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INNOVATIVE METHODOLOGIES IN MECHANICAL DESIGN: QFD VS TRIZ TO DEVELOP AN INNOVATIVE PRESSURE CONTROL SYSTEM

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ABSTRACT

A mechanical device to control kart's tire pressure was developed. This valve must blow air when temperature's tire and pressure rise with a not acceptable shape deformation and a corresponding modification of the vehicles trim. With the new solution, drivers can drive faster and more safely. Two design methods have been utilized: QFD and TRIZ. The first one, Quality Function Deployment, offers a clarification tool for organizing the information flow in a structured way, and TRIZ, Theory of Inventing Problem Solving, is an efficient tool in the discovering the solution principles. With TRIZ's Table, technical and physical contradiction are put in evidence and eliminated to improve the robustness of the device. The two methods interact one another and offer the best path for the development of a new design.

Keywords: innovative methodologies, QFD, Triz.

INTRODUCTION

The aim of the present paper is to apply an innovative designing method, named TRIZ , compared with another method already studied and analyzed for years by our research group and not only: QFD. To solve this task, we started to study both methods at theoretical and practical levels [1, 2, 3].

To compare method's results we build a specific project structure, to organize any activity involved in the work, then, we started with a design concept of a simple mechanical device linked with kart's wheels pressure.

At the end of the work we applied some concepts about cost analysis, design for manufacturing and design for assembly and we compared both methods in order to launch a proposal to link QFD and TRIZ in a third and more powerful design method.

Work plan

At the beginning, we developed an activity list in order to see project's timing. We built the list (WBS- work breakdown structure) and its Gantt diagram (Figure-1):

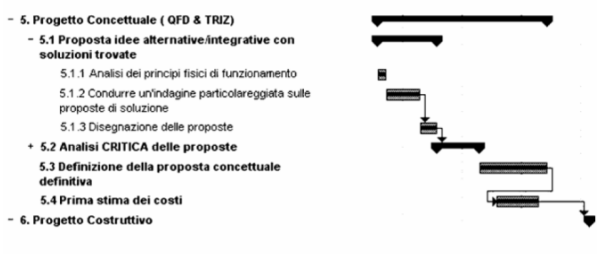

Figure-1. Detail of activity list and Gantt.

Any activity is completed with starting and ending date, percentage of complement and so on, in order to maintain under control our projects development. This kind of project management is very powerful for works like the present one, where some steps of the project needs to be repeated and compared [4].

Description of the problem

The second step of the work was the analysis of mechanical problem to solve with our two methods. We studied and try to give a concept solution to a problem linked, in the present example, to kart's wheel pressure. We can try to improve vehicle's performance controlling tire's pressure, parameter which changes during races, test runs and so on. If we develop a device to maintain this pressure at the same value all the time, a driver can drive faster and safer; moreover, we should develop an object conform to races rules and so on.

Physical analysis

Before starting any kind of project, we perform a physical analysis to see what kinds of parameter were involved in this problem. In this analysis, we discovered that tire's temperature and pressure were linked to friction and wheel shape. In the diagram (Figure-2) we can see that in one test run tire's pressure is right only inside the rectangle, so control is needed in the beginning and in the end of the race.

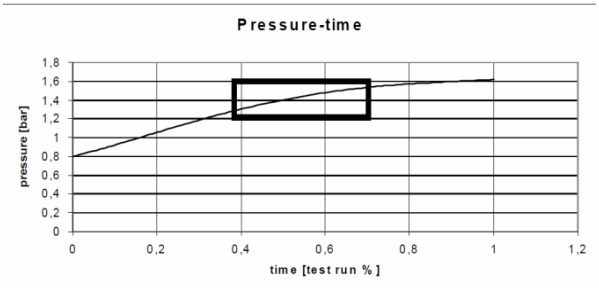

Figure-2. Physical analysis.

Commercial valves analysis

Next phase of the work is about the analysis of commercial solution regarding pressure valves and so on. We studied some catalogues to see what kind of products

we can buy and related working principles. We built some Tables to list any kind of solution found and to relate anyone to our task.

We found that there is a lot of solution, but any of them cannot be used in our project. So we must develop a new one.

METHODS - QFD

Background

Quality professionals refer to QFD by many names, including matrix product planning, decision matrices, and customer-driven engineering. Whatever you call it, QFD is a focused methodology for carefully listening to the voice of the customer and then effectively responding to those needs and expectations.

First developed in Japan in the late 1960s as a form of cause-and-effect analysis, QFD was brought to the United States in the early 1980s. It gained its early popularity as a result of numerous successes in the automotive industry [5].

METHODOLOGY

In QFD, quality is a measure of customer satisfaction with a product or a service. QFD is a structured method that uses the seven management and planning tools to identify and prioritize customers' expectations quickly and effectively.

Beginning with the initial matrix, commonly termed the house of quality, depicted in Figure-3, the QFD methodology focuses on the most important product or service attributes or qualities. These are composed of customer wows, wants, and musts. (See the Kano model of customer perception versus customer reality.)

