Mastery of future generations of products & TRIZ

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Abstract

The design of new and innovative products depends on the knowledge and mastery of many parameters. Among these, two parameters are shown to indispensable when the sector is very competitive: the design tools and methodology to be used and how to select them..

So, to fully master their future generations of technological products, industrial firms mostly use their own "toolboxes", often limited to one or two tools. Our research deals with a very successful design and problem-solving: TRIZ.

We assessed TRIZ's possibilities and limitations in the way it affects "the managed evolution of technological products". Our first approach in this presentation enables the formalization of designer skills mainly based on intuition when designers envisage developing their products based on the enhancement of legacy products. We define the area of validity of this method to help the designer make decisions by presenting and commenting on the results of an experiment carried out in agro-business.

Finally, we discuss the follow-up to these pioneering works that will eventually enable the integration of the TRIZ laws of evolution in the digital chain of engineering design.

1. Technological innovation is vital for company survival

Innovation is generally perceived as positive. It is often the result of a process and the represents permanent change in companies [2]. It sometimes happens that it generate radical changes, the so-called disruptive innovations, that these disturbances can be economic, social, technological, etc.

According to Christensen [5], company leaders in any given sector, even when given positive media coverage, can nevertheless be relegated to a less prominent position by “newcomers”. There are two possible explanation:

- Economic motivations underlining the risk of cannibalization and of a loss in value of existing employees thus reducing the incentive of existing firms in contrast to newcomers;
- Power stakes and organizational rigidity of leaders.

In these explanations, Christensen associates the evolution of technologies and customer needs with economic interest. The fall of the leaders then becomes a play in two acts. In the first, the leader is confronted with a "disruptive" innovation. Current customers consider it far from efficient and the innovation is of little economic significance for the leader. Consequently, he does not invest. However, the other companies treat it as an opportunity to the extent that their meager resources allow. The second act is played out some years later. Meanwhile, both the leader’s products and the newcomers’ have improved. The leader’s performance is still ahead of the newcomers’. But consumers needs only gradually changed. The newcomers’ products now suit them perfectly, and what is more they are less expensive. Exit the former leader and long live the new!

The model of technology evolution and consumers needs should henceforth be an integral part of basic decision-taking tools with respect to conventional technological trajectories and ***S*** curves [11 , 14].

Christensen's view is that only disruptive innovations set a problem for leaders. But according to his model this can be explained by an excessive increase in price and performance with respect to customer expectations. Such evolution must be due all the same to faulty “progress” innovation management.

This problem leads us to make an inventory of the main areas of research enabling identification of future generations of manufactured goods. We differentiate two different paths of evolution. A first path enables the company to identify its future generations of products by improving legacy products for which we propose a method and the second which allows the company to make a technological bound ahead and to identify disruptive innovations.

In this paper we submit two additional approaches which help us to master this complex system: future generations of manufactured goods. We can only briefly mention them in this paper and discussions would enable us to clarify certain points.

2. Genetic analysis of products evolution: a parallel with biology

2.1 A systematic approach to innovation methodology

According to Gogu [7], one systematic innovation approach can be found in phylogenesis. This is inspired by the phylogenetic principle of evolution of species known to biology. In the evolution of bio-systems, ontogenesis reproduces phylogenesis, on a reduced scale of time and space. Ontogenesis represents a series of successive states occupied by every individual of the species during its existence, from development and genesis (fertilization) until death. Phylogenesis represents a series of successive states occupied by the ancestors of the species starting from genesis. The phylogenic algorithm was developed by the author and his co-workers by the extrapolation of the phylogenic principle from evolution of the species through to the development of technical systems. The phylogeny algorithm uses primal elements (initial elements), generalized morphological objects and several operators' types:

- of combination,
- of recombination,
- of migration,
- of mutation,
- of selection.

Unlike the operators used in the genetic algorithms, these operators are determinist and not probabilistic. The operators of combination, recombination and migration are applied to primal elements to obtain a population of generalized morphological objects which are subjected to the operators of mutation to obtain a population of solutions. The Final Solution is obtained by the application of the operators of selection on the population of solutions. In this paper, we present the second approach enabling the identification of future generations of innovative products. It is additional to the present analysis and is essentially based on a determinist vision of technological future.

3. A determinist vision of technological future: TRIZ

3.1 General presentation

TRIZ is a method of innovation or, more exactly, a method of resolution of creative problems. This method is much appreciated by an ever-increasing number of companies worldwide, whatever their field of activity. It capitalizes the knowledge of the genetic analysis of products together with the forward-looking method and historic analysis. This method is situated at the same level as the methods of creativity [4], it's main objective, in its initial version, the so-called " Classical-TRIZ ", is to favor the emergence of ideas, to supply concepts of solutions over a short time span (cf. Figure 1).

