

Analysis of pump body casting by using casting process simulation

Mr. Rohit L. Dhongade, Dr. S. K. Patil

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 body 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 or gating and hence we get defect free components. This task is achieved through software known as AutoCAST, which is exclusively used for casting process

Keywords— Pump casing, Hot spot, Gating system, Simulation, Solidification



1 INTRODUCTION

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 NX10 modeling software. Once the component is modeled, it is simulated using unique casting software known as Auto-

N. Jaykumar et al. [1]: here in this paper the study of design and analysis of pump body casing with iteration is done. In the first iteration the as the time progressed, the casting start to solidify and various stage of solidification with respect to time are observed and the changes in gating system design and remeshed and the result the results are observed where the results show shifting of hotspot towards the riser.

Harshil Bhatta et al. [2]: In this paper author has attempted study of gear box casing which is having problem such as shrinkage, cold shut, mismatch and crack in casting. Author tried different size riser for casting to avoid the defect.

U. S. Khade et al. [3]: Here the author redesigned the

CAST. 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.

The design of gating system consists of various elements like pouring basin, sprue, sprue well, runner and ingates. They act as the way for the flow of molten metal from pouring basin to various parts of the mold cavity and with influencing the casting quality and economy. Number of casting defects are happens due to the faulty design of the gating system and poor pouring. Proper design of feeder helps in avoiding the solidification related defects (hot spot). Also helps in improving the yield of the casting.

gating system for the disc brake component in such a way that it consumes less metal. And casting yield is increased and and remelting and recycling costs are reduced. Author analyzed the initial gating system and these gating systems modified with different parameters and compared the result for modified gating system and according to that riser modification is done.

Hasan iqbal et al. [4]: investigated the impeller shaped casting using MAGMASOFT Software. The effect of the location and size of risers and gates on parameters such as filling pattern, pressure and velocity, cooling rate, solidification and related defects were studied. The predicted results were then compared with experimental data, and an excellent agreement between them was reported.

C.M .Chaudhari et al. [5]: Indicated that one of the reasons is the complex casting process; the other is the lack of theoretical guidance. In view of the reasons above, the current casting process is usually designed according to designers experience and intuition. These has inevitably led to repetitions and readjustments in practice, thus giving rise to more scraps and higher cost.

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2 NUMERICAL SIMULATION USING AUTOCAS-T-X SOFTWARE OF PUMP BODY CASTING

Simulation based trials do not involve wastage of material, energy and labour, and do not hold up regular production. Computer simulation provides a clear understanding of the casting phenomena to identify the location and extent of internal defects, ensuring defect-free castings. Thus, numerical simulation of casting can be considered as an important method to make casting technique change from experience test to science guidance. It requires a standard .stl file of the methods layout. However, the application of proper boundary conditions leads to accurate results of simulation. Here the dimension of pump body casting is shown below in fig.1. the CAD model is Done by using NX-10 with proper allowances which is required for the casting.

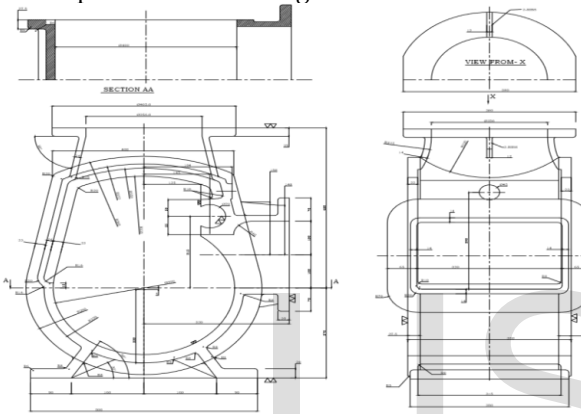


Fig.1 Dimension of Pump body Casing

2.1 Part and mould box

Here in this the Casting material used here is Cast iron and mould material is green sand as per the foundry requirement. The prerequisite of this software is to create the part model in CAD software and save it as a standard .stl file for importing in Auto CAST. The mould box dimensions have been taken as 1000*1100*1000 mm as shown in Fig.2 The entire mould containing the casting is automatically subdivided into cubic elements for internal computations such as thickness, solidification and mould filling. The element size is defined as 7.61 mm.

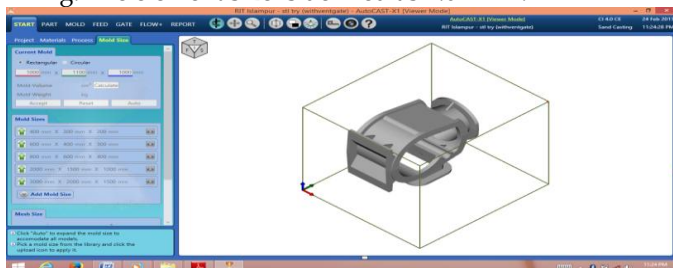


Fig.2 Mould shape and size

The thickness function allows two types of thickness computations: section thickness 55.47 mm and X-Ray (Radiography) thickness: 509.61 mm (Fig. 3). It is helpful in understanding the thickness in casting. So it is easily observed section having more thickness. So helps in understanding the section which solidifies last. The map is shown below to understand the approximate value of the thickness.

