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Hazard Identification and Risk Assessment in Roller Mill – Case Study

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ABSTRACT:

Roller Mills are used to grind or crush plastic, ore, grain into fine particles for usage in various industries such as chemical industry, glass fiber industry and coal industries. During the operation, the roller mills are subjected to failures due to high vibrations, low roller pressure, low Mill pressure and higher wear of grinding tools. These kinds of failures are a greater threat for the Roller milling industry as the respective material production is affected. To overcome this issue, Risk Based Maintenance (RBM) approach and Failure Mode Effective Analysis (FMEA) is employed in the industry taken for study. Risk Based Maintenance helps in reducing the failure rate that is happening in machines and the resulting breakdown are managed with establishing action priorities. FMEA mainly deals with the estimation of risk caused by the unexpected failures due to components of the roller mill and the probability with which the failures occur is determined by Risk Priority Number (RPN). The results of this study helps to find the maintenance activity needed to be taken at the highest priority for the roller mill. The priority order thus made is based on the risk level that helps in reducing the overall risk of the equipment.

Keywords: Roller Mill, Risk Based Maintenance, FMEA, Risk Priority Number

I. INTRODUCTION

Roller Mill involves major processes, run by many important equipments for Crushing, grinding of particles. This Mill must be placed or located in very safe zone and must safeguard the equipment from unexpected failures.The equipments failures will affect the total productivity by consuming money and time. Analysis of hazard is very important for any firm so as to know the level of risk the area holds and accordingly necessary safety steps can be implemented. Only by means of ensured safety the worker and machines perform well.The risk involved for both men and machine are studied with great importance, control measures are recommended for all hazardous activities. The unexpected delay times and the downtimes caused by the failures of the components can have drastic effects on the equipment which in turn leads to poor output.To avoid such failures periodic risk assessment for all vital components of the pulverizing mill must be conducted based on which the maintenance schedule must beplanned.

II. CONSTRUCTION DETAILS OF ROLLER MILL

Material to be milled or ground such is fed through a discharge opening in a hopper to a pair of cooperating rolls that are mounted within a housing. The discharge opening is enclosed by a sliding gate which is biased to the closed position and can be opened by manual operation of a pull rod. An adjustable setting mechanism is incorporated with the pull rod and enables the gate to be held at an infinite number of open positions. To adjust the spacing between the rolls, the shaft of one of the rolls is journalled within bearing assemblies that are mounted for sliding movement with respect to the housing. A rod is secured to each slidable bearing assembly and is threadedly connected to a shaft which carries a sprocket. By driving the sprockets in unison, the shafts will be rotated to thereby move the bearing assemblies and adjust the spacing between the rolls. The movable roll is mounted for yieldable movement away from the fixed roll by compression springs which are located around the shafts and bear between an abutment on the shaft and the housing. Adjustment of the spacing between the rolls can be accomplished without changing the spring tension.

III. FAILURES IDENTIFIED IN THE ROLLER MILL

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In Roller mills different types of failures occurs due to many reasons. These failures are the major reasons to stoppage of the working of mill. There are some failures such as accidental (failure due to entry of foreign particles or materials) and some are uncontrollable and unavoidable (wear and tear). The most frequently occurring failures in roller mills are discussed below.

3.1 Bearing Failure

The Bearing failures are caused due to the bearings that are placed at the both ends of the rotor. The occurrence of damage at this bearings will leads to the stoppage of the mill. Then the needed replacement must be done to make the mill work again. The major problems here are due to High temperature, Improper Bearing Lubrication, Bearing fatigue, Bearing Misalignment and Improper Bearing mounting.

3.2 Overloading of Mill

This failure will leads to the stopping of working of mill. The various factors that leads to this failures are loading particles continuously in a faster rate without noticing whether the process has been completed, worn out hammer and more air ingress

3.3 Failure due to Low Pressure in Mill and Roller

The low pressure causes a press forces between the rollers that are higher because of a new adhesive forces that has been created. This leads to failure of both Mill and Roller.

