Optimization of riser neck for aluminium casting by using simulation tool

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***Abstract*— The Gating and riser system design play very important role for improving casting yield. These defects can be reduced by making suitable changes in feeding constraints, such as feeder location, size, shape etc. and also by making some changes in feeder neck dimension. By choosing the correct set of parameters we may lead to the desired quality and yield, but difficult to achieve it. This is the reason that a need has arisen for computer aided casting simulation tool coupled with solidification simulation to reduce the number of shop floor trials and obtain enhanced yield and high quality, in minimal possible time. In this paper an auto industry part model is considered to study the solidification behaviour of aluminium alloy A356 along with detection of hot spots in castings with the help of AutoCAST XI simulation software and the effect of neck height on casting yield is also being studied.**

***Keywords*— AutoCAST XI, casting simulation, gating and riser design, hotspots, shrinkage cavity**

Introduction

Casting is a manufacturing process used to make complex shapes of metal materials in mass production that may experience different defects such as gas porosity, pin holes, blow holes, shrinkages and incomplete filling. In recent years, cast aluminum alloy have been used widely in automobile industry. The use of aluminum alloy castings for structural components offers significant opportunities for reducing the weight of automobiles, since aluminum alloy components are typically about half the weight of the steel, cast iron, or ductile iron component. An important factor that leads to a decrease in the mechanical properties of castings (notably ductility and fatigue life) is the presence of microporosity [1]. Prediction of the liquid metal during solidification has been important to consider the different modes of shrinkage and trace the evolution of the liquid metal free surface.

Computer Simulation provides a powerful means of analyzing various physical phenomena occurred during casting process [2, 3]. Simulation is tool which gives idea about methoding, filling and solidification of casting component. It also helps in reducing the time required to produce a new casting by eliminating the number of foundry trails. There are number of casting simulation software's available nowadays in market such as AutoCast [4], SolidCast, Magmasoft, ProCAST, which were developed by different firms keeping in mind about casting problems and are used in foundries worldwide. Shrinkage is a major defect in sand casting and often becomes a cause of casting rejections and rework in casting industry. Shrinkage is a phenomenon concerning the reduction in the size of a casting during its transition from a liquid to a solid state. The volume in both the liquid and solid phases changes under the influence of temperature. The difference in density of the liquid and solid phases, which causes a significant difference in the volume of these phases, should be taken into account. The phenomenon of metal shrinkage has a substantial impact on the quality of castings. It is however possible to minimize by providing risers at the hotspots region in the casting. Riser is a reservoir in the mould that serves as a source of liquid metal for the casting to compensate for shrinkage during solidification, also riser neck is provided to slow down the liquid metal into the mould cavity and helps in easy removal of riser from the casting after solidification.

Shrinkage porosity analysis is done by introducing a new gating system to solid model designed in CAD consisting of four cavity mold. To get the shrinkage porosity to optimize level in casting part there were number of iterations performed using casting simulation software. As result of new gating and feeding system there was reduction in shrinkage porosity (about 15%) and improvement in yield (about 5%) was observed [5]. The simulation process of casting solidification with the AutoCAST-X software of an intricate shape small size casting of LM6 (Al alloy) metal was studied [6]. With the help of AutoCAST software hotspots in the casting were located and also optimum position for placing riser in the casting was suggested. The simulation study has shown the improvement in feeding, yield and quality of the casting [7]. A new idea where optimization of casting feeding is done with the help of feed paths. The computation of feed-paths is done by method known as Vector Element Method (VEM) [8]. This method is used for benchmark Al-alloy casting where feeder optimization is done with the help of VEM based software. To minimize shrinkage porosity in casting design and location of a feeding system is essential to ensure good quality of castings [10]. In present work small size automobile part of aluminum alloy (A356) is taken for study. By performing software simulation and optimizing riser neck height yield of casting was calculated.

I. MODELLING AND SIMULATION

A. Data Collection

In this stage for selected casting the data regarding the existing defects, process parameters, materials, methods design is collected and analyzed. Input to the simulation program is the 3D solid CAD model prepared in PRO-E and converted into STL format. So 3D solid CAD model of part was created as shown in Fig. 1.

