional driver distractions such as yawning, head tilt and facial alignment.

In 2013, Chuang-Wen *et al.* unveiled "Car Safe," the first sleepiness detection software for Android smartphones. The software switches between two camera pipelines, assessing tiredness through head posture and eye blink rates. The back camera considers vehicle-based safety measures, determining the driver's proximity and potential lane changes.

EOG (Electrooculogram signal that detects cornea-retina potential difference) was used by Shahadas *et al.* in 2013 to track eye movements and determine if the driver is sleepy. Researchers have used physiological signal-based methods to identify sleepiness, and future vision-based assessments can be integrated with electromyography, electrocardiography, and electroencephalography to decide more precisely regarding a driver's condition.

3. Methodology

3.1 Face Detection

The first step of Algorithm #039 is to select the income area VHS frame. The algorithm of Viola Jones (5) was used for this purpose. The first real-time facial recognition was introduced in 2001 by Paul Viola and Mike Jones. Using simple property values, this method classifies images (5). Its primary benefits are swiftness and sensitivity, as it achieves a comparable detection speed state-of-the-art methods and becomes relevant faster than most. The use of block-like characteristics rather than discrete pixels is among the distinguishing features of this algorithm. The block box is first used to determine the sum of the pixels. Features are created by combining box totals. Referring to the included search window.

Cube characteristics are displayed in Figure 1. Two rectangular features are displayed in (a) and (b); (c) and (d) exhibit three and four rectangular features, respectively [5].

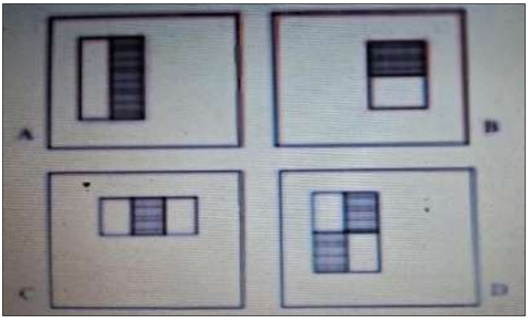

Fig 1: Rectangle features in relation to the detection window that surrounds them

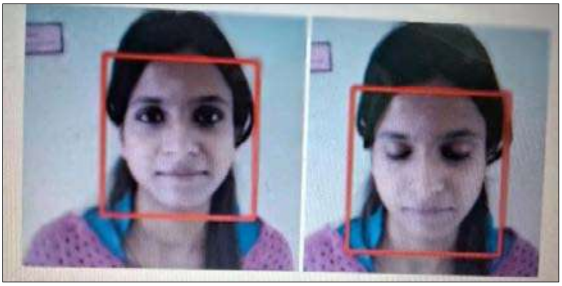

Fig 2: (a) Front Face (b) Down face [1]

To calculate these rectangular features faster and more accurately, Viola, Jones developed a form of representation called integral representation. They showed how to use this complete picture, four table references, and any sum in rectangles to calculate any amount. When the classifier prepares to choose the finest feature out of all of them, it uses the features selected by the ads. [5]. Ad boosting is an algorithmic method that uses a inadequate learning system to find a single rectangle. By classifying the fewest sample errors, For every feature, the weak learner chooses the optimal threshold classification function. Most of the frame is taken up by the portion of the picture that is not the face. Viola, Jones created "Cascade of Classfiersandquot; apply the method in practice. The roles are broken down into several stages of classification using the methodology mentioned above. The 6000 functions are executed one by one and not all at once. If the window fails for the first set of properties, it is abandoned and all its properties are removed. If successful, the window is advanced to the next step, and so on. The window is chosen as the face region because it performs all these tasks.

Viola Jones' approach was successfully used to locate the face region next video Figure 2 illustrates.

3.2 Eye Detection

The Viola Jones algorithm's detection of the facial rectangle is named after facial region of interest (ROI). The eyes in this position are again located using The Cascade of Viola Jones classifier. Viola Jones included components similar to Hear [6] for eye detection. Again, the area around the eyes is detected using these parameters with an audio cascade classifier. The pair of eyes is then removed for additional handling. Figures 3 (a), (b) show the results of using Viola, Jones index to identify students.

