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Minimization of Casting Defects Using Casting Simulation Technique and Casting Defects Analysis Using Design of Experiment

Atul A. Bhujugade[1], Vijay B. Sabnis[2]
[1,2]Mechanical Engineering Department, Karmaveer Bhaurao Patil college of Engineering & Polytechnic, Satara.
Shivaji University, Kolhapur, INDIA.

Abstract-In this paper Computer simulation technique and design of experiment used for casting defects analysis. In the first part using casting simulation technique analysis for shrinkage porosity defect is performed and new gating system designed. Number of iteration performed using simulation software to achieve optimum design. With new gating system reduction in shrinkage by (about 2.85 %) and yield improvement by (about 9.85 %) is observed. In the second part DOE used for casting defects analysis so sand related and pouring practices related parameters considered are moisture content, sand particle size, mould hardness and pouring temperature. Taguchi based L9 orthogonal array was used for the experimental purpose and analysis was carried out using Minitab software for analysis of variance (ANOVA).

Keywords— Casting defects, Casting simulation and optimization, Yield improvement, Taguchi method, Parameter optimization.

I. INTRODUCTION

Foundry industry suffers from poor quality and productivity due to the large number of process parameters, combined with lower penetration of manufacturing automation and shortage of skilled workers compared to other industries. Global buyers demand defect-free castings and strict delivery schedule, which foundries are finding it very difficult to meet. Casting defects result in increased unit cost and lower morale of shop floor personnel. The defects need to be diagnosed correctly for appropriate remedial measures; otherwise new defects may be introduced. Unfortunately, this is not an easy task, since casting process involves complex interactions among various parameters and operations related to metal composition, methods design, molding, melting, pouring, shake-out, fettling and machining. For example, if shrinkage porosity is identified as gas porosity, and the pouring temperature is lowered to reduce the same, it may lead to another defect, namely cold shut [1].

Casting defects analysis is the process of finding the root cause of occurrence of defects in the rejection of casting and taking necessary steps to reduce the defects and to improve the casting yield. Techniques like cause-effect diagrams, design of experiments (DoE), casting simulation, if-then rules (expert systems) and artificial neural networks (ANN) are used by various researchers for analysis of casting defects.

II. EXPERIMENTAL WORK

Experiments were performed in a medium scale ferrous foundry producing stainless steel components. The proposed method of casting defects analysis involves two techniques. In the first technique of casting simulation methoding related defects was considered and second technique used Taguchi optimization method in this sand related defects and pouring practices related defects considered for analysis. Therefore for the experimentation component named bearing spider were selected. After carrying out rejection analysis it was found that in cast component bearing spider the rejection was maximum up to 12%. Therefore this component was selected for the analysis.

A. Casting Simulation For Bearing Spider

The problem must be defined first, to ascertain the need and type of simulation. There is focus on two types of projects in casting simulation: (1) Casting defect analysis (Shrinkage porosity), and (2) Yield improvement of an existing casting.

1) Data Collection: In this stage for selected casting the data regarding the existing defects, existing yield, process parameters, material, existing method design is collected and analysed. Input to the simulation program is the 3D solid CAD model of the casting in the .STL format. So 3D solid CAD model of bearing spider was created as shown in the figure 1. This is the most important stage, since incorrect or incomplete data will lead to inaccurate simulation and wrong conclusions.

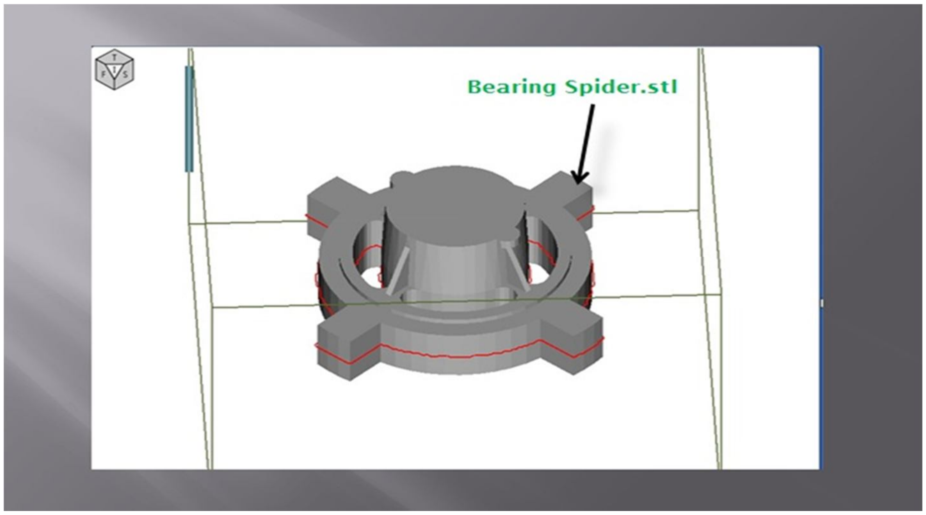

Figure 1: 3-D Model of Bearing Spider.