3.4 Temperature Failure

The High temperature involved during the working of the roller mill in Crushing, and grinding process could cause a temperature failure in mill.

3.5 Failure due to Wear

Wear Failure occurs mostly in roll material, roll pass design, and in system factors such as temperature, loads and sliding velocity.

3.6. Rotor Shaft Failure

One of the major failures in roller mill is the rotor shaft failure. Mostly this failure occurs due to shearing of the shaft. The failure originate from key hole area of the shaft and propagate to other parts of the shaft and finally the whole shaft get cut off. Even though the probability of occurrence is less, the failure leads to stoppage of mills.

IV. METHOD OF APPROACH

V. A Risk Based Maintenance (RBM) approach determines the most economical use of maintenance resources with the end goal of minimizing any risk of a failure. Assets that have a greater risk and consequence of failure are maintained and monitored more frequently while assets that carry a lower risk are subjected to less stringent maintenance monitoring. Here the risk based maintenance strategy is influenced by FMEA tool for risk assessment for Roller Mill.

This Risk Based Maintenance (RBM) method consists of four sections: Identification of scope, Risk assessment, Risk evaluation and maintenance planning. Using this methodology we can estimate the risk caused by unexpected failure in the Roller mill as a function of probability and the consequence of failure.

4.1 Identification of Scope

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The components of the equipment (Roller mill) are identified and are divided into subsystems. Each component is analyzed one at a time and the required data with respect to failure mode, cause & effect are collected. Relationships (Physical, operational and logical) between each and every components are studied.

4.2 Risk Assessment

Risk assessment is done for most vital components of the pulverizing mill that may lead to potential failures. An FMEA approach is carried out to identify and analyze potential failure modes of the various parts of a pulverizing mill.This tool is used to quantify the risk of each failure scenario.

5.3 Risk Evaluation

An acceptable risk criteria is determined for all the failures and compared with the estimated risk of each failure. Great attention is necessary for failures that produce unacceptable risk and accordingly maintenance policies are determined for the components involved.

4.4 Maintenance Planning

Subsystems (components) that failed to meet the acceptable risk criteria are studied with keen importance with objective to design maintenance program for risk reduction. At this time period the maintenance activities for all critical events must be decided and implemented. Thus by these effective maintenance activities the occurrence of failure can be easily reduced by monitoring the systems.