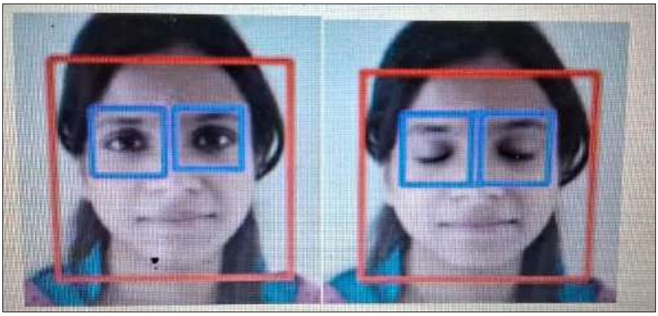

Fig 3: (a) Opened Eyes (b) Shut Eyes [1]

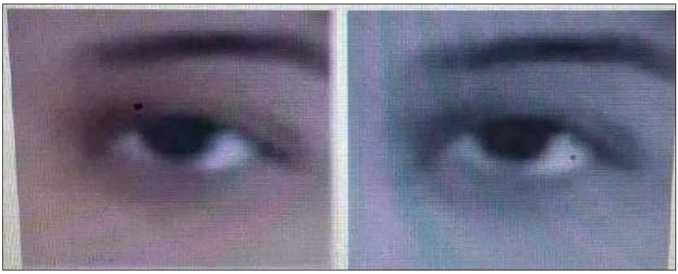

Fig 4: Visual Image (a) Image in colour (b) Image in greyscale [1]

3.3 Eye Blink Identification

A step-by-step explanation of the suggested blink detection approach is given in this section.

i) Grayscale conversion: First, the coloured eye picture is made grayscale. Algorithms for grayscale conversion employ the following three steps to convert a colour image to grayscale.

Use the values from the picture pixels for the green ("G"), red ("R"), and blue ("B") colours.

ii) Apply any formula. to combine the RGB values to get a single gray value.

iii) An image pixel's old RGB value is changed to a new grayscale value.In terms of greyscale conversion, "Luminosity Algorithm" It has been used with. [9]

iv) Then considering human sensitivity, it creates a weighted average. [9].

v) The calculated value is changed to the pixel's original value. Figure 4 depicts the impact of the 2. Luminosity Formula on the ocular region.

3.4 Corner Identification

Points where two edges converge are known as corners. Our suggested blink detection technique 1 makes use of corner points and a single point at the lower lid. A Harris angle detector was used to find these locations. Harris angle detector, one the most commonly used angle and POI detectors are not affected by changes in lighting, rotation, scale, or picture noise. The Harris Detector only considers the direction when calculating the angular difference [7]. It selects one of the following scenarios for a certain point using a mathematical process [7]. A flat area suggests the existence of no directional change

1. Edge signifies that the direction of the edge has not changed.
2. The corner suggests a substantial shift in all directions.

The notion that exists a corner just the meeting point of two edges converge is used by this corner detector. It is, in other words, the location where the pair of edges diverge. You can spot it in image 1 because of the gradient's enhanced variance in both directions.Harris Corner Finder determines this "variation". After Using the input eye to apply the Harris Corner Detector, we obtain the points displayed in Fig. 5, and Fig. 6(a) and (b) provide the portion of the line segment's midpoint and the line drawn between the two points, respectively

Fig 5: After applying, corner points

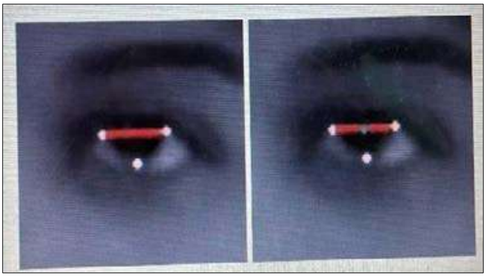

Fig 6: (a)The line section connecting the two top points (b) Midway connecting the points of the corners in green [1]

3.5 Identifying Drowsiness

The program also uses a predefined 3 criteria for somnolence to ascertain the condition of the motorist. A person's blinks generally last 100 to 400 milliseconds (10). This spans0.1 –0.4

seconds. thus, if someone is sleepy, their eye check must be longer than two seconds. A two- alternate time limit was established. If the motorist closes their eyes for two

seconds or more, An Alarm is turned off. to alert them. Fig. 7 shows the somnolence alert.

