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Design and Analysis of Gating System at Various Orientation for Rear Break Drum by Using Casting Simulation Software

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***Abstract*: Casting has been the most typical, widespread and convenient manufacturing process. Inadequate development of the gating system and the riser leads to numerous casting flaws. Considering the traditional knowledge of gating and riser design and suggestions from skilled casting experts, the development of flaw free casting is concern in the casting production. The use of casting simulation for mass casting production has been a powerful tool for assessing mold filling, temperature distribution and cooling of casting and for detecting internal flows such as porosity, sand inclusions and cold shut. It is used to troubleshoot existing castings, as well as to develop new castings without trials on the shop floor. The presence of defects is of significant concern as production casts. Several flaws are just an aesthetic thing while others may be adverse to component performance. Fortunately, the Indian Foundry Sector is now identified as one of the key thrust regions in which priorities are considered for technology transfer and permeability needs. In India, many of the foundries follow traditional approach, focused on trial-and error casting production technique which in turn leads high rejection rates as well as time required for development and money loss.**

***Keywords*: Casting, Computer-aided design, Simulation, Optimization, Defects.**

1. Introduction

India is the second most important manufacturer of casting products throughout the globe following China. Hence the foundry sector of the manufacturing is an important. The casting process delivers the largest selection with design and process variables in terms of cast material mass, size intricacy, production size and quality of products.

In the casting process, the crystallization rate has a significant effect on the microstructure of cast metal, which will in effect affects the material properties such as strength, hardness, machinability, etc. of the cast metal. The appropriate construction of the riser / feeder needed to accomplish directional solidification is crucial however it may lead in any faulty casting with shrinking cavity or reduced yield. The weight of the gating system and the riser plays a vital role in enhancing yield per part. The Gating system varies as per the morphology of each component. As the cast component material solidifies between liquids and solidus temperatures and transfers their condition from liquid to solid, considerable amounts of shrinkage usually occur. Not even all metals shrinks. Others extend, like grey cast iron, wherein minimal density graphite flakes appear as result of the solidification. Feeder provides molten metal for overcome the shrinkage which causes metal solidification. The feeders /risers must have adequate resources can supply the necessary quantity of molten metal and solidify as a last part after the casting has fully solidified. For quality castings, therefore, adequate design of the riser system and good control of process specifications are essential. The traditional technique to riser design is focused on the method and experience of trial and error. But it consumes lot of time and the energy of man.

Recently the use of casting simulation software is raising day after day in Indian foundry sector as it effectively replacing or eliminates the shop floor trials to accomplish defect free castings repetitively.

Casting process simulation was initially developed in universities from the early ' 70s, primarily in Europe and the United States, and has been considered to be a much more significant breakthrough in casting development over the last 50 decades. The key resources for the casting simulation software are 3D mold cavity geometry with gating and riser framework, thermo-physical characteristics of the mold and the casting material. The 3D design of the mold cavity feeder dimension has to be provided manually.

Today, there are various dedicated casting simulation softwares are available in market -CLICK TO CAST, ADSTEFAN, MAGMASOFT, ProCAST, Solid CAST, and AutoCAST. And this various casting simulation software's developed to perform computational modeling of mold cavity filling by liquid metal flow, temperature distribution, casting solidification mechanism in various casting manufacturing processes, mainly Green sand molding, investment or wax casting and die pressure casting. It is extremely useful for the application of the foundry to conceptualize and forecast casting results in such a way as to provide guidance for the refinement of the product including the design of the mold in order to achieve the desired casting quality.

