Casting Design And Simulation of QRL Cylinder For Defect Minimization Using Autocast Software

Prof. Gayatri J. Abhyankar[1], Omkar M. Mestry[2], Roshan R. Dharne[3], Pooja V. Gokhale[4] ,Vasant P. Dabholkar[5]
[1, 2, 3, 4, 5]Dept of Mechanical Engineering
[1, 2, 3, 4, 5] Finolex Academy of Management & Technology, Ratnagiri ,India.

Abstract- *Metal casting is a dominating field of production processes used to produce mechanical parts of complex shape and size. It is always considered as a backbone of production industry. The paper covers the detailed analysis carried out to reduce defects in Quick Rise and Lower cylinder (QRL) which is used in john deer tractor assembly. QRL Cylinder casting had many defects, mainly due various parameters like improper pouring, incorrect gating system, feeder position etc. Large number of casting were getting rejected because shrinkage and porosity. Auto Cast analysis provided modified layouts of casting set up for minimization of defects. In first layout percentage rejection is reduced from 4.82% to 3.2 %. In second layout percentage rejection is reduced from 3.2 %to 2.4 %. The overall rejection rate of castings is considerably reduced using the modified layouts.*

Keywords- Auto CAST, Casting Defects, Simulation, Optimization etc.

I. INTRODUCTION

Foundry industries are essential to manufacture value castings with least number of eliminations to satisfy the consumer necessities in market. Metal casting is dominating field of production processes which is used to produce mechanical parts of complicated shape and size and it is being backbone of production industry.[3] The development of the foundries depends mainly on the skill of the workers. Some foundries work with trial and error method because of which most of the foundries have very less control on rejections. Because of non standard selection of parameters many times foundries fail to meet the quality demands of customers, which finally leads to financial loss to the foundry. Hence many of the foundries are working towards casting defect minimization.[12]

To analyze and suggest the method for standardizing the casting process one reputed foundry is selected, Sound Casting Pvt. Ltd. Kolhapur. It mainly manufactures automotive parts, established in 1987, is India's one of the trusted names in the area of automotive sector. They manufacture fully joint casting. They also carry out some machining processes. They develop and sell Quick Rise and Lower cylinder (QRL) which is used in john deer tractor assembly.

II.CAUSE AND EFFECT DIAGRAM-

Kauro Ishikawa of Tokyo University, Japan, developed fish-bone diagram probably called Ishikawa diagram used to give causes attributed towards its effects [1]. By referring literature number of parameters affecting the casting defects are listed.

Using the influencing parameters, fish bone diagram is constructed. It gives the details of affecting parameters on defective casting. Similarly Casting defects can have particular cause.

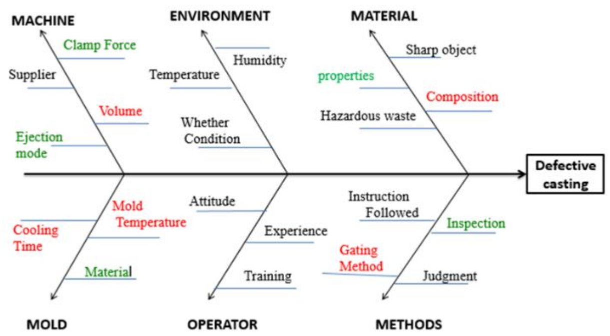

Fig. 1.1 Fish bone diagram for defective casting

III. NEED FOR AUTOCAST

The study of casting was planned to minimize the casting defects. It was found difficult to get the results through actual experimentation. Hence by using the data of the process the analysis was carried out using simulation software, AutoCast, Which provides systematic layout to tackle defects occurring in casting. It helps to track path of process in casting. By using AutoCAST-X software; simulation has been performed and various parameters are checked such as gating system and feeder location, pattern allowance etc. [2]. The dimensions of standard mould box were used for simulation purpose. Casting simulation provides the exact temperature curves which has helped to recognizing the hotspot location ,solidification and cooling time, shrinkage porosities etc.