Fig 7: Drowsiness Warning [1]

3. Conclusion

The current article was about eye blink sensor for sleep alarm. When used with a high-resolution camera and in well-lit environments, this technology produces incredibly accurate results. This shows that it worked perfectly in ideal conditions. For most people, this approach is effective. with various physical attributes, whether wearing glasses, taking care of facial hair, treating certain eye diseases, or covering the mouth. To improve blink tracking, consistent eye point identification needs to be used across all frames. The main focus is on the angle detection method and the consistency of follow-up work. Some more efficient methods might be applied to more accurately identify eye focal points every time a video image. In the future, driver physiological data and vehicle measurements could be combined. This combination of data can help provide critical safety information to improve future vehicle and driver monitoring technologies.

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Chapter - 51
Monitoring Environmental Sustainability through Data-Driven Real-Time Tracking of Carbon Footprint

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Chapter - 51

Monitoring Environmental Sustainability through Data-Driven Real-Time Tracking of Carbon Footprint

Ranjita Sinha, Sandip Haldar, Akash Dutta and Avik De

Abstract

The pressing need to address climate change and lessen greenhouse gas emissions has underscored the importance of accurately and efficiently monitoring carbon footprints. This study introduces an innovative method for tracking carbon footprints in real-time, allowing for precise and ongoing measurement of emissions from different origins. Through the integration of data from diverse sensors, monitoring devices, and data streams, this system delivers current information on carbon emissions, empowering individuals and groups to make well-informed choices to support sustainable environmental management. By amalgamating data collection, conversion factors, and immediate data processing, the proposed framework computes and presents real-time visualizations of carbon footprints. A comprehensive dashboard provides constant updates, patterns, and comparisons, enabling users to oversee their carbon emissions and pinpoint areas for enhancement. The system also involves alert mechanisms to proactively manage excessive emissions or noteworthy deviations from baseline values. This research paper underscores the significance of real-time carbon footprint tracking as a tool for environmental oversight and sustainable practices. The approach adds value to the domain by presenting an uncomplicated and effective solution that combines diverse data sources, permitting continuous monitoring and analysis. It empowers individuals, entities, and policymakers with actionable insights to create efficient strategies for reducing emissions, fostering a future that is more attuned to sustainability and environmental consciousness.

Keywords: Real-time carbon footprint tracking, environmental monitoring, sustainability, greenhouse gas emissions, emission reduction, sensor integration.

1. Introduction

The growing concern over climate change and the pressing need to reduce greenhouse gas emissions have highlighted the critical importance of accurately and efficiently monitoring carbon footprints. The ability to monitor carbon emissions in real-time is essential for effective environmental management and the promotion of sustainable practices. This research paper introduces a data-centered approach aimed at continuously and precisely measuring emissions from various sources, utilizing mathematical principles and backend technologies.

This research paper has two main objectives. Firstly, it aims to create a robust real-time system for tracking carbon footprints that can integrate data from diverse sources and provide current insights into carbon emissions. Secondly, it underscores the significance of real-time monitoring as a valuable tool for sustainable environmental management and its potential to inform effective strategies for reducing emissions.

2. Methods

- **Data Collection**

A comprehensive array of sensors, monitoring devices, and data streams are strategically deployed to capture carbon emissions data. The selection of instruments is based on rigorous criteria to ensure accurate and reliable measurement of emissions.

- **Conversion Factors**

Conversion factors are derived from scientific research and carefully selected to ensure precise estimation of emissions. These factors are applied to the collected data to calculate carbon footprints.

- **Real-time Data Processing**

Advanced mathematical algorithms and techniques are employed to handle large volumes of data generated by the sensors and devices.

Real-time updates and analysis enable immediate insights into carbon emissions for informed decision-making.

3. Results and Discussions

- **Dashboard Visualization**

The system presents data through a comprehensive dashboard offering visualizations, trends, and comparisons. Graphs, charts, and customizable views enable real-time monitoring and identification of areas for improvement.

- **Case Studies**

Case studies highlight practical applications of the real-time carbon footprint tracking system. Examples demonstrate how individuals, organizations, and communities effectively manage their carbon emissions using the system.

- **Evaluation and Validation**

Rigorous evaluation and validation processes are employed to ensure the accuracy and reliability of the tracking system. Benchmark comparisons are conducted against established standards to assess the system's measurements.

