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OPTIMIZATION OF CASTING DEFECTS ANALYSIS WITH SUPPLY CHAIN IN CAST IRON FOUNDRY PROCESS

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Some of the foundries are in need of meeting production targets and due to the urgency they ignore the rejections. The objective of this paper is to analyze the various defects, [1] from molding process in a cast iron foundry. The Failure Mode Effects Analysis (FMEA) in quality control [2-6] with suitable supply chain for mold making process considering rejection rates are identified and analyzed in terms of Risk Priority Number (RPN) to prioritize the attention for each of the problem. The optimum levels of selected parameters [7] are obtained in this analysis.

Key words: FMEA, foundry, cast iron, quality, defects

INTRODUCTION

The FMEA technique [8-9] is used to identify and prioritize the potential failures of manufacturing process. The process starts with a flow chart which shows each of the manufacturing steps of a product. The potential failure modes and causes for each of the process are identified, followed by the effects of failures on the product and product end users. The risks of these effects are then assessed accordingly.

MATERIAL AND METHODS

The FMEA technique consists of three major steps as outlined in Table 1.

Terminology in FMEA

- ***Failure Mode*****:** Physical description of a failure - is the manner in which the process fails to perform its intended function.
- ***Failure Effect*****:** It is an impact of failure on process and equipment; it is an adverse consequence that the customer / user might experience.
- ***Failure Cause*****:** It refers to the cause of failure.

Table 1 **Major Steps of FMEA Task**

FMEA	Results
Identify Failures(failure description)	Causes of failure ---Mode of Failure ---Effects of failure
Prioritize Failures(Asses RPN)	Occurrence x Severity x Detection
Reduce Risk through	reliability, test plans, manufacturing changes, inspection, etc.

FMEA VARIABLES:

- ***Severity of effect (S)*****:** Severity measures the seriousness of the effects of a failure mode. Severity categories are estimated using 1 to 10 scale.
- ***Probability of occurrence (O)*****:** Occurrence is related to the probability of the failure mode and cause.
- ***Detection (D)*****:** The assessment of the ability of the "Design Controls" is to identify a potential cause. Detection scores are generated on the basis of likelihood of detection by the relevant company design review, testing programs, or quality control measures.
- ***Risk Priority Number (RPN)*****:** The Risk Priority Number is the product of the Severity (S), Occurrence (O), and Detection (D) ranking. The RPN is a measure of design risk and will compute between "1" and "1000."

EXPERIMENTAL SETUP

Experiments were carried out by a FMEA team in Ammarun Foundry, Coimbatore (AF) for mold making process [9] and the details of rejections collected for three months are as per Table 2.

The Figure 1 clearly indicates the percentage of rejection and the severity of the defects to be controlled.

The causes for the defects are studied [10-13] with various foundry environmental conditions involving men, material, machines, and movement. The casting defects are analyzed involving selected parameters and their levels.

As per rejection analysis it was found that the component AF 5008 Pressure Plate rejection was maximum due to cold metal, blow hole and sand inclusion and this component is selected for analysis by FMEA and DOE method [14].

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The FMEA team has carefully studied and suggested remedial measures. After implementing the remedial measures, they found that there is an improvement in RPN as per Table 3 which indicates that the rejection of castings reduced considerably.

Proper selection of the casting parameters can result in minimum casting defects [15-16]. Optimization of these parameters based on 3 levels and 4 factors is adopted in this paper to minimize the casting defects. L9 orthogonal array was used with design factor and their levels are shown in Table 4

Experimental layout for L9 Taguchi orthogonal array-total 9 experiments were carried out and response were recorded out of 10 products in %.

Table 2 **Rejection data sheet**

2015	PR	TR	CM	BH	SI	OT
Jun	4 214	512	203	139	97	73
July	3 979	322	120	93	64	45
Aug	3 512	190	98	31	43	18
TL		1 015	421	263	204	137
TL / %		100	41	26	20	13

PR- Production, TR-Total Rejection, CM-Cold Metal, BH-Blow Hole. SI-Sand Inclusion, OT-Others, TL- Total, TL%- Total Percentage

Table 3 **New RPN for AF 5008 Pressure Plate Casting**

Defects	Potential failure mode	Potential cause for failure	RPN
Cold Metal	Small shot	Due to rapid solidification	320
Blow Hole	Internal voids with depression	Moisture left in mold and core	252
Sand inclusion	Inclusion of sand	Improper ramming of sand	175

