Optimization of Foundry Parameters for Reducing Casting Defects

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Abstract— Production of casting involves various processes like pattern making, moulding and assembly, core making and melting etc. A casting defect may be result of a single cause or a combination of causes. The single castings have one or more defects. These can be minimized by taking corrective actions in the tools like pattern, mould making, core making and melting process. This paper presents a systematic procedure to identify as well as to analyze major casting defects carried out at Bharat Fritz Werner, Bangalore, India. High casting reject levels, both internal and customer returns have a considerable adverse effect on productivity, delivery performance, customer satisfaction and employee moral. Diagnostic study carried out on Castings revealed that the contribution of the four prominent defects in casting rejections are blow hole, shrinkage, mismatch, and oversize. It was noticed that these defects are frequently occurring at particular locations. So it preferably necessary to reduce it as much as possible by appropriate analysis of the defects which includes the root cause analysis so that actual reasons behind occurring the defects can be find out to make the corrective action. Outcome of the validation trials showed substantial reduction in rejection of castings. This study aims to implement a novel approach to improve the quality (reducing the defects) of a foundry by Lean Six Sigma methodology.

Keywords: Lean Six Sigma, Casting Defects, Iron Foundry, Sand Casting

I. Introduction

The principle of manufacturing a casting involvescreating a cavity inside a sand mould and then pouring the molten metal directly into the mould. Casting is a very versatile process and capable of being used in mass production. The size of components is varied from very large to small, with intricate designs. Out of the several steps involved in the casting process, moulding and melting processes are the most important stages. Improper control at these stages results indefective castings, which reduces the productivity of foundry industry. All foundry processes generate a certain level of rejection that is closely related to typeof casting, the processes used and equipmentavailable. However, in most foundries a substantialproportion of rejection result from lack of shop floor supervision and technical control, and the use of poorly maintained and inadequate equipment. The rejected casting can only be re-melted and the value addition made during various processes such as melting, moulding, fettling and heat treatment etc. is a lost irrecoverably. Casting process is also known as process of uncertainty. Even in a completely controlled process, defects in casting are found out which challenges explanation about the causes of casting defects. The complexity of the process is due to the involvement of the various disciplines of science and engineering with casting. The cause is often combination of several factors rather than a single one. When these various factors are combined, the root cause of a casting defect can actually become a mystery. Objective of thispaper isto reduce defects of casting (blowholes and porosity) by using Lean Six sigma methodology.[1]

II. Literature review

To reduce the rejection rate of castings, a detailed literature review was carried out for identifying the major defects which leads to rejection of castings. Previous literature has shown that there are few research studiesrelated to rejection control of castings in foundry using different simulation models and also someresearch papers which gives solutions to solve the major defects during gating and feeding process incastings.

Casting defect analysis which has been carried out using techniques like cause-effect diagrams, why-why analysis, design of experiments and if-then rules (expert systems).Most of this work isfocused on finding process-related causes for individual defects, and optimizing the parameter values toreduce the defects. The defects have been classified in terms of their appearance, size, location, consistency anddiscovery stage and inspection method. This helps in correct identification of the defects. For defectanalysis, the possible causes are grouped into design, material and process defects parameters also toaccomplish defect analysis taking benefits of both approaches; new hybrid approach for defect analysis isproposed.

Various forging defects that occur in a forging industry causes high rejection rates in thecomponents and this paper describes the remedial measures that can reduce these defects in the hot forging. He describes the remedial actions that to be done in order to reduce the rejection rates. Theremedial actions includes the proper use of anti scale coating, venting process to prevent the under filling,the simulation software for determining the material flow, proper lubricant instead of furnace oil.[2]

III. Problem definition

Sand casting is used to manufacture complex shapes of various sizes depending upon the customer requirements. The basic requirements in making a casting are pattern making, preparing a mould, pouring molten metal, cooling of mould, shakeout, fettling. The main causes of rejection in castings are due to improper pattern, improper gating system, improper control of sand parameters, improper molten metal composition.

IV. Objectives

The main objective is to reduce casting rejections in Foundry produced and Supplied Castings to organization from 20% (200000 ppm) to < 2%(20000 ppm) by

1) Reducing the Process Defects and WMS Defects in Foundry.

2) Reduce methoding& Pattern making defects.

