International Journal of Interdisciplinary Innovative Research & Development (IJIIRD)
ISSN: 2456-236X
Vol. 11 Special Issue 03 | 2026

Modeling, Simulation and Process Development for Sand Casting Process

Rohit G. Madake[1], Prof. Maheshkumar A. Sutar[2]

[1]M.tech Student, Department of Mechanical Engineering, Ashokrao Mane Group of Institution, Maharashtra, India

[2] Head of Department, Department of Mechanical Engineering, Ashokrao Mane Group of Institution, Maharashtra, India

DOI: 10.5281/zenodo.20614850

ABSTRACT

The various parts of automobile products are made by using the casting process as it is economical and can produce complex geometry. SOLIDCast is a very powerful tool to visualize mold filling, solidification, and cooling and to predict the location of internal defects. The foundry industry suffers from poor quality and productivity due to a large number of process parameters. Casting simulation can save the material and number of foundry resources involved in a foundry trial. A large number of foundries use the trial-and-error method in casting production, which affects the productivity of a company. In today's competitive age of foundries are required to more active and efficient. The objective of the study is to design the methoding system and optimize it. This project aims to study the existing method for qualitative prediction method and develop some empirical model which will provide a quantitative prediction of defects using casting simulation software for ductile iron casting considering geometric and thermal parameters. Prediction of the size and location of shrinkage defect by considering geometric and thermal parameters during solidification in a casting.

Keyword: - SOLIDCast, Simulation, Gating system, Shrinkage, Sand Casting.

1.INTRODUCTION

In the current scenario, foundry industry follows continuous improvement policy and efforts are being taken to improve the product and process parameters of various certified components. The present study analyses the current process and suggests improvements based on computer simulation and testing. Casting operation itself including the pouring of the molten material into the mold, the elements and functions of the different parts of the mold during the manufacture of the cast part, and the problems and possible defects encountered during the employment of the manufacturing process of casting. In this section, we will examine the specifics of good mold and gating system design in order to manufacture higher quality castings and minimize defects that may occur during the casting process.

SOLIDCast contains built-in tools that help to create an effective rigging system, not just test a given gating and riser design. The gating and riser design wizards take you step-by-step through the process, providing an effective and repeatable design path. Once the rigging system has been developed, It can verify the design by using comprehensive fluid flow analysis from FLOWCast and combined thermal and volumetric analysis from SOLIDCast ensure that you are creating a sound casting. Once the design is verified, you can optionally fine-tune the results using OPTICast, to automatically ensure the most efficient design, highest yield, and best properties.

2. SIMULATION PROCESS

The steps involved in the simulation process are as illustrated below,

1. A process study of the given casting and problem identification.
2. Study of parameters that are affecting the process of the component.
3. Creation of 3D CAD model of existing casting.
4. Study and compare defect prediction models.
5. Predict shrinkage and cold shut defects and validate it using benchmark casting.
6. Carry out experiments to develop the best suitable model.
7. Analysis of present riser and gating system using simulation software and verification of actual casting defects with software results.
8. Carrying out multiple simulations to remove casting defects which consist of changing casting parameters such as riser size, no. of risers, gating size and locations, use of chills, etc.
9. Predict metallurgical properties.

10. Develop a model to provide a prediction of metallurgical properties by considering various parameters in a casting.

3. CASE STUDY

In this case study, the part is having the shrinkage defect in the development stage with existing gating system so we need to redesign the gating system and verify it with the simulation results. Fig.1 shows geometry of the part

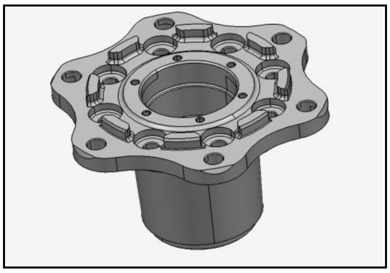

Fig -1: Casting Model

3.1 Design Calculation of gating system

- **Pouring time**

As we know pouring time depends on the casting materials, complexity of the casting, section thickness and casting size. As we know our product size is less than 450 kg and average thickness is less than 15 mm so we have to used a standard formula used for thin walled casting of thickness 2.5 to 15mm and weight less than 450 kg.

