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Failure Mode Effective Analysis in Core Making Process

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Abstract: *Failure Mode And Effect Analysis (FMEA) is a technique to identify and prioritize potential failuresof a process. This paper reports the description of FMEA methodology in a foundry. It isused as a tool to assure products quality & as a mean to improve operational performance of the process.Theproblem identified in the various steps of core making process leads to high rejection are studied and analyzes by FMEA.*
Keyword: *Failure mode and effect analysis, Risk priority number, Potential effect of failure, Failure analysis.*

I. Introduction

This paper aims to use the well-defined tool FMEA (failure mode and effect analysis) to find out the problems in core various steps of core making process and to analyse them in order to identify which of these are more critical when compared to one another. This helps designer to find identify the problems in advance and take necessary action before the failure of the component.

It starts with a process flow chart thatshows each of the manufacturing steps of a product. The potential failure modes and potential causes for each ofthe process steps are identified, followed by the effects of failures on the product and product end users. Therisks of these effects are then assessed accordingly.[1]

II. Methodology

FMEA

A failure modes and effects analysis (FMEA) is a process by which the identification and the evaluation of process is done for classification by activity which helps to identify potential failures and then prioritizing with the minimum of effort and costs. Failure modes are faults that affect the intended function or actual. An effect analysis refers to principle of FMEA is to resolve increasing customer satisfaction.

FMEA was first. Later, various groups and departments of NASA used FMEA principles under variety of names in mid 1950s and 1960s. Ford Motor Company published instruction manuals for FMEA in the 1980s and the automotive industry collectively developed standards in the 1990s. Engineers in a variety of industries have adopted and adapted the tool over the years.

III. Failure Analysis Techniques

Various techniques are used to identify the mode of failure of a part or component. Following are some of the major techniques

Field inspection

The most useful and primary approach is to inspect the failure on site as soon as the failure has occurred. This visit should be documented in detail with photographs and should also contain insights from the various personnel involved in operation and maintenance of the component. If possible the failed component should be brought back to laboratory for more detailed study,

Macroscopic examination

This type of examination is done at a magnified scale of 1x to 100x range. The main purpose of this is to observe the gross features of the fracture and presence or absence of cracks, defects, corrosion or oxidation. Working at such magnification it should be possible to make an initial assessment of the origin of fracture and other defects and thus narrow down the region of the fracture for further study at higher magnification.

Microscopic Examination

This type of examination is made at a magnification greater than 100x for microstructure analysis. To achieve such magnification we need instruments like Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), X-ray microprobe analyzer and so on. Microstructure analysis is essential because it helps to identify important features like grain size, inclusion size, crack growth, arrangement of phases and so on and give a better understanding of the microstructure and the cause of failure.

Timing of an FMEA program

One of the most important elements for the successful implementation of an FMEA technique is its timeliness. It is meant to be a "before-the-event" action and not an "after-the-fact" exercise. Actions resulting from an FMEA can reduce or eliminate the chance of implementing a change that would create an even larger concern. Ideally, FMEA's are conducted in the product design or process development stages, although conducting an FMEA on existing products or processes may also yield benefits.

Why do FMEA's?

FMEA has been an indispensable tool for industries such as aerospace, automobile industries and Government agencies (Army, Navy, Air Force, etc) because of the following reason

- Improves design by discovering unanticipated failures
- Highlights the impact of the failures
- Provides a method to characterize product safety
- It records and documents the logic of the engineers and related design and process considerations
- It is an indispensable resource for new engineers and future design and process decisions.

Steps to conduct a FMEA

[1] Review the design or process

The reviewing of the design or process is to identify all of the components of the system at given level of the design or process hierarchy and determine the function or functions of each of those components. Many components have more than one function.

[2] Brainstorm potential failure modes

Identify failure modes for each component/system. Typically there will be several ways in which a component can fail. Potential Failure Mode comes from things that have gone wrong in the past, concerns of designers, and brainstorming. A potential failure mode represents any manner in which the component or process step could fail to perform its intended function or functions. Brainstorm the potential failure modes for each function for each of the components identified.

[3] List potential failure effects

Determine the effects (both locally and globally) associated with each failure mode on the system. The effect is related directly to the ability of that specific component to perform its intended function. An effect is the impact a failure could make if it occurred.

[4] Assign Severity ratings

Assign a severity ranking to each effect that has been identified. The severity ranking is an estimate of how serious an effect would be should it occur. To determine the severity, consider the impact the effect would have on the customer, on downstream operations, or on the employees operating the process. The severity ranking is based on a relative scale ranging from 1 to 10.

Rank	Effect	Rank	Effect
1	None	6	Severe
2	Very Slight	7	High Severity
3	Slight	8	Very High Severity
4	Minor	9	Extreme Severity
5	Moderate	10	Maximum Severity

[5] Assign Occurrence ratings

Determine the failure's probability of occurrence. Assign an occurrence ranking to each of those causes or failure mechanisms. The occurrence ranking is based on the likelihood or frequency, that the cause (or mechanism of failure) will occur. The occurrence ranking scale, like the severity ranking, is on a relative scale from 1 to 10 as shown in Table.

Rank		**Occurrence**	**Rank**	**Occurrence**
1		Extremely Unlikely	6	Medium likelihood
2		Remote Likelihood	7	Moderately high likelihood
3		Very Low Likelihood	8	Very High Likelihood
4		Low Likelihood	9	Extreme Likelihood
5		Moderately Low Likelihood	10	Maximum Likelihood

[6] Assign detection rating

To assign detection rankings, identify the process or products related controls in place for each failure mode and then assign a detection ranking to each control. Detection rankings evaluate the current process controls in place. The Detection ranking scale, like the Severity and Occurrence scales, is on a relative scale from 1 to 10.