V. METHODOLOGY

The methodology begins with the collection of rejection rate of various castings for the previous year fromthe quality control reports of the foundry. From this the casting having the highest rejection rate andthe major causes of rejection is identified using quality tools such as defective factor check sheet, Paretoanalysis and Cause and effect diagram. The detailedDMAIC methodology is as follows :

A. DMAIC-Based Methodology for Casting Process Improvement:

Six Sigma is a project-driven approach and by which the organization can achieve the strategic goal through effectively accomplishing projects. Deploying the organization's strategic goal into feasibility, projects play an important role in achieving success of Six Sigma implementation. As per literature review there should not be too many factors in project selection.

1) Define:

The first phase of DMAIC is to define and identify key issues and problems through both the voice of customer and the voice of business, as well as the analysis of casting processes. From the literature and views of experienced foundry personnel, casting defects is the most dissatisfaction area in this industry. The casting defects for the said foundry for year 2014 was found to be 19.69%, which is accounted for Sigma value of 2.3. Therefore to increase the Sigma value of green sand casting process for differential housing castings, most influencing parameters are identified.

PROPERTIES									
Clay content (%)	LOI(%)	Compression strength(PSI)	Permiability No.	Scratch hardness	Alkali Content	Silica content (%)	Fines	Acid demand value	AFS No.
0.08	3.8	542	342	88	0.03	99.6	0.32	8.8	42.16
0.08	3.6	542	342	88	0.06	99.2	0.28	8.8	43.42
0.06	0.04	542	341	82	0.06	99.6	0.08	0.08	36.47
0.05	0.08	562	326	82	0.06	99.8	1.3	0.08	42.91
0.05	0.06	542	326	88	0.04	99.6	0.72	0.07	34.29
0.06	3.8	542	326	88	0.06	99.2	0.28	8.8	43.48
0.06	3.8	562	326	88	0.06	99.2	0.3	0.08	39.47
0.08	0.04	542	342	88	0.04	99.8	0.22	0.07	39.88
0.06	0.05	548	326	88	0.06	99.6	0.12	0.08	39.4
0.04	0.05	542	326	88	0.06	99.6	0.24	0.06	38.86
0.06	0.04	542	326	88	0.06	99.5	0.6	0.08	42.58
0.09	3.7	562	326	88	0.08	99.2	0.34	8.6	41.79
0.08	0.06	542	342	88	0.06	99.6	0.64	0.08	43.88
0.06	0.05	542	342	88	0.05	99.8	0.16	0.07	36.05
0.08	3.8	562	326	80	0.08	99.2	0.82	8.8	46.71
0.08	0.05	542	326	82	0.03	99.6	0.12	0.08	33.13
0.05	0.06	542	326	88	0.06	99.6	0.18	0.08	36.88
0.12	0.08	542	326	82	0.09	99.2	0.56	8.8	41.67
0.08	0.05	562	326	77	0.05	99.6	0.26	0.08	42.4

Table 1: Properties of Foundry Parameters

After intense brain storming, several influencing and controllable process parameters are identified and measured. The effective range of the parameters identified is studied for its effects on the Sigma performance of the process. Performance measures of the existing process are determined by collecting data from the foundry floor. The most significant parameters in the current research are green strength, permeability and moulding, sand temperature from sand shop, core sand temperature from core shop, pouring temperature from melt shop and mould hardness from mould shop.

2) Measure

In this stage, considered process parameters, that influences the Critical to Quality (CTQs) are identified and measured. The data regarding the castings produced from the foundry during the year 2014 is collected and the top castings with highest defects are identified using Pareto charts .

3) Analyse:

Pareto analysis is done to identify the top castings with high rejection rate. The quantity inpercentage with its CP numbers are plotted and the cumulative percentage for the number of repeats are plotted.Fig 1. shows critical castings which have repeated rejections over the period of one year.

From the above quality tools the cause and Effect Diagram for the defects like Blowholes, Shrinkage, Dimensions not ok and surface finish are constructed. Fig:2shows the cause and effect diagram for Blowholes which causes high rejection rate ofthis casting.

4) Improve:

The purpose of the improvement phase is to identify and implement changes so that the overall casting processes performance can be improved and the common-cause variations in the casting processes can be reduced.

The Six Sigma methodology uses structured experimentation to optimize process settings.

Here, the process wisdom and experience of the in-house team members is combined with the knowledge and expertise of the Gemba Consulting specialists to develop innovative solutions.The root cause validation GEMBA analysis is done to arrive at the final root cause for the defects.

The Control limits where plotted for the readings obtained. It is observed that the Compressive strength crosses the upper control limit and lower control limits at certain times which leads to defective casting being produced. Fig. 3 shows the Control limits plotted for compressive strength.

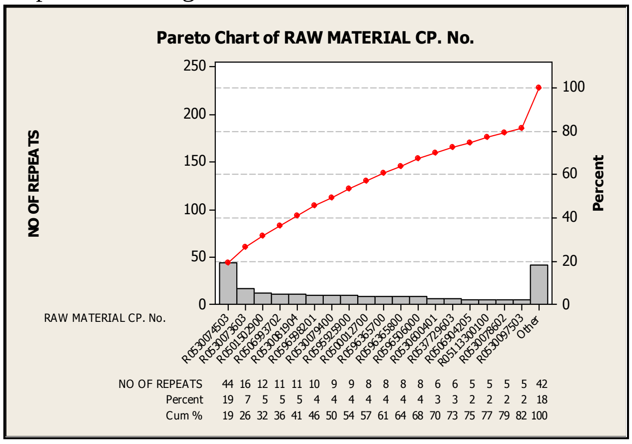

Fig. 1: Pareto Analysis for Top CP Numbers

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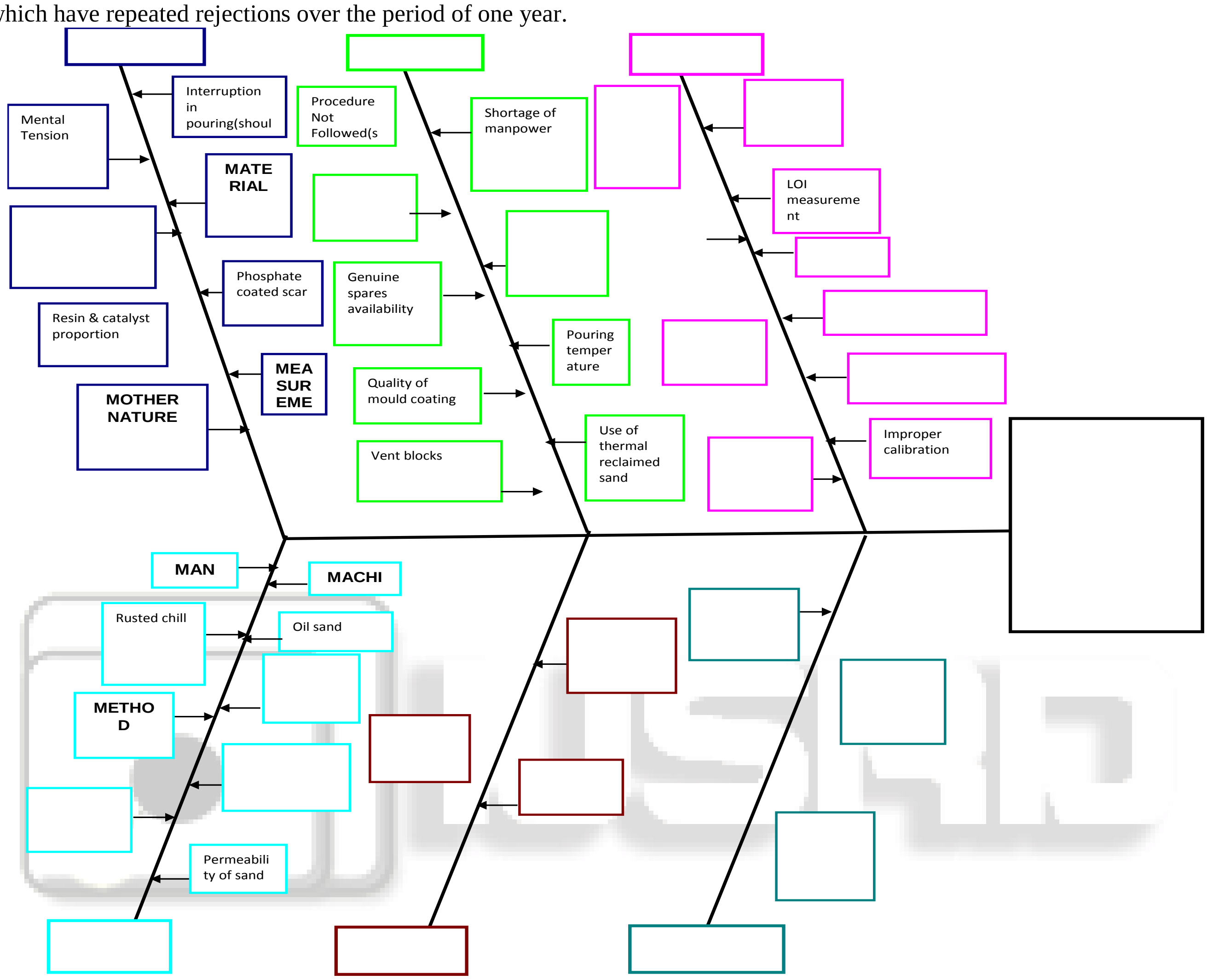

