Triz as a support methodology for new product development

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Abstract

Growing demands and rapid changes in markets compel organizations to think more about innovation and continuous improvement. Nowadays, any growth strategy, and even its own survival in the markets, is increasingly being applied by new approaches and management methodologies. The study developed in the scope of this paper focused on the approach and interpretation of the use of the TRIZ methodology, in search of new ways of solving problems, identifying their support tools. Another concept explored and related to TRIZ is the New Product Development (NPD). The present paper aims to approach the concept of TRIZ regarding NPD and the way they are related by following innovative doctrines appealing to creativity. Within this paper and through the analysis of the different fields investigated, a diagrammatic model was proposed contemplating concepts and relations between them. In order to analyze the feasibility of the implementation of this same diagrammatic model in an industrial environment, a case study was presented in a company that uses TRIZ, and through a conclusive analysis, it is verified that the proposed model can be used as support in solving problems of an innovative and creative nature inherent to the implementation of new management processes and their improvement.

Keywords: TRIZ, NPD, Lean, Innovation, Problem-solving.

1. Introduction

The Inventive Problem Solving Theory, better known by its Russian acronym, adapted to the Latin alphabet, TRIZ - Teoriya Resheniya Izobreten skikh Zadach - is a methodology specialized in the resolution of problems of an innovative and inventive nature, based on the study of them and the planning and implementation of solutions, based on the study of the patterns of circumstances in which problems occur.

It is a methodology widely used in the areas of engineering and management, having great importance in improving the effectiveness in the development of new products and improvement of existing products by the organizations. Contrary to what one might think, the TRIZ methodology is not based on the intuitive and spontaneous creativity of the individuals but demonstrates that the skills of being innovative and creative can be learned (Lopes, 2015).

The knowledge and application of this methodology becomes beneficial for a wide range of NPD market segments and continuous product improvement being a natural amplifier of innovative and effective decisions. TRIZ alternates critical thinking of the population in order to promote enrichment in decision-making and in dealing with the problems inherent in innovation (Savransky, 2000).

The market has increasingly shown its competitive, dynamic, changing nature, making it necessary for organizations to be efficient, effective, productive and flexible. Therefore, with high responsiveness in the least possible time, thus making a difference, companies that present more and better results, generators of
innovation. Therefore, it should be noted that through systematic product innovation there will be greater success in the acceptance of new or improved products by the market, and in gaining new segments. Being the TRIZ methodology, in a perfect connection with the success of the companies, increasingly, it can be seen that the simple application of good traditional engineering practices may not result in remarkable results, often having to make decisions about problems that occur naturally in an innovative organization and TRIZ being an asset to this type of occurrences, causing companies not to lose competitive advantage (Matos, 2017).

TRIZ, as it can be applied at both the product and service levels, can be applied in a variety of areas, such as risk management, product design/design, problem solving, business management, strategic planning, analysis of causes, research and development, technological forecasting, educational planning and, finally, public relations and publicity, among others (Kurosawa, 2014).

In short, TRIZ consists of the recognition that a system evolves towards the increase of ideality, through the resolution of contradictions, minimizing the introduction of new resources. It can be said that for the creative solution of problems, the TRIZ methodology provides a dialectical form of thinking.

Also, Zhang and Shang (2010) state that TRIZ is considered a kind of innovative theory, which works mainly by solving contradictions. This methodology, based on the evolution of technical systems, basically consists of several types of methods, calculations to solve technical problems, innovative exploration, etc. As the overall understanding of system resolution.

According to Soares (2008), the TRIZ methodology consists essentially of: 39 engineering parameters; 40 inventive principles; resolution matrix of contradictions 39x39; 76 standard solutions; the Inventive Problem Solving Algorithm (ARIZ); an engineering and effect knowledge base, and a series of methodological systems for understanding the problem and implementing its solution. This author also points out that TRIZ is based on the idea that all technical problems have already been solved in some way in the past, and that the principles inherent in their solutions are stored in databases resulting from the analysis of thousands of patents, which began to be required in the former USSR in the second half of the twentieth century.

2. The importance of TRIZ methodology in NPD

The success of organizations is increasingly related to the concept of innovation, which is increasingly seen as a moment of inspiration or a discontinuous and unpredictable occurrence, coming to be seen as a planned and managed activity. Companies are increasingly feeling the need for a continuous and systematic kind of innovation. This is crucial for increasing the efficiency of organizations, improving their competitiveness and profitability. In this context, the Lean philosophy presupposes a systematic search for continuous improvement of processes, by reducing waste and increasing efficiency. Lean can be applied in virtually all areas and functional activities of companies, making them more efficient and competitive, and therefore more apt to integrate NPD processes, namely those that use TRIZ methodology tools, as one of their means of support (Dias, 2015). On the practical level, TRIZ can be seen as a set of analytical tools that aid in the detection of contradictions in systems, in formulating and problem solving through the elimination or mitigation of found contradictions (Navas, Abreu and Dias 2016).

