Visualizing the air traps as function of fill velocity in casting: a CFD based case study

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ABSTRACT

The present study focus on the prediction of the air traps in the casting method as the function of the flow velocity. Cold shuts being the major defects in the casting method, studying the how the cold shuts are form can helps in redesigning the mold helps in the improve the quality of the product. In order to resolve this procedure the CFD based VOF model is used to study the formation of the cold shuts based on the aluminum AlSi7Mg with the operational temperature of 700C by varying the flow velocity ,it is found that the as the velocity of the flow increases the number of the air traps in the model exhibits a nonlinearity ,

Keyword : - *casting method, VOF model, air traps*

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1. INTRODUCTION

Casting is the one of the oldest manufacturing technique, which is still being in use. This method is simple that the part to be made is made a impression in the media and the molten metal is made to flow into the impression. Some of the methods later have modified into shell, the investment casting, and many more, but the procedure remains same. In the simple method it consist of the cope and drag boxes were the cope box is made to fill with the mold support material such as the green sand or silica or HIS steel and the impression is made with the model. Later the drag box is made to place on the cope box and the mold media is again rammed in to the drag box until the impression is tightly packed later the spruce and runners and the gates are cut to make the molten metal to flow into the cavity made. There are many possibilities of formation of the defects both the surface and the volume defects based on the mold material and the casted material.

Air traps are on such defects, which happen due to trapping of the air while the fluid is filled into the mold cavity. The formation of the air traps. When the flow of the molten metal flows with the high velocity and due to the turbulence factor overlapping of the two flow layers will entrap the second phase air and the oxide smoke to form the irregular voids causing the air traps in the mold volume. They appear either on the casting surface or in the body of a casting. The factors that caused the defects are due to excessive moisture content and the organic content in the sand inadequate gas permeability of the molding sand . Poor venting of mould. Low pouring temperature and incorrect feeding of the casting

2. LITERATURE REVIEW

An attempt has been made by the (Uday A. Dabade, Rahul C. Bhedasgaonkar)(2013)[1] to obtain the optimal settings by using the DoE of the moulding sand and mould related process parameters of green sand casting process of the selected ductile iron cast component. The green sand related process parameters considered are, moisture content, green compression strength, and permeability of moulding sand and mould hardness (in horizontal direction). The case study made by the (Bernard, Alain, et al)(2003)[2]In order to reduce the time and costs of the products development in the sand casting process, the SMC Colombier Fontaine company has carried out a study based on tooling manufacturing with a new rapid prototyping process. This evolution allowed the adequacy of the geometry used for the simulation to the tooling employed physically in the production. This allowed a reduction of the wall thickness to 4 mm and retained reliable manufacturing process.the approach of The metal flow and solidification behaviours in a multi-cavity casting mould of two automotive cast parts were simulated in three dimensions. The commercial code, FLOW-3D® was used because it can track the front of the molten metal by a volume-of-fluid (VOF) method and allows complicated parts to be modelled by the fractional area/volume obstacle representation (FAVOR) method.has been by the (Kermanpur, A., Sh Mahmoudi)(2008)[3]. Finite element algorithms are presented for the entire casting process from the mould filling stage to the prediction of the final distorted shape. The various algorithms available in the literature for solidification modelling are discussed in detail by the (Lewis, R. W., and K. Ravindran.)[2000][4]

3. METHODOLOGY

In order to find the how the clod shuts ae formed in the casting the commercial CFD VOF solver Solidhink cliktocast software is used. The pulley model is chosen so that the model has the bot the smooth continuous surfaces and the intricate groves, which could be the geometric effect on the flow and filling of the mold.

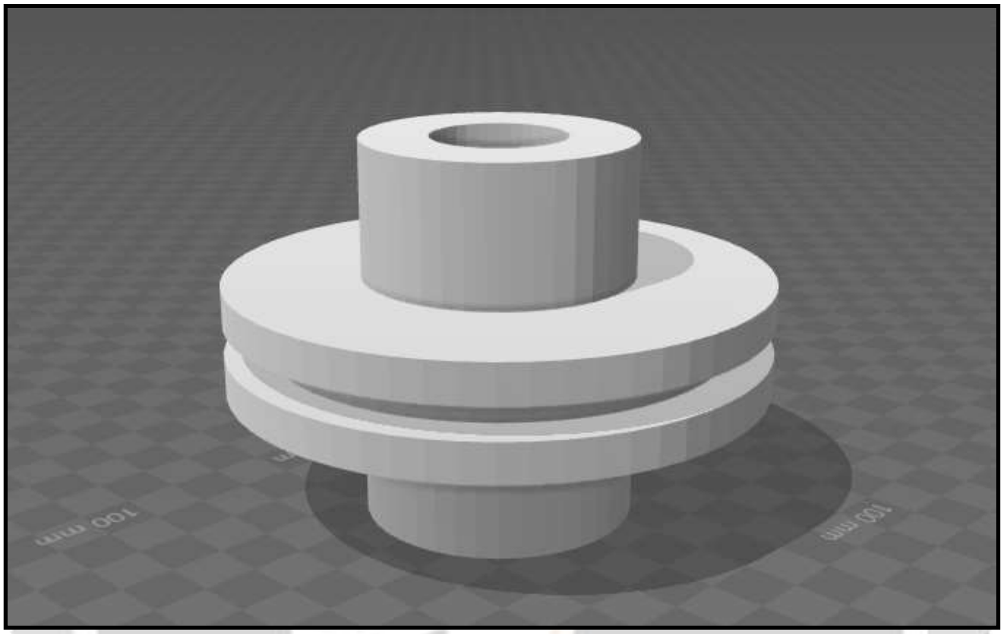

Figure - 1 the 3D Model of the pulley which is used for the casting simulation

Since the simulation is the based on the fluid, the meshing was made using the tetragonal mesh with the element size of 3mm and total of 9024 nodes with 38635 tetragons and the 10140 triangular split elements.

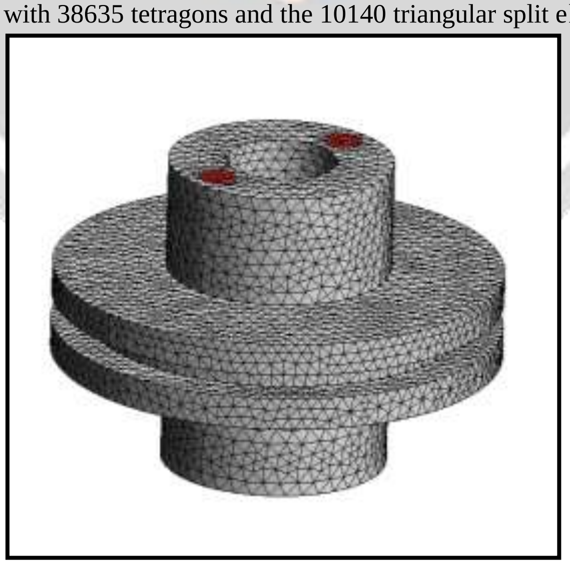

Figure -2: the finite element model of the pulley model with the tet meshing and the boundary conditions as shown in the red color as gate locations.

The boundary conditions are the basic for conducting the simulