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Determination of Optimal Riser Diameter in Minimizing the Defects in Aluminium Castings through Simulation

Mohideen Abdul Kadhir Badhusha. A[1], Prof. Kannan. M[2], Mohammed Raffiq S.K[3],

1,3 – Scholars, Dept.of Mechanical Engg, Thiagarajar College of Engg, Madurai, India
2 – Faculty, Dept. of Mechanical Engg, Thiagarajar College of Engineering, Madurai, India

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ABSTRACT:

Sand casting is one of the oldest and cheapest metal shaping processes known to human beings. Casting process is subjected to many defects and it is necessary to eliminate them. One of the main defects in castings is "Shrinkage Cavity". It is caused due to many factors such as volumetric contraction both in liquid and solid state, poor casting design, low strength at high temperature, etc. Shrinkage defects can be minimized by attaching a riser during the casting process. This study is about designing a riser with an optimal diameter to minimize the defects in the aluminium castings, through simulation by Solidcast software. Theoretically designed model (V-block) has been analyzed thermally in Solid Cast simulation software for riser diameters 10mm, 15mm and 20mm, to reduce the shrinkage cavities in the castings. The temperature distribution in the castings and solidification time is obtained from the simulation for all the three diameters and compared with each other. In this case, the aluminium castings with 10 mm riser diameter tend to possess less amount of shrinkage cavities when compared to the castings with riser diameters 15 mm and 20 mm.

Keywords: shrinkage cavity, Aluminium castings, optimum riser diameter, solid cast simulation

1 INTRODUCTION:

Casting process is subjected to many defects and it is necessary to eliminate them. One of the main defects in castings is "Shrinkage Cavity", which can be eliminated by attaching a Riser to the casting. (C. M. Choudhari, et all, 2013) [1] In the present global and competitive environment, foundry industries need to perform efficiently with minimum number of rejections. Also they have to develop casting components in very short lead time. Casting process is still state of art with experienced people, but these experience needs to be transformed in engineering knowledge for the better growth of the foundry industries. Some foundries are working with trial and error method and get their work done. Factually, most of the foundries have very less control on rejections, as they are always on the toes of production urgency; hence they ignore the rejections and salvage the castings. Majority foundries are failed to maintain a satisfactory quality control level. (Sunil Chaudhari, et all, 2014) [2].

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Foundry industries in developing countries suffer from poor quality and productivity due to involvement of number of process parameters. Even in completely controlled process, defects in castings are observed and hence casting process is also known as process of uncertainty which challenges explanation about the cause of casting defects. (Rajesh Rajkolhe,et all, 2014) [3]. There is an increasing demand in manufacturing environment for the best quality of casting products at the right time and quantity. In order to survive in the competitive market and to achieve customer satisfaction trial-and-error method to produce defect free casting products from design to manufacturing is too costly and not effective. Modernization is the only key to improve casting quality and productivity. (A.K.Gajbhiye, et all, 2012) [4]. In the current global competitive environment there is a need for the casting units and foundries to develop the components in short lead time. Defect free castings with minimum production cost have become the need of foundry. The gating and riser system design plays an important role in the quality. (Swapnil A. Ambekar, et all, 2014) [5]. Significant amount of cast iron castings are being used to fabricate components such as engine blocks, cylinder heads etc., In response to consumer demands for the increase in performance with excellent castability and machinability, the use of cast iron has grown dramatically from the past. Production of cast iron castings is a complex process which involves many parameters that affect the quality of castings. But production of aluminium castings are comparatively easier. (Sarath Paul, et all, 2014) [6]. Casting has various stages like pre-casting processes like pattern making, core making, molding and mold assembly making, casting processes like furnace charging, melting, holding and pouring, and post-casting processes like shakeout, inspection and dispatch etc. In India, many foundries have followed conventional and manual operations. Today's competitive environment demands lower manufacturing cost, more productivity in less time, high quality product, defect free operations. Mold shifting, crushing, lower surface finish, shrinkage, porosity, cold shut and extra material are common casting defects due to these manual operations. These defects directly affect on productivity, profitability and quality level of organization. (Anirudda Joshi, et all, 2014) [7]. Green sand casting process involves many process parameters which affect the quality of the castings produced. It is possible to optimize green sand casting process parameters by Design of Experiment method such as Taguchi method. The Taguchi Method is a powerful problem solving technique for improving process performance, yield and productivity. Using Taguchi analysis, the effect of various process parameters at different levels on casting quality can analyze and optimal setting of the various parameters can obtained. (S.S.Jamkar, et all, 2014) [8]

2 EXPERIMENTAL PROCEDURE:

ANALYSIS ON SOLID CAST SOFTWARE:

Solid cast is a theoretical simulation software used to analyze the castings by simulating on a computer. By simulating the process, we hope to predict potential defects in the castings and redesign the process to eliminate the defects, before the production of the castings. It can also be used to determine the temperature distribution, solidification time and hotspots in the castings.

