DESIGN AND ANALYSIS OF GATING SYSTEM FOR PUMP CASING

N.JAYAKUMAR[1], Dr.S.MOHANAMURUGAN[2], Dr.R.RAJAVEL[3]

[1] Ph.D research scholar, School of Mechanical Engineering, AMET University, Chennai, India

[2] Professor and Head, Department of Automobile Engineering, Saveetha University, Chennai, India

[3] Professor and Head, School of Mechanical Engineering, AMET University, Chennai, India

ABSTRACT

Design of gating system is vital in any molding or casting processes, in order to get defect free components. As far as the casting of pump casing is concerned, finding the "Hot Spot" is very important, as most of the casting defects occur at the "Hot spot". "Hot Spot" is the part of casting that gets solidified last. The "Hot Spot" usually occurs at the thickest cross section of the casting. By simulation, the most appropriate location is selected for incorporating the Gating system (gate, sprue, runner and riser) so that the "Hot spot" will be shifted to the Riser and hence we get defect free components. This task is achieved through software known as WINCAST, which is exclusively used for casting process.

Key words: Pump casing, Hot spot, Gating system, Riser, Solidification, Iteration, Mesh generation.

1. INTRODUCTION

The Sand Casting (Green Sand) molding process utilizes a cope (top half) and drag (bottom half) flask set-up. The mold consists of sand (usually silica), clay and water. When water is added, it develops bonding characteristics of the clay which binds the sand grains together. And, when applying pressure to the mold material, it can be compacted around a pattern which is either made of metal or wood, to produce a mold having sufficient rigidity to enable metal to be poured into it to produce a casting. The process also uses coring to create cavities inside the casting. After the molten metal is poured and subsequently cooled, the core is removed.

The material costs for the process are low and the sand casting process is exceptionally flexible. A number of metals can be used for castings in sizes from ounces to many thousand pounds. The mold material is reclaimable, with between 90 and 95% of the sand being recycled, although new sand and additions are required to make up for the discarded loss. These features, combined with the relative ease of mold production, have ensured that the green sand molding process has remained as the principal method by which castings are produced.

V.Gopinath[1] employed a plate casting of dimension 240x150x25 mm with the combination of different riser dimensions. Cylindrical riser of hemispherical bottom with H/D=1 were taken for his analysis. Solidification simulation was made with ANSYS software, then the solidification time and optimal riser diameters were compared with experimental results.

Manjunath Swamy H M [2] optimized the gating and risering system by using casting simulation software ADSTEFAN. Through several simulation iterations, it was concluded that defect free casting could be obtained by modifying the initial gating ratio 2:2:1 to 2:1.76:1, by shifting the location of sprue from centre to end and by providing the risers at location prone to formation of shrinkage porosity which led to the decrease in size of the shrinkage porosity about 97%.

M. Masoumi [3] experimented a direct observation method in which he showed various flow patterns resulting from different gating designs and they were recorded by a video camera and further analyzed by a computerized system. The experimental results indicated that the geometry and size of the gate and the ratio of the gating system could have a great influence on the pattern of mold filling.

Naveenkumar [4] developed a simulation tool and its application to a pump casing that was manufactured by using a sand casting route. A simulation software called ADDSTEFEN was used to design optimization of riser system by fluid flow and solidification for pump housing through several simulation iteration, it was concluded that defect free casting could be obtained by modifying the initial riser system i.e.by location of riser from outer circumference to inner side which is prone to formation of shrinkage porosity and lead to elimination of shrinkage porosity.

P.Prabhakara Rao[5] discussed a newly developed simulation tool and its application to a crusher component that was prototyped via sand casting route. Results of casting trials showed a high level of confidence in the simulation tool known as ProCAST. ProCAST is a three dimensional solidification and fluid flow package developed to perform numerical simulation of molten metal flow and solidification phenomena in various casting processes, primarily die casting (gravity, low pressure and high pressure die casting) and sand casting.

Vipul M Vasava [6] investigated and described in his paper about the porosity formation in the casting component of Housing. He felt that in the current environment, many casters still use the trial and error approach for process development. The capability to produce sound casting component of high quality and at the same time, reducing product costs & development times is the most challenging job for the foundry today.

By his simulation, he observed that porosity can be reduced by changing appropriate gating system, riser design and modification.

In today's competitive world and with the most modern manufacturing techniques available, the manufacturers must be pretty good in satisfying the need of the customers and consequent to that they need to be quality conscious. In mass production, it is almost impossible to inspect each and every product that is produced and hence we are forced to adapt to production techniques that need minimum or no quality inspection involved. In the sand casting process that we adopt, the casting component is modeled first, using CATIA V5 modeling software. Once the component is modeled, it is simulated using unique casting software known as WINCAST. As the result of simulation, a proper gating system is designed. A perfect gating system for the casting ensures defect free components and shuns quality inspection.

