

Application of Failure Mode Effect Analysis (FMEA) to Reduce Downtime in a Textile Share Company

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Abstract: Downtime is significant among the role players of production loss and low productivity. The case company is currently experiencing high downtimes and it is producing less than 48% of its capacity. This case study aims at reducing the high downtime through the application of Failure Mode Effect Analysis (FMEA) as a major productivity improvement tool. Both secondary and primary data were collected through documentation assessments, observations and discussions with key people in the weaving section. The findings of the research show that, this particular section of the company, the recorded downtime is found to be very high compared to actual operation time. The loom machines are down daily for 38.69% of the total production time on average which highly affects the productivity. As a result, the failure modes, their effects and cause of the weaving/loom section of the company are prioritized using the Risk Priority Number (RPN). The corrective actions that the company should take to improve its productivity are articulated. Taking the FMEA result of the loom machines processes and focusing on the vital few causes of the identified failure modes that contribute more than 50% of the RPNs, the company can decrease the downtime of the section by 299.04hrs/day.

Keywords: Downtime, failure mode effect analysis, productivity.

1. Introduction

It is long years ago that manufacturing firms were in search of a method to identify every possible failure during a process and developed Application of Failure Mode Effect Analysis(FMEA) (Mhetre et al., 2012). It is a step by step and systematic process for identifying potential failures before they occur, with the aim to eliminate or minimize the risk associated with the failures identified (Mhetre et al, 2012; Ambekar et al., 2013). Carl S. Carlson (2012) also articulated an advice that FMEA should be the guide to the development of a complete set of actions that will reduce risk associated with the system, subsystem, and component or manufacturing/assembly process to an acceptable level.

As one of the core production sections of the company, the weaving section at the case Textile Share company experiences very high downtime and this study will focus on the FMEA application in the weaving process line to identify the modes of the failures, their causes and effect and it came with a suggestion of some remedial actions to reduce the recorded high downtime.

2. Problem Statement

In the weaving section of the case company, 1653 hours of downtime is recorded daily according to the compiled daily performance evaluations of the same section. If the machines work with full capacity, the daily working hours of the 178 machines is; 178 machine x 24hrs/machine, which could have been 4272 hrs/day. This shows that the weaving machines are down for 38.69% of the total working hours.

3. Objective of the Study

The objective of the study is to reduce the downtime of the case company through the application of FMEA as a major productivity improvement tool.

4. Methodology

The primary data were collected from the case company through observations including recordings, measurements and discussions with line managers and operators. To get relevant secondary data, the documentations of the company, with special focus to weaving section, were

critically assessed. Finally, FMEA was applied as a problem solving tool to analyze the collected data. In addition, cause-effect diagram and Pareto analysis were among the supporting analysis methods applied in this research. After FMEA was conducted and tabulated and the failure modes were identified and prioritized, the

downtime observation continued with the respective causes of the failure modes on 10 selected general purpose machines. The FMEA conducted according to the procedures depicted in the figure below.