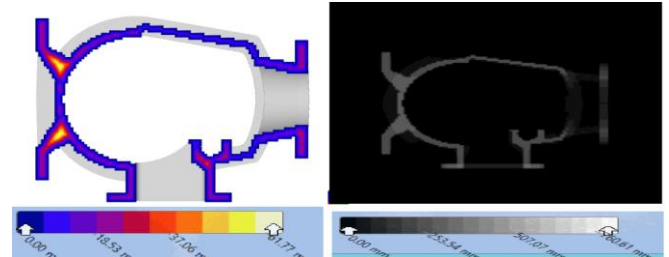


Fig.3 Part thickness and radiographic map

Part process compatibility has been checked using the optimize function. Here three parameters are checked for part-process compatibility viz. part weight, part size and minimum thickness as shown in Fig. 4.

Compatibility index = \sum_i importance of parameter i
 \times compatibility of parameter $i = 100 \%$.

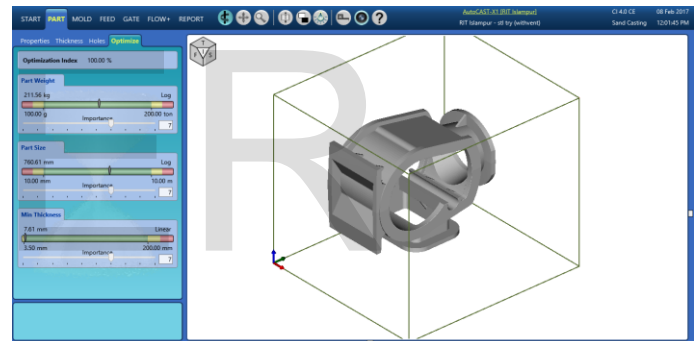


Fig.4 Part process compatibility evaluation

The parting line is created using the volumetric mesh elements. Parting direction is selected as horizontal. Moldability index is 100 % which is computed on the basis of metal to mold volume ratio, and number of mold elements as shown in Fig. 5.

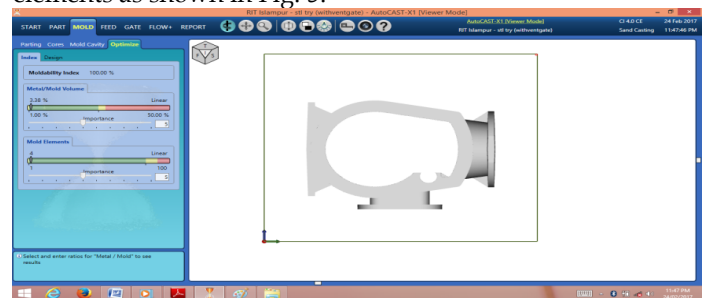


Fig.5 Parting plane and moldability index

Casting solidification is simulated and the results are shown as cooling animation, feed metal paths, and shrinkage porosity distribution. The feeder design can be automatically optimized, driven by user constraints. Here, the last solidifying region of the casting or hotspots in casting has been identified as shown in Fig.6 here in this case gating system is provided to the casting in such a way that the hot spot is shifted towards the gating system. So the shrinkage defect is avoided. Gating located closest to major hotspots to allow feed metal transfer during volumetric contraction that accompanies solidification shrinkage. Simulation helps in reducing the shrinkage and reduced hotspot and crack with help of autoCAST.

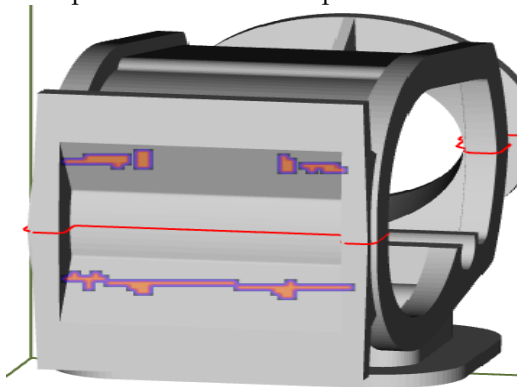


Fig.6 hotspot indicating last solidification region

2.2 Solidification Simulation

Casting solidification is simulated to view the progress of cooling from casting surface to interior, and to predict the location of shrinkage defects such as porosity and cracks. This helps in verifying and optimizing the design of gating so that the desired quality and high yield are achieved. Here, two main results are produced:

- Cooling animation: progressive solidification (casting surface to interior)
- Feed metal paths: directional solidification (thin to thicker regions)

The progressive solidification is indicated by isothermal maps (equal temperature). The directional solidification is indicated by feed paths (temperature gradients). Both are color coded (white=high temperature, blue=low temperature) as per the scale displayed. A third result, shrinkage porosity is also generated by interpreting the above two results. This is expected in regions of high temperature and low gradient. Casting simulation can be used for analysis of casting defect related methoding such as shrinkage porosity by by mould filling solidification analysis.

