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TRIZ: A New Approach to Problem Solving

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Abstract:

The aim of this work is combining technology road mapping (TRM), a methodology for technology and innovation planning, and TRIZ, an approach for systematic inventive problem solving. The overall objective is to develop an enhanced methodology for systematic innovation planning, strategy and problem solving. This paper is focussed on providing an understanding of TRM and TRIZ, and conceptualising ways in which they can be combined.

It highlights the benefits of the method and how it can be applied. ARIZ is the main analytical and solution tool of TRIZ. It provides specific mechanisms for development of technological systems rather than the conventional approach to a creative problem.

Key words: TRIZ (Theory of Inventive problem solving, ARIZ (Algorithm for inventive problem solving), Technology road mapping.

1. Introduction:

Problem solving is the heart of improving both product designs and the processes to make them. Continuous improvement is identifying and overcoming one problem after another, assisted by our own problem-solving methodologies selected from a huge palette of those that are known. Most of the time we make small improvements; once in a while we make a big one.

TRIZ (pronounced *trees*) is a Russian acronym that means Theory of Inventive Problem Solving. It is a systematic approach for breakthrough solutions to tough-nut problems based on finding a creative solution if one is possible. In industries that are compressing product and process development times, innovation cannot be a sometime thing. It has to occur regularly.

However, in engineering, as well as in much other human activity, the core process of creative problem solving remains trial-and-error, and when ideas are proposed without rules for generating them, the problem-solving process also remains stochastic. "Let's try this. Did it fail? Well, let's try another approach." We try different ideas until we either find a solution or give up. Although idea generation seems chaotic, most steps to a problem solution follow a vector of psychological inertia, which is a pathway guided by the cumulative constraints of recognized perceptions, previous experience, knowledge, common sense, and cultural background. These lead the problem solver in traditional directions, while the solution may lie far from the path of inertia.

Trial and error has been enhanced by methods such as brainstorming, morphological analysis, Plan, Do, Check, Act (PDCA) storyboards, and synectics. These methods are quickly learned and easy to use, but when applied to challenging engineering and manufacturing problems, they remain too intuitive and stochastic to stimulate creativity.

2. Literature Review:

There are many techniques and methodologies to problem solving, and one of them is TRIZ methodology. TRIZ is a Russian word that stands for "Theory of Inventive Problem Solving" or TIPS, which is the equivalent phrase for TRIZ in Russian [3]. TRIZ was developed in 1946 by Genrich Altshuller and his colleagues in the former USSR, and it is now being used widely throughout the world in solving complex inventive problems [4] [5][6].

From his thorough study and analysis, Altshuller selected and examined the most effective solutions - "the breakthroughs [5] [8]." As a result, the following three main findings are concluded [4] [6] [8]:

Repetitive problems and solutions occurred across industries and sciences

- Patterns of technical evolution and advancement were repeated across industries and sciences
- Innovations used scientific effects outside the field where they were developed

The above main findings are applied in TRIZ for creating new products or inventions and also to improve current products, systems, and services.

TRIZ was created based on the theory or belief that "there are universal principles of invention that are the basis for creative innovations that advance technology, and that if these principles could be identified and codified, they could be taught to people to make the process of invention more predictable [4]". Altshuller discovered that invention is nothing more than the removal of technical contradiction with the assistance of a set of known principles. He emphasized that one does not have to be born an inventor in order to be a good inventor, and he criticized the trial and error method that are normally used to make discoveries [7].

3. Motivation:

The main goal of this research is to perform a study on TRIZ problem-solving methodology by reviewing its fundamental concepts and the various TRIZ applications in solving engineering-related, technology-related or scientific-related, and also non-technology-related problems. Several objectives of this paper are as the following:

- To review past research and works on TRIZ problem-solving methodology.
- To highlight in detail several engineering applications and non-engineering or non-technical applications that have used TRIZ.
- To propose several suggestions that can help improve TRIZ problem-solving effectiveness

4. Theory of Inventive Problem Solving:

Genrikh Altshuller and his school started developing TRIZ in Russia in 1946. The main axiom is that evolution of technological systems is governed by objective laws, which Altshuller called Laws of Technological System Evolution. They can be used instead of blind search to consciously develop technological systems (or to solve problems). To formulate these laws, Altshuller analyzed some 400,000 invention descriptions from different fields of engineering gleaned from world-wide patent databases. He selected and examined the most effective solutions--the breakthroughs.

