DESIGN AND ANALYSIS OF GLOBE VALVE FOR REDUCING SHRINKAGE DEFECT

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Abstract: The main aim of this research is to reduce shrinkage defect in investment casting, through study and analysis. To reduce this defect, we have done changes in design of gating system through analytical designing and then verified it in industry.

***IndexTerms* – gating design. Soft Cast software, investment casting, shrinkage defect.**

I. INTRODUCTION

Investment casting is one of the oldest metals forming process and it is also known as “lost wax” casting. Investment casting process is capable for making millions of parts per year. The volumetric contraction accompanying solidification of molten metal manifests in defects like shrinkage cavity, porosity, centreline shrinkage, corner shrinkage and sink. These defects can be minimized by designing an appropriate feeding system to ensure directional solidification from thin to thick sections in the casting, leading to feeders. Major parameters of a feeding system include: feeder location, feeder shape and size, sleeves and covers, feeder neck shape and size, chills, and fins. The effect of these parameters on directional solidification by mapping the temperature gradients between the hot spot in the casting and hot spot in the feeder casting simulation can minimize the wastage of resources required for trial production. In addition, the optimization of quality and yield implies higher value-addition and lower production cost, improving the margins. Simulation programs are fast, reliable, and easy to use. This has been achieved by integrating method design; solid modelling, simulation and optimization in a single software program, and automating many tasks that otherwise require computer skills.

II. PROBLEM SPECIFICATION

In one of the casting foundry industry, they are facing the shrinkage defects produce in globe valve casting product. These defects are occurring at a time of solidification process. This defect can be seen after machining the component.
From surveying whole process of investment casting in casting company found a reason for defects in casting product. Many researchers reported that about 90% of the defect in casting is due to wrong design of gating & risering system and only 10% due to manufacturing problems. Company is manufacturing globe valve part in which they have found shrinkage defect after machining process. Due to shrinkage defect parts are rejected so that it is necessary to reduce the rejection by reducing the shrinkage defect.

III. MODELLING AND EXPERIMENTATION

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IV. PREPARE YOUR PAPER BEFORE STYLING

- **EXISTING GATING SYSTEM DESIGN**

➢ In Investment casting process most of the small parts are assemble in a tree type structure. But some of the parts that cannot be form into a tree type structure because of their heavy weight and complex geometric shape. Those kinds of parts are making as separate parts.

Calculation of initial gating system

- Pouring time (t) = (2.4335-(0.3953) logW) √W=10s
- Average filling rate = Weight of casting /Filling time = 1.198 kg/s
- Initial pouring rate = 1.5 x Average pouring rate = 1.797 kg/s
- Runner Volume =width of runner x height of runner x length of runner= 10.04 X 105mm3
- Casting modulus = Casting volume/Surface area = 4.48 mm
- Layout modulus = 9.9 mm

- Feeder modulus = 6.72mm
- Freezing ratio (k) = mf/mc
  =1.49
- Casting Yield = (weight of actual casting/ weight of poured metal) x 100
= 45.38%

➢ Here above analytical calculation is for existing gating system design. Here we can see that the weight of the method is more than the weight of the casting. Also the casting yield is also low. If casting yield is improve some minor percentage, and then weight of the method will be less. Benefits of the high casting yield is less pouring time, less pouring material, less machining process, etc.

- **MODIFIED GATING SYSTEM DESIGN**

➢ It is necessary to take certain parameter for making a new gating system design. For those parameters such as, feeder location, feeder size, feeder shape, sleeve etc. should be taken for the new design. Out of this parameter three parameters are taken into account such as feeder location, feeder size and feeder shape. Based on these parameters new design is developed. Analytical design calculation for the new gating system is given below.

Calculation of initial gating system

- Pouring time (t) = (2.4335-(0.3953) logW) √W= 9.4s
- Average filling rate = Weight of casting /Filling time = 1.2 kg/s
- Initial pouring rate = 1.5 x Average pouring rate = 1.8 kg/s
- Runner Volume =width of runner x height of runner x length of runner= 11.22 X 105mm3
- Casting modulus = Casting volume/Surface area = 4.48 mm
- Layout modulus = 9.7 mm
- Freezing ratio (k) = mf/mc =1.8
- Casting Yield = (weight of actual casting/ weight of poured metal) x 100 = 47.6%

➢ From the above calculation it can be seen that casting yield is higher than the initial gating system design. So that method weight is less as compared to previous design. Here the design is based on modulus and the freezing ratio is 1.8. Ideally freezing ratio should be 1 to 2.3 for the optimum design of feeder design. Here the optimum value is 1.8 for the feeder design and based on that the design is created in 3D cad software.

