International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 04 | July-2015 www.irjet.net p-ISSN: 2395-0072

Yield Improvement of Cast Part Using Computer Aided Casting Simulation

Mohamad Riyaz S H[1], Prasad U Raikar[2]

[1] *Student, Product Design and Manufacturing, PG Center VTU, Belagavi, Karnataka*
[2] *Asst. Prorf., Product Design and Manufacturing, PG Center VTU, Belagavi, Karnataka*

---***---

Abstract – *Casting Simulation may use by the engineers in foundry to assure quality of cast parts and yield optimization without charging out shop floor trails, it also helps engineers to analyzing and optimizing of feedability of a casting during design phase. Casting simulation helps to visualize mould filling, solidification of casting and to predict the hot spot location where internal defects such as shrinking porosity. An internal defect occurs at the time of solidification, these internal defects can be eliminated by proper design of feed system. Yield is the ability of casting to manufacture acceptable casting in effective manner. Improved yield offers many benefits as material cost, better process control. By using computer casting simulation, an optimum gating and feeding system can be designed to improve yield, quality of casting and also eliminate internal defects. In this paper feed system is designed to eliminate hot spot location from the casting of pulp valve body part that is Guide face.*

Key Words: Yield, hot spot, casting simulation, feed system.

1. INTRODUCTION

Casting is a one of process of manufacturing used to make complex shapes of metal materials in mass production and/or individual production. There are two stages in casting, one is filling process and another is solidification of cast, in casting. In casting process, gating system consists of pouring cup, runner, sprue, sprue well and ingate or gates, which is designed to guide liquid metal filling into the mould cavity. Risers are used to compensate shrinkage caused by casting while solidification of cast part. At casting process, design flow system is important for production of quality and efficiency of a product. [1]

It is difficult to avoid that many different defects occur in casting, such as blow holes, internal porosity and improper filling. Improving the cast quality becomes important role. Casting quality is depending on the proper gating/riser system design. Therefore there is a need for use of a computer-aided casting simulation tool with CAD, and optimization functions to ensure the quality of casting. The bottlenecks and non value added time in casting development can be minimized by adopting computer-aided methods, solid modeling and casting simulation technologies. [2]

1.1 Gating System

In general the term used for describing the cross sectional area of the gating components is known as "Gating Ratio", generally defined as the ratio of sprue area to the runner area to total gate area.[1][3]

Gating systems can be classified into two types and they are:

1. Pressurized gating system.
2. Non-Pressurized gating system.

Non-Pressurized gating system:

Where the restriction in the flow of the fluid is near to the spruce is known as Non-Pressurized gating system. Here the choke of this type of the system is near sprue or at the end of the sprue or exactly below the sprue where the solid impurities are less and the metal tends to solidify at faster rate uses this type of gating system.

Pressurized gating system:

A pressurized gating system is known to as which maintain the back pressure on the gating system by restricting the fluid flow at the gates, this type of gating generally requires the total gate area not to be greater than the area of the sprue. Choke is a very important area in the gating system where it determines the mould filling time for the metals with huge amount of solid impurities generally uses the pressurized gating system.

1.2 Feeding Technology

Riser is a reservoir to hold an extra metal which compensate the liquid metal in the mould for the shrinkage solidification. It also helps in good quality casting which are free from the cavities both internal and external shrinkage cavities. There are some five requirements of the riser and they are. [3]

- It is to be the portion which has to be solidified at last.
- It should promote the directional solidification and the solidification should end in the riser itself.
- Correct volume of the molten metal so as to compensate shrinkage.
- It should completely cover the casting section which is to be fed.
- It should ensure maximum yield as much as possible.

Chvorinov's Formula: The time for solidification of castings given by

$$T = K\frac{V^2}{A^2}$$

Where,

K= Constant
V= Volume of casting in mm
A= Surface area of casting in mm^2

Inscribed Circle method:

This method was developed by Heuvers. He obtained the riser diameter by identifying the largest circle (hot spot) that can be formed in the section to be fed, and the riser diameter is obtained by multiplying the diameter of the largest circle it normally ranges from1.5 to 3.