2. Problem definition

A case study is being performed to build a casting on an automated high-pressure molding machine (SINTO FBO-II). Break Rear Drum 180 number is used as a casting part for the case study. Mahindra and Mahindra, the automotive industry of Nashik and Chennai, are the main customers of this casting. The production of this casting is carried out by the Malati Founders Pvt. Ltd., Shri Laxmi Industrial Estate, Hatkanangle Kolhapur. Such casting orders have been supplied by this foundry since the last 12 years, and the foundry has now expanded and installed a new advanced factory. For this factory, castings are being produced on a SINTO FBO-II high-pressure molding machine with a modified gating system. But this machine has a mold size (length) of 550 mm x (breadth) of 450 mm and a cope and drag height of 200 mm each. Previously, the mold of this casting was produced on a jolt squeeze molding machine and simultaneously two castings were made in a single horizontal mold with 65% casting yield.

While designing new gating system for this casting with default mold size of SINTO machine, various restrictions are occurring. In order to improve the performance of casting and for mass production, attempts are made to build the gating system in different orientation as per the machine mold size.

Fig. 1. Previous pattern of the casting

Fig. 2. Casting under case study (Break Rear Drum 180 no.)

3. About Altair inspire cast

Altair Inspire Cast (formerly Click2Cast) software is a rapid, convenient, effective and affordable casting simulation environment aimed at creating high-quality components with improved productivity via highly flexible consumer experience. It's the only resource for both learners and professionals, including product designers and foundry experts. Consumers should imagine anything starting from the early design phase Standard casting defects such as air trapping, shrinkage, porosity, cold shutdown, mold erosion and correction, avoiding expensive downstream corrections. Guided process models provide five simple steps to visualize Gravity Die, Gravity Sand, Investment, High Pressure, Low Pressure Die Casting and Tilt Pouring. Altair Inspire Cast's creative curriculum allows users to enhance product quality and design better products within a few hours of training.

4. Material and methodology

Table 1
Chemical Composition of Break Rear Drum

Element	C	Si	Mn	S	P
Weight	3.4 %	2.0 %	0.6%	0.1%	0.1%

Table 2
Mass and Volume of Casted Break Rear Drum

Mass	10 Kg
Volume	1.3778×10^6 mm³

Break Rear Drum was developed in CATIA V5 along with the gating and riser system and simulation is executed in Altair Inspired Cast Simulation Software. Initially a hotspot analysis is carried out in order to obtain a defect prone area and according to this riser system has been developed. Hot spot analysis of the Break Rear Drum indicates that there is a shrinking prone area near the bore at the bottom. This related to the development of the riser to eliminate the shrinkage defect in the Break Rear Drum. Defect free reports from simulation software with a different orientation of mold casting are taken into account.

Table 3
Input parameters for the software

	Single Casting	Double Casting
Casting Material	Cast Iron	Cast Iron
Material Grade	GJL 200	GJL 200
Pouring Temperature	1400° C	1400° C
Mold Size	(L) 550 mm x (B) 450 mm x (H) 400 mm	(L) 550 mm x (B) 450 mm x (H) 400 mm
Mold Material	Green Sand	Green Sand
Mold Filling Time	5.71 sec	8.15 Sec
Average Thickness	10 mm	15 mm

A. Development of method in Inspire Cast simulation software

The following steps are performed on Inspire Cast software

1) The 3-D model creation in CATIA along with gating system.
2) 3-D model file (.CATPart) is imported in Inspire Cast software.
3) Arrange the 3-D model in correct direction.
4) Assigned the Gravity direction (mold filling direction)
5) Casting 3-D model is assigned for the material, grade and pouring temperature.
6) Assign runner system.
7) Assign in gate system.
8) Holes are identified or designated and core is defined with its characteristics.
9) Risers are defined and then exothermic sleeves are may or may not be assigned with their parameters
10) For the entire assembly, the mold box is chosen

according to the appropriate dimensions and the molding process and the material selected. The parting line is appropriately adjusted, considering the ease of removing the pattern from mold cavity.

11) Gravity molding process is selected as per pouring time.
12) Average thickness will be automatically generated by analyze the casting model.
13) Program is run by selecting solidification and mold filling.