$$t = S\sqrt{W} \text{ in sec}$$

Where,
S = Coefficient taking into account of casting wall thickness
W = Mass of casting product.
Here,
S = 2.2 for table in which average thickness is between 8 to 15 mm

Thickness of casting, mm	2.5-3.5	3.5-8.0	8.0-15.0
S	1.63	1.85	2.20

Table 1: Value of 's' for different wall thickness

W is given by equation which is W = Mass of the casting product dividing by casting in yield in present unit is kg.

$$t = 2.2\,(\sqrt{39.78 * 100})$$

t = 13.42 ≈ 14 second

- **Choke area (Ac)**

The choke area is determine by using following formula

$$A = \frac{W}{dtc\sqrt{2gH}}$$

Where,
A = choke area, mm^2, W = casting mass, kg
t = pouring time, s, d = mass density of the molten metal, kg/mm^3
g = acceleration due to gravity, mm/s^2 , H = effective metal head (sprue height), mm
C = efficiency factor which is a function of the gating system used
Here,
W = 39.78 kg., H = 240 mm , C = 0.9

$$Ac = \frac{37.24}{0.89*10^{-6}*7.25*14*\sqrt{2*9810*152}}$$

Ac = 201.62 mm^2

- **Design of sprue**

Sprue height = 240 mm
Area of sprue well = 2*area of sprue choke = 2*201.62 = 403.24 mm^2

- **Design of runner**

By considering the ratio of gating system as,

Ac:Ar:Ag = 4:3:2
There for
Ar = 3Ac= 3*201.62 = 604.86 mm^2
Height and width of runner
Height of runner = width of runner = a
There for $a^2 = (604.86)$
a = 24.59 ≈ 25 mm

- **Design of Ingate**

Here,
Ag = 2Ac = 2*201.62 = 604.86 mm^2
No. of gates = 1
Ag = 403.24 mm^2
Height of ingate = a = 20 mm
Width of ingate = 2a = 40 mm
There for
$a = \sqrt{403.24} = 20$ mm

- **Design of riser**

By referring cain's method,
We know,
volume of casting = 1909853.04 $mm^{3,}$ Area of casting = 274309.52 mm^2
Volume of riser = $\frac{\pi D^2}{4}$
Surface area of riser = $\pi D^2 + \frac{\pi D^2}{4} = 1.25\pi D^2$
$X = \frac{SA_{casting}/V_{casting}}{SA_{riser}/V_{riser}} = \frac{274309.52/1909853.04}{1.25\pi D^2/1.25\pi D^3} = \frac{0.1436D}{5} = 0.0287D$
$Y = \frac{Volume\ of\ ruser}{volume\ of\ casting} = \frac{0.25\pi D}{1909853.04} = 4.122*10^{-7}*D^3$
Based on the Chvorinov's rule, Caine developed a relationship empirically for the freezing ration of follows.
$X = \frac{a}{Y-b} - c$
Where,
Y = riser volume/casting volume
a, b, and c are constants whose values for different materials are as follows.

Material	Value of		
	A	b	c
Steel	0.1	0.03	1.00
Al	0.1	0.06	1.08
C.I.,Brass	0.04	0.017	1.00
Gray C.I.	0.33	0.03	1.00
Al Bronze	0.24	0.017	1.00
Si Bronze	0.24	0.017	1.00

Table 2: Value of A, B, and C for Different Materials

$$X = \frac{a}{Y-b} - c$$
$$0.0287D = \frac{0.33}{4.112*10^{-7}*D^3 - 0.03} - 1$$
$$0.0287D = \frac{0.33-(4.112*10^{-7}*D^3)+0.03}{4.112*10^{-7}*D^3 - 0.03}$$
$1.18*10^{-8}*D^4 - 0.00086D = 0.33 - 4.112*10^{-7}*D^3 + 0.03$
Take diameter D = 91.5 ≈ 92 mm
And H = h = 138 mm.
Summary of the design calculation of the gating system is
1. Pouring time is 14 second.
2. Choke area is the 201.62 mm2.
3. Sprue height is 240 mm
4. Height and the width of the runner is 25 mm.