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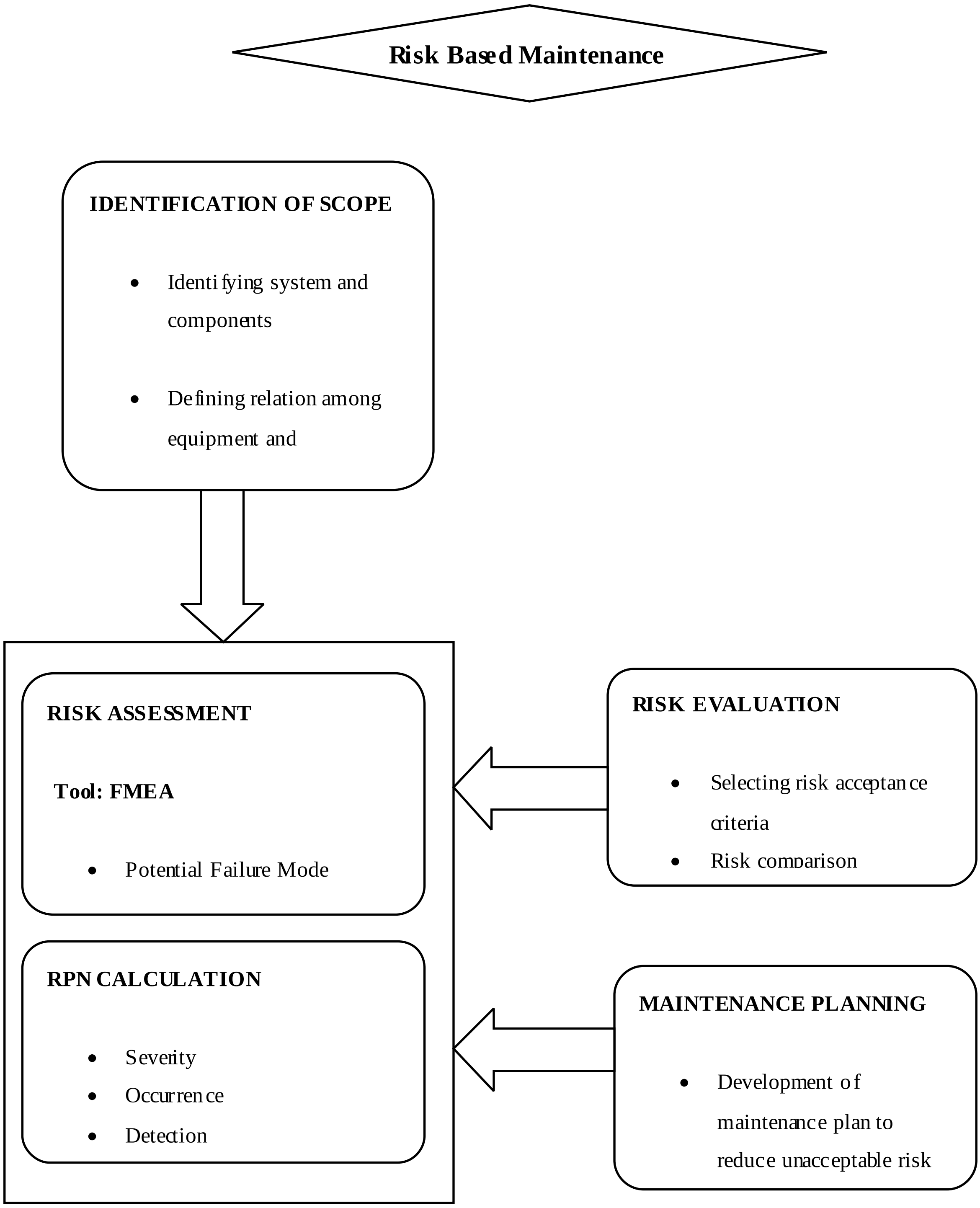

Fig a. RBM Methodology

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VI. METHODOLOGY OF IMPLEMENTATION

After analyzing all the failures in the Roller Mill the methodology adopted is implemented. All the steps involved in the Risk based maintenance strategy has been carried out in a step by step manner.

5.1 Identification of Scope:

The scope here is about the study of failures in the Roller mill. As discussed earlier the equipment consists of many complex components. Here the most vital components of the mill whose failure will severely affect the production n Manufacturing Industries are considered for RBM. The hierarchy of the System, Subsystem & components are shown in Table 1.

Table 1: Classification of Units

System	Subsystem	Components
Manufacturing Industry	Roller Mill	Gear Box
		Mill Shaft
		Bearing
		Grinding Table
		Main Door
		Rollers
		Bearing Housing

5.2 Risk Assessment

FMEA were made for all the vital components so as to identify the Potential mode of each failure, the risk involved in each failure stages, their cause and effect and corrective actions required. Risk quantification is done with the help of RPN (Risk Priority Number) calculation.

5.2.1 Terminologies in FMEA

The following are some basic FMEA terminology considered for the analysis

A) Failure

The loss of a function under stated conditions.

B) Failure mode

It is the way by which a failure occurs in the system or function which is under investigation. The failure state of an item is described under consideration. It is the result of the failure mechanism

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C) Failure cause and mechanism

Defect in requirements, design, process, material handling, which are the underlying cause or sequence of causes that initiate a process that leads to a failure mode over a specific period of time. A failure mode may have more potential causes.

D) Failure effect

Quick consequence of a failure in operation, function or functionality or status of some item/component.

SEVERITY:

The consequences of a failure as a result of particular
failure mode, the severity may be ranked from 1 to 10 based on its effects. A table shown below represents severity ranking based on the effect, Impact rate and ranking.