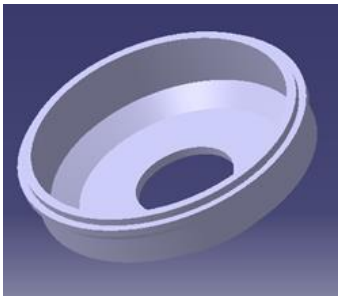

Fig. 3. 3D Model of final casting

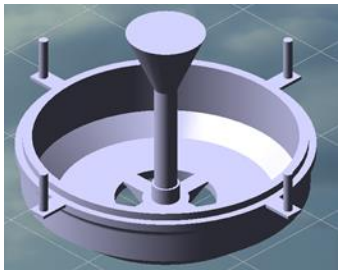

Fig. 4. 3D Model of design no. 1

Fig. 5. 3D Model of design no. 2

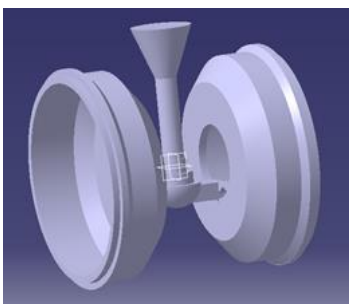

Fig. 6. 3D model of design no. 3

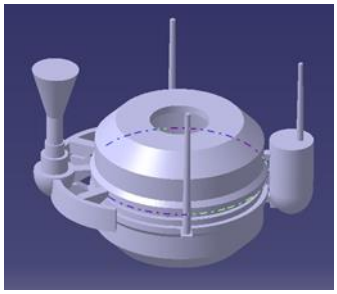

Fig. 7. 3D Model of design no. 4

5. Altair inspire cast results

Design: 1

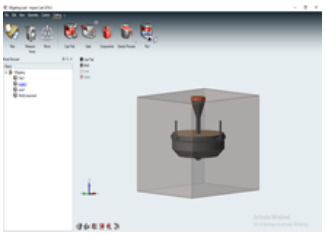

Fig. 8. Mold assembly

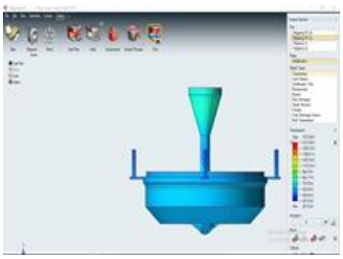

Fig. 9. Temperature

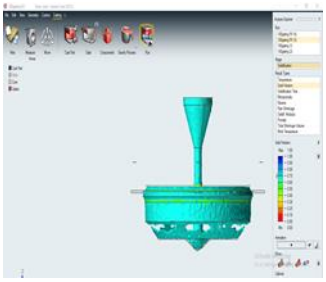

Fig. 10. Solid fraction

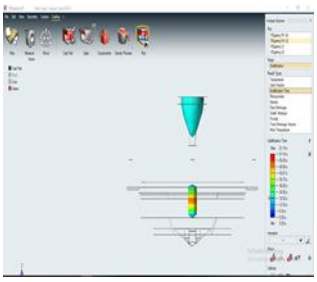

Fig. 11. Solidification time

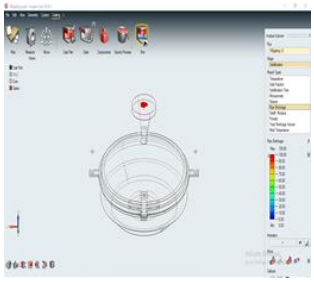

Fig. 12. Pipe shrinkage

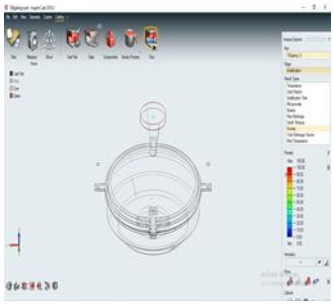

Fig. 13. Porosity

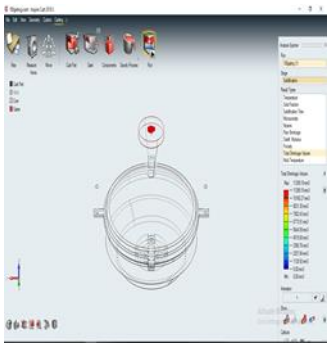

Fig. 14. Total shrinkage volume

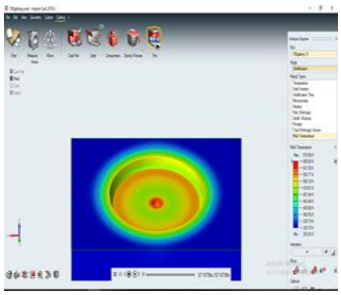

Fig. 15. Mold temperature