System Conflict:

From this work, Altshuller developed the concept of System Conflict. A problem requires creativity when attempts to improve some system attributes lead to deterioration of other system attributes. Collisions, such as weight versus strength or power versus fuel consumption, lead to System Conflict. Creatively solving such a problem requires overcoming the conflict by satisfying all colliding requirements.

Ideality Principle:

A second fundamental axiom of TRIZ is the Ideality Principle, which is that technological systems evolve toward increasing ideality. No system is a goal in itself, but only a "fee" for realizing the function desired of the system. The lower the fee, the more ideal the system.

At the ultimate, an Ideal System needs no energy to operate, costs nothing to produce, occupies no space, has no failure modes, etc. The Ideal System is no longer a physical entity, but the required functions are performed. In real systems, the "degree of ideality" can be characterized by costs measured in dollars, and by other means, compared with the aggregate of the useful functions performed by the system.

These laws are very helpful because they give designers a general direction for creative thinking. They are more frequently applied to practical problems using three principal sub-systems of TRIZ. (See **Figure 1**). One subsystem is the Algorithm for Inventive-Problem Solving (Russian acronym ARIZ), which is a set of sequential, logical procedures aimed at eliminating the system conflict at the heart of the problem.

A second sub-system, Standard Approaches to Inventive Problems ("Standards" for short), is a set of rules for problem solving based on the laws established by Altshuller stating that many problems from different areas of technology can be solved by the same conceptual approaches. The third sub-system, the Knowledgebase of Physical, Chemical, and Geometric Effects, greatly facilitates problem solving by suggesting analogies from prior creative solutions.

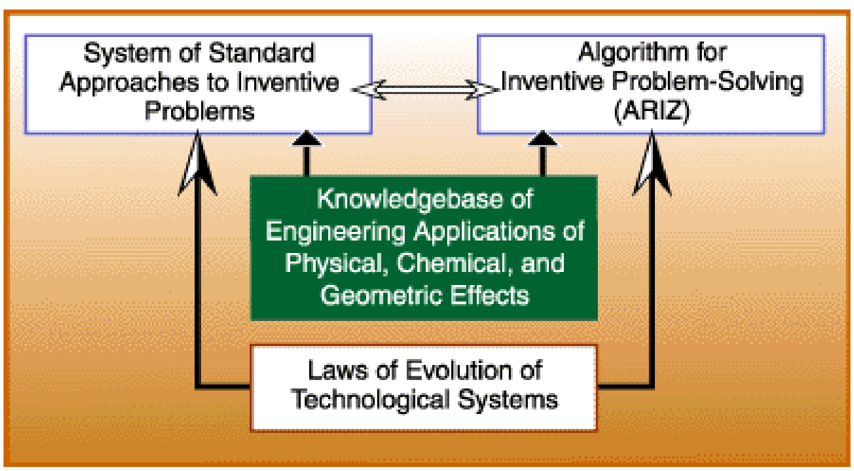

Figure 1 Principal subsystems of TRIZ

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3. Algorithm for Inventive - Problem Solving (ARIZ):

ARIZ is the solution tool of TRIZ and it provides specific mechanisms for development of technological systems rather than the conventional approach to a creative problem. Traditional thinking tires to "leap" to a solution from the problem as given. The more difficult the problem, the more "leaps" before finding a solution.

On the other hand, TRIZ assumes that the degree of difficulty of a problem largely depends on the way it is formulated. The clearer the formulation, the easier to arrive at a solution. In the TRIZ approach, inventive-problem solving as a solution-seeking procedure is replaced by a process of problem reformulation. Through a chain of successive reformulations of the problem, it is transformed from ill-defined and frequently incorrectly-formulated mush into a lucid formulation of the root conflict. A solution either becomes obvious or it becomes clear that the problem cannot be resolved because we do not presently have the required technology or the scientific knowledge.

