How to Reduce Cost in Product and Process Using TRIZ

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Abstract

People learning TRIZ frequently have difficulty with the issue of cost, since cost reduction is a pervasive theme throughout industry, yet many techniques of TRIZ do not deal with it explicitly. But, if beginners don't have success in applying TRIZ to the first problem that they try, they will frequently abandon efforts to learn the TRIZ system.

Teaching beginners how to formulate and solve cost-related problems requires that they gain a thorough understanding of the Ideal Final Result, System Operator, and Function Analysis, and the use of parameters and functions to define the problem before trying to apply tools like the separation principles and the 40 principles, organized in a way that makes it easy for them to succeed. Product and service examples from the electronics, medical and heavy machinery industries and a manufacturing plant case study from the plastics industry will be used to illustrate the concepts and the method of teaching the concepts.

1. Introduction

People use the word "cost" to describe a wide variety of problems in the development, production, and delivery of products and services. Newcomers to TRIZ, who frequently expect TRIZ to solve all problems instantly, may be frustrated by lack of support they perceive for solving their "cost" problems. If the beginners do not have success with their first problems, they will not persist in learning more advanced TRIZ skills, so alleviating this frustration is important in order to get more people practicing TRIZ.

Giving beginners a step-by-step process makes teaching and learning easier. It guides them through the analysis of the causes of their cost problems, which in turn guides them to use appropriate TRIZ tools to eliminate the problems. For a tutorial on TRIZ in Six Sigma see [1]

1.1 The causes of cost problems

When people complain that a product or service costs too much, the TRIZ analyst approaches the problem like any other. If trained in classical ARIZ, the analyst uses the methods of finding the operational and temporal zones of conflict of the problem, the contradictions, exaggerations of the contradictions, and the formulation of the problem to be solved. If trained in Six Sigma or other quality improvement disciplines, the analyst uses the root cause analysis methods. In either case, observation of many situation shows that the cost issues are caused by the following:

1. Cost of raw materials
2. Cost of labor
    - 2.a. Production of parts
    - 2.b. Assembly of final product OR deliver of service
    - 2.c. Testing the final product or service before delivery
    - 2.d. After-sale support (customer service) for either products or services
3. Cost of transportation
    - 3.a. Transportation of raw materials
    - 3.b. Transportation of parts
    - 3.c. Transportation of finished products, or transportation involved in delivering services.
4. Management costs
    - 4.a. Management of suppliers
    - 4.b. Management of the organization (engineering, design, production, procurement, service, support, sales, marketing, employee training, human resource costs, etc.)
    - 4.c. Management of customer relationships
    - 4.d. Cost of poor quality (labor costs for testing, analysis, and rework, materials costs for replacement of bad raw materials or parts, transportation costs for the replacement, warrantee costs for replacement of bad products or repairing the effects of bad services, and the cost, which is impossible to calculate, of damage done to the company's reputation with the customer.)

Beginners' attempts to apply TRIZ to cost problems most often fail because they view the problem only at the system level of the original presentation of the problem. The System Operator and the Ideal Final Result are the TRIZ-specific methods that can "liberate" them from this problem, but they are not the ones that beginners usually master first.

Popular business literature abounds with cases that illustrate the problem of viewing the problem at the wrong system level. Business Week Magazine [2] cited well-known examples of companies outsourcing manufacturing to China and services to India because of lower labor costs. They project that the Chinese and Indian advantages will last 10-15 years. But a TRIZ evaluation of the specific projects that they review shows that the issues are not simple:

- Manufacturing costs can be reduced by changing the product design. The cost of a single design change may be high, but the reduced cost of global management, supplier qualification, and transportation should be included in calculating the cost of the change. A similar case was examined in [3] in which a small manufacturer of motorcycle windscreens was advised to switch from a US supplier to a Mexican supplier to save on labor cost for parts. Examination of the parts showed many opportunities for simplification and reduction of labor in production. The electronics industry has many cases where a high-cost producer transferred production to a low-cost producer, and after answering all the questions from the low-cost producer, realized that they could have simplified the design and produced it themselves.
- Indian engineers now do 3-D CAD simulations for companies in other countries, at 20% of the cost. But, what is the cost of separating simulation from design? The next step may not be better design because of better simulation (as the article suggests) but transferring the whole design to the Indian company. This may be good from the point of view of the customer (better products cheaper) and for the Indian company (new business) but it is not good for the company that started the process. Quoting the Business week article:

