First presented at the Altshuller Institute TRIZCON2000, May 1, 2000

Effective Approaches to Solving Technical Problems by Combining TRIZ with VE

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Abstract

In this paper, I propose the practical and effective approach to create the highly innovative solutions by applying the concept of contradiction solution of TRIZ to the functional approach of VE.

To be more concrete, firstly good concepts are to be created for the solution of technical problems in accordance with the practical procedure of VE which is called 2nd look VE Job Plan for redesigning for quality improvement. Then some of TRIZ techniques are to be applied to create the useful ways to overcome the drawbacks of the created concepts still keeping the advantages of them. It means a solution of contradictions remaining in the created concepts.

The TRIZ technique I utilized this time is IPS (Innovative Problem Solving) of IWB (Innovative WorkBench software introduced by Ideation International Inc). It consists of 5steps, one of which is an especially useful tool. It is called PF (Problem Formulator). PF is able to illustrate the relationship between the advantages and drawbacks of the created concepts in the Functional Graph on computer display. Moreover, PF provides Directions automatically on the computer display, which gives us hints (recommendations) to create innovative ways to overcome the drawbacks of the created concepts without sacrificing the advantages. In another word, PF is a very useful tool to give us hint (recommendation) to solve the technical contradictions.

The approach I discuss in this paper has already been proved to be effective in our application to real project at X automotive manufacturer (the unit of Gas Driven Heat Pump).

1.Introduction

Most of manufactures in Japan often apply VE (Value Engineering) as one of the effective methods to design high-valued product. (Incidentally, high-valued products mean the products, which keep good balance between cost and quality of product from the viewpoint of VE)

Because VE has a serial procedure (VE Job Plan) whose effectiveness has already been proven. This system as a whole is called the functional approach. When this approach is taken, superior products with higher value are created with required functions. This is a characteristic method for problem solving and is the foundation of VE activities.

However, even if engineers are good practitioners, it's hard for them to create ideas that always lead to high-valued designs.

Because all they can do is to create a lot of ideas through Brainstorming when they reach Idea generation step of VE Job plan. This means that they have no choice but Brain-storming to create ideas. Though Brain-storming is not ineffective tool, it depends on each person's creativity. Namely, it is very difficult to create excellent ideas beyond psychological inertia by utilizing only Brain-storming constantly.

Therefore, in this article, in order to create high-valued idea through VE activities effectively, we would like to introduce effective ways to combine TRIZ tools with VE Job Plan.

2.VE application an Basic Stages of a product Life Cycle

In the study or activities of VE, actually VE itself is classified into three categories in accordance with each stage of product life cycle. Those categories are "0" look VE, 1st look VE and 2nd look VE. Those terms may sound funny because Japanese authorities have named them in Japanese sense. But they are generally accepted and used in the VE field in not only Japan but also other countries. The "0", 1st and 2nd look VE correspond to the VE at the planning &development stages, the designing stage and the manufacturing stage of product life cycle respectively. The brief explanation about the meanings is given as follow.

"0" Look VE: VE at Planning/Development Stages

In order to create a product that is fitted for customers' needs, one has to develop and output fine specifications fulfilling customers' requirements on product. And to do that, he has to apply VE methods or techniques from earlier stages of a life cycle. Recently "0" Look VE is called marketing VE occasionally.

1st Look VE: VE at Designing Stages

1st look VE helps one select or decide necessary structural attributes of a product and develop manufacturing specifications, which is called a manufacturing plan for next stage. Therefore, 1st look VE will be intended to select out or decide the basic structure of a product as well as shapes, quality, accuracy and other attributes of individual material so carefully that those selections meet conditions specified in development plan.

2nd Look VE: VE at Manufacturing Stages

Based on the manufacturing plan developed by engineers of an already designed or repeatedly created product, 2nd look VE will help them analyze the should-be functions, generate a better alternative idea or modify the manufacturing method designed by engineers.