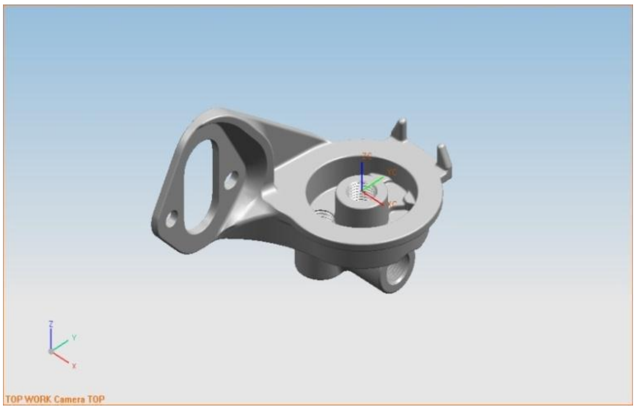

Fig.1. Solid model of part to be cast

TABLE I
INFORMATION OF CASTING PROCESS PARAMETERS

1	Material grade	AlSi7Mg
2	Pouring temperature	705 ^{0}C
3	Type of core	CO_2 cured
4	Density	2480 kg/m^3
5	Total poured weight	479.27 g
6	Casting weight	378.04 g
7	Function of part	Automobile sector
8	Molding box size	174.43 x 185.88 x 146.02 mm
9	Casting process	Sand casting
10	Chemistry of component	7% Si, 0.3% Mg, 0.2% Fe, 0.1 % Zn

B. Gating system

New gating system was designed (for single cavity mould) using theoretical formulae used for gating and risering system design. Feeder was designed by modulus method and Caines method of feeder design. Single feeder with appropriate size was used to feed the cavity mould as shown in Fig. 2.

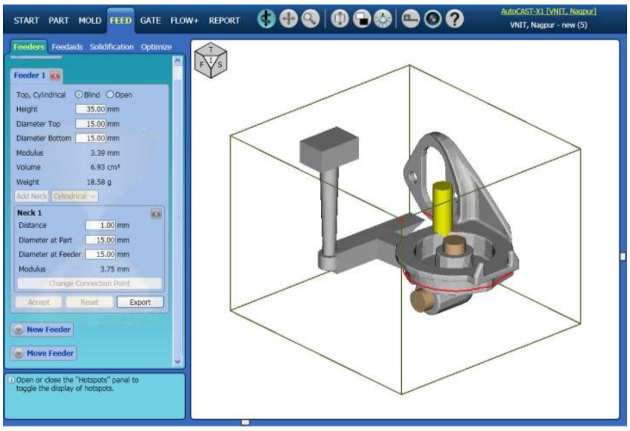

Fig. 2 Solid model with gating system

TABLE II
DIMENSIONS FOR GATING AND RISER SYSTEM

Parameters	Values
Volume of casting	141.06 cm^3
Surface area of casting	421.44 cm^2
Total gate area	2.83 cm^2
Total gate volume	8.14 cm^3
Diameter of riser	15mm
Height of riser	35mm
No. of gates and riser	1

C. Simulation and optimization

In the present work, simulation of mould filling, solidification behavior of green sand aluminum alloy castings have carried out by using VEM based casting simulation process and the effect of riser neck on the yield have studied. Also with the help of AutoCAST software the hotspots have detected within the casting part by feedpath method. The Fig. 3 shows the feedpaths converging at particular position in part. In this gating system, single separate ingate is provided to casting to fill the mould cavity. Pouring is through central sprue and single ingate are attached to the runner.

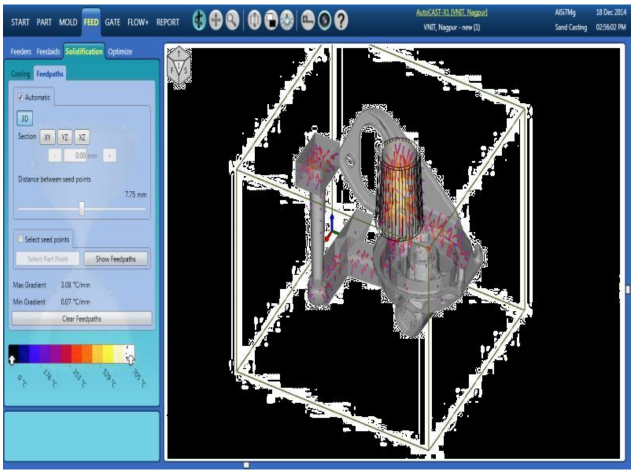

Fig. 3 Feedpaths in solid 3D model

D. Shrinkage porosities

Simulation for mould filling and solidification analysis with this gating system reveals that the severe shrinkage porosities of non acceptable range exist in the casting of the single cavity mould. Liquid to solid conversion plot shows that the height of riser neck is insufficient, due to which feeders are not properly feeding the casting during solidification though feeder sizes and locations are correct. This results in occurrence of shrinkage porosities inside the casting and hence causes rejection. Therefore, it is necessary to make suitable changes in riser neck system to remove or reduce the level of shrinkage porosities [9].

Therefore, to minimize the shrinkage porosities in part number of iterations for riser neck was performed and optimum parameters for riser neck were selected.

