Risk Based Maintenance: An Approach for Reducing Breakdown

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Abstract - *An* active working of the processing plants highly relies on maintenance patterns implemented and their reliability. In the processing plants which have high demand for products, effective and efficient operation becomes very crucial. This should be addressed by enhancing the total production. Prior to increasing demand for its production, evaluation of reliability and planning required for maintenance are unavoidable. The main objective of this study was to detect and determine major breakdowns which were causing losses in production for company and then, to recommend possible methods through which the problems identified could be minimized. The evaluation of breakdown pattern was aimed towards improving manufacturing performance by understanding the prospects of risk-based maintenance. In the study, a root cause analysis was carried out for determining root causes of the breakdowns and possible parallel up gradation prospects were identified as well for implementation such that the downtime could be reduced.

***Key Words*: Breakdown Analysis, Risk Based Maintenance, Root Cause Analysis**

1.INTRODUCTION

In this present competitive work space, organizations are underneath immense pressure for selling their product and goods in marketplace. Processing plants which have higher product demand needs to run for longer time. Without properly planning and preparing schedules for preventive maintenance, there are high chances of failures in processing system at any time and levels. Downtime only occurs when there are parts replacement or repairs that have damaged. The total time during which components function efficiently before its replacement is stated as life of components. Reliability can be described as ability of system as well as components for functioning at stated conditions for certain assigned time period.

A production plant can be any site where money, materials, machinery, men, equipment, etc. are interconnected to each other for production of various products and the techniques of maintenance has a direct impact towards the aspects of business performances of plant like profitability and productivity. Loss in one day output due to unplanned breakdown in plant cannot be recovered without extra amount incurred in the process [1]. The methodology of RBM provides proper tool for planning of maintenance and then making associated decisions for reducing the equipment failure probability and failure consequences. For making proper RBM related decisions, it is very much important to utilize suitable methodologies and techniques, proper investigation of process while executing risk analysis and then analysis of structured and detailed results [2]. The major roles and duties of maintenance department in the production plant is to make sure that the system availability is of required level for getting proper and sufficient output from plant and hence improving total productivity [3]. Likewise, cost of maintenance could exceed by 20% to 30% of total operating cost of plant [4] and in some of the large scaled industries which are plant based, the cost of maintenance could account up to 40% of total operating budget. Development and implementation of maintenance concept can be a very difficult process which might be struggling because of various issues, such as of consistent and systematic process, or say lack of proper work frame [5].

1.1 Risk Based Maintenance

RBM (Risk Based Maintenance) arranges resources related to maintenance toward assets which carries higher risk if they failed. RBM is defined as a procedure for identifying most efficient utilization of resources associated to maintenance. It is done so as to optimize effort of maintenance across facility for minimizing possible risk of failure.

There are mainly two phases on which strategy of risk-based maintenance is concerned:

- **Risk assessment**

It should be done in well facilitated plant and probability scale and impact should be stated previously and individually for each production area or sites. Scaling should be easier and understandable for production and maintenance staff who works in evaluated production site for enabling them to deliver detailed estimation.

- **Planning of Maintenance on basis of risk**
  The 2nd step involves focusing on assets in red area in risk matrix as it has maximum risk of losing quality, productivity or safety. It is mostly observed that maintenance analysis works on risk centered area is considered as extreme as well as boring. So, it becomes very important to stress out that energy as well as time spent on logical strategy of maintenance is actually worth effort applied. Any unpredicted breakdown in one of the risky assets increases cost of analysis by multiple folds.

PROBABILITY OF OCCURANCE					
4	High	High	High	High	High
3	Medium	Medium	High	High	High
2	Medium	Medium	Medium	High	High
1	Low	Medium	Medium	Medium	High
0	Low	Low	Medium	Medium	High
RISK	0	1	2	3	4

Fig-1: A Simple Risk Matrix

1.2 Risk Priority Number (RPN)

It is not measurement for the risk, but for priority of risk. By calculating RPN, it becomes easier for distribution of limited resource of maintenance to utmost significant failures. The formula for calculating RPN of a system is derived as [6]:

RPN (Risk Priority Number) = (Severity of failure) x (Likelihood of detection of failure) x (Frequency of failure).