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PROCEDURE:

- The CAD model of the V-block is designed using Creo Parametric 2.0 and saved as STL file.
- Solid cast is invoked and Add shape tool is used to import the STL file to solid cast.
- Add shape tool is also used to design the riser and the fill material.
- After the completion of model, the model is meshed using 'create mesh' option

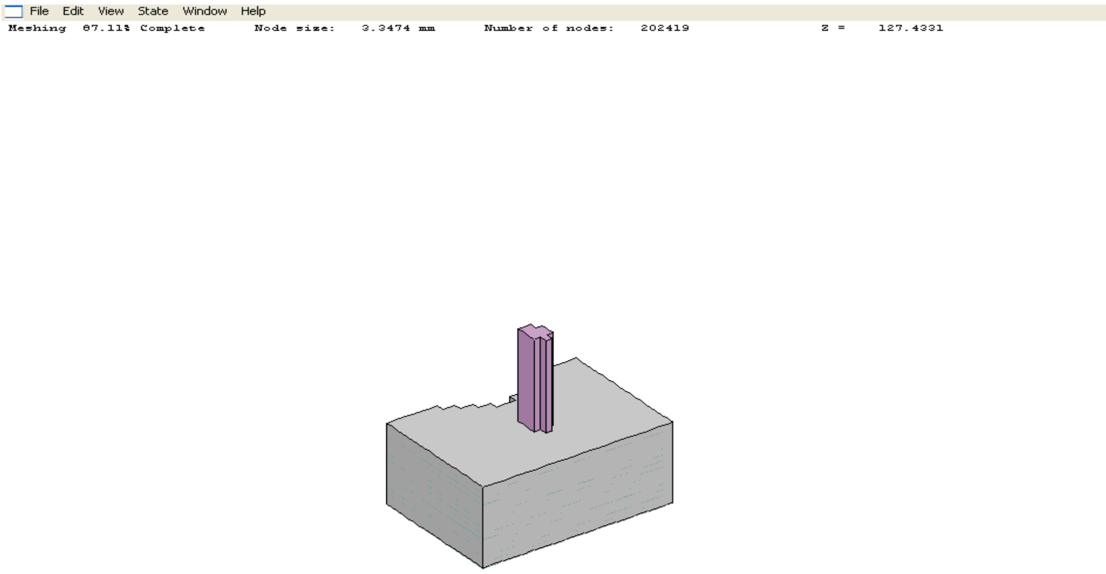

Fig 1: Meshing

- The weights of the aluminium and silica sand is found by clicking on mesh weights option.
  Weight of Al casting = 0.718 kg

  Weight of silica sand = 11.159 kg
- After the meshing is completed, simulation is done using 'start simulation' option.
- The simulation runs for about 7 minutes and the initial and final casting temperatures are obtained for simulation.
- The temperature distribution is obtained by using 'start Flow cast' option.
- The simulation is obtained in a form of animation where the molten metal is poured and filled into the casting.

3 RESULTS AND DISCUSSION

TEMPERATURE DISTRIBUTION:

The temperature distribution of castings with riser diameters 10mm, 15mm and 20mm are simulated using solid cast software and the results are interpreted as follows.

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Temperature distribution-Riser diameter 10mm:

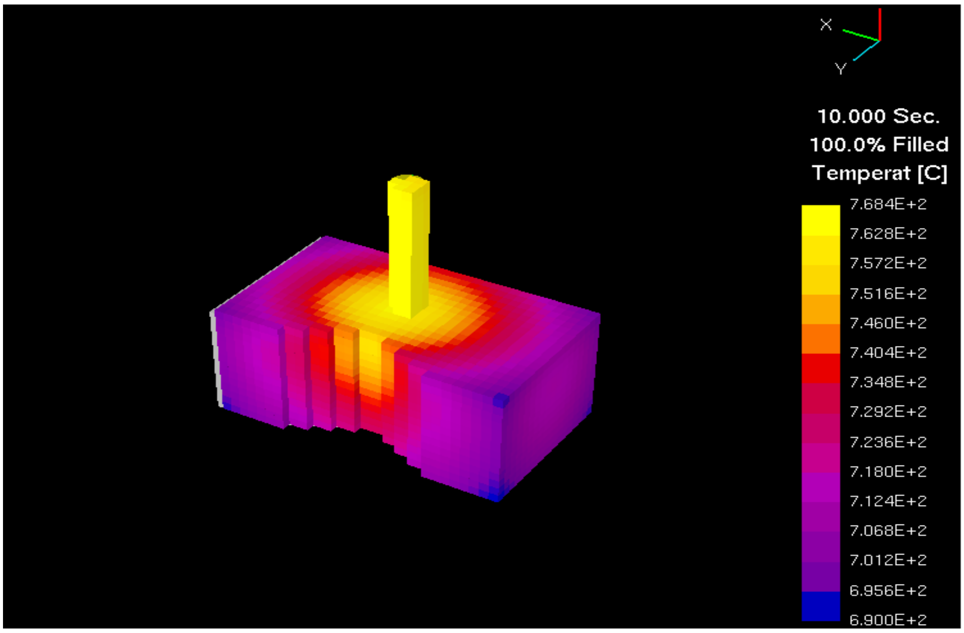

Fig 2: INFERENCE:

The yellow region in fig 2 is the part that solidifies at the last. The possibility of shrinkage defects at that region is more than the other regions.

