Solidification Analysis and Optimization Using Pro-Cast

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Abstract:
Now days in Industries it is very important to save time and money in manufacturing product, because there is lots of competition in industrial world. Main objective of this project is re-designed of component using Pro-cast software and increasing of this product life. Many researchers reported that about 90% of the defects in castings are due to wrong design of gating & risering system and only 10% due to manufacturing problems. Casting simulation process can able to solve these problems. It has observed that various type of simulation software has been used in foundry, out of which FEM and VEM based casting simulations are widely used in foundry. To study the solidification behaviour of material and detection of hot spots in castings with the help of mentioned above casting simulation software. The simulated results also compared with the experimental works.

Keywords: - *Design of Experiment, ProCAST, Sand casting process*

1. Introduction

Recently, due to the development of computer technology, an effort is done to predict casting defects directly as a consequence of the physical phenomena that are involved. A modelling approach based on an improved description of the physical processes has become a more realistic practical and straightforward option. Shrinkage related defects result from the interplay of phenomena such as fluid flow, heat transfer with solidification, feeding flow and its free surfaces, deformation of the solidified layers and so on. Casting, one of the economical manufacturing processes used in industries, is a complicated process, which involves considerable metallurgical and mechanical aspects. The rate of solidification governs the microstructure largely, which in turn controls the mechanical properties like strength, hardness, machinability, etc. The location, size and shape of riser in a casting depend on the geometry of the casting, mould design and thermal properties of metal, old and other process parameters. Wrong designed riser results either defective casting with shrinkage cavity or lower yield, as directional solidification has not achieved.

There are number of casting simulation software are developed and are used in foundry worldwide. The application of casting simulation softwares are also increasing day to day in Indian foundry as it essentially replaces or minimizes the shop floor trials to achieve the desired internal quality at the highest possible time.

The main inputs for the casting simulation process are:

1) Thermo-physical properties (density, specific heat, and thermal conductivity of the cast metal as well as the mould material, as a function of temperature).
2) Boundary conditions (i.e. the metal mould heat transfer coefficient, for normal mould as well as feed aids including chills, insulation and exothermic materials).
3) Process parameters (such as pouring rate, time and temperature).

2. Review

Feng Liu et al [1] in this paper, with the aid of parametric modelling technology of runner and riser are modelled parametrically. By varying each parameter, it is easy to get different casting CAD models. These models output data populate the orthogonal matrix, which is used in the orthogonal array testing strategy to define the most suitable combinations of runners and risers parameters. After inputting the completed orthogonal matrix data and all CAD models into the simulation software the simulation result can be obtained. **Marco Aloe et al [2]** observed that Gating systems, overflows, venting channels can be optimized using numerical simulation. Solidification related defects can also be predicted taking into account cooling channels and die cycling so as to accurately reproduce production conditions. ProCAST readily addresses all these issues but also includes advanced features to better assess the casting quality. **Mohammad Sadeghi et al [3]** observed that ProCAST software used to simulate the fluid flow and solidification step of the part, and the results were verified by experimental measurements. By this Paper he concludes that 1) Comparison of the experimental and simulation results indicates that defects in the pieces are placed at the predicted places by simulation. 2) If the die temperature is reduced from the optimum temperature range, probability of cold flow defects and air porosities increase. 3) Determination of optimized places of overflows by simulation led to decrease of some casting defects such as cold shots and air porosities. **Dr. S. Shamasundar et al [4]** observed that in gravity die casting of Aluminium parts, computer simulation can be a useful tool for rapid process development. Limitation of the conventional die design and gating design has been elaborated. Advantages of computer simulation based design enumerated. The procedures thus described have been demonstrated with two case studies of application of ProCAST simulation at Ennore Foundries. It is demonstrated that the foundries can derive mileage by resorting to FEM simulations of the casting process for process development and optimization.

