International Journal of Manufacturing and Mechanical Engineering
Volume 1, Number 1 (2015), pp. 33-39

http://www.irphouse.com

Application of Casting Simulation for the Manufacturing of Rotor Disc

K. Dileep Kumar[1] and Dr. K. Srinivasulu Reddy[2]

[1]PG Student, Department of Mechanical Engineering, SNIST, Hyderabad, India
[2]Professor, Department of Mechanical Engineering, SNIST, Hyderabad
E-mail: [1]dil.deepak.kumar@gmail.com, [2]k.srinivasulureddy@gmail.com

Abstract

Casting is the oldest and widest method using in the Indian foundry. In Industries it is very important to save time and cost in manufacturing the product. Many researchers reported that about 90% of the defects in castings are due to wrong design of gating &riser system and 10% due to manufacturing problems. By replacing the existing trial and error method with casting simulation in foundry can reduce the rejection rate (defects) of the products from 8.5 to 3.5%. Casting simulation process can able to solve these problems. Here we are focusing on the component rotor disc which is a part of disc brake assembly used in the transport vehicles for braking purpose. This paper discusses the study of solidification behavior of Cast Iron rotor discand detection of hot spots in castings with the help of casting simulation software ProCast.

Keywords: rotor disc, casting simulation, riser, casting defects, ProCast.

1. Introduction

A disc rotor is the rotating part of a disc brake assembly normally located on the front axle. It consists of a rubbing surface, a top-hat and a neck section. Cast iron is a material (that has been commonly used to create components of varying complexity for a long time. This is because it is relatively inexpensive and easily formed into complex shapes. But it attains better mechanical properties when used ceramic composites.

ProCast is software using the Finite Elements Method (FEM) for simulating and analysis of various casting processes. It is a fluid flow package which is 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. It allows the modeling of Thermal heat transfer (Heat flow), including radiation with view factors, Fluid flow including mold filling, Stresses fully coupled with the thermal solution (Thermo mechanics). Besides that, it also includes microstructure modeling and porosity modeling. Special models are included in order to account for thixo casting and lost foam. Specific features are included to account for processes such as high pressure die casting, centrifugal, tilt. Finally, customized models for foundry processes, such filters, sleeves are included.

The processes carried out in ProCast are discussed below precisely.

1.1 Casting Process Modeling

Generally the simulation software has three main parts.

Mesh cast: the program reads the CAD geometry and generates the mesh,

Pre cast: adding of boundary conditions and material data, filling and temperature calculations,

Datacast & ProCast: solver, evaluation.

Mesh generation →Material assigning→Boundary conditioning →Datacast→ProCast

3D CAD and simulation tools are utilized to improve the casting process design. Computer simulation based on the design procedures described above have been implemented with one example. Let's consider a Rotor disc casting for the present study. Materials used in automobile industry are made of Cast Iron. During simulation of the casting process, mold filling and solidification are examined and gravity casting process is optimized. Fig 1.1&1.2 represents the 3D model of rotor disc and rotor disc with gating system respectively.

