TenStep Supplemental Paper

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TRIZ (Theory of Inventive Problem Solving)

TRIZ is a creative problem solving technique that relies on the following to achieve creative solutions:

- Understanding the problem as a system
- Devising an ideal solution first
- Solving contradictions

Prior to TRIZ, the common belief was that invention was the result of an accidental finding or a sudden idea. Inventive methodology traditionally was more trial and error and had no precise function or theory to support it. TRIZ provided inventors with a theory that, when used precisely, would help them solve problems efficiently.

Information and findings mined out of more than two million patents were analyzed and categorized to reveal an objective for inventive problem solving. The theory that portrays the evolution of technological innovation is called TRIZ. TRIZ is different from any other inventive methodology used today because it is based on technology, not psychology.

To successfully incorporate TRIZ, it is necessary to understand the concepts behind TRIZ.

Technical Systems

Any system that performs a function is called a technical system. A technical system can consist of one or more subsystems.

According to TRIZ, every technical system comprises individual sub-systems. These sub-systems transfer energy between them. In TRIZ, subsystems that do not engage in energy transfer cannot be teamed together as a technical system.

For example: The simplest form of a technical system can be a pen and a paper. Unless the pen is made to write on the paper, the two cannot be called as a technical system. However, when the pen is used to write on paper, there is energy transfer and hence it becomes a technical system. This theory is the primary basis of TRIZ.

An example of a more complicated technical system is a car. A car has many subsystems like brakes, transmission, tires, engine, etc. Each of these subsystems can also be considered a technical system with its own subsystems. For example, the brake can be considered a separate technical system, with brake pad, brake pedal, hydraulic cylinders, brake oil, etc. as its subsystems.

If improved technical system performance is desired, then it must be reduced to its simplest form; i.e. to the smallest subsystems possible. Each subsystem must be scrutinized for performance. Improvements in the sub-systems help improve the performance of the entire technical system. Hence, every subsystem must be at its operational best for superior technical performance.

According to TRIZ, all technical and subsystems are mortal and deteriorate when aged. They must be eventually replaced with new and more efficient systems.

Levels of Innovation

Another key concept in TRIZ that decides the outcome of an inventive problem is level of innovation. A level of innovation decides the inventive value of every invention. TRIZ classifies innovations into five distinct levels based on the axiom, "Not every invention is equal to its innovative value."

- **Level 1** - *Simple technical system improvement.* Such improvements are directly related to the expertise relevant to the technical system.
- **Level 2** - *An invention by solving a technical contradiction.* This requires expertise from different areas of the same industry, relevant to the technical system.
- **Level 3** - *An invention by solving a physical contradiction.* It needs expertise from different industries, relevant to the technical system.
- **Level 4** – *A new technology with a breakthrough solution that requires expertise from different areas.* This level of innovation is for inventions that use a new technology instead of an old technology to solve a technical problem.
- **Level 5** - *Using new techniques.* This level belongs to those who constantly update technology and devise new techniques to achieve higher existing technology performance.

An observation of engineering patents revealed that about 77% of patents belonged to levels 1 and 2. However, practical application of TRIZ will help achieve inventive problem solution up to level 3.

Law of Ideality

The third concept in the TRIZ methodology is the Law of Ideality. This law states, "Any technical system, throughout its lifetime, tends to become more reliable, simple, effective – more ideal."

So, according to the law, the more one tries to improve a subsystem or a technical system, the more it moves to an ideal operating condition, i.e. ideality. What does ideality do to a system? The answer – lower maintenance and hence lower operating costs, higher return on investment, and optimal usage of energy and resources.

Conventional vs. TRIZ approach

Conventional approach –To execute a specific plan; to build a customized/dedicated device.

The TRIZ approach – Execute a plan without introducing a new device/technique in the technical system.

In TRIZ, the availability and optimal utilization of resources will push the technical system to its ideal state. Basically, one can judge an invention from its ideality, i.e. "The further an invention is from its ideal state, the more complex the system will be, and vice versa".

