TRIZ Based Methodical Invention Function Model

Prabhdeep Singh Bajwa, Dalgobind Mahto

Abstract—In industrial projects, various techniques and methodologies are employed to improve the productivity by implementing better design and alternatives before the starting of the project. This study proposes a methodology which is an integration of enhanced FAST (combination of FAST-Function Analysis System Technique & TRIZ- Theory of Inventive Problem Solving) and 40 inventive principles with brainstorming.

Index Terms— Brainstorming, inventive, value, TRIZ, FAST, function model, productivity.

1 Introduction

The Value Methodology advancement can draw its roots back to World War II where it developed out of necessity. Key materials used in manufacturing military and civilian products were in short supply. Alternative materials needed to be found. Ingenuity and creative thinking to find solutions was evident in large scale improvisations, and substitutions, often yielding better and less costly results than the original designs. In 1947, this unstructured process was developed and formalized, into what is now called the Value Methodology, by Lawrence D. Miles, an engineer in the Purchasing Department of General Electric. This methodology focused on the functions which manufactured components had to deliver, and created the process of function analysis. With the constraint of describing each function performed in only two words -- an action verb and measurable noun -- all physicality of the product or process is removed, thus freeing the mind to think more freely about alternatives. This process later evolved into the formal practice called Value Analysis.

In today's market, Value Engineering has proven to be an important improvement tool. It has been used to reduce manufacturing and procurement costs typically by 15 to 25 percent. Today, Value Engineering is practiced throughout the world with many organizations dedicated to its use and promotion. However, Value Engineering is not immune to technology obsolescence. In today's world of globalization and increasing competitive pressures, one must innovate or die. The Cornerstone relationship in Value Management is Value = Function / Cost.

The greatest strength of the Value Management Process is that it is highly structured and economically driven. Work is organized from conception through implementation. Good value options are clearly identified with the preferred option to increase Function while decreasing Cost. Cost reduction while holding Function constant is often selected. One of the greatest strengths of Value Management is FAST diagramming. FAST diagrams are an outstanding analytical technique, which can be used to analyze and manage the most complex processes.

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The major weakness of Value Management is reliance on psychologically based brainstorming techniques. Obviously, the value achieved from a project will depend directly on the degree of innovation embodied in the solution. Brainstorming techniques are limited by psychological inertia and the collective experience of the people in the brainstorming session.

More participants will broaden the base but the group quickly becomes unmanageable as size increases. Another weakness is that many practitioners are drawn to simple cost reduction projects. In fact, the most common problem definition proposed by managers is "Our costs are too high." Some people accuse Value Engineers of sacrificing Function in favor of Cost reduction. One attractive opportunity to improve the Value Management process is to strengthen the Identify Alternatives step. Taking a Value Engineering approach to this problem tells us that in order to increase Value, we must increase Function (strengthen the Identify Alternatives step) without adding any additional Cost or at least, by assuring that customers are willing to pay the additional Cost in order to obtain the improved Identify Alternatives step. With the two-word function description as the backdrop, the creative process of generating ideas and alternatives to deliver the same, or improved, functionality is conducted. To stimulate this idea generation, Miles relied on a technique which was in vogue and gaining widespread use at the time. That technique was called Brainstorming. Brainstorming was introduced in 1939 by a contemporary of Miles', an advertising executive by the name of Alex F. Osborn [1]. The brainstorming technique is universally known and practiced in a number of situations, and is often the first and only creativity tool used by many. Its effectiveness in many situations is the main reason for its popularity. However, its major drawback is that it relies on the experiences, skills, talents and backgrounds of the people in the room during the brainstorming activity. This is where the structured aspects of the Miles process breaks down into a free-flowing, unstructured frenzy of rapid fire idea generation where quantity is stressed over quality.

2 Methodology

2.1 Theoretical work

In accordance with TRIZ applications, the advantages and imperfections can be concluded as follows:

- Advantages
- Systematic process to resolve problems
- More effective and efficient solutions obtained by fewer efforts.
- The adaptability to integrate with other methodologies to resolve much complicated and difficult problems.
- Imperfections
- The subjective judgments of problem-solving process.

For the purpose of the accomplishment of more and more complicated construction projects, TRIZ is applied and modified in this chapter. In addition, its defects will be refined through other useful methodologies. And, this systematic innovation model will be developed by the following concept along with a simple example of constructional elements. The following is the concept diagram.

