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Providing the Hybrid model in analyzing and selecting innovative projects of product design with approach to quality function deployment & value engineering (Case Study: SAPCO Company)

Mohammadreza Motadel[+1], Mohammadali Afshar-Kazemi[2], Abbas Toloie-Eshlaghy[3]

[1]Industrial management Department, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[2]Industrial management Department, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[3]Industrial management Department, Science and Research Branch, Islamic Azad University, Tehran, Iran

Abstract. With promoting the level of diversity and expectations of customers for products, the importance of recognizing and applying such tools for identification and transmission of customer needs in all production processes has increased. On the other hand reduction of the cost for survival in the emerging global scenario, more than ever is visible. Quality function deployment is a way which began in Japan in the years of 70s as an effective method (useful) to identify customer needs and building these needs in the final product has been proven and also the value engineering is a way which expanded in America after World War II, And is still a less expensive option to respond to customer needs in an effective manner. In this study, the research and review of various studies about both expansion of performance and value engineering method, has been tried with combining these two methods as a powerful tool for identifying innovative projects and creativity in improving product design. The model has been presented during a case study analysis.

Keywords: quality function deployment, value engineering, value index, VEQFD[1] model

1. Introduction

Trade and growth performance of growing competition range is largely related to customer behavior. There was a time that a customer looking for a product with good quality material and excellent access was willing to pay whatever amount the cost was, but today the situation has changed and in the current conditions a customer is looking for excellent quality with very little cost. In other words, customers are looking for quality, performance, reliability and lifetime cost per unit with lower cost and are willing to use pay services to pay later. (A. yer. S. S. - 2001, 88). So, a product being competed in the emerging global scenario should have such issues as performance, beauty, delivery, quality and cost. With competition becoming tougher than in the past, producers have to understand the cost factor is important to request a product. In fact, for organizations that are facing serious competition, the market price was constantly under pressure and maybe a competitive price today is not competitive tomorrow (Williamson, 1997) to achieve the target of cost and quality in new projects some tools such as Quality function deployment and value engineering function, can be combined and applied. Combining these two methods through multi-professional teams will create a powerful tool for increasing product and service value and is efficient for analysis and selecting new projects (Gabriel and Amihud, 1992, 1).

2. Literature review

[+] Corresponding author. Tel.: +98 912 313 1643
E-mail address: Dr.Motadel@yahoo.com 2, afshinafshar44@gmail.com 3, toloie@gmail.com

[1] VEQFD: value engineering & quality function deployment

2.1. Quality Function Deployment

QFD is a means to destroy or at least, reduce the quality differences. This procedural tool includes the customer needs in the product features during the product planning (Gandhinathan .R, Raviswaran, 2004). This method was developed in Japan in the early 1970, and in the end of the decade, had received much success in the U.S. (Gabriel and Amihud, 1992). QFD, among 26 major programs, is on the fourth level among American and European producers and Japanese manufacturers, and if properly guided in a correct manner, the use of the other seven methods and qualitative tools for planning is recommended (A. yer. S. S. - 2002, 88). The major tools for QFD are the quality matrixes. In this model the matrix widely used to QFD is called the house of quality. The matrix is employed to convert market's data to product strategy in order to trade, (Hasuer, 1998) house of quality contains various information that according to the type of items contained, the use of it will change.

2.2. Value engineering

Value Engineering is a management technique with a systematic approach for seeking the best balance between cost function, reliability and efficiency of a product or project (Zimmerman, 1982). Value engineering schedule has six stages. Of course, this quantitative is expressed differently in various books. Pre-study phase, phase of creativity, implementation phase, phase of analysis function, evaluation phase, phase of report.

3. Methodology & Data analysis

3.1. The research goals

- Recognizing the importance and weight of each factor of customer dissatisfaction in disk systems and automotive clutch 405.
- Recognizing the most important factor of customer dissatisfaction in disk systems and automotive clutch 405.
- Identifying the most effective functional requirements in reducing the customer dissatisfaction of disk systems and automotive clutch 405.
- Identifying the most important Plan to improve effective components in reducing customer dissatisfaction of disk systems and automotive clutch 405.
- Designing a Conceptual and applicable model from the combined value engineering approach and expansion of quality performance, to increase product value.

3.2. Research Methodology

In this study, the research methodology of the survey approach is modeling trend, and in terms of purpose is applied.

4. Integrated model

The VEQFD model is a systematic model to pass expectations of the customer to identify projects to improve components in order to increase customer satisfaction levels and enhance their value, directly to improve product design process. Figure (1) has shown the model in schematic form. The model is implemented in the form of a case study for disk systems and automotive clutch 405 as follows.

