Paradigm Shift in Casting Defect Analysis and Control using Quality Control Tools and Simulation for Production of CI Casting

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ABSTRACT

In foundry, sand casting is the most commonly used process amongst all the available alternatives. Casting soundness in sand casting includes weight of the casting, free from cavities- pinholes or gross and other defects, physical and mechanical properties like strength and hardness etc. which could be varying within limits. The extent of conformance to specification and customer satisfaction are generally considered as basis for quality. In most of the foundries development of new castings is done with empirical methods with probably large number of trials and consequent cost of poor quality, rejections, delays etc. This excessive rejection may have considerable adverse effect on productivity, delivery performance, customer satisfaction and employee morale. In addition, it may also reduce yield, waste valuable raw material and energy, and consume management time in problem solving. Therefore, an attempt has been made for analysis and controlling defects of gear case cover by using quality control tools. Use of simulation software is recommended to reduce trials during for validation, reduce lead time and controlling the rejection. Though the rejected casting can only be remelted, the value addition made during various processes such as molding, melting and fettling etc. are lost irrecoverably.

Key Words: Defect, quality, Rejection and Simulation.

1. INTRODUCTION

Foundry is the most basic input industry and stringent demands of quality and quantity are being placed on it. In 2015, the production of grey iron castings in India's foundries amounted to around 6.83 million metric tons (68.1% of total casting production). India is the second largest producer of castings [1]. Green sand molding is the most popular amongst all the molding methods and accounts for 90% of sand molded castings. Quality of these sand casting can be improved by putting more efforts on preventing the defect rather than merely detecting the defect. The defects in the casting considerably reduce the total output of casting besides increasing the cost of their production. It is therefore essential to understand the causes behind these defects so that they may be suitably eliminated. Hence with rapid industrialization and growth in the fields of production, the use of computers based systems is recommended in sand casting process to produce sound castings economically for controlling the casting defects in this digital era. Use of computer based systems are to be used as human expertise is scarce, human expertise is expensive and is not always accessible and humans can be inconsistent and susceptible to bias in their day to day actions.

2. LITERATURE REVIEW

Casting defect is deficiency or imperfection contrary to the quality specifications imposed by the design and service requirements.

Elbel et al [2] has mentioned that one of the powerful tool for defect analysis is an expert system developed . It is a computer programme based on the knowledge of experts for solving the quality of castings. They presented the expert system developed in the VSB-Technical University of Ostrava called 'ESWOD'. The ESWOD programme consists of three separate modules: identification, diagnosis / causes and prevention / remedy. The important aspect need to be considered at greater depth is an identification of casting defects which forms the bases before implementation.

Narayanswamy and Natrajan [3] reviewed various casting defects. They categorize defects into filling related defects (FRD), shape related defects (SRD), Thermal defects (TD) and defects by Appearance. Out of these defects the filling related defects are to be given importance for the analysis and it is mainly due to the quality of sand. The shape related defects, defects by appearance and thermal defects are due to various factors in mould making process and melting process.

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Joshi and Jugulkar [4] presented the systemic approaches to find cause of defects occurred due to manual operations. From the analysis it was found that the manual metal casting operations are done with some negligence and carelessness. So, by suggested some other remedial issues and by implementing them it reduced total rejection more than 30%. If automation is implemented then it reduces defects by more than 70%. This systematic study proves that by means of effective analysis of tools and processes, it is possible to control the casting defects.

Andreas Felsberger et. al. [5] reviewed study of use of decision support systems for manufacturing systems. Decision support systems (DSS) are about developing and deploying IT-based systems to support decision processes. DSS is an interactive computer information system that solves the problem of non-structures and can help decision makers to use data and models. DSS reduces the quantity of data to a high quality structured amount; due to this, decisions are made to support the manufacturing process. The process is determined as an identification of alternatives as possible solutions for an upcoming ill-structured problem.

Dr. Thoguluva Raghavan Vijayaram et. al. [6] discussed in brief about extensive use of computers in foundries mechanization. Foundry mechanization and modernization are of considerable importance today when the foundry has evolved from an ancient art into a modern science and it is fully controlled and monitored by computers. Modernization is the only key to improve casting quality and productivity. It was mentioned that fatigue and strain on the workers and staffs have been considerably reduced with the use of computers in foundries. Computers help to simulate the casting solidification during validation. The use of finite element analysis is an important tool to study the temperature and stress distribution, and microstructure evolution. The expert systems are mainly used for casting defect analysis and have wide engineering applications. The software packages like AFS Solid 2000, ProCAST, MeshCAST, AutoCAST were used for designing and analysis of foundry process to minimize errors during production to reduce rejections.

Dr. B. Ravi et. al. [7] in their paper have developed model for the design of product, tooling, methoding and process plan. It is helpful in improving the quality of the casting.