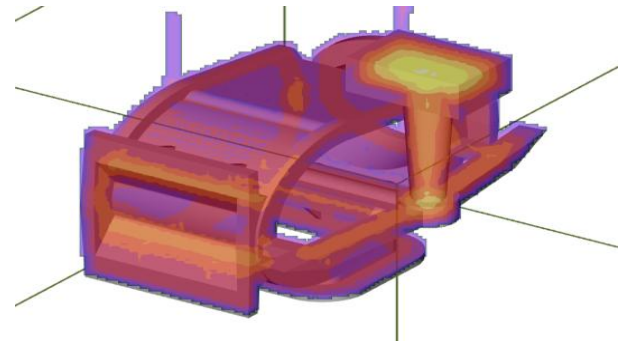


Fig.7. Cooling simulation of casting

Visualizations of 3D as well as 2D cooling simulation have shown that there exists no isolation in the casting. This result also validates the proper design and location of the feeder. The total solidification time required was 1.49 hrs and maximum and minimum temperatures of the casting observed at the end of solidification were 726 degree C and 402 degree C respectively. Fig.7 shows casting cooling simulation. The gating system, riser effect the on casting parameters such as filling pattern, pressure and speed, cooling rate, solidification and related defects.

Feed metal paths enable visualizing the directional solidification of a casting. It flows microscopically along the

feed paths from regions that solidify later, to regions that solidify earlier (along highest temperature gradients) to compensate the solidification shrinkage. Ideally, feed paths should end inside a feeder. Long and hot feed paths converging inside the casting imply a local hot spot that can result in a shrinkage porosity defect. Short and cold feed paths are usually harmless

2.3 Shrinkage porosity

The shrinkage porosity was computed from the temperature and gradients using metal-specific process characteristics, which can be adjusted to calibrate the results with respect to the observed location of shrinkage porosity. The shrinkage porosity is displayed as dots inside the casting. Suggest that the casting defect can be improved by proper location of gating and feeder system by using simulation technology which improves the shrinkage porosity. Here the shrinkage porosity happens at the pouring basin. So it doesn't affect the casting. As shown in fig. 8.

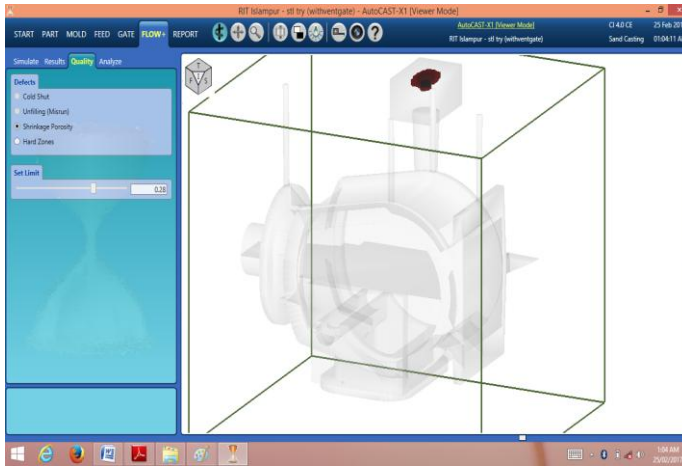


Fig. 8 Shrinkage porosity in casting

to junction solidification and incomplete fill due to sudden variations in thickness.

Gating was placed at last solidifying region using AutoCAST-X software. This approach has helped in minimizing the solidification related defects, thereby providing a defect free casting. This study shows that Simulation can be of great use in optimizing the gating dimensions and increasing the gating yield of casting.

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2.4 Cooling Curves

Cooling curves of the casting and gating system is observed by placing virtual thermocouples. At different location so the temperature distribution in that section can be easily observed in the casting. Here it is observed that the temperature is more towards the gating by observing the graph. As shown in the fig. 9.

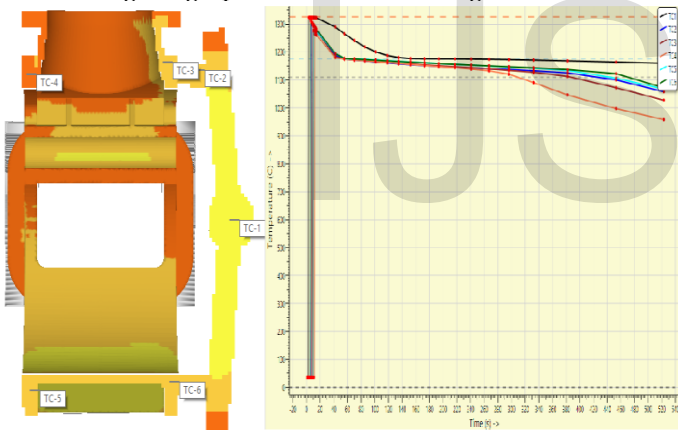


Fig.9 Cooling Curves

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3 CONCLUSION

In this study, it was observed that solidification simulation enables visualization of the progress of freezing inside a casting and identification of the last freezing regions or hot spots. This facilitated the optimized placement and design of gating with improvement in yield while ensuring casting soundness without expensive and time consuming trial runs. Proper design of gating system has immensely helped in achieving the directional solidification. There by solving the problems of failure due