A model algorithm for estimating carbon footprints typically involves the following steps:

1. Data Collection: Gather data on various activities and processes that contribute to carbon emissions. This can include energy consumption, transportation, waste generation, manufacturing processes, and more. Data can be obtained from utility bills, fuel consumption records, transportation logs, and other relevant sources.
2. Emission Factor Calculation: Determine emission factors specific to each activity. Emission factors represent the amount of greenhouse gas emissions produced per unit of activity. These factors can be obtained from databases, industry standards, scientific research, or government publications. Different activities may have different emission factors based on the type of fuel or energy source used.
3. Activity Data Conversion: Convert the activity data into a standardized unit that corresponds to the emission factors. For example, energy consumption data can be converted into kilograms of carbon dioxide equivalent ($CO2$ e) using emission factors specific to the energy source.
4. Calculation of Carbon Footprint: Multiply the activity data by the corresponding emission factors to calculate the carbon emissions for each activity. Sum up the emissions from all activities to obtain the total carbon footprint.
5. Output and Reporting: Present the calculated carbon footprint in a meaningful and understandable manner. This can include providing a breakdown of emissions by activity category, comparing emissions over time, or benchmarking against industry standards or targets.
6. Sensitivity Analysis and Scenario Modelling: Perform sensitivity analysis to identify key drivers of carbon emissions and assess the impact of changes in activity levels or emission factors. Scenario modelling can help explore the potential outcomes of adopting different mitigation strategies or adopting cleaner technologies.

7. It's worth noting that carbon footprint estimation can become more complex when dealing with indirect emissions (Scope 2 and Scope 3 emissions), such as emissions from purchased electricity, supply chain activities, or product use. Advanced algorithms may consider more detailed calculations and incorporate additional data sources for a comprehensive analysis.