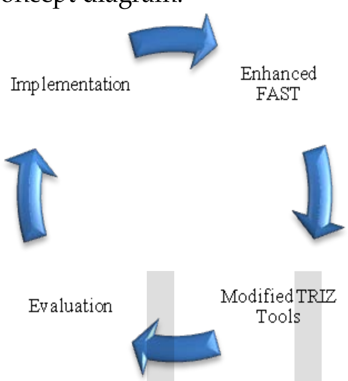

Fig. 1 The concept of systematic innovation model.

Briefly speaking, to integrate TRIZ with other methodologies and the concept of VE is the core of this study. In accordance with Figure 1, this systematic innovation model will be divided into five steps as the sections afterwards. The following paragraphs delineate brief contents of these sections.

2.2 Enhanced Functional Analysis

The advanced VE/TRIZ methods that are recommended are actually a synthesis of the work of three contributors to creativity and problem solving: Lawrence Miles, Genrich Altshuller and Alex Osborne.

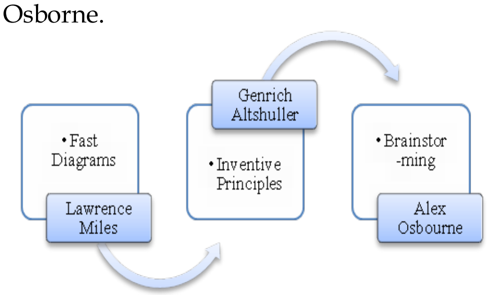

Fig. 2 Incorporation of VE/ TRIZ methodology.

The steps in the combined process are as follows.

Step 1 - Basic Fast Diagram

• Begin the Value Management process in the usual manner with a Pre-Event to define the problem to be solved, establish the measure(s) of success and obtain management sponsorship and commitment.

• Continue with the Value Management process by building the FAST diagram.

• After the FAST diagram is completed, build a functional model of the major logic path in the FAST diagram. This model is built much like a classic FAST diagram except that functions can be either useful or harmful, corresponding to the definition of Ideality. The functional model deconstructs a problem by creating a functional diagram that relates the useful and harmful factors in the system. Unlike a FAST diagram, the modified functional model can include objects, system, actions, parameters and conditions as well as functions.

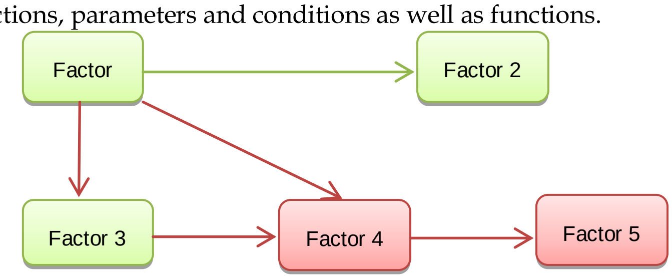

Fig. 3 Basic FAST Diagram

TABLE 1 FUNCTIONAL MODEL OF THE MAJOR LOGIC PATH

[Useful] Factor 1	Produces	[Useful] Factor 2
[Useful] Factor 1	Produces	[Harmful] Factor 4
[Useful] Factor 3	Counteracts	[Useful] Factor 1
[Useful] Factor 3	Produces	[Harmful] Factor 4
[Harmful] Factor 1	Produces	[Harmful] Factor 5

Useful factors are shown in green. Harmful factors are shown in red. The arrows connecting the factors describe their relationship. A solid arrow means that the first factor produces the second factor. An arrow with a short line through the shaft means that the first factor counteracts the second factor. There are eight basic relationships that can exist as listed in figure 4. The functional model of the major logic path can now be analysed to identify opportunities to improve the useful functions in the model. At this point, improvement of useful functions is the only way to increase Ideality because the model contains no harmful functions at this point.

• TRIZ inventive principles can be used to generate ideas for improvement. This is typically done in a brainstorming session based on the principles of Osborne. Whenever a group is brainstorming a problem or issue, the users face a significant problem of psychological inertia. Alex Osborne developed brainstorming techniques to help overcome the psychological inertia people face when attempting to conceive creative problem solutions. Psychological inertia results because our human experience is limited and we tend to think of a problem solution that is similar to problem solutions that we have previously experienced. Participants in a brainstorming session can work together to break down psychological inertia based on the breadth of their collective experiences but it can never be eliminated. Because TRIZ is built on such a broad knowledge base, it can dramatically reduce psychological inertia and develop a nearly exhaustive set of abstract solutions. The abstract solutions must then be applied to the real world prob-

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lem to create a problem specific solution opportunity. Because the major logic path functional model is a nearly pure functional model (i.e. it does not reflect the components of the system in any level of significant detail, it tends to generate new product concepts. Improving useful functions at this point often means generating completely new product concepts.

