**Introduction**

In a socio-economic context as tricky as the one we are faced with, the company that possesses only a slight lead, will have automatically the advantage over its competitors and will dominate the market as long as it maintains this lead. The mastery of quality tools which allows new products to be put on the market is almost identical from one company to the other (Sushkov, 1996). Thus, there they are, evenly matched in terms of competitiveness and "time-to-market".

The philosophy of Value Analysis, developed by many quality gurus, remains attractive. Its steps are clear and structured, helped by many tools allowing engineers to progress in a systematic way when designing new products. But a certain stage of this progress concerns generating ideas, finding solutions, solving problems, so systematic thinking is no longer present in this process. One vaguely cites terms such as : organize a brainstorming session, create a reflection group whose role will be to put into practice various creativity tools, etc. In the end, even if the processed problem is modelised, returned, trolled and husked, the heart of the imaginative device, the one that takes the decisions, is always in fact a human being alone who come up with the idea. This random generation process of ideas is like a black hole in the fourth step of V.A., because the stage of idea generation can never be estimated in advance. If one can, after a significant number of experiments, estimate the time of the idea generation stage, when the problem reaches a superior level of complexity, this time span might evolve exponentially.

Then along comes TRIZ method, with its tremendous aptitude to generate concepts, to stimulate the creativity of engineers and everything became systematically simpler. A greater number of ideas are generated, their pertinence is very real and today's number of case studies are advancing almost as rapidly as the enterprises that have understood the importance of Altshuller's work. Thus, in a V.A. strategy everything becomes simpler, the generation of ideas is quasi - systematic, the pertinence of found solutions is not brought into question and the black hole becomes clearer… .

**Statement of TRIZ limits**

Among all the ambushes that enterprises meet during a period of reflection on their product development needs, there often appears to be a zone of uncertainty in the accuracy of targeting these needs. Indeed, there is often a tendency to overestimate these needs and to move straight on to innovation and in this quest of excellence the different people involved can become a bit lost. Engineers, technicians, collaborators and other financial supporters don't hold the same view on innovation. A single solution to this last problem could address many issues in one time. There is therefore the important task of understanding the real needs, in terms of innovation, by succeeding in increasing precision to define the enterprise's problem.

The socio-economic context no longer needs to be described. Actually, the "fast - innovation" is a reality and everyone hurries to appear to be the most effective in this area. In this gigantic poker game, some accept defeat and others put down their hands claiming that they hold the wild cards, but all this undeniably cheat at the data game. One does not innovate to innovate, otherwise we might lose ourselves in the abyss of a sterile reflection. The effort is, nevertheless, entirely laudable. Indeed, entirely launched in the name of innovation, an enterprise should be motivated to move forward, not to remain stagnant, while competitors find out later, what they could have found now. And if this sentiment is shared by all members of the company, it is an entire hierarchy that is committed to this policy going toward an ideal, looking for ideas, in search of the "blessed" solution, the unavoidable enlightening of spirit. The arrival of TRIZ could have let us to think that this generation of ideas was going to be systematized, so innovate… again and again… .

But things are not that simple. After interviews with TRIZ users, some limits of the method came to light. These limits are of three orders :

***Limit 1*** : The system's complex nature imposes a growing diversity of technological areas producing uncertain data. When instating a problem and processing the method, a fundamental phase on which the pertinence of the released solution depends, resides in its projection vis-à-vis the standards identified by Altshuller. This diversity sometimes creates a problem of identification of the model with these standards (Royzen, 1996) in which the quantity is voluntarily limited to optimize the time in which the solution is found. This method has required years of development, the evolution of systems for such a long time would require that TRIZ benefits from implementation, to be enriched with these new data. For example It might be difficult to locate a problem parameter such as noise or bandwidth (out of the 39 available) when processing the conflict solving stage with the contradiction matrix. Is the presence of a new technique like "Tailor the DNA of a bacteria" necessary to be added to the 40 actual principles.

One solution to this would consist of building a still-improved set of parameter, permanently available (on the net for example). A center of TRIZ development linked with an international patent agency, could then implement all TRIZ resources when necessary.

***Limit 2*** : All innovation concerns the important evolution of a product or a system from one generation to the next (Cavallucci, 1997). This evolution, while applying TRIZ, concerns essentially the product, the system, which is the object of the prospective of transformation. But all products, all systems, are manufactured by another system (of production) who is also found at a certain stage of its evolution. The problem is that TRIZ can concentrate only on one or on the other, and the object, the product, is at the very heart of the innovation. Then the production system introduced to generate it often becomes a victim of this innovation. As an example to this, handling gas is difficult and a solution can be found in converting it into a liquid but such solution requires a lot of new changes in the production system. A second limit appears here, therefore, which concerns the link that unites all products to their production system. This very important link can not be absent when first modeling the problem. We have been requested to undertake a second TRIZ application on the production system itself, after having developed the product. This is indeed a foreseeable possibility but nothing obliges us to further develop the production system if this latter supports the product evolution without itself evolving. Moreover, what about situations where the production system does generate an opportunity for a product evolution? For example, glass finish was improved not by changing the glass or solid roller to convey it, but with a liquid tin bath that "floats the glass" (Altshuller, 1984) a new production system that generates a product evolution. This second limit, seems very important to us and merits a closer look (see later in this paper)...