Figure 1 summarizes the relationship between VE application stages and the characteristics.

VE Application Stage	VE at Planning/ Development Stage **"0"look VE**	VE at Designing Stage **1st look VE**	VE at Manufacturing Stage **2nd look VE**
Starting point (Input)	*Customers' Requirements	*Development/ Design Specifications	*Manufacturing Specifications
Creation (output)	*Development/ Design Specifications	*Manufacturing Specifications	*Manufacturing Specifications (Redesigning) *Product
Duties	*Basic Ideas Generation *Crystallization and Selection of Ideas *Selection of Condition for Having Necessary Function *Selection of Design	*Selection of Structural Attributes (System, Structure, Materials, Shapes, Appearances and others)	*Review of Structural Attributes Selected out

Figure 1. VE application stages and the Characteristics

As the Figure 1 indicates, it's possible to apply VE method to each stage of a product life cycle. However, all the types of VE do not have any useful tools except Barnstorming to create high-valued ideas. Therefore, applying TRIZ to three types of VE activity is very significant.

However, we would like to focus on the application some of TRIZ tools to 2nd look VE this time, because we had opportunity to utilize them to 2nd look VE activities at X automotive manufacturer. Actually, we mainly combined IPS (Inventive problem solving), one of the effective contemporary TRIZ tools being developed by Ideation International, with VE Job Plan of 2nd look VE.

3.Mutual collaboration through combination TRIZ With VE

Though we are not concerned with some topics about combination of TRIZ with "0" and 1st look VE in this article, I want to emphasize that TRIZ is very useful not only 2nd look VE but also "0" and 1st look VE naturally.

Therefore, I would like to touch on the topics regarding Mutual collaboration of both TRIZ and VE briefly. Figure 2 summarizes Mutual collaboration.

VE Application Stages	Application of TRIZ tools	Merits of TRIZ tools
0 Look VE	*Patterns of technological evolution *DE(Directed Evolution)	Reveal the high-valued concepts of new generation product for customers
1st look VE	*AFD (Anticipatory Failure Determination)	Reveal and resolve potential problems with new product being designed
2nd look VE	*Effects *IPS (Inventive Problem Solving)	Resolve the problems that occur in the actual manufacturing process

Figure 2. Mutual collaboration of both TRIZ And VE

4. Combination TRIZ tools with 2nd look VE

We had an opportunity to support X automotive manufacturer through redesign project of A product. (A product is a unit of Gas Engine Driven Heat Pump) As you know, most of the manufactures, especially automotive manufactures actively introduce VE methods as one of valid tactics to become strong competitor against rival company in the marketplace. To be concrete, they utilize VE not only for cost reduction but for technical problem solving of product. Here, we would like to summarize the relationship between VE Job Plan and TRIZ tools we utilized at X manufacturers' project this time.

Figure 3 shows that what kind of TRIZ tools

we utilized in each step of VE Job Plan (procedure of 2nd look VE).

Basic Phase	2nd look VE Step (Procedure)	Application of TRIZ tools
Definition of function	Step1 Information Collection	Not used
	Step2 Definition of function	Not used
	Step3 Development of Functional diagram	Not used
Evaluation of function	Step4 Cost analysis function	Not used
	Step5 Evaluation of function	Not used
	Step6 Identification of lower-value functions	Not used
Development of alternatives	Step7 Idea generation-brainstorming	Innovation Guide in IWB
	Step8 Preliminary evaluation	Not used
	Step9 Refinement of selected ideas	IPS in IWB (Especially Used Problem Formulator)
	Step10 Final evaluation	Not used

Figure 3 Relationship between VE Job Plan And TRIZ tools at X manufacturers' Project

5.CaseStudy: X manufacturers' Project

I would like to explain the details of the case according to the procedure (VE Job Plan) by which we guided engineers (project members) at X manufacturer as management consultant.

