HOW TO TURN AN INVENTION INTO AN INNOVATION ?
AN APPROACH BASED ON A REVERSE USE OF TRIZ*

NGASSA Armand, BACHELET Rémi*, TRUCHOT Patrick ***

** Equipe de recherche en génie industriel (ERGI)*
Laboratoire Centrale de Génie Industriel de Lille (LCGI)
Ecole Centrale LILLE - Cité scientifique
BP 48 – F 59651 Villeneuve d'Ascq cedex, France
*** Equipe de Recherche des processus Innovatifs (ERPI)*
Laboratoire de Recherche en Génie des Systèmes Industriels de Nancy (LRGSI)
ENSGSI, 8 rue Bastien Lepage
BP 647- 54010 Nancy cedex, France
armand.ngassa@ec-lille.fr

Abstract : The normal course of a design process starts from the expression of a need and tries to address it and fin a solution for it. Our paper deals with the opposite question "once there is a solution, how to find the problem"? When a researcher or a lab makes a finding he is faced with a new challenge: finding to what problem, to what need it can be applied.

This question has been the subject of many contributions, most noticeably in history of technology, economy and sociology of innovation. However these contributions are often of little help in the actual process of technology transfer.

Our paper pinpoints the different way in which this "problem-finding" question can be tackled. The new approach we suggest is an upside-down use of TRIZ. This action consists in considering the new material as a specific solution, going back to its related class of generic solutions and, thus, finding the kind of problems it corresponds to. Once this had been done, we suggested the use of other tools, like patent monitoring, in order to find out the domains in which similar problems appeared.

Our research is based on a case study at a laboratory in material science, where we helped the researcher to detect applications fields for a newly-invented material.

Keys words: Creativity- Technology transfer – TRIZ – innovation – TechOptimizer

Introduction

Continuously bringing innovations to the market is widely recognized as a key issue for the profitability and survival of firms nowadays. Modern times have seen the development of a series of methods aimed at assisting new product design.

In many situations, innovation is linked to the research works. That is the reason why many companies invest lot of money in research and development. This mechanism of knowledge transfer from a research organism to the companies has been studied a lot in literature (Fransico Uchua et al 2002). However, in the case of advanced research, results are often far away from the possibilities of industrial application. Thus, some of these innovative research

* *Teoriya Resheniya Izobretatelskikh Zadatch*

results are given up by researchers because they do not find the correspond to industrial needs.

The intention of our proposal is to show how the combined use of TRIZ and technological monitoring could allow to solve this obstacle. TRIZ, which was created in 1946 by Genrich Altshuller is the Russian acronym of an expression meaning "Theory of the resolution of inventive problems" (*Teoriya Resheniya Izobretatelskikh Zadatch*).

TRIZ fosters a structured approach which is both compatible with:

- the analytic approach of an engineer
- the creativity required for design

TRIZ is also very useful in quickening and shortening the design cycle.

The numerous international articles published on TRIZ reveal that it offers a great potential for generating innovations. They are most often based on industrial case studies implementing Altshuller's reasoning (Altshuller, 1988):

- In order to solve a specific problem, it is necessary to reformulate it as a generic problem.
- To every category of generic problem, there is a class of generic solutions.
- The designer must re-interpret the generic solution to find a specific, actual solution to the specific problem.

Now our question is: does TRIZ allow not only finding specific solutions to specific problems, but also to revert to the specific problems matching a specific solution? Our literature review on this subject highlights two ways of tackling did not lead us to any existing study of this possibility. This paper is dedicated to introducing and explaining a new method, which we shall name "reverse TRIZ".

The essentials of TRIZ

In order to design TRIZ, G. Altshuller and his team studied tens of thousands of patents (2.5 million have been analyzed today). Their purpose was to identify the general schemes determining process of inventing. Some concepts and analytical tools were created in order to explain what Altshuller named "inventive problems". These concepts, along with certain rules are the essence of any inventive problem (Kim,2000, Cavallucci 2002). Using TRIZ's tools within this framework will increase the creative potential (Royzen, 1993, Greek, 1999).

Let us point out two concepts :

- ❑ ***Identification of a contradiction :*** a contradiction arise when improving a parameter (called « A ») worsens another parameter (called « B ») (see figure 1). This contradiction can be lifted through a series of principles or recommendations, which are a generalization inferred from the study of patents. This will help finding a solution to the problem without making a compromise. Solutions generated in this manner show a high level of inventiveness.