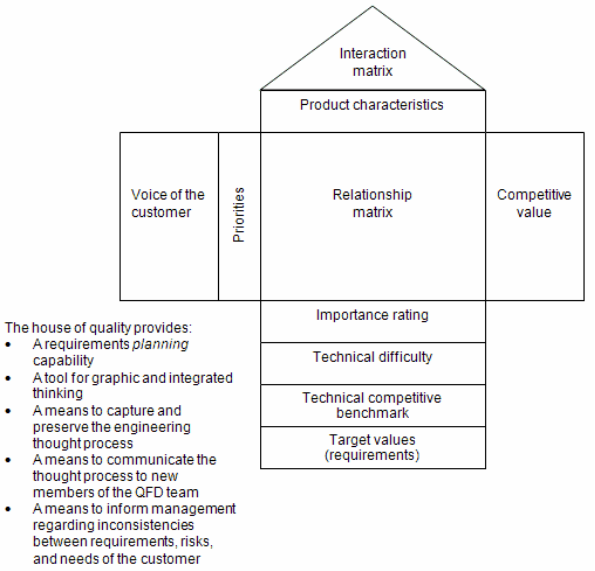

Figure-3. House of quality.

Once you have prioritized the attributes and qualities, QFD deploys them to the appropriate organizational function for action

Thus, QFD is the deployment of customer-driven qualities to the responsible functions of an organization.

Many QFD practitioners claim that using QFD has enabled them to reduce their product and service development cycle times by as much as 75 percent with equally impressive improvements in measured customer satisfaction.

Quality Function Deployment is a method which analyzes products environment, customer needs and can explain some parameters to reach a higher level of quality of our product. It starts with an analysis of customers, then with some matrixes (interrelation, relation and so on) can explain what parameters need to be deployed to obtain the right device.

In the present work, QFD analyzes the following parameters:

- safe
- reliability
- simple use
- race rules conformity
- costs

We can see that the above parameters are quality ones, not technical ones. The reason because this method is developed to obtain an improvement of quality in our device.

With these indications, we start to build technical specifications and we obtain the first device (Figure-4).

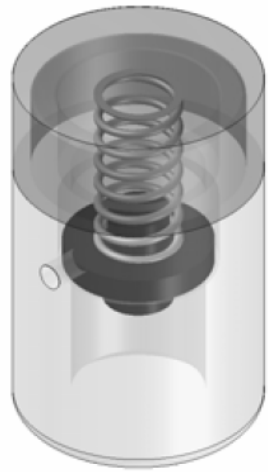

Figure-4. QFD obtained device.

In the picture we can see the device obtained by QFD. It is a simple pressure valve but as small in order to be able to be installed directly on the wheels, in the place of the usual cap. It works with a shutter and a spring, like any other solution.

Methods - TRIZ

Background

Projects of all kinds frequently reach a point where all the analysis is done, and the next step is unclear. The project team must be creative, to Figure out what to do. Common creativity tools have been limited to brainstorming and related methods, which depend on intuition, fiat and the knowledge of the members of the team. These methods are typically described as psychologically based and having unpredictable and unrepeatable results [6].

METHODOLOGY

TRIZ is a problem solving method based on logic and data, not intuition, which accelerates the project team's ability to solve these problems creatively. TRIZ also provides repeatability, predictability, and reliability due to its structure and algorithmic approach. "TRIZ" is the (Russian) acronym for the "Theory of Inventive Problem Solving." G.S. Altshuller and his colleagues in the former U.S.S.R. developed the method between 1946 and 1985. TRIZ is an international science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. More than three million patents have been analyzed to discover the patterns that predict breakthrough solutions to problems.

TRIZ is spreading into corporate use across several parallel paths - it is increasingly common in Six Sigma processes, in project management and risk management systems, and in organizational innovation initiatives.

TRIZ research began with the hypothesis that there are universal principles of creativity that are the basis for creative innovations that advance technology. If these principles could be identified and codified, they could be taught to people to make the process of creativity more predictable. The short version of this is:

"*Somebody someplace has already solved this problem (or one very similar to it.)*

Creativity is now finding that solution and adapting it to this particular problem."

The research has proceeded in several stages during the last sixty years. The three primary findings of this research are as follows:

a) Problems and solutions are repeated across industries and sciences. The classification of the contradictions in each problem predicts the creative solutions to that problem.
b) Patterns of technical evolution are repeated across industries and sciences.
c) Creative innovations use scientific effects outside the field where they were developed.

Much of the practice of TRIZ consists of learning these repeating patterns of problems-solutions, patterns of technical evolution and methods of using scientific effects, and then applying the general TRIZ patterns to the specific situation that confronts the developer. Figure-5 describes this process graphically.