***Limit 3*** : One stage of product development is a response to a demand. This need, often expressed by consumers or simply by laws of market internationalization, continues its path to stages of being modeled, research of solutions, rapid prototyping and tests, industrialization before entering its phase of major development. During all these stages the product undergoes before its implementation, a multitude of tools are made available to engineers and researchers to help them in their task. TRIZ is in fact only one link in this chain of the product development. A limit appears here which concerns the tackling of product development problem on a global scale. In other words, is it possible to efficiently integrate TRIZ with others tools (Verduyn, 1996) (even fitted ones) at global development stages of a new product? The engineer, when facing with the hundreds of tools available to help him in every product development stages, might be a bit lost in term of efficiency if he simply pick one of them whenever needed. A simple approach to the pertinence of some tools and methods is given figure 1.

|  |
| --- |
| figure1.gif (15118 bytes)*Figure 1: Simple approach of some tools and methods efficiency at various stage of product development.* |

**Links with the production system**

One of the limits evoked previously consists of establishing links between the innovation that the method tends to generate and the production system that is supposed to generate it.

Actually, only a few parameters are taken into account and the current trend of tendency demands that one first proposes the innovation and that only, and then the production system to manufacture it. Of course nothing prevents the inventor from using TRIZ again on the production system itself to make up for the problem (the contradiction) answer of the innovation, without any guarantee of success. It appears clearly, here, that the ideal would consist in evaluating the different products and production systems evolution degrees at the very first of a TRIZ application.

The logical function "or exclusive" (figure 2) can model the initial situation of our problem:

|  |
| --- |
| figure2.gif (4805 bytes)*Figure 2 : Logical scheme of the result M* |

There is a methodology M allowing the product to evolve (from Pn to Pn+1) with or without development of the production system (from Sn to Sn+1).

One of the first tasks of this methodology M therefore consists in knowing if we are in a configuration of a P and S linked evolution. The next step consists in specifying the degree of evolution of S and if it is a function of P.

In other words : Do we have : Sn+x = f(Pn+y) ?

Where x and y are respectively the level of evolution of the production system and product.

To define clearly these data x and y, let us observe the levels of innovation clearly shown by Altshuller (Altshuller, 1988).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Degrees of inventiveness** | | | | |
| **Level** | **Degree of inventiveness** | **% of solutions** | **Knowledge origins** | **Number of solutions to be forecasted** |
| 1 | Obvious solution | 32% | Person's knowledge | 10 |
| 2 | Minor improvement | 45% | Company's knowledge | 100 |
| 3 | Major improvement | 18% | Knowledge of an industry | 1000 |
| 4 | New concept | 4% | Knowledge of all industries | 100000 |
| 5 | Discovery | 1% | All knowledge's on the earth | 1000000 |

Table 1: Degrees of inventiveness according to Altshuller

Considering that the production system is also a system (such as the product) it appears logical to think that S follows these same degrees of innovation. Their respective level on a life cycle curve is identical as well. What is left to define is what links Xs and Xp.

Can a product P evolving from x=1 see S evolving from x=1 ?

That is not obvious at all, Xp can evolve from x levels without Xs necessarily evolving. One can nevertheless draw several conclusions :

*Conclusion 1* : The ideal situation would be to maximize Xp evolution while minimizing Xs.

*Conclusion 2*: There is, for all innovation in a product/process couple, a profitability switchover point to be defined in terms of Xs and Xp.

*Conclusion 3* : It would be useful to benefit from an indicator being able to define the system's degree of evolution. The difference between S and P could then be established and would give important information's regarding the profitability of the evolution. This criterion "E" (figure 3 and 4) could then be integrated into decisions to be taken before the evolution, because logically, to minimize E is to minimize the cost of evolution.

|  |
| --- |
| figure3.gif (4103 bytes)*Figure 3 : Approach of the criterion E 's location in the diagram of a product / process evolution.* |

|  |  |
| --- | --- |
| With : | ep : Degree of difficulty for the Pn to Pn+1 evolution  es : Degree of difficulty for the Sn to Sn+1 evolution  E = ep - es |
| Where : | E < 0, very expensive solution  0 < E < 1, profitable solution  E > 1, very profitable solution |

In a TRIZ logic system development, the E criterion and its role can be represented as follows :

|  |
| --- |
| figure4.gif (14827 bytes)*Figure 4 : Criterion E and its location in a TRIZ algorithm (after Domb, 1996).* |

**Conclusion**

These limits, that are here only cited, must be studied in depth so as to perfect a method which has just arrived on the industrial market and has been of such great help. But in this endless quest of innovation, the enterprise is no longer alone to face the "blank page syndrome" generated by the solution research stage. From the moment it can rely on increasingly effective innovation tools, whose objectives are very clear : to conduct a research prospective related to the consumer's needs, to identify the totality of a system's environment's functions, to minimize costs and "time-to-market". Among all this, TRIZ remains the only to propose ideas, technological research targets. That is to say, it aims at increasing engineer's creativity, by exposing a problem beyond individual ideas, through a prism whose optical particularity is to send back an image (a model) of the problem to a group of others, previously solved, to propose proven solutions. But do not believe that it brings ready made solutions, TRIZ only provokes these solutions with the ideas it gives to engineers who still remain the quality analysis keepers. Finally, as any tool, TRIZ has its own limits. The research path remains therefore open for reflection on continuous improvement of TRIZ itself. But in the current socio-economic context, the strength of the method resides in its aptitude to reduce research solution steps during product development. It allows the generation of innovating concept in a tremendously short time. All this is possible without making any concessions on the answer's quality and pertinence. Many enterprises, universities, research laboratories and other professional organisms have already understood this and the extent of competence in TRIZ is gradually being hierarchised.

Undoubtedly, an interesting path of research is in the thorough study of the links between the product and its production system. This study which has only been touched upon in this article will possibly extend to the definition of a global and generic methodology of product's and engineering system's evolution. An indispensable theory for any enterprise/company heading towards the twenty-first century.