2.1. The TRIZ methodology and the concept of Innovation

Innovation can occur accidentally and/or through a "stroke of genius" or through the manifestation of some inspired element. However, after the development of the TRIZ methodological tool, it became possible to systematize the innovation itself (Dias, 2015).

As an alternative to accidental innovation, systematic innovation also occurred according to certain standards. This finding is in line with studies of the phenomena of complexity, where predictions are far less common, much less exact results: instead, patterns are detected in innovative problem solving. And such patterns were detected by Altschuller (1999), of the information obtained through the myriad of patents analyzed, applying them as a way of advancing the systems through their various evolutionary stages (Dias, 2015).

In general TRIZ is applied in the following way, according to Yang and Chen (2011): an inventive problem is reformulated into a generic TRIZ problem, and then the methodology tools are introduced to analyze and propose a general solution, which transforms it into a particular solution adapted to the concrete inventive
problem that gave rise to this process. Thus, a generic solution is interpreted to solve a specific inventive problem, as illustrated in Figure 1.

![TRIZ Methodology Diagram]

**Figure 1** - TRIZ process in problem solving. Source: Adapted from Matos (2017).

In 1946, Genrich Altshuller developed an approach to the theme of innovation levels and their measurement, since not all innovations are identical. An innovation can be a simple change to an existing product or, at the opposite extreme, the development of a technological system totally different from the ones that existed until then. Altshuller systematized the solutions described in patent registers, dividing them into five levels (Altshuller, 2001):

- **Level 1**: Routine solutions using methods well known in their area of expertise. This category constitutes about 30% of the totality. This level is not considered innovative.

- **Level 2**: Small corrections in existing systems using methods known in the industry. About 45% of the totality.

- **Level 3**: Important improvements that solve contradictions in systems typical of a given branch of industry. About 20% of the totality. This is where creative design solutions come in.

- **Level 4**: Solutions based on the application of new scientific principles. About 4% of the total. At this level the problems are mostly solved by replacing the original technology with new technology.

- **Level 5**: Innovative solutions based on scientific discoveries that have never been explored before. Less than 1% of the totality.

TRIZ assist in the elaboration of solutions of levels 2, 3, 4 and 5 where TRIZ tools can be a useful support, according to the level of innovation (Ramos, 2015). The five levels of innovation are shown in Figure 2.

![TRIZ Levels Table]

**Figure 2** - TRIZ tools incorporated in the 5 levels of innovation. Source: Adapted from Matos (2017).

The authors of the theory sought to exclude level 1 of the concept of innovation, so they have not developed
tools for this case, and that this is due to the fact that it does not make sense to apply TRIZ to products that already exist and will not be changed. The use of the TRIZ methodology in the fifth level of innovation for "new discoveries", is a more current and futuristic approach that points TRIZ as an important tool used in NPD, nowadays and in the future (Matos, 2017).

Levels 2 and 3 are classified as being "innovative" and level 4 of an "inventive" character. This does not mean that each level is better than the previous level, but rather different. But it can be considered a good level that allows solving the limitations of the system itself, bringing it closer to the ideal system. However, the higher the level of innovation, the more detailed is the analysis and the research, and the more expensive the NPD process or the implementation of improvements (Matos, 2017).

According to Navas, Abreu and Dias (2016), TRIZ aims to assist the development of projects and the solutions generate, especially in environments characterized by profound changes or based on the application of radical scientific discoveries, where the use of traditional engineering and management practices cannot produce remarkable results. The practice of traditional engineering attempts to solve such problems finding acceptable compromises, while TRIZ aims to eliminate such a commitment. TRIZ seeks to overcome these conflicts through the application of creative solutions.

The TRIZ methodology is based on the following grounds (Navas, Abreu and Dias, 2016):

- Ideality;
- Contradiction;
- Resources;
- Systematic Approach;
- Functionality.

The TRIZ methodology can be seen and used at various levels. At the highest level, TRIZ can be seen as a science, as a philosophy or a way of being in life - a creative way and a permanent quest for continuous improvement (Navas, Abreu and Dias, 2016).

### 2.2. The TRIZ methodology integrated in LEAN Philosophy

The Lean philosophy has been adopted by a number of industrial sectors, increasingly moving away from the approach focused solely on reducing office waste and reducing costs, to a new approach that seeks to increase consumer value by introducing new products or features and the elimination of superfluous activities (Machado and Tavares, 2008).