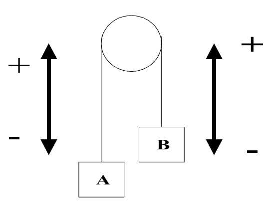


Figure1. Identification of a contradiction

- ***The contradiction Matrix :*** the findings of G. Altshuller shows that there is a limited number of inventive principles : all in all there are no more than 39 inventive principles (numbered 1 to 40). Now the problem is to formulate a problem as a contradiction between these 39 inventive principles. This is done in the form of a 39X39 contradiction matrix with each matrix cell crossing each improving feature with each worsening feature. Writing down the matrix related to a specific problem reveals a framework of generic situations. Each generic situation has been solved in the past and can be solved again using the same ways that were successful before (Altshuller,1988).

An introduction to Reverse TRIZ

One of the main objectives of reverse TRIZ is to fight against what Altshuller called psychological inertia. Psychological inertia is a kind of self-limitation or self-censorship in the search for solutions. Our goal is to track innovative ways of solution, since designer has a natural bias toward exploring only the fields of expertise that are already know to him (Altshuller, 1988, Rosenau, 1998).

The tools and concepts we shall use are those developed by Altshuller, but we shall use them in a different way: The original research of Altshuller aimed at finding solutions for problem using a procedure as shown in figure 2 below.

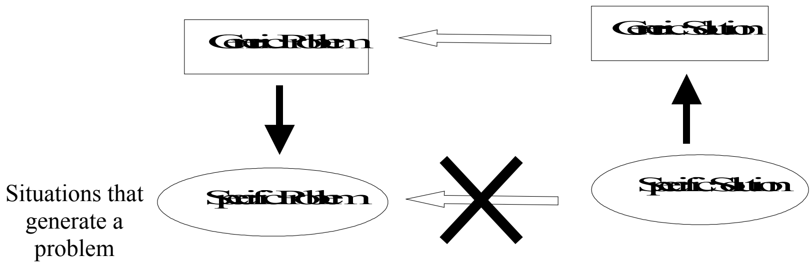


Figure 2. Principle of reverse TRIZ

Through application of this principle, the designer is able to turns a specific problem into a generic one. Once this is done, he is able to use a second category of TRIZ tools.

These tools help identifying generic solutions through a database containing a series of physical principles and examples that are instrumental in passing from a generic solution to a specific solution that can be applied (weeb, 2002).

The big change we are proposing means using this last phase "the other way round" instead of finding solutions to a problem, we want to find problems matching an existing solution.

In our experiment, we have considered the shape memory alloy as a solution. We are trying to find what kind of industrial problems could be solved using Reverse TRIZ (figure 2). We are not opposed to the original TRIZ method, but using it differently (Ngassa and al, 2002).

Application of Reverse TRIZ: Introducing the problem

The physic and mechanics lab (LPMM) in Metz, France has developed a new industrial process. This process produces a thin layer of shape memory alloy (SMA). SMAs are materials which have the ability, after deformation, to return to their initial shape. This change occurs as a phase transition, as soon as the heated alloy reaches a "critical temperature". When this transition occurs, the SMA exerts an interesting amount of force, which is usable in a whole range of situations.

Thus we have an invention displaying specific properties, but no known industrial applications.

Le LPMM lab has requested help from the industrial engineering lab (LRGSI) in order to work out a panel of industrial applications to these thin layer SMAs. We have taken this request with the objective of testing Reverse TRIZ.

Thus the objective of our study is to point out a series of industrial applications for a whole range of thin layer SMAs, each SMA displaying its own special set of properties.

In order to reach this goal, we have to:

- establish an analysis of technological needs in the current industrial environment,
- seek out existing industrial applications for these materials
- envision the creation of innovating activities.

On the basis of these results, it will be possible to start a market research in order to evaluate the actual needs as well as the conditions for selling on these markets.

Experimental protocol

Figure 3 shows a step-by-step account of our Reverse TRIZ experimental protocol. These protocols have been tested during this study. After this testing phase, we found it useful to write them down and express them as an occurrence of a generic method.

