

Optimization of Feeder Design Using virtual Simulation Technique - A Case Study

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Abstract - The ability of a molten metal to get the shape of the mould is a casting process. Casting is a defect prone manufacturing process. A variety of defects measuring from 3-6% of the total casting produced are commonly in the acceptable level. Metal casting industries are continuously exposed to ever increasing demands regarding their competitiveness, sound quality products as well as in developing their specific casting process. The casting development process for a new product was in the past determined within the foundry using "personal experience" as well as "shop floor trial and error". In order to achieve continuous improvements, controlled processes and close customer-vender relationships, foundries have introduced QMS which in turns enable implementation of quality requirements using CAE tools like FEA and simulation of casting techniques which are effective and reliable tools in order to achieve reliable and calculable product development and production processes. Simulation based approach has helped in the improvement of the feedability index which represents yield of riser and quality of casting. The methods layout of a casting is an important activity in tooling development. It involves critical decisions regarding part orientation in mold, parting line, cores, cavity layout, feeder's size and its location, feedaids and gating system dimensions. An improper layout leads to either poor quality or low yield, affecting manufacturing costs and productivity. Here an attempt is made to virtually simulate feeding system design in order to obtain optimum risering solution by using AutoCAST simulation software.

Key Words: Volumetric shrinkage; Hot spot; Casting simulation; Feeding system design; Riser modulus; Casting yield; and Optimum design

1. INTRODUCTION

Manufacturing is the backbone of any industrialized nation. A basic Casting process is one of the earliest metal shaping and forming process. It means pouring molten metal into a refractory mold cavity and allows it to solidify. The solidified object is taken out from the mold either by breaking or taking the mold apart. The solidified object is called casting and the technique followed in method is known as casting process or in other word it's a process wherein there is shortest distance between raw material and a finished good.

1.1 AutoCAST casting simulation:

The AutoCAST software developed at I.I.T. Bombay in collaboration with Advanced Reasoning Technologies provides a single integrated easy to use environment for casting method design, solid modelling, and simulation. AutoCAST is the world's most intuitive, incredibly fast, and truly integrated casting software for methods design, simulation and optimisation. It is widely preferred and adopted software to improve the quality and yield of existing castings, to develop new castings quickly without foundry trials, and to reduce the total cost in collaboration with customers. It provides a complete solution for casting methods design and optimization. It helps Regarding Part Analysis (Design for Manufacture), Methods Design (Mold layout, Part orientation, Feeders layout, gating system layout,) and Quick Simulation wherein it verifies the methods design by checking possible defects like mold erosion, filling time, and shrinkage porosity through casting simulation. Casting design involves converting the part design to the tooling design: orientation in the mold, parting line, application of draft and allowances, feeding and gating systems, core boxes and other elements. Simulation includes mold filling and casting solidification, useful for optimizing the design of gating and feeding systems respectively ⁽⁷⁾

1.2 Case study:

The component under study is a 1.9 Kg Cast Iron coupling used in Hydraulic application. The material specifications are as follows.



Fig. 1: Cast Iron coupling component under study

C	Si	Mn	S	P	Cr	Cu
2.8 %	2.3 %	0.9 %	0.03%	0.01 %	0.17 %	0.7 %

The material has pouring temperature of 1342- 1350 °C with pouring time of 7 to 8 seconds.

In this paper, efforts are attempted to modify the existing feeding system design of a component. The casting are manufactured by shell mold casting by heating metallic pattern up to 200° C and dumping resin coated sand over heated pattern with a dwell time of 10-15sec to form a thin shell as shown in fig. 2 which represents cope and drag portion of mold .Fig.3 and 4 represents core and core assembly.