IV. LITERATURE REVIEW

Kassie et al (2013), have utilized factual investigation technique for improving procedure parameters of casting process. They distinguished deformities by direct perception of the blemished casting or from an exact interpretation of the imperfection, including just the criteria of shape, appearance, location and dimensions[12]. Kamble (2016), implemented different casting defects with the help of causes and effect diagram. In this evaluation numerous casting faults and their incidence cause were identified [1]. C. M. Choudhari et al (2014), optimized location of feeder and carried out various simulation trials.This facilitated the optimized result and 20% yield is improved while changing feeder location without wasting time and money. This approach has helped in minimizing the solidification related defects, thereby providing a defect free casting [3]. Pandit et al (2011), studied the techniques for design of a casting which is an essential action in tooling improvement. It includes decisions concerning part alignment in mold, parting line, cores, cavity layout, feeders, feed aids and gating system [11]. An incorrect design leads to either reduced feature or low yield, disturbing industrialized costs and productivity. Narayanswamy et al (2016), reviewed various casting defects. The regular measurement of elimination due to these faults is variable from 12.86% to 15.01% [13]. Mr. Siddalingswami (2015), suggested methodology which might be useful for foundries for controlling and decreasing the imperfections.[5] The principle target to do this exploration work is to limit rejections rate in 4R cylinder block casting, there are assortments of issues identified with item quality in enterprises in this task work diverse casting deserts are examined out by Advance systems. Dabade et al (2013), joint and castoff the enterprise of trials and computer aided casting imitation methods to examine the sand related and method related defects in green sand casting [14]. Sadekar et al.(2014) found that yield is the capability of a foundry to manufacture acceptable casting in an effective way. Improving yield offers many commercial as well as financial benefits to the foundry. Along with direct cost control, high yield is also associated with better process control, and therefore improved cost control. optimum gating system can be designed by using simulation software and rejection rate reduced from 10.6% to 1.52% ,also considerable improvement is seen in the yield of casting.[4]

V. QRL CYLINDER

QRL cylinder is a part of Sound Casting Pvt. Ltd. It is used in john deer tractor assembly. Manufacturers of QRL were facing major problems due to defective casting. To improve the casting process and minimize the casting defects, the analysis was planned for increase productivity of QRL Cylinder. Hence this project aims to reduce rejection level and to increase process capability of QRL Cylinder. The flowchart given covers the processes for manufacturing the QRL cylindar;

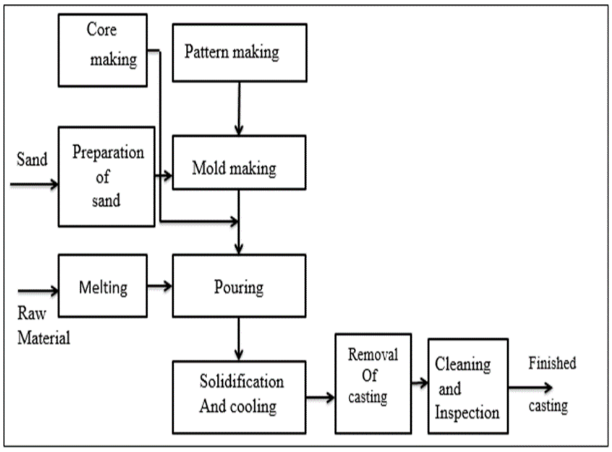

Fig. 1.2 Process Flow for manufacturing of QRL cylinder

The probable cause of defects occurring in casting was shrinkage and porosity [15]. With reference to research paper and fish-bone diagram the main reasons like faulty gating, feeding system are identified which can provide more yield.

VI. MODELLING AND SIMULATION

1 .CAD Modeling using Auto cast Software.

The present gating system poses chances for the core to break and create uneven casting. Hence it was decided to change the model of gating. Hence the model of casting, shown in Figure 1.3 was prepared using Solidworks Software.

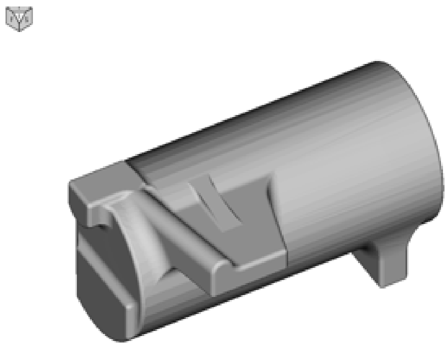

Fig.1.3. Solid model of QRL cylinder

2. Data Collection

The data regarding various process parameters, existing casting defects, material properties, design methodology of casting was collected from shop floor and analysed for experimentation purpose. The three dimensional solid CAD model was prepared in solidworks and converted into STL file formate which was used as input in simulation program. Subsequently mould box dimensions and parting line were selected.

