A Review of Multiple Criteria Decision Making Tools

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***Abstract*: Multiple-criteria decision making (MCDM) is a division of operations research that explicitly evaluates multiple criteria in decision making environment. In our day to day life there are typically multiple criteria that need to be solved in making decisions. Cost always stands first inthe criteriafor making decisions. Quality is the criterion that conflicts with the cost. Cost and customer satisfaction are the other two conflicting criteria. In management we are interested in getting high returns at the same time reducing our risk. The stocks that have potential of bringing high returns typically also carry a high risks of investment. Failure mode and effect analysis (FMEA) was one of the first systematic techniques for failure analysis. It was developed by an engineers in the late 1950s to study problems that may arise from miss using of military systems. FMEA is a first step of effectiveness study of a system. It involves in reviewing as many components and subsystem as possible for identifying the failure modes and their causes and effects. FMEA deals with the qualitative aspects of a system. Quality function deployment (QFD) is a tool to transform user demands from qualitativeinto quantitative parameters. QFD is designed to back up the planning process and to focus on features of a new product, market segments, and company or technology development needs.**

***Key words*: MCDM tools, FMEA, QFD**

I. INTRODUCTION

FMEA is an effective tool or methodology for the failure analysis and is the backbone in reliability, safety and quality engineering. Quality management and development process is primly concerned with a process type of FMEA. A FMEA analysis helps to sort out the potential failure modes. It is extensively employed in improvising industries in multiple phases in the life cycle of the product. Effects and analysis phase deals with the process of studying the concept of those failures on different grounds. Functional analyses are required as an input to correct failure modes at all the levels for functional FMEA. FMEA is used to catalyse the risk reduction based on the failure mode effect severity reduction and lowering the failure. The FMEA is the principle used in inductive analysis performed by understanding the failure mechanism. FMEA can also be used as a design phenomenon that can be employed in systematically analysing component failures and to find the consequences on the operations. The analysis is classified into two sub-analyses, the first phase is the FMEA and next stands the critical analysis. In thedevelopment process of FMEA the analyst may requireall the possible failure modes of the system, which is under analysis. FMEA can be carried out at the system, assembly, process and part level. FMEA should be properly documented before the hardware design process. FMEA can help in guiding decision making process. It is probably the most important consideration. In some case, the FMEA would be of low value where decision making process or the analysis is processed after the completion of hardware design or process. Once when the FMEA is performed considering all possible modes of failure, it is first and foremost benefit inthe early identification of all critical system for failure so they can be rejected or minimised through design modification in the beginning stages of the product development process, which means that the FMEA should be carried out in the system level as soon as the design information is available to the preliminary level of production, as design process continues. Quality function deployment (QFD) is a tool to transform user demands which are available in qualitative terms to quantitative terms, which can be easily interpreted, to deploy the functions affecting quality and to change the methods for achieving the design quality in subsystems in manufacturing process. QFD is designed to perform planners focus on characteristics of a new component from viewpoints of market and company segments that technology development is needed. The techniques which gives charts or graphs and matrices, with the assistance of the tools from fuzzy sets and their concepts can approximate data to a numeric precision. Traditional FMEA analysis has shortcomings which affects the risk evaluation process and the appropriate correct actions. It is very difficult to achieve very accurate results using traditional FMEA. The problem is solved by using RPN (risk priority number). It can be obtained or solved by different combination of three factors. So the fuzzy logics is used in the traditional FMEA. It can be applied to solve any type of problem. The rating factor is given as triangular fuzzy number and the relative importance among them O (occurrence), S (severity) and D (decision) is also a triangular number so that the new fuzzy FMEA method is introduced.

