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APPLICATION OF VALUE ENGINEERING TECHNIQUES: A CASE STUDY OF BENZENE SAMPLE CONTAINER

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ABSTRACT

The team employed the value engineering (VE) technique in designing of a new benzene container having an objective to reduce the purchasing cost while maintaining its functions as well as its safety level in practice. It was shown that a new container designed in this study using an aluminum cap, with a butyl rubber septum and having a 240-ml bottle in volume could replace the existing sample container. This replacement contributes greatly to a 98% reduction of the total purchasing cost of the sample container or 1,986,687 Bahts/year. The results of this case study strongly confirm that VE is a very beneficial tool that can be used in practice with reasonable amount of effort and it should be utilized more to reduce unnecessary costs in an organization.

Keywords : Value engineering techniques.

INTRODUCTION

A refinery department is one of several departments in a company "A" (not a real name) that plays a key role in producing petroleum products. Recent production expansion covers new chemical products, such as concentrated benzene, para-xylene, and so on. With this expansion, new production technologies, product sampling methodology as well as tools required have been introduced along with the process of developing new products. The methodology of product sampling and tools required are to ensure the quality of new product according to specifications.

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In this research the products that concern are petroleum products whose their sampling processes can be performed in an open system but the samples, themselves, are to be kept in a closed system. The closed system prevents the exposure of operators to the substances, which are considered to be highly toxicated. However, using glass as a material of bottles does not seem to be the best option due to many aspects of its properties. One of the important aspects is that it is very fragile, which means the risk of having chemical spillage is high. Another aspect is the existing set of material is quite expensive because of the fact that this specific type of materials (Polytetra-Fluoro Ethylene (PTFE) coated silicone septum) is needed to be imported. According to prior record, company "A" spends about two million Bahts annually.

To assist the situation, the teamof investigators applied the technique of VE to determine if there are other types of materials and designs that are functionally appropriate for the benzene container instead of the existing one.

METHODOLOGY

The seven-phase job plan of Mudge (Mudge, 1971) of VE was employed in this study. In addition, this job plan also gives attention to the psychological aspects especially in the "General Phase". The functional analysis is performed to ensure that the new design of a product conforms to the functional requirements in the "Function Phase". To provide background of the seven-phase job plan, brief details of each phase are given below.

General phase

The general phase plays a critical role that can help to build a strong structure for other phases. The main objective of this phase is to develop good human relation and to build team spirit.

Information phase

This phase aims to gather and analyze all relevant information in order to obtain essential facts and fully understands the problem. As examples of the relevant information of the product under this study, the pictures of the product components are shown in Figures 1, 2 and 3 and brief details are also given.

Figure 1. Glass bottle sizes 1,000 ml and sizes 250 ml.

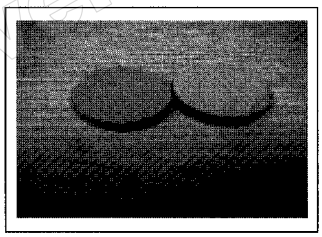

Figure 2. Septum.

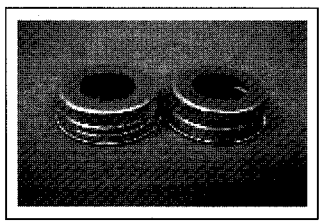

Figure 3. Aluminum cap.

Currently, only two types of caps are used and made from plastic with Ø 30 mm, and aluminum with Ø 25 mm used for the 1 litter bottle and the 250 milliliter bottle, respectively. The bottle consumption rate is 26 and 72 bottles per week for the 1 litter and 250 milliliter, which contribute to the imported cost of 14,690 and 24,480 Bahts/week, respectively.

Function phase

The functional approach is a group of techniques applied within the job plan that set the VE apart from all other cost prevention and reduction programs. The aim of this phase is to reveal the functions of all goods or services and thus identify the nature of products and services, respectively (Akiyama, 1991).

Numerical evaluation of functional relationships

To analyze the functions of each component being studied are entered in the work sheet entitled "Evaluation Summary Work Sheet" as shown in Table 1. All the functions determined were each given a letter in an alphabetical order to facilitate comparison. These key letters were used throughout the succeeding comparisons and evaluations of the functions as shown in Figure 4.

The evaluation started by relating function A to function B and to determine the level of importance. As there was always a difference in the level of importance between any two functions, the difference was rated by weight factor-1, 2, or 3 - indicating minor medium and major differences, respectively.

Table 1. Evaluation summary work sheet.