Design 1: There are almost no defects in final simulated casting. Some of the defects are visible but are induced in the gating system which is a secondary element and will be cut out during the fettling process. The development of casting with this design is basically very simple. No requirement of core, so less set-up time and cost of production.

Design: 2

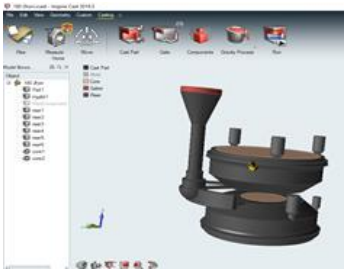

Fig. 16. Mold assembly

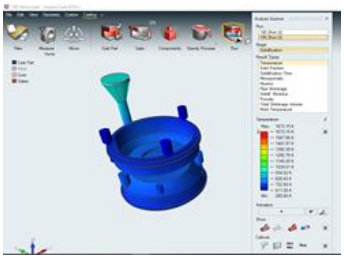

Fig. 17. Temperature distribution

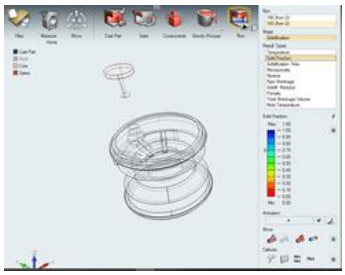

Fig. 18. Solid Fraction

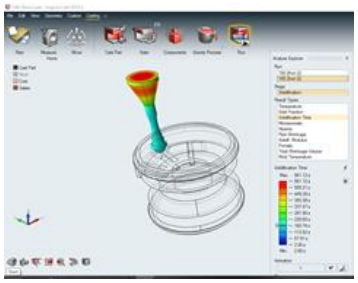

Fig. 19. Solidification Time

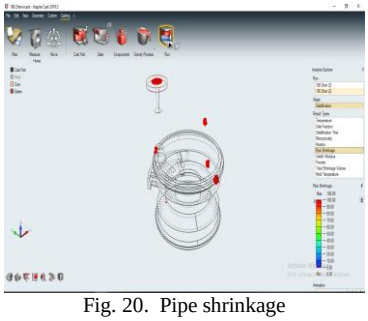

Fig. 20. Pipe shrinkage

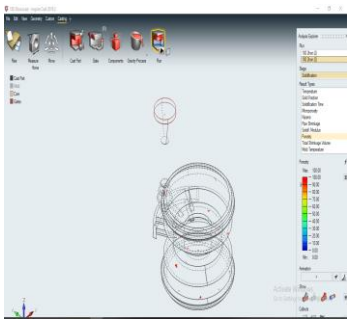

Fig. 21. Porosity

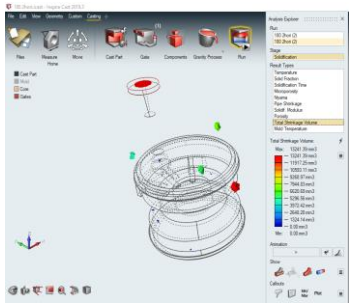

Fig. 22. Total Shrinkage volume

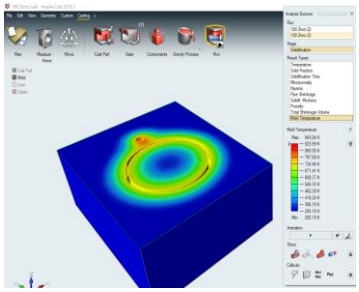

Fig. 23. Mold Temperature

Design 2: For the production of the final casting, this design requires the core, which will increase the final casting cost and the core setting time, as well as the core setting, may cause problems in the assembly of the molds.