For global competency in manufacturing, both technological resources and technological capabilities are essential. However, this paper does not include resources and capabilities other than technology and is based on survey . There is ample scope for application of this computer simulation model for manufacturers. Companies could conceptualize this model and optimize their use of valuable resources for routine and innovative solutions. Such endeavor in turn may find new markets and customers. Also, standardization plays a vital role in quality assurance and hence controlling the rejections. Further research confirms that concepts discussed in this can be applied in practice with precision.

3. METHODOLOGY

The first step in the defect analysis is to identify the casting defect correctly. Then the identification of the sources of the defect is to be made. The involvement of the various variables in the process makes difficult to identify the exact source of the defect. Systematic analysis is required to control or reduce the defects by taking the necessary corrective remedial actions. Implementation of wrong remedial actions makes the problem complicated and severe. In this paper the vital few causes of rejection of casting was analyzed using defect diagnostic approach as shown in the fig. 1 below.

4. DATA COLLECTION AND ANALYSIS

For identification of batch of manufacturing of a product certain code is developed. It also helped in tracing the date and heat number of a batch to which defective casting belongs. The coding system used in the industry includes first two digits to represent date. Next symbol represents month of manufacturing. Last two digits represents the year of manufacturing. Also, the code no indicates heat number of a furnace. The following fig. 2 indicates percentage defects of each type of defect during the study for the three months October, November and December before formulation of strategy.

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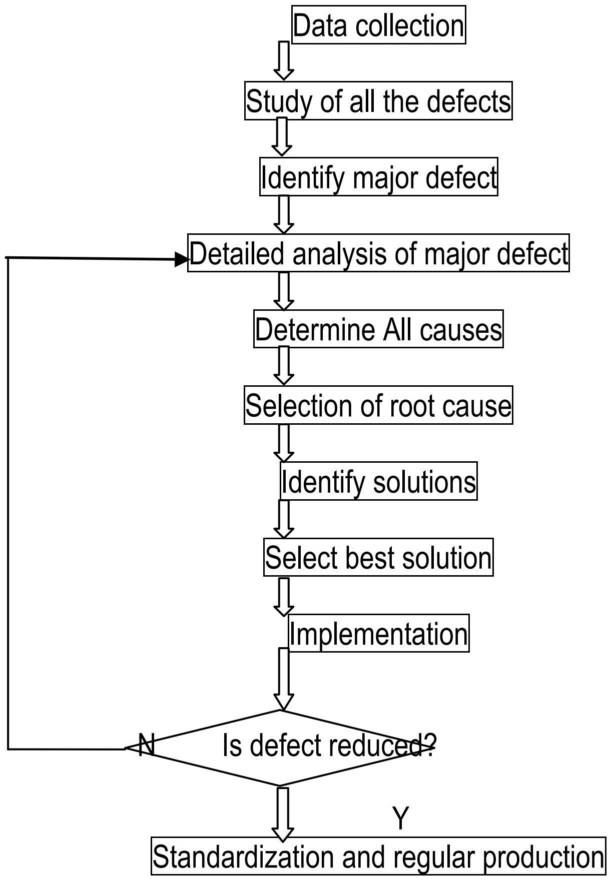

Figure 1: Methodology for defect analysis and control

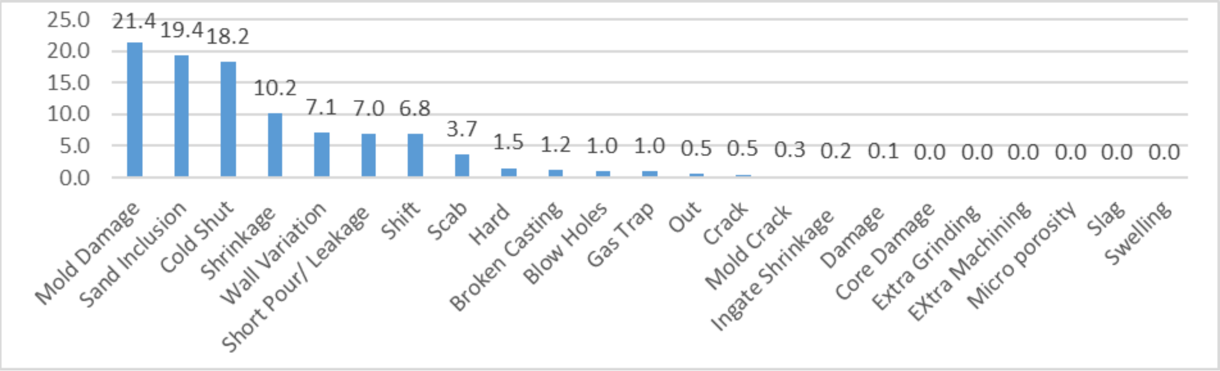

Figure 2: Each defect in percentage during the study for the first three months Oct., Nov. and Dec.