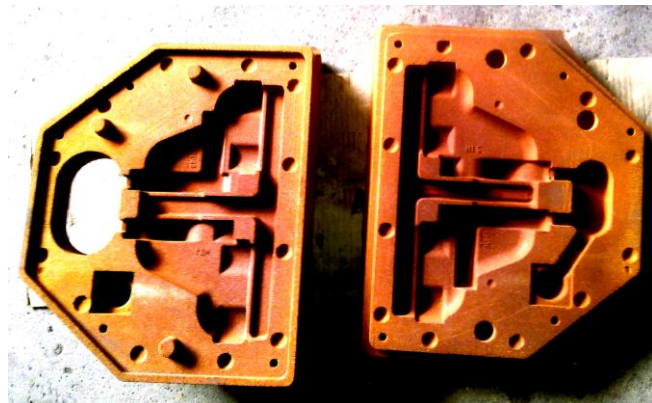


Fig- 2. Split Shell mold for casting showing casting cavity

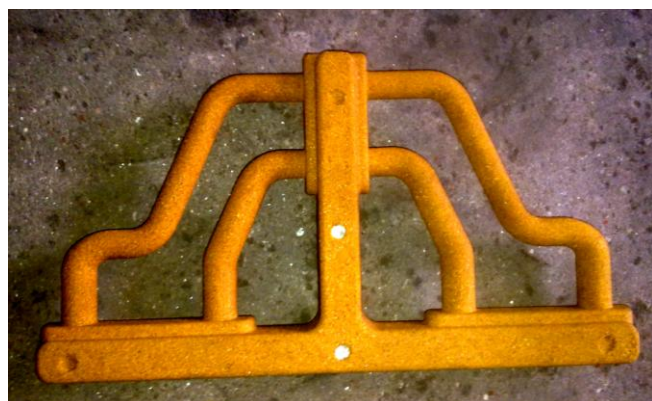


Fig- 3. Resin coated sand core made by hot box method

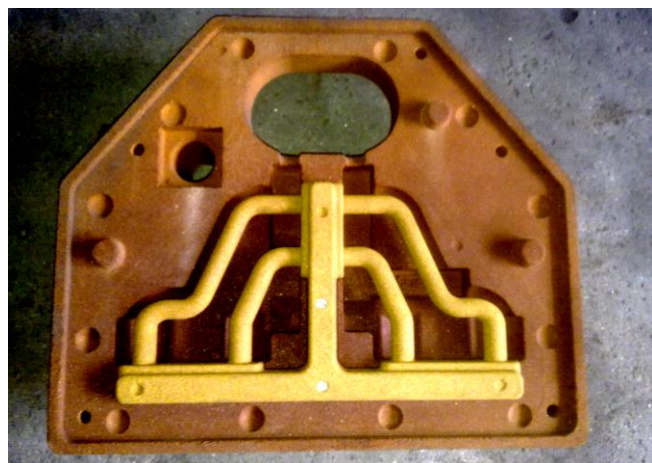


Fig- 4. Core assembly

1.3 Present situation:

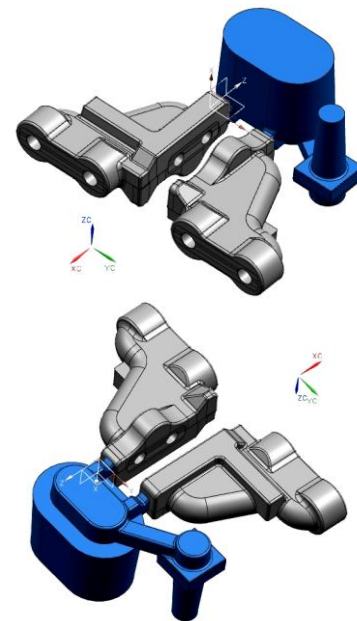


Fig. 5. Previous gating and risering system-CAD model of methoding Top and bottom side layout with two castings per mould.

In order to achieve an economical profitable manufacturing process, most patterns are fitted with the maximum amount of cavities (In present condition it is 2 castings in a single shell mold). In many cases a non-symmetrical layout is the result, especially in relation to orientation of component in mold cavity as well as location of gating junction. Because of lack of permeability and common riser for both cavities and also due to different flow patterns gating system, the whole filling process of both cavities is inherently uneven. The gas is not able to come out of mold cavity and it forms a blow hole , shrinkage cavity and micro holes over inside and outside of casting. As shown in Fig.1 and 6 casting shows a blow hole and internal shrinkage cavity and micro pin holes defects. The casting yield is of 54 % with previous condition of gating system as shown in fig.5 which is required to be optimized.