Lean production is focused on the flow of value that gives rise to products, aiming at maximizing value and eliminating waste, optimizing the entire process and not only of its constituent parts. The idea is to make the value circulate continuously throughout the organization, reaching the consumer as soon as possible (Matos, 2017). Figure 3 shows the principles of the Lean philosophy.
Figure 3 - Principles of Lean Thinking. Source: Adapted from Matos (2017).

The Lean philosophy is based on five fundamental principles (Womack and Jones, 1996):

1. **Value** - Specification of the value of a particular product that the customer really wants, that is, the characteristics and functionalities of the products that satisfy the customers' needs and expectations must be identified - quality, quantity, time requirements and service.

2. **Value Chain or Stream** - Identification and analysis of the flow of value for each product. It is translated by the sequence of activities and processes involved in the sequence of processes involving the product, which must be analyzed and defined. Consequently, activities that do not add value to the product should be identified.

3. **Flow** - Establishment of a continuous flow of value. Once the value chain and its wastes are identified, the organization must create a continuous flow, which is characterized by the ability to produce only what is needed for the moment.

4. **Pull** - Let the customer "pnavasull" the product through the implementation of the Pull system. This production system tries to let the customer lead the processes, that is, it allows production only when the order is made by the customer. So this is the only way to produce just what is needed and when needed, because only what the customer really wants is produced.

5. **Perfection** - Seek for perfection. After applying and upholding the above principles, the organization must constantly seek innovation and continuous improvement, and consequently perfection in the processes of waste disposal and value creation. In this way only activities that add value must be present in the processes.

Given the above principles, the main goal of the Lean management paradigm is to increase value creation by reducing waste, which means, creating more value with less resources. A Lean organization understands what constitutes value for the customer, and from that definition, focuses on the key processes to increase it. The ultimate goal will be to create a perfect process of creating value for the customer, continuously seeking improvement (Domíngues, 2013).

Lean thinking should encompass all employees in the organization, sometimes requiring significant changes in attitudes and behaviors. Lean leaves deep marks both in organizations as well as in people who work and
collaborate in them. A Lean thinking environment requires a "learn to see" approach, with the goal of finding obstacles (wastes) that need to be removed. At the beginning of Lean implementation, a large majority of improvements can be achieved with relatively simple solutions. With the advancement of the Lean implementation process, the growing need for truly innovative solutions is emerging, and radical changes are sometimes necessary (Machado and Tavares, 2008).

The TRIZ methodology has a set of different analytical techniques and instruments, which can be used together or separately, in the generation of solutions for detected problems or in the analysis of failures. Several Lean techniques and concepts can be used in conjunction with TRIZ instruments. As a potential solution generator, TRIZ will be able to assist in the creation and development of Lean Management environments. The combination of Lean's analytical tools with TRIZ's innovative capability can bring significant benefits to organizations (Machado and Tavares, 2008).

TRIZ does not compete with other methodologies nor does it intend to replace them, but can be used to highlight its weaknesses, and can synergistically complement other methodologies, namely Lean.

In analyzing the topic, Radeka (2007) identifies a parallelism between TRIZ and Lean. The first step in solving a problem with TRIZ is to analyze the problem, trying to find ways to frame it, in order to create an ideal solution. Through TRIZ it is sought that the problem has an ideal end result, that is, a solution that avoids unnecessary waste and damages. As an example, in the automotive industry, the ideal end result is the customer-ready automobile, without it having to think about the quality, labor, raw material or supply chain involved. This is a result that falls within the scope of Lean practice, namely the fifth principle of Lean thinking – perfection (Radeka, 2007).

Lean is popular within many organizations, and is perhaps the main innovation tool for most. Many top management elements have resorted to Lean, and many engineers have been looking for specific training in this area. But there is the notion that TRIZ can complement the weaknesses of the Lean. While the Lean is efficient in finding problems that need solving, TRIZ is quite effective in overcoming the contradictions (Radeka, 2007).

3. Successful Case of application of the TRIZ Methodology

This case regards a configuration of a low-pressure chemical vapor deposition (LPCVD). In a work published by Robles et al. (2009) it is shown an example of improvement success according to the use of the TRIZ methodology, and the tool used was the matrix of contradictions. According to Figure 2 it can be seen that this improvement corresponds to a level 2, being highlighted as a "small improvement" in the classification of the inventive levels.

