A Review Failure Mode And Effect Analysis (FMEA) Implementation

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Abstract- *FMEA is a useful tool for anticipating and averting issues with systems, products, and processes. It is concentrated on preventing issues, improving safety, and raising customer happiness. The US military forces formally introduced FMEA in the late 1940s. With their clear dependability and safety requirements, the aircraft industry employed it as a design process in the 1960s. Ford Motor Company introduced FMEA to the automotive industry in the late 1970s for safety and regulatory reasons. They also used it to enhance design and production.*

FMEA is currently widely utilised in a range of industries, including semiconductor processing, food service, plastics, power plants, software, and healthcare. It is used extensively in manufacturing industries during various stages of the product life cycle. A successful FMEA activity enables a team to identify potential failure modes based on prior experience with similar products or processes, allowing the team to design those failures out of the system with the least amount of effort and resource expenditure, thus shortening the development cycle and decreasing costs. The many FMEA methodologies and applications that have been created to date are highlighted in this study.

Keywords- FMEA, Occurrence, Reliability, RPN, Severity, Process FMEA, Design FMEA

I. INTRODUCTION

The American Military developed the FMEA discipline. Procedures for Conducting a Failure Mode, Effects and Criticality Analysis, Military Procedure MIL-P-1629, is dated November 9, 1949. With its apparent reliability and safety needs, the aerospace industry developed FMEA as a formal design approach in the 1960s. Ford Motor Company developed FMEA to the automobile sector in the late 1970s for use in safety and regulatory analysis. Additionally, they used it to enhance design and production. The aerospace, military, automotive, electrical, mechanical, and semiconductor industries are just a few of the industries that have implemented FMEA. The risk priority number (RPN) value is used by the majority of modern FMEA techniques to assess failure risk. It is desirable to be able to continually get better.The reliability of power plants has recently become a major concern in both industrialised and developing nations. Risk analysis and RAMS (reliability, availability, maintainability, and supportability) have grown to be significant challenges in the power industry. Unforeseen failures, which have resulted in unexpected costs in the thermal power station, are frequently the main sources of customer unhappiness. However, the frequency of failures and their effects can be decreased with adequate RAMS and risk analysis integration into each maintenance procedure in the thermal power station.

Types of FMEA

According to the nature of the application, there are three fundamental forms of FMEAs: **Concept FMEA (CFMEA)**: Before hardware is established, the idea FMEA is used to evaluate concepts in the early phases (most often at system and subsystem level). It focuses on potential failure mechanisms connected to a concept proposal's suggested functionalities. This kind of FMEA takes into account early-stage system interactions as well as interactions between individual system components.

- **Design FMEA (DFMEA):** In order to confirm the set design parameters for a particular functional performance level, at the system, subsystem, or component level, this type of FMEA aims to identify and prevent failure modes of products that are related to their design. The primary purpose of this kind of FMEA is to identify potential failure modes during the early stages of design development in order to eliminate their effects, choose the best design option, and create a documentation base to support future designs in order to reduce the likelihood that defective products will reach consumers.
- **Process FMEA (PFMEA)**: This kind of FMEA focuses on probable process failure modes that are brought on by flaws in the manufacturing or assembly process.

Manufacturing FMEA and Assembly FMEA are the two different types of process FMEA. The failure modes in manufacturing FMEA are often dimensional or visual. These are typically relationship dimensions, missing parts, and improperly assembled parts in an assembly's FMEA.

II. LITERATURE REVIEW

This section discusses the research that has been done by many researchers to advance and apply FMEA in various fields.