As per the Pareto principle the defects which are responsible for 77% of rejections of gear case cover are identified as mold damage, sand inclusion, cold shut, shrinkage, wall variation These defects then are further analyzed to identify the causes. Their analysis is presented below in table 1.

Table 1: Why-why analysis of the Vital Few Defects of Gear Case Cover

Sr. No.	Defect	Causes
1	Mold Damage	Molds are not handled properly and low strength of sand
		Poor ramming
		Unskilled mold operator
2	Sand Inclusion	Sand drop in mold cavity
		Less cohesiveness of the sand
		sand is not used within one hour after its preparation
3	Cold Shut	Improper fusion
		Fluidity is less
		Lower carbon percentage and low pouring temperature

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4	Shrinkage	Uneven cooling rate
		Abrupt change in cross sectional area and insufficient feeding
		Insufficient chills and riser and gating system is not designed properly
5	Wall Variation	Misalignment of cores
		Shifting of cores
		Core does not have proper core print

5. FORMATION OF REJECTION CONTROL STRATEGY

Following are the strategy suggested to control the defects and hence the rejection of casting.

1. Sand ramming should be done properly in the corners initially so that mold will have sufficient strength throughout after performing molding operation.
2. Sand must be used within one hour after its preparation and if not used within one hour then should sent back to muller to control its properties as it loses its properties with the passage of time.
3. Carbon percentage should be kept on higher side i.e. it should be closer to the upper limit i.e. 3.55 instead of keeping it closer to lower limit i.e. 3.45 and pouring temperature should be adjusted considering the degree of superheat to 90^{0}C.
4. Methoding is required to be redesigned to avoid shrinkage. Instead of using trial and error method for the same as per current practice it was decided to make use of simulation software to design the methoding as the facility is available in the cluster. The use of software is going to reduce cost, energy and time which otherwise is more for development of casting.
5. Properly dried shell cores are to be used which will have sufficient strength and will not be responsible for temperature loss of molten metal when poured into cavity.

Methoding is done and is validated using AutoCAST simulation software [8] before implementation. Thermal analysis of the part during simulation is shown below in fig. 3. It clearly indicates that the casting does not have defect like cold shut or shrinkage.

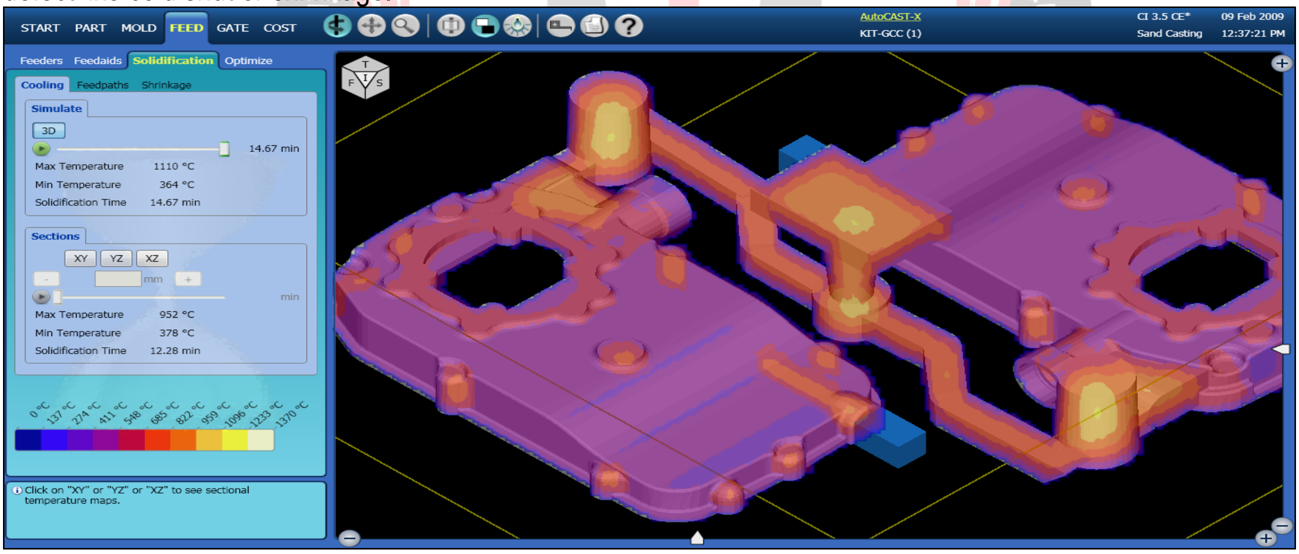

Figure 3: Thermal analysis of Multi-cavity Gating System

6. IMPLEMENTATION OF REJECTION CONTROL STRATEGY

Following fig. 4 shows the percentage casting defect and fig. 5 shows rejection before implementation of the strategies for the period of three month (October, November and December) and after implementation of the strategies for the period of next three months (January, February and March) with modified methoding.