II. LITERATURE REVIEW

B. Almannai, et al(2008) developed an integrated approach for a manufacturing automation technologies involving QFD and FMEA. They used QFD to find the best manufacturing alternative and FMEA to identify the risks involved in the system design and during implementation. The stages involved linking of investments in automation based on evaluation criteria. This was computed using the QFD matrix. In the second stage, the alternative solution was selected by transforming the first QFD matrix to a second

matrix to make sub evaluation criteria. The final stage in the process involved the risk assessment of the alternative solution using FMEA and the troublesome areas were noted in FMEA analysis. They conducted a case study in seals division at Rolls-Royce compression systems plant in Inchinnan; the selection and acquisition of eight chip forming machines and was found that this produced good results and it allowed people issues to be addressed appropriately[1].AlaaHassan,et al (2010) developed quality/cost based conceptual process planning by employing QFD and FMEA. Composite process capability index is incorporated for selecting the process alternatives by QFD. Activity based costing method is used to estimate the manufacturing cost. The process alternatives are selected using QFD approach and the capability of the process element, capability of the quality characteristic is estimated and the process failures are analysed using FMEA by calculating the Risk Priority Number (RPN). Manufacturing costs are estimated using ABC method and the cost of failures are estimated using cost based FMEA. He employs this approach in auxiliary shaft cover of a car engine and estimates the best alternative process [2].Francesco Lolli ,et al(2015), stated the ineffectiveness and inaccuracy of the FMEA in prioritizing risks and proposed Flow sort which involves multiple decision makers in scoringfailures. They applied this method to a plastic bottle manufacturing plant using blow moulding process [3]. James Scott, et al (2014) proposed an integrated method involving Analytic Hierarchy process-Quality Function Deployment (AHP-QFD) and chance constrained optimization algorithm approach for integrated supplier selection and order allocation. The proposed method was employed in a bioenergy industry and the results checked for accuracy with the help of Monte-Carlo decision support system [4].Ashraf Labib, et al (2015), proposed a system involving Fault Tree Analysis (FTA), Reliability Block Diagram (RBD), Risk Priority Number (RPN), and Analytic Hierarchy Process (AHP) for learning the Hurricane Katrina disaster and the results are mapped into specific decisions for the allocation of resources and prevent the repetition of the failures or disasters [5].AyhanMentes, et al(2015), employed an integrated system involving ordered weighted geometric averaging (OWGA) and generalised mixture operators to overcome the shortcomings of the prioritizing of risks with the help of RPN. A case study on motor yacht fuel system was conducted and the results were more accurate than RPN which leads to duplicated risk values [6].ZHANG Yong (2013), employed Analytical Hierarchy process to establish the risk assessment in urban fire. The paper employed Correlation degree method for setting up the weight coefficients of the assessment system and applied the proposed method in a city called Haikou for assessing the risk involved in the case of urban fire [7].R.Parameshwaran, et alused Fuzzy Delphi Method (FDM), Fuzzy Interpretive Structural Modelling (FISM), Fuzzy Analytical Network Process (FANP), and Fuzzy Quality Function Deployment (FQFD) for making a conceptual design of a mechatronics system. The prototype created using these are monitored and the Fuzzy Failure Mode Effect Analysis (FFMEA) was used to rank the potential failures and the models were redesigned based on the results [9]. Daniel Podgorski (2014), employed Analytic Hierarchy process (AHP) for selecting the key performance indicators for measuring the performance of Occupational Safety and Health management systems. The proposed method would solve for the specific conditions of the enterprise which includes the types of working hazards, size or industry sector [12]. Dong (2007) provided an FMEA analysis tool which was based on the fuzzy utility cost estimation to overcome the disadvantages of the traditional FMEA with which the cost due to failure is not defined. This approach used utility theory and fuzzy membership functions for assessing O, S and D. The utility theory was said to have a nonlinear relationship between the cost due to failure and the ordinal ranking. The application of fuzzy membership functions represented the team opinions. The risk priority index (RPI) was developed for the prioritization of failure modes [18].

III. TOOLS OF QUALITY

The Seven Basic Tools of Quality is a designation given to a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality.They are called basic because they are suitable for people with little formal training in statistics and because they can be used to solve the vast majority of quality-related issues.The main or the effective tool of quality is the cause and effect diagram.