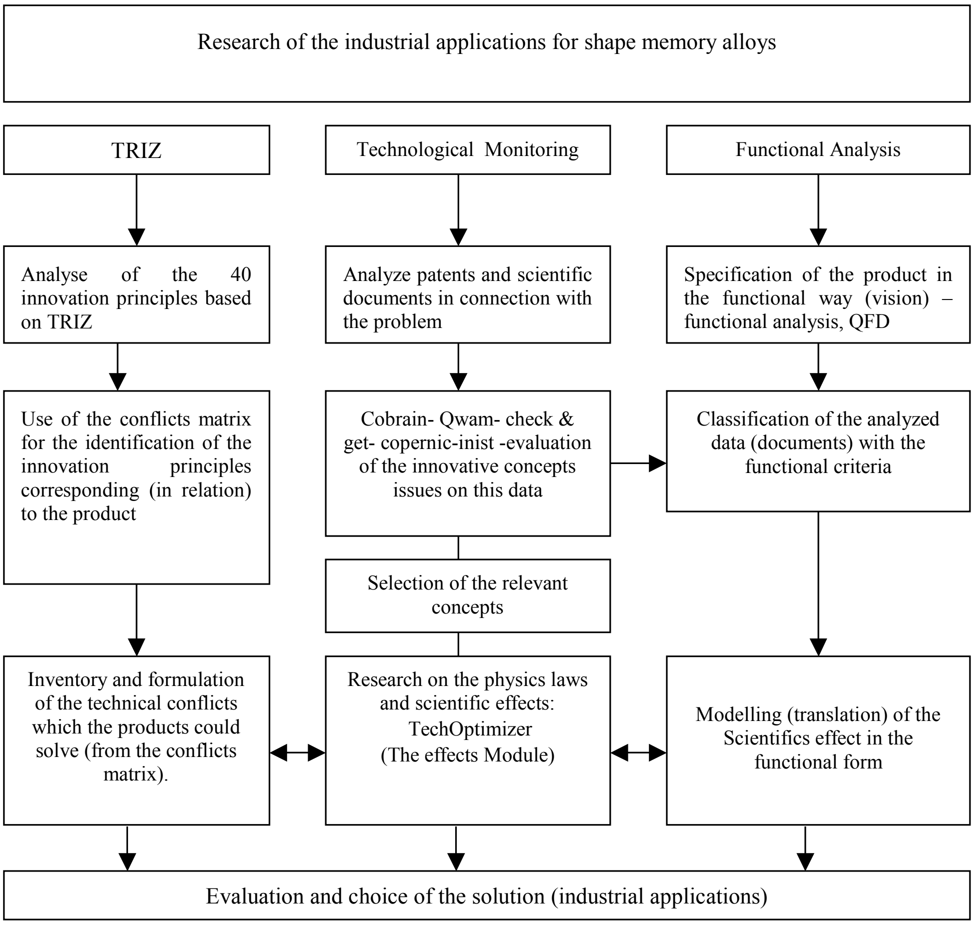


Figure 3. The experimental protocol

We wil at are instrumental in implementing each of them.

We characterize 4 steps :

Step 1 : Collecting and analyzing starting information

The initialization phase consists in gathering all the pieces of information in order to reformulate our problem. In this stage, we aim at expressing the problem as a series of cause-effect relationships for functions which can later turn out to be either desirable or prejudicial. The invention is the subject of a functional analysis and it points out ideas for further research.

The "*Institut National Polytechnique de Lorraine*" (INPL) owns several documentary databases and patents which support a bibliographical research that can be accessed via the internet. On the topic of SMAs, we have been able to fetch more than 160 papers in French and English. A research on these documents with the help of Knowledgist* brings forward other concepts that can be the starting point for further research.

The another tools we implemented in this stage were Functional Analysis and Quality Functions Deployment. This choice was justified by the vision they provide: they do not see the problem as an object but through his role and functions (Baessler and al, 2002,Yamashina and al, 2002).

During this stage, we also visited the LPMM laboratory in order to gather the basis existing concepts and ideas on this particular alloy, as well as its physical and chemical characteristics. After this visit, we were able to establish a functional structure with main and sub functions as well as functional constraints. Each function leads to a specific research and help see the problem in a new manner. Theses tools also allow looking at all sides of the problem, thus avoiding missing important innovations.

The table pending displays a sample of the main functions that our invention can satisfy:

Chart 1 : Extract of the QFD matrix

Function	Origin
To change the form	Temperature
To change the dimension	Temperature
To provide a mechanic work	The memory effect zone (deformation)
To conduct electricity	Electric conductibility
To conduct the heat	Thermic conductibility

Having these functions, which we shall consider as “specific solutions” from a TRIZ point of view, we can research the matching generic solutions.