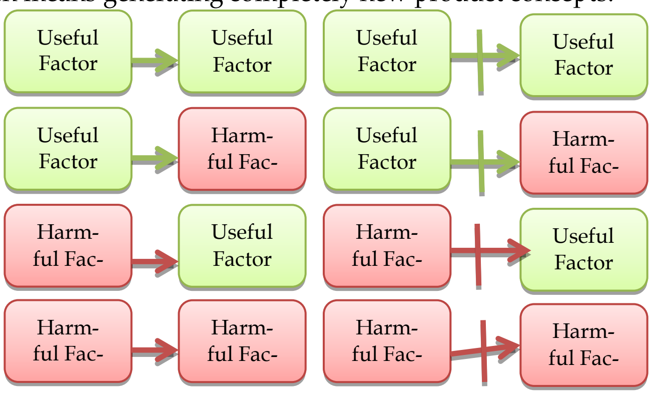

Fig. 4 Basic Possible Relationships

Step 2 – Incorporating Design Elements into the Functional Model

• Next, we take a departure from traditional FAST models. We can add the physical components of the system as objects in the model. The concept here is that an object can produce a function.

• The functional model of the major logic path with the physical components added can now be analysed to identify opportunities to improve the useful functions in the model and to improve the usefulness of the system components. Here we have the opportunity for improvement of useful functions as well as the opportunity to improve the system components. Improvements to the components could be additional functionality and/or cost improvements.

• TRIZ inventive principles can be used again to generate ideas to improve the usefulness of functions and components in the functional model of the major logic path with the physical components added.

Step 3– Adding Harmful Functions

• Finally, we add harmful functions to the model. Harmful functions can include consequences of the functions in the When direction. The harmful function is the “consequence of” that function. The functional model can also include costs, because costs are by definition, harmful functions.

• The functional model of the system including physical components of the system, harmful functions and cost elements can now be analysed for opportunities. At this point there are three types of opportunities to consider:

1) We can improve a useful function,
2) We can reduce a harmful function or
3) We can resolve a contradiction.

This analysis leads to opportunities both for product improvements and cost reductions.

• TRIZ inventive principles can be used again. In this instance we can generate ideas to improve the usefulness of functions and components in the functional model and we can also investigate ideas to reduce or eliminate harmful functions and we can pursue ideas to resolve any contradictions in the system.

2.3 TRIZ Tools

Traditional TRIZ tools, such as “Su-field Analysis,” are not objective sufficient to influence other specialists when transiting specific problems into general ones. Despite the functional tools of TRIZ, some references suggest replacing them with AHP and GRA in order to increase the objectivity of defining problems and choosing the most appropriate engineering parameters. Moreover, the advantages from AHP can be briefly listed below. [2, 3, 4, 5, 6]

- Higher objectivity
- Systematic and logical process to define and organize tough problems
- The gradual steps to break down main system problems for subsequent analysis
- Objective analysis of the importance of each in depth problems

Step 4: Define the main problems and decompose them into hierarchy: This stage illustrated with Figure 5 mainly describes how to decompose the main problem of the system into several requirement indices and to determine their correspondent weights via AHP. According to the definition of the technical contradiction, it is trying to improve a feature/parameter that may result in a contradiction. In one word, the improving parameter is obtained before the worsening one. First, managers/engineers should identify the macro problems of the system by questionnaires, brainstorming, or other method. Second, these main problems are decomposed into sub-problems and further into requirement indices. This step is achieved by questioning external specialists, internal managers, senior engineers, or even the first-line workers, which is the assumption of this study. [7, 8, 9]

Step 5: Input the improving and worsening parameters: In reference to preceding section, individually highlight the improving and worsening parameters in the rows (improving ones) and columns (worsening ones) of the updated contradiction matrix.