An example of the use of the contradiction matrix relates to chemical reaction deposition during the fabrication of electronic components. Chemical vapor deposition (CVD) consists of contacting substrates with one or more reactive gases. The gas chemically reacts to deposit a solid film on substrates. One way of producing microelectronic components is to use a low pressure chemical vapor deposition reactor: (LPCVD) with a vertical configuration (Figure 4A).

In analyzing the development of the reactor, the authors verified that several disadvantages have arisen related to the performance and configuration of the reactor. A contradiction is identified to improve the quality of the deposition of a silicate film on small fins; the space between the fins should be large to permit complete circulation of the gases between the fins and efficient deposition of silicates.

As a result, the number of fins within the reactor is very low affecting productivity. The problem is stated as "increasing productivity in the reactor without radically changing its shape". The two parameters for the generic problem are as follows: "Productivity" to be improved, but it degrades the "Form" of the system.

The use of the contradiction matrix provides four inventive principles in the following hierarchical order: 14 (sphericity), 10 (previous action), 34 (rejection and regeneration pieces) and 40 (composite materials). Next, was selected Principle 14 "sphericity" which is decomposed into 3 sub-principles:

- Replace linear parts or flat surfaces with curves and cubic shapes by spherical shapes;
- Use rollers, spheres, spiral domes;
Replace linear motion with a rotating motion (use the centrifugal force).

One interpretation of this principle is to change the shape of the useful work area; should be spherical. This solution is shown in Figure 4B. The new reactor has a capacity of 90 fins, while the initial one has a capacity of only 25; consequently, productivity is radically improved.

![Figure 4 - Reactor capacity of 25 fins (A); Ballast with capacity for 90 fins (B). Source: Robles et al. (2009).](image)

4. Case Study

The objective of this study was to evaluate the applicability of the TRIZ methodology in an Industrial environment in Portugal. To this end, a Portuguese SME (small medium enterprise) of renown in the metalworking sector was selected. Its mission is to manufacture products and commercialize services in the field of metal mechanics and HVAC systems (heating, ventilation and air conditioning), which aim at total customer satisfaction and which are distinguished by their high level of quality, which is one of the main values adopted by the company, together with the valorization of its human resources, loyalty to its partners (suppliers, customers, employees, etc.) and collaboration for an improvement of the environment.

About company’s most significant management strategy, it can be concluded that it is its relationship with its suppliers and customers, which distinguishes it more from its competitors: in this context, the company can be characterized as an organization which, through customer requests, always works in order to obtain the best results of processes for the production of an established product, always trying to avenge in the market, since the involvement of suppliers and customers in the planning and production processes, make the final products meet the pre-defined requirements as much as possible and can avenge in the market.

With the customization of the products manufactured, the company works according to the specific requests of its customers, and with a very competitive quality/price ratio. Thus, customers do not seek other companies over this one, nor does it produces new products without being at the request of its customers. Involvement of suppliers helps a lot in meeting product requirements.

In terms of company management at the process level, the company has the conditions and needs to choose the use of the TRIZ methodology to improve or solve a problem, so it was founded that the main sectors affected in the company with TRIZ implementation were reflected in: warehouse management; quality management and production management, which contribute to many improvements, and the TRIZ tool used in problem-solving processes is the Matrix of Contradictions.

These improvements have a huge impact, because being applied in the process surroundings, consequently there are associated improvements. The fact that there are improvements in the warehouse management allows to obtain improvements in the organization of the stock and reduce production times that will have advantages in productivity and reduction of costs, taking advantage of the value of the TRIZ methodology in a Lean way of working.
5. Conclusions

Organizations need to have analytical tools appropriate to the implementation of systematic innovation and increased creativity. In this field TRIZ is applied in the NPD, as an innovation tool that allows finding innovative and creative solutions to problems in an efficient and effective way.

The general procedure of the TRIZ methodology begins with the identification of specific problems. These are then transformed into generic problems, in which generic solutions are subsequently selected for each problem. And finally, these solutions are tailored to specific problems, identified initially, resulting in innovative and creative solutions. Through the tools of support of the TRIZ methodology, it is possible to outline tasks, make a structural analysis, identify and formalize the contradictions and, finally, find solutions. Thus, through this methodology, it is possible to benefit the various functional areas of industrial companies.

About the TRIZ methodology, the advantage that seemed to be the most striking was its great simplicity of application, resulting in creative and innovative solutions. Since its application area is much more comprehensive than what concerns mechanical systems, it is possible to apply the TRIZ methodology in a wide range of branches of activity and functional areas, within organizations, starting from their generic standard solutions.

Through the case study carried out for this paper, it was concluded that the company studied currently applies the TRIZ methodology in warehouse management, and with that has obtained good results in solving innovative and creative problems inherent to stock management processes by using the Matrix of Contradictions.

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