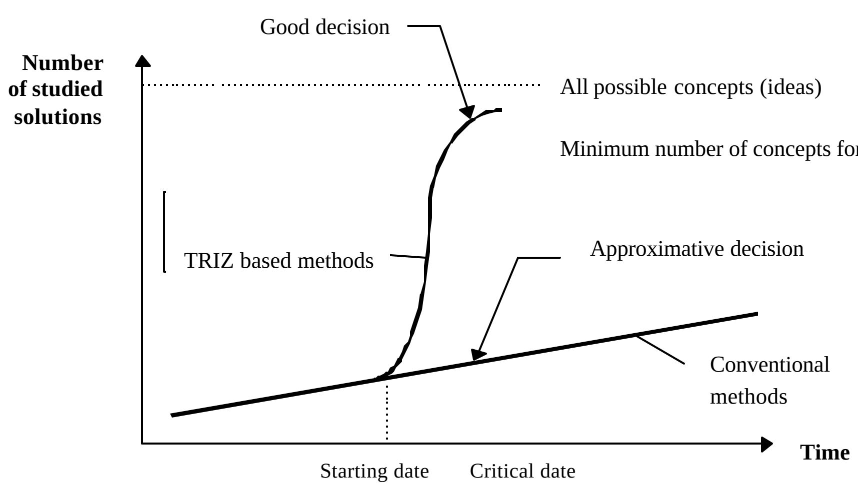


Figure 1. : Interest of directed evolution, conceptual diagram proposed by IDEATION

We observe today an increasing enthusiasm on the part of companies worldwide for this new approach, only known to the general public since the early' 90's. The speed of appropriation of this tool by users is an essential factor; the training courses intended for Research and Development or design engineers last from three to five days.

We take care two point out that TRIZ cannot supply more viable solutions than those at present available in the fields the science covers. This allows us however to obtain an almost exhaustive set of solutions in a relatively short given time. This advantage is crucial when decisions must be taken quickly.

3.2 TRIZ laws of evolution

3.2.1 Complex corpus of knowledge

The laws of evolution are a set of experimental laws describing the evolution of the technical systems through time [10]. The aim is to stimulate the creativity of the engineers [4] and thus allow them to formulate concepts of solutions without any other specific guidelines.

There are, today, several expressions of these laws including those formulated by Genrisch Altshuller in the late‘70s’ and those proposed today by contemporary authors [13 , 12], [8]. Having cross-checked the views expressed by the various authors, we present in this paper only the laws on descriptive character and forward-looking character derived from TRIZ.

- Law N°1: law of increase of degree of ideality by the system.
- Law N°2: law of complementarity of the parts of a system.
- Law N°3: law of uneven development of the parts.
- Law N°4: law of coordination of rythms.
- Law N°5: law of transition from the macro-level to the micro-level and increased use of fields.
- Law N°6: law of increase of dynamism and controlability.
- Law N°7: law of complexification leading to simplification.
- Law N°8: law of evolution towards the diminution of human invovement.

3.2.2 Proposition of a hierarchical organization of TRIZ laws of evolution by Vladimir Petrov

Review in recent works dealing with the TRIZ method allowed us to identify some attempts by authors from various horizons at the classification, structuring and even the hierarchical organization of the laws of evolution of technical systems. We present one of these interpretations (cf. Figure 2) demonstrating that there is still difficulty in the application of knowledge corpus to action pertaining to Research and Development.