2) Method Design: In existing methoding, single cavity with five risers out of that one riser at the top of boss and another four riser on the rib was used. Feeder was not feeding the casting properly which results in shrinkage porosities inside the casting and yield with existing system 51.49%.In this stage a new gating system was designed (for four cavity mould) using theoretical formulae used for gating and risering system design. Feeder was designed by modulus method [16]. Method design with four cavities mould as shown in Figure 2. AutoCAST software used to analysis of methoding system for casting i.e. bearing spider.

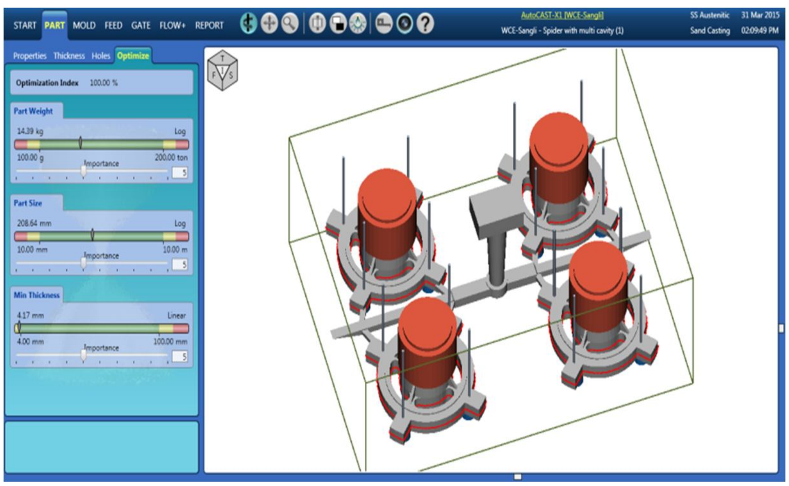

Figure 2: Methoding System for Bearing Spider.

3) Simulation And Optimization: In this research paper AutoCAST-X casting simulation package is used for mould filling and solidification analysis. At the initial stage, the gating and risering system for the four cavities of the mould was designed and solid modelled as shown in Figure 6. In this gating system, two separate ingates is provided to each casting to fill the mould cavity. Pouring is through central sprue and eight ingates are attached to the runner. The yield with this iteration was 61.24 %. Therefore, to minimize the shrinkage porosities number of iterations for gating system design of bearing spider was performed and optimum design for gating system was selected. In new optimum methoding, direct chills in moulding were used in four cavities and provision was made to escapement of gases from the mould cavity (refer Figure 3).

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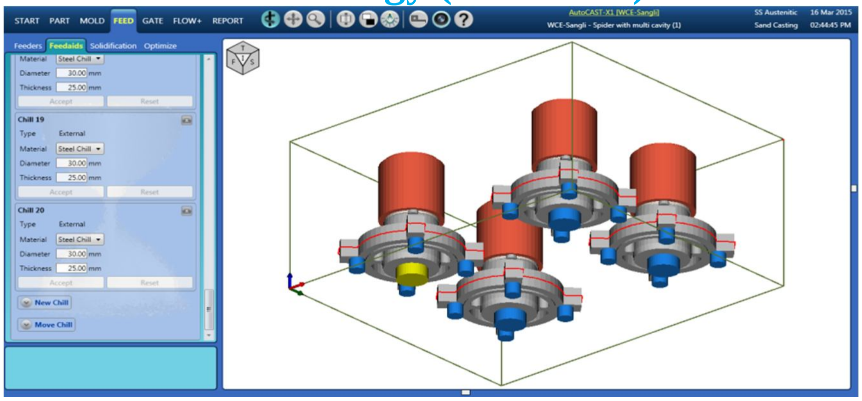