Fig. 6. Internal shrinkage cavity revealed by slicing the component at parting plane

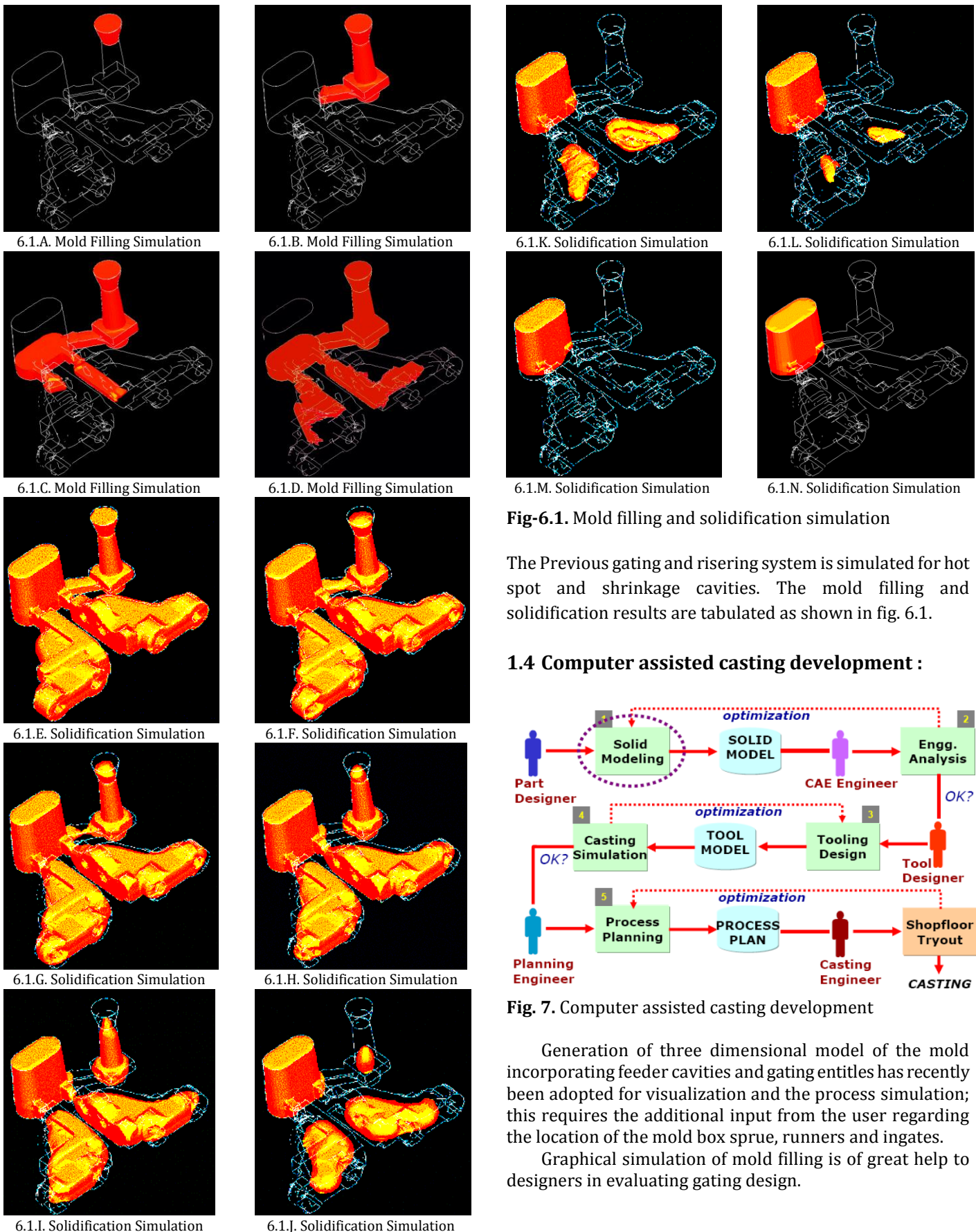


Fig-6.1. Mold filling and solidification simulation

The Previous gating and risering system is simulated for hot spot and shrinkage cavities. The mold filling and solidification results are tabulated as shown in fig. 6.1.