Table 2: Severity Ranking

Sl. No	Effect	Failure Impact	Rank
1	Extremely Harmful	Hazardous Without Warning	10
2	Extremely Harmful	Hazardous With Warning	9
3	Very High	Equipment not functioning/ Unknown cause and uncontrollable	8
4	High	Equipment not functioning/ known cause and uncontrollable	7
5	Moderate	Equipment not functioning/ known cause and uncontrollable	6
6	Low	Equipment functioning/ low impact on operating	5
7	Very Low	Equipment functioning/ Insignificant impact on operating	4
9	Minor	Equipment functioning/ Insignificant impact on operating	3
10	Very Minor	Equipment functioning/ Well known cause and	2
11	Negligible	Equipment functioning with negligible failures	1

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OCCURRENCE

The probability of repeated problem is called occurrence. The table below represents ranking for the occurrence of failure.

Table 3: Occurrence Ranking

Sl. No	Probability	Frequency Of Occurrence	Rank
1	Very high (persistent failures)	Few times a month	10,9
2	High (frequent failures)	2-3 times a month	8,7
3	Moderate (occasional failures)	Few times a year	6,5,4
4	Low (relatively few failures)	Once in a year	3,2
5	Remote (highly unlikely failures)	Once in three years	1

DETECTIONThe means of detecting the failure mode by, operator or any responsible worker is called detection. The table below represents detection ranking.

Table 4: Detection Ranking

Sl. No	Detect ability	Failure Detection By Periodic Observation	Rank
1	Almost impossible	No possibility for detection	10
2	Very remote	Difficult for detecting irregularities	9,8
3	Low	Control will hardly detect irregularities	7,6
4	Moderate	possible to detect irregularities	5
5	Highly moderate	Likely to detect irregularities	4
6	High	Errors identifiable by periodic check	3
7	Very high	Equipment check is likely to find the shortcomings	2,1

5.2.2 Basic Analysis Procedure for FMEA:

The basic steps for performing an FMEA include

- Assembling the team.

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- Establishing the ground rules.
- Gathering and making review of relevant information.
- Identifying the item or process to be analyzed.
- Identifying the functions, failures, effects, causes and controls for each item or process to be analyzed.
- To Evaluate the risk associated with the issues identified by the analysis.
- Prioritizing failure and assigning corrective actions.
- Performing corrective actions and re-evaluate risk.
- Distribute, review and update the analysis, as appropriate.

5.2.3 Risk Evaluation Methods:

An FMEA incorporates few methods to evaluate the risk associated with the potential problems identified through the analysis. The most common method for risk quantification is Risk Priority Number (RPN).

Risk Priority Numbers:
Risk Priority Number (RPN) method is used to assess risk for which the following factors must be considered:

- To Rate the severity for each effect of failure.
- To Rate the likelihood of occurrence for each cause of failure.
- To Rate the likelihood of detection for each cause of failure (i.e. the likelihood of detecting the failure before it affect the equipment).
- To Calculate the RPN by obtaining the product of the three ratings(S,O,D)
  RPN = Severity x Occurrence x Detection

The RPN can then be used to compare issues within the analysis and to prioritize problems for corrective action.

5.3 Risk Evaluation

An acceptable risk criteria was developed based on the employees skill and ability to bring back the equipment to its original running condition, frequency of equipment breakdown and maintenance activities. The estimated risk for individual component is compared against the acceptable risk criteria. Component (Subsystem) whose estimated risk exceeds the acceptable risk criteria were identified and for which maintenance plan are to be modified in order to lower the level of risk. A risk index was calculated in order to facilitate this comparison. The risk index is the actual risk divided by acceptable risk. Thus any component whose risk index is greater than 1 is considered to be critical.

5.3.1 Acceptable Risk Criteria

The acceptable risk level is nothing but the product of Confidence (ability of worker to catch up the failure), Breakdown (occurrence rate of Breakdown during operation of mill), and Maintenance (Maintenance activities performed at specific period of time).