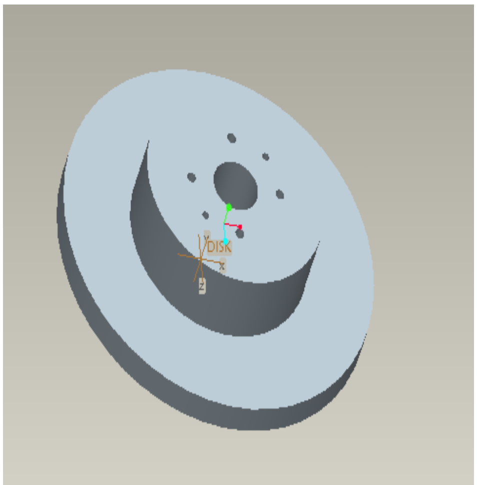


Fig. 1.1: Model of rotor Disc without gating

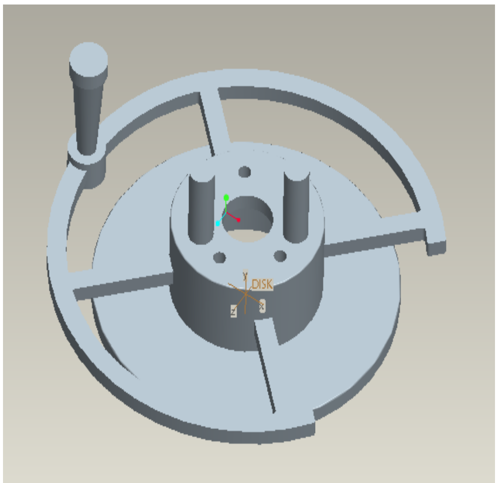


Fig. 1.2: 3D model of modified gating system

2. Methodology

The purpose of this paper is to simulate the mechanism of the solidification of Cast Ironcastings, and analyze the results to give some aspects of logical thoughts for component designation, and to optimize the casting parameters in order to achieve better properties of Cast Iron castings. The procedures were mainly divided into three stages. They are Simulation Preparation, Computer Aided Simulation on ProCast, and Analysis. Each stage contained several steps. Researcher followed this operation flow to try and examine different influencing factors, such as molten metal temperature, mold material, inlet velocity, and substrate pre-heating temperature. Figure.2.1 gives the procedure showing the entire methodology followed for the present work and succeeding this section, the substantial software.

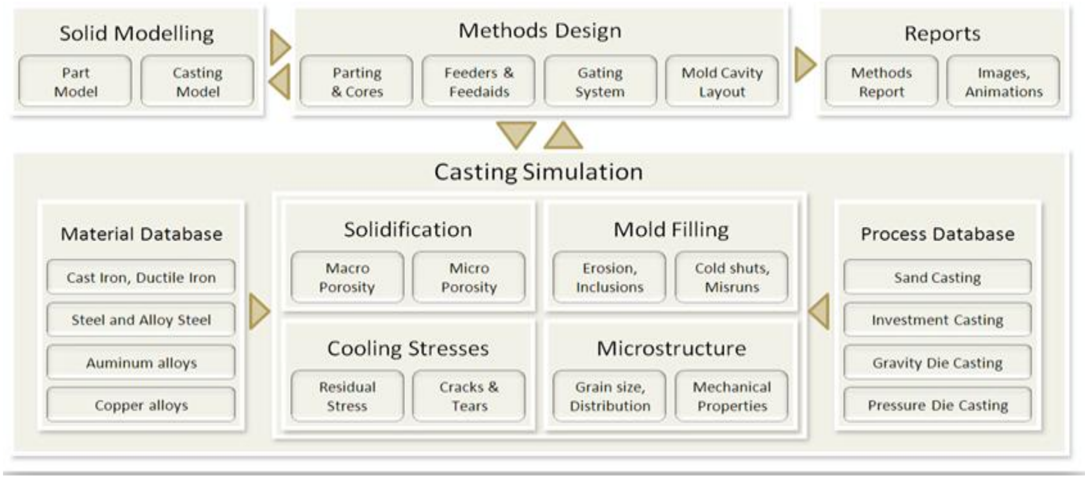


Fig. 2.1: Methodology

Table 2.1: Cast Iron Composition

Material	Composition %
Fe	93
C	3.30
Si	2.16
Mn	0.67
Cr	0.13
Mo	0.29
Ni	0.10
P	0.02
Ti	0.02
Cu	0.31

3. Results and Analysis

3.1 Mold Filling

The mold filling is to be directed by the user of software by selecting the surface of the pouring basin above the sprue. The fluid flow speed in the casting by default it will take some value or can also be specified by us The ProCast simulation solved for mold filling and solidification processes at the same time. The mold filling processes of the initial and modified gating systems are able to be visualized from Figures. 3.4(a) & (b). It is found that for every succession of one second fraction of solid and temperatures are changing (encompasses pouring basin, sprue and runner system, gatings, casting and feeder) will be filled up Figures.3.4(c)&(d). It can be seen that down sprue and feeder were filled up simultaneously since their dimensions and shapes are very similar. Though the down sprue is the entrance of the molten metal it was not filled up or completely wetted during the mold filling of cavity. Generally, the mold filling is successful as a result of proper design of straight runner system. It can be seen that the straight runner and gatings were filled up with in the first few second.

