

Failure mode Effect Analysis of Rollers in Mill Stand

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Abstract: The failure modes and effects analysis (FMEA) is a procedure in product development and operations management for analysis of potential failure modes within a system for classification by the severity and likelihood of the failures. A successful FMEA activity helps a team to identify potential failure modes based on past experience with similar products or processes, enabling the team to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs. The objective of this study is to analyze different failures associated with rollers in the mill stand using Failure Mode Effect Analysis (FMEA). The values of severity, probability of occurrence and detection of each failure mode are taken according to the FMEA criteria and based on these values, Risk Priority Number of each failure mode is calculated.

Keywords: Failure Modes and Effects Analysis (FMEA), Potential failure mode, Risk priority number (RPN)

I. INTRODUCTION

In the past few decades, many actions and research works have been undertaken to prevent potential accidents and to promote safety in the chemical processes; the output of these measures is the systematic management of safety in these processes. One of the key elements of safety management systems is to identify hazards, to assess risks and their control, which helps security professionals to investigate the ability of rational decision to reduce the risk and severity of accidents and their consequences [1].

FMEA is a systematic method, which is applied because of the following reasons:

- 1) To identify and prioritize potential failure modes in a system, product, process, or service;
- 2) To define and run measures in order to eliminate or reduce the incidence of potential failure modes;
- 3) To record analysis results in order to provide a comprehensive reference for solving future issues and problems [2].

FMEA could be described as a structured method to find and identify failure modes in a system, object, or an activity and calculation of the failure effects on upper steps [3] [4].

In rolling mill operation a four roll high stand tandem mills including two work rolls and two back-up rolls are used to decrease force and power of work roll as well as increase the accuracy and thickness uniformity of thin sheets. Repeated loading under bending and compressive stresses, severe friction and wear under corrosive environments at elevated temperatures are some conditions that backup rolls should endure during mill campaign [5]. The main reason for premature failure of the forged back-up roll can be the combined effects of mechanical and metallurgical factors. Mechanical factors include rolling parameter misalignment, uneven roll surface, lubrication, bearing, rolling speed seizure, insufficient stock removal during grinding and the experience of operators [6,7]. Metallurgical factors comprise the presence of nonmetallic inclusions, localized overloading, casting defects, temperature gradients due to insufficient cooling and phase transformations. It was observed [7] that spalling, cracking, metal pick up and subsequently strip welding are three critical factors responsible for the poor service life of backup and work rolls during milling operation.

In this study failure modes of rollers in mill stand are identified and failure analysis is carried out using Failure mode effect analysis (FMEA)

II. METHODOLOGY

Introduction to Failure Mode Effect Analysis

The failure mode and effect analysis is used to identify and analyzed: (a) all failure mode of different parts of the system, (b) effects of these failure mode on the system and (c) how to circumvent the failure and/or moderate the effect of the failure system. FMEA is a step by step methodology for identifying all potential failures with in the process. "Effect Analysis" denotes to studying the consequences or impact of those failures [8]. The motivation for undertaking a Process FMEA is to continually develop products and process consistency thereby increasing customer satisfaction [9]. FMEA is a very efficient method which is needed to be engaged with in companies and manufacturing industries for an engineering design, production process and new product in production and planning sphere in product life cycle. Purpose of FMEA is founding links between causes and effects of failures, as well as searching, solving and drawing the best decisions regarding solicitation of applicable action.

RPN methodology

The RPN is a mathematical product of the severity, the occurrence and the detection. The number is used to identify the most critical failure mode, leading to corrective action [10]. RPN scoring is based on the fact that numbers with higher risk priority have priority for analyzing and resource allocation aimed at improvement, and the team should work on failure modes having a higher RPN. RPN is obtained by multiplying three factors of intensity, possibility of occurrence, and detection possibility [11]. It is calculated using below Equation

$$\text{RPN} = \text{Severity} \times \text{Occurrence} \times \text{Detection}$$

RPN to evaluate the risk level of a component or process. The RPN is obtained by finding the multiplication of three factors, which are the severity of the failure (S), the probability of occurrence (O) and the probability of detection (D). In this study, we used risk criterion number to determine the level of acceptable and unacceptable risk in RPN. Risk criterion is an index for separating acceptable and unacceptable risks in the system studied. A failure that its RPN number is greater than the risk criterion is considered as unacceptable risk and a failure that its RPN is lower than the risk criterion is called acceptable risk.

