Research Article

A Case Study: A Process FMEA Tool to Enhance Quality and Efficiency of Bearing Manufacturing Industry

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Abstract: This Paper is an attempted to represent the potential tool for evaluates the problem of manufacturing process by implementing the process FMEA. This study has a goal to concentrate and eliminate the potential problem for manufacturing process of bearing in company through executing the Failure Mode and Effect Analysis. Various possible causes of failure and their effect of sub system has been evaluated for improving the reliability of the product as well as bottom line of the manufacturing can be improved. Process FMEA having some parameters needed to define which are Severity values, occurrence number, Detection and Risk priority Number (RPN). On the basis of the parameters some of the suggestions are proposed for avoiding the possible risk and ultimately decrease the loss to the industries in terms of money, time and quality.
Keywords: Bearing race, Failure mode effect analysis (FMEA), Potential effect of failure, Potential failure mode, Risk priority number.

INTRODUCTION

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 [12]. The motivation for undertaking a Process FMEA is to continually develop products and process consistency thereby increasing customer satisfaction [8].

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.

LITERATURE REVIEW

Aerospace industries are critical to the safety and accidents must be prevented, FMEA provides the precautionary methodology to the Aerospace industries

in 1950s [10]. Then Ford motors are experiencing the potential problem in research and development (R & D) so in order to overcome this problem they have published the handbook on FMEA in 1984. As a result of it automobile manufacturers in America also introduced the FMEA into management of suppliers and it is become part of checking system [13]. After that FMEA have linked or joint with number of standard system like along with ISO 22000, and valuable results can be obtained in processing and packaging industries [7]. The FMEA have a sufficient potential to reduce the cost and improve the reliability of the wind turbine system [3]. Failure mode and effect analysis can be modify to get the effective supplier in the terms of Supply chain risk hierarchy process [11]. Time and money can be optimized by implementing the FMEA in the fly wheel and flywheel housing manufacturing [4]. Decision making can be done with the ease because of the prioritized cause and its potential. New products in the automotive industries are invented using the FMEA [2]. In the design stage, FMEA provides the one failure reporting, analyses the failure effect and it corrective action in each of the test, production and operation [1]. Thus the failure mode and effect analysis is become a critical part of the process or product improvement thus it is extensively used in number of quality improvement approach.

Concept of FMEA

Failure mode and effect analysis is an analytical technique (a paper test) that combines technology and experience of people in identifying probable failure mode of product or process and planning for its abolition. FMEA is a "before-the-event" action requiring a team effort to easily and inexpensively alleviate changes in design and production.

FMEA can be explained as a group of events projected to
- Recognize and evaluate the potential failure of a product or process and its effects.
- Identify actions that could eliminate or reduce the chance of potential failures.
- Document the process.

FMEA can be used as an individual project tool. However, it is strongly recommended that use to generate corrective action in a process improvement project. An FMEA is not a trivial tool rather it requires significant effort from a diverse team.

FMEA method use at [9]:
- Formation of the product concept, for checking whether all prospects of the customer are included in this concept.
- Define the product, in order to check whether projects, service, supplies are appropriate and controlled in the right time.
- Process of production, in order to check whether documentation primed by engineers is fully carried out.

- Assembly, for checking whether the process of the assembly is compatible with documentation.

- Organization of the service, in order to check whether the product or the service is pleasant with recognized criteria.

DOCUMENTATION PROCEDURE FOR FMEA
Item and its Functions
Specify all the functions of an item, including the environment in which it has to operate.

Potential Failure Mode
- Considering past failures, present reports, brainstorming.
- Describe in technical terms and not as customers will see.
- For e.g. cracked, deformed, loosened, short circuited, fractured, leaking, sticking, oxidized etc.

Potential Effects of Failure
- As perceived by the customer (internal/end user).
- For e.g. erratic operation, poor appearance, noise, impaired functions, deterioration etc.

Severity
Severity is the assessment of the seriousness of the effect of the potential failure mode. In this we have to determine all failure modes based on the functional requirements and their effects. An example table of severity is given below.

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 bycertain item- Noticed
1	None	No effect

Class
Classification of any special product characteristics requiring additional process control

Potential cause /Mechanism of failure
Every cause/mechanism must be listed concisely
- E.g. of Failure Causes are inadequate design, incorrect material, inaccurate life assumption,

poor environmental protection, over stressing, insufficient lubrication etc.
- E.g. of Failure Mechanisms are fatigue, wear, corrosion, yield, creep etc.

Occurrence
Occurrence is the chance that one of the specific cause/mechanism will occur. In this step, it is necessary

to look at the cause of a failure and how many times it occurs. Looking at similar products or processes and the failures that have been documented for them can do

this. A failure cause is looked upon as a design weakness. An example for occurrence rating is given in following table.