We will only give the outline at the steps where we did not utilize TRIZ tools. And, we will describe as many contents (including opinions) as possible at the steps (step7, step9) where we utilized them.

5.1 Step1: Information Collection for VE

The case study we will describe in this article is based on VE activities related to both cost reduction of existing product and improvement of units' performance for coping with environmental problem. Therefore, we collected information regarding the above-mentioned products' situation at Step 1.

Figure 4 shows the portion of information related to the project.

Project name: GHP (Gas Engine Driven Heat Pump)
Scope of subject matter: Units of exhaust pipe
Cost Target: keeps actual cost of existing Product (prototype)
Performance: improvement of exhaust pipe for protecting environment.
(Reduction Nox, High efficiency)
Etc.

Figure 4 Information Collection

In my opinion, we can utilize ISQ (Innovative Situation Questionnaire) as useful tool to get information regarding VE subject matter. Thus we want to use ISQ at step1 next time.

5.2 Step 2: Definition of Function

The purpose of the step 2 is to clarify should-be functions. Because customers always expect to get on hand the functions they need to have at a lowest cost.

Therefore, we have to define each of such functions required by customers simply with just a noun and a verb.

5.3Step3:Development of Functional diagram

The purpose of the step 3 is to clarify the function to be fulfilled by the subject matter (Unit of exhaust pipe). That is, we have to illustrate the interrelationship of all the functions identified at step 2. To be concrete, we have to organize Functional System Diagram, which systematically defines mutual

subordinate relations of each defined function by the logic of purpose and means.

Figure5 shows the portion of Functional System Diagram related to the subject (exhaust pipe).

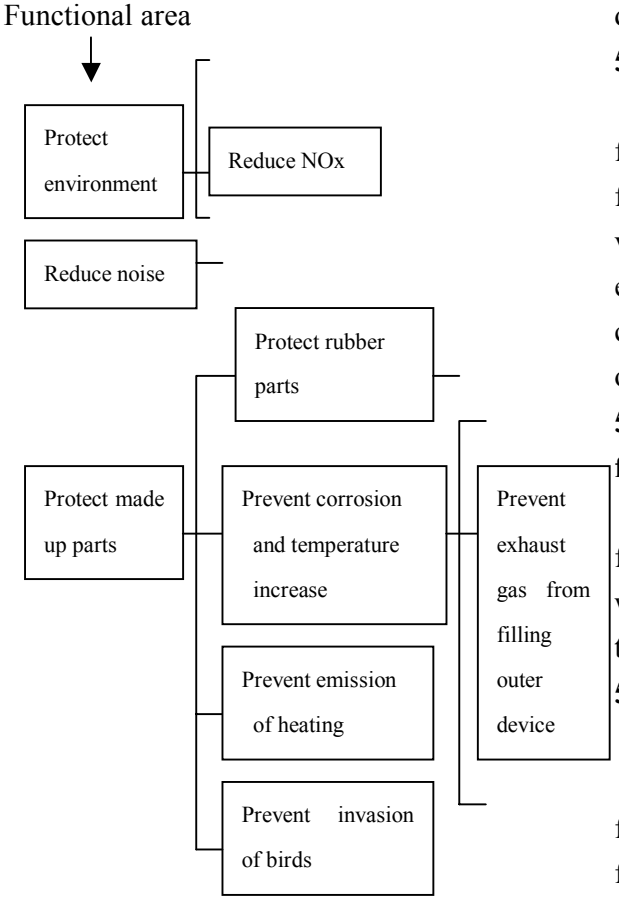

Figure 5 The portion of Functional System Diagram of exhaust pipe

Incidentally, Functional System Diagram is called Functional Analysis System technique (FAST) in USA.

We think that utilizing Problem Formulator (PF) to organize such Diagram is very convenient. Therefore, we would like to apply PF at step3 next time.