Fig. 2: Cause and Effect Diagram for Blowholes

B. IMPROVE:

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Fig. 3: Control Limits for Compressive Strength

C. CONTROL

The last phase is control phase and the purpose of this phase is to sustain the benefits of the new process and to ensure that previous problems do not resurface. For complete success of Six Sigma, proper documentation of the process is recommended. The critical process parameters are continuously monitored and documented to update the information.[2]

VI. RESULT AND DISCUSSION

In this case study, DMAIC based Six Sigma approach implemented to optimize the processes parameters of a foundry. The cause and effect diagrams and GEMBA root cause validation provides an insight into the process parameters, affecting the casting process. Thus, from the analysis, it can be concluded that the process parameters such as moisture content (%), green compressive strength (g/cm2), pouring temperature (0C) and mould hardness are the significant parameters taken into account when designing further experiments. [2]

VII. CONCLUSIONS

Foundry process involves number of stages. At each stages no. of & different type of defect generated due to some operation related or due to incorrect process are related. The defect need to be diagnosed correctly for appropriate remedial measures,This paper deals with the fact that the efficiency and performance level of the casting process can be improved by adopting a Six Sigma approach. It is concluded from the analysis that, the quality can be improved by Six Sigma i.e. (DMAIC) approach of parameters at the lowest possible cost. In this work, reduces the two defect Blowholes and Shrinkage which have higher percentage in the total rejection of the foundry.

REFERENCES

[1] R. B. HEDDURE "Casting defect reduction using Shainin tool in CI Foundry – A case study" , International Journal of Productivity and Quality Management, vol. 5(2), pp. 200 – 212, 2010.
[2] Sushil Kumar, P.S. Satsangi and D.R. Prajapati" Six Sigma an Excellent Tool for Process Improvement – A Case Study "International Journal of Scientific & Engineering Research Volume 2, Issue 9, 1 ISSN 2229-5518,2011.
[3] J. Antony, and R. Banuelas, "Key ingredients for the effective implementation of Six Sigma program", Measuring Business Excellence, vol. 6 (4), pp. 20–27, 2002.
[4] T. Arita, and P. McCann, "Regular monthly income by wearing your shorts at the comfort of your", Journal of International Management, vol. 8, pp. 121–139, 2002.
[5] P.B. Barua, P. Kumar, and J.L. Gaindhar, "Surface roughness optimization of V process castings through Taguchi's method", AFS Transactions, vol. 45, pp. 763–768, 1997.
[6] J. Cheng, "Six Sigma business strategy in Taiwan: an empirical study", International Journal of Six Sigma and Competitive Advantage, vol. 3 (1), pp. 1–12, 2007.
[7] J.A. Ghani, I.A. Choudhury, and H.H. Hasan, "Application of Taguchi method in the optimization of end milling parameters", Journal of Materials Processing Technology, vol. 145, pp. 84–92, 2004.
[8] S.V. Deshmukh, and R.R. Lakhe, "Six Sigma awareness in Central Indian SMEs", International Journal of Productivity and Quality Management, vol. 5(2), pp. 200 – 212, 2010.