1.4 Computer assisted casting development :

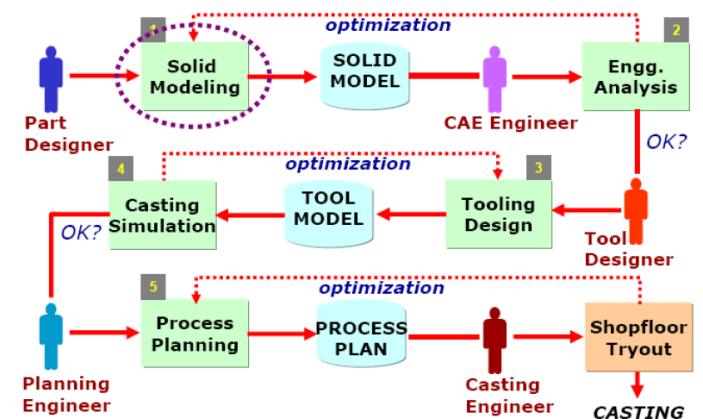


Fig. 7. Computer assisted casting development

Generation of three dimensional model of the mold incorporating feeder cavities and gating entitles has recently been adopted for visualization and the process simulation; this requires the additional input from the user regarding the location of the mold box sprue, runners and ingates.

Graphical simulation of mold filling is of great help to designers in evaluating gating design.

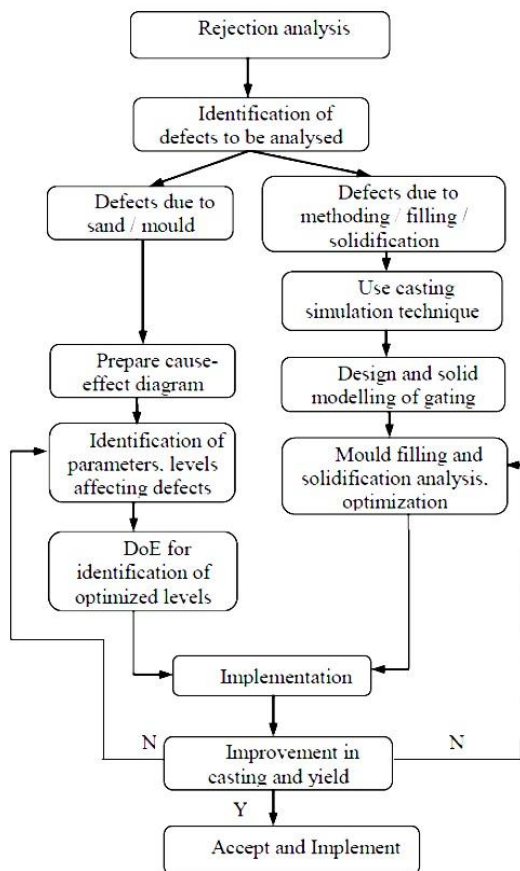


Fig. 8. Proposed Methodology for method design

2. DEVELOPMENT OF METHODING USING AUTOCAST SIMULATION SOFTWARE:

The following steps were performed on AutoCAST software so as to get the methoding for the casting

1. The 3-D model from CATIA is converted in to the .STL Format.
2. The model is assigned the material- FG 260 shell mold casting
3. Surface area, number of holes, volume, weight etc. were calculated.
4. The parting line and parting plane is suitably adjusted taking into consideration the ease of removing the pattern from the cope and drag part.
5. The cored characters were generated.
6. For the whole assembly the mould box is selected as per the company's regular practice.
7. Feeding function is carried out to locate shrinkage.
8. The analysis through it showed the two dominant areas which were prone to the shrinkage and micro porosities.
9. For these areas to be taken care of the feeders were provided as visible in the figures.
10. The runner bar ,sprue, ingates was designed so as to feed the molten metal to the farthest point from point of metal pouring.

11. The total model is created and the pouring is simulated. Since the pouring time calculations showed that pouring time of around 5-6 seconds is sufficient, the system was again designed for that much second and simulation is carried out. This gives the idea of the sizes of ingates, runner, sprue etc.