Modeling

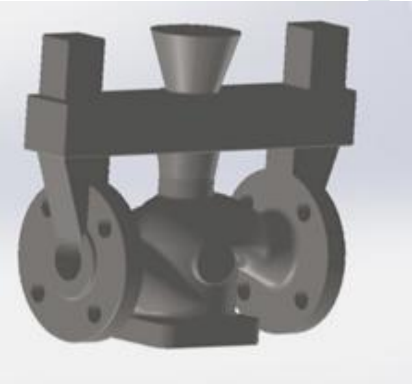


Fig. 1.Existing design

Fig. 2.Modified design

Simulation

SoftCAST is based on the radically new Vector Method for casting solidification analysis. Unlike the Finite Element Method (volume elements) and the Boundary Element Method (surface elements), it uses vector elements to analyze the progress of solidification inside a 3D casting model. This greatly increases the computation speed without compromising the accuracy of results.

Input: - The main input to SoftCAST is a solid model of the cast component, which can be created using a commercial 3D CAD system and imported in an industry-standard .STL format. Other inputs include cast metal, mold type and process parameters.

Output: - The following some main results are provided in this work after solidification analysis:

- Location of the hotspots or last freezing zones
- Refined temperature profiles of solidification on any cross-section
- Information on geometry modulus, significant modulus at any zone, yield
- Automated report generation

General Flow Work of Simulation: -
Step: 1 Converting a .STL file into .SDF format
Step: 2 File load (Casting)
Step: 3 File Load (Method Layout)
Step: 4 Select section for temperature map
Step: 5 Computations of Temperature Map and Hot Spot
Step: 6 SoftCAST Analysis Results

Results

Hotspot: - The most important information generated by a SoftCAST simulation is the location of the hotspots. Hotspots are the last freezing zones in a casting. SoftCAST accurately locates all hotspots in the casting, and displays them in order of their intensity (low to high intensity scale).A relative scale is used to show the hotspots at different temperature intensity bands or levels (from level 1 to level 9). Level 9 is the highest relative temperature intensity level. If any hotspot is located in the major intensity level (7 to 9), it will show the possibility of shrinkage defect.Here the intensity level 8 and level 9 is shown in below figure.

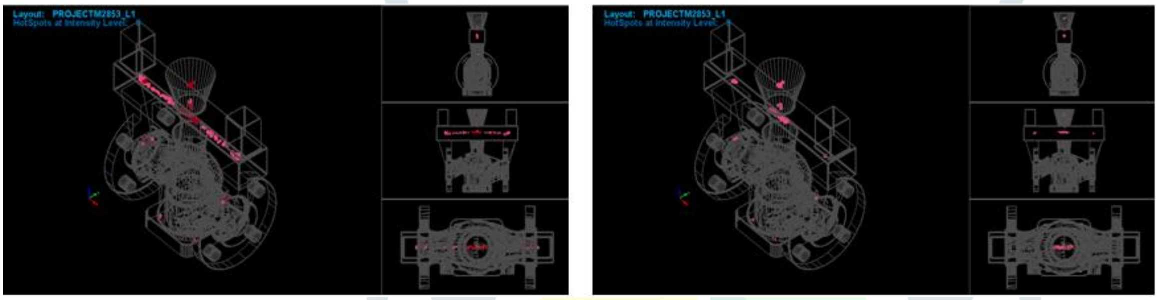


Fig. 3.Existing design analysis

From the figure 3 and figure 4, we can see that the hotspots are located in particular location. Hotspot is the last freezing zones, so that there is possibility of shrinkage defect after solidification. Ideally hotspot should come in the gating system/feeding system. If any hotspot located in the casting it will shows the possibility of the shrinkage defect.

Temperature Maps: - Another result is generated by the software is Temperature Maps at different section of the casting part. The temperature maps within the casting, as seen through the section temperature analysis in SoftCAST, provide a wealth of information on temperature distribution, thermal gradients and moduli within the various sections. SoftCAST enables the user to take sections through the casting, in any of the three orthogonal planes: XY, YZ, or ZX.

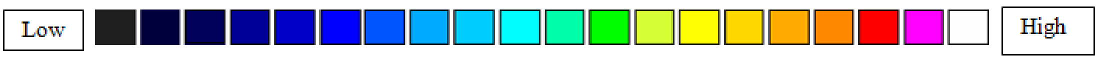
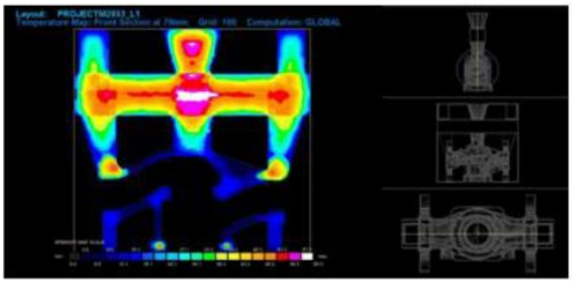