  India will only get there if it has more to offer than cheap labor. Any developing nation has that. So Wipro and other Indian tech leaders, including Tata Consultancy and Infosys Technologies, are upgrading their services. They're automating processes to skip manual steps and using analytical software to mine data about their clients' customers.

What is not noted in the article is that all three of the companies that are used as good examples have studied TRIZ.

The Six Sigma practioners have seen the same issue of treating the problem at the wrong system level. Nilakantasrinivasan [4] lists the 5 causes of failure of DMAIC (the process optimization phase of Six Sigma, which is known by the acronym for the steps-- define, measure, analyze, improve, control) as

1. Pseudo problems in processes with high detectability
2. Pseudo problems due to absence of business process management
3. Lack of control in "completed" DMAIC projects
4. Acute focus on cost reduction
5. Inappropriate use of DMAIC

When TRIZ is combined with Six Sigma, it is common for students to have problems that are the result of one of these "pathologies" of DMAIC. In a recent class, a student presented a problem in which a part of a printing machine was changing shape over time, causing deterioration in the output. Two years before, someone had replaced a steel shaft with a nylon one to save money on parts (problem 4—focus on cost instead of customer needs, and problem 3—not having a control system to measure the performance of the shaft.) Using some very basic TRIZ and basic design engineering, the student found solutions that would be stable over time with the right rigidity. But the company suffered the cost of the change and the cost of 2 years of customer complaints in the mean time!

1.2 Tools of TRIZ

Beginners are usually introduced to TRIZ as a series of tools and techniques, then, as they become more proficient, they learn to view TRIZ as a thinking system. It will not help beginners improve to lecture them on the need for thinking! As beginners, they need to see that the tools they have learned can help them with cost problems, or they will be discouraged and stop trying to learn TRIZ.

1.2.1 Function Analysis, The Contradiction Matrix, and the Forty Principles

The matrix and the 40 principles have been one of the most popular tools with TRIZ beginners, in spite of the criticism of TRIZ experts that its use leads to low-level solutions. See Slocum [5]. Showing beginners how to use the matrix and the 40 principles gives them a fast start with TRIZ thinking, particularly if the approach is one of eliminating the contradiction, not just finding a better compromise.

Some version of function analysis (su-field analysis, TOP, subject-action-object, problem formulator model) is usually the beginner's entry point to use of the Contradiction Matrix. (See Rantanen [6] for one beginner approach.) A key point that has been emphasized by Sickafus[7] is that the functions and functional relationships of objects (or systems) are the result of the attributes of the objects or systems. By articulating the attributes, the analyst will find opportunities for changing the costs of the system. If this had been done for the printer shaft, the problem would have been avoided.

For example, a transparent plastic drinking cup has the attributes of small weight, excellent confinement of liquid, poor thermal insulation, and ease of observation of the level of the liquid, among others. If the goal is to reduce the cost of the cup, the analyst must find out what is causing the cost (materials, processes, transportation, customer service, design, etc.) and, when removing the cost, be sure that the functions and the attributes that the customer values are not removed. See also Ball [8]

Darrell Mann [9] has created a business matrix, using the format of Altshuller's contradiction matrix [10]. Mann's direct cost parameters for the business matrix are as follows:

- R&D Cost
- Production Cost
- Supply Cost
- Support Cost

He also includes some of the same parameters used in the classical Altshuller matrix and others that cause costs to increase:

- Complexity of the system
- Complexity of control
- System-generated harmful factors
- Time and risk issues for the R&D, Production, Supply, and Support

In the classical Altshuller matrix, (See [11] for definitions) the issues that most frequently are used to describe cost-related problems are

- Speed of a process
- Duration of action
- Loss of energy, loss of material, loss of information, loss of time
- Reliability
- System-generated harmful factors
- Ease of operation, ease of production, ease of repair
- System complexity
- Extent of automation
- Productivity

Frequently, formulating the problem as a contradiction will lead directly to the solution, without using the matrix explicitly. For example, many industries have the apparent physical (inherent) contradiction

We want lots of inventory (to avoid production delays, or to respond quickly to customer service needs)

We want no inventory (to avoid the cash flow problems.)

