A Research on Failure Mode and Effect Inquiry on Tea Leaves Processing - Leaf Shredder Machine

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Abstract— India is a large exporter of tea leaves and has industries involving in Tea Leaves processing. There are generally three stages in the processing of tea leaves and many machines are involved that cater to various process to convert the raw tea leaves to usable products. In the first stage there is a machine titled Leaf Shredder that is critical in the process as the entire process is a product based and a breakdown of this machine in particular affects the entire process from that point. This study focuses on the failure modes of the Leaf Shredder machine and its effect. The Total Quality Management (TQM) tool - Failure Mode and Effect Analysis (FMEA) is used in this study. The critical functional components of the Leaf Shredder are five in number. Through the study, data has been collected and the Risk Priority Number has been calculated. Based on the Risk Priority Number value it is seen that the Cutting Knife, Main Shaft and the Bearing are the components that are having a tendency to fail. The Reason of failure was analyzed. From the analysis it is seen that the main cause of failure is due to improper maintenance of the components and unbalancing of the cutting knife weight. A well thought of plan of action to maintain the Tea Leaf Shredder will bring down the failure rate and improve the reliability of the product layout.

Keywords--Leaf Shredder Machine, Failure Mode and Effect Analysis, Product Layout, Risk Priority Number, Reliability.

I. INTRODUCTION

India is the 2nd largest producer of tea in the world both in terms of tea plantation and processing tea leaves to get the tea product. The consumption of tea products is also high in India. The tea plantation and adjoining industries in India are clustered in the states of Assam, West Bengal, Tamil Nadu, Kerala and Karnataka. The health of tea industry depends upon the productivity with which Tea leaves are grown in Tea plantations and the effective processing of tea leaves in the concerned processing units. This study focuses on the critical components that are likely to fail in one particular machine called leaf shredder used for tea processing (which is a part of a product layout of processing tea leaves) using the TQM tool "FMEA".

II. LITERATURE REVIEW

Literature review from the existing body of knowledge has yielded the following:

The weak links causing failure in the system is assessed based on the weightage given for the failure factors which progresses in reasonable and accurate assessment of safety [1]. The difference between traditional failure analysis and Electronic Design Automatic (EDA) - Simulation based FMEA was analysed and it is found that the EDA has a clear detection on the failure and is termed to be comprehensive [2]. The analysis on mechanisms and the control over the system is brought together to provide the function model which is transformation from hardware and the software through which the FMEA results in safety enhanced real time embedded system [3]. The poor performance is explored through fish bone diagram to analyse the teaching effectiveness. The remedial actions can be developed through the factor analysis [4]. Practicing the logical mechanism of managing the risk has lowered the value of RPN below 100 which is the limit of acceptance [5]. Improvement as a continuous progress through the measures on operation procedure standardization, inspection throughout the process are established through FMEA [6]. The risk factor impact on the decision framed based on FMEA reinforces the framework for the supply chain since there prevails a poor integration and the firm concentrates on core competency [7]. To provide optimal results in capability enrichment on the process of manufacturing the Bush through integrating Operational safety measures and technology involved in the process [8]. CTC machinery processing is a conjoint for the Green and Orthodox tea, the manufacturing of tea is expressed in stages where the data is through a wide spread survey in India [9].

III. DISCUSSION & RESULTS

The objective of this study is to identify the machine that is causing the product layout to breakdown in the processing of tea and identifying the potential causes for the same and suggesting strategies to improve the situation.

The study has been carried out in four parts: Following the introductory and the literature review part, the third part deals with applying the FMEA tool in steps on the identified machine for study - analysis and finally followed by the findings and concluding remarks.

The study has been carried out in three phases:

A. Phase 1: Identifying the Machine for Study Using FMEA

The process adopted in a Tea industry has been shown in figure 1. From the layout it is seen that processing of Tea adopts a product layout which has three stages.

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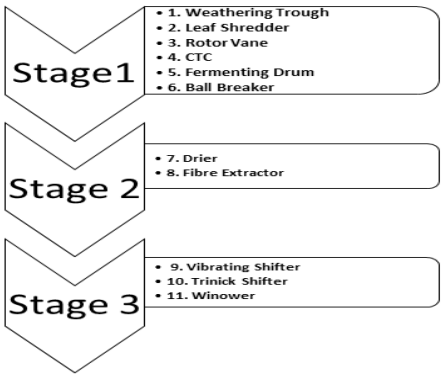

Fig 1. Three Stages of a product layout for processing Tea

From the data collected, it has been noticed that the downtime due to the breakdown is high in Leaf Shredder Machine (576 hours in a month of 24 working days, each day the tea being processed for 24 hours – 3 shift/day x 8 hour/shift).

It was decided to study the critical components leading to breakdown of the leaf shredder machine using FMEA.

B. Phase 2: Listing the Potential Failure Modes of the Identified Machine and the Corresponding Root Causes

From the maintenance data sheet of the Leaf Shredder Machine, the following components as shown in Table 1 have been identified as the components that have failed and are the cause for breakdown of the machine in particular.

TABLE 1. Components of Leaf Shredder Machine and Critical Components

Sl. No.	Component	Criticality of the Component
1	Motor	Not Critical
2	Main Shaft	Critical
3	Cutting Knife	Critical
4	Drive belt	Not Critical
5	Bearing	Critical

From Table 1 it is seen that three components have been bought under the critical component list as they have been the components that have broken down causing stoppage of the entire process. This lead to the conduct of FMEA study on the identified three critical components.

Root Causes for failure of the Leaf Shredder Machine:

1. When lubrication is not made in proper cycle for the bearing.
2. Over loading of the Tea Leaves.
3. When weight is unbalanced it affects the bearing.
4. The heat produced rises the temperature in the shaft and it gets jammed.

C. Phase 3: Study on Severity, Occurrence and Detection of Three Critical Components.

In this study under FMEA it was decided to determine the Risk Priority Number (RPN) for each of the critical components, followed by identifying the root causes to enable decision makers to initiate remedial actions to improvise the situation.

RPN was calculated by devising strategies to calculate Severity (S), Occurrence (O) and Detection (D) as shown in tables 2, 3 and 4 respectively.

1) Severity (Severity Rating):

The potential seriousness of failure effect is analysed for a Leaf Shredder. This is done by scoring the effect on a 1 to 5 (or 10) scale. First the severity to go with each score is defined. A scheme has been suggested.

TABLE 2. Severity Rating Table

Score	Rating Criteria
5(9-10)	Potential dissatisfaction – Potential risk causing definite breakdown.
4(7-8)	High potential dissatisfaction. – significant Machine disruption
3(5-6)	Medium potential dissatisfaction – Potential small problems, inconvenience
2(3-4)	Medium potential dissatisfaction – May notice the potential failure and may be a little dissatisfied.
1(1-2)	The machine operator will probably not detect the failure undetectable.

2) Occurrence:

It is termed as occurance ranking and it takes into account the likelihood of the occurance of potential failures in a Leaf Shredder.

The probability assessment can be made. This is done on a 1 to 5 (or 10) scale.

A scheme for possible occurance rating has been suggested.

TABLE 3. Occurrence Rate Table

Score	Rating Criteria
5(9-10)	Very high probability of occurance.
4(7-8)	High probability of occurance.
3(5-6)	Moderate probability of occurance.
2(3-4)	Low probability of occurance.
1(1-2)	Remote probability of occurance.

3) Detection:

It is termed detection rating. This is the final rating aims on establishing how detecting the potential fault will be.

A scheme for detection rating has been given.

TABLE 4. Detection Rate Table

Score	Rating Criteria
5 (9-10)	The Machine user and maintenance team will probably not detect the failure. (undetectable)
4 (7-8)	The Machine user and maintenance team will probably detect the failure Close to zero probability of detecting potential failure cause.
3 (4-6)	The Machine user and maintenance team probably will not likely to detect potential failure cause.
2 (2-3)	The Machine user and maintenance team will have a good chance of detecting potential failure cause
1 (1)	The Machine user and maintenance team will be almost certain to identify potential failure cause.

4) RPN Calculation:

RPN = Severity rating × Occurrence rating × Detection rating

RPN value indicates design risk. In general, an item with the highest RPN and severity rating is to be given immediate consideration.

Data was collected and with the resulting data RPN has been calculated and is shown in table 5

TABLE 5. RPN Calculation

Machine	Potential Failure mode (Critical Components)	Severity (S)	Occurance (O)	Detection (D)	Risk Priority Number (RPN)
Leaf Shredder	Cutting Knife	4	4	3	48
	Main Shaft	3	3	4	36
	Bearing	3	2	4	24

IV. CONCLUSION

From the calculation of RPN it is seen that the most critical componentis Cutting Knife with an RPN of 48. But all the tree critical components have a high RPN and hence all three have been concluded to be equally critical. Based on the root cause listed in phase 3, by taking appropriate remedial action the downtime can be reduced.

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