Temperature distribution-Riser diameter 15mm:

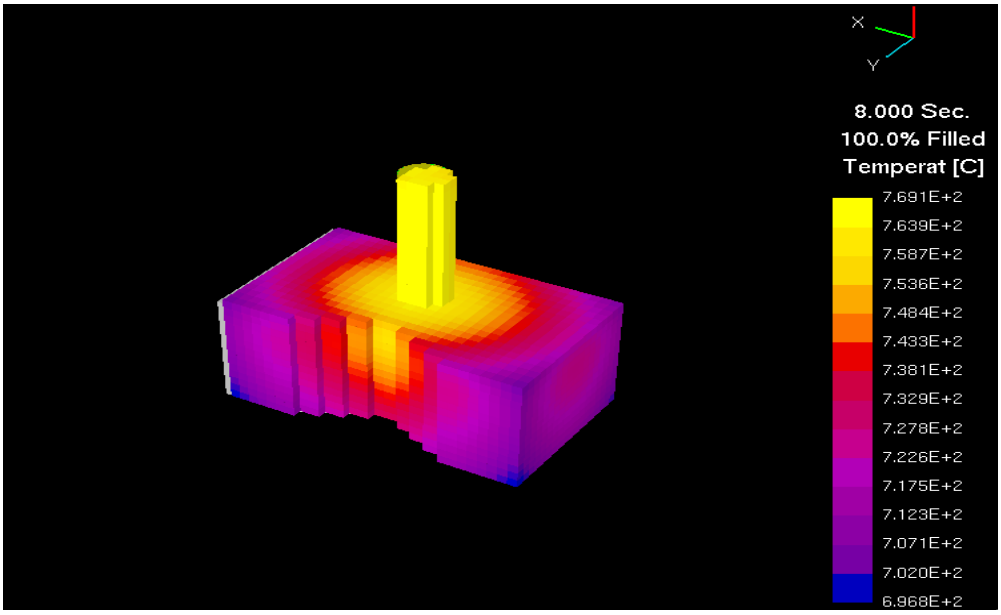

Fig 3:

INFERENCE:

Compared to the temperature distribution of the casting with riser diameter 10mm, the above figure shows more shrinkage as the yellow region is broader in fig 3.

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Temperature distribution-Riser diameter 20mm:

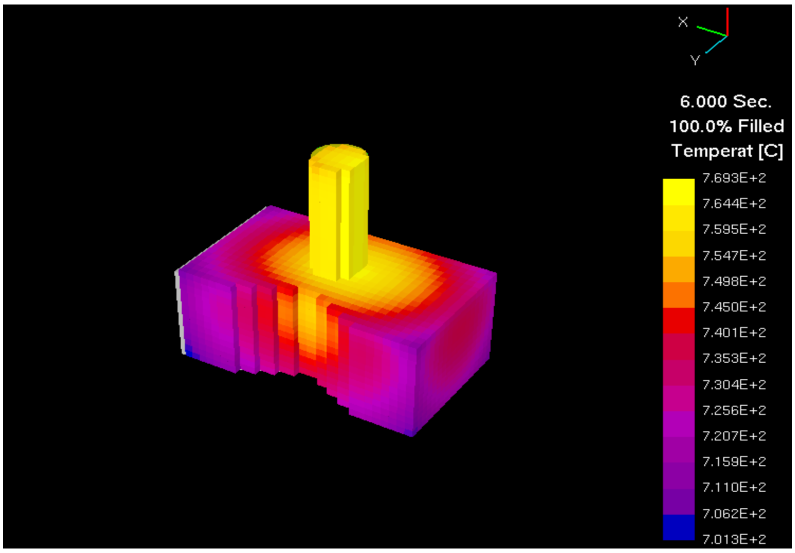

Fig 4:

INFERENCE

The temperature distribution in fig 4 is uneven and the area which is last to solidify is more compared to fig 2 and 3. Hence the casting with 20mm riser diameter will posses more shrinkage than the castings with 10mm and 15mm riser diameters.

RESULT

The area which solidifies at the end are prone to shrinkage defects, ie. the area near the riser. Considering all the three cases of riser diameters, case 1 with riser diameter 10mm tends to possess less amount of shrinkage defects, because the temperature distribution is even and the area which is last to solidify is minimal compared to other castings with 15 and 20 mm diameters.

4 CONCLUSION

The theoretical simulation of temperature distribution was obtained using solid cast simulation software and the results were used to determine the optimal diameter to reduce the defects in Aluminium castings manufactured.It is studied from simulation, that the area which solidifies at the end are prone to shrinkage defects. From the simulation, we can infer that the casting with 10 mm riser diameters will possess the less amount of shrinkage defects than the castings with 15mm and 20mm riser diameters.

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