Diverse techniques were put forth by researchers in the area of product concept design. The following is a discussion of the outstanding work carried out by the various researchers in this field:

Sutrisno et al. (2016) came to the conclusion that FMEA overly depends on RPN and ignores the business environment in which an organisation operates. As a result, the impact of a failure mode on the economy, management, and operations may not be accurately measured. In order to determine the most appropriate future actions by analysing the internal and external aspects that the companies confront, Sutrisno et al. (2016) introduced integrating SWOT (strength, weakness, opportunity and threat analysis) study into FMEA.They first identified the SWOT factors before utilising FMEA to list the failure modes. They represented the internal organisational strengths and weaknesses as well as the opportunities and threats that could be raised by taking particular actions in the future. The SWOT technique was then used to determine the preference ratings and benefit indices for potential future actions. The BCOR2 technique and SWOT analysis were combined in the third and last major step to provide the chosen course of action. A single action's benefit, implementation cost, magnitude of impact, and organisational resiliency to that action are represented by BCOR2. The action is more appropriate for the organisation the higher the ultimate recommended score. The research also used a case study of a gas producing company to demonstrate the effectiveness and utility of SWOT analysis. After integrating SWOT analysis into FMEA analysis, not the action with higher RPN but the more suitable future actions were chosen to be implemented after thorough evaluation of business environment. SWOT analysis addressed the aspects of benefit, cost, opportunity, risk, and organisational readiness that FMEA did not. This could lead to improved decisions being made without ignoring the effects of the business environment. Consequently, the SWOT analysis approach could be a useful tool to enhance the choice of future FMEA actions **(Sutrisno et al., 2016).** Even if SWOT analysis is a useful tool, one aspect of the research should be highlighted: the grading method for the SWOT approach contained some subjective information. For instance, in order to calculate an action's benefit, the FMEA cross-functional team must rate the impact of the activity. The end result could be impacted by this.

Peeters etal. (2018) mentioned the FMEA’s disadvantages as well. First, FMEA could be very time consuming if it is applied thoroughly. Secondly, FMEA is challenging when it is applied for a new and complex system, because FMEA requires team members to have knowledge and experience on the system. Third, through FMEA, it is difficult to achieve enough depth of analysis to fully understand the relationship between the system and failure behaviours. Therefore, they suggested that combination of FTA and FMEA might help improve the overall performance of failure analysis. FTA represents Fault Tree Analysis. It is an approach that analyzes the system from top to down. That means, unlike FMEA, FTA is a structured approach that considers system level, function level, and component level in a system. FTA is a logic diagram uses logic gates, such as, “OR”, “AND”, and inhibit or conditional gates to represent the relationships between system failures and cause of failures. With that, the method the authors used was to apply FTA, first, to identify possible failures level by level described above. Then, they applied FMEA to analyze the criticality of the failures in each level. In other word, based on RPN, critical failures and, in the end, future actions were decided. The contributions of this type approach were, first, it provided more detailed failure analysis since different levels of the system were analyzed thoroughly. Secondly, this approach provided efficiency for analyzing a system. Because FTA analyzes the system from top to down, in a structured manner and this can offer better understanding of a system. They also conducted a case study in an additive manufacturing company for metal printing to present the idea. The company was satisfied with the result.

Chang, and Sun (2009) introduced applying DEA to enhance assessment capacity of FMEA.They discuss that the fundamental problem of FMEA is that it solely relies on RPN to quantify the risk of failures without properly taking factors that contribute to risk into consideration. This may result in inaccurate decision in terms of tackling with failures. DEA, as a linear programming-based methodology, tests inputs and outputs to offer efficiency scores among DMUs. DMU stands for Decision Making Unit. Efficiency score of a DMU is the ratio of the sum of weighted inputs and the sum of weighted outputs. DMU is equivalent to failure mode in FMEA. SODs in FMEA are equivalent to multiple inputs in DEA. With that, the higher the efficiency score the higher priority a failure mode has.

Spreafico et al. (2017) conducted a wide and very thorough state-of-the-art review of FMEA and its improvement from 1978 to 2016. They collected documents from both academia and industry and classified the documents based on authors, source, and four technical classes. The technical classes were applicability, cause and effect, risk analysis, and problem solving of the FMEA.