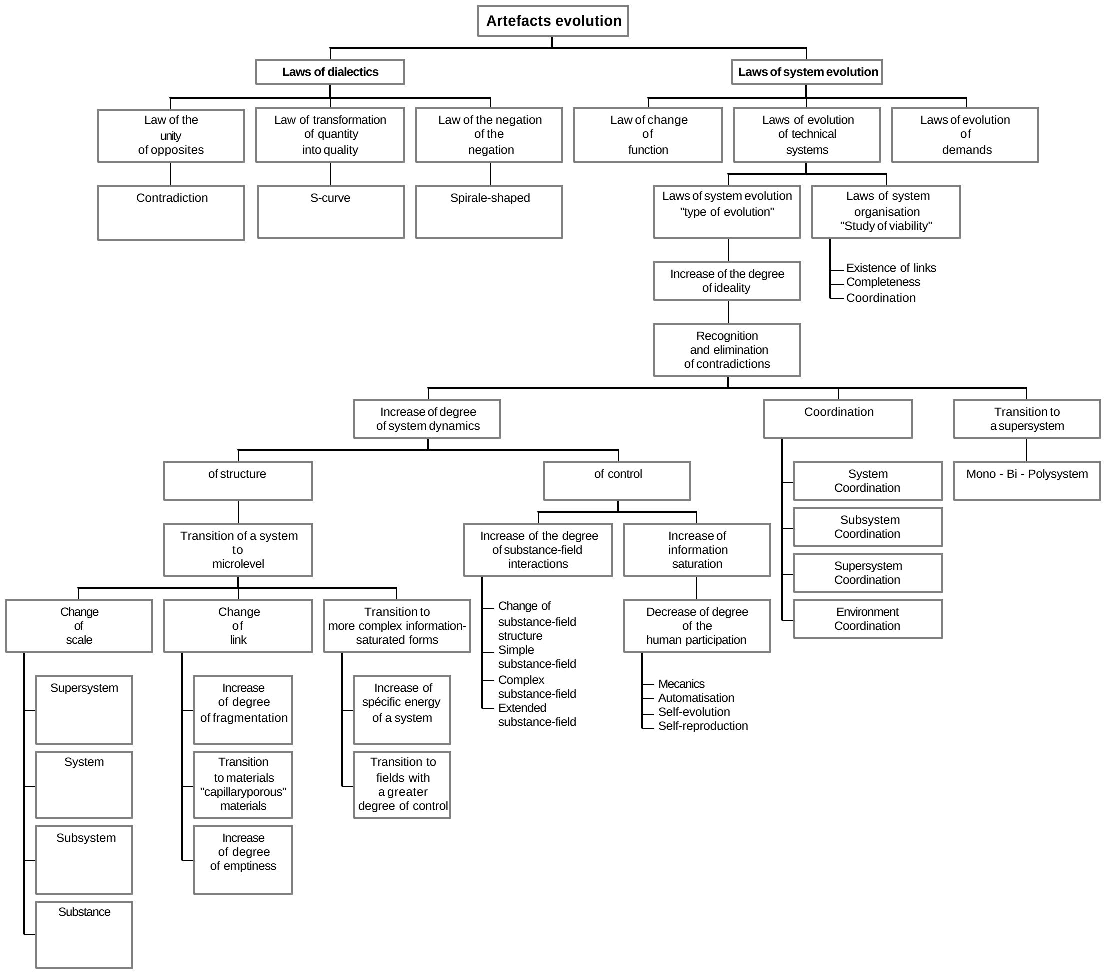


Figure 2. : Hierarchical organization of the main laws of evolution of artefacts, according to Vladimir Petrov.

4. An industrial experiment

4.1 Purpose of the experiment

To estimate the efficiency of the various methods of identification of the future generations of manufactured goods, the problem is analyzed as an innovation problem via the improvement of a legacy product.

We studied a problem concerning animal foodstuffs.

The foodstuff in question produces some tartar deposits on canine teeth, a major problem for dogs health. We modeled this problem diagrammatically by following the stages described in the proposed method [6], (cf. Figure 3).to identify possible future generations of this dog food.

4.2 Proposed method of identifying future generations of products by enhancing an existing

This proposed method of identifying future generations of manufactured goods [6], from the point of view of enhancing an existing product (cf. Figure 3), partially uses the characteristics of a tool, Innovation Work Bench™, which we describe in this article. We present the results of an industrial experiment in terms of ways of obtaining potential solutions, to present the advantages of this method but also its limits within the framework of a Research and Development activity.