Determination of the severity rate

Severity is a rating corresponding to the seriousness of an effect of a potential failure mode. Severity or seriousness of the risk is considered just in case of "the effect"; reducing the risk severity is possible only through changing the process and the manner of performing activities.

Determination of the occurrence rate

Occurrence is ranked according to the failure probability, which represents the relative number of failures anticipated during the design life of the item. The effects of a failure mode are normally described by the effects on the user of the product or as they would be seen by the user.

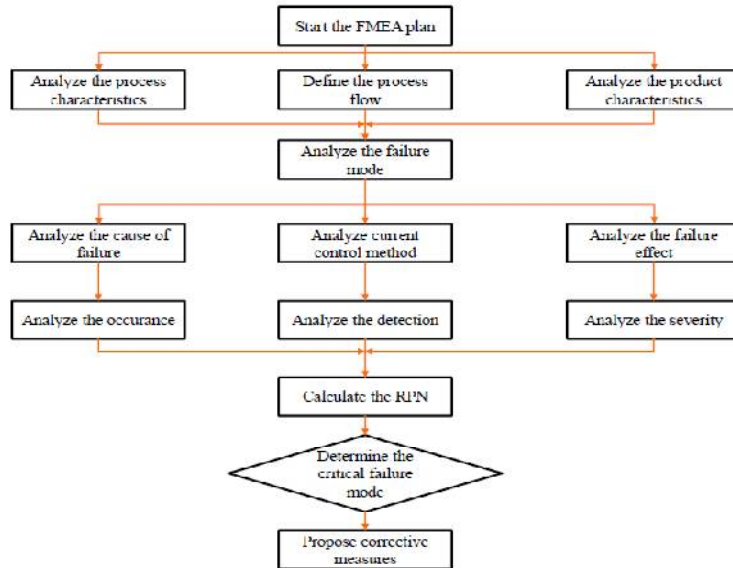


Fig.1: FMEA Flow chart

Risk detection probability rate

Detection possibility is an assessment of the ability existing to identify a cause/mechanism of a risk occurrence. In other words, detection possibility is a rating corresponding to the likelihood that the detection methods or current controls will detect the potential failure mode before the product is released for production for design, or for process before it leaves the production facility. Assessing control process of standards, requirements and laws of labor and how to apply them to achieve this number are very useful. In the RPN methodology the parameters used to determine the “criticality” of an item failure mode are, the severity of its failure effects, its frequency of occurrence, and the likelihood that subsequent testing of the design will detect that the potential failure mode actually occurs. **Tables 1-3** show the qualitative scales commonly used for the severity, the occurrence and the detect ability indexes [12].

Table 1: Table of severity

Code	Classification	Example
10	Hazardous without warning	Very High ranking affecting safe operation
9	Hazardous with warning	Regulatory non compliance
8	Very High	Product become inoperable with loss of function, Customer very much dissatisfied
7	High	Product remain operable but loss of performance, customer dissatisfied
6	Moderate	Product remain operable but loss of comfort/convenience
5	Low	Product remain operable but loss of convenience and customer slightly dissatisfied
4	Very low	Non-conformance noticed
3	Minor	Non conformance by certain Noticed
2	Very Minor	Non-conformance by certain item- Noticed
1	None	No effect

Table 2: Table of occurrence

Code	Classification	Example
10 and 9	Very High	Inevitable Failure
8 and 7	High	Repeated Failures
6 and 5	Moderate	Occasional Failures
4,3 and 2	Low	Few Failures
1	Remote	Failure Unlikely

Table 3: Table of detection

Detection	Rank	Criteria
Extremely Likely	1	Can be corrected prior to prototype/ Controls will almost certainly detect
Very High likelihood	2	Can be corrected prior to design release/very high probability of detection
High Likelihood	3	Likely to be corrected/high probability of detection
Moderately	4	Design controls are moderately effective
Medium likelihood	6	Design controls may miss the problem
Low Likelihood	7	Design controls are likely to miss the problem
Very low likelihood	8	Design chance of detection
Very low likelihood	9	Unproven, Unreliable design/poor chance of detection
Extremely unlikely	10	No design techniques available/control

III. RESULTS AND DISCUSSION

Failure Modes of Rollers:

The following are the different failure modes of Rollers are identified

Table 4. Severity, Occurrence and Detection Criteria Ranking and Risk Priority number [13]