5. Height and the width of the ingate is 20 mm and 40 mm.
6. Diameter and height of riser is 92 mm and 138 mm

3.2 Simulation of the gating system

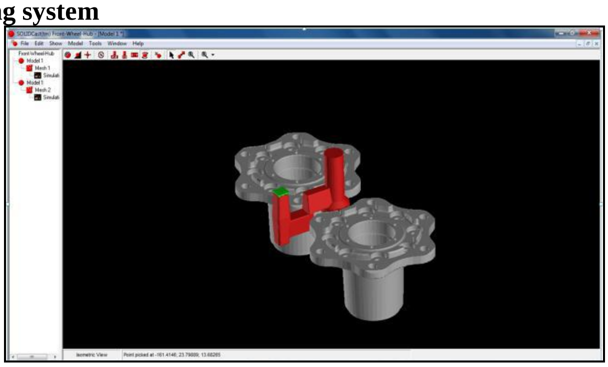

Fig -2: Model with existing gating system

In the simulation, the first step is to import or create the model. In our case, a complete gating system has been imported from the Solid Works. Fig.2 shows the model with existing gating systems. To simulate any of the gating systems, it is necessary to state the actual field conditions so material details and initial boundaries are the important steps in the process. As per the details provided by the company the material is ductile cast iron. The software can take different properties according to the casting material. The properties to be considered are thermal conductivity, specific heat, density, initial temperature, etc. The meshing is one of the most important steps in the simulation. Meshing size highly affects the simulation results as well as the node shape. As the node size is smaller, we will get more accurate results but also it will consume more time for the operation.

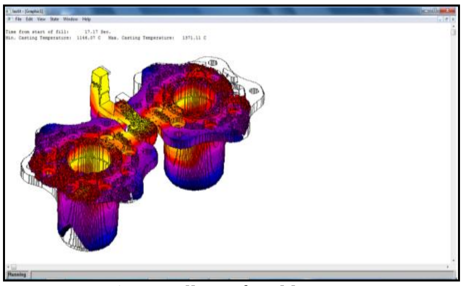

Fig -3: Filling of mold cavity.

As we start the simulation the mold filling process is started. Fig.3 shows complete filling of mold cavity. After mold filling mold started to get solidified Fig.4 shows the completely solidified model.

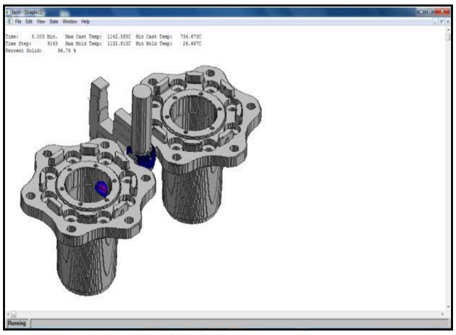

Fig- 4: Solidification of casting

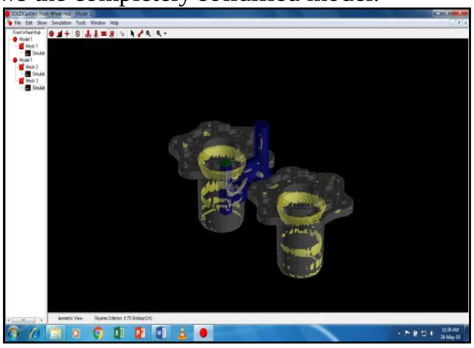

Fig- 5: Plotting the results

The simulation shows number of hot region as well as cold region by which we can imagine what will be the result of the simulation.

3.3 Result & Discussion

As we can see in Fig.5 the region which is going to solidify at last, to analyze the result we need to take a cut section of those regions. Fig.6 shows the simulated results for cutting plane 1.