Table 4 **Factors and their level**

Sl. No	Code	Factors	Levels		
			1	2	3
1	A	PT temperature	1 390	1 420	1 460
2	B	IC	0,11	0,21	0,31
3	C	MC	3,1	3,4	3,7
4	D	SB	60:1	60:1	60:1.2

PT-Pouring Temperature °C, IC- Inoculant Content, MC-Moisture Content %, SB- Sand Binder Ratio

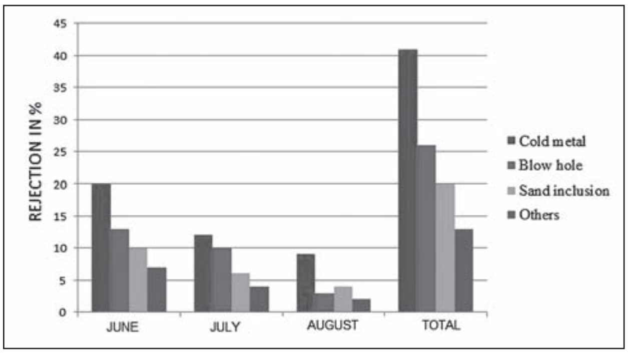

Figure 1 Percentage of Rejection

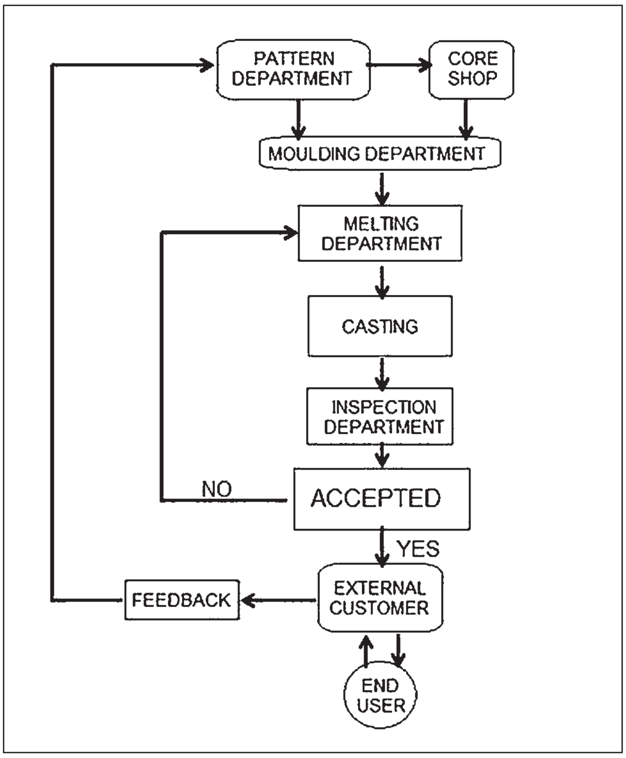

Figure 2 Supply Chain flow Diagram

Table 5 **Results of ANOM**

Factors	Levels (dB)			Optimum level
	1	**2**	**3**	
A	- 31,20	- 35,47	- 31,20	1&3
B	- 33,67	- 32.37	- 31,84	3
C	- 32,68	- 32,10	- 33,21	2
D	- 32,37	- 31,80	- 33,65	2
Optimum mean = - 29,02				

RESULT AND DISCUSSION

Analysis of experimental results was performed using Minitab software and ANOM results obtained were given in Table 5.

The result indicates that the percentage of rejection is minimum at first level and third level of pouring temperature (A1&A3), third level of inoculants (B3), moisture content (C2) and sand binder ratio (D2).

SUPPLY CHAIN PROCESS

The Figure 2 indicates clearly the supply chain flow diagram of a foundry. This helps the foundry to assess the process flow in production of castings. It also indicates the internal supplier and internal customer relationship and external supplier and external customer relationship for continuous process improvement [16] based on the feedback from the customers.

CONCLUSION

The following conclusions were drawn from the present investigation:

1 Pareto principle is used to identify and evaluate different defects and causes and is very useful for taking remedial actions.

2 By FMEA method, the potential failure mode and potential cause for failure of defect are analyzed.

3 Casting defects are minimized with optimal level settings of process parameters.

4 All factors considered contributes to the quality of performance.

The optimized levels of selected process obtained are pouring temperature (1 390° C & 1 460° C), inoculants (0.3), moisture content (3,1 %), and sand: binder ratio (60: 0.1).

The percentage contribution of error is within 10 % with effective supply chain management which indicates that, no important factors were left out from analysis.

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Note: The responsible professional / Translator for this article are
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