Design: 3

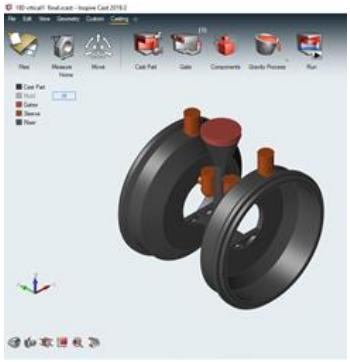

Fig. 24. Mold Assembly

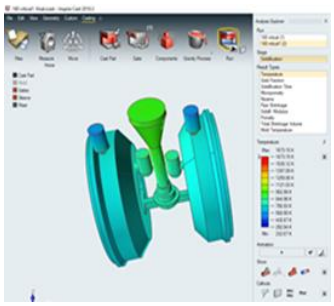

Fig. 25. Temperature Distribution

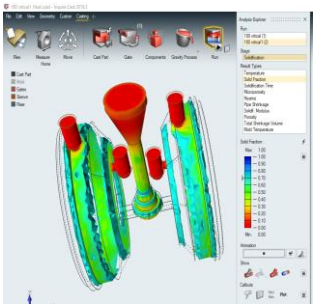

Fig. 26. Solid Fraction

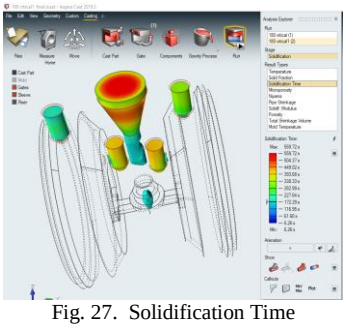

Fig. 27. Solidification Time

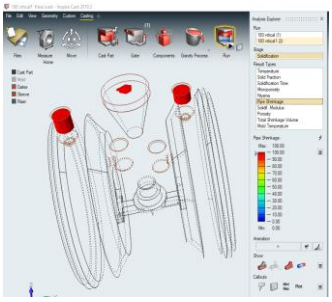

Fig. 28. Pipe shrinkage

Fig. 29. Porosity

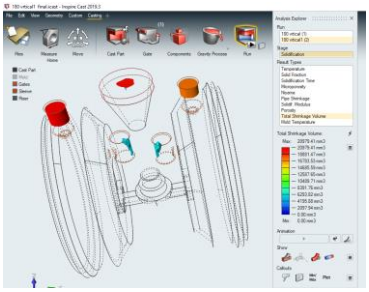
Fig. 30. Total Shrinkage volume

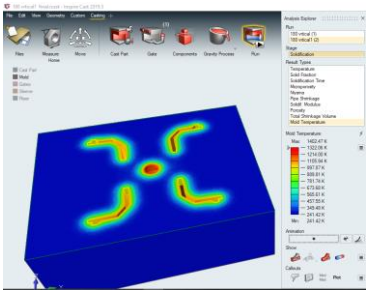
Fig. 31. Mold Temperature

Design 3: In this vertical orientation design casting yield is also very high without any defect. The mold and core assembly is very simple and less time-consuming, with easy removal of the pattern. To Enhanced performance of riser the use of insulating sleeves is helpful.