Key letter	Functions	Weight	Adjusted weight
A	Contain sample	15	16
B	Level indication	6	7
C	Chemical resistance	12	13
D	Hold septum	9	10
E	No-leakage and no-evaporation	13	14
F	Convenience of usage	2	3
G	Light weight	0	1
H	Non-slip	1	2

	B	C	D	E	F	G	H
A	A-2	A-2	A-1	A-1	A-3	A-3	A-3
B		C-2	D-1	E-2	B-2	B-2	B-2
C			C-1	E-1	C-3	C-3	C-3
D				E-1	D-2	D-3	D-3
E					E-3	E-3	E-3
F						F-1	F-1
G							H-1

Figure 4. Numerical evaluation chart.

Legend : Evaluation weight factors of differences in level of importance
1 = minor, 2 = medium, and 3 = major

The conclusion of the function analysis phase is as below.

The basic functions of the container are:

1. Contain sample
2. No leakage and no evaporation
3. Chemical resistance
4. Hold septum
5. Level indication

And, the secondary functions are:

1. Convenience of usage
2. Non slip
3. Light weight

Creation phase

This is one of the most important phases of VE job plan. At this point, the team of investigators went through a brainstorming process to design the new benzene container based on its required functions determined in the previous phase as a guideline for the team members during the brainstorming process.

Evaluation phase

The evaluation phase, directed towards the development of preliminary alternatives, was considered to be a continuation of the creation phase. At this phase, every idea generated in the creation phase was expanded, either individually or combined with other ideas, into potentially workable solutions to attain the desired or required functions. The Analytical Hierarchy Process (AHP) was employed.

Analytical hierarchy process

The AHP model was designed by TL Saaty (Saaty, 1980) as a decision making support tool. It is suitable for complex decisions that involve qualitative comparison of elements. Once a hierarchy has been established, the pair-wise comparison matrices at each level are needed for further analysis. Generally, two options of how to generate the metrices are available, consensus vote and individual judgments. Under this study the latter was utilized to avoid considerable amount of time spent on the discussion process. The AHP allowed each decision-maker to specify a value and then combine individual judgments. The mean was used to the individual judgments in order to obtain group judgment for each pair-wise comparison (See Figure 5).

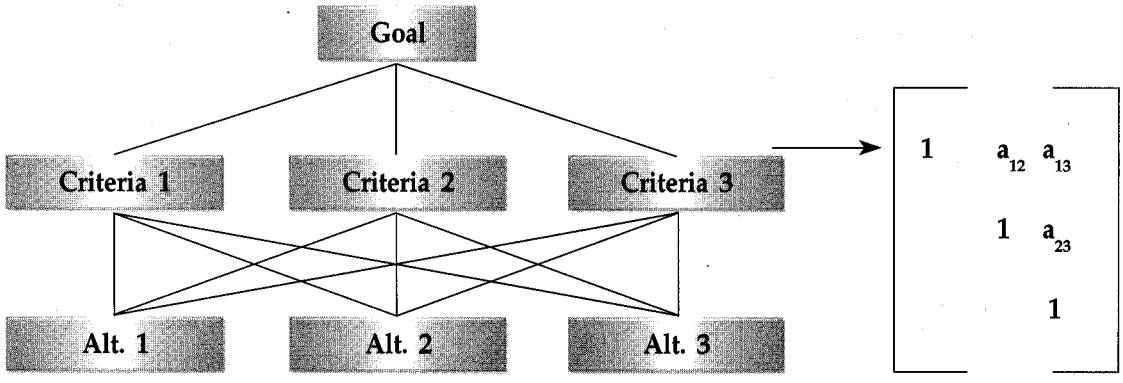

Figure 5. Consensus vote.

Let (a_{ij}) represents an n x n pair-wise comparison matrix formed by taking the mean of the individual judgments and let (w_1, w_2. w_n) represents the weights derived from the matrix. Then the relationship can be expressed by formula number (1).

$$\sum_{i,j} a_{ij}\, w_j \Big/ w_i - n^2 \quad \text{.....(1)}$$

The formula number (1) draws the relative departure of (a_{ij}) from consistency. This was followed by the fact that under a perfect consistency the team of investigators would have $a_{ij} w_j / w_I = 1$. Based on the relationship in equation number (2), the formula number (1) can then be modified to equation number (3)

$$\sum_{j} a_{ij}\, w_j = \lambda_{max}\, w_i \quad \text{.....(2)}$$

$$\sum_{i,j} a_{ij}\, w_j \Big/ w_i = \eta\lambda_{max} \quad \text{.....(3)}$$

The deviation from n^2 was selected and then divided it by n^2. As a result, an index of a relative departure from consistency was obtained, as shown in equation number (4).

$$(n\lambda_{max} - n^2)\, n^2 = (\lambda_{max} - n) \Big/ n \quad \text{.....(4)}$$

The consistency ratio (C.R.) was computed by taking the ratio of the above expression to the random index listed in Table 3. If the C.R. is less than 0.10, then the group judgment was considered being consistent.