A)Cause & Effect Diagram

Graphical representation of the trail leading to the root cause of a problem. The first step is to decide which quality characteristic is the most affected, or the outcome or effect you want to examine which forms the backbone of the diagram. Theribs are the major categories, and Medium size bones refer to secondary causes, while Small bones are root causes.

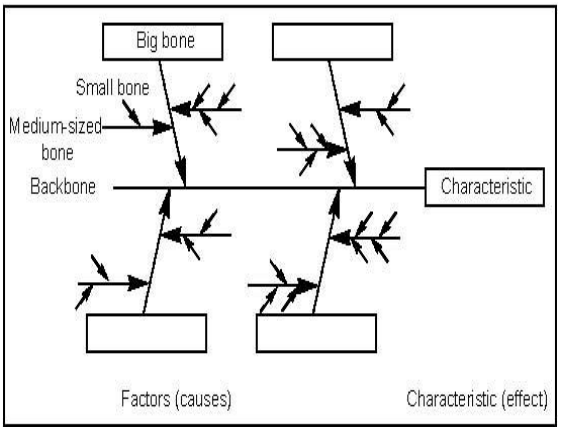

Fig. 1 Sample fish Bone Diagram

B) FMEA-Overview

FMEA is a systematic method of identifying and preventing system, product and process problems before they occur.FMEA is focused on preventing problems, enhancing safety, and increasing customer satisfaction.Ideally, FMEA's are conducted in the product design or process development stages, although conducting an FMEA on

existing products or processes may also yield benefits.FMEA is a tool that helps to,

- Prevent System, Product and Process problems before they occur
- reduce costs by identifying system, product and process improvements early in the development cycle
- Create more robust processes
- Prioritize actions that decrease risk of failure
- Evaluate the system, design and processes from a new vantage point.

C) Quality Function Deployment

Quality Function Deployment (QFD) is a way of making the 'voice of the customer' heard throughout an organization. It is a systematic process for capturing customer requirements and translating these into requirements that must be met throughout the 'supply chain'. The result is a new set of target values for designers, production people, and even suppliers to aim at in order to produce the output desired by customers. Once a team has identified the customers' wants, QFD is used for two fundamental reasons:

- To improve the communication of customer wants throughout the organization.
- To improve the completeness of specifications and to make them traceable directly to customer wants and needs

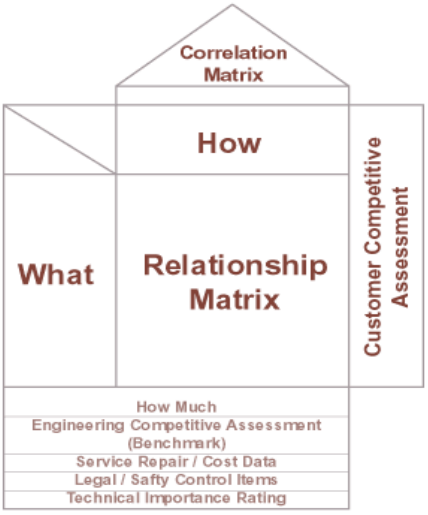

Fig. 2 Sample House of Quality

IV. CONCLUSION

This paper proposes the multiple criteria decision making tools and its applications for enhancing the risk evaluation in any kind of the product or the process. Due to the drawbacks in Traditional FMEA approach and their RPN's, new methods were proposed for prioritizing and evaluating risk. This paper is based on the alternative methods for evaluating risks.

It can be observed from the procedure of Traditional FMEA that there are possibilities forflaws in risk evaluation and RPN calculation and it is not sturdy enough to prioritize the risks. For an example the O, S and D value gives RPN and the RPN would be the same for different combinations of O, S and D but the important risks cannot be prioritized.

A number of alternative methodologies were proposed for overcoming the drawbacks that were discussed in the traditional FMEA approach. It can be seen that the fuzzy rule based system is mostly sought for producing better results for prioritizing the risks.

The purpose of this paper is to classify the existing literature which applied different methods for improvising the performance of FMEA and also to provide a path to future research to solve the shortcomings of FMEA.

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