Design: 4


Fig. 32. Mold Assembly

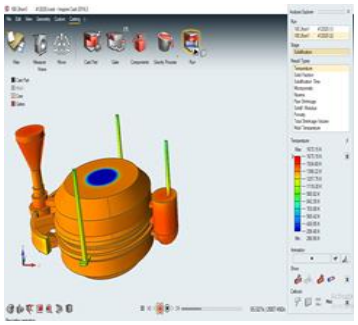
Fig. 33. Temperature Distribution

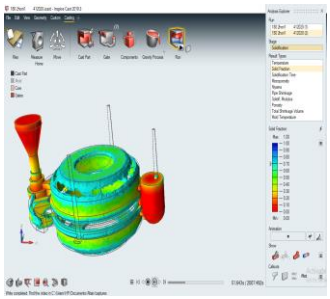
Fig. 34. Solid Fraction

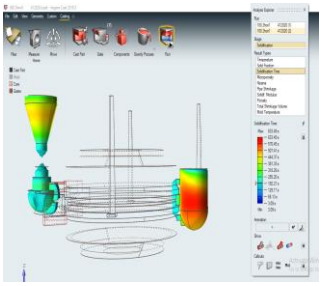
Fig. 35. Solidification Time

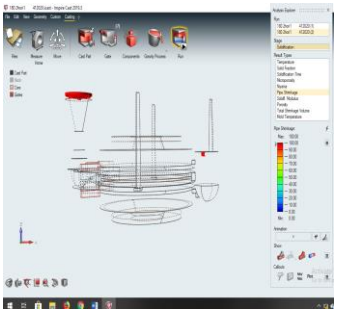
Fig. 36. Pipe shrinkage

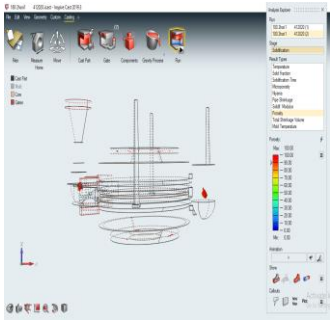
Fig. 37. Porosity

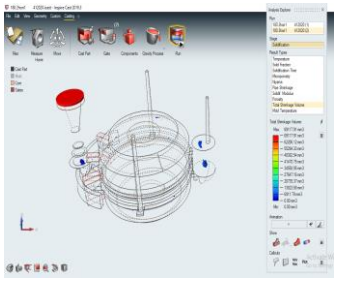
Fig. 38. Total Shrinkage volume

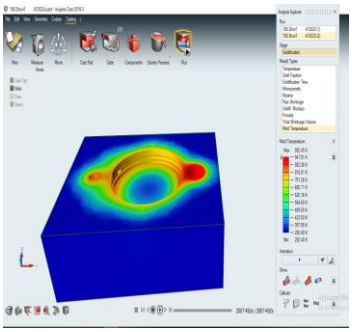

Fig. 39. Mold Temperature

Design 4: This design shows a much lower yield and may also have a lower risk of porosity at the top surface of the casting and therefore this design is not acceptable

6. Altair inspire cast results analysis

Table 4
Observation of casting simulation result

Design No.	Casting Yield	Casting Defect	Accept / Reject
Design No. 1	78.93%	No Any Defect	Acceptable
Design No. 2	85.22%	May Chance of porosity and shrinkage adjacent to riser neck and casting	Acceptable
Design No. 3	81.47%	No any defect	Acceptable
Design No. 4	64.52%	May chance of porosity at top surface of casting.	XXX

7. Conclusion

The simulation of the Break Rear Drum casting is executed on the ALTAIR INSPIRE CAST software at different orientation by applying appropriate input parameters. Enhanced casting yield is achieved by constructing gating systems at various casting locations. This casting simulation displays virtual casting defects that may occur after casting solidification, such as porosity, shrinkage and solidification time, temperature distribution, solidification fraction. Simulation software reduces shop floor trails rejection rate, and production time and helps in minimizing cost of casting production. Such modified designs will provide enhanced efficiency with improved yield and increased profits.

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