ARIZ is the set of successive logical procedures to reinterpret the initial problem through consecutive reformulations. Its structure consolidates two major ideas: System Conflict and the Ideality Principle. Since a technological problem becomes an inventive one when a System Conflict should be overcome, the problem for inventive-problem solving must include special subroutines to reveal and clarify these conflicts. **Figure 2** shows the basic flow of problem reformulation using ARIZ.

Solving a problem using ARIZ starts with a transition form a vaguely (or even wrongly) defined initial problem into a mini-problem that is formulated by the following rule, "Everything in the system remains unchanged, but the required function is realized."

The next step of formulation of the System Conflict, followed by a "Model of the Problem," which is a simplified scheme of the conflict. The Conflict Domain is specified to narrow the area of analysis. The next step is assessment of the available material and energy resources.

The problem is treated by selecting a critical system resource in the Conflict Domain and formulating an Ideal Final Result (IFR). Usually, to realize the IFR, this resource must possess contradictory physical properties, such as both cold and hot, opaque and transparent, electro conductive and electroinsulative, and so on. Such a condition, called a Physical Contradiction, is the cause of System Conflict.

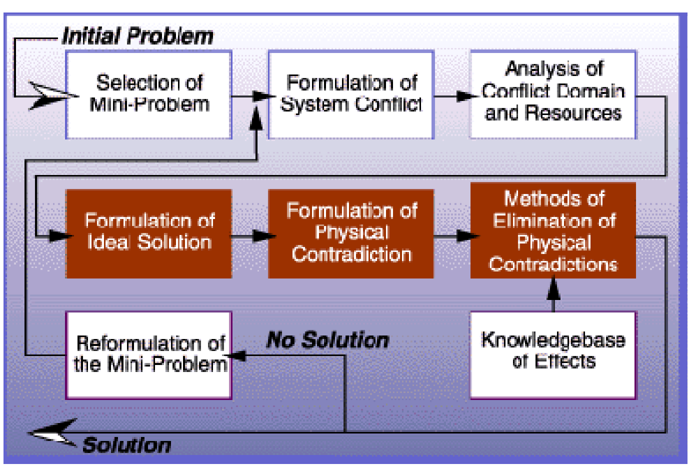

Figure 2 Basic flow of problem reformulation using ARIZ

ARIZ offers three generic methods for overcoming Physical Contradictions:

1. Separation of opposite properties in time: During one interval an object has property P; during another interval it has anti-property -P.
2. Separation of opposite properties in space: Part of the object is given property P while another part is given anti-property -P.
3. Separation of opposite properties between the system and its components:

The whole system has property P while its components have the opposite property -P.
The key to success is to assume that you do not understand the nature of the problem. Instead, develop the discipline to forego thrashing for solutions and continue refining the problem definition down to the Conflict Domain and the basic Physical Contradiction using the ARIZ logic process. Software is available to prompt inventive problem solvers on the Standards and the Knowledgebase, but these are only aids. People solve inventive problems.

5. Conclusions:

Now a day problem solving getting more challenging because all parts that need to be assessed are changing rapidly and there always possibilities that by the time if one solution is formulated a new problem may arise. It is better if TRIZ includes a step that uses artificial intelligence technique such as case based reasoning, genetic algorithms and neural networks in generating several alternatives to the problem, and later the optimal solution is derived from a pool of possible solutions.
Based on the review on TRIZ and its application performed in this paper, it can be concluded that TRIZ has an enormous influence on the problem-solving and decision-making process. TRIZ problem-solving methodology is still gaining further popularity since its application has been extended beyond its initial problem domain, which is engineering and technology-related. TRIZ is now widely used in education in instilling more systematic problem-solving strategy in students so that they are able to effectively and efficiently solve new problems without depending too much on others.
In conclusion, TRIZ is the most suitable problem solving methodology, if we want to solve problems by studying certain patterns in the current problem and try to find previously solved solution that are similar to the conceptual design of the problem at hand, and from there a specific solution can be derived. Most of the problem solving methodologies attempts to solve problem by trying to directly find specific solution to the problem which is time consuming approach, costly and will not give guarantee that the specific solution is suitable because it has been not tested in the past. TRIZ uses past general solution to derive a specific solution for the current problem. So it saves significant amount of time and energy in investigating new product.

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