Figure 3: Chill is added to Take Care of Hotspot in to the Feeding System

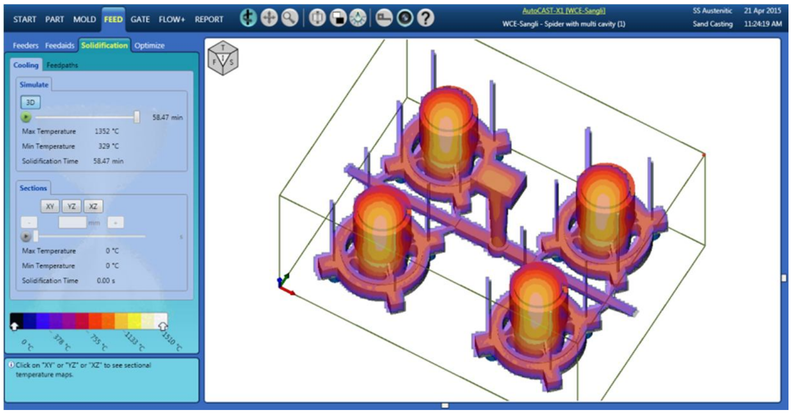

Figure 4: Hotspots Absorbed in Riserring System.

Simulation carried out of bearing spider for solidification using the FEED + SOLIDIFICATION module of AutoCAST-X software and it was found that hot spot has taken out into the riser and which was our aim. So with this also we identified that our risering design is been optimal. Also from fig 4 gives idea about how the hot spot got absorbed into the riser.

4) Quality Checking For Bearing Spider: The quality function shows the position and extent of various defects related to mould filling and casting solidification. These are based on the simulation results.

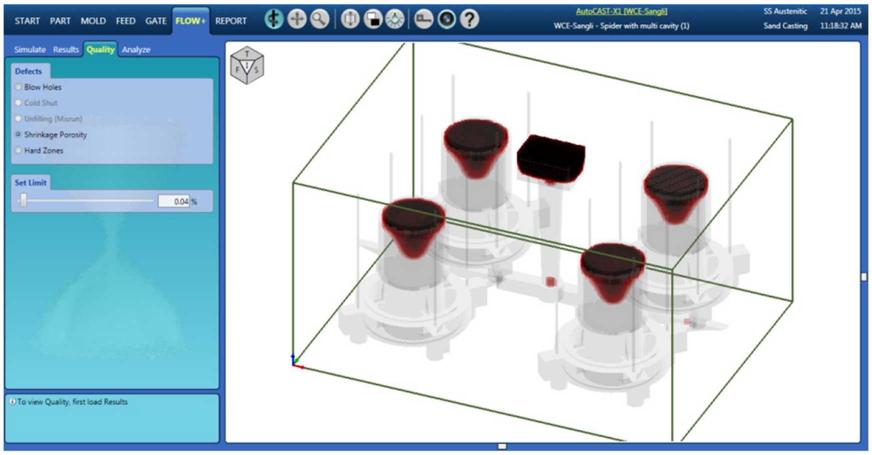

Figure 5: Shrinkage in Bearing Spider

From the above figure 5 shows that our methoding design is been optimum and it was found that shrinkage zone in the risering system. So shrinkage is occurring at riser and that is our ultimate aim so with this same method design defects related to method design got minimised in simulation trial and which verified in the actual shop floor trial. Finally optimum methoding system was implemented and it is found that rejection due to shrinkage porosity was reduced by 2.85%. Also yield got improved by 9.85%.

B. DOE For Casting Defects Analysis

Process parameters of green sand casting that influences the identified defects in casting of bearing spider with their levels are shown in table 1.

Table 1. Ranges and Levels of Parameters

Parameter designation	Process parameters	Range	Level 1	Level 2	Level 3
A	Moisture content (%)	2-3.5	2-2.5	2.5-3	3-3.5
B	Sand particle size [AFS No]	30-45	30-35	35-40	40-45
C	Mould hardness	70-85	70-75	75-80	80-85
D	Pouring temperature	1540-1585	1540-1555	1555-1570	1570-1585

Four parameter with at three different levels therefore L9 orthogonal array is selected for the experimentation [12]. The response variable was the % rejection of casting due to defects which is ratio of rejection due to considered process parameters to the quantity poured. As per L9 orthogonal array 9 experiments were performed randomly and % of rejection in each experiment was considered as the response variable.