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

Current Design Control

The control activities generally include Prevention Measures, Design Validation, and Design Verification Supported by physical tests, mathematical modeling, prototype testing, and feasibility reviews etc.

Detection

- Relative measures of the ability of design control to detect wither a potential cause/mechanism or the subsequent failure mode before production.
- Supported by physical tests, mathematical modeling, prototype testing, feasibility reviews etc.

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

Risk Priority Numbers (RPN)

RPN is the indicator for the determining proper corrective action on the failure modes. It is calculated by multiplying the severity, occurrence and detection ranking levels resulting in a scale from 1 to 1000.After deciding the severity, occurrence and detection numbers, the RPN can be easily calculated by multiplying these 3 numbers: *RPN = Severity × Occurrence ×Detection.* The small RPN is always better than the high RPN. The RPN can be computed for the entire process and/or for the design process only. Once it is calculated, it is easy to determine the areas of greatest concern. The engineering team generates the RPN and focused to the solution of failure modes.

Recommended Actions

Beginning with high RPN and working in descending order
- The objective is to reduce one or more of the criteria that make up the RPN.
- Typical actions are design of experiments, revised test plans, revised material specifications, revised design etc.
- Important to mark "None" in case of no recommendation for future use of FMEA document.

Responsibilities and Completion Dates

Individual or group responsible for the recommended actions and target completion date to be entered

Actions taken

Brief descriptions of the action taken to be entered after actual actions are taken by the team.

Revised RPN

Recalculation of Severity, Occurrence and Detection rankings after implementation of recommended actions and thus calculation of revised RPN.

Revised RPN=revised (*Severity× Occurrence × Detection*)

FMEA Procedure [6]

The process for conducting FMEA can be divided into following steps. These steps are briefly explained as follows.

- Step 1: Collect the functions of system and build a hierarchical structure. Divide the system into several subsystems, having number of

components.
- Step 2: Determine the failure modes of each component and its effects. Assign the severity rating (S)of each failure mode according to the respective effects on the system.
- Step 3: Determine the causes of failure modes and estimate the likelihood of each failure occurring. Assign the occurrence rating (O) of each failure mode according to its likelihood of occurrence.
- Step 4: List the approaches to detect the failures and evaluate the ability of system to detect the failures prior to the failures occurring. Assign

the detection rating (D) of each failure mode.
- Step 5: Calculate the risk priority number (RPN) and establish the priorities for attention.
- Step 6: Take recommended actions to enrich the performance of system.
- Step 7: Conduct FMEA report in a tabular form.

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 4.

Table 4: FMEA analysis of bearing race

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	SEV	Potential Causes	OCC	Current Control Prevention	Current Control Detection	DET	RPN
1	Internal Diameter Grinding(Inner Race)	Inner Diameter ± then specificat ion	Size Variation	8	Previous machine variation follow	5	Setup CNC programm ed process, First piece Inspection	In process Inspection	4	160
					Poor Grinding Wheel Quality	4	Setup CNC programm ed 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
		Concentr ation variation	Ovality & Out of Roundne ss	7	Improper mounting and Clamping system	6	machine specificati on details	100% inspection	3	126
					Miss match of wheel and bearing race	3	Setup CNC programm ed process, First piece Inspection	In process Inspection	2	42
					Wheel spindle not in centre	2	Setup CNC programm ed 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
					Improper Heat treatment	1	Material hardness testing	In process Inspection	7	56
2	Centre less Grinding	External diameter ± then specification	Square ness	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	6	Clamping system	7	machine specification details	In process Inspection	3	126
					Type of Cut	7	Machine maintenance instruction	In process Inspection	2	84
3	Deburing, 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 author have made the graph of the main causes who are having highest Risk priority Number which is illustrated in below Fig. 1. Though this figure it is easy to concentrate on the main causes of the failure of the bearing manufacturing process
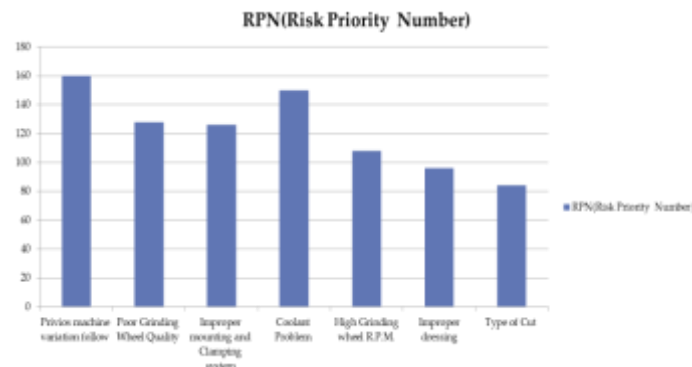

Fig. 1: Cause having highest risk priority numbers

CONCLUSION

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 comprises the systematic approach to failure detection, occurrence and its possible impact on the process. By following standard steps, 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.

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