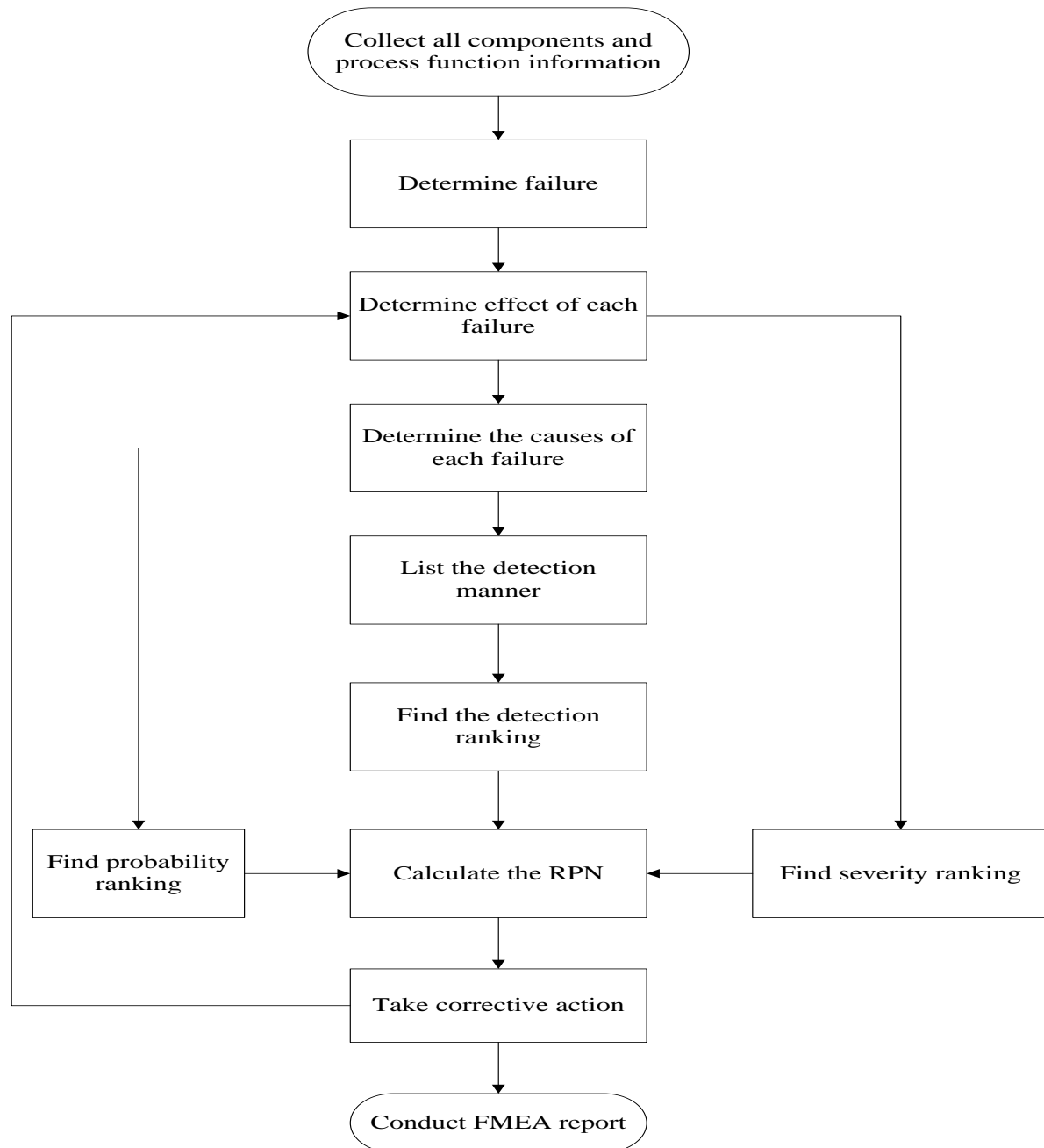


Fig. 1. FMEA procedure (Adopted from Rakesh et al., 2013)

5. Literature Review

The Textile industry is one of the earlier large-scale economic activities that led the industrialization process centuries ago in Ethiopia (FDRE MoI, 2017). Ethiopia's long history in textiles started in the year 1939 when Dire Dawa Textile Factory, the first garment factory in Ethiopia, was established (Alliance Experts, 2017). Presently, the Ethiopian textile industry is the third largest manufacturing industry, next to leather and beverage industries and the main product of the sector is 100% cotton textiles according to a report by the

Ethiopian Embassy in China (2017). Based on these facts, the government of the federal democratic republic of Ethiopia has given top priority for the development of the textile sector and considers it to be a strategic sector for export expansion and rapid industrial development (FDRE MoI, 2017).

The case Textile Share Company, one of the oldest textile mills in Ethiopia, is founded in 1961 by the Italian government as a war compensation to Ethiopia. Currently, the company has a total capacity of producing 15 tons of spin fiber, 50,000 meters of fabric, 82,000

meter squares of finished fabric, and 10,000 pairs of garment products.

Downtime can be defined as an event that stops manufacturing processes for a significant length of time and the stop events include machine or equipment failures, raw material shortages and changeover time (Subramaniam et al., 2009). In other words, downtime is the period which the process is off-line and not producing any products or adding value to the products. It can also be called idle time, downtime, or off line period. The seven wastes in any production company are excess inventory, overproduction, waiting time, unnecessary transport, processing waste, inefficient work methods and product defects (Davies and Merwe, 2015) and the waiting time is contributed by the downtime. Hence, it is much important to know how much and when downtime the process is experiencing and to be able to attribute the lost time to the specific source or reason for the loss (O'Brien, 2015). It is a common operations and production management key performance indicator (KPI). Production companies obviously aim to reduce the amount of downtime in a production process or at the very least should be able to control it to an acceptable level and use it to the manager's advantage (Leanmanufacture.net, 2017).