This problem can be re-expressed as a technical (trade-off) contradiction as

Ease of production gets better. (or ease of repair, for the service issue)
Quantity of material gets worse.

Before using the matrix, the student can see that the coupling between ease of production or repair and quantity of material suggests that the production process requires large amounts of material. This understanding could lead directly to the TRIZ scientific effects method. That is, benchmarking solutions from other industries. The Just-in-time method pioneered by Toyota but now widely practiced, in many cases eliminates inventory. But, its successful application requires that all the processes in the system be refined to have predictable process times, high quality, extreme customer responsiveness, and no rework.

If work at that level of quality is not possible, or if the formulation of the contradiction is not possible, then the student can proceed with the classical matrix or Mann's matrix. For example, the classical matrix shows that principles 35 (Parameter change), 23(Feedback), 1(Segmentation) and 24 (Intermediary) are the most frequently used to solve this contradiction, and there are common inventory management solutions that use all of them. The very popular method of Theory of Constraints is a direct application of 35, 23, and 1 in surprising ways—by only managing the inventory at the constraint points (changing the parameters that are measured, using feedback, and segmenting the process into constrained and unconstrained resources) practioners of TOC can dramatically reduce inventory throughout the system. The automotive and aerospace industries have made use of a combination of 35 and 24 by having all inventory maintained by the suppliers or the customers. For replacement of critical parts, a new method is to use 24 with principle 26 (Copying) and keep make the parts as needed, from an inventory of metal, plastic, and ceramic powders, using "desktop manufacturing" (previously known as rapid prototyping) equipment.

1.2.2. The System Operator

Observation of many cases in industries as diverse as health care delivery, electronics, heavy equipment, and chemical research has shown that it is almost universally true that the root cause of cost issues is making decisions on the wrong level, which is why the TRIZ System Operator, shown in Figure 1, is a key tool to improving product or service costs.

Many people would apply orthodox quality management concepts and ignore the corrective action column. It is included here because rework of specific services and products may be less expensive than discarding defective products, or apologizing to customers who received defective services. The same System Operator thinking needs to be applied to the cost analysis system to decide what level solution, and what time scale solution to apply.

FIGURE 1. The System Operator Matrix

	Past (preventive)	Present	Future (corrective)
Sub-System	What could have been done at the sub-system level, to prevent the costs?	What are the sub-systems? Components? Should we go below that level to look for a solution?	What could be done after the sub-systems are produced, to reduce the cost of using them?
System	What could have been done to prevent the problem, at this level?	**The immediate problem**	Could anything be done after the pro-duct or service is produced, to reduce the costs of delivering it?
Super-System	What could have been done at the super-system level to prevent the costs?	What is the immediate super-system? What is above that? How high should we go?	What could be done at the super-system level, to correct the problems that are causing costs to be too high?

This example illustrates the power of the contradiction formulation and the System Operator:

The CEO of an equipment manufacturing and service company needed a "breakthrough strategy" to solve a cost problem that he described as crippling his company. The company had a large number of distributors, some with a very long history with the company, and some merged into the company more recently as a result of acquisitions. About 15% of the distributors were described as "value added"—they really understood their customers, accelerated the sales process, and contributed to custom solutions. About 50% were considered to be unnecessary costs, adding nothing, and the rest made occasional contributions. When the TRIZ analyst expressed this situation as a physical (inherent) contradiction

We want distributors
We don't want distributors

and started explaining the separation principles, the CEO interrupted with the remark, "That's the solution, and I hate it." When asked why, he explained that he now saw co-existence of the multiple distributor types in multiple subsystems (analogy to phase space) as the solution, but he'd have to spend money on lawyers to change the contracts. He then used the System Operator to understand both preventive and corrective aspects of the subsystems he wanted to create, and the preventive actions needed in the supersystem that would manage the new distributor networks. The CEO and his staff had spent 3 years on a variety of ineffective solutions. They were true TRIZ beginners with less than one day of training when they used TRIZ to develop their new strategy, which is working very well in practice.