Modulus Method:

The modulus of a casting or a feeder is simply defined as the ratio of the volume of the riser to the surface area through which the heat is taken out.

$$M_c = \frac{V_c}{A_c}$$

Where,

M_c = Modulus of the casting

From the Chvorinov's rule the freezing time of the casting is proportional to modulus square.

$$T_t = K^2 M_c^2$$

And if the modulus of feeder exceeds the 1.2 of the modulus of casting then it is satisfactory in most of the circumstances.

$$M_t = 1.2M_c$$

Feeding Risers, or appendages, are added to a casting in order to feed the shrinkage in a casting. Solidification takes place simultaneously in both the casting and risers, and liquid flows from the risers to feed the casting. The flow is driven by solidification shrinkage, contraction of the liquid and the solid as they cool, and gravity. The possible feeding mechanisms are illustrated in Fig.1 [4]

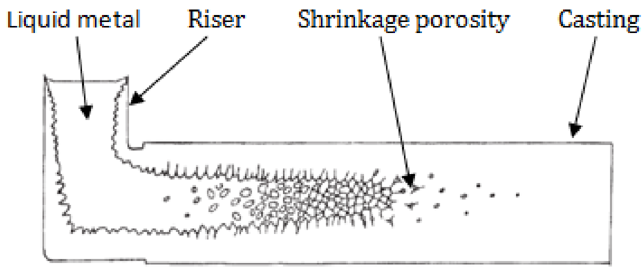

Fig. 1 Schematic representation of the feeding mechanisms in a solidifying casting. [4]

2. CASTING SIMULATION FRAMEWORK

Yield improvement of cast can be done by using casting simulation programs. The following Fig.2 represents simulation framework for feeder design and optimization. [2]

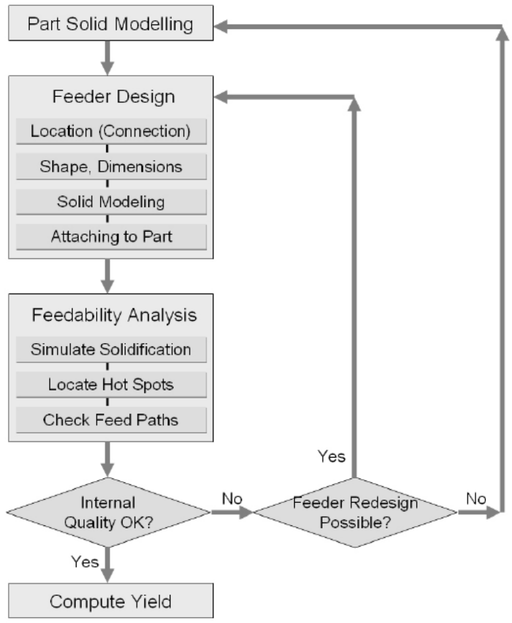

Fig. 2 Framework for feeder design and optimization [2]

- The first step in framework is part solid modeling. To do cast simulation first a CAD model of part being casted has to be prepare, and also feed system that is runner bar, ingate, risers also be prepared in CAD. These CAD models saved into standard .STL format.
- The second step in framework is the feeder design, which is carried out by finding suitable position or location to connect or match the

feeder, calculating its dimensions, and preparing it in solid model and attaching it to part model.

- The third step is feedability analysis is carried out by flow simulation and solidification simulation which is followed by indentifying presence of hot spots inside the casting and connection between feed paths. Before simulation it is important to give material property of cast material, mould property to the part.
- The forth step is in framework, if any defects are occurring, then feeder design (riser design) modified. If any defects are not visualized then the design is good. If quality of cast cannot be improve by feeder design, and then cast part design has to be modified.
- Finally, casting yield is calculated and compared with other design, and one which gives higher yield is used for implementation.

3. CASTING SIMULATION

Casting simulation is carried out in this work, by use of SOLID-Cast software which is created by, Finite Solution Inc. This program works based on finite difference method (FDM). In finite difference method mesh is rectangular in shape and made by a series of cube-shaped blocks which are called as nodes. SOLID-Cast software has built in flow simulation program that is FLOW-Cast. SOLID-Cast helps to simulate solidification and FLOW-Cast helps in flow simulation of casting.

Simulation in this paper is done on Guide face which is a body part of pulp valve, material of guide face is cast iron.

3.1 Solidification Simulation of Guide Face

To do solidification simulation material properties and mould properties as need, table 1 show material properties of guide face and table 2 shows mould properties.

