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# The Process FMEA Tool for Boring Operation of Crankshaft to Enhance Quality and Efficiency

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***Abstract*—The FMEA is a operative tool to detect and fully recognize potential failure modes and their causes, and the effects of failure on the system or end users, for a given product or process. It is an engineering analysis that systematically analyzes product designs or manufacturing processes , finds and corrects flaws before the product gets into the hands of the customer. This paper goals to identify and eliminate presentand potential problems from a manufacturing process ofcrankshaft in the company through the application ofFailure Mode and Effects Analysis (FMEA) for improving theconsistency of sub systems in order to ensure the quality whichin turn augments the foot line of a manufacturing industry.Thus the various possible causes of failure and their effectsalong with the prevention are deliberated in this work. Severitynumber, Occurrence number, Detection number and Risk PriorityNumber (RPN) are strictures, which need to bedetermined. Furthermore, some actions are anticipated whichrequire to be taken as quickly as possible to evade potentialrisks which aid to improve efficiency and effectiveness of crankshaft manufacturing processes and increase thecustomer satisfaction. The prevention endorsed in this papercan significantly decrease the loss to the industry in stretch ofboth money time and quality.**

## I.INTRODUCTION-

An FMEA should be the guide to the development of a complete set of actions that will decrease risk allied with the system, subsystem, and the component or manufacturing process to an satisfactory level. FMEA ultimately deals with identifying the failure modes and analyses of their effects on component.FMEA is sketchily classified into three major types, viz. System FMEA, Design FMEA, and Process FMEA. For System FMEA, the foremost objective is to improve the design of the system. While for Design FMEA, the impartial is to improve the design of the subsystem. Additionally, to improve the design of the manufacturing process, Process FMEA is used.

## II. CONCEPT OF FMEA-

Failure Mode and Effects Analysis is a tool designed to recognize potential failure modes for a product or process, to assess the risk associated with those failure modes, to rank the issues in terms of significance and to identify and carry out corrective actions contrary to most serious concerns.

In general, FMEA consists of the following points to be analysed –

1. Item- An item is the emphasis of the FMEA project. For a System FMEA this is the system itself. For a Design FMEA, this is the subsystem or component under analysis.For a Process FMEA, this is usually one of the specific steps of the manufacturing or assembly process under analysis, as signified by an operation description.

2. Function - A function is what the item or process is intended to do, usually to a given standard of performance or necessity.

3. Failure mode - A failure mode is the method in which the item or operation potentially fails to meet or deliver the anticipated function and associated requirements.

4. Effects – An effect is the consequence of the failure on the system or end user.

5. Cause - A cause is the specific reason for the failure, preferably found by asking “why” until the root cause is determined. For Process FMEAs, the cause is the manufacturing or assembly deficit that results in the failure mode.

6. Severity- It is a ranking number linked with the most serious effect for a given failure mode.

Table 1. Table for 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 becomes 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 – Customer Discomfort |
| 5 | Low | Product remain operable but loss of comfort/convenience - Customer Slightly Dissatisfied |

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| | | |
|---|---|---|
| 4 | Very Low | Nonconformance by certain items – Noticed by most customers |
| 3 | Minor | Nonconformance by certain items – Noticed by average customers |
| 2 | Very Minor | Nonconformance by certain items – Noticed by selective customers |
| 1 | None | No Effect |

7. Occurrence- It is a ranking number associated with the likelihood that the failure mode and its supplementary cause will be present in the item being analyzed.

Table 2: Table for 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 |

8. Detection - It is a ranking number connected with the best control from the list of detection-type controls, based on the criteria from the detection scale.

Table 3. Table for Detection

| Code | Detection | Criteria |
|---|---|---|
| 1 | Extremely Likely | Can be corrected prior to prototype/ Controls will almost certainly detect |
| 2 | Very High Likelihood | Can be corrected prior to design release/Very High probability of detection |
| 3 | High Likelihood | Likely to be corrected/High probability of detection |
| 4 | Moderately High Likelihood | Design controls are moderately effective |
| 5 | Medium Likelihood | Design controls have an even chance of working. |
| 6 | Moderately Low Likelihood | Design controls may miss the problem. |
| 7 | Low likelihood | Design controls are likely to miss the problem |
| 8 | Very low Likelihood | Design controls have a poor chance of detection |
| 9 | Very low likelihood | Unproven, unreliable design/poor chance for detection |
| 10 | Extremely Unlikely | No design technique available/Controls will not detect |

9. Risk Priority Number (RPN) - It is a numerical grade of the risk of each potential failure cause, made up of the arithmetic product of the three elements: Severity, Occurrence and Detection.
i.e. R.P.N. = S*O*D.

