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Modified Failure Mode and Effect Analysis (MFMEA) for Machineries in Sugar Industry

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Abstract

Reliability is defined as the ability of an item to perform a required function without failure under stated conditions for a stated period of time. Improving reliability in an industry is very important and useful to the quality and production. One of the most consumed grocery item by all over the world is sugar and sugar industry plays an important role in economic development of country. The Failure Mode Effects Analysis (FMEA) is one of the fine tools for reliability improvement. Failure prevention is recognized as one of the major enablers of attaining continuous quality improvement in industries. Theoreticians have been propagating the employability of failure mode and effects analysis (FMEA) as the technique for identifying and rectifying failures in achieving continuous quality improvement. Mostly in these kinds of industries no Reliability and Total Quality Management (TQM) techniques are used. Unexpected failures and quality reduction in components and machineries of sugar industries are the major problems without any TQM approaches. This paper aims to prevent failures and problems by applying the tool of TFMEA and to improve the quality and production of sugar industries.

Keywords: Total Quality Management; Sugar industry; Failure Mode and Effect Analysis (FMEA); Severity (S); Occurrence(O); Detection(D); Risk Priority Number (RPN); Modified Failure Mode and Effect Analysis (MFMEA).

Introduction

Sugar industry plays an important role in economic development of country. India is the second largest producer of sugar in the world. The Indian sugar industry is the second largest agro industry located in the rural India after the cotton textile with the 453 operating sugar mills. 4 million hectares of land is under sugarcane with an average yield of 70 tons per hectare.

NOMENCLATURE

TQM	-Total Quality Management.
TFMEA	-Total Failure Mode and Effective Analysis.
S	-Severity.
O	-Occurrence.
D	-Detection.
RPN	-Risk Priority Number.

Cogeneration is an important source of income for sugar industries. India faces a peak electric generating shortage of over 20% and an energy shortage of 12%. One of the methods of savings energy in sugar mills is cogeneration. The demand of sugar is very high in the world market. So sugar industry is the leading industry, which produces sugar with the help of sugarcane mostly. In sugar industry, different sizes of sugar crystals and also some by-products such as bagasse, molasses, filter cake and ash are produced. Out of these, some are used an input resource in other plants like power plant and distillery for optimal utilization of waste produced in sugar industry. The outputs of power plant (electricity and steam) used in mills, distilleries, residences of sugar industry and supply to grid for sell. The molasses is the waste of sugar which is used for the production of ethanol, so molasses is a by-product of sugar industry. Sugar is an essential product for human consumption. Sugar is mainly produced from sugarcane which is mostly grown in tropical regions of the world. Sugars are a major form of carbohydrates and are found probably in all green plants, they are also found in significant amounts in most fruits and vegetables. There are three

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main simple sugars namely sucrose, fructose and glucose.

Failure Mode And Effective Analysis

Failure Mode and Effect Analysis is an important quality tool used in the manufacturing and other industries to improve the product quality and productivity. It is a systematic procedure to identify the potential failure modes, and their causes and effects. In this project FMEA is applied in a sugar industry located in Erode-Tamil Nadu, India to analyze the failures occurred in the process and is used to find out the most significant parameters affecting that process. It can also be used to asses and optimize maintenance plans. FMEA is usually carried out by a team of experienced and skilled ENGINEERS and expert's knowledge. The failure modes are identified and ranked with help of Risk Priority Number (RPN). RPN is the product of occurrence (O), severity(S) and detection (D) of failures. That is,

RPN = O*S*D

Each factor is rated on a scale 1–10. Generally, the failure mode having higher RPN will be given more important. On the basis of higher RPN, the most significant parameters affected the process flow and quality given first priority.

FMEA is a technique that identifies, first, the potential failure modes of a product during its life cycle; second, the effects of these failures; and, third, the criticality of these failure effects in product functionality. FMEA provides basic information to reliability prediction, and product and process design. FMEA helps engineers find potential problems in the product earlier and thus avoids costly changes or reworks at later stages, such as at the manufacturing stage and at the product warranty stage. In the FMEA process, product functions must be carefully evaluated, and the potential failures must be listed. This analysis process provides a thorough analysis at each detailed functional design element. It allows FMEA to be a very useful tool in quality planning and reliability prediction.