Table-1: Material properties

Thermal conductivity	36.322 W/m-K
Specific heat	460.24 J/kg-k
Density	7200 kg/m^3
Initial temperature	1370 ^{o}C
Solidification temperature	1124.478 ^{o}C
Freezing rang	89.256 ^{o}C
Latent heat of fusion	230115.6 J/kg

Table-2: Mould Properties

Thermal conductivity	0.59 W/m-K
Specific heat	1075.288 J/kg-k
Density	1521.71 kg/m^3

The following Fig. 3 shows the solidification simulation of Guide face casting,

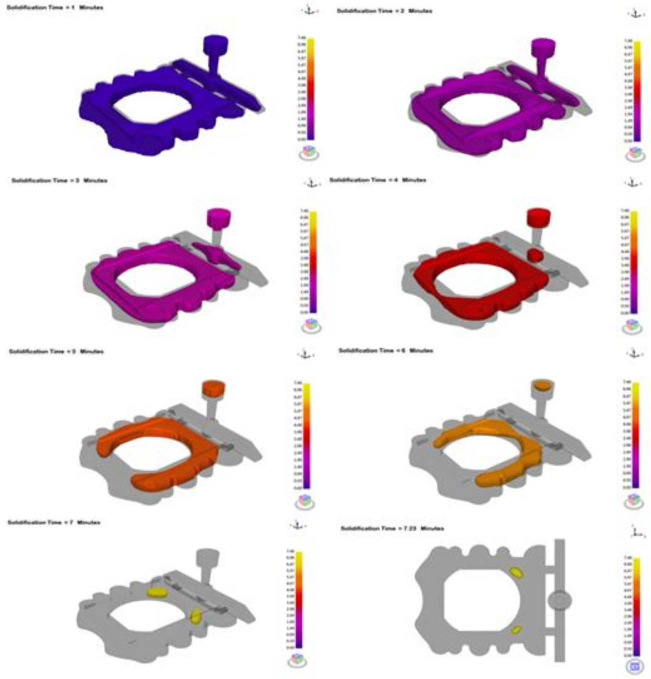

Fig. 3 Solidification simulation of Guide face

From solidification simulation it is found that there are two locations where last solidification casting taking place. Fig. 4 shows hot spot location present in the casting, the portion where hot sport accurse at that location casting will solidify last. Due to directional solidification in casting while changing its phase from liquid to solid, this last solidification in casting accurse where volume by area will be more. [5]

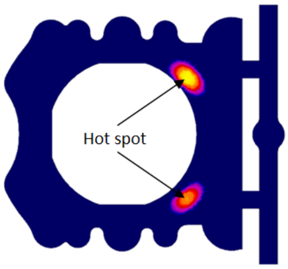

Fig. 4 Hot sopt in Guide face

This hot spot can be removed by using Riser; From the Chvorinov's rule the freezing time of the casting is proportional to modulus square. Therefore riser has to design to remove hot spot, the riser size should be such that the last solidification take place in it, if defect accurse in riser, it not lead any problem although riser is removed later from casting. [6]

3.2 Solidification Simulation with Riser

The modules of riser should be more than the modules of casting or the modules of region where hot spot present. Here Riser is designed by taking modules of riser is 1.5 of casting modules that is M_r=1.5M_c. The following Fig. 5 shows simulation result of Guide face with Riser.