10. Controls- They are the methods or actions currently planned, or are already in place, to reduce or eliminate the risk accompanying with each potential cause.

11. Recommended actions- They are the tasks proposed by the FMEA team to diminish or eliminate the risk associated with potential causes of failure.

12. Action Taken- It is the precise action that is implemented to reduce risk to an acceptable level.

13. Revised RPN – It is Recalculation of Severity, Occurrence and Detection rankings after execution of recommended actions and thus calculation of revised RPN.

Revised RPN= revised (Severity× occurrence × Detection).

## III. BASIC PROCEDURE FOR FMEA

- Assemble the team.
- Launch the ground rules.
- Gather and review significant information.
- Recognise the item(s) or process(es) to be analyzed.
- Identify the function(s), failure(s), effect(s), cause(s) and control(s) for each item or process to be analyzed.
- Evaluate the risk associated with the issues recognised by the analysis.
- Prioritize and assign corrective actions.
- Perform corrective actions and re-evaluate risk.
- Allocate, review and apprise the analysis, as suitable.

## IV. CASE STUDY AND FMEA ANALYSIS

A crankshaft is main assembly part of the engine. It is found below the cylinder head. The crankshaft is an integral component of combustion engines. Piston are mounted on the crankshaft and it is responsible for motion of piston from T.D.C. to B.D.C.

Manufacturing of crankshaft consists of number of processes. Starting from selection of material, Forging, Rough machining to Finish machining crankshaft travels through different machine to carry out specific operation.

FMEA technique is applied to boring operation of crankshaft. Potential failure modes, potential causes , severity, occurrence, detection, recommended actions, etc are recorded based on the observations taken at factory floor. RPN is then calculated to analyze the risk. Recommended actions are prescribed based on the observations. Revised RPN number is calculated after recommended actions are partically implented on the shop floor.