3.2 Solidification

Temperature contour of solidification and solid fractions:

For the cast material (Cast iron, solidification will start when the temperature drops below 1290°c, and fully completed beneath 300°c. Solidification is a result of heat transfer from internal casting to external environment. The heat transfer from the interior of the casting has to go through the routes of [3]

Internal liquid convection above liquidous temperature during mold filling, the solidified metal conduction after complete solidification achieved throughout the bulk of casting, the heat conduction at the metal –mold interface, Heat conduction within the CAST IRON mold and Convection and radiation from mold surface to the surrounding.

In the present case we compare the solidification simulation results of the rotor disc castings at different time intervals and different gating systems as shown in the Figures.4.1&4.2. Solidification time is proportional to volume to surface area ratio (modulus of casting) [5], therefore the faster solidification rate at the runner tip is expected.

3.3 Various Gating systems

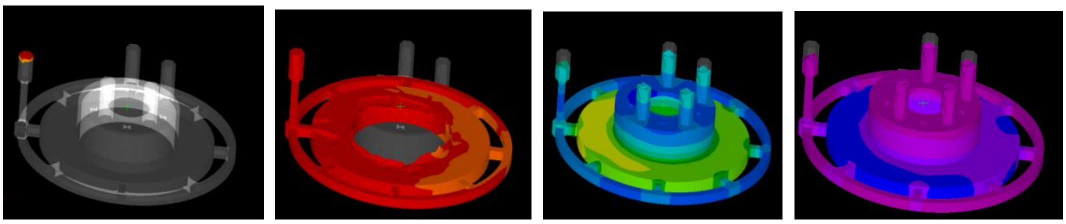
Since there are long list of possibilities for a gating system of a particular casting, various gating systems were tried and tested in the ProCast software. One of those gating system with ingates settling all around the casting can be seen in the figure 3.4(a). Molten metal is poured at a temperature of 1250°c with a yield of 60%. A defect usually seen in plate castings is the free end distortion which is avoided through an improvised gating system. The main defect with this gating system is that the ingates solidify before the molten metal reaches the Mold thereby providing no inlet to the mold and leading to a partial filling for the casting.

Moreover with such a gating system high turbulence is seen as in the figures 3.4(a) &3.4(b). Hence, a remedy for such defect would have been to increase the temperature of the pouring molten metal so that the molten metal reaches the cavity and then solidifies. A Simulation at 1200°C is done again and a defect free casting is obtained during the simulation processes. Accordingly, the turbulence levels are quite high in the initial gating system and the stresses in the casting are quite high after the solidification. A modified gating system is prepared and gating calculations performed with a yield of 80%. The molten metal is poured at 1250°C with the temperature and solidification behavior of the molten metal as shown in the figures 3.4(a) & 3.4(b).Once simulation is complete, a defect free casting is obtained with a yield of 80%.On comparison of the entire defect free castings yield, turbulence, flow, etc are to be taken into consideration such that a sound casting could be provided to the user. A defect free gating system with perfectly sound casting was the one with the modified gating system. This Gating system has higher yield, lesser turbulence of flow during mold filling and hence it has been chosen as the optimum gating system.

3.4 According to the result analysis obtained from the simulation

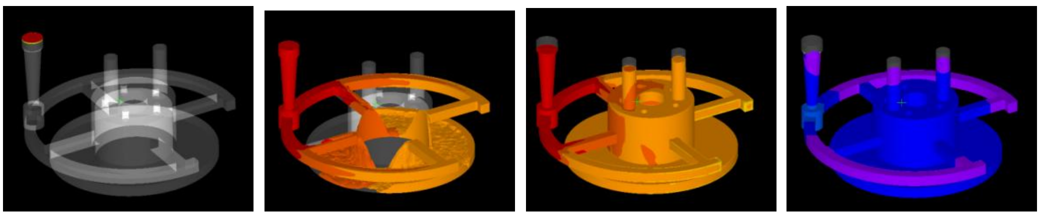
Control points temperature time tracking

The figure 3.4(a) &3.4(b) shows the temperatures changes at the casting steps. The fraction of solids and liquid metal in the mushy zone is a function of time and temperature. The solidification process is considered when the last drop of liquid metal is dissolved into solid, in a way the temperature range at the start of mold filling to the end is same in initial gating system. In the modified gating system the temperature variation between nodes at the start is not in a uniform way but at the end of solidification it attains uniformity throughout the mold. The porosity is obtained in initial gating system where as in modified gating system it is not, because of the suitable gating and riser to the component of rotor disc.