E. Casting solidification simulation

Similarly liquid solidification plot shows feeder placed inside the core works satisfactorily and results in sufficient feeding of casting during solidification and hence reduction in level of shrinkage porosities inside the casting. Here red and orange region denotes liquid metal present in riser and blue and violet are solidifying region which has lower temperature than riser region.

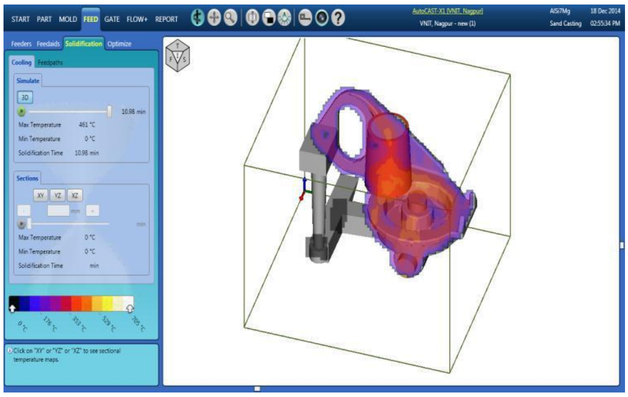

Fig. 5. Liquid Solidification plot

F. Cooling curves

Fig. 6 shows the temperature variation of molten metal in the mold cavity. By placing six thermocouples at different locations in casting part the behaviour of molten metal w.r.t time was observed. Fig. 5 shows various thermocouples TC1, TC2…TC6 variation with time. From the cooling curve graph, TC5 take more time to solidify and TC6 takes least time to solidify.

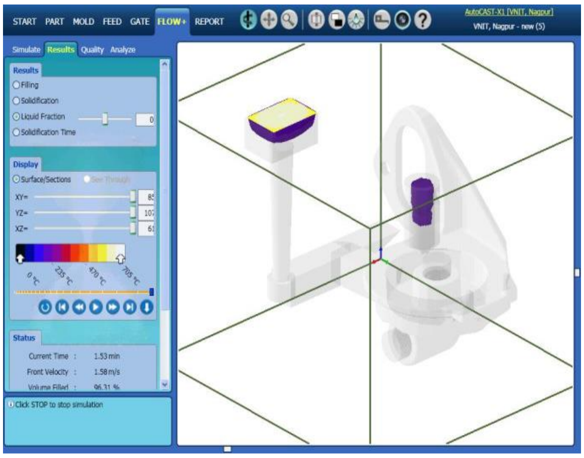

Fig. 4 Liquid fraction

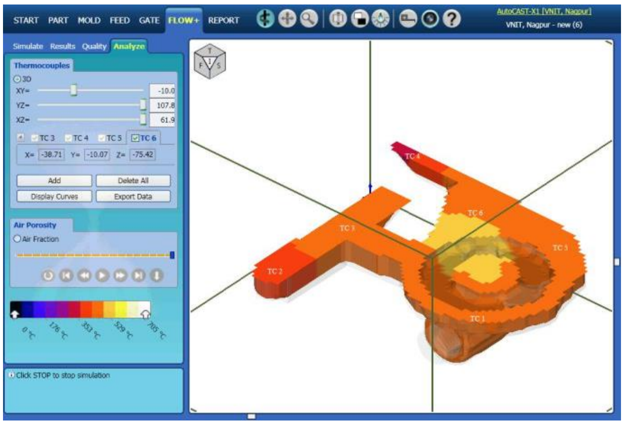

Fig. 5 Thermocouples placed at various positions in part

From the simulation results obtained on AutoCAST XI the effect of riser neck height on casting yield was studied by keeping all parameters constant as shown in below table. The optimum height of riser neck obtained by four iterations was 7 mm and maximum yield obtained was 78.8%.

TABLE III
DIMENSION OF GATING SYSTEM, RISER AND RISER NECK

Sr.No	Riser Height (mm)	Riser Diameter (mm)	Neck Diameter (mm)	Neck Height (mm)	Yield (%)
1	35	15	10	5	72.89
2	35	15	10	6	75.52
3	35	15	10	7	78.88
4	35	15	10	8	76.63

II. CONCLUSION

1. In the present work, the effect of riser neck on the nature of solidification have studied by using VEM based simulation software so that casting yield has increased by approximately 6.0 %.
2. The benchmark study reveals that the use of casting simulation software reduces the iteration time for modification of methoding and to reach at a safe design of riser neck.
3. The optimum neck height was 7 mm for that yield of casting part was maximum.
4. By number of iteration the shrinkage porosity and associated defects are reduced to minimal level.
5. The quality and yield of the casting can be efficiently improved by computer assisted casting simulation technique in shortest possible time and without carrying out the actual trials on foundry shop floor.

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