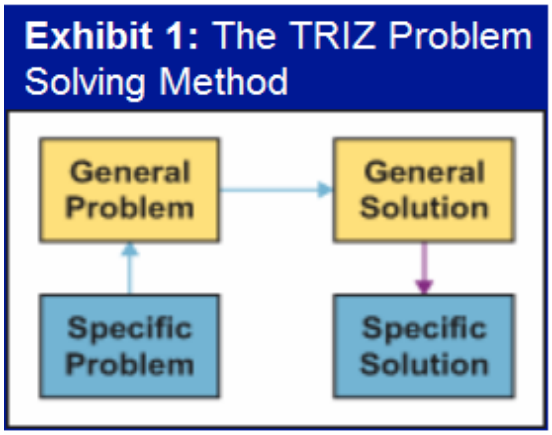

Figure-5. The TRIZ problem solving method.

TRIZ, "Teoriya Resheniya Izobretatelskikh Zadatch" or "Theory of inventive problem solving" is a method who can be used in any kind of subject, from mechanics to economy, etc… Is a very powerful instrument and we applied that with his software CAI: Techoptimizer.

The first task of this method is the formulation of the "Ideal Final Result", the final objective of the work. Than, with this result we can deploy a functional analysis and than we can start to solve problems we face in the work.

With software we built a functional diagram (Figure-6) where we set any component of the valve-system and we set relations between them.

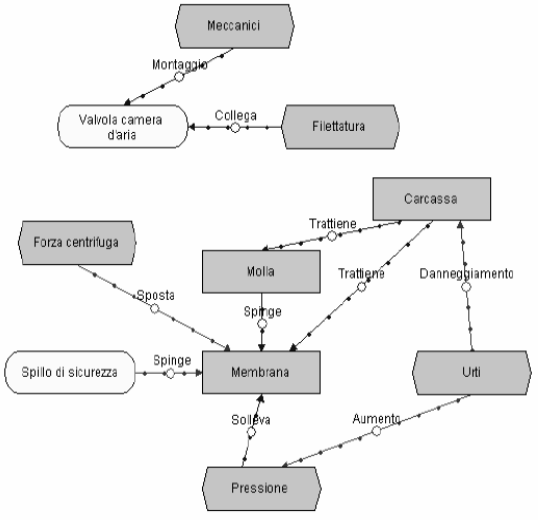

Figure-6. TRIZ analysis.

In this diagram we set any kind of relation, good and harmful, and we set how these relations interact with parameters of the valve, project parameters and so on.

Then we started solving any problem of the project. In the field "problem manager" (Figure-7) we found any problem linked to our project ordered by seriousness.

TRIZ suggest to solve problems comparing them with patents database, effects database and so on, to find out some conceptual solution to use.

When this is impossible TRIZ offers 40 principles of solution, ways to solve problems without creating new contradiction.

In this work TRIZ developed these parameters to improve:

- hostile environment resistance
- precision of the device
- reduce dimensions of the device
- material choices
- simplify production and assembly

We can see that this is technical parameters, so we thought to unify technical specify of both methods.

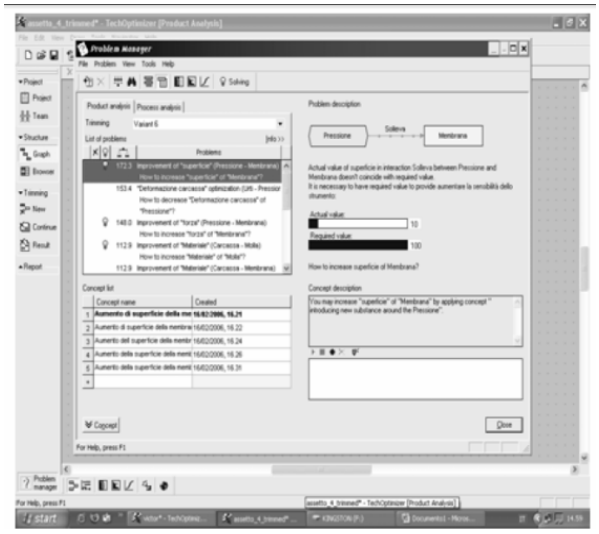

Figure-7. Problem manager.

Project optimizations

To conclude this work we applied some project optimizations:

- costs analysis
- design for manufacturing
- design for assembly

With this improvement we developed a device with few components and with good solution for automatic production. With cost analysis we found that materials are the most heavy component of the price of the valve, so the component to reduce to obtain a good price for customers. This kind of methodological optimization can be applied to every kind of projects: industrial design, mechanical design, electronic engineering, civil constructions, etc. [7-17].

CONCLUSIONS

We found that both methods developed a device conform to specifics of the project, so QFD and TRIZ are very useful instruments for mechanical design. TRIZ in particular is very powerful and strong but isn't too easy to use.

QFD is a method to improve quality aspects of the devices; TRIZ instead is dedicated to the solution of the problems. QFD studies customers needs instead TRIZ thinks that an innovative product can satisfy users.

We found that QFD and TRIZ can be integrated to generate a third designing method. Both can be used in some sort of sequence. First QFD, with his analysis, than TRIZ with his method to solve problems.

In any case method order can be changed to avoid any waste of time and organization in the project.

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