At step 0 **at 250th step** **at 500th step** **at 1000th step**

Fig 3.4: (a)Mold filling and Temperature variations of initial gating system at various stages.



At step 0 **at 250th step** **at 500th step** **at 1000th step**

Fig 3.4: (b)Mold filling and Temperature variations of modified gating system at various stages.

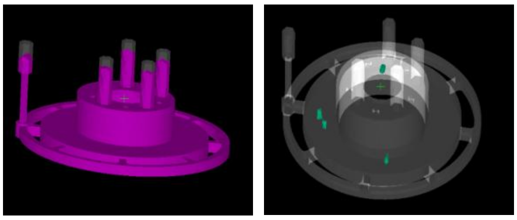
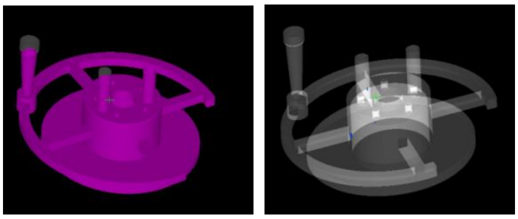



Fig 3.4(c) Initial gating system porosity **Fig 3.4**(d)modified gating system porosity

Fig. 3.4(c) &Fig.3.4(d)Shrinkage Porosityin initial gating system at various spots and No Shrinkage Porosity in modified gating system at anyspots respectively

4. Conclusions

1. By using the Simulation software it is helpful to foundry industries to abort thetime associated for trial and error and to reduce the cost involved, scrap rate, defective components and to produce a sound casting.
2. The simulation tool utilized has a provision of visual and analysis of mold filling and solidification at a time on a high integrity part.
3. The Identification of defects is carried out precisely after the solidification, like shrinkage porosity, distortion, cracks, and warm holes respectively.
4. The defects found out can be shown in the form of variant graphs at specified nodes by line graphs in software, or by numerical values manually.
5. By replacing the trial & error with virtual world simulation, can be able to determine the amount of material to be used, time required and can determine the cost of different manufacturing products.
6. The simulation software used,brings an integration in casting process between the foundry engineers and design engineers and reduces the communication gap.

References

[1] Application of Commercial Software Package"ProCast" to the Prediction of Shrinkage Porosity inInvestment Castings. www.mmat.ubc.ca/databases/Details.asp?id=354, accessed during February, 2011.

[2] B.Ravi (2008), Casting Simulation and Optimization:Benefits, Bottlenecks, and Best Practices, Technical Paper forIndian Foundry Journal, Special Issue.

[3] M.R Bharkudarov, C.W Hirt (2005), Castingsimulation: mold filling and solidification-Benchmarkcalculations using flow-3d

[4] Campbell, John (2004) , Castings Practice–The 10Rules of Castings

[5] Viswanathan, W.D.Porter (2000), Feedability Analysis and Optimization Driven by Casting Simulation, Indian foundry journal, 53(6), 71-78, 200

[6] Guharaja, S.NoorulHaq and Karuppannan, K.vM.(2006), Optimization of Green Sand Casting ProcessParameters by Using Taguchi‟s Method, International Journalof Advanced Manufacturing Technology, v. 30, n 11–12, p.1040 –1048.

[7] Hu-Hong jun et al (2006), Application of the softwareProCast in the casting of solidification simulation by, MaterialScience and Technology ,(14), pp.292-295

[8] Moreira, Jose and Ribeiro, C.A.Silvia (2003),Confrontation of two solidification simulation software to aparticular use into foundry industry, Material Science Forum,v455-456, Advanced Materials Forum II: Proceedings of the IIInternational Materials Symposium,

[9] Ravi, B (2005), Metal Casting–Computer AidedDesign and Analysi, Prentice Hall of India Private Limited,New Delhi