Acceptable Risk = Confidence x Breakdown rate x Maintenance
Risk Index = Estimated Risk / Acceptable Risk

Table 5: Failure Mode & Effect Analysis for Component Failures:

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Sl. No	Component Details	Potential Failure Mode	Potential Effects Of Failure	S	Potential Causes	O	D	RPN	Recommended Actions
1	Gear box	Gearbox defect	Due to inadequate lubrication caused by mixing	6	Mainly due to oil contamination or incorrect lubrication	3	2	36	Mixing of lubrication shouldbe in a correct manner
2	Mill Shaft	Shaft cut	Breakage in mill shaft, Damage to bearing housing	10	Fatigue	2	7	140	Usage of high strength material, Reduced disc diameter
3	Bearing	Knocking at both ends	Vibration, Unusual noise	5	Friction due to improper lubrication, Bearing defect, Temperature increases due to rotor imbalance	3	5	75	Regular check of Rotor balancing and hammer missing
		Knocking at coupling end	Vibration, Unusual noise	6		4	4	96	
		Knocking at free end	Vibration, Unusual noise	4	Imbalance of rotor, bearing defect	5	4	80	
		Temperature increases in bearing	Damage of bearing	7		2	3	42	
4	Grinding Table	Bending defect	Due to heavy compression	7	Compression limit increases than the standard value	4	3	72	Compression should be given at correct value and material should be selected should withstand compression
		Fire crack occurs	Friction is the main reason	6	It also occurs due to temperature changes and friction occurs	3	3	54	Lubricated oil should be applied wherever friction happens

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5	Main Door	Defect in main door	Air ingress, Mill overload, Poor operation	7	Locking mechanis m, Failure of hinge connectors	4	6	168	Redesigning lock mechanism and hinges
6	Rollers	Torque failure occurs	Traction changes	8	Variation of traction between two drive wheels	3	6	144	Traction should not be varied
7	Bearing housing	Housing damage	Damage of bearing	7	Improper balancing, Inappropri ate coupling, Fastener damage	4	7	196	Increasing the periodicity of preventive maintenance, routine monitoring

Table 6: Acceptable Risk Factors

Confidence Ranking		**Breakdown Ranking**		**Maintenance Ranking**	
Confidence Level	**Rank**	**Breakdown level**	**Rank**	**Maintenance Level**	**Rank**
Incapable	10,9,8	Persistent failure	10,9	Low	10,9
Slightly capable	7,6,5	Frequent failure	8,7	Satisfactory	8,7
Moderately capable	4,3	Occasional	6,5	Moderate	6,5
Highly capable	2,1	Rare Highly unlikely	4,3 2,1	High Very high	4,3 2,1

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Table 7: Risk Index Calculation

S. No	Components	Acceptable Risk Level	Estimated Risk	Risk Index
1	Gear Box	60	36	0.6
2	Mill Shaft	168	140	0.833
3	Bearing	90	96	1.0667
4	Grinding Table	60	72	1.2
5	Main Door	175	168	0.96
6	Rollers	120	144	1.2
7	Bearing Housing	252	196	0.777

From the above table it is found that 4 Components violate the risk criteria: **Mill Hammer, Mill shaft, Mother Plate, Bearing housing**. Much attention must be paid to these critical components and advanced maintenance activities must be performed at regular intervals with proper maintenance schedule.

5.4 Maintenance Planning

Maintenance activities are planned accordingly to reduce the mill outage and repeated breakdown that affects the production of entire system.

Planned Activities:

- Preventive maintenance schedule is to be modified with keen importance and its frequency must be increased.
- Turn around maintenance must be carried out periodically with the help of TAM committee to reveal safety expectations.
- The confidence level of employee may be enhanced by period training on failure mode and their effects.
- Hazard identification programs must be conducted for workers every year.

VII. CONCLUSION

The paper presents a methodology for enhancing maintenance activities of Roller mill. The Risk-based maintenance approach ensures that the reliability of equipment can be increased easily. In addition to that the cost of maintenance activities including the cost of failure also can be reduced to expected level. The study of failures of complex item in Roller mill helps in identifying the risk associated within the system and also helps in decision making to reduce overall risk to the equipment. Effective maintenance plans have been proposed to improve the efficiency of the system.

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