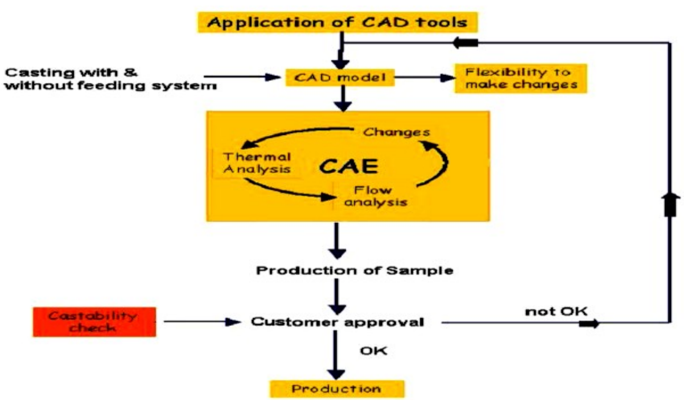


Fig. 1 Flow pattern of computer simulation

Ravneetkakriaet al [5] He observed that the effects of the selected process parameters on the surface finish and the subsequent optimal settings of the parameters were accomplished using Taguchi's method orthogonal arrays; experiments were conducted as per experimental plans given in this array. The results indicate that the selected parameters significantly affect the surface finish of LM-6 Aluminum alloys castings. The confirmatory experiments have also been carried out to verify the optimal settings of the parameters. **V. V. Mane et al [6]** he focused on finding process-related causes for individual defects, and optimizing the parameter values to reduce the defects. This is not sufficient for completely eliminating the defects, since parameters related to part, tooling and methods design also affect casting quality, and these are not considered in conventional defect analysis approaches.

3. FE Analysis using ProCAST

Figure 3.1 shows a flowchart, in which 3D CAD and simulation tools are utilized to improve the system design of the casting. The castings geometries presented here were meshed with MeshCAST, which requires the Generation of a surface mesh before meshing the enclosed region with tetrahedral elements.

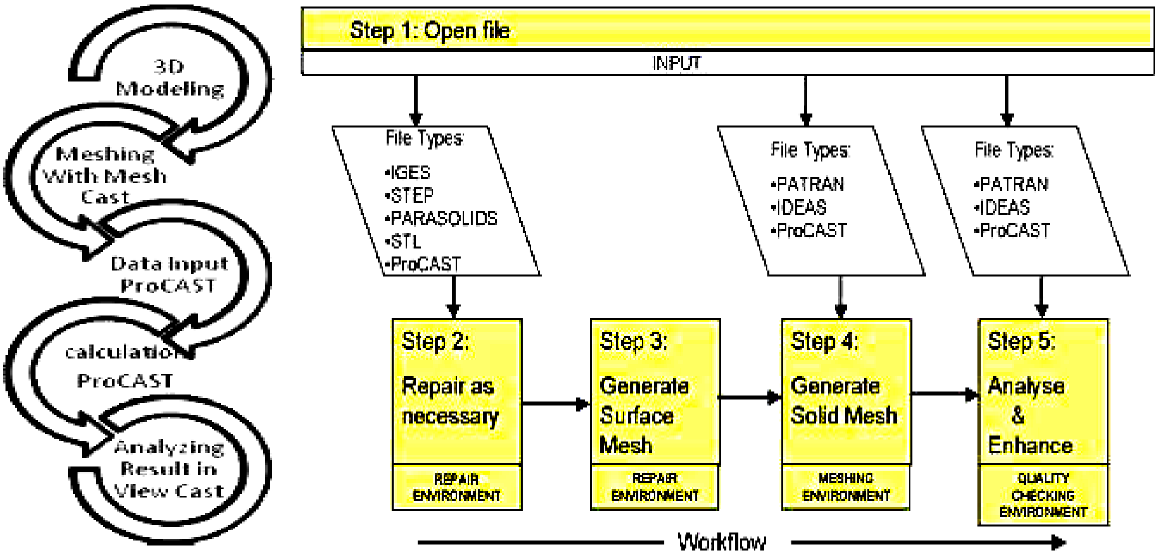


Fig. 2 Steps needed to make a simulation.

STEP 1. 3D CAD Modelling

The modelling has been performed on the Solid works 2009 version and then after the analysis works has been performed on the ProCAST 2009 version.