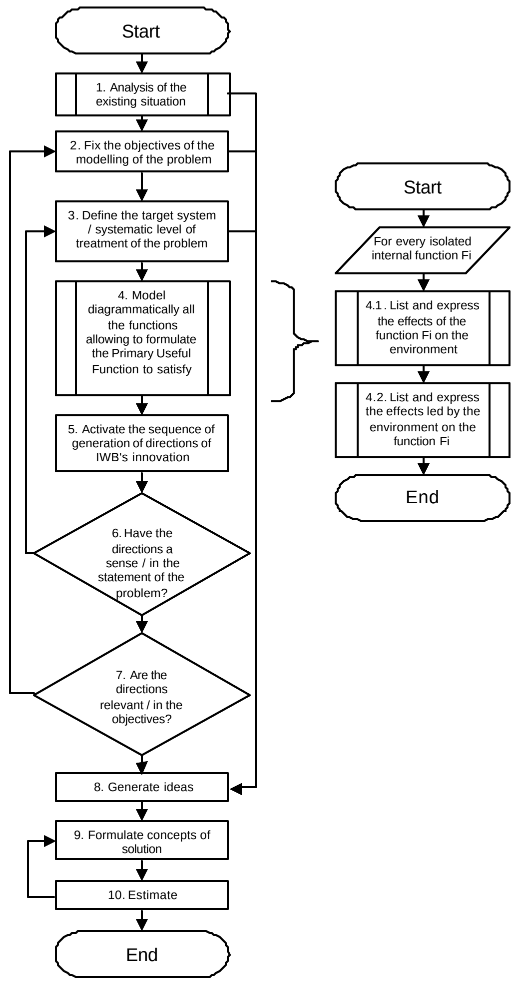


Figure 3. : Method proposed to model the problem of identification of the future generations of manufactured goods by enhanced of an existing product

The IWB™ method proposes a schematic diagram, a general guide only, of a proposal for the methodologic analysis of a technological problem.

Therefore, without utilizing the information contained within the IWB™ databases, we use this outline schema as a starting point only, to subsequently codify and integrate it in our self-developed algorithm.

This algorithm then constitutes a formalization of utilization, in fact a veritable “users’ guide and manual”.

4.3 Objectives and actions to be implemented in each stage of the method

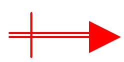
To clarify the objectives of each stage of the method (cf. Figure 3), we present below actions to be implemented these various stages.

- Stage n°1: enable the filling-out of an identification questionnaire dealing with the context of the system: " Innovation Situation Questionnaire " (ISQ)™.
- Stage n°2: the objectives of the session can be decided, in term of performances whether they are technical, economic, temporal, etc.
- Stage n°3: involves identifying a systematic level, as Le Moigne [9] described to define the limits of the problem. The situation 1 opposite, illustrates bad targeting of the problem making nonsense of the propositions of ways of innovation relative to the formulation of the problem.
- Stage n°4: leads to the implementation o f a sequence of systematic questioning [8]. For every expressed function (**P**rimary **U**sful **F**unction), the following eight typical questions can be put:

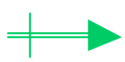
- "Does this function produce another function?"

- "Does this function cause a negative effect?"

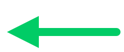
- "Does this function eliminate a negative effect?"



- "Does this function prevent a useful function?"

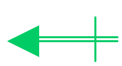


- "Is this function is produced by a useful function?"

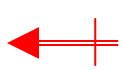


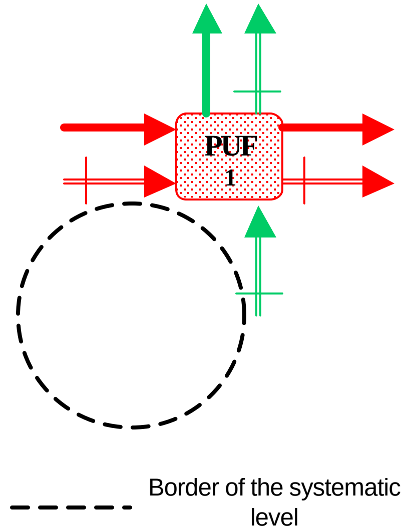
- "Is this function is caused by a negative effect?"

- "Is this function is eliminated by a useful function?"

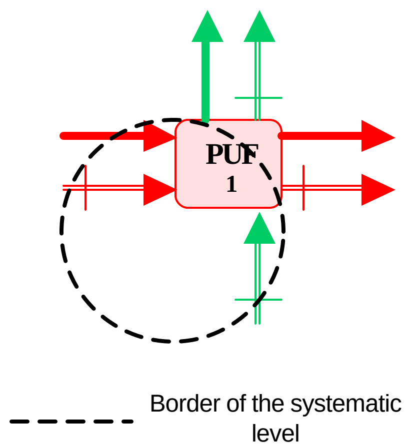


- "Is this function is prevented by a negative effect?"