The 3 constraints stated above are evaluated on a scale of one to ten, therefore as follows:

- Severity of failure (S):
  1 = No impact on performance, still works, no any threat; 2-4 = Poor performance, still works; 5 = Some damages and limited functioning; 6-9 = Almost useless, strictly restricted function; 10 = Serious danger, inoperable.
- Frequency of Occurrence (O):
  1 = Low uncertainty, high experience of operating, no chance; 2-4 = Low uncertainty and good chance, some experience of operating, some design validation testing; 5-7 = No experience of operating and testing – design on the basis of analysis, some chance; 8-9 = Wild guesses in model, lack of information regarding operating and loading conditions, no testing, good occurrence chance sometime throughout product life; 10 = 100% Occurrence chance throughout product life.

- Likelihood of Detection and Avoidance of failure (L):
  1 = 100% Detection and avoiding chance; 2-9 = few or little chances of detection and avoiding; 10 = no chances of detection and avoiding.

2. A CASE STUDY AT CG FOODS (NEPAL) PVT. LTD.

A case study was done at CG Foods (Nepal) Pvt. Ltd., Sainbu, Bhaisepati, Lalitpur, Nepal. The study was mainly focused on the breakdown analysis for the fiscal year 2019/2020, which was then followed by proposing a model and schedule for the implementation of the RBM.

2.1 Breakdown Analysis of Fiscal Year 2019/2020

The breakdown pattern of the machineries in noodles plant was analyzed of the data obtained of fiscal year 2019/20. The main objective of this was to know about the capacity of machine and its downtime, for maximizing the capacity of production and then to enhance new schedule of maintenance. The analysis was performed on noodle plant, where all the repetitive breakdowns were analyzed including the parts which were critical and were within breakdown condition. Similarly, the breakdown reasons have also been inspected and analyzed with the help of Why-Why analysis and Fish Bone Diagram. With the help of this methods and analysis, root causes for breakdown in plant were determined.

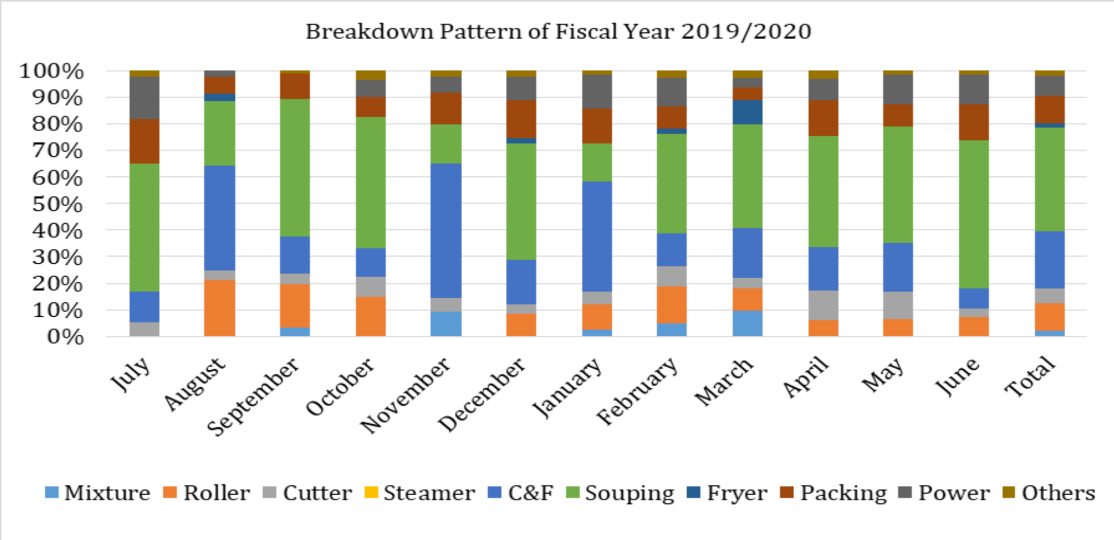

Fig-2: Bar graph showing breakdown pattern of fiscal year 2019/2020

From the above bar-graph, we can see that the major breakdown occurred in the fiscal year 2019/020 was in the souping section. The souping section mainly consists of souping rod, souping net, net guide, chain conveyor, guide path, anvil shaft. The rod holds the souping net which is conveyed using chain conveyor. The path of the souping net is adjusted using net guide and guide path, such that the noodle after cutting are sent to the cake box in the group of six cakes. The souping unit consists of 18 souping nets which are held with the help of 32 souping rods. So, for identifying root cause of breakdown in souping section, we used "Why-Why Analysis" and "Fish Bone Diagram" techniques.

2.2 Fish Bone Diagram

Fish Bone Diagram, termed also as Cause and Effect Figure or Ishikawa Drawing, helps in identifying various possible reasons for a problem or effect. These diagrams are mostly used in "analyze" step of DMAIC (define, measure, analyze, improve, control) approach of Six Sigma for solving problem.

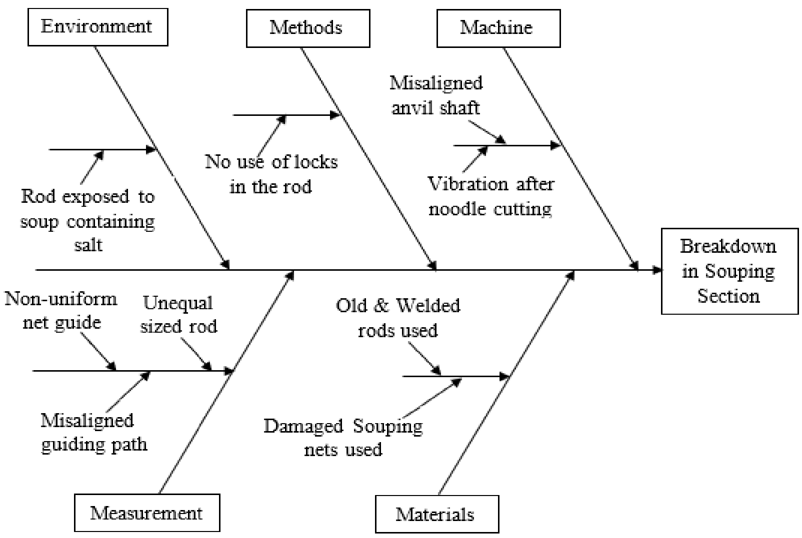

Fig-3: Fish Bone Diagram of Souping Section

2.3 Why-Why Analysis

The technique of questioning which leads to root cause(s) identification of a problem can be stated as Why-Why Analysis. It is performed for identifying possible solutions to problems which addresses its root causes. So, while doing why-why analysis of the souping section, I was able to come up with the following 5 questions which were helpful in doing the root cause analysis.

1. Why was there frequent breakdown in the souping rod?

A: The frequent breakdown was due to the misalignment of the rod.

2. Why was there misalignment in the rod?

A: The misalignment in the rod was because of the use of welded rods.

3. Why were there old and welded rods used?

A: The old and welded rods were used because the rods were not of equal length.

4. Why was there vibration in the souping net just after the noodle cutting?

A: The vibration was because of the misalignment of the anvil shaft.

5. Why was there misalignment of anvil shaft?

A: The misalignment was because of the use of same shaft for a very longer period of time.