5.4Step 4: Cost analysis function

The purpose of the step 4 is to find out cost spent to achieve a specified function (functional area). To be concrete, we determined functional area to be evaluated on the functional system diagram and also identified current cost by each functional area.

Functional System Diagram of exhaust pipe has 11 functional areas.

In this article, we are not concerned with the VE tools of the step 4 because they do not directly relate to the purpose of this paper.

5.5 Step 5: Evaluation of function

The purpose of the step 5 is to establish functional evaluation value (cost objective by function). As a matter of fact, VE have a variety of tools to establish functional evaluation value. However, we are not concerned with the VE tools of step 5 because of the same reason mentioned above.

5.6Step6: Identification of lower-value functions

The purpose of the step 6 is to choose functional area with lower value. It means that we find out the functional area that is required to create ideas for improvement.

5.7Step 7: Idea generation brainstorming (Apply Innovation Guide in IWB)

The purpose of the step 7 is to generate ideas for achieving specific functions. Specific functions belong to functional area with lower value. Therefore, they are seeds of alternatives. At this step, efforts are made not for preparing definite alternatives that can be used immediately, but for obtaining hints that serve as a basis of alternatives.

Under usual VE activities, we make an effort to create ideas through brainstorming from the viewpoint of Functional-oriented Idea Generation by VE. However, we adopted Innovation Guide in IWB at this step as a useful tool stimulating a person's brain at this project. Because we believed that it strongly support brainstorming and bring out the

effectiveness of brainstorming. Therefore, we utilize both Innovation Guide and brainstorming at this step. (Actually, most of VE members were not accustomed to utilize Innovation Guide without brainstorming directly.)

Figure 7 shows the relationship between Innovation Guide and brainstorming at VE activity.

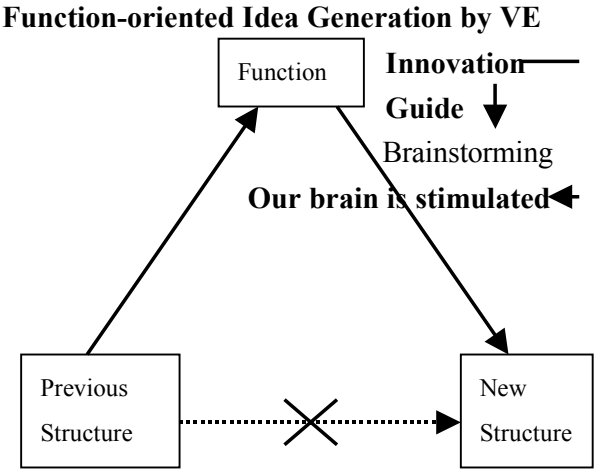

Figure 7 relationship between Innovation Guide and brainstorming at VE approach

Basic concept of Innovation Guide is based on some of 76 standard solutions and Effects and it gives us useful physical, chemical or geometric effects which leads to good idea with achieving specific functions. Therefore, Innovation Guide is compatible with this step of VE activities.

As the result of using Innovation Guide, VE members (Engineers) were able to generate innovative ideas within limited time compare to brainstorming only.

5.8 Step 8: Preliminary evaluation

The purpose of the step 8 is to select ideas that are expected to enhance values from generated ideas. We will evaluate ideas from aspects of both technical and economic possibilities that are closely related to function and cost.

Step 9: Refinement of selected ideas (Apply IPS in IWB)

The purpose of the step9 is to prepare alternatives that are expected to improve value, refining the ideas selected through step8. Selected in step8 were ideas expected to improve value. However, many of such ideas can not be used as they are. In addition, generally speaking, ideas at this stage are partial ideas, including those related to structure and those concerning materials. Such ideas, as they are, can not be presented as alternatives. It is, therefore, necessary to combine and refine ideas and to organize them into high-valued alternatives. However, under ordinary VE activities, we often come up against some drawbacks (It is called Technical Contradiction or Physical Contradiction in TRIZ field) each alternative has after combination of ideas. Moreover, before we met TRIZ methodology, we had no choice but solutions by utilizing our experience and knowledge. But, now we have learned TRIZ. So, we decided to adopt IPS in IWB at this step as an effective tool to find out inventive solution for overcoming drawbacks.