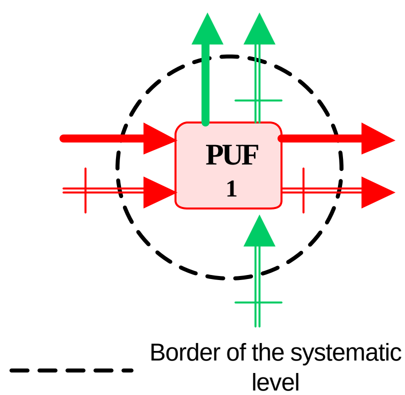




Situation **1**



Situation **2**



Situation **3**

- Stage n°5: uses one of the features of the Innovation Work Bench™ method which consists in automatically generating a set of tracks of coherent reflections with the achieved modelling.
- Stage n°6: this intermediate validation stage enables checking that modelling of the problem is well-targeted with regard to the bordary of the defined systematic level.
- Stage n°7: this second validation stage enables checking that the proposed ways of evolution the statement of the problem. Situation 2 invites the user to redefine their modelling in relation to the initial statement of t he problem whereas Situation 3 offers relevant and coherent grouped potential directions of evolution.
- Stage n°8: this stage, dedicated to the generation of idea, can spontaneously reveal itself during the first three phases of the method, but it should be systematically operated by the working party at the present stage [3].
- Stage n°9: consists in formulating global concepts of solutions of a system, it should be implemented by the working party.
- Stage n°10: this last stage enables the assessmnt of the concepts expressed in the stage n°9 from scientific and technical documentary knowledge bases.

4.4 Illustration

We implemented the proposed method during an industrial study in the field of agri-business. The systematic method we proposed (cf. § 4.2) allowed us t o obtain very detailed modeling of the problem (cf. figure 4).

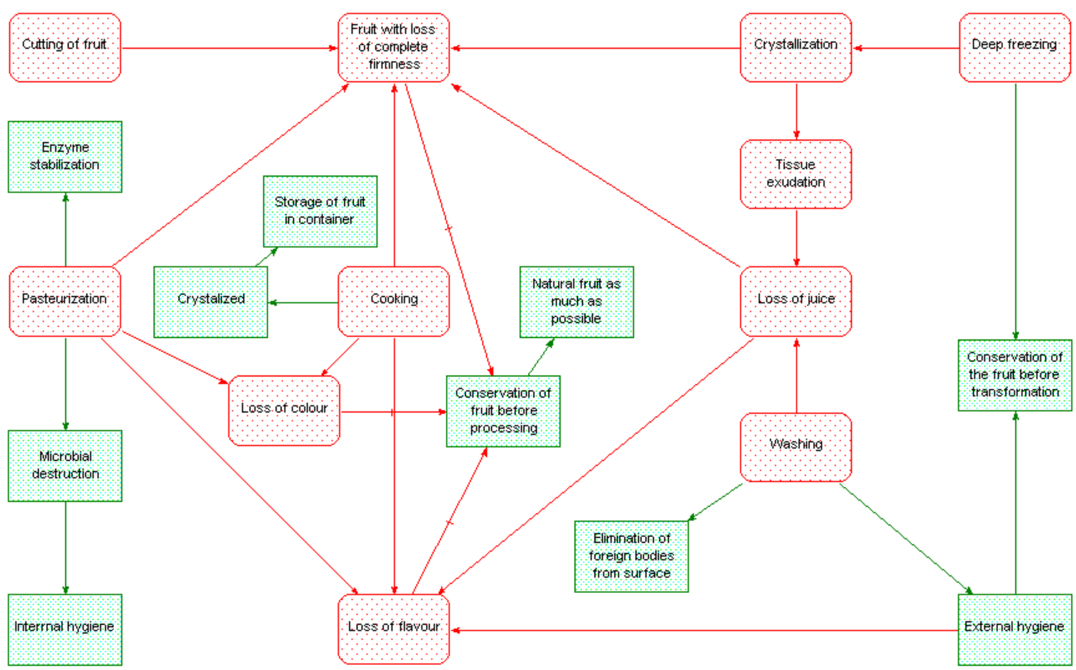


Figure 4 : Example of modeling of an industrial problem realized from the method proposed in § 4.2

4.5 Analysis of the results of the experiment

4.5.1 Results

Eight weeks were necessary for a team of five persons (no specialist of the dog food) to identify 32 tracks of reflection. These allowed to generate 212 possible ways of evolution. At last, our modelling allowed us to propose to the company about forty potential states of development to envisage their future generations of products. We used various data bases of physical effects of Innovation Work Bench™° and TechOptimizer™ to identify relevant concepts.

4.5.2 Conclusion of the experiment

- Key points:
  - The method of modelling of the statement of the need (cf. Figure 3) was validated with regard to preliminary analyses which we made (not presented in this document) on the following aspects:
    - reduction of the time of modelling by 30 % with regard to a manual treatment.
    - enrichment of the established model. This one allows to double the number of possible ways of evolution with regard to a manual treatment.
- Weak points:
  - the abundance of the tracks of proposed reflections imposes an important time of analysis.
  - the lack of tool of validation of the feasibility of the concepts identified in phase n°6 of the method compromises a little this one.

Where the problem in question does not required an important solution level, this method can be used. However, where the problem required a more important and innovative level of solutions, it would seem advisable to use the laws of evolution for which we propose another formalization of use [6].

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