Table 4. Table for Fmea

| **Subsystem** | **Potential Failure Mode** | **Potential Effects of Failure** | **sev** | **Potential Causes of Failure** | **occ** | **Current controls** | | **Det** | **R.P.N** | **Recommended Actions** | **Responsibility &Target completion date** | **Action Results** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Prevention** | **Detection** | | | | | **Actions Taken** | **Sev** | **Occ** | **Det** | **RPN** |
| **Diameter** (43.05 +/- 0.13) | Oversize | Loose Fitment | 6 | 1.Improper mounting 2. Excess run out 3. Improper input stock 4. Material Properties | 5 | 1. Proper mounting of workpiece. 2. Improper Steady setting. 3. Deskilled Labour. 4. Improper maintenance of MQC Sheet. | 1. By Visual inspection. 2. By visual inspection. 3. By use of Gauge. 4. from MQC sheet | 8 | 240 | 1. Use of Position sensor on HMC. 2. Proper Steady setting. 3. use of Skilled Labour. 4. Regular check for Material properties. | | 1. Mounting of Position Sensor. 2. Proper Fixture used. 3. Process Automated. 4. Checking of parts at fixed interval. | 6 | 2 | 4 | 48 |
| | Under size | No Assembly | 3 | 1.Wornout Tool insert. 2. Improper Steady. 3. Hardened workpiece Material. | 5 | 1.Replacement of tool insert. 2. Proper oiling of steady. 3. Improper Material properties from MQC sheet. | 1. By Visual Inspection. 2. By Visual Inspection. 3. From MQC Sheet. | 7 | 105 | 1.Maintaining preffered input stock. 2. use of fixture. 3. Regular Checkup of material prioperties from sample. | | 1.Optimum input stock set. 2. Proper fixyure used. 3. 5 in 1 checkup of parts for material properties. | 3 | 2 | 3 | 18 |
| **Depth** (34.40 +/- 0.25) | Oversize | No assembly | 5 | 1.Semiskilled labour. 2. Improper tool. 3. Improper Mounting. | 4 | 1.Appointing Skilled labour. 2. Periodic Tool replacement 3. Proper Mounting of Workpiece. | 1. By visual Detection. 2. Improper surface finish. 3. by Visual inspection. | 7 | 140 | 1.Use of Automation. 2. Use of Hard material for tool. 3. Use of Position sensors. | | 1.Process automated on HMC. 2. Altering the material of tool. 3. Position sensors used for proper allignment. | 5 | 2 | 4 | 40 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Under size | No Assembly | 5 | 1.Improper tool insert. 2. Improper input stock. 3. Faulty measuring instrument. | 4 | 1.Replacement of tool insert. 2. Proper input stock setup. 3. Use of accurate measuring instrument. | 1. Visual Detection. 2. Stock setup given. 3. Using Gauges. | 6 | 120 | 1.Use of sensor for detection of improper tool insert. 2. Proper programming for cnc. 3. Use of Digital measuring instrument. | | 1.Position sensor used. 2. Validation of porgram prior to operation. 3. Use of digital measuring instrument. | 5 | 1 | 4 | 20 |
| **Runout with respect to Centering** (0.025) | Excess runout | Out of Rotation | 8 | 1.Improper Holding of workpiece in Chuck. 2.Improper tool change frequency. 3. Excess Stock. 4. Faulty Measuring Gauge. 5. Improper Pressure and Setting of Steady. 6. Deskilled labour. | 5 | 1.Check rotation of workpiece with respect to center. 2. Tool change at regular interval. 3. Check for Excess stock. 4. Proper maintanence of measuring gauge. 5. Ensure oiling of steady at regular interval. 6. Appoint skilled Labour. | 1.Free Run of workpiece and by visual detection. 2. By visual detection. 3. Excess Heating of workpiece. 4.Using Presized Measuring unit. 5. Excess Heat Generation. 6. Visual inspection. | 6 | 240 | 1.Proper Fixture designing. 2. Automatic tool changer from Pallet. 3. Fixed Stock setup using automation. 4. Use of Presized measuring system. 5. Process automation. 6. Process automation. | | 1.Accurate Fixture Designed. 2. Used Automatic tool changer and ensured change of tool after specific lot. 3. Fixed stock setup by use of programming. 4. Used presized measuring system. 5. Process Automated. 6. Process Automated. | 8 | 2 | 3 | 48 |
| **Surface Finish** | Rough Surface Finish | Bearing wearout | 7 | 1.Tool wearout. 2. Excess feedrate. 3. High speed. | 5 | 1.Tool replacement. 2. Maintain optimum feed rate. 3. Maintain Optimum speed. 4. Depth | 1.Checking of tool insert. 2. Excess heating of workpiece. 3. Visual | 6 | 210 | 1.Tool change after regular interval. 2. Process automation and proper programming. | | 1.Tool change after regular interval from ATC. 2. Proper programming. 3. | 7 | 2 | 2 | 28 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 4. Excess depth of cut. (50 micron) | | cut below 50 micron is preffered. | detection. 4. Visual detection. | | | 3. Process automation. 4. Proper programming. | | Optimum speed maintained and process automised. 4. Process automised. | | | | |
| | High Surface Finish | Bearing Failure | 5 | 1.Deskilled labour. 2. Damaged tool Insert. 3. Depth of cut of 0.1mm. 4. High speed of rotation. | 4 | 1.Appointment of skilled labour. 2. tool replacement. 3. Proper Adjustment. 4.Maintaining Optimum speed. | 1. Visual detection. 2. Visual Detection and excess feed. 3. Excess heating pf workpiece. 4. Visual detection. | 5 | 100 | 1.Process Automation. 2. Tool change after regular lot. 3. Proper Prgramming and process automation. 4. Proper programming and process automation. | | 1.Process automised. 2. Tool chnaged after specific lot of machining. 3. Process automised. 4. Process automised. | 5 | 1 | 3 | 15 |

## V. CONCLUSION

FMEA for Boring operation as been validated. FMEA is continuous improvement tool used in manufacturing unit. Continuous record of failures and actions taken should be noted duly and reqired changes can be made in the FMEA report. FMEA saves both, time and money of company. FMEA report has to be followed by the employer on the shop floor. It helps to eliminate the problem in less period of times hence saving time. Failure Mode,Effects and Criticality Analysis (FMECA), advancement in FMEA can been used for criticality analysis.

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