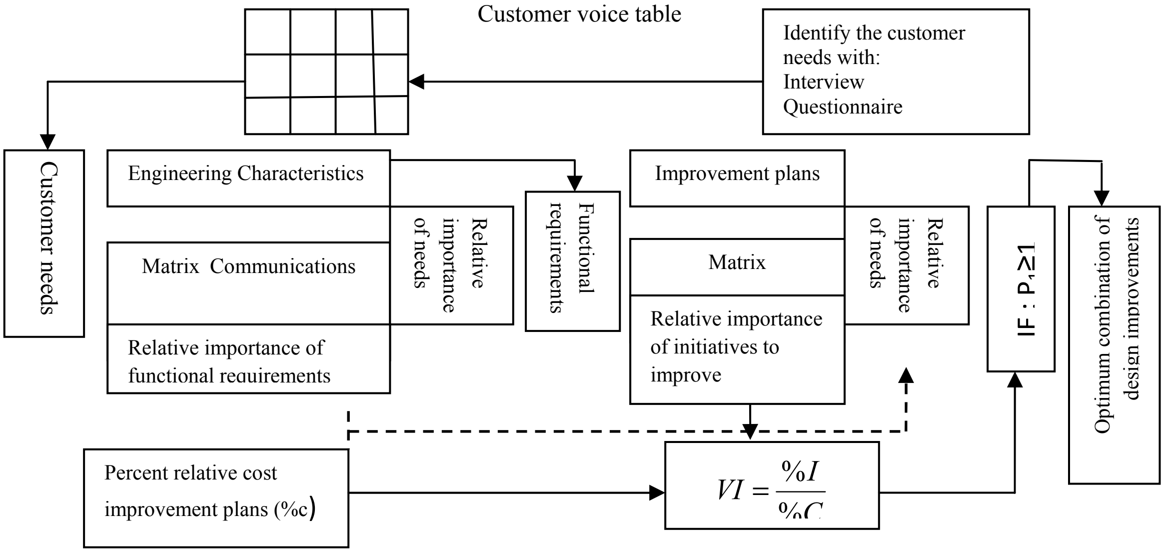

Fig. 1: the combination model of QFD & value engineering

4.1. Identifying customer needs and expectations of the product

To save time, the information that was obtained from previous projects in the organization was used to identify customer needs and expectations of the disk system and clutch. Identified needs of the system were classified in five groups, which include: comfortable gear, no abnormal pedal firmness, vehicle suitable elasticity, lack of sound, no car shaking. Prioritizing customer requirements with regard to getting some comments will be more important. Therefore, using paired comparisons technique, does these prioritizing and the results obtained from prioritizing needs in the relative importance column enters the house of quality matrix. After identifying customer needs, the engineering features that are somehow related to customer needs should be identified. This is done by design engineers. Results are in the top row at house of quality. Communication matrix is showing the effectiveness of each functional requirement on customer's needs. Power relations between functional needs and each customer requirement are diagnosed by experts. To determine a numerical scale of power relations with a very strong relationship in the ninth, a strong relationship in the seventh, a moderate relationship in five, a poor relation in the third and a very weak relationship in one, is used. Relative weight of functional requirements is calculated according to the following relationship:

$$W_j = \sum_{i=1}^{m} I_{n_i} . d_{ij} \quad (1)$$

$$w_j = \frac{W_j}{\sum_{j=1}^{n} W_j} \quad (2)$$

In relation (1), I_{n_i} is the relative importance of i need, and d_{ij} is communication matrix that expresses association of functional requirements j with i need. Completed matrix of the House of Quality is shown in

Table.1: the house of quality matrix

	Depreciation fluctuations	Amount of inertia	amount of Lubrication	Tolerate of heavy	Dynamic Balance	Neutralization impact	Abrasion resistance	Easy clutch operation	Torque Transfer	Gradual connection	Relative weight required
lack of sound	0.006	0.006	0.021	0.036	0.051	0.047	0.036	0.006	0.017	0.006	0.3921
comfortable gear	0.006	0.017	0.017	0.006	0.032	0.006	0.006	0.009	0.006	0.009	0.2171
no shaking car	0.017	0.006	0.006	0.024	0.04	0.024	0.013	0.006	0.042	0.028	0.2429
no abnormal pedal firmness	0.006	0.023	0.027	0.009	0.017	0.006	0.028	0.042	0.006	0.032	0.1851
elasticity suitable vehicle	0.052	0.006	0.009	0.032	0.047	0.006	0.009	0.009	0.035	0.012	0.137
											sum
Absolute weight of functional requirements	0.2276	0.0181	0.232	0.0148	0.0247	0.0266	0.0459	0.0267	0.0197	0.0126	0.0152
Relative importance of functional requirements	0.079	0.101	0.064	0.108	0.011	0.2016	0.117	0.086	0.055	0.066	

4.2. The Matrix of Product Design

After identifying functional requirements, identifying plans in order to improve the parts are bound to functional requirements. The results of this stage are placed in the top row of the product planning matrix. The Power of relationship between projects to improve and functional requirements is also clear by experts with a numerical scale similar to what the relationship matrix was applied to quality homes.