The Resource Engineering, Inc. (2015) defined FMEA as a tool that (a) identifies the relative risks designed into a product or a process, (b) initiates an action to reduce those risks with highest potential impact, and (c) tracks the results of the action plan in terms of risk reduction.

Moreover, Joshi et al. (2014) gave a detailed definition of FMEA; it is a structured approach to:

- Evaluate a process/product to identify where and how it might fail
- Estimate the risks of specific causes associated with these failures
- Assess impact of these failures
- Minimize the impact and chance of these failures by taking the appropriate actions

- Identify parts/products in systems that majorly call for a change

Therefore, FMEA is very helpful in identifying and prioritizing recorded failure in relation to their causes and effects.

6. Results and Discussion

Fig. 2. indicates that with the decrease in the downtime of machines in the section results in the overall production loss of the company. The resulting loss-curve also lies between the plan and performance curves of the Plan-Performance-Loss curve as can be seen in Fig. 3.

Plan >>>>Performance
Loss >>>> Performance;
Hence:
Plan >>>>Performance <<<<Loss

The following chart shows the relative downtime vs production loss based on data recorded for three consecutive years (2013/14 to 2015/16). As can be seen, the downtimes in hours recorded in the three years and their effect on the loss of production in meters are proportional.

Hence, the performance of the section is suffering not only being of much lower than the plan but also less than the loss. This condition is intolerable for any production company. A performance less than a plan can be acceptable to some extent, because constraints are always there in the line of production, but a performance much less than a loss is awesome and worthy of urgent solution.

The above result is also validated by actual observation of the looming section and focused group discussions made by the authors experts and line managers. As a result, a step by step process revision was made before the application of the FMEA tool to reduce the downtime.