Using this two-step approach of papers analysis and concept research, we have been able to find several hundreds of concepts.

The next stage was to evaluate these concepts and select those better suited to contributing to our starting problem. This evaluation was conducted with two filters

1. a pre-evaluation phase conducted with the help of the client.
2. a second evaluation with a groups of experts in different domains. Here is a quick summary of the results we have found.

Step 2 : Discovery of the generic solutions

Now we want to conduct a systematic scanning of the 40 inventive principles of G. Altshuller, comparing them with properties and functions of our SMA. Our purpose is to select and pick up those who provide the best fit for our study.

Here we chose a series of principles that seemed close enough to properties displayed by our SMA, like principle 30. Principle 30 has been picked up since our alloy is thin while the inventive principle implements flexible membranes and thin films to resolve contradictions.

Other principles were chosen as shown in table 2:

Chart 2 : Principles used in our study

Choice of the Principle	The principle	Justification of the choice
Principe 30 : Use a thin and/or a flexible membrane	• Incorporate flexible shells and thin films instead of solid structures • Isolate an object or system from a potentially harmful environment using flexible shells and thin films	The SMA seems to be like a thin plate.
Principe 35 : Change an object's physical state (e.g. to a gas, liquid, or solid)	• Change the degree of flexibility • Change the temperature	The SMA can be flexible, and it is functional (usable) in a variable interval of temperature.
Principe 17 : changement des dimensions	• If an object contains or moves in a straight line, consider use of dimensions or movement outside the line • Use a stacking arrangement of objects instead of a single level arrangement • Re-orient the object or system, lay it on its side	The SMA can achieve all the principles quoted.
Principe 37 : use the thermal expansion	• Use thermal expansion (or contraction) of materials to achieve useful effect. • Use multiple materials with different coefficients of thermal expansion to achieve useful effects.	The SMA dilates according to the temperature.
Principe 40 : use the composite materials	• Change from uniform to composite (multiple) materials where each material is optimized to a particular functional requirement	The SMA is a composite containing copper

Thus we have identified a series of generic solutions.

During step 2, we have also conducted an in-depth survey around the invention. This extensive study was implemented thanks to the internet and a bibliographical research. We had now a more precise knowledge of the various points at stake.

Once the first two steps are over, we can start thinking about a series of applications and if a function has a negative effect, a ‘way around’ can sometimes be found to reduce this effect.

Step 3: Formulating generic problems

Now we have a series of generic solutions, we need to find the generic problems that they can solve. To fulfil this purpose, we need to draw up on inventory of the design parameters that are at the source of contradictions. This is achieved through a systematic analysis of the contradictions matrix: we aim at pointing out every technical contradiction that can be solved by the generic solutions we have as an input. This is a lengthy process since it requires a 'manual' search of the 39X39 matrix and an extraction of generic problems. Fortunately some computer applications supporting TRIZ, like *TechOptimizer*[1] can be of help there.

Since we find many (hundreds) design parameters, we need to find out which are the most important. This is achieved through retaining the ones that:

1. come out the most often
2. use the most contradiction principles that we found in stage 2, two being the minimum

using this 'filter', we were able to retain 67 technical contradictions (see figure 3).

The next stage consists in analysing these contradictions one by one:

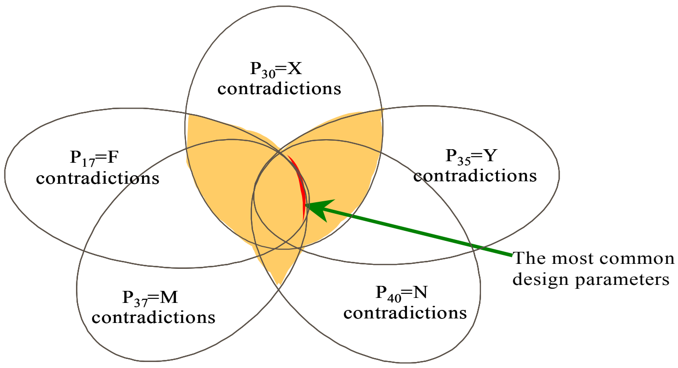


figure 4. The most common design parameters

Step 4: researching fields of application and implementation

Once the generic problems have been listed out, they have to be sorted according to their relevance. What we are looking for might not be a single generic problem, but can be a combination of several of them.