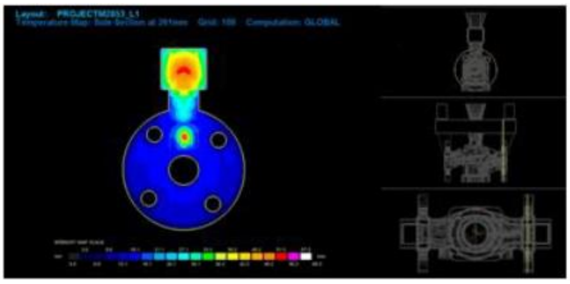
Figure 5. Relative temperature map scale

Variables of

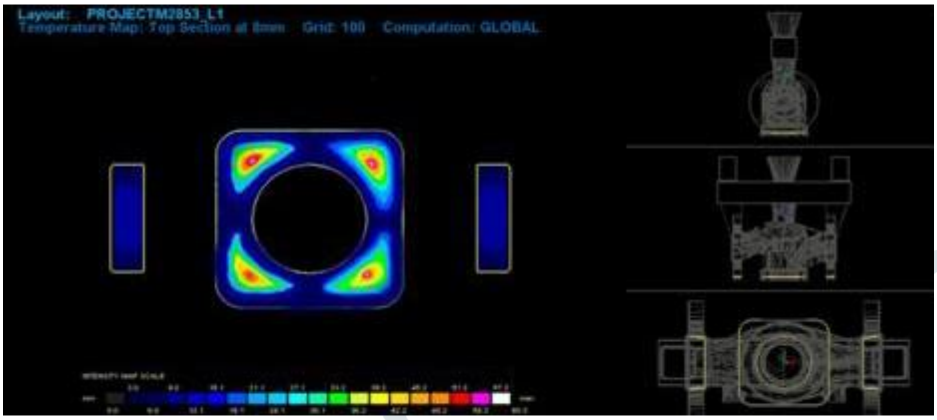
There are two options for viewing the section temperature maps, i.e. Global and Local comparisons. When viewed globally, we have a comparison of the temperatures in that section with that of the hottest point in the entire casting configuration. In the local comparison, all points in the section are compared with the hottest point within that section itself. Here the section is compute globally at different section as shown in below figure.



Front section



Side section



Top section

New Design Results:-

Here in the new modified design is based on three parameters such as feeder location, size and shape. Both Simulation result is shown in below figure as discuss as earlier.

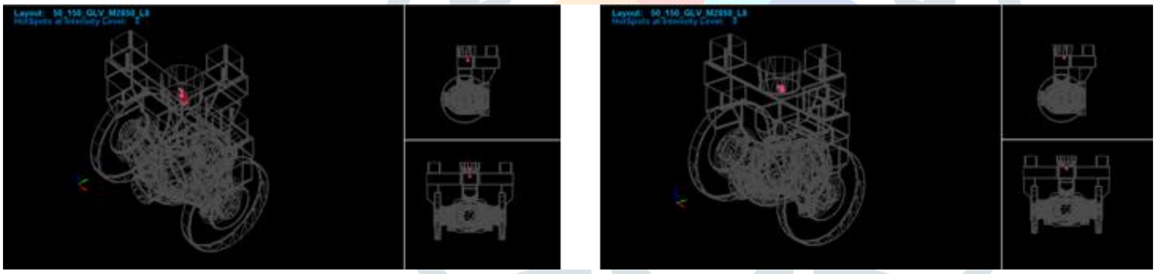
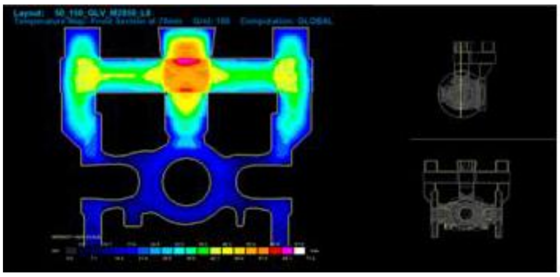
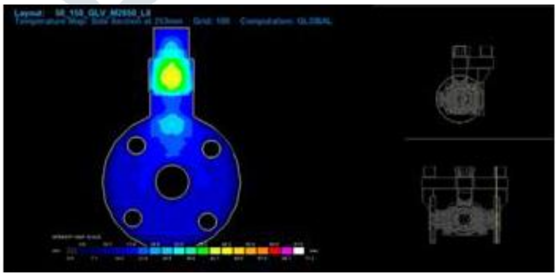