S. No	Failure	Severity	Occurrence	Detection	RP N
1	Saddle spalls	10	5	8	400
2	Pressure Cracks	8	5	7	280
3	Bond related spalls	7	7	8	392
4	Insufficient shell depth	7	4	5	140
5	Barrel Edge Spalls	6	6	4	144
6	Band Firecracks	4	6	7	168
7	Ladder Firecracks	4	5	5	100
8	Localized Fire Cracks	5	3	6	90
9	Journal failure from shock over load	9	4	8	288
10	Journal failure from bending fracture	9	6	7	378

11	Journal failure from drive end torque	10	5	9	450
12	Journal failure from worn and seized bearings	7	5	4	140
13	Thermal breakage	10	4	5	200
14	Pinholes and Porosities	2	2	3	12
16	Inclusions	6	5	4	120
16	Hard and soft Spots	2	4	9	72
17	Peeling	2	8	4	64
18	Banding	3	7	5	105

IV. CASE STUDY AND FMEA ANALYSIS

A Bearing race is very critically fabricated using planned process sequences. The FMEA for the Inner race of the bearing is shown in the below Table 5

Table 5: FMEA analysis of bearing race[14]

Process Failure Mode and Effect Analysis										
Part/Product No					Key Contact Person : ****			Doc. No : X/FMEA/**		
Part/Product Description :					Key Contact No : *****			Rev. No :		
Customer Name(if Any) : ****					Case Team : *****			Revision Data		
Customer drawing No : ****										
Other Details (if Any)										
Opera-tion No	Process Description	Potential Failure Mode	Potential Effect of Failure	S E V	Potential Causes	O C C	Current Control Prevention	Current Control Detection	D E T	R P N
1	Internal Diameter Grinding(Inner Race)	Inner Diameter \pm then specification	Size Variation	8	Previous machine variation follow	5	Setup CNC programmed process, First piece Inspection	In process Inspection	4	160
					Poor Grinding Wheel Quality	4	Setup CNC programmed process, First piece Inspection	In process Inspection	4	128
					Outer Diameter size variation	3	Process Drawing work instruction, First piece Instruction	100% inspection	3	72
		Concentration variation	Ovality & Out of Roundness	7	Improper mounting and Clamping system	6	machine specification details	100% inspection	3	126
					Miss match of wheel and bearing race	3	Setup CNC programmed process, First piece Inspection	In process Inspection	2	42
					Wheel spindle not in centre	2	Setup CNC programmed process, First piece Inspection	In process Inspection	3	42

		Surface Roughness+ than Variation	Grinding Marks	6	Coolant Problem	5	Temperature Sensor	Temperature Sensor	5	150
					High Grinding wheel R.P.M.	7	Setup CNC programmed process, First piece Inspection	In process Inspection	3	108
		Surface Roughness↓ than Variation	Cracks on Rings	8	Excessive Feed Rate	3	Setup CNC programmed process, First piece Inspection	In process Inspection	3	72
					Improper dressing	5	Tool and work piece material Inspection	In process Inspection	3	96
2	Centre less Grinding	External diameter ± then specification	Squareness	5	Inner diameter having squareness	5	Process Drawing work instruction, First piece Instruction	100% inspection	2	50
		Ovality and Out of roundness	Wall thickness variation		Clamping system	7	machine specification details	In process Inspection	3	126
					Type of Cut	7	Machine maintenance instruction	In process Inspection	2	84
3	Deburring, cleaning, Inspection, Packing	Dust and rust inside	Fictional problem at customer end	6	Improper cleaning	2	Work Inspection	Pre dispatch Inspection	3	36

Since above table consist of number of causes of failure, among which it is needed to identify most critical cause for the failure of the process. For that purpose the graph of the main causes who are having highest Risk priority Number which is illustrated in below Fig. 2. Though this figure it is easy to concentrate on the main causes of the failure of the bearing manufacturing process