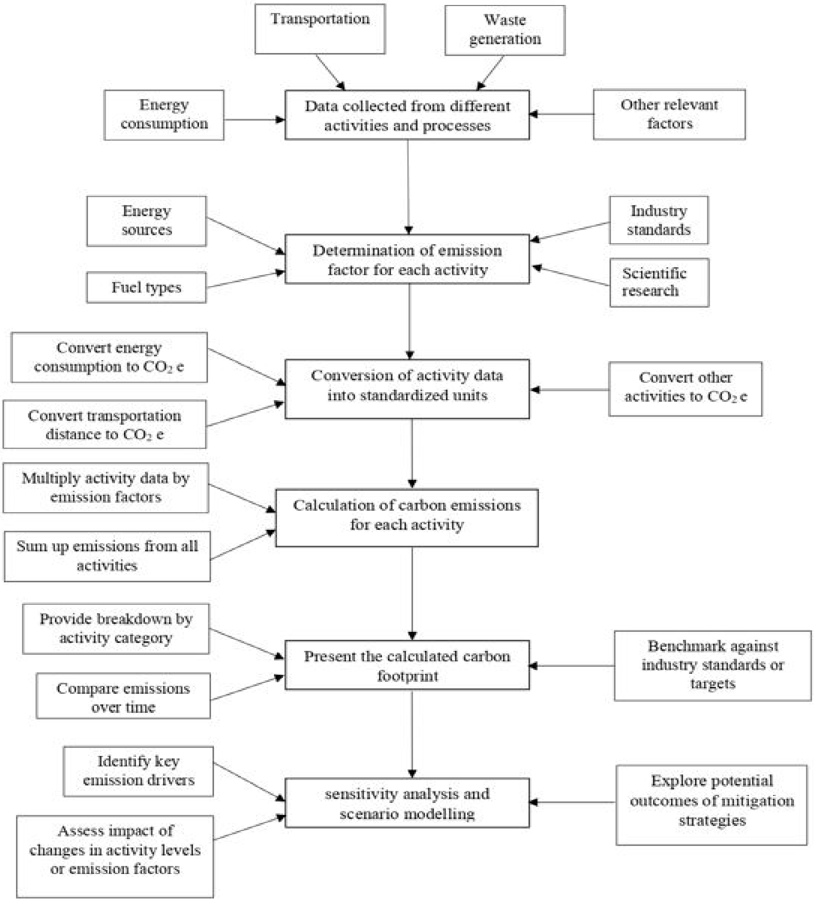

Fig 1: Flow chart

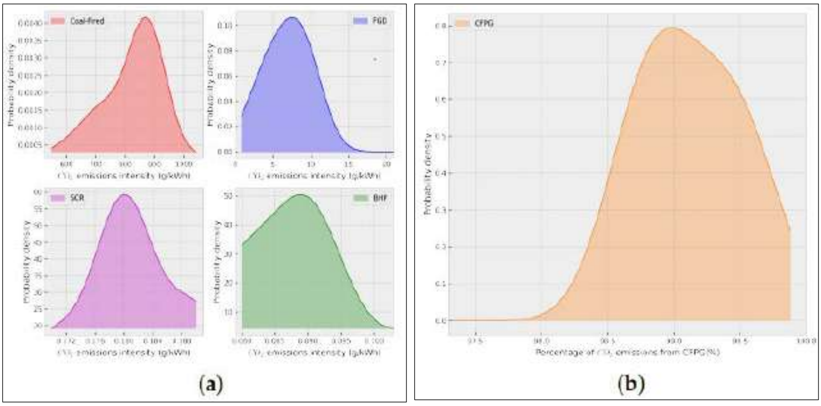

Fig 2: (a) Distribution of CO_2 emission intensity in varying stages. (b) Percentage of CO_2 emissions from coal-fired units

4. Risks and Challenges

- **Data Accuracy**

Ensuring the accuracy of data collected from diverse sources and instruments poses a challenge. Calibration and quality control measures must be implemented to minimize inaccuracies and discrepancies.

- **Data Privacy and Security**

The collection and storage of real-time carbon footprint data raise concerns regarding privacy and security. Robust data protection measures and adherence to relevant regulations must be implemented to safeguard sensitive information.

- **Technological Limitations**

The scalability and compatibility of the tracking system with different sensors and devices may pose technological challenges. Continuous monitoring and analysis require a robust infrastructure capable of handling large volumes of real-time data.

5. Conclusion

The research paper underscores the significance of real-time carbon footprint tracking as a mathematical tool for sustainable environmental monitoring and management. The proposed data-driven approach, with its integration of diverse data sources and real-time analysis capabilities, empowers individuals, organizations, and policymakers with actionable insights for effective emission reduction strategies. By leveraging mathematics and backend technologies, this research paper presents an elegant solution for continuous monitoring and analysis of carbon footprints, fostering a more sustainable and environmentally conscious future.

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Chapter - 52
Quasi Yagi-Uda Antenna for 5G Applications

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Chapter - 52

Quasi Yagi-Uda Antenna for 5G Applications

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Abstract

In this paper a compact microstrip monopole patch antenna is proposed for 5G applications. It is designed for 3.5 GHz frequency. The antenna has a dimension of 55×50 mm2. In this work, the substrate material used is FR4 which has a relative permittivity of 4.4 and height 1.6 mm is used. This proposed antenna is designed and simulated using CST electromagnetic simulator software. The simulation results show a return loss < -20 dB. This antenna has achieved a bandwidth of 67MHz and a peak gain of 3.25 dBi is obtained.

Keywords: Monopole, planar antenna, Yagi Uda antenna, 5G antenna.

1. Introduction

In modern communication system 5G antennas are extensively used for transmitting and receiving user data efficiently. For such communication systems, antenna elements offering light weight, low cost, moderate gain, easy fabrication etc. are extremely important. Such requirements are fulfilled by various types of microstrip antennas proposed in the literature [1, 3]. Although there are a large variety of antenna available in literature, because of the simple geometry, high gain, easy incorporation with other microwave circuits, Yagi antennas are very much appropriate in wireless communications. However, in general planar Yagi antenna yields a narrow bandwidth (<10%). Researchers have proposed numerous Yagi antennas to enhance their performance by taking advantage of their fundamental principles. Consequently, a new antenna called quasi-yagi antenna was projected in order to enhance the performance of the conventional Yagi antenna [4].

The planar Yagi antenna consists of one dipole antenna which acts as feed, is called the driven element. There are multiple director elements which are placed towards the end-fire direction to enhance the gain of the antenna. This is obtained by forwarding the electromagnetic energy in a specific direction. By increasing the number of director elements, the front-to-back ratio and the gain of the yagi antenna can be improved. However, the over-all size of the antenna increases by this technique. The antenna proposed here is compact and simple in design and operates at 3.5 GHz centre frequency which supports 5G communication system.