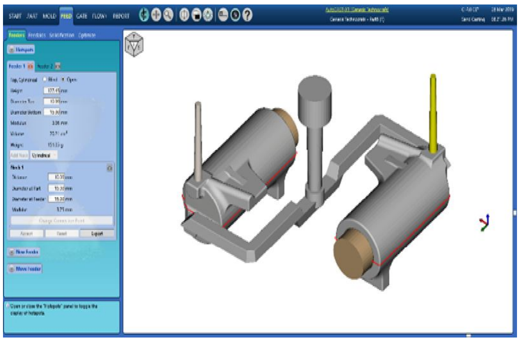

Fig. 1.4 Model of QRL after importing into Auto CAST software Gating system

Pouring temperature, casting material, type of casting etc. were entered as input in AutoCAST-X software for analysis [16]. Analysis was done based on input data .The Fig.1.5 shows the feedpaths converging at particular position in part. Single separating gate was provided to fill the mould cavity and gating system modified. Pouring was done through central sprue which was attached to the runner.

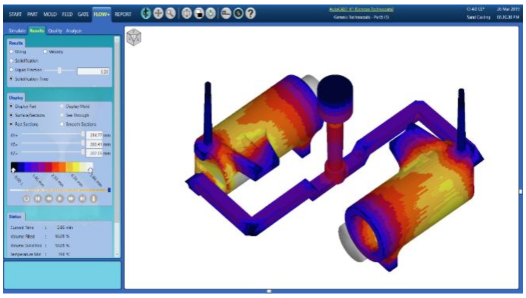

Fig.1.5 cooling of molten metal

During inspection, it was found that the castings contained hollow surfaces which occurred due to improper flow of molten metal. Shrinkage and breakage of core was the result of improper metal flow at the entry.

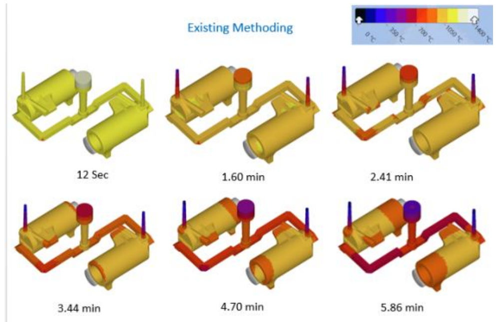

Fig.1.6 Solidification Temperature feature allows to see temperature in casting.

To overcome the problem of high pressure, which may result in core damage, the gating system was redesigned. Liquid Fraction feature was used to identify casting locations with isolated liquid metal locations, which may lead to shrinkage porosity defect in the casting as shown in fig 1.6

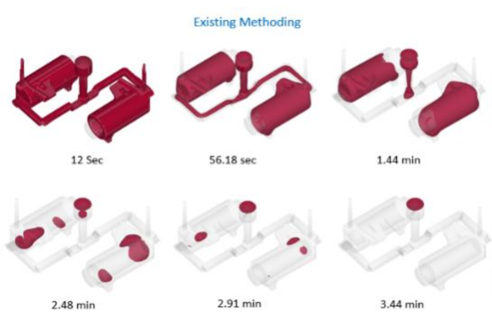

Fig.1.7Liquid Fraction feature

The FEED module permits planning and optimizing the feeders with or without the feedaids to achieve the preferred feature with high yield. Casting solid model was simulated and result was obtained by studying feed metal paths and cooling profile. The feeder design was inevitably optimized, compelled by user constraints. Fig. 1.7 shows the last solidified region of casting which was optimized by simulation.