1) Analysis Of Experimental Results: Analysis of experimental results was performed using Minitab 16 software and ANOVA and main effect plots obtained are given in Table 2 and Figure 6 respectively. ANOVA in Table 2 indicates that moisture content, green compression strength and mould hardness parameters significantly influence the % rejection.

Table 2. ANOVA for S/N Ratio Including Percentage Contribution

Sr. No.	Source	Degree of Freedom	Seq. Sum of Square	Adj. Sum of Square	Adj. Mean Square	% Contribution
1	Moisture Content	2	13.8042	13.8042	6.9021	61.32
2	AFS No.	2	5.1309	5.1309	2.5654	22.79
3	Mould Hardness	2	1.2035	1.2035	0.6017	5.346
4	Pouring Temperature	2	2.3717	2.3717	1.1858	10.536
5	Total	8	22.5102			

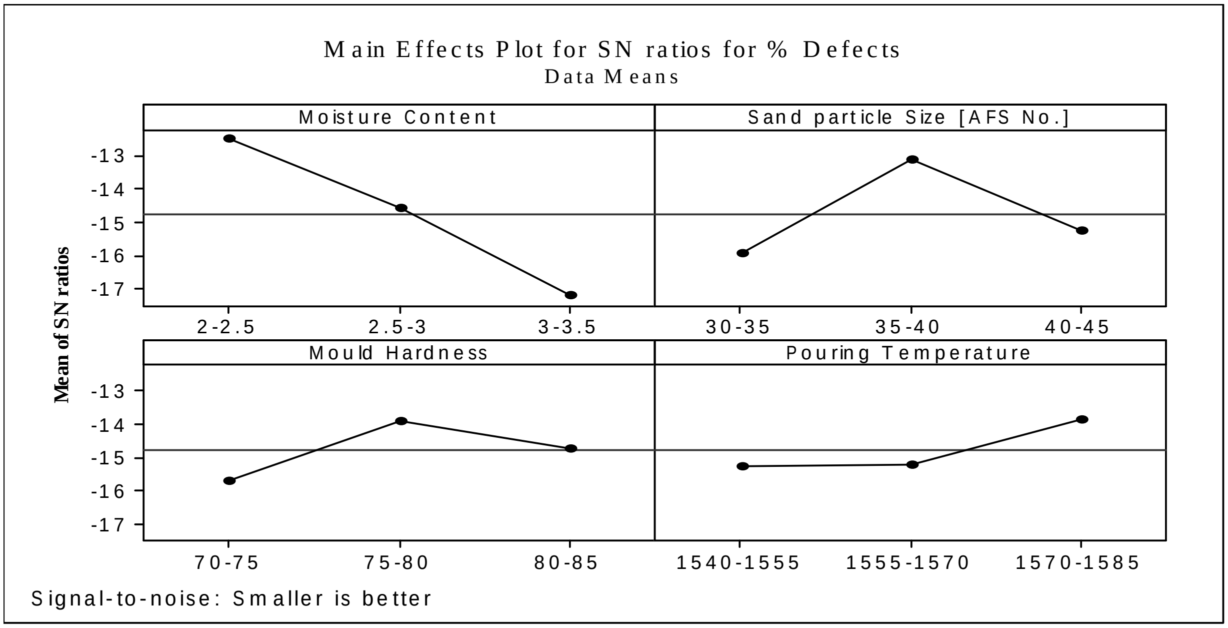

Figure 6: Main Effects Plot for SN ratios for % Defects

ANOVA table 2 shows that most significant parameter is moisture content which contributes 61.32% and second significant parameter is AFS No. It is clear from fig 6 that the casting defects are minimum at the first level of parameter A (A1), the second level of parameter B (B2), the second level of parameter C (C2) and the third level of parameter D (D4).

2) Conformation Experiments:

Three confirmation experiments were performed at the optimized settings of the process parameters, results of which are shown in Table 3. Prior to the application of Taguchi method rejection due to sand related defects and pouring practices related defects for bearing spider after implementation simulation result was 8% which is reduced to maximum up to 3.55 %.

Table 4.5: Results of Confirmation Experiments:

Experiment no.	Rejection
1	3
2	4.33
3	3.33
Total average of % rejection	3.55

III. CONCLUSIONS

Analysis of defects like shrinkage porosities computer aided casting simulation technique is the most efficient and accurate method. .Design of experiments method such as Taguchi method can be efficiently applied for deciding the optimum settings of process parameters to have minimum rejection due to defects for a new casting as well as for analysis of defects in existing casting.