Table 3. Likely detection of failures and corresponding ranking

Rank	**Occurrence**	**Rank**	**Occurrence**
1	Extremely Likely	6	Moderately Low Likelihood
2	Very High Likelihood	7	Low Likelihood
3	High Likelihood	8	Very Low Likelihood
4	Moderately High Likelihood	9	Remote Likelihood
5	Medium likelihood	10	Extremely Unlikely

[7] Calculate RPN

The RPN is the Risk Priority Number. The RPN gives us a relative risk ranking. The RPN is calculated by multiplying the three rankings together. Multiply the Severity ranking times the Occurrence ranking times the Detection ranking. For example,

Risk Priority Number (RPN) = (Severity) X (Occurrence) X (Detection)

Calculate the RPN for each failure mode and the corresponding effect. RPN will always be between 1 and 1000. The higher the RPN, the higher will be the relative risk. The RPN gives us an excellent way to prioritize focused improvement efforts.

[8] Develop an action plan to address high RPN's

Develop an action plan by which reduction in the RPN. The RPN can be reduced by lowering any of the three rankings (severity, occurrence, or detection) individually or in combination with one another

[9] Take action

The action plan outlines what steps are needed to implement the solution, who will do them, and when they will be completed. Responsibilities and target completion dates for specific actions to be taken are identified. All recommended actions must have a person assigned responsibility for completion of the action. There must be a completion date accompanying each recommended action. Unless the failure mode has been eliminated, severity should not change. Occurrence may or may not be lowered based upon the results of actions. Detection may or may not be lowered based upon the results of actions. If severity, occurrence or detection ratings are not improved, additional recommended actions must to be defined.

[10] Re-evaluate the RPN after the actions are completed

This step is to confirm the action plan had the desired results by calculating the resulting RPN. To recalculate the RPN, reassess the severity, occurrence, and detection rankings for the failure modes after the action plan has been completed.

IV. Case study and FMEA analysis

Sl no	Problem discription	Potential failure causes	S	O	D	RPN	Recommended Action
1	Less scratch hardness	i)Less addition of resin	8	8	3	192	i) Provide auto dosing system using PLC unit for addition of sand, resin and activator. ii) Calibrate Auto Dosing System once in every shift, as per guidelines provided. iii) Train operator for auto dosing system. iv) Ensure preventive maintenance of pumps at everyweekend. v) Prepare work instruction sheet for mixing operator.
		ii) Expire Bench Life of sand mix.	8	6	3	144	i) Consume the sand mix within one hour. If machine isstopped for more than one hour transfer the sand mix to othermachine. ii) Prepare work instruction sheet for core making machineoperator & display it on each machine.
2	Damaged / cracked cores	i)Sliding plate movement	7	6	3	126	i) Provide clamps for clamping the plate before strapping the core.
		ii) Loose piece jam	6	5	3	90	i) Clean the core box by compressed air after every core iswithdrawn from core box to prevent sand trapping and jamming of loose piece. ii) Update work instruction sheet prepared for core making operator
		iii) Parallelity of core box plate	6	5	3	90	i) Ensure parallelity of core box with core box plate when corebox is mounted on the plate. ii) Prepare work instruction sheet for core box maintenancegroup which is loading & unloading the core box from coremaking machine.

3	Resin balls in mixed sand	i)Scrapper gap increased	7	6	4	168	i) Ensure 1.5 mm gap between scrapper & bottom of mixer bytemplate at the start of every shift. ii) Provide a slot on the scrapper to lower the scrapper byloosening the bolts to maintain the gap. iii) Update the work instruction sheet &display it at mixer in mixing section for mixing operator. iv) Ensure the gap & condition of scrapper at every weekendby maintenance dept.
4	Uncured cores	i) core box vents chocked	6	6	3	108	i) Clean the core box vents by compressed air at the start ofevery shift. ii) clean / replace the vents after the core box is unloaded from machine by core box maintenance group
		ii) low air gassing pressure	6	5	3	90	i) Prepare machine operating parameter chart & display it on the core making machine. ii) Ensure the air pressure on the gauge with the pressurespecified in the machine operating parameter chart. iii) Ensure the interlocking of the air pressure switch with the core making machine. iv) Remove the sand particles trapped which hampersinterlocking of pressure switch with machine.
		iii) sealing cord of gassing head damaged	6	4	3	72	i) Replace the cord after every four months. ii) Ensure the cord for damage at every weekend bymaintenance dept. iii) Update work instruction sheet for maintenance group.

S –severity**, O-**occurrence **, D-**detection

V. Results and Discussion

The results of FMEA study

Type	Failure cause	RPN value
Less scratch hardness	Less addition of resin.	192
Damaged / cracked cores	Sliding plate movement.	126
Resin balls in mixed sand	R / B in sand mix.	168
Uncured cores	Core box vents chocked.	108

The table reveals that the “low scratch hardness” of the cores due to less addition of resin /activator in the mixing step is havethe greatest RPN in production process.

VI. Conclusion

FMEA documents potential failure modes and potential effects for future use in the industry. It has a systematic approach in failure, detection and possible impact on the process. The methodology operated allowed to study and analyze every single step of core making process and toachieve an exhaustive knowledge and improvement of product and process. FMEA aids to improve and plan preventive and schedule maintenance of the process equipments. Thus
improves operational performance of the core making process.

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