2. METHODOLOGY

2.1 Design of Gating System

An ideal optimum gating system should:

1. Fill the mold quickly.
2. Fill the mold with a minimum of turbulence.
3. Establish thermal gradients, which promote soundness.
4. Avoid reoxidation of metal in the gating system.
5. Remove slag and dross from the metal as it flows through the gating system.
6. Not distort the casting during solidification.
7. Maximize casting yield.
8. Be economical to remove.
9. Be compatible with the pouring system used.

In the gating system for EN-GJL-250 casting, the above theoretical concepts were followed to design the gating system needed to ensure defect free castings. Parameters for the gating system design are shown in Table 1.

Parameter	**Values**
Gating system adopted	Pressurized gating
Gate Type	Parting line gating
Runner Type	Trapezoidal
Sprue type	Circular cross section
Pouring Time	6-8 seconds
Gating Ratio	1.2 : 1.1 : 1
Sprue Area	1885 mm²
Runner Area	550 mm²
Ingate Area	520 mm²
Casting weight	21 kg

Table.1. Summary of Gating System Design Parameters

2.2 Component Modeling

The Pump Casing was modeled using the conventional 3-D modeling software Pro-Engineer. Figure.1 shows the comprehensive model of the pump casing without meshing and Figure.2 shows the same model with meshing without gating system.

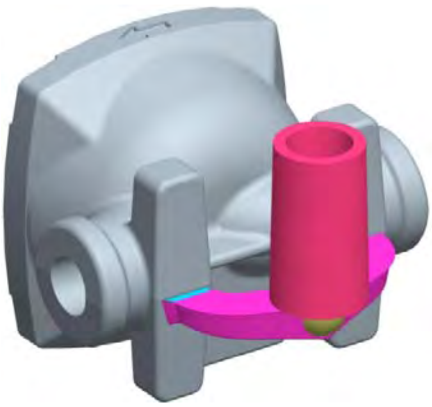

Figure.1. Pump Casing Model-Unmeshed

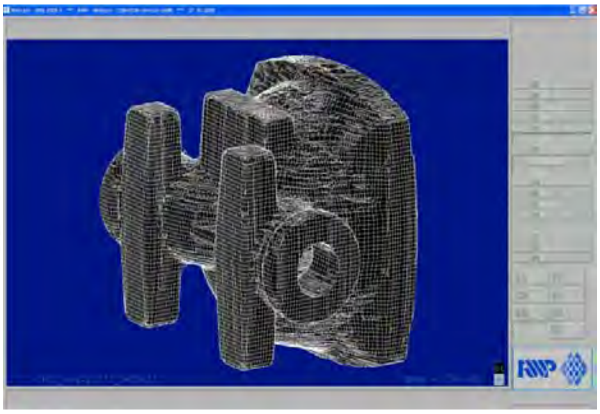

Figure.2. Pump Casing Model- Meshed

2.3. Simulation-First Iteration:

Once the component modeling was completed, it was subjected to simulation and the “Hot Spot” was identified. As soon as the “Hot spot” was identified, a proper gating system was designed. This is known as first iteration. Simulation using WINCAST software includes four modules or stages known as

1. Data Conversion
2. Mesh Generation
3. Temperature Field Calculation
4. Result Representation

2.3.1 Data Conversion

When the component model was created, all the data were saved in IGES format which is not supported in WINCAST. Hence the data of the model was converted into STL format which is supported by the WINCAST software. WINCAST follows the strategy of slicing 3D structures into several number or 2D layers by inserting horizontal cutting planes.

2.3.2 Mesh Generation

Mesh generation is the first and foremost task of any finite element analysis and generating FEM mesh is decisive for the success of the casting simulation program. Several approaches were and still are being pursued in this context. The pump casing model was meshed into finite number of elements which enable accurate results. The details of mesh generation of finite element model for the first iteration is shown in Table.2

Parameter	**Values**
Total number of nodes	5026
Total number of elements	9930
Total number of layers	74
Total number of boundaries	120

Table.2. Meshing Details for First Iteration

2.3.3 Temperature Field Calculations

The temperature field calculations includes the following

1. Mesh details: Here, the comprehensive meshing details such as no of nodes, no of layers, no of elements etc are calculated.
2. Time scan detail: This gives us the information about at what time, the execution begins and at what time the execution ends.
3. Material definition: This gives us details about the material used for casting and mold. Here, the material used for casting was EN-GJL-250 and for the mold is green sand.
4. Boundary conditions: The required boundary conditions are applied here at all the sides.
5. Execution: The actual execution starts here.