Step 6. Develop the “Judgmental Matrix.” Before defining objective weights of each requirement indices, managers/engineers have to develop the “Judgmental Matrix” first. It is a square matrix of size n × n and composed by pair-wise comparisons about the extent of the importance of each index with the relative scale measurement shown in Table 2, a questionnaire of pair-wise comparisons towards the same relative people mentioned in Step 1 is used as well.

TABLE 2 PAIR-WISE COMPARISON SCALE. [10]

Numerical Rating	Verbal judgements of preferences
5	Strongly preferred
4	Moderately to strongly
3	Moderately preferred
2	Equally to moderately
1	Equally preferred

2.4 Evaluation Stage

Step 11. Evaluate the technical, economical, and other feasibility: After the tests, at least one gathering should be hold for the effectiveness evaluation of this alternative and its tiny corrections, which can be analysed through meetings or the famous brainstorming method, "Delphi method." Steps for Delphi method are described below.
i. Elucidate the subject and task to the analysis team.
ii. Develop the first round Delphi questionnaire. (Team members are questioned separately.)
iii. Analyse and reduce the first round responses.
iv. Prepare the second round Delphi questionnaire.
v. Analyse and reduce the second round responses. (Steps iii to v are repeated as long as desired or necessary to achieve stability in the results.)
vi. Construct the conclusion by the analysis team.
Step 13. Make a decision: Following the composite evaluation of feasibility, innovation team could judge the effectiveness of the tentative solution by pre-set criteria (requirement indices or others). Fortunately, if the tentative solution meets the criteria, it will be regarded as final solution. On the contrary, if this alternative cannot meet the pre-set criteria, it is abandoned and replaced with other tentative solution developed again. If two or three specific solutions were rejected as well, it might be essential to re-assess the improving and worsening parameters. In other words, it might make the process of problem solving return back to section 2.4.
Step 14. Create the output: After the tentative specific solution meets the pre-set criteria eventually, it is taken as the final answer to practical situation or projects of larger scale. In addition, the process of solving this problem will be documented and recorded in the knowledge base for management.

2.5 Implementation Stage

Along with the age of knowledge-explosion, it is more and more important for each organization to store, accumulate, and manage knowledge gained via headwork or analysing, deducing, model operating, etc. Also, knowledge can be lessons learned, historical information, or whatever.

3 Discussions

Again we are left to resolve a contradiction: - to improve the effectiveness of VE workshops, Structured Innovation/ TRIZ techniques should be used; but, - because they are complex and difficult to teach, they should not be used. The TRIZ Inventive Principle Exclude (remove a critical element from the system) would suggest one way to resolve this contradiction is to remove the training -- apply the Inventive Principles without teaching the underlying science (TRIZ). How can this possibly be accomplished? The short answer is: by stealth! This "stealth" approach has been practiced by a few Value Methodology facilitators over the past several years, who have reported (subjective) improvements in brainstorming results. This "stealth" approach has been practiced by a few Value Methodology facilitators over the past several years, who have reported (subjective) improvements in brainstorming results. One empirical study suggests that while actual ideas recorded may in fact have decreased, the ideas were more complete, better formulated and a higher percentage were evaluated as potentially valuable. The result was a significant net positive impact on the ratio of good ideas to the overall number of ideas generated in the brainstorming session. A majority of workshops conducted using the TRIZ Enhanced Brainstorming approach have reported that between 25% and 40% additional ideas were generated as a direct result of the application of the TRIZ methodology.

4 Conclusion

Value Management and TRIZ can be incorporated all the way through FAST diagrams. Value Management relies on a variety of brainstorming techniques to produce dilemma solutions. The cost-effective significance of the development, for sure, depends ahead identifying a pioneering, soaring assessment clarification. For the most part, brainstorming technique used in Value Management is psychosomatic in character and weighed down by psychosomatic sluggishness which tends to limit the number and quality of thoughts. TRIZ in contrast, is a scientifically based problem solving methodology driven by a widespread awareness. TRIZ can generate a large set of prospective solutions that are exceedingly inventive. The mishmash of Value Management with TRIZ offers a prospective to categorize higher value solutions more swiftly than either technique alone. This model leads to opportunities both for product improvements and cost reductions by utilizing the TRIZ inventive principles. The purpose of the TRIZ line of attack is to breed ideas to advance the efficacy of functions and components in the well-designed function model and in unison, also examine thoughts to diminish or reduce detrimental functions.

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