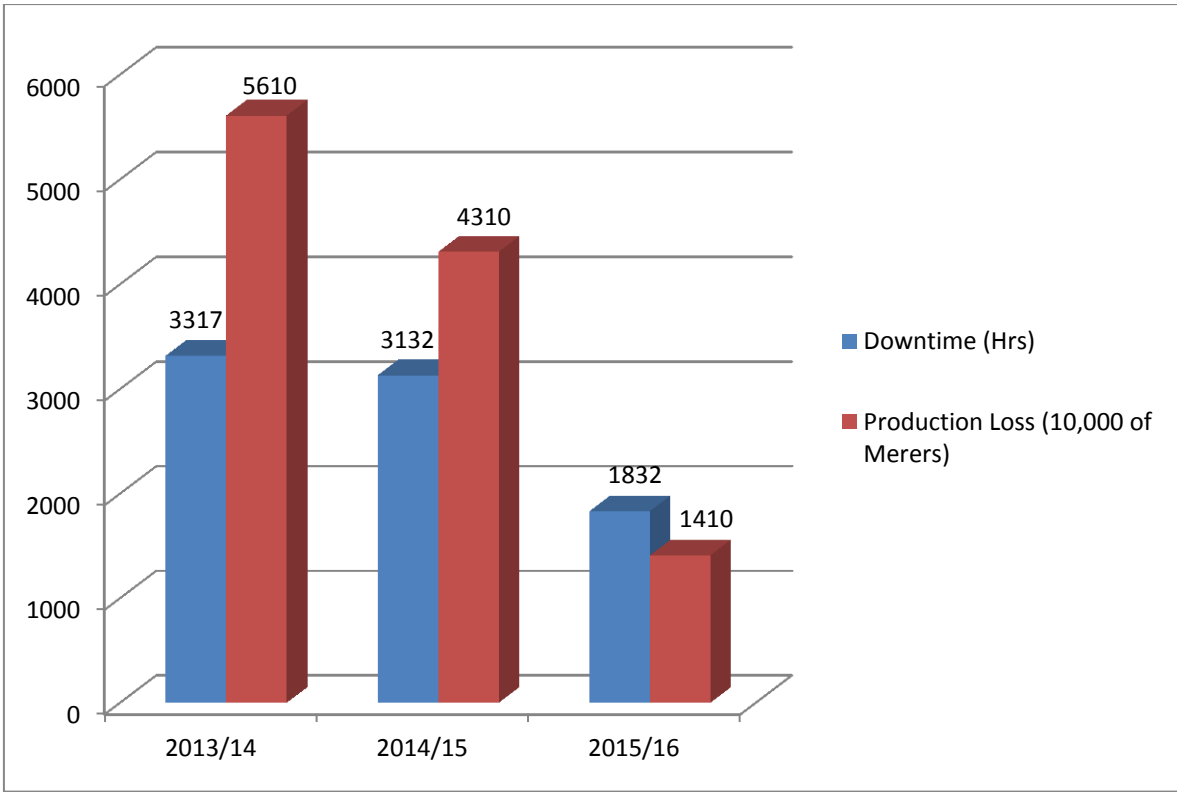


Fig. 2. Downtime vs production loss in the looming subsection

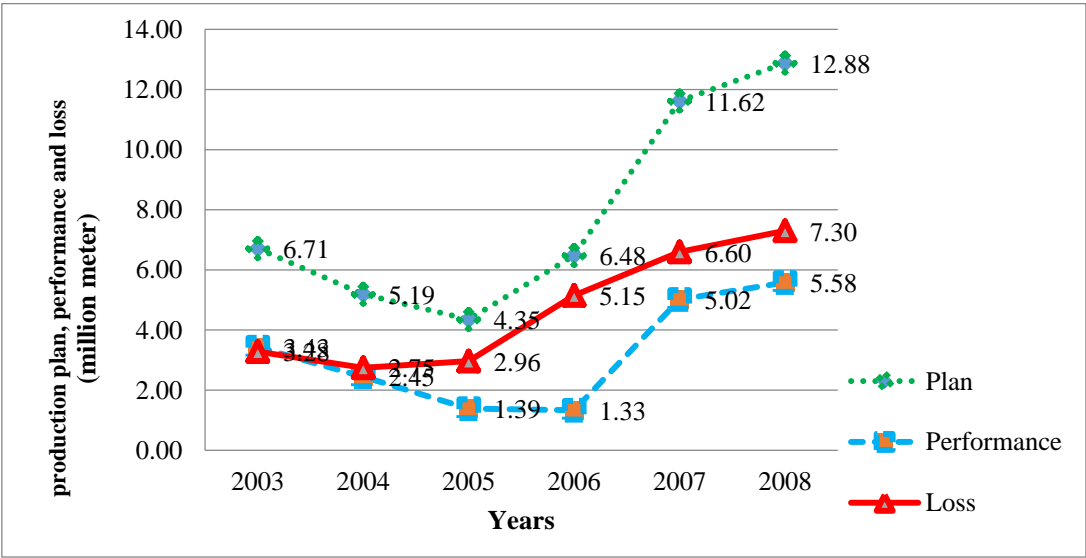


Fig. 3. Production Plan-Performance-Loss curve of the loom subsection

Application of FMEA of the Loom Section

In the application of FMEA, the potential failure modes, their respective effects, their potential causes and control mechanisms were fed in to an FMEA sheet and the RPN is calculated. Then, the results of the FMEA sheet is translated into graphical presentation. However, this representation is only with respect to the causes of the failure modes. While there are several several causes for a single failure mode, the subsequent analysis were made based on the causes of the failures. The resulting FMEA templated table result shows *eighteen potential causes* with *seven potential failure modes* and *three critical effects* were identified in the loom section.

As can be seen in Fig. 5 several failure modes and their respective effects were identified. Moreover, the various failure modes and their respective contribution to the higher downtime of the section were identified.

Pareto Analysis

Pareto analysis of the resulting causes also result in 20% of the causes of the failure modes with high RPNs that contribute more than 50% of the RPN are four, the effect being the downtime of the process. Further observations of these vital few causes on the loom machines were also made and the results show the downtime hours that can be reduced to the possible minimum with optimized efforts and resources.

Hence, a single machine experiences 0.07hrs of reducible downtime in a single operation hour on average due to the four vital causes of the identified and prioritized failure modes. This hourly downtime of a machine can be translated into the 24hrs working day of the company (three shifts) and resulting in 1.68 hrs/day (24hrs x 0.07). Therefore, the total downtime of the 178 loom machines that can be reduced is 299.04hrs/day.