3. Validating the Result obtained Using Auto CAST Software

The model of existing system was analyzed and the areas of shrinkage were noted using Auto CAST software. After analysis, sample castings were prepared and machined. The QRL were found with shrinkage near the areas as analyzed in Auto CAST software. Hence again one more design modification in gating system was done to minimize the casting defects and to create uniform filling by molten metal in to the mould. [14]

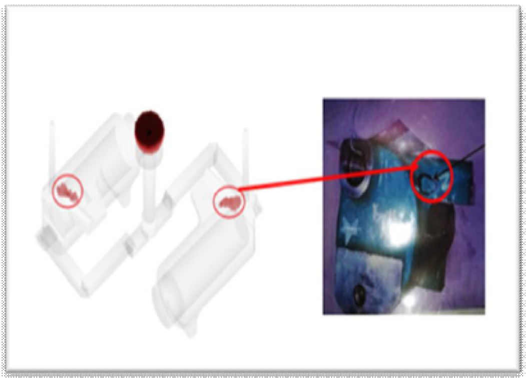

Figure 1.8 Existing model of QRL with shrinkage as mentioned in Auto CAST software

VII. MODIFIED GATING SYSTEM

a. Modified layout 1

In order to eliminate the shortcomings of the current gating system, a model with new gating system was designed. In this new gating system, the feeders were added nearer to the main casing body. A model with new gating system was prepared using AutoCAST software. Simulation showed improved casting. There was a slight increase in the weight of metal in gate and runner, but the quality of casting was improved.

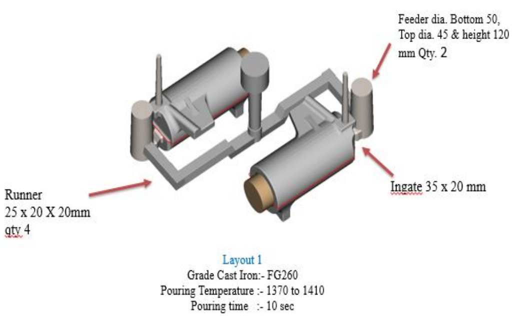

Fig 1.9 Modified layout 1

The cost of extra metal was negligible compared to cost saving because of minimization of rejection of casting. In the previous model the drag gating was exactly at the center of the QRL, but in the new design, the gating in the drag is slightly away from the center to have a better stream of molten material when it is poured into the mould cavity.

This change in the gating system allows the molten material to flow in such a way that the gases are pushed away and ensures no gas being trapped in the molten metal.vent holes are provided to release the gases evolved when molten metal enters the mould cavity. The thickness of the runner was increased when compared to the existing design to have sufficient flow of molten material. Two gates were fixed at the cope side and one at the drag side. The gating at the drag was to provide uniform flow of molten metal at the bottom portion and to direct the molten metal entering from the top to fill the mould completely.

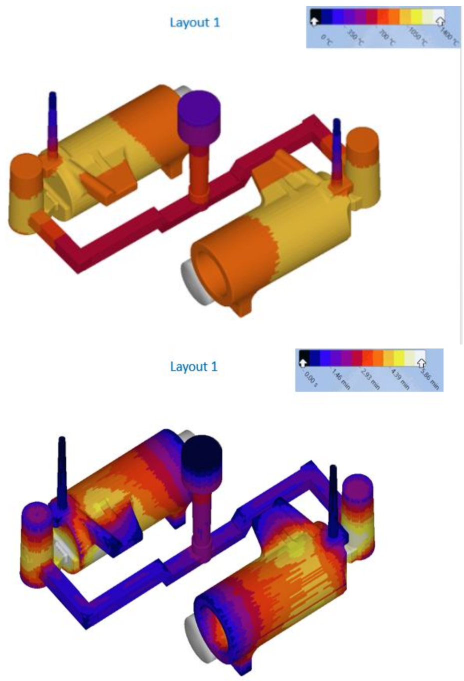

Fig.1.10 solidification and cooling temperature distribution

The mould feeling process and solidification simulation with existing gating system analysis disclosed that the shrinkage porosity exist in casting mould in non acceptable range which is shown in fig.1.8. Solidification and cooling temperature distribution, shown in Fig.1.10 shows that due to improper location of feeder and inadequate riser dimensions, proper feeding of molten material is not possible. This produced the shrinkage porosities inside the casting. Therefore, it was necessary to modify riser neck system to remove or reduce the level of shrinkage porosities [9].

Therefore, to minimize these defects in part, number of iterations for riser neck and feeders were performed and optimum parameters for riser neck were selected.