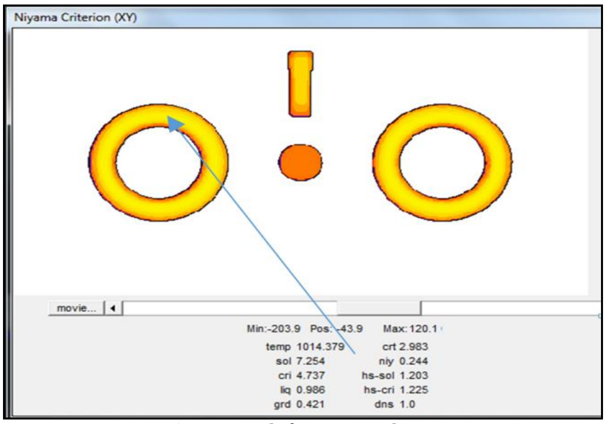

Fig- 6: Result for cutting plane 1

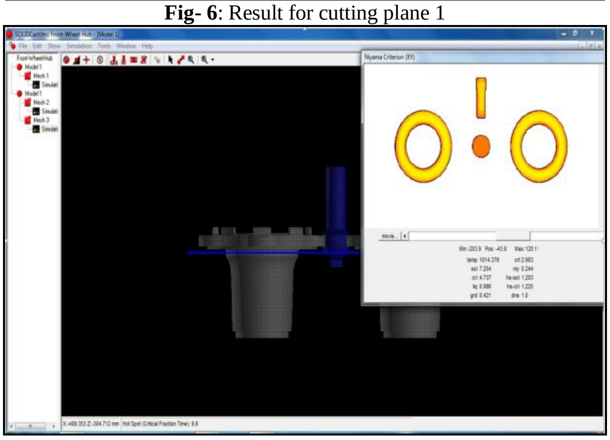

Fig- 7: Simulated Result

Simulated result shows the value of different criteria's, as the defect in the existing casting is shrinkage so we considered Niyama criteria. The value of the criteria is must be above 0.75. The actual result of existing layout shows value 0.244, which indicates the possibility of shrinkage. Now we proposed the new gating system to avoid the rejection. We suggest a exothermic sleeve for continuous feeding of hot metal. Simulation was conducted with new gating system. The Niyama value comes 0.968. The results are found Okay with new gating system.

4. CONCLUSIONS

This study was conducted on existing gating system and improved gating system, Improved gating system gives defect free results. Casting simulation helps to reduce the number of trials required in the development stage. Exothermic sleeve maintains the metal temperature in the riser and helps to compensate the liquid shrinkage during the solidification process.

5. REFERENCES

[1]. Dr.B.Ravi "Casting simulation and optimization: Benefits, Bottlenecks and Best practices" Technical paper for Indian foundry journal, Special issue, January 2008

[2]. Shashank V. Gulhane, A.D. Shirbhate "Effect of improved gating system by using standard gating ratio" International journal of engineering trends and technology (IJETT), Volume 22, No.4, April 2015.

[3]. Naveen Hebsur, Sunil Magnshetty "Casting simulaton for sand casting of Flywheel" IOSR Journal of mechanical and civil engineering, www.iosrjournals.org, Volume 11, Issue 4 Ver.VII ,PP 37-41, July-August 2014.

[4]. Swapnil L. Kolhe, Prof.S.N. Aloni, S.K. Chouksey "Design and analysis of gating system for casting using simulation software in foundry industries" International journal of innovative research in science, Engineering and Technology, Volume5, Issue 7, July 2016

[5]. Vivek S.Gondkar, K.H. Inamdar "Optimization of casting process parameter through simulation" International [6]. journal of application or innovation in engineering and management" Volume 3, Issue 6, 6 June 2014. Pandit, U.Dabade, "Optimization: Need of today's competitive age A case study on simulation using AutoCAST" Institute of technology, Nirma University, Ahmedabad,8-10 December 2010.