Figure 8 shows the procedure of refinement of alternatives by combining IPS with this step at VE activities.

VE members tried to find out the inventive ways to overcome drawbacks according to the procedure being shown Figure 8.

They could get inventive ways to overcome those through practice of IPS. Especially, Problem Formulator is a wonderful tool. Because PF give us a lot of hints to generate inventive ideas to overcome serious drawbacks. However, TRIZ practitioners have

to pay attention that IPS can not give us concrete ways directory. Therefore, When VE practitioners will apply TRIZ (including IPS) at VE activities, they should learn TRIZ methodology, especially classical TRIZ by Altshuller, before practice.

Figure 8 shows Procedure of Refinement

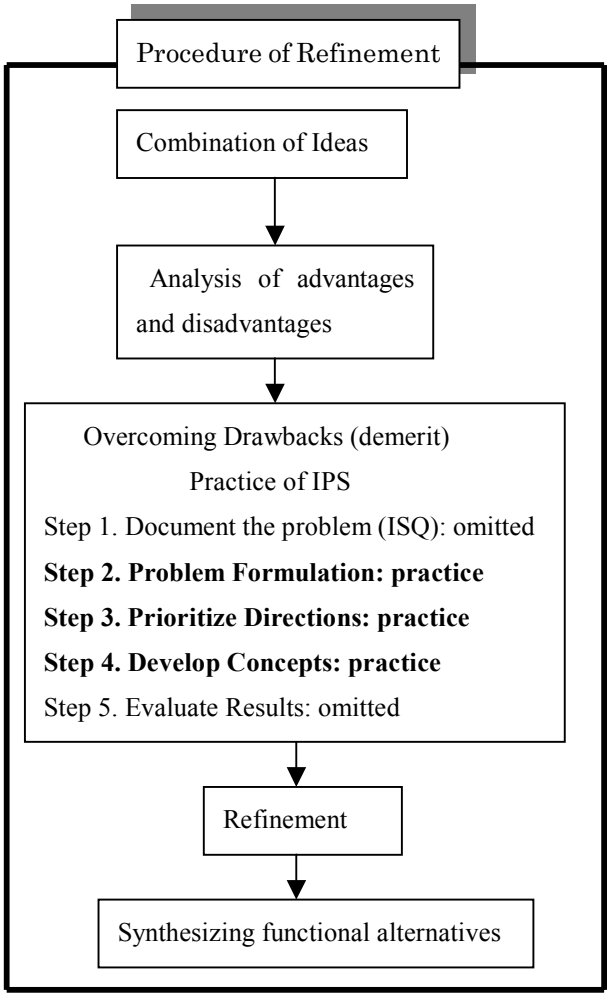

Figure 8 Procedure of Refinement

By the way, we organized the graph shown the relationship between useful functions and harmful effects alternatives have through step2 of IPS after analysis of advantages and disadvantages alternatives have. After that, we chose Directions to find out inventive ways to overcome drawbacks at step 3 of IPS.

Frankly speaking, we think that several Directions have given VE members great hints which lead to inventive ways.

Figure 9 shows Graph that was made by utilizing PF. Figure10 is one of Directions that VE members chose.