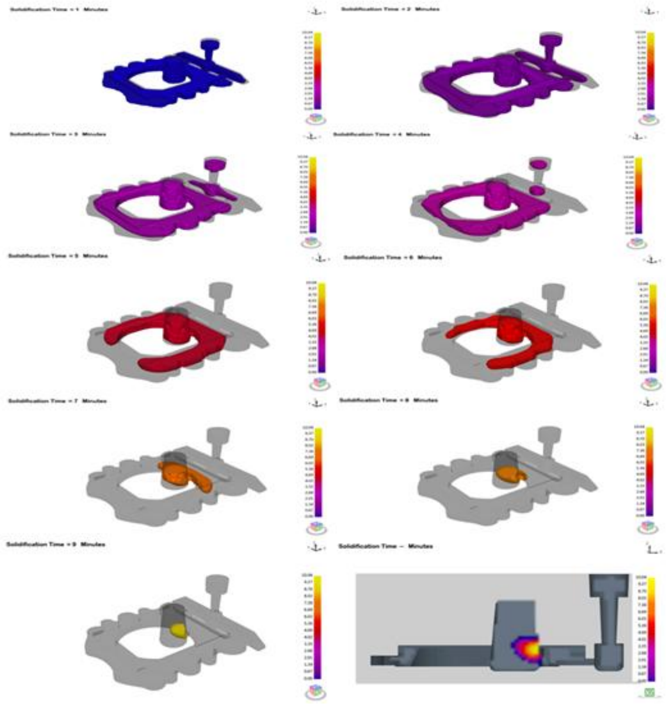

Fig. 5 Solidification simulation of Guide face with Riser

From solidification simulation of Guide face with riser it is found that the last solidification location is in riser, the below Fig. 6 show the hot spot location in guide face casting after using riser.

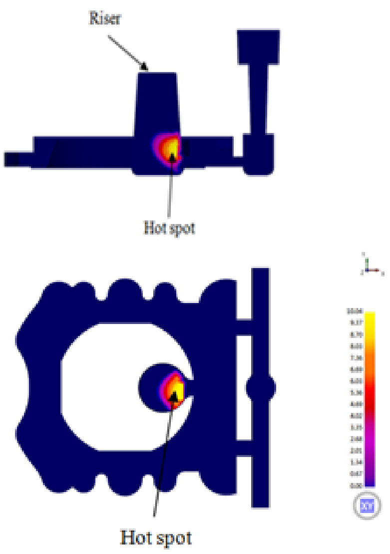

Fig. 6 Hotspot location in Guide face with riser

It is seen that after placing riser between two hot spots which are present in guide face without riser, those hot spots are moved in to the riser, and remaining casting part will be sound casting means defect free.

4. Yield calculation

Casting yield is defined as "ratio of casting mass to actually mass of the metal has entered into the mold cavity". This is expressed by following equation. [6]

$$C_y = [W_c / (W_c+W_g)]\times 100\ \%$$

Where,

W_c = weight of casting the material

W_g = weight of the feed system (spure, runner, riser)

Yield of Guide face casting

Weight of the casting = 12.2kg

Weight of feed system = 5.15kg

$$C_y = [12.2 / (12.2+5.15)]\times 100$$

$$C_y = 70.31\%$$

5. CONCLUSIONS

Computer aided casting simulation is essential tool for casting defects production and troubleshooting those defects and cast optimization. It helps to assure quality of casting and yield improvement without doing shop floor trails.

The proper design of riser and specific location of riser in casting part helps not only to provide material to casting while shrinking on solidification, but also helps to remove hot spot from the cast part.

From simulation of guide face with riser it is concluded that the designed riser, and gating system, the chances of getting shrinking defect is in riser. From this design yield of casting will be 70.31%.

By carrying out casting simulation, lot of material, time and cost can be saved which are required in shop floor trials. From casting simulation casting products can be develop very fast and time required to development of cast parts will be low.

REFERENCES

[1] Richard W. Heine, Carl R. Loper, Philip C. Rosenthal, *"Principles of Metal Casting"*, Tata McGraw Hill, 1976. p 1-22, 178-253, 491-506, 557-572.

[2] B. Ravi, Durgesh Joshi, *"Feedability Analysis and Optimisation Driven by Casting Simulation"*, Indian Foundry Journal, 53(6), pp. 71-78, 2007

[3] A.K. Chakrabarti, *"Casting Technology and Casting Alloys"*, Eastern economy edition, PHI Learning Pvt. Ltd. 2011, pp. 1-84.

[4] Qingyou Han, *"Shrinkage Porosity and Gas Porosity"*, ASM Handbook, Vol. 15: Casting, ASM Handbook Committee, 2008, p 370-374.

[5] B.S. Nagendra Parashar, R.K. Mittal "Elements of Manufacturing Processes", eastern economy edition, PHI, 2011, pp. 203-229.

[6] Rabindra Behera, Kayal.S, Sutradhar.G, "Solidification behavior and detection of Hotspots in Aluminium Alloy castings: Computer Aided Analysis and experimental validation", International Journal Of Applied Engineering Research, Volume 1, No 4, ISSN-09764259, 2011, pp. 715-726.

[7] Mayur Sutaria, B. Ravi, *"Computation of casting solidification feed-paths using gradient vector method with various boundary conditions"*, The International Journal of Advanced Manufacturing Technology October 2014, Volume 75, Issue 1-4, pp 209-223.