2.1 SEVERITY (S)

Severity is the assessment of the seriousness of the effect of potential failure of the system, subsystem or component severity is applicable only to effect of failure mode severity is rated by ranking in which 1 is for no effect and 10 for the most severe (serious) effect. It is convenient to write these effects down in terms of what the user might see or experience in terms of functional failures.

Examples of these end effects are: full loss of function x, degraded performance, functions in reversed mode, too late functioning, erratic functioning, etc. These numbers prioritize the failure modes (together with probability and detect ability). Below a typical classification is given. Other classifications are also possible. Severity only decides the losses of severe accident which affects man, machine, and the environment.

Table 2.1 Traditional ratings for severity of a failure

RATING	EFFECT	SEVERITY OF EFFECT
10	Hazardous without warning	Very high severity ranking when a potential failure mode effects safe system operation without warning
9	Hazardous with warning	Very high severity ranking when a potential failure mode affects safe system operation with warning
8	Very high	System inoperable with destructive failure without compromising safety
7	High	System inoperable with equipment damage
6	Moderate	System inoperable with minor damage
5	Low	System inoperable without damage
4	Very low	System operable with significant degradation of Performance
3	Minor	System operable with some degradation of Performance
2	Very minor	System operable with minimal interference
1	None	No effect

Types of FMEA

There are three main types of FMEA in use today.

- System FMEA: Used to analyze complete systems and/or sub-systems during the concept of design stage.
- Design FMEA: Used to analyze a product design before it is released to manufacturing.
- Process FMEA: Used to analyze manufacturing and/or assembly process.

The Process FMEA is probably the most commonly used and is also the least complex, in most cases.

Weak Spots of Traditional FMEA

A major problem in FMEA implementation is to utilize the FMEA report in the overall quality system implementation to improve the product and the manufacturing operations. So the problem is not only to generate the FMEA report, but also to use the FMEA information in the overall quality system operation to achieve the goal – to improve the product/process design. The major problems are,

- In FMEA based on S, O, D values RPN is calculated which is a complex process as the S, O, D scores are complex to perform.
- But there is a chance of occurrence of a same RPN value for different combinations of S, O, D.
- The success of FMEA lies on the effective retrieval of the tables and other relevant information to prevent further recurrence of failures. However, the traditional FMEA does not effectively support this process because of the absence of a simple codification and retrieval system. So we have

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to go for advanced and modified new FMEA technique.

- FMEA tables do not incorporate titles, which can be filled only through team effort.
- It does not assure any accuracy in estimating the mode and effect of the failures.

Modified FMEA

In the recent past, researchers and practitioners have been attempting failure prevention as one of the major enablers of attaining continuous quality improvement [2]. For this, Failure Mode and Effect Analysis (FMEA) technique is adopted to reduce the probability of system failure and achieve good product quality. However, there has been no significant effort made by the researchers to overcome the pitfalls of FMEA. This practical gap is overcome by applying a technique called Modified Failure Mode and Effect Analysis (MFMEA).

MFMEA is a technique was designed with the primary objective of overcoming the deficiencies of the conventional FMEA technique. It was anticipated that the different depths of FMEA implementation in organizations will have an impact on the success rate of MFMEA implementation. Particularly, the traditional FMEA process is not exhaustive and hence, does not contribute towards failure prevention holistically. In order to overcome this situation, this project reported that the improved version of FMEA technique called as Modified Failure Mode Effect Analysis (MFMEA).