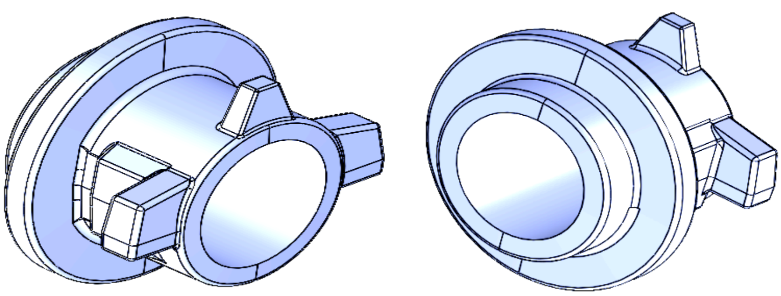


Fig. 3 Model of release bearing housing

STEP 2.Meshing with MeshCAST

The work steps which you follow when using MeshCAST depend upon the following: the nature of your project, the intended use of the meshes generated by MeshCAST and the type and quality of CAD model you use as the initial input.

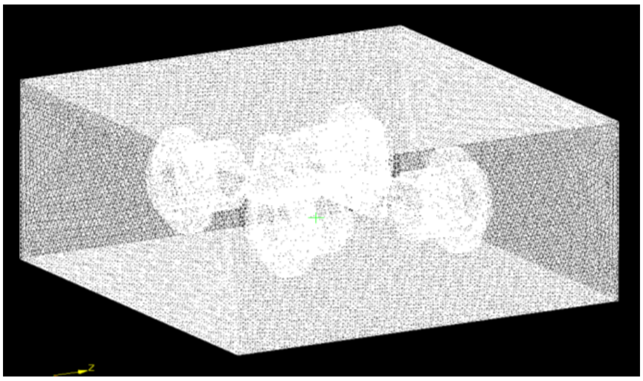


Fig. 4 Meshing in MeshCAST

- Import meshing file in PRE CAST

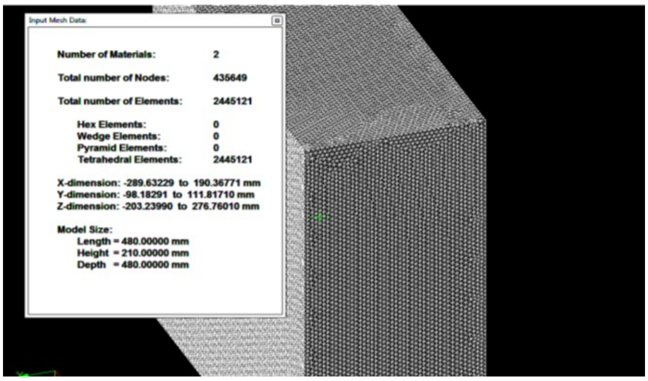


Fig. 5 Import meshing file