12. The quality health checks were calculated

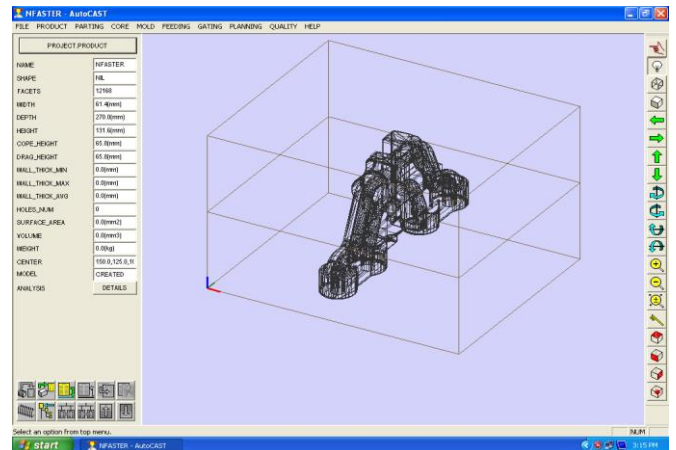


Fig. 9.1 Importing .stl file format 3D model

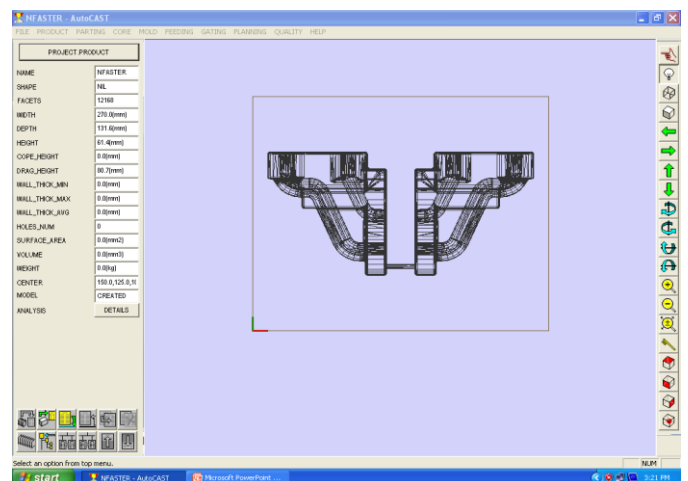


Fig. 9.2 Selection of Casting Process as shell molding

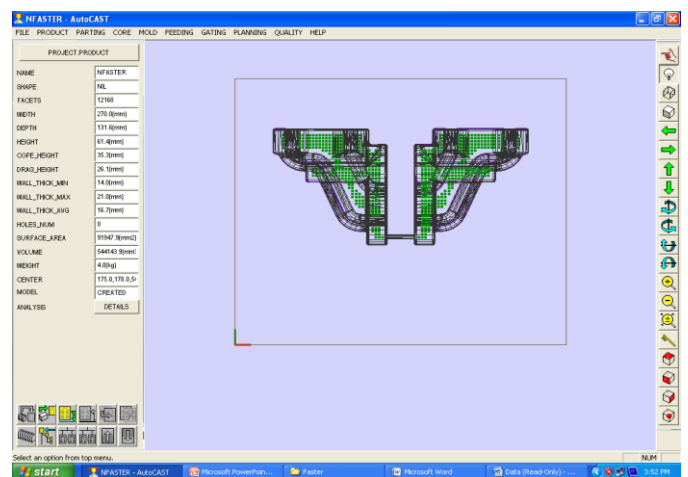


Fig. 9.3 Selecting component Properties

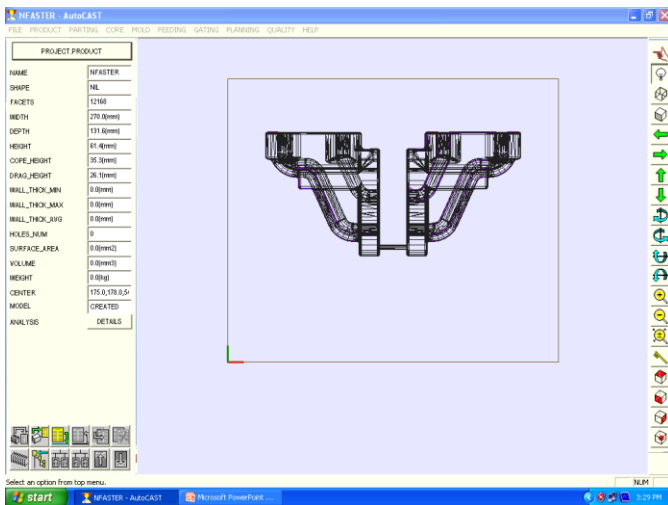


Fig. 9.4 Selection and Model in Mold

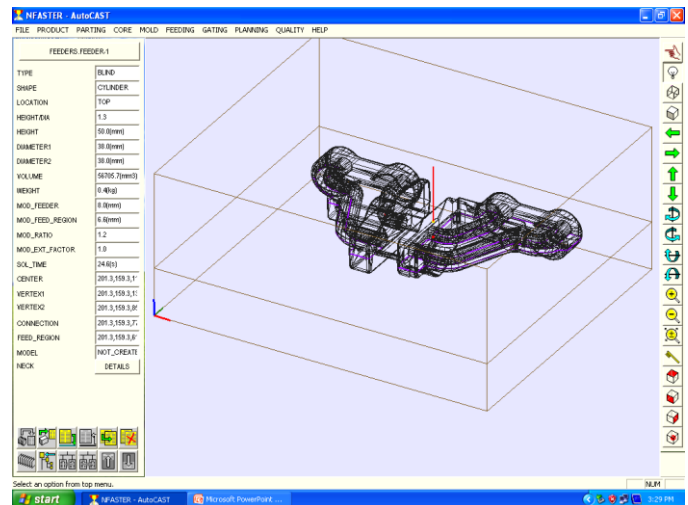


Fig. 9.7 Design and Model of Feeder

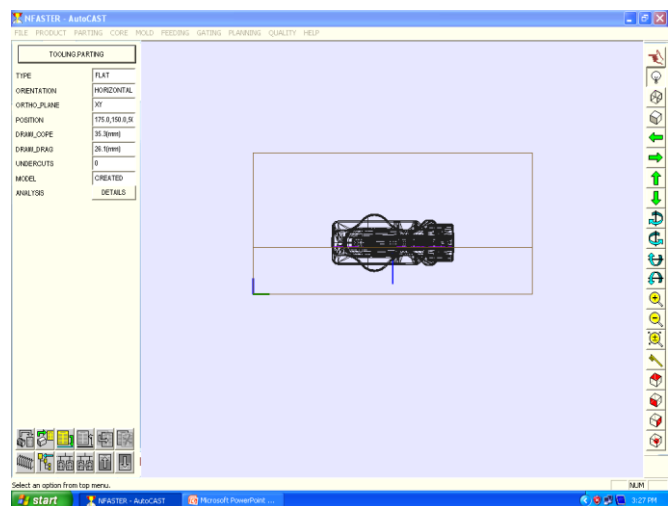


Fig. 9.5 Selection of Parting Line

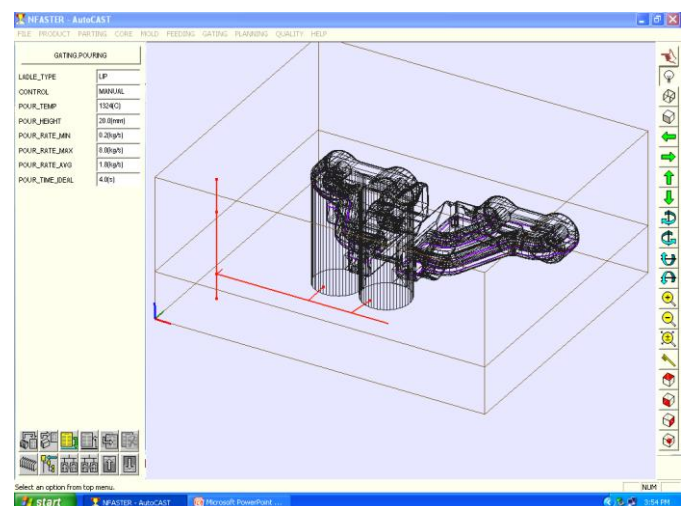


Fig. 9.8 Design of Runner bar and gating system