MFMEA IN Sugar Industry

Even though TQM in process industries has been applied in most of the fields, it is obviously not performed in sugar industries. Due to overcome this, the research study of Devadasan et al. (2003) and Alfred et al. (2011) on TFMEA was studied. By this study the MFMEA technique is derived as per requirement in sugar industry. The framework of MFMEA is shown in Figure 5.1. As shown, the scope of applying MFMEA extends towards preventing failures occurring in all departments. This facility infuses totality in identifying, analyzing , rectifying and preventing the recurrence of failures. . This facility of MFMEA also ensures that every failure is prevented from a total point of view of the entire organisation. These aspects are ensured by developing new MFMEA tables (from TFMEA design) in a company for implementing MFMEA programme

As mentioned earlier, traditional FMEA or RPN method is criticised as complex and unrealistic to point out the failures. So that the new MFMEA method is introduced for develop a new table design to identify the major failure and reason with the recommended control measures and incharge department to do it. This method features on the departments included in the failure components. In the case of sugar industry machineries the two different departments of 'Quality &Inspection' and 'Maintenance' are involved in the failures. Here the major failure occurring components in this industry are analysed. The new proposed MFMEA technique was applied and then the results about the failures and incharge to recover the failure were made.

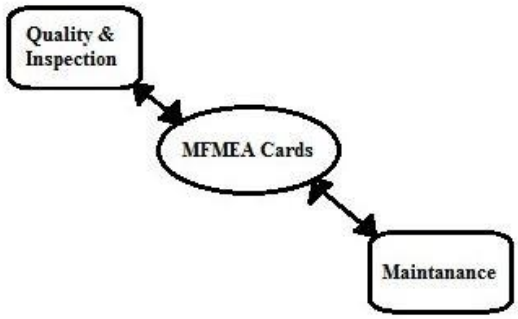

Fig.5.1 Framework of MFMEA.

MFMEA Tabulation

Treditional FMEA For Cane Carrier

Table 5.1 FMEA for Cane Carrier

Unit	POTENTIAL FAILURE MODE	CAUSE OF FAILURE	CAUSE OF FAILURE	S	O	D	RPN	RANKING	Recommended Actions
Cane carrier	Cane carrier shaft	*Casting Defect*	Unit Shut down	*8*	*4*	*7*	*224*	*1*	

MFMEA for Cane Carrier

Component Name: Cane Carrier
Date:
Part Name: Carrier Shaft
MFMEA No.: 1
Updated By:
Members Present:
Departments: Quality Inspection (QI)
Maintenance (M)

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Table 5.2 MFMEA for cane carrier shaft

Hazard type	Failure Mode	Cause Of Failure	Effects Of Failure	Severity Rating		Responsible Departments	Recommended Control Measures	Approved By
				QI	M			
Breakage in shaft	Cane carrier shaft	Casting defect	Unit Shut down	9	5	QI		

Results and Discussion

By performing the new TQM technique of MFMEA in sugar industry machineries obtained results has shown above in the tables for only one failure mode. As same as this failure, all the other failures like baggase carrier, mills, evaporator, boiler, raw juice pump can also be performed by the new method. By per the severity rating of each department comparison in the table, we can allot the incharge department for each failure. So that the allotted department should start recovering the failure to avoid it and reviewing the MFMEA cycle again to maintain continuous quality and reliability of machineries.

As the result of this paper, we obtain the certain merits in performing TQM by applying the new MFMEA method in the industries which are given below. And the further improvement in this method may also be found

Advantages of MFMEA

In this work, MFMEA technique is used instead of FMEA. In MFMEA, only Severity(S) is considered. In MFMEA the in charge departments are assigned to rectify the hazards. The MFMEA team will review the results given by departments and they follow up them. By making some modification in FMEA we can have the following advantages and the advantages are:

- In MFMEA in charge departments are assigned with ratings.
- Based on ratings the departments will act.
- Recommended actions should be reviewed by MFMEA team.

Conclusion

The results of conventional FMEA technique is limited to only design and production functions, in order to overcome these issues in this project a new technique named as MODIFIED FAILURE MODE AND EFFECTS ANALYSIS [MFMEA] has been proposed. The unique and important feature of this technique is that it spontaneously facilitates team formation for the purpose of preventing the failures from recurring. After designing MFMEA technique and its practical implementation procedures, an implementation study was undertaken. Also the literature knowledge was interpreted to develop the FMEA tables. The experiences of carrying out this work indicated that MFMEA would be a powerful technique for preventing failures holistically in organizations. Moreover, even in the case of small size organizations, it may take about a year to finish the updating and changing process required for successful and complete implementation of MFMEA. Hence, future researchers may consider evolving appropriate changes in management strategies for successfully implementing MFMEA.

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