2.4 Availability of System

The data of breakdown in the plant over a period of one year was collected and then breakdown analysis was carried out. Following the analysis of breakdown data, it was observed that major breakdown was in the souping section. After that, successful implementation of root cause analysis was done for the breakdown in souping section and then the calculation of availability of the system was performed.

The availability of the system is calculated using the formula:

$$Availability = \frac{Total\ running\ time}{Total\ running\ time + Effective\ stoppage\ time}$$

The total operating time throughout the study period was found as 3,13,080 minutes. Effective time of stoppage after subtracting downtime because of scheduled maintenance job was determined as 1,08,276 minutes.

∴ System Availability = (313080)/(313080+108276)

= 0.743

= 74.3%

Thus, the studied system was operating for 74.3 % of total provided operating time.

2.5 Proposed Model of RBM

In order to improve the overall system availability and to minimize the frequent failure of souping section during plant operation, a completely new risk based maintenance model was proposed. This risk based maintenance model was prepared by taking into account the analysis results obtained from Fish Bone Diagram as well as Why-Why Analysis.

The proposed model for improving system availability is presented in the figure below:

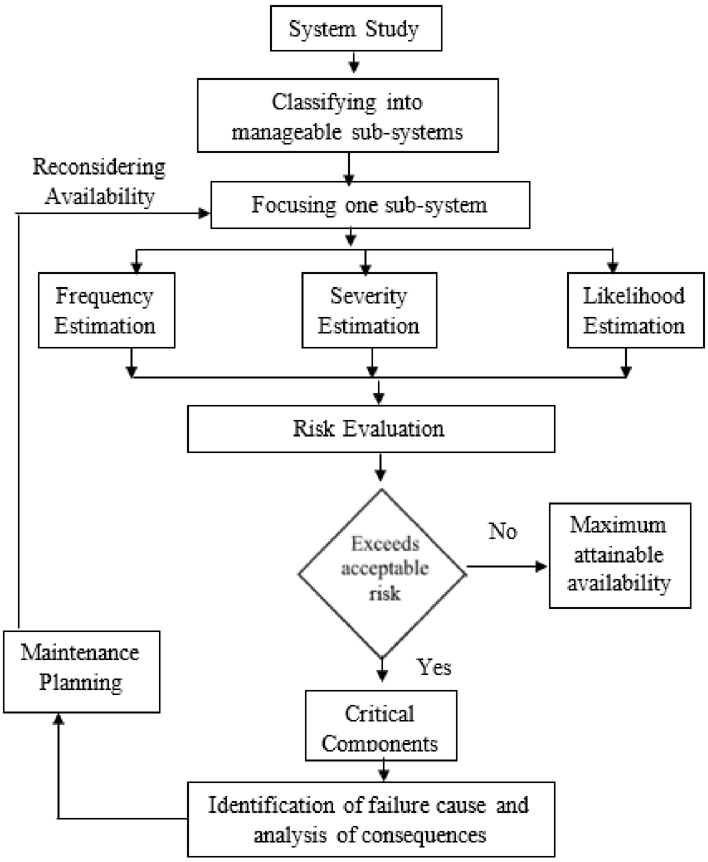

Fig-4: Proposed Model of RBM

2.6 Risk Assessment of Components

The noodle plant had several components. According to the earlier studies, souping section wsa the major component in system which had excess downtime effect. Hence, assessment of risk was focused mainly towards it. Calculated RPN of some components in the souping section has been presented in table below:

Table-1: Risk Priority Number of Components in Souping Section

S. No.	Item	Severity	Frequency	Likelihood	RPN
1	Souping Rod	9	10	9	810
2	Souping Net	5	7	9	315
3	Net Guide	2	2	5	20
4	Guide Path	4	2	6	48
5	Rod Lock	9	10	7	630
6	Chain Sprocket	2	2	3	12
7	Chain Conveyor	3	7	6	126

According to the data collected, downtime because of guide path failure in souping section is 0 over given time range of 12 months. Risk (or Risk priority number) for guide path failure is 48. Such that, RPN = 48, is considered as risk which is acceptable. Only components beyond risk value are considered for planning of maintenance. Components having higher risk are: souping rod, souping net, rod lock and chain conveyor.