In the same way, the group of investigators determined the relative departure of an individual from the group judgment. If ($a_{ij}^{(k)}$) was the matrix of judgments of the k^{th} individual and (w_1, w_2,...w_n) were the weights calculated from the group pair-wise comparison matrix (a_{ij}), then the formula number (5) is used to represent the relative departure of the individual's judgments from those of the group of investigators.

$$\sum_{i,j} a_{ij}^{(k)} w_j \Big/ w_i - n^2 \quad \text{.....(5)}$$

The consistency ratio was computed in the usual way. For the individual to be compatible with the group, this measure should not be expected to exceed 0.10. This result enabled users to identify individuals and subgroups that were odds with the group as a whole.

Investigation phase

The objective of this phase is to further refine the selected ideas into workable solutions. Following the refining of the selected ideas, criteria related to workability and costs of the new design were identified. The tests were performed to validate that the new design is applicable for use in the workplace. For this study, this step was done by turning the filled container upside down to check for leakage or droplet of the sample. In addition, the measuring equipment was used to inspect the level of air contamination.

Table 3. Random inconsistency index.

n	1	2	3	4	5	6	7	8	9	10
R.I	0	0	0.58	0.90	1.12	1.24	1.35	1.40	1.45	1.49

Recommendation phase

This is the last phase of Mudge job plan and is the most difficult part of the entire job plan. The objective was to motivate positive action, to prevent the generation of negative reaction, and to propose a change.

In the study, the company was able to design new benzene sample container with lower cost while maintaining the same level of performance, reliability and safety. The team of investigators was advised to conduct refresher training for all operators who are responsible for sample taking such as how to handle sample container safely and the proper use of aiding equipment to prevent reoccurrence of accidence

RESULTS

It was revealed that the newly designed container was a little smaller and lighter than the existing one. And also, 98% cheaper than the old material used. It was also shown that the Mudge's job plan was appropriate for a specific nature of this study that concerns with the change of material specifications.

Results of functional analysis of the product under this study are shown in Table 2.

Table 2. Function analysis work sheet for benzene sample container.

Qty	Part name	Function definition		Supporting function	
		Verb	Noun	Basic	Sec.
1	Bottle	contain	Liquid sample	X	
		able to see	Liquid level insight	X	
		none react	with chemical	X	
		handle	comfortable		X
1	Cap	hold	Septum	X	
		open/close	Bottle		X
1	Septum	seal	Bottle	X	
		prevent	evaporate	X	

Once the consistency ratio was estimated, the consistency ratio was accepted if it was consistent with the following given value. If it was greater than that value, the priorities should be revised:

n 5, CR should not > 10%
n = 4, CR should not > 9%
n = 3, CR should not > 5%
(Tonsirikongkol, 1999)

where "n" is the sample size.

As the content of the matrix was consistent, the composite matrix was determined. An alternative was preferred which had the highest composite weight. AHP not only give the best alternative but it also tells the ranking of other possible alternatives. Owing to some reasons or limitations, if the best alternative cannot be used, then the second best alternative can be selected. This is the advantage of AHP.

Results of both tests indicated that there were no leakage nor droplet and no air contamination. Therefore, it can be concluded that the new design of product is safe for use. The investigation on costs of all new designs were performed by comparing the costs of all alternatives and the set of a 240-ml bottle with the Aluminum cap and the Butyl Rubber Septum is the best alternative with the total cost of 5.48 Bahts/set.

DISCUSSIONS

Overall, the team of investigators agreed that VE is a systematic technique that is very useful for analyzing products based on their functionalities. As demonstrated by the results of this study that a substantial amount of unnecessary cost can be eliminated by using different materials and/or designs. The team of investigators wishes that this study would establish the strong understanding in the fundamental of VE and its potential benefits in the company. Moreover, the team of investigators hopes the contribution of this study will go beyond the recognition in the benefit of VE technique itself to open the minds of people to other techniques as well.

REFERENCES

Akiyama, K.1991. *Function Analysis: Systematic Improvement of Quality and Performance.* Productivity Press Inc., Cambridge, Massachusetts.

Mudge, A. E. 1971. *Value Engineering: A Systematic Approach.* McGraw-Hill Book Company, New York.

Saaty, T. L. 1980. *The Analytical Hierarchy Process.* McGraw Hill Book Company, New York.

Tonsirikongkol, V. 1999. *A.H.P.* Graphic and Printing, Bangkok.