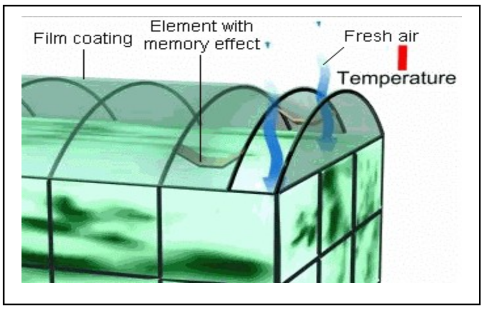
Then the last step to the end result is to find corresponding industrial applications. This latest process can be difficult because of many parameters and the wide range of scientific domains involved. The best way to tackle this is to have a group of experts in different domains. These domains being not only technical, but also non technical: marketing, strategy…

Finally, drafting the final proposal integrating all these points of view is the role of the person managing the Reverse TRIZ. He can also help in testing and implementing some of them.

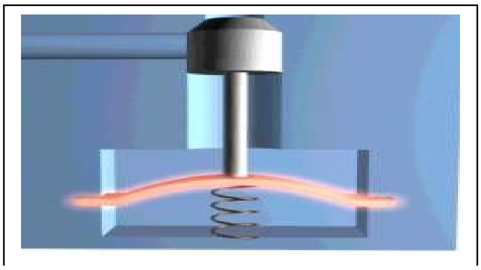
Results of our study

The first and foremost measure of success is the usefulness of the study for our client. We present below on figure 5 some of the results which were reached and appreciated by the lab which requested the study.

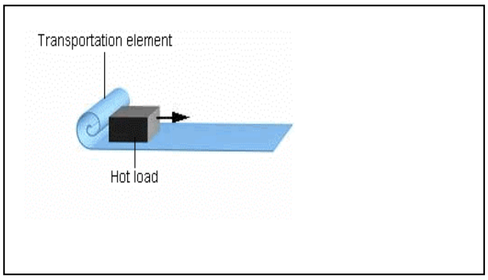
[1] **TechOptimizer©**, is a computer application supporting TRIZ. It contains a representation module featuring more than 7500 scientific effects.



The frame for hotbeds and greenhouses has a framework. A light-transparent screen made of an elastic material is secured to the framework. The framework is manufactured of corrugated strips of a Shape Memory material (for example, nickel titanium alloy. At some temperature inside the hotbed, the framework is in a laid out state and protects the hotbed from the outside air. When the hotbed temperature is above the predetermined level, the framework strips become assembled. When the outside air cools down below the predetermined temperature, the framework regains its initial elongated shape.



Stop valve
The stem of the proposed stop valve is moved by a control diaphragm. It is made of a Shape Memory Alloy. When the diaphragm is heated, its material undergoes structural changes. This changes its shape and causes deflection. The diaphragm is connected to the valve stem. So the diaphragm deflection displaces the valve stem. The valve closes the pressure piping of the hydraulic system. A return spring brings the stem back.



the transportation element is a metal strip made of 1 to 2 mm thick titanium nickelide alloy. The transportation element is provided with a memory of a roll formed of a band at a temperature over 343 K. One of the band ends is rigidly fixed on the frame. The other end lies freely on the frame at a normal temperature. As a hot product is loaded on the band, one of the band ends is heated. It begins recovering the original shape of the roll. This generates a force that pushes the product towards the other end of the band. When the hot product is unloaded, the mobile band end cools down and regains the flat shape.

Figure 5. Application examples (extraction from techoptimizer™)

Conclusion

In this paper, we have proposed a new method to find applications for an invention. Our method is based on the use of TRIZ in a Reverse manner, which we call "Reverse-TRIZ". We associate TRIZ with other tools as well, most noticeably QFD, database research and *TechOptimizer*, a computer application which helps implementing TRIZ.

Implementing and testing Reverse TRIZ as a four steps method study brought forward very conclusive results. The quantity as well as the quality of the generic problems found, the applications proposed for thin layer SMAs are fully satisfying for our client.

We do not see an opposition between "traditional TRIZ" and Reverse TRIZ, the two methods can even be combined, being more complementary than antagonistic. Combinating the two approaches can be used when doubt arise whether "anything has been missed" at a sensitive phase like liking generic to specific problems. In this situation, TRIZ and Reverse TRIZ could be used one after the other to perform a kind of double-check.

To sum this paper up, we think Reverse TRIZ is an appropriate method for transferring an emerging technology to the market.

Acknowledgement:

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