- Apply Mould material as Silica Sand

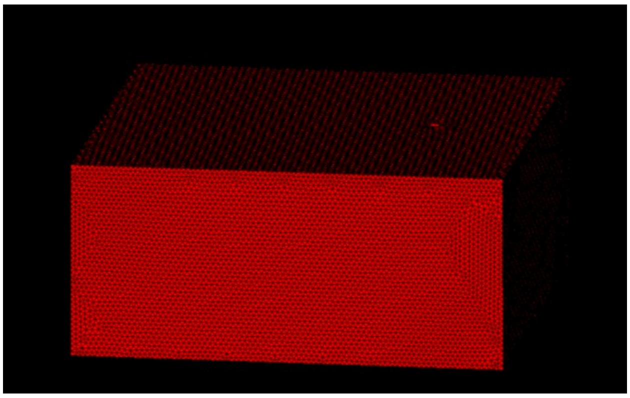


Fig. 6 Mould material as Silica Sand

- Apply interface between mould and Casting

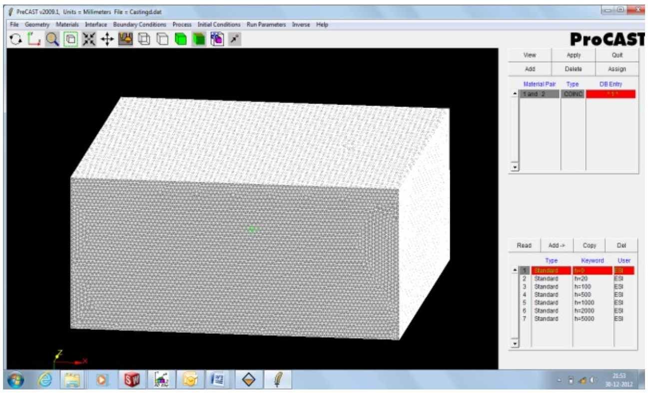


Fig. 7 Interfaces between Mould and Casting

- Apply Air cooling to all mould surfaces

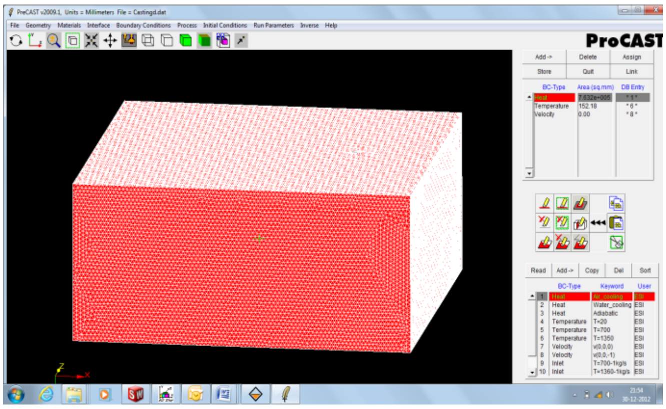


Fig. 8 Air Cooling

- Apply inlet velocity to pouring cup.

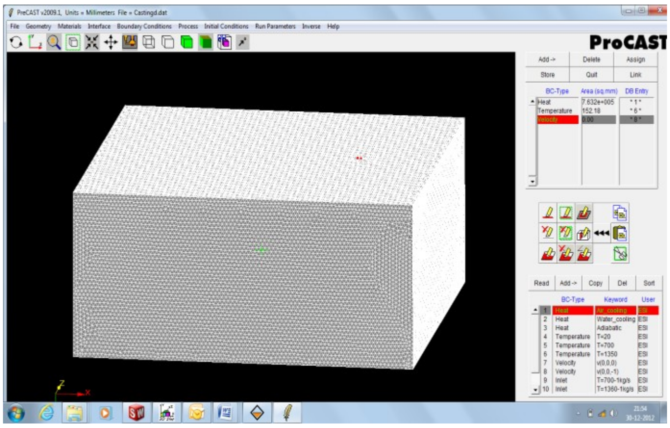


Fig. 9 Inlet Velocity

- Apply inlet temperature to Pouring Cup.