4.2.1. Determination of the relative importance of projects to improve parts

The relative weight of Plans to improve components is calculated according to the following relations:

$$W_{p_j} = \sum_{i=1}^{n} w_j . d_{ij} \qquad (3)$$

$$w_{p_j} = \frac{W_{p_j}}{\sum_{j=1}^{m} W_{p_j}} \qquad (4)$$

In relation (3), w_i is relative weight of i required performance and d_{ij} is communication matrix that expresses the relationship of j improvement plan with i functional requirement. Completed matrix design of product is shown in Table (2).

Table2 : Matrix Product Design

Plans to improve parts / function	Clutch torque capacity set	Optimize the amount of mass inertia	Improved recoil strep	Increased spinal clutch shell	Improved type of grease	Transmission gear engagement can be increased	Increasing fatigue tensional springs	Increasing fatigue, a ball springs	keyboard limit increased abrasion	Increase in resistance against abrasion and finger fracture	increased resistance against wear pads	Recovery gear	Reduce cable elasticity	Reduce the tensional spring stiffness coefficient	Relative weight of functional requirements

al requirements															
Depreciation fluctuations	0.003	0.003	0.003	0.003	0.001	0.003	0.003	0.003	0.017	0.003	0.001	0.008	0.003	0.003	0.067
Amount of inertia	0.005	0.003	0.003	0.008	0.003	0.003	0.003	0.003	0.005	0.003	0.003	0.003	0.003	0.025	0.055
amount of Lubrication	0.003	0.003	0.003	0.003	0.003	0.005	0.012	0.015	0.003	0.003	0.025	0.012	0.003	0.008	0.087
Tolerate of heavy	0.003	0.005	0.003	0.003	0.003	0.016	0.015	0.011	0.009	0.003	0.003	0.005	0.008	0.003	0.007
Dynamic Balance	0.003	0.008	0.003	0.003	0.019	0.021	0.011	0.007	0.003	0.027	0.003	0.007	0.003	0.003	0.202
Neutralization impact	0.008	0.006	0.012	0.019	0.008	0.009	0.005	0.003	0.003	0.003	0.003	0.008	0,008	0.016	0.108
Abrasion resistance	0.008	0.005	0.003	0.013	0.016	0.013	0.009	0.005	0.008	0.008	0.005	0.006	0.003	0.005	0.065
Easy clutch operation	0.003	0.014	0.003	0.008	0.019	0.012	0009	0.009	0.017	0.008	0.003	0.001	0.023	0.003	0.066
Torque Transfer	0.022	0.01	0.003	0.003	0.003	0.015	0.007	0.007	0.021	0.003	0.003	0.013	0.003	0.003	0.102
Gradual connection	0.003	0.003	0.014	0.003	0.005	0.003	0.003	0.003	0.003	0.003	0.013	0.003	0.003	0.003	0.08
															sum
Absolute weight of Plans to improve parts	0.0059	0.0061	0.0047	0.0059	0.0078	0.0102	0.0083	0.0067	0.0077	0.0083	0.0062	0.0073	0.0054	0.006	0.096
Relative importance of Plans to improve parts	0.093	0.371	4.907	6.146	8.140	10.548	8.5905	6.925	7.968	8.569	6.288	7.573	5.564	6.621	

4.3. Calculating relative percentage of cost for components improvement plans

If information is available, cost techniques can be used to calculate the cost of each improvement project otherwise we can use approximate methods for determining the relative percentage of improvement plans cost. In this study, paired comparisons techniques are used to estimate the relative percentage of the cost. To calculate the index value of parts improvement plans due to limited resources such as time, Budget, and professional resources and ... we cannot focus on the entire improvement project. Therefore, plans with higher values on at least a maximum (Pareto rule) can spend fewer resources to reach the desired result. In this study Index value is more valuable for identifying improvement projects and the focus on these projects in the next phases of value engineering is defined according to relation (5):

$$ValueIndex = \frac{\%I}{\%C} \quad (5)$$

Percent plan to improve the relative importance= I%

Percent relative cost improvement plans= C%

In relation to the above scheme operating expenses is placed against its importance in enhancing customer satisfaction level of the product. Therefore, an index value greater than the number one indicates that this recovery plan cost in comparison with its importance for increasing customer satisfaction is less and so these plans are more appropriate choices for improvement. The results of the calculation index value are inserted in the table (3):