2.7 Maintenance Schedule for the System

Consequences because of the failure of important component were studied and found that it contributed 3218 minutes total downtime. By using schedule of risk based maintenance, theoretically, maximum of 3218 minutes downtime could be minimized. Bureau of Indian standards was adhered to for proposing the schedule of maintenance and revealed in the table below. Also, along with the proposed maintenance schedule, risk-register has been attached, which shows the risk value of the risk before implementing risk-based maintenance and risk value after implementation of the risk based maintenance. The risk register provided, thus can be used to compare the initial and final risk values of the risks, which might occur in the souping section or which are occurring in the souping section.

Table-2: Proposed Maintenance Schedule

S. No.	Operation of Maintenance	Replacement frequency/Repair/Inspection	Relation with consequence
1	Confirm that souping rod are in fixed position	Every time the rod comes out the chain	Rod out due to lock problem
2	No two souping nets follows the same path	Every time a new batch is loaded	Uneven size of net guide
3	Tightening all the bolts and screws	Once daily	Chain conveyor out of path
4	Alignment of the guide path	3 months	Problem in the distribution of noodle in cake box
5	Ensure that all the rods are fixed with lock	Every time a new batch is loaded	Rod out of the chain
6	Grease lubrication of sprocket	Once a week	Sprocket wear
7	Rod should not be bent	Once a week	Rod out of the chain
8	Net should not be damaged	15 days	Noodle conveying problem

Table-3: Risk Register

Risk ID	Risk	Impact	Impact Value	Probaility	Risk Value	Type of Treatment	Existing Control	New Controls	New Impact Value	New Probability	New Risk Value
1	Breaking of Rod	Stoppage in Production	4	5	20	Avoid	Replace the rod	Replace rod and put locks	3	2	6
2	Breaking of Net	Stoppage in Production	4	3	12	Avoid	Replace with old net	Replace with new	2	1	2
3	Loosening of bolt	Vibration in Machine	3	4	12	Accept	Tighten the bolt	Tighten bolt using	2	2	4
4	Misalignment of guide path	Increase in wastage	3	5	15	Accept	Correcting alignment	Replace path with	2	1	2
5	Damage of sprocket	Stoppage in Production	3	4	12	Avoid	Change sprocket	Timely lubrication and	1	2	2
6	Vibration in anvil shaft	Increase in wastage	3	5	15	Accept	Synchronise timing and correct	Replace anvil shaft	2	2	4

2.8 RECALCULATION OF AVAILABILITY

With the implementation of RBM, few failures associated to critical components could be circumvented. Thus, actual time of stoppage can be decreased. New effective time of stoppage calculated for system with in consideration is 65,058 minutes. The recalculated value of system availability using above formula is:

Availability of the System = 313080/(313080+65058)

= 0.828

= 82.8%

Which means, system now works for 82.8% of the total time in the given time period.

Previously, the availability was 74.3%.

Hence, the percentage increase in the availability achieved is:

% increase = ((82.8-74.3)/74.3)*100%

= 11.24%

3. CONCLUSIONS

The work presented here has proved maintenance planning importance in processing plant. The model proposed here could be globalized for any kind of processing plants. The proposed model advised for executing the plan of maintenance, is very much effective for the proposal of new schedule for maintenance.

Assessment of risk for different components within the system guides for determination of the components which are critical. Hence, focusing towards critical components instead of examining all system components has benefit of using optimum resources for maintenance.

This case related to breakdown in the souping section of noodle plant was taken into account for demonstrating this proposed model. At existing condition, the plant's availability was calculated to be 0.743. The availability value recalculated after implementing RBM was 0.828. By applying the RBM, an increase of 11.24% in systems availability could be achieved efficiently.

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