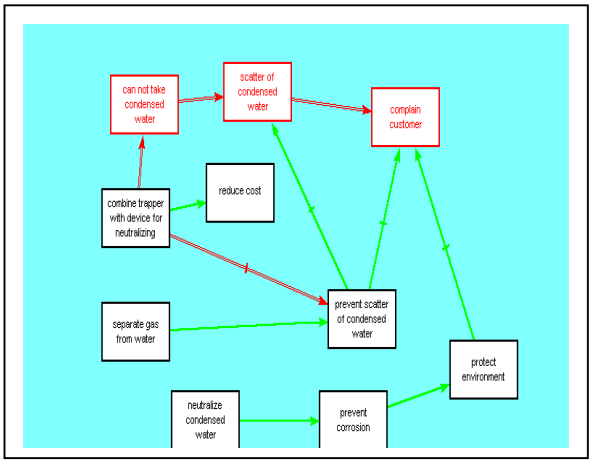

Figure 9 Graph regarding to alternative

3. Find a way to resolve the contradiction: [the] (combine trapper with device for neutralizing) should exist to obtain [the] (reduce cost), and should not exist in order to avoid [the] (can not take condensed water) and also avoid hindering [the] (prevent scatter of condensed water).

Figure 10 Direction for resolving serious TC

VE members could get inventive ways to resolve a serious Technical Contradiction through the Direction.

Strictly speaking, they could reach inventive ways by creating ideas through Direction oriented approach (See Figure 10). On their way to reach inventive ways, they used several Illustrations installed in IWB as concrete hint for analogical thinking.

One of Illustrations they utilized for extracting an inventive way and the strongest

point of inventive alternative they designed are given as follow (Figure 11).

The contents of it are unfortunately confidential because they try to file an application of patent.

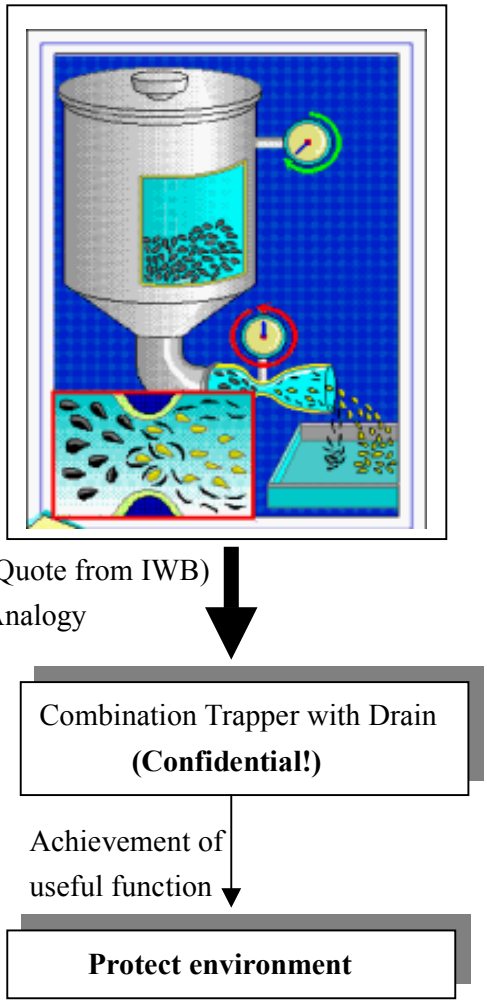

Figure 11 Analogical thinking

5.10STEP 10:Final evaluation

The purpose of the step 10 is to guarantee that altered contents will inevitably improve the values of subject matter. To be concrete, we have to evaluate both technical and economic feasibility of alternative.

6.Conclusion

In this paper, I proposed effective approaches to solving technical problems by combining TRIZ with 2nd look VE through the real procedure I applied at X automotive manufacturer. I am sure that such approach will be proved to be effective and practical in VE field. Because, it was proven that TRIZ (especially IPS) Strongly supports step 7(idea generation) and 9(refinement of selected ideas) of VE Job Plan. To be concrete, above-mentioned TRIZ tools stimulated VE members to create ideas supported by technology.

Next time I would like to apply another TRIZ tools (for example, DE or AFD) to “0”or 1st look VE through VE activities. And, I want to verify that we can combine TRIZ tools with not only 2nd look VE but both “0”and 1st look VE too.

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