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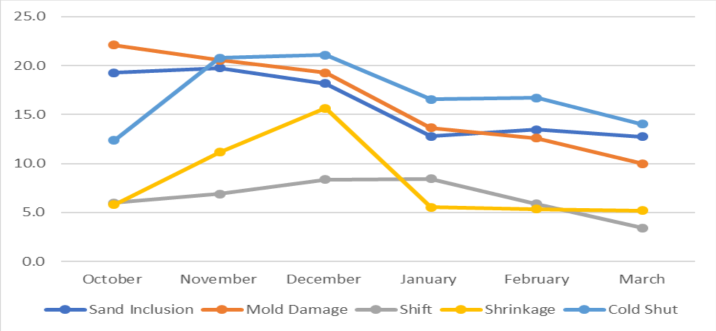

Figure 4: Vital few defects in percentage before and after implementation of strategy for 3 months each

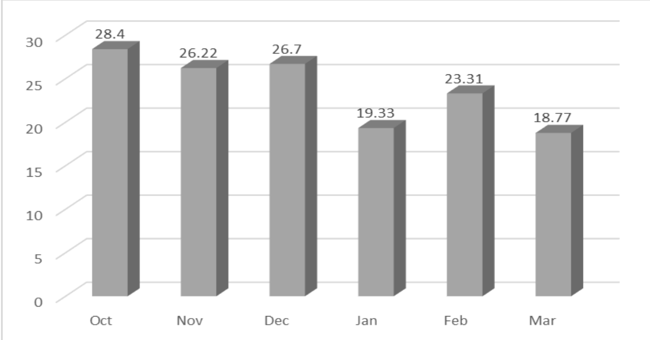

Figure 5: Rejection in percentage before and after implementation of strategy for 3 months each

7. CONCLUSION

Upon surveying it was noticed that the foundry had not standardized its production processes in different areas. Lack of maintenance of equipment as well as inadequate equipment were the main cause for high level of defects. Not only the Percentage rejections of vital few defects of gear case cover but also the overall rejection reduced from 28.4 % to 18.7 %. after implementation of strategies. Though substantial reduction in rejection levels was achieved due to analysis of the rejections, suggestions made for process improvements and use of better equipments, instruments as well as infrastructural changes, there is much scope left in further reducing the rejection percentage in the foundry by carrying the further activities such as technical training for staff and workers, use of simulation software for development activities on regular basis, analysis of the other defects, further improvement in areas of infrastructure and automation, implementation of expert system for analyzing the causes of defects.

REFERENCES

[1] 49th Census of World Casting Production, Modern castings, December 2015, pp. 26-31

[2] T. Elbel Y. Králová,, J. Hampl, "Expert System for Analysis of Casting Defects – ESVOD", Archives of Foundry Engineering, ISSN (1897-3310), Volume 15, Issue 1/2015. 17-20

[3] C. Narayanaswamy, K. Natarajan, "Optimization of casting defects analysis with supply chain in cast iron foundry process", METALURGIJA 55, 4, 2016, 815-817 815, ISSN 0543-5846

[4] Joshi Aniruddha, Jugulkar L.M, "Investigation and analysis of metal casting defects and defect reduction by using quality control tools", International Journal of Mechanical and Production Engineering,2, 2014, 87-92, ISSN:2320-2092

[5] Andreas Felsberger, Bernhard Oberegger, Gerald Reiner, " A Review of Decision Support Systems for Manufacturing Systems", SamI40 workshop at i-KNOW '16, Graz, Austria,2016, pp. 1-8

[6] Dr Thoguluva RaghavanVijayaram, Dr Paolo Piccardo,(2012), "Computers in Foundries", Metallurgical Science and Technology, Vol. 30, Issue. 2,2012, pp. 28-38

[7] Dr. B. Ravi, Rahul Chougule "Concept on Cost Modelling and Reduction in Foundry Industry"- National Convention on Cost Cutting and Advancements in Forging, Sheet Metal Forming & Fasteners and Modern Foundry Techniques, Maratha Sheraton, Sahar, Mumbai, 14-15 Feb 2005.

[8] Dr. B. Ravi &. M. n. Shrinivasan, "Computer aided gating and metal rising simulation" at 40th Annual convention of IIF, Madras, 1992, pp. 269 - 283

 DOI : 10.18231/2454-9150.2018.0212