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An Improved Failure Modes and Effects Analysis as a New Framework to perform the Function Analysis Phase of products in the Value Engineering

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ABSTRACT: Increasing product value is a topic that is always a concern for manufacturers. In the case one of the best methodologies is value engineering. There are different steps for performing value engineering in different sources. One of the important and primary phases in performing value engineering is the functional analysis phase. According to this paper, it is possible to perform the product function analysis phase in the proposed improved failure modes and effects analysis framework that is one of the ways of the correct performance analyzing of the products in the National Standard of America. Using of proposed framework not only performs the function analysis process step by step but also reveals one of the hidden factors which are effective on the value of the product functions. In this way, failure risk is revealed in order to calculate the real value and recognize the low-value functions for introducing to the value engineering creativity phase. On the other hand one of the advantages of using the framework presented in this paper is that due to the symmetry of the time to run failure modes and effects analysis and implement value engineering, it integrates a part of the implementation of failure modes and effects analysis and value engineering.

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1. INTRODUCTION

Producers should be able to sell their products with the increasing competitive ability to stay in the market. Value engineering seeks to satisfy customers and increase the competitiveness of the product by enhancing its value in order to increase product sales in the market. This is done by identifying and eliminating low-value and unnecessary product functions and finding low-cost creative solutions to provide other types of product functions in a quality manner. There are various phases in different standards and resources for value engineering [1-3]. One of the main phases of value engineering is the product function analysis phase that during it, every product function should be identified, analyzed, and decided about. Correct performing of this phase plays an effective and important role in the final result of value engineering performance. But when the worth of each function should be determined separately in the product function analysis phase, the customer cannot influence it in determining the product function worth, because failure risk and reliability of each function are not understandable for the customer. This can distort the worth set for the functions and consequently the value set for them. As this determined value for functions is the basis of the decision to continue the value engineering process, ultimately, the expected improvement from the implementation of value engineering for the product is not achieved. The presented method in this paper can reveal the reliability and failure risk of each product function and interfere with it to determine the real worth of the product. So in this paper, a new framework has been presented to perform the product function analysis phase by improving the traditional Failure Modes and Effects Analysis. (FMEA) is one of the methods to analyze the failure risk of the product in American National Standard and also it is one of the ordinary ways to identify factors and analyze possible failure effects on the products [4, 5]. Improvement of the traditional FMEA and combination of it with other methods and techniques is an issue that some research is done about it. In each of these studies, the purpose of FMEA improvement is getting the new capabilities and advantages. For example research on the combination of Fault Tree Analysis (FTA) and FMEA methods. Because the full implementation of each of these methods on one product is very time consuming. Therefore, in each of these studies, a combined method is presented to perform the analysis of product exhaustion risk with less time [6-8]. Also, there are some researches about the combination of FMEA and Quality Function Deployment (QFD) as an ordinary way in quality engineering. This way some limitations are covered and a new method is examined in quality control [9, 10]. In this paper, a framework has been offered to perform the product function analysis phase by improving traditional FMEA. FMEA and value engineering are two methods separate from each other that the purpose of one of them is increasing reliability and another one is

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Table 1. Sample table of the proposed improved FMEA

Item / Function	Potential failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) / Mechanism(s) of Failure	Occurrence	Current Design Controls Preventive	Current Design Controls Detective	Detection	*RPN*	Function Type (*FT*)	Function Cost (*FC*)	Function Worth (*FW*)	Function Failure Risk (*FFR*)	Function Modified Worth (*FMW*)	Modified Value Index (*MVI*)	Recommended Actions	Severity	Occurrence	Detection	*RPN*	*MVI*

increasing product value which are done independently. This paper offers a framework to perform the product function analysis phase in the FMEA framework, by the combination of value engineering basics and FMEA.

2. METHODOLOGY

In this research by improving the traditional FMEA, a framework is presented to perform the value engineering product function analysis phase. By use of the proposed improved FMEA, all goals of the product function analysis phase are achieved. In addition, the use of this framework has some advantages that were mentioned before. The most important advantage is the disclosure of failure risk of each function which is difficult to apply in estimating the worth of functions because it is not tangible to the consumer. Using the proposed framework, this parameter is made visible and applied in calculating the real worth of product functions and their real worth is used to identify low-value product functions to introduce to the value engineering creativity phase. In this method, new columns have been added to the ordinary FMEA table which includes:

· Function Type (*FT*) coefficient

· Function Worth (*FW*) coefficient from the customer's viewpoint

· Function Cost (*FC*) coefficient

· Function Failure Risk (*FFR*) coefficient

The above coefficients are determined using the provided supporting tables...

· Function Modified Worth (*FMW*) coefficient

The amount of this column for each row is defined as follow:

$$FMW = FW \times FFR \tag{1}$$

· Modified Value Index (*MVI*)

Using the function modified worth coefficient and its cost coefficient, a parameter is calculated that can be used as modified value index to decide whether to continue studying the value for the relevant function.

$$MVI = FMW \times FC \tag{2}$$

It is necessary to a threshold be defined for MVI based on the company policies. Table 1 shows an example of the table used in the improved FMEA.

3. RESULTS AND DISCUSSION

To complete the above table for a sample product that is a surgical chair, first the columns of the ordinary FMEA up to *RPN* calculation for each row completed. By completing the improved FMEA table, after identifying high-cost functions on the basis of the Pareto rule, *FMW* and *MVI* were calculated and the rows whose *MVI* is below the threshold defined by The manufacturer were identified. These functions are in fact costly and low value product functions that had to be decided about in the analysis phase of the product functions. Therefore, by examining the value of *FT* for this category of product functions, for cases where *FT* equals 0, that is, we are faced with a costly and low-value but removable function. Therefore, the removal of the relevant function from the product is recommended, as a result of which the overall value of the product is somewhat upgraded and the risk of failure is reduced to some extent. When *FT* equals 1, it means we confront high-cost, low-value and irremovable functions. These functions are introduced to the creativity phase to continue the value engineering process and find creative actions for value increase

4. CONCLUSIONS

In the presented method in this paper, without the need to perform the function analysis phase of value engineering separately which will be time-consuming and costly, by performing the proposed improved FMEA framework, a criterion named *MVI* as an index is used to decide about each product function. As mentioned before after identifying the costly functions of the product according to Pareto law, the

amount of *FMW* and *MVI* calculated for them and according to the values of *FT*, *MVI,* and *RPN* and based on the provided auxiliary table, the appropriate action to continue studying the value of each function is determined. On the other hand, one of the advantages of using the framework presented in this paper is that due to the symmetry of the right time to implement FMEA and the right time to implement value engineering, unifies part of the work of implementing FMEA and implementing value engineering. This way causes to decrease parallel work, save time and cost, and increase the speed of product development and its offering to the market. As mentioned before, about the sample product, by completing the improved FMEA, the appropriate action to continue studying the value of each function is determined. Also, the main part of failure risk analysis and value engineering product function analysis phase are done at the same time by using this framework that causes to offer products to the market fast and also decrease their prices.

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