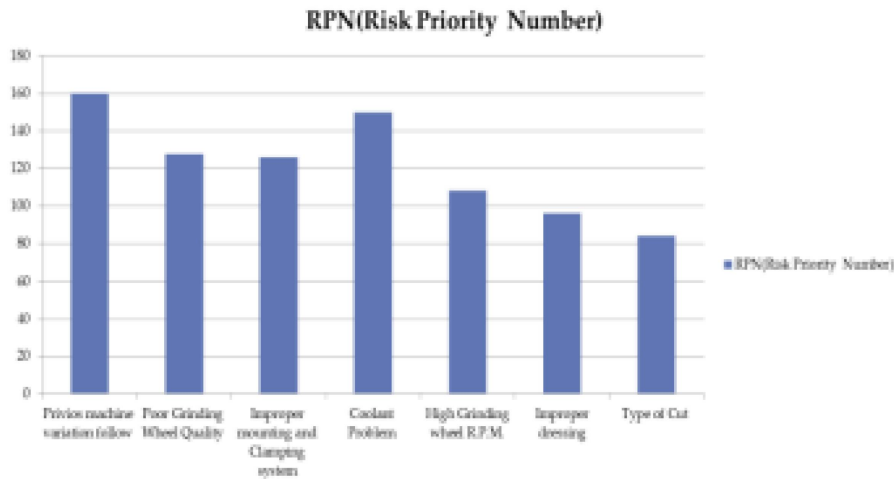


Fig 2: Cause having highest risk priority numbers

V. CONCLUSION

FMEA identified the potential failure modes, their causes, and the effects on the system for a given process. Based on RPN calculation spalling, journal failure from shock overloads, drive end torques had maximum risk when compared to other failure FMEA can identify morerisks and an important point is that choosing an appropriate method plays a crucial role in identifying more risks.FMEA is a methodology for documenting the various failure modes and its potential effect analysis for future use in same industry or it will become valuable for other industries of similar sectors it will reduce the set up time and improve the quality of product and ultimately customer satisfaction can be increased. FMEA are continuously concentrates on the improvement of the efficiency of manufacturing process and quality of the product by reducing the non-conformance rate of the production system.

REFERENCES

- Mirghiasi, Z. (2009) Hazard Identification and Risk Analysis. B.Sc. Graduation Thesis, Abadan Petrochemical Unit300, PUT.
- Wirth, R., Berthold, B., kramer, A. and Gerhard, P. (1996) Knowledge-Based Support of System Analysis for Analysis of Failure Modes and Effects. *Engineering Applied Artificial Intelligence*, **9**, 219-229.
- Rozenfeld, O., Sacks, R. and Rosenfeld, Y. (2009) CHASTE—Construction Hazard Analysis with Spatial and Temporal Exposure. *Construction Management & Economics*, **27**, 625-638.
- SAE (2002) Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects in Manufacturing and Assembly Processes (Process FMEA), and Potential Failure Mode and Effects Analysis for Machinery (Machinery FMEA)
- Hamid Reza, Ahmad MonshiMohdHasbullah Idris, "Premature failure analysis of forged cold back-up roll in a continuous tandem mill", *Materials and Design* 32 (2011) 4376-4384
- Wu Q, Sun DL. Analysis of surface and sub-surface initiated spalling of forged cold work rolls. *Eng Fail Anal* 2008;14:401-10
- Ray AK, Mishra KK, Das G, Chaudhary PN. Life of rolls in a cold rolling mill in a steel plant operation versus manufacture. *Eng Fail Anal* 2000;7:55-67
- Mhetre RS, Dhake RJ; Using failure mode effect analysis in precision sheet metal parts manufacturing company. *International Journal of Applied Sciences and Engineering Research*, 2012; 1(2): 302-311.
- Johnson KG, Khan MK; A study into the use of the process failure mode and effects analysis (PFMEA) in the automotive industry in the UK. *Journal of Materials Processing Technology*, 2003; 139(1-3): 348-356.
- Palady, P. (1995) *Failure Modes and Effects Analysis: Predicting & Preventing Problems before They Occur*. PT Publications Inc., Florida.
- Rakesh R, Jos BC, Mathew G; FMEA analysis for reducing breakdowns of a sub system in the life care product manufacturing industry. *International Journal of Engineering Science and Innovative Technology*, 2013; 2(2): 218-225.
- Narayanagounder, S. and Gurusami, K. (2009) A New Approach for Prioritization of Failure Modes in Design FMEA Using ANOVA. *World Academy of Science, Engineering and Technology*, **3**, 477-484.
- TadisettiPreamsa, Anga Kiran Vikram Varma,(2014) Failure Analysis of Rollers in mill stand using Failure mode Effect Analysis, *International Journal of Engineering Sciences & Research Technology*, 3(7), 151-159
- RiddhishThakore et al., (2015) A Case Study: A Process FMEA Tool to Enhance Quality and Efficiency of Bearing Manufacturing Industry, *Scholars Journal of Engineering and Technology*, 3(4B):413-418