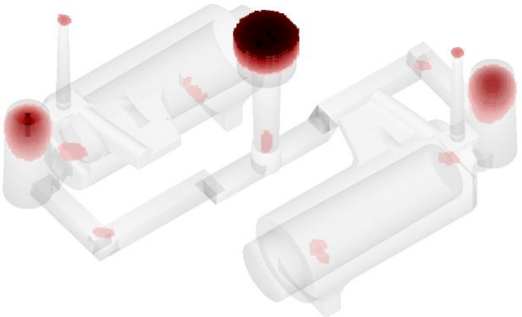

Fig. 1.11Shrinkage porosity observed in the part.

b. Modified layout 2:

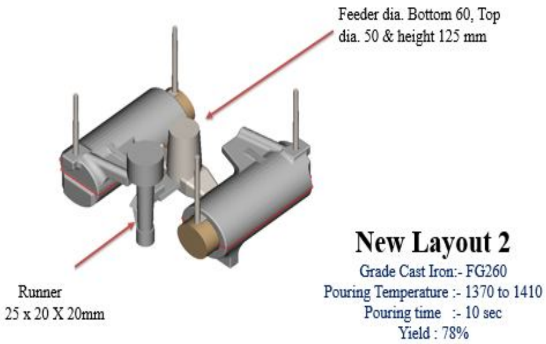

Fig. 1.12 Modified layout 2

Feeder location has been changed according to simulation modification in design and has been located precisely at the center of the gating system as shown in Fig.1.12.

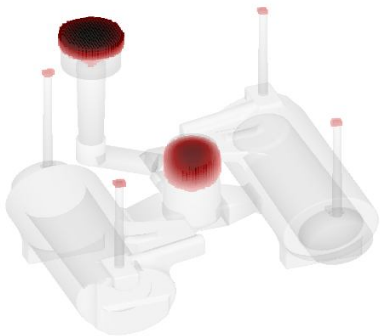

Fig.1.13 No shrinkage found on QRL region

The liquid solidification plot shows feeder placed inside the core works well and results in sufficient feeding of casting during solidification and hence decrease in level of shrinkage porosities inside the casting [5].

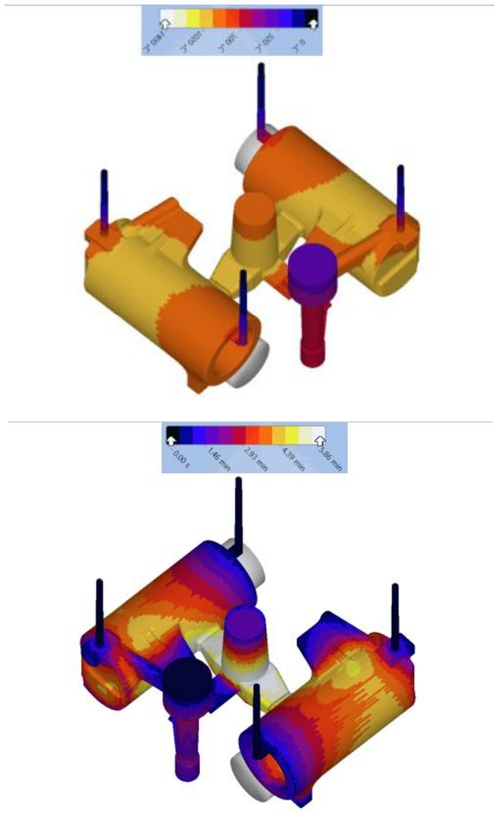

Fig.1.14 temperature variation of molten metal

Fig. 1.14 shows the temperature variation of molten metal in the mould cavity. Here red and orange region denotes liquid metal present in riser and blue and violet are solidifying region which has lower temperature than riser region.

VIII. RESULT OF SIMULATION AND EXPERIMENTAL VALIDATION

Few experiments were performed to study the effects of factors causing dimensional variation in QRL cylinder. Finally for validation of first and second model available from AutoCast, experimentation was done to analyze the improvement in the quality of casting.

IX. CONCLUSION

With the modifications suggested using AutoCast software, considerable minimization of defects is observed.