1.2.3. The Ideal Final Result (IFR)

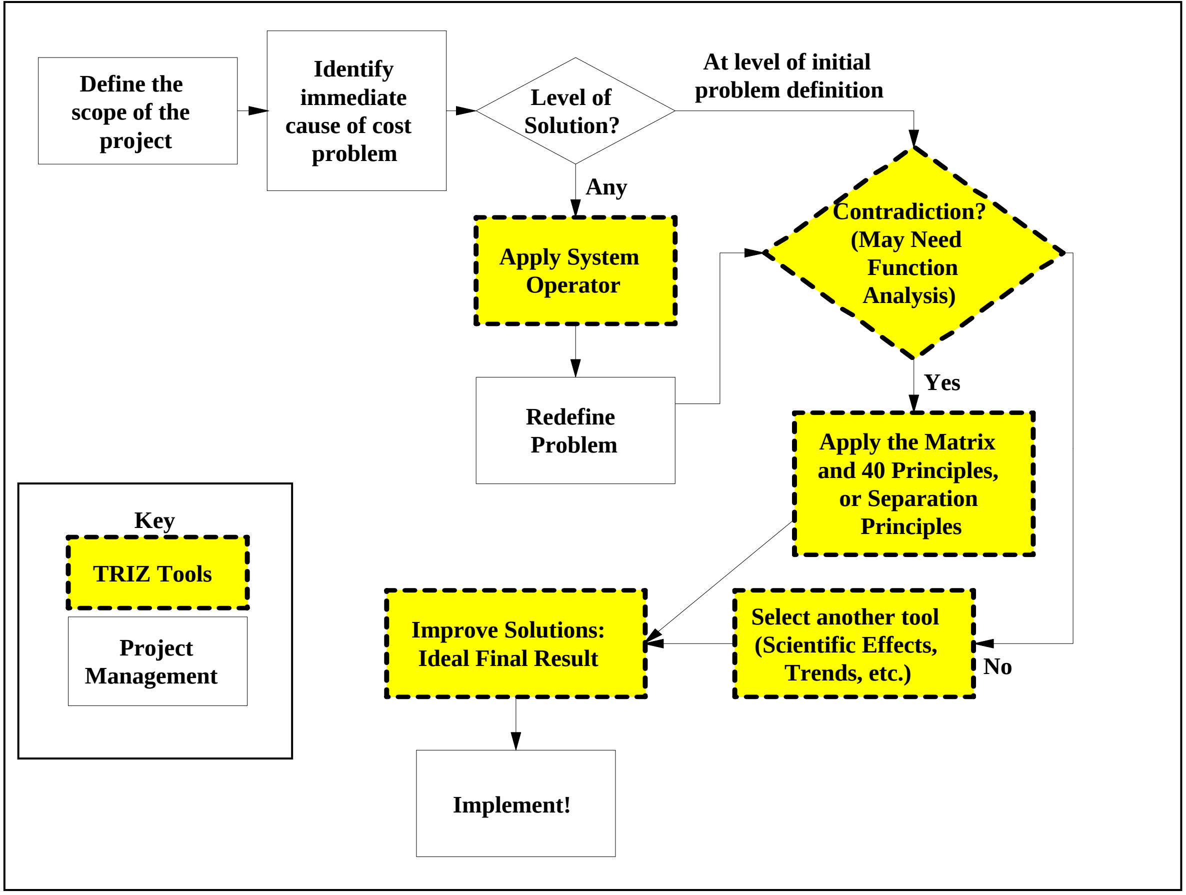
The Ideal Final Result is no different in cost problems from its use in any other problem, but it remains a difficult tool for beginners because it is the tool that challenges psychological inertia the most. Regardless of whether the beginner uses the "Itself" method (see [9] for extensive examples) or the value equation method (see [6]for examples) the challenge of envisioning a system that delivers all the benefits but doesn't exist, or delivers the benefit without cost or harm, is frequently too much mental distance from the beginner's past experience. For this reason, we have put the IFR at the end of the process, to refine the solutions, rather than at the beginning, where it is found in more general problem solving.