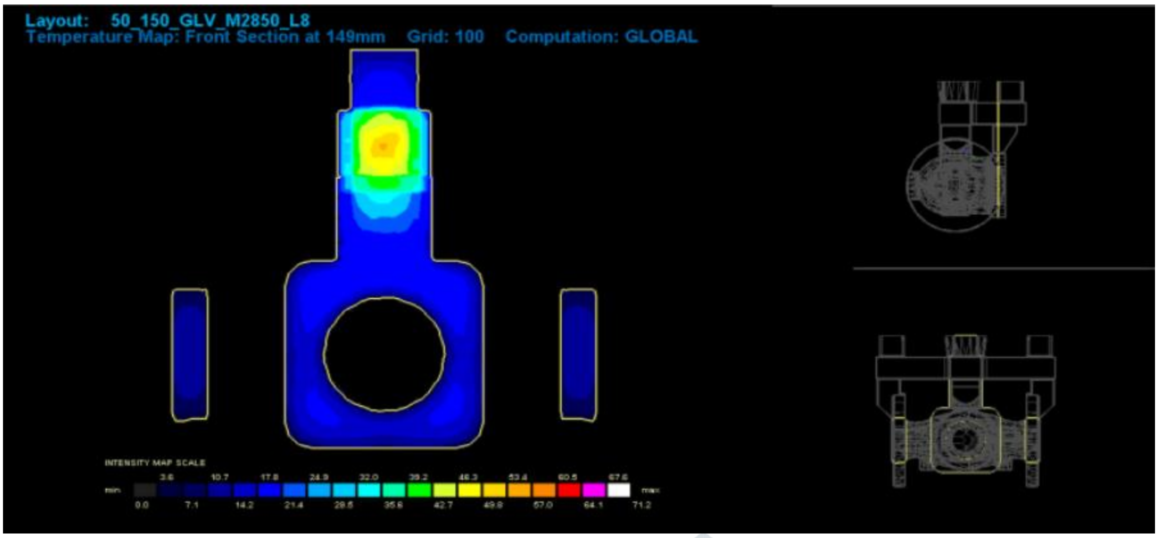
Fig. 4 Modified design analysis

From the above two hotspot result, we can see that the hotspot is completely shifted in to the gating/feeding system. Now there is no any hotspot location inside the casting part. So that, less chances of shrinkage defects inside the casting.





Front view **Side view**



Top view

In the temperature distribution map, hot zone is completely shifted in to feeding system as shown in above three different sections. So that last solidified zone is feeding system.

Comparison

Fig. 5 Defective parts using existing design

Front view of final result

Rear view of final result

Top view of final result **Side view of final result**

Fig.6 Parts using new design

CONCLUSION

- It was observe that simulation software is to predict the shrinkage defect inside the casting parts .
- It helps to predict the shrinkage porosity defect inside the casting parts without shop floor trial

Unique features of project

Casting yield improve up to 2.22%, which indicates the new method design weight is less as compared to initial method and also shrinkage defect is also reduce to a minimum level. Proper design of feeding system helps to reduce the casting defect.

REFERENCES :-

[1] M. Sutaria, D. Joshi, M. Jagdishwar, B. Ravi, "Feeding System Design and Evaluation using Temperature Gradient (Feed Path) Maps", American Foundry Society,2011

[2] Dr. B. Ravi, "Computer-aided Casting Method Design, Simulation and Optimization", Silver Jubilee Seminar Institute of Indian Foundry men (Indore Chapter), 13 March, 2008

[3] C.M.Choudhari, B.E.Narkhede, S.K.Mahajan, "Casting Design and Simulation of Cover Plate using AutoCAST-X Software for Defect Minimization with Experimental Validation", 3rd International Conference on Materials Processing and Characterisation (ICMPC),2014

[4] Rabindra Behra, Kayal S., Sutradhar G, "Solidifivation Behaviour and Detection of Hotspots in Aluminium Alloy Casting: Computer Aided Analysis and Experimental Validation.

[5] Dr. B. Ravi, Casting Simulation and Optimization: Benefits, Bottlenecks, and Best Practices, Indian Foundry Journal January, 2008

[6] Durgesh Joshi, Dr. B Ravi, "Feedability Analysis and Optimization Driven by Casting Simulation", Indian Foundry Journal, 2007

[7] Dr. B.Ravi, "Casting simulation-Best Practices", Transaction of 58th of IFC, 2010

[8] Dr. B. Ravi, "Casting solidification Feed-path computation and Industrial Application", Trans. Indian Inst. Met, 2012

[9] M. Sutaria, et all, "Automatic Optimization of Casting Feeders Using Feed-Paths Generated by VEM," Proceedings of the ASME 2011 International Mechanical Engineering Congress & Exposition IMECE, 2011 [10] P.N.Rao, Tata McGraw-Hill Publishing Company Limited, New Delhi, pp126- 180

[11] TV RamanaRao Metal Casting Principles and Practice, New Age International (P) Ltd.1999, pp121-162

[12] Commercial Version of Oriental SoftCASTTM 3.5 Casting Simulation Software

[13] Ram Prasad, Progress in Investment Castings, licensee InTech, pp 25-72