2. Geometry of the Proposed Antenna

Antennas for 5G technology have become one of the main components in the rapid development of 5G communication system. Different shapes and structures of patch antennas have been attempted to develop efficient 5G antennas since last couple of years. 5G technology uses many frequency bands in modern communication system. In our proposed antenna we have chosen the mid-band spectrum. The frequency band chosen for this antenna is 3.5 GHz. 5G antenna design has been a challenging task for many years. Here a single element quarter wave mono pole microstrip patch antenna has been designed for 3.5MHz. The antenna type we have chosen is planar Yagi Uda antenna. In this antenna a driver element and two director elements are designed. Parametric studies were made in the size and location of the directors to achieve the desired result. Fig 1 and Fig 2 show the final geometry and frequencyb response of the antenna. The dimensions of the final geometry of the designed antenna is given in Table-1. The final geometry of the proposed antenna achieves a bandwidth of 67MHz.

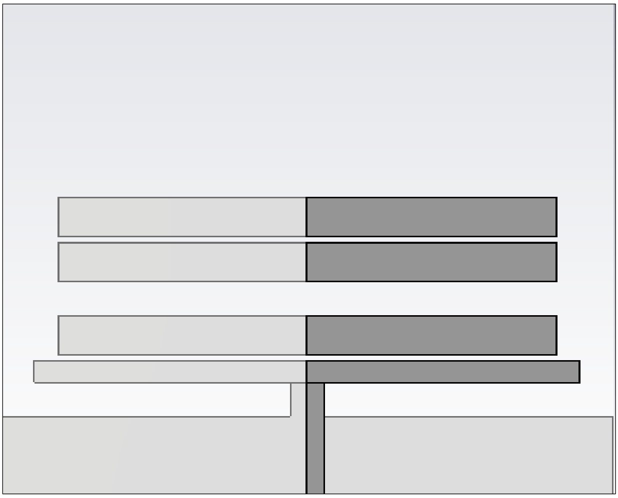

Fig 1: Final Geometry of the proposed Yagi Uda antenna

Table 1: Antenna dimensions of the final geometry

S. No.	Objects of the Antenna	Dimension (mm)
1.	Substrate size	55x50
2.	Substrate thickness	1.6
3.	Ground plane	55x8
4.	Feed	11.5x1.5
5.	Driver	24.5x2.2
6.	Director	22.35x4

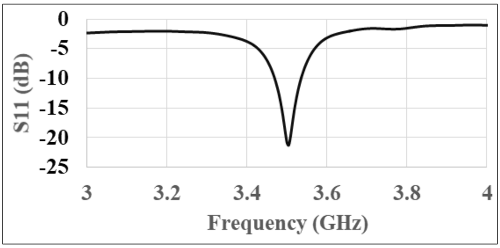

Fig 2: Frequency response of the antenna

3. Results and Discussion

The proposed antenna operates at the frequency of 3.5 GHz which is as expected. The return loss achieved at this frequency is <-20 dB as shown in Fig 3. The -10dB cut off frequencies is coming at 3.469 GHz and 3.535 GHz, which yields a good bandwidth of 67 MHz. In the design, the gap between the antenna objects is kept at more than 4mm so as to make the fabrication process easy.

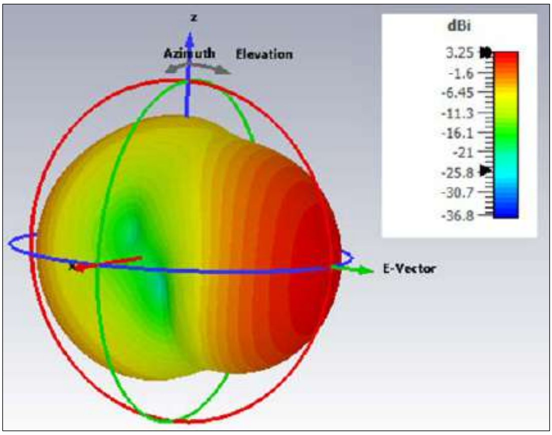

Fig 3: 3D radiation pattern of the proposed antenna

4. Conclusions

In this paper, a quasi bi-layer Yagi antenna designed to operate at the 5G band is presented. Both the upper and bottom layers of the yagi antenna consist of driven elements and director elements. Full-wave investigation of the projected patch antenna was done by using the electromagnetic simulator CST Microwave Studio. The antenna radiates at 3.5 GHz band of 5G communication and it give a bandwidth of 67 MHz and it gives a peak gain of 3.25 dBi.

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