Table .3: Index value of improvement plans for components

Plans to improve parts	Clutch torque capacity set	Improved recoil strep	Reduce cable elasticity	Recovery gear	increased resistance against wear pads	Increase in resistance against abrasion and finger fracture	keyboard limit increased abrasion	Increasing fatigue, a ball springs	Increasing fatigue tensional springs	Transmission gear engagement can be increased	Improved type of grease	Increased spinal clutch shell	Reduce the tensional spring stiffness coefficient	Optimize the amount of mass inertia
Relative importance of percent improvement plan	6.09	6.37	4.91	6.15	8.14	10.5	8.59	6.93	7.97	8.57	6.39	7.57	5.56	6.22
Percent relative cost improvement plans	14.0	6.9	2.1	2.8	5.2	4.8	6.8	2.13	7.5	10.1	3.3	8.1	4.9	9.3
Index Value Improvement Plan	0.41	0.94	2.34	2.19	1.57	2.20	1.26	0.52	1.06	0.85	1.94	0.94	1.14	0.67

5. a mathematical model to identify the optimum combination of improvement designs

At this stage we tried to use a mathematical model for improvement designs with regard to index value and other indicators to find an optimum combination, so this way the customer viewpoints both organizational factors involved in improvement projects are prioritized. For this purpose, clutch keyboard and disc system are classified into three sub-page; keyboard, disk , leverage systems and Gearbox, then the index of recovery plans which their value is greater than one are classified in these three groups and by using paired comparisons technique the weight of Each indicator is marked. Finally, the decision matrix below was obtained:

Keyboard set= A_1

Disk set= A_2

Gearbox and lever set = A_3

Available manpower needed= X_1^+

Level of technology required= X_2^-

Importance for the organization= X_3^-

Table.4: decision matrix

OPTION	X_1^+	X_2^-	X_3^-
A_1	5	Very much	Average
A_2	6	Average	Important
A_3	2	Little	Average
A_4	3	high	Very important

$$W_j = (W_1 = 0.191, W_2 = 0.424, W_3 = 0.375)$$

The 3! Rating Permutation of options is formed and with the order form at each stage of transition one of the Permutations is selected and we formed a Sub-set of coordinated (SKL) and a Sub-set of non-coordinated (RKL), as you see below:

Sub-set of coordinated= S_{KL}={ $A_1 \geq A_2, A_1 \geq A_3, A_2 \geq A_3$ }

Sub-set of non-coordinated= R_{KL}= { $A_1 \leq A_2, A_1 \leq A_3, A_2 \leq A_3$ }

Given that $A_K \geq A_L$ it means that option A_K is better or at least equivalent preferred option with A_L, if in ranking sub-set the weight is $r_{Kj} \geq r_{Lj}$ with $+W_J$, and if $A_K \geq A_L$ then $r_{Kj} \leq r_{Lj}$ with $-W_h$ are weighting. Then a measure (Ti) of test ratings for the i Permutations is created as follows:

$$T_i = \sum_{j \in s''_{KL}} W_j - \sum_{j \in R''_{KL}} W_j ; i = 1,2,3,...$$

With previous:

$$\begin{Bmatrix} S'_{KL} = \{J // \;_{kj} \geq r_{lj}\}; k,l = 1,2,3,...m; k \neq l \\ R'_{KL} = \{J // \;_{kj} \leq r_{lj}\}, k,l = 1,2,3,....m; k \neq l \end{Bmatrix}$$

Coordinated sets SKL (split from S'KL) also indicates the subset of all the parameters $r_{Kj} \geq r_{Lj}$ for their subset indices R'KL indicates inconsistency with the rank of sub i Permutation. With the steps that are expressed above, Ti can be calculated for each Permutation. From all of the Ti, we found $MAX_i T_i$ that represents the best combination of projects improvement. According to the results of solving the above model, T_6 the highest amount is allocated, the optimum composition is related to $P_6 = (A_3, A_2, A_1)$ thus the projects improving priority items A3 is the first, A2 is the second and A1 is the third in priority.

6. conclusions

According to the results of completed quality matrix the first and second Hypothesis were rejected and the third one was accepted. The VEQFD model is a Useful tool that has occurred from the two methods; the QFD and value engineering. VEQFD increases accuracy in decision making to improve product quality and so it enables us to find the best method of allocating available resources to ensure maximum customer satisfaction. In this study, due to time limit the only functioning part of the analysis value engineering sector combined with the QFD has been discussed. Future research in the next phases of value engineering with input from such a phase analysis is suggested, and the value index of the solution proposed at the end of the value engineering process with the index value calculated for analysis phase for every improvement plan should be compared. In order to use more of the concepts and terminology of customers and better and more realistic modeling of the problem, QFD and value index can be used in a fuzzy environment.

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