After implementation of casting simulation technique it is observed that minimization of methoding related defects such as shrinkage porosity reduced up to the 0.89% and yield improved by 9.85% with newly designed gating system .

The optimized levels of selected process parameters obtained by Taguchi method are: (A): Moisture content 2-2.5 % (B): Sand Particle Size 35-40 (C): Mould Hardness 75-80 and (D): Pouring Temperature 1570-1585° C.

With Taguchi optimization method the % rejection of casting due to sand related defects and pouring practices related defects is reduced from 8% to a maximum upto 3.55%.

IV. ACKNOWLEDGMENT

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REFERENCES

[1] V.V.Mane, Amit Sata and M.Y.Khire, "New approach to casting defects classification and analysis supported by simulation", Indian foundry Information (2009) 3, pp. 9-18.
[2] S. Guharaja, A. Noorul Haq and K. M. Karuppannan, "Parameter optimization of CO2 casting process by using Taguchi method", International Journal of Advanced Manufacturing Technology (2009) 3, pp 41-50.
[3] George W. Anselman, Victor Rowell and Albert M. Prewitt, "AFS Handbook", American foundry society (1997), pp 4-50
[4] B.ravi , "casting simulation and optimization: benefits, bottlenecks", Indian foundry journal, 2008, pp.3-5.
[5] H.C.Pandit and S.M.Ingale, "Casting Optimization Aided By Simulation", International Conference on Sunrise Technologies,13th – 15th Jan 2011, pp.4-7.
[6] B. Ravi, "Casting Design and Design for Casting," Technical Presentation, Ford Research Center, Dearborn, July 21, 1999, pp.1-6
[7] B. Ravi , "Digital Methoding: Child's Play? Yes and No.", Steel and Alloy Steel Castings (SAS-2001) pp 1-4.
[8] B.Ravi, "Casting simulation-best practices", Indian Foundry Congress, Ahmedabad-2010.
[9] Uday A. Dabade and Rahul C. Bhedasgaonkar, "Casting Defect Analysis using Design of Experiments (DoE) and Computer Aided Casting Simulation Technique", Forty Sixth CIRP Conference on Manufacturing Systems (2013), pp 616-621.
[10] Achamyeleh A. Kassie and Samuel B. Assfaw, "Minimization of Casting Defects", IOSR journal of Engineering, Volume 3 (2013), pp 31-38.
[11] Sandeep.v. Chavan, Rajeev.K.Tavildar, "Casting Defect Analysis and Optimization Using Computer Aided Casting Simulation Technique", International Journal of Innovative Research in Science, Engineering and Technology, Volume 3 (2014), pp 1-5.
[12] 12. Rasik A Upadhye and Ishwar P Keswani , Optimization of Sand Casting Process Parameter Using Taguchi Method in Foundry , International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 7, September - 2012 ISSN: 2278-0181.
[13] Annual book of ASTM standards, Section one, Iron and steel products, Volume 01.02, 2013.
[14] AutoCAST-X casting method design and optimization, 3D Foundry Tech Private Limited, Mumbai, Date of issue: January 2014.
[15] Feeding and risering guidelines for steel casting, Steel founders society of America, 2001.
[16] S. Santhi and B. Ramakrishna Surya, Design of Gating and Riser System for Grate Bar Casting, Indian Foundry Journal, Vol. 61 No.1, ISSN 0379-5446, January 2015.
[17] Rajesh Rajkolhe and J. G. Khan, Defects, Causes and Their Remedies in Casting Process: A Review, International Journal of Research in Advent Technology, Vol.2, No.3, March 2014 E-ISSN: 2321-9637.
[18] Nevagi S.P. and Uday A. Dabade, "Effect of EDM process parameters on surface integrity of Inconel 718", Master of Technology Dissertation report, Walchand college of Engineering, Sangli, August 2011.
[19] Phadke Madhav S., "Quality engineering using robust design", Prentice hall (1989), Englewood Cliff, New Jersey.
[20] Hasan Oktem,Tuncay Erzurumlu and Mustafa Col, "A study of the Taguchi optimization method for surface in finishing milling of mould",The International Journal of Advanced Manufacturing Technology (2006),48, pp. 694-700.
[21] Syrcos G.P., "Die casting process parameters optimization using Taguchi method of design of experiment", Journal of Master Process Technology (2002) 135, pp. 68-74.
[22] P. Bidulya, "Steel Foundry Practice", Mir Publishers, Moscow, 1968s".