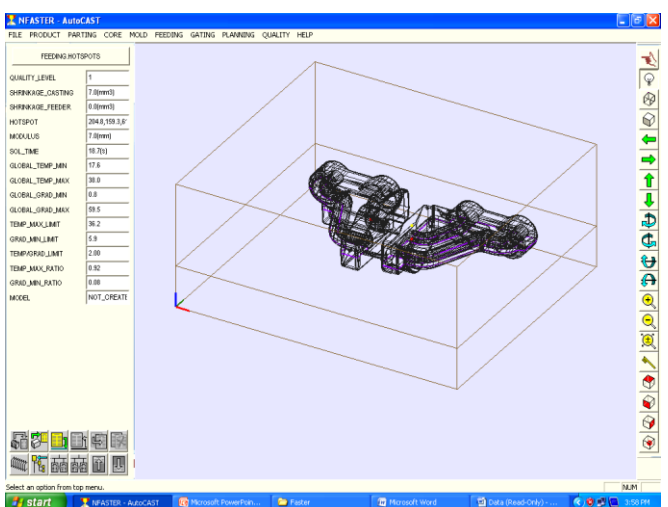


Fig. 9.6 Check for internal shrinkage Defect

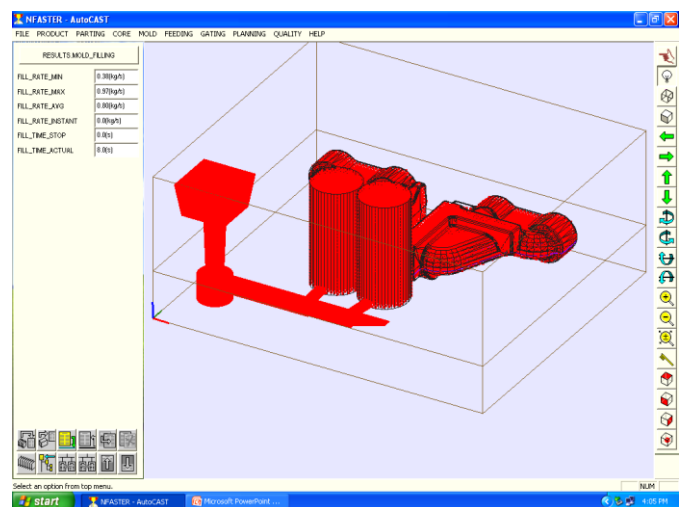


Fig. 9.9 Visualization of mold filling

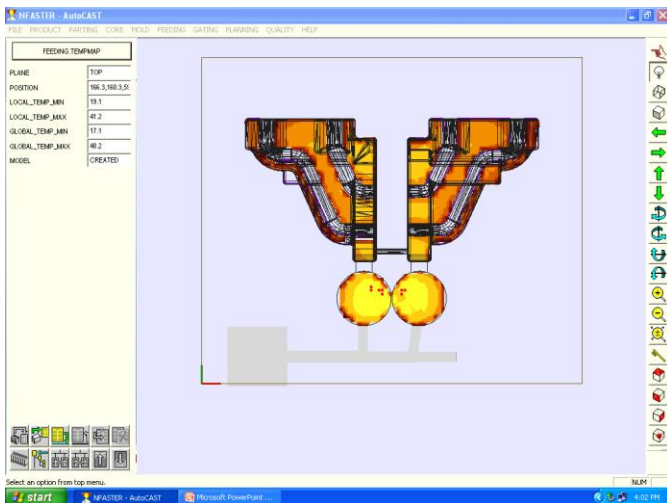
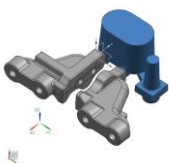


Fig. 9.10 Shrinkage cavity shifted to riser with red dots

3. EXPERIMENTAL RESULTS:

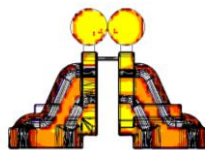
Experimental trials are carried with modified gating system which shows following results.

Previous design



Casting yield 54%

Modified design



Casting yield 64%

4. CONCLUSION

Simulation of present casting is done in the AutoCAST software by selecting proper parameters. The software has provided a modified gating and risering system. With proposed gating and risering system the percentage of yield has improved from 54% to 64%. The virtual simulation has shown the hotspot, where shrinkage may arise. By using simulation the bottlenecks and non-value added time in casting development can be minimized. Casting simulation can minimize the wastage of resources required for trial production. In addition, the optimization of quality and increased yield implies higher value-addition and lower production cost and improving the profit.

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