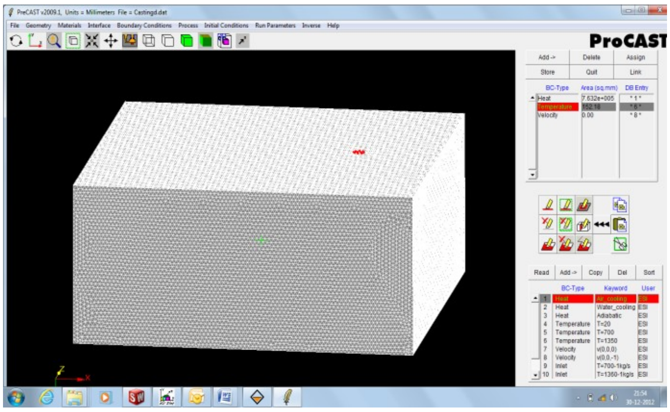


Fig. 10 Inlet temperature

- Define Process for Filling
  Gravity Filling

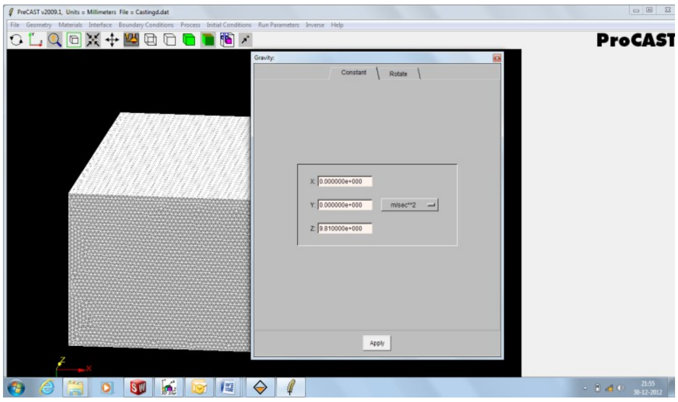


Fig. 11 Gravity Filling

- Apply Initial Condition for Mould

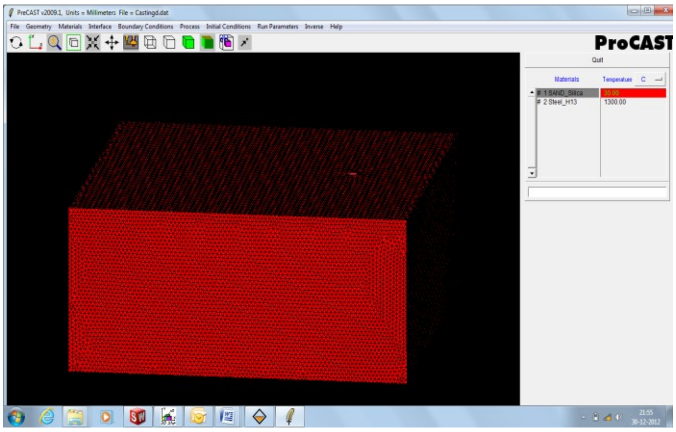


Fig. 12 Initial Conditions for Mould

- Apply Initial Condition for Casting

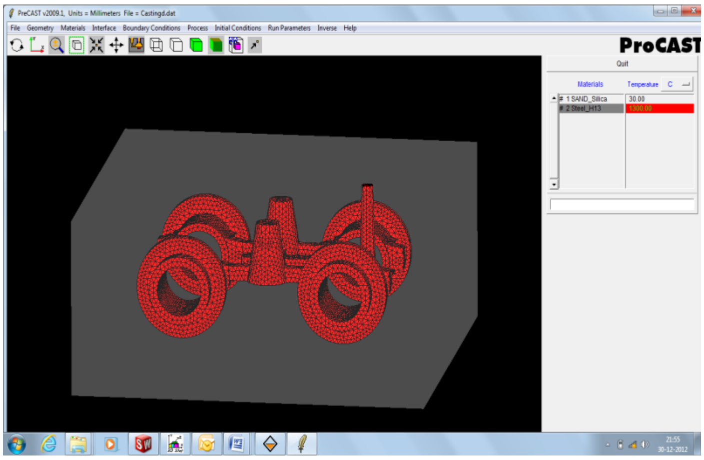


Fig. 13 Initial Conditions for Casting

STEP 3 Define Run Parameter for Release Bearing Housing Simulation.

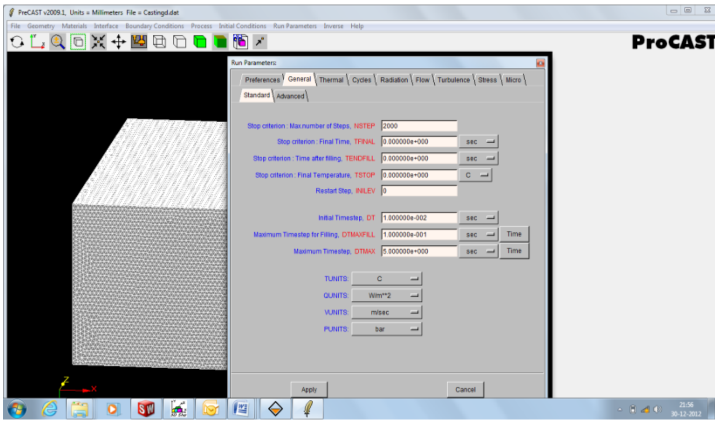


Fig. 14 Run Parameter

STEP 4 Calculation: temperature distribution

Figure indicates the temperature distribution over entire part. Maximum temperature at the centre of the part so that the maximum chances of porosity occurs at that region.