Buchanan et al. (2005) identify the process perspective as an important part of sustaining change, and it connects to the timing and flow of events and what implementation methods are used. Too slow or too fast change can both be problematic: “Change which is delayed may not deliver benefits. Change which is rushed may not allow time to adapt, and create initiative fatigue, encouraging decay”(Buchananet al., 2005, p. 202) Done et al. (2011) describe that companies with change activities that happened in a planned, consistent sequence succeeded with their interventions in a long-term perspective while those with poor handovers and discontinuous phases failed with their initiative sin the long run. Planning was also identified as a success factor when implementing Lean, where planning and follow up as well as setting targets were deemed central .

Beer et al. (1990) find that the change process must be flexible and adjusted to problems encountered during the implementation. In implementing Six Sigma, Coronado and Antony (2002) raise the role of the project managers of the implementation. They are vital for the success of implementations. Other authors mention change champions as the leaders of the change (cf. (Doneet al., 2011)) and their knowledge and suitability are important in change initiatives.

Hovmark and Norell (1994) proposed the guidelines for design work, analysis of product features, product design review and team-building in design work (GAPT) model which described the application of design tools such asdesign for assembly (DFA), FMEA and quality function deployment (QFD). The implementation of the DFA method had been followed in three product development projects for two years. Designers, production engineers and project leaders were interviewed before, during and after the implementation. They demonstrated that the DFA method could be used for four different purposes, corresponding to the levels of the GAPT model. On the team-building level, the application of the method contributed to more cooperation between designers and production engineers and better communication. Conditions and outcomes when using the DFA method are discussed with regard to the GAPT model.

Dong and Kuo (2009) proposed a state-of-the-art (new)approach to enhance FMEA assessment capabilities. Through data envelopment analysis (DEA) technique and its extension, the proposed approach evolves the current rankings for failure modes by exclusively investigating superoxide dismutase (SOD) in lieu of RPN and to furnish improving scales for SOD. Through an illustrative example, they claimed that DEA could not only complement traditional FMEA for improving assessment capability but also provide corrective information regarding the failure factors severity, occurrence and detection. It is shown that the proposed approach enabled manager/designers to prevent system or product failures at an early stage of design. They proposed a unique new, robust, structured approach which may be useful in practice for failure analysis. They also claim that their methodology overcomes some of the largely known shortfalls.

Wolforth et al. (2009) investigated that component in programmable systems often exhibit patterns of failure that are independent of function or system context. They showed that it is possible to capture, and reuse where appropriate, such patterns for the purposes of system safety analysis. They described a language that enable subtract specification of failure behaviour and defined the syntax and semantics of this language.

Hassan et al. (2010) presented an approach to develop a quality cost-based conceptual process planning (QCCPP).Their approach aims to determine key process resources with estimation of manufacturing cost, taking into account the risk cost associated to the process plan during the initial planning stage of the product development cycle. The quality characteristics and the process elements in QFD method are taken as input to complete process failure mode and effects analysis (FMEA) table. They called this technique as “cost-based FMEA”. They also presented a case study to illustrate their approach.

III. CONCLUSION

The performance of the finished products depends on the quality and dependability of the items and the manufacturing procedures. They are crucial indicators for gauging client happiness as well. All parties concerned should take certain steps to ensure the quality and reliability of the products or processes in order to meet the needs of the customers. FMEA is one of the most effective techniques for assessing the reliability of products or processes. The FMEA has largely been criticised for its limited effectiveness in enhancing designs. Customers are placing greater demands on businesses for reliable and high-quality products. FMEA is a simple technique to identify which risk is the most concerning, necessitating action to stop a problem before it starts. The creation of these specs will guarantee that the end product satisfies the stated requirements. A worksheet containing the crucial details about the system, such as the revision date or the names of the components, must be generated before beginning the actual FMEA. On this worksheet, each item or function related to the topic should be listed logically. The failure mode is not eliminated by an FMEA's initial output, which is the prioritisation of failure modes according to their risk priority scores. There is a need for additional action, possibly outside of the FMEA. Researchers that are serious about conducting their research in this field would benefit much from reading this publication

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