The Contradiction Theory

Genrich Altshuller conceived the popular concept of TRIZ by observing real life situations. He believed that solving contradictions provided cost effective solutions for inventive problems. He also believed that solving a contradiction and thereby solving a problem was the best way to push the technical system to ideality.

According to TRIZ, a contradiction occurs when ideality for a specific subsystem causes contradiction within another subsystem.

In an effort to push a specific subsystem parameter to ideality, performance of a parameter relevant to another subsystem might be affected. The result - technical inefficiency/contradiction to that subsystem. The solution to this problem often leads to a compromise between the desired result and the contradiction. Hence, poor performance.

In order to clearly distinguish contradictions, Genrich Altshuller classified contradictions into three categories – technical, physical and administrative.

- **Technical contradiction:** To understand a technical contradiction, consider an example - i*ncreasing the power/output of an airplane's engine.* Practically, this requires the size and weight of the engine to be increased proportionally to the power required. However, an increase in the weight of the engine will require a heavier and stronger wing to support the engine. An increase in the wing size will cause substantial drag and hence risks. Due to these design constraints, the inventor compromises on the engine power and incorporates a design that has the right balance between power and size/weight.
- **Physical contradiction:** A physical contradiction occurs when opposite properties are desired from the same system at the same time. For example, every plane requires landing gear during take-off and landing. However, it is desired that the landing gear must not be present during flight as it increases drag and reduces the speed. This is a classic example of a physical contradiction – the landing gear is both required and not required for the same plane. The solution is to split the requirement based upon time. In other words separate the system (landing gear) into two separate entities depending on time for which it is desired or not desired, i.e. make the landing gear retractable.
- **Administrative contradiction:** A typical example of an administrative contradiction is the need for higher investment with little money, i.e. "I want more money but I do not have money."

A Problem Solved by TRIZ

The following is an example of a case where TRIZ was used to solve a problem.

A South American meat plant regularly supplied substantial quantities of meat to the United States by air. Because the flight duration was long, refrigeration was essential.

Hence, the company installed refrigeration systems in the plane. This seemed to work efficiently for the company until competition for the supply of meat increased. Competition demanded a higher quantity of meat supply. In order to achieve this objective, the plant decided to increase the quantity of meat sent per flight.

However, the large volume occupied by the refrigeration systems limited the potential increase in meat quantity. The company applied TRIZ to help them solve this problem.

The application of TRIZ prompted an innovative solution - Fly the plane at high altitudes (between 15000 and 25000 feet), where the temperature is below 32° F, a sufficient temperature to refrigerate the meat.

The potential of TRIZ in solving problems such as these is evident. In this case, the application of TRIZ allowed the meat company to increase quantity of meat per flight by optimally utilizing its resources.

Evolving Technical Systems

Genrich Altshuller proposed a few distinct types of technical system evolution. These are:

- **Dynamization.** Every technical system that undergoes evolution transforms itself from an initial rigid structure to a flexible structure. For example, consider the landing gear of a plane. During the fabrication of a landing gear assembly, first the tires, i.e. rigid subsystems, are joined with the retractable system, which renders the whole technical system flexible.
- **Multiplication.** Every system multiplies from an initial single subsystem to an array of subsystems, which together form the technical system. For example, initially the knife was just a piece of metal sharpened at the edges. Then, different blades were added to diversify its application. Today, the modern pocket-knife has evolved into a multi-utility device.
- **Transformation from macro to micro.** With the passage of time, all technical systems will be reduced to their simplest possible micro level, i.e. molecules/atoms. For example when the computer was first invented, its CPU occupied a large room. Eventually, through the process of development, its size was reduced. Today, the size of the computer has been reduced to laptops and palmtops.

Summary

Over the years, TRIZ has developed into a comprehensive tool for inventive problem solving. Many theories, such as Functional Diagramming, Su-Field Analysis, ARIZ, Patterns of Evolution, and Anticipatory Failure Determination™ have also been developed based on basic TRIZ concepts.

TRIZ is of immense value to industries as it focuses on removing issues that hinder the effectiveness of a technical system. Efficient application of TRIZ will generate increased productivity, reduce technical problems/contradictions, prevent huge and unwarranted investments and ensure effective utilization of resources.