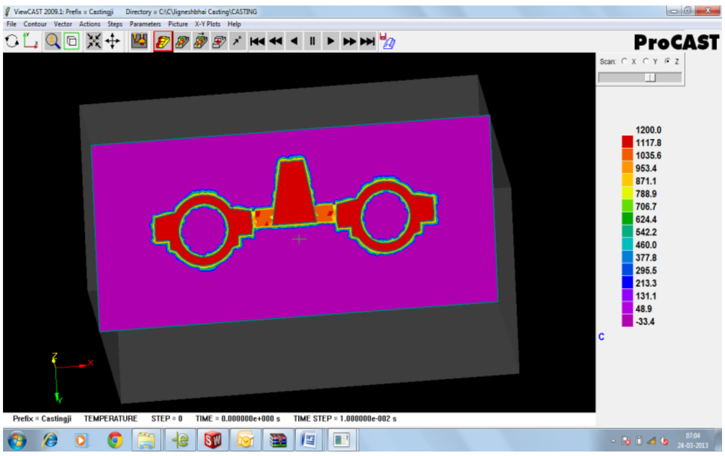


Fig. 15 Molten state of pouring metal

STEP:-5 Analyzing Result

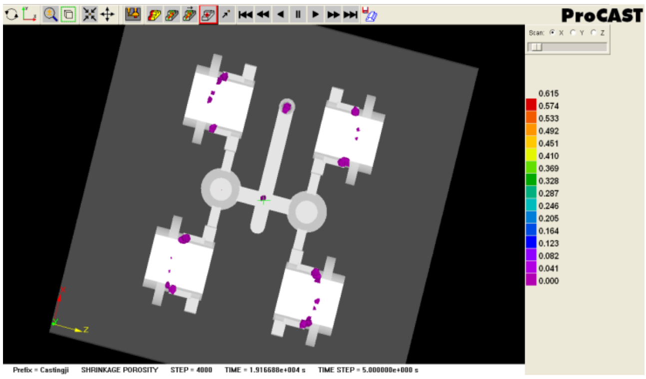


Fig. 16 Shrinkage Porosity

4. Comparison of FEA Results with Experimental Results (Validation)

Experimental results are taken by x ray we get the % of porosity is 3.152% and in FE Analysis by using ProCAST we get the % of Porosity is 4% as shown in table

	Experimental Results	FE Analysis Results	Percentage Variation
Shrinkage Porosity	3.152%	4%	0.848%

5. Optimization of release bearing housing

Any optimization problem has three basic ingredients:

- Optimization variables, also called design variables denoted as vector x.
- Cost function, also called the objective function, denoted as f (x).
- Constraints expressed as equalities or inequalities denoted as gi(x)

Although computer-based optimization methods for an application in structural mechanics have been available for several years, they are not very popular. There are several reasons for this:
1. Modelling for computer-based optimization is often complex and time-consuming
2. Optimization results and quality strongly depend on boundary conditions and load cases
3. Optimized models are sometimes difficult to interpret and/or produce in reality.