2.3.4 Result Representation

As the temperature field calculations are over, the model was executed. During execution of the project, we got the following results. As the time progressed, the casting started to get solidified. We could see the various stages of solidification with respect to time. The parts that get solidified last are called “Hot Spots” of the casting product. Figures.3, 4, 5 and 6 show the temperature analysis with respect to time. The actual solidification starts at 1175ºC. From Figure.6 (after execution) we were able to find out the “Hot Spot” of the casting and a suitable gating system was incorporated accordingly.

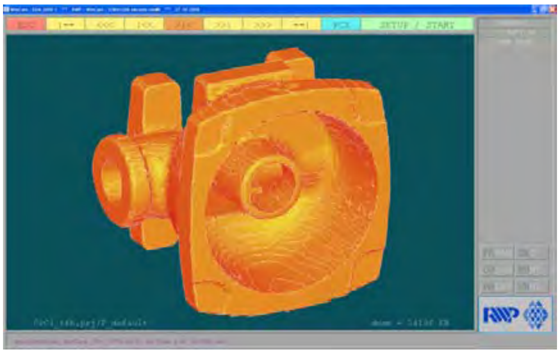

Figure.

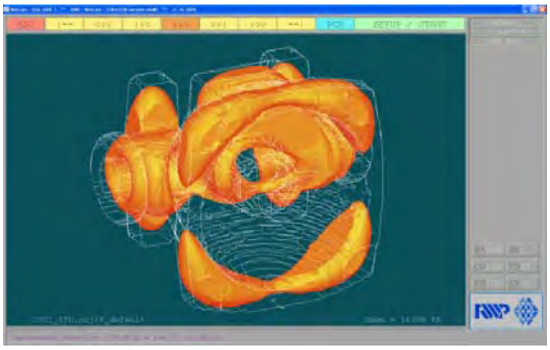

Figure.4

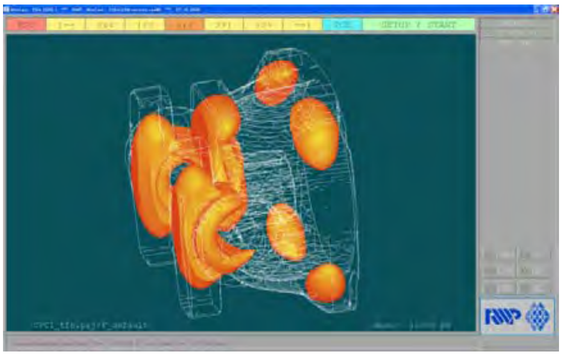

Figure.5

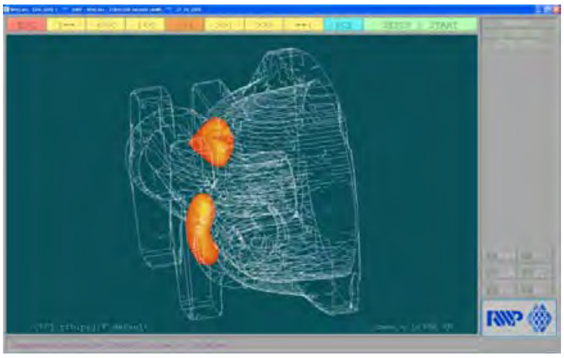

Figure.6

2.4. Simulation-Second Iteration:

The component is remodeled with the incorporation of the gating system. Now, the remodeled component with proper gating system was subjected to simulation. Similar to the first iteration, the second iteration also had four stages viz Data conversion, Mesh generation, Temperature field calculations and Result representation. The finite element model with gating system is shown in Figure.7 and meshing details for the second iteration is given in Table.2.

Parameter	**Values**
Total number of nodes	2863
Total number of elements	5634
Total number of layers	74
Total number of boundaries	90