- AutoCAST has proven its importance in the analysis of casting, which would not have been easy in actual experimentation. AutoCAST simulation has given a better model which resulted in minimum defects and improved yield.

- In first layout percentage rejection is reduced from 4.82% to 3.2 % .
- In second layout percentage rejection is reduced from 3.2 %to 2.4 %
- One more modification layout is suggested for future implementation and improvement in casting process.

X. ACKNOWLEDGMENT

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REFERENCES

[1] Bhushan Shankar Kamble (2016), "Analysis of Different Sand Casting Defects in a Medium Scale Foundry Industry - A Review", International Journal of Innovative Research in Science, Engineering and Technology , Vol. 5,ISSN(Online): 2319-8753

[2] C. M. Choudhari et al (2014) "Casting Design and Simulation of Cover Plate using AutoCAST-X Software for Defect Minimization with Experimental Validation", ICMPC, 6, pp. 786 – 797, 2014.

[3] C. M. Choudhari, et al (2014), "Methoding and Simulation of LM 6 Sand Casting for Defect Minimization with its Experimental Validation". 12th Global Congress On Manufacturing And Management, GCMM 2014

[4] D. Sadekar, et al (2014) "Yield Improvement of Castings using Computer Aided Simulation – A Case Study", International Journal on Theoretical and Applied Research in Mechanical Engineering, 3, pp. 1-4, 2014.

[5] Mr. Siddalingswami et al (SEP.-2015), "Advanced techniques in casting defects and rejection analysis: a study in an industry", International Journal of Innovations in Engineering Research and Technology [IJIERT] ISSN: 2394-3696 VOLUME 2

[6] K. Kanthavel, K. Arunkumar (2014), "Investigation of chill performance in steelcasting process using Response Surface Methodology," Procedia Engineering,97, pp. 329 – 337, 2014.

[7] ManikandaPrasath K (2014), "Optimal Riser Design in Sand Casting Process Using GeneticAlgorithm," International Journal of Scientific & Engineering Research, 5,pp. 371-374.

[8] Jolly MR et al (2000) "Use of simulation tools in the practical development of a method for manufacture of cast iron camshafts. In: Modeling of casting, welding and advanced solidification processes" (MCWASP IX) Aachen, Germany, pp. 311–318, 2000.

[9] Utkarsh S. Khade1 and Suresh M. Sawant (2014), "Gating Design Modification Using 3D CAD Modeling and Casting Simulation for Improving the Casting Yield," ISSN 2250-3234, 4, pp. 813-820, 2014.

[10] Swaroop S. Magdum andBaliram R. Jadhav,(2015) "Design and Development of Casting by Simulation Technique for Yield Improvement in Foundry Industry," Volume 3 Issue VI, IC Value: 13.98 ISSN: 2321-9653, 2015.

[11] HarshwardhanPandit, et al ,(2011), "A case study on simulation using AutoCAST", INSTITUTE OF TECHNOLOGY, NIRMA UNIVERSITY, AHMEDABAD 382 481

[12] A. Kassie1 et al (May. 2013) "Minimization of Casting Defects", www.iosrjen.org, Vol. 3, e-ISSN: 2250-3021, p-ISSN: 2278-8719

[13] Narayanaswamy.C et al (2016), "Review Analysis of Casting Defects with Respect to Indian Standards in Cast Iron Foundry", Journal of Chemical and Pharmaceutical Sciences, ISSN:0974-2115

[14] Uday A. Dabade, et al (2013)"Casting Defect Analysis using Design of ExperimentsDoE) and Computer Aided CastingSimulation Technique", www.sciencedirect.

[15] A.K.Gajbhiye et al (2014) "Minimization of Shrinkage Porosity in A Sand Casting Process By Simulation In AUTOCAST-X Software with Experimental Validation by Destructive testing", IJMER ISSN: 2249–6645, Vol. 4 .

[16] Harshil Bhatt et al (2014), "Design Optimization of Feeding System and Solidification Simulation for Cast Iron"doi: 10.1016/j.protcy.2014.08.046

[17] V.V. Nimbalkar (2015),"Analysis & Simulation of Casting to Eliminate Casting Defects" ,International Engineering Research Journal (IERJ) Special Issue 2 Page 2231-2234, 2015, ISSN 2395-1621