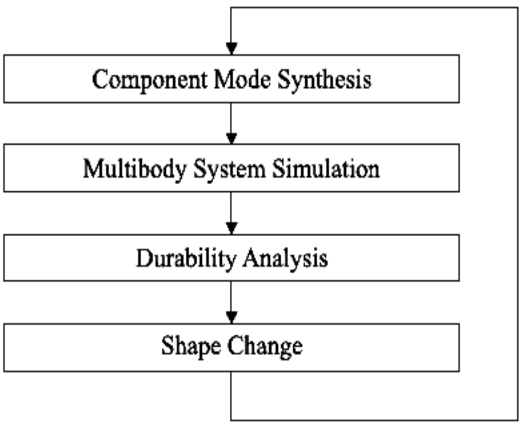
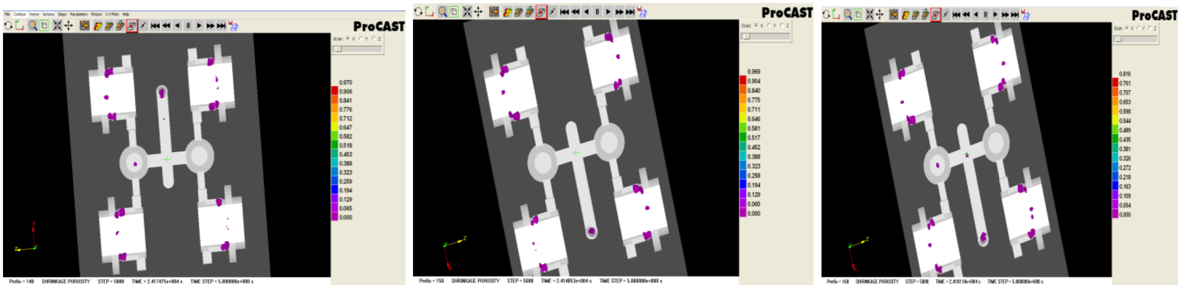


Fig. 17 Stages of Optimization Process

5.1 Effect of Riser Height on Shrinkage Porosity

140 mm　　150 mm　　160 mm



Shrinkage Porosity: - 6.5 %　　Shrinkage Porosity:- 12.9%　　Shrinkage Porosity:- 5.4 %

Fig. 18 Different shrinkage porosity on riser height

5.2 Pro-Cast analysis result for different riser height

Table 1 Riser height and shrinkage porosity

Riser Height(mm)	Shrinkage Porosity (%)
140	6.5
150	12.9
160	5.4

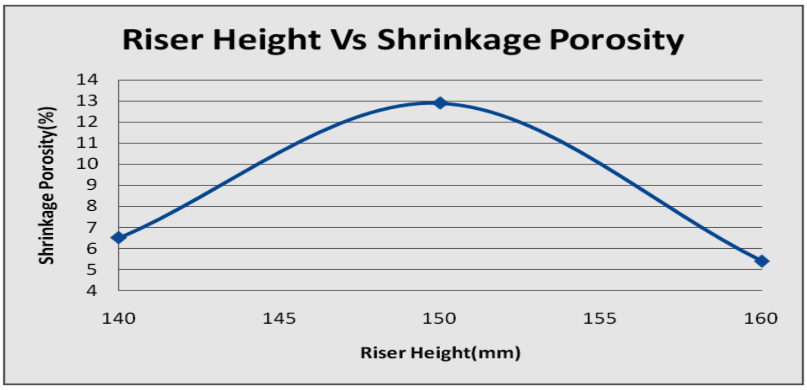
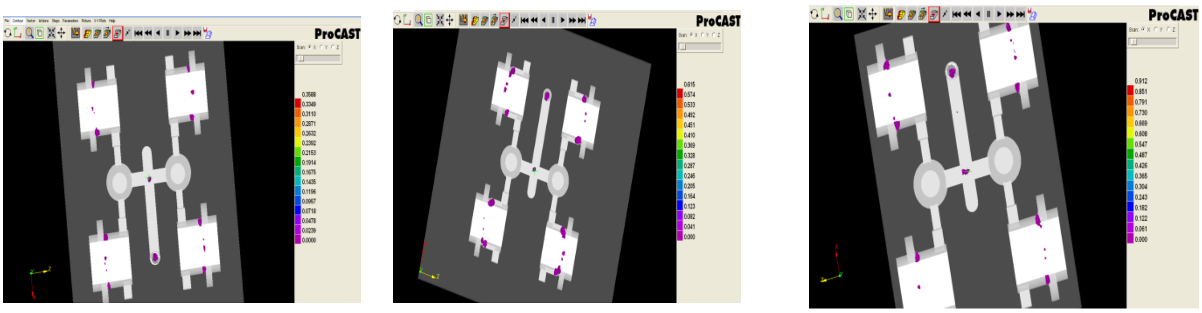