Table.3. Meshing Details for Second Iteration

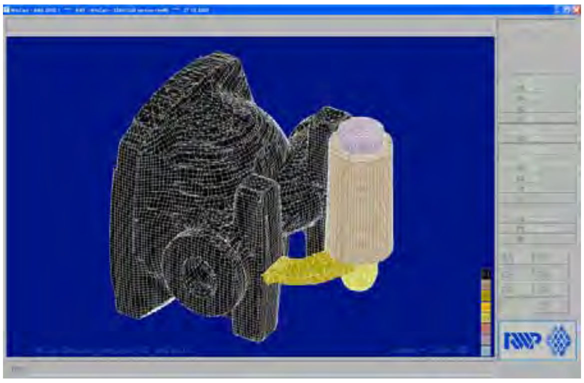

Figure.7

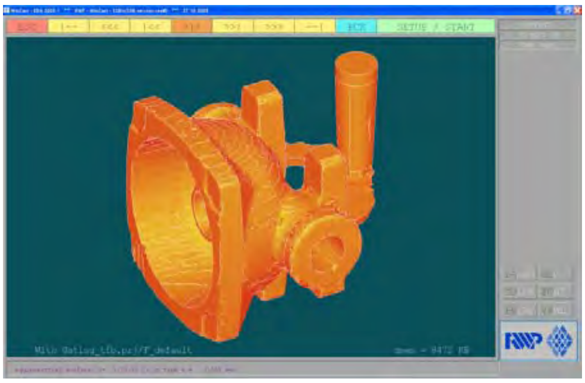

Figure.8

3. RESULT AND DISCUSSION

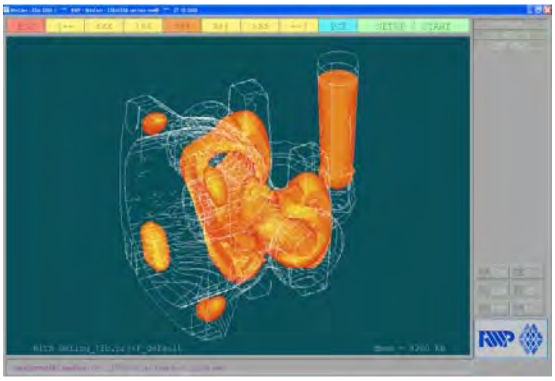

Figure.9

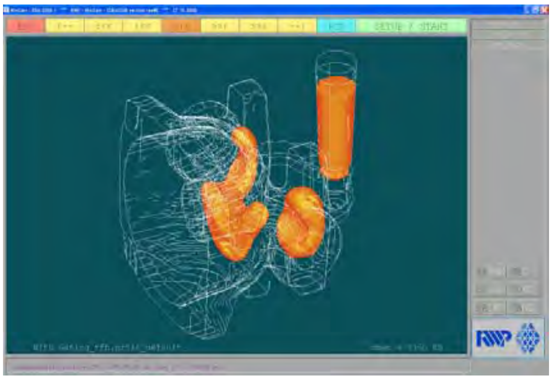

Figure.10

Figure.8 shows the beginning of the solidification process at 1175°C. As the solidification process continues, the spots with smaller cross sections cool faster and the spots with bigger cross sections take longer time for solidification which can be seen in Figure.9. After the completion of second iteration, we were in a position to witness three hot spots. Among them, the biggest "Hot Spot" was shifted to the riser. This is seen in Figure.10.

4. CONCLUSION

From figure.10, we can see three "Hot Spots" and the largest of them is being present at the riser. Therefore we could come to a conclusion that the above design of gating system for the pump casing is correct. Though, we have encountered with more than one "Hot Spot" for the pump casing, they did not produce any casting defects such as internal cracks, porosity, blow holes, warpage or sink marks, because of the phenomenon known as Graphite Expansion or Graphite Growth, which normally occurs if the material used for casting is Gray Cast Iron or its equivalent materials. As we have used EN-GJL-250 for the casting, Graphite expansion in EN-GJL-250 compensated the shrinkage that occurred at the "Hot spot" during solidification and hence we did not run into any kind of casting defects.

5. REFERENCES

[1] V.Gopinath, N.Balanarasimman, "Effect of Solidification Parameters on the Feeding Efficiency of

[2] LM-6 Aluminium Alloy Casting", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684 Volume 4, Issue 2 (Nov. - Dec. 2012), PP 32-38, www.iosrjournals.org.

[3] 2.Manjunath Swamy H.M, J.R.Nataraj, C.S.Prasad, "Design Optimization of Gating System by Fluid Flow and Solidification Simulation for Front Axle Housing", International Journal of Engineering Research and Development,vol.4,PP.83-88,October 2012.

[4] M. Masoumi, H. Hu, "Effect of Gating Design on Mold Filling", Transactions of the American Foundry Society, Vol-113,Pg 185-196, 2005.

[5] Naveenkumar, Bharat.S.Kodli, "Design Optimization of Gating System by Fluid Flow and Solidification Simulation for Pump Casing by Sand Casting", IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 4, Aug-Sept, 2014, ISSN: 2320 – 8791, www.ijreat.org.

[6] P.Prabhakara Rao, G.Chakraverthi, A.C.S.Kumar, B.Balakrishna, "Application of Casting Simulation for Sand Casting of a Crusher Plate", International Journal of Thermal Technologies, Vol.1.No.1 (Dec2011)

[7] Vipul.M.Vasava, Prof.D.R.Joshi, "Identification of Casting Defects by Computer Simulation-A Review", IJERTTV Vol.21.Issue.August-2013.