When used well, the IFR will liberate the TRIZ practioners from previous system concepts and superficial finding of root cause. In a batch processing industrial application, the student came to class with the assignment to reduce the cost of periodic maintenance of a facility which was used to remove a contaminant from brine, which was a by-product of the production process. She applied the IFR at several levels—at the most extreme, asking why any water had to be used to create the product. The answer was that it was the only method known 70 years ago when the process was established, and the use of water was free. Now, there are other processes, and water is expensive, and water treatment after contamination is even more expensive, and the company is investigating switching to an ideal production process. (Meanwhile, the student's charter was a 25% cost reduction, and she applied TRIZ at the system and subsystem level and found savings of 60% was possible very quickly.)

2. Step-by-step problem solving for cost-related issues

Figure 2. is a flowchart for solving cost problems. There is no new TRIZ theory presented here—this is a practical arrangement of tools and techniques that makes it possible for beginners to get effective results quickly. After they get useful results, they are very likely to be motivated to learn TRIZ in greater depth, and to be able to work at a more holistic level that characterizes TRIZ advanced practitioners.

FIGURE 2. The beginners' flowchart for cost problems



3. Case study

NOTE: details of the case study are limited exclusively to the TRIZ activities. Details of which business and polymer are not revealed, so that cost savings information can be outlined to show the value.)

In 2003, a Dow Plastics business found itself responding to meet the ever more rigorous needs of a cost-driven marketplace, for a technology tuned over decades. It convened a group of technical experts to redesign its "most effective" standard process technology for manufacturing facilities for this family of products. To stay competitive in costs, they needed to drastically reduce the capital needed to build future plants. Requirements seemed ever-tightening, calling for lower energy use, better ergonomics for operating personnel, and lower monomer residuals in product. The process, being decades old, had technology and equipment systems considered highly optimized ---oh, the psychological inertia!

Since the work was done within a Design for Six Sigma framework, the methods used were not limited to TRIZ tools, but TRIZ came into play at a number of points in the project. In problem analysis, the major sources of cost (by unit operation) established which opportunities, on the basis of function fulfilled, to pursue. An overall Ideal Final Result helped outline the zones of conflict / pathways to innovation so that sub-groups could divide and attack each opportunity with the most appropriate tools. Substantial use of technical contradictions and inventive principles helped address trade-offs.

The group assembled a dozen alternative systems by using a morphological box at the high, conceptual level. A Pugh concept selection matrix helped narrow the candidates to four (including today's, for comparison) for which the intermediate level of detail enabled cost estimations. Elements of IFR contributed to the evaluation criteria.

Breakthrough was achieved in control of monomer residuals, handling of raw materials, and reactor design to handle a wider range of heat removals for multiple products. The reduction amazed even the project team, when the capital cost of a plant built to the new standard dropped by more than 25%, from nearly $110 million to <$80 million.

4. Conclusion

A methodology paper like this cannot have a conclusion, in the sense of summarizing all the data and drawing a concluding message from the data. Rather, the paper ends with two invitations:

1. To the TRIZ community to experiment with the method presented here for helping beginners have early successes and to report on successes, failure, and recommendations for improvements.
2. To the Six Sigma community, to build TRIZ into Six Sigma to get the benefits of structured creativity for DMAIC and DFSS projects.

The growth of TRIZ depends on the ability of TRIZ experts to make it easy for TRIZ beginners to have early successes, so that the beginners will decide to do the work that will increase their knowledge and capability. This simplified TRIZ problem solving method is proposed as one way to give beginners that experience of success.

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