Fig. 19 Riser height Vs Shrinkage porosity

5.3 Effect of Runner Height on Shrinkage Porosity

Runner Height:-18mm　　Runner Height:-16mm　　RunnerHeight:22mm



Shrinkage Porosity: - 2.43%　　Shrinkage Porosity: - 4.78 %　　Shrinkage Porosity: - 8.2 %

Fig. 20 Different shrinkage porosity on runner height

5.4 Pro-Cast analysis result for different runner height

Table 2 Runner height and shrinkage porosity

Runner Height(mm)	Shrinkage Porosity (%)
16	4.78
18	2.43
22	8.2

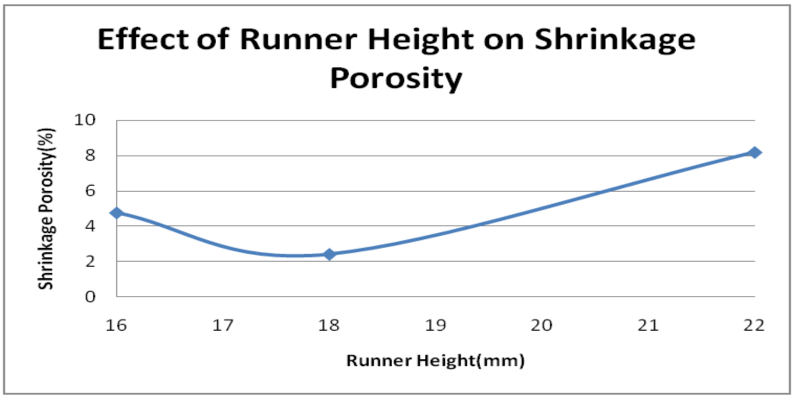
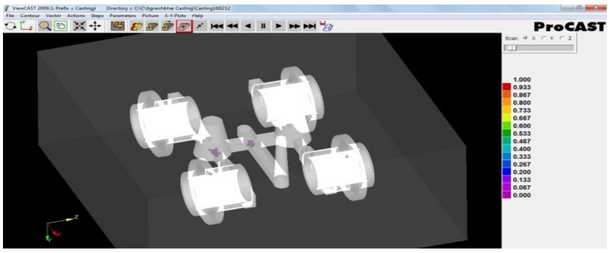


Fig. 21 Runner height Vs Shrinkage porosity

After finding individual effect on shrinkage porosity we have combined both parameter like riser height and runner for finding combined effect on shrinkage porosity which shows that 18 mm Runner Height and 160 mm Riser Height Combination gives shrinkage porosity of 6.70% which is not optimum. Runner Height 18 mm & Riser Height 160 mm



Shrinkage Porosity: - 6.70%

6. Conclusion

(1) Casting simulation technology has sufficiently matured and has become an essential tool for casting defect troubleshooting and method optimization. It enables quality assurance and high yield without shop-floor trials, and considerably reduces the lead-time for the first good sample cast.

(2) By moving the trial and error process into the virtual world and determine the cost of different design and process options. By minimizing real world trial and error (and surprises) making castings right the first time.

(3) From above thesis work, we found that when riser height increased from 130 to 160 shrinkage porosity is increased but not in linear proportion. Another Parameter that has major effect on shrinkage porosity is runner height. We have change the runner height from 16 to 22 in

between these optimum value for runner height is 18 with minimum shrinkage porosity 2.43% and reduces 30% Casting Rejection Rate.

7. Acknowledgment

Release bearing housing is the product of Arrow techno cast Pvt. Ltd. (Shapar GIDC - Rajkot). We have been greatly benefited by Mr.Vipul Patel with his valuable suggestions and ideas. It is with great pleasure that we express our deep sense of gratitude to him for his valuable guidance and constant encouragement throughout this work.

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