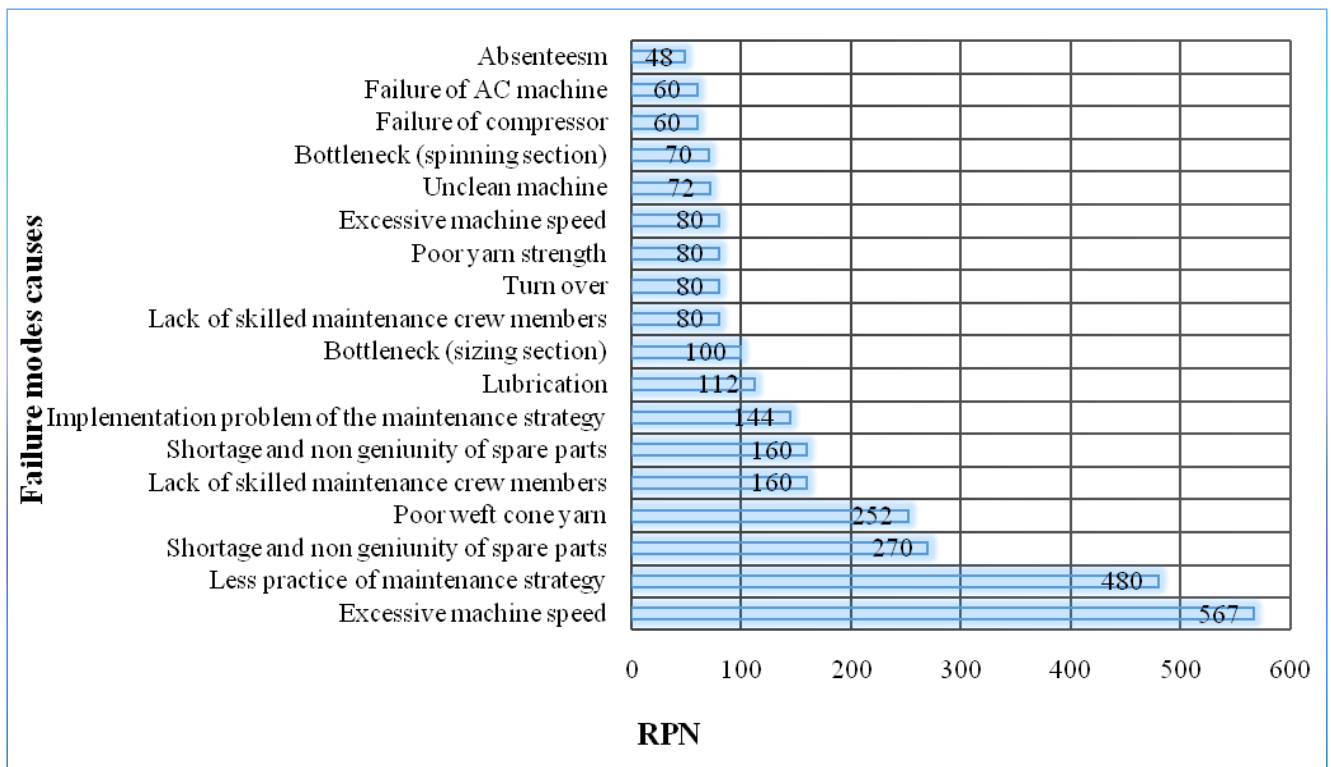
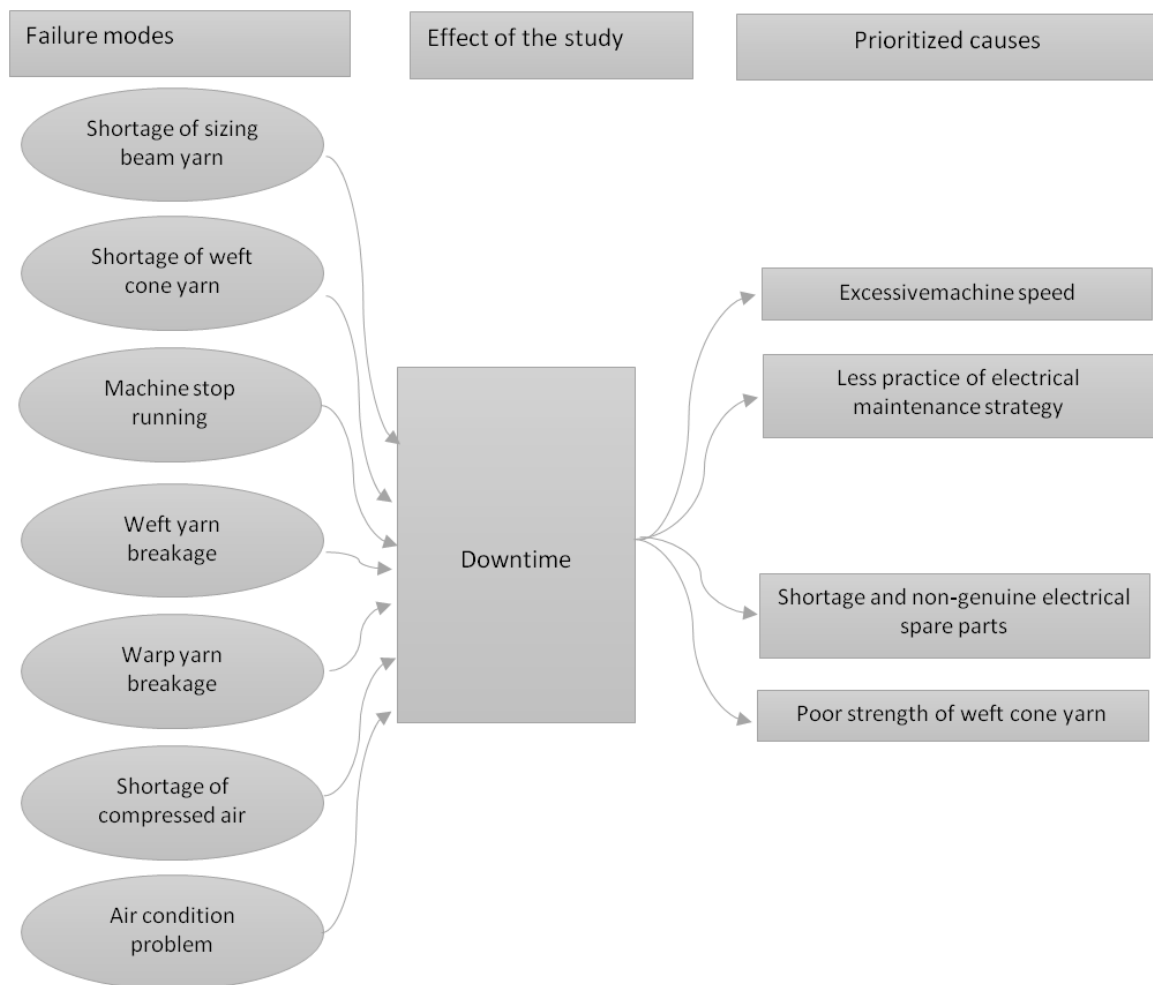


Fig. 4. Graphic Representation of the FMEA sheet results (causes of the failures identified)

Table 1. Observations on the four vital causes of failure modes in a single hour

| Prioritized Causes | Results of the Observations (Seconds) | | | | | | | | | | Average DT (hrs) |
|--|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|------------------|
| | Obs 1 | Obs 2 | Obs 3 | Obs 4 | Obs 5 | Obs 6 | Obs 7 | Obs 8 | Obs 9 | Obs 10 | |
| Excessive machine speed | 62.0 | 118.0 | 31.0 | 56.0 | 48.0 | 86.0 | 73.0 | 61.0 | 144.0 | 29.0 | 0.02 |
| Less practice of electrical maintenance strategy | 64.7 | 64.7 | 64.7 | 64.7 | 64.7 | 64.7 | 64.7 | 64.7 | 64.7 | 64.7 | 0.02 |
| Shortage and non genuinity of electrical spare parts | 48.5 | 48.5 | 48.5 | 48.5 | 48.5 | 48.5 | 48.5 | 48.5 | 48.5 | 48.5 | 0.01 |
| Poor strength of weft cone yarn | 33.0 | 45.0 | 62.0 | 101.0 | 62.0 | 74.0 | 51.0 | 29.0 | 11.0 | 85.0 | 0.02 |
| Total | | | | | | | | | | | 0.07 |

**Fig. 5.** Failure modes-Effect-Cause diagram for the four prioritized causes

7. Conclusion and Recommendation

In this case study research, downtime is found to be one of the most significant role players for higher production loss and low productivity. As a result of the FMEA application in the weaving section of the case company, seven potential failure modes, three critical effects and eighteen potential causes were identified. By using Failure Mode Effect Analysis as a major tool to identify failure modes of the different loom machines in the weaving process and by focusing on the vital few causes of the failures, the research enables us to reduce the downtime of the subsection by 14.2%.

In other words, the findings of the research showed that, by taking appropriate corrective actions on the 20% of the causes of the failure modes that contribute more than 50% of the RPNs, it is found that the section can save a downtime of 299.04hrs/day.

Therefore, from the above result, it can be concluded that by applying failure mode effect analysis in the other sections of the textile production processes, the case company can reduce its down time by a larger proportion. This in turn results in higher productivity. Finally, the authors recommended the case company to apply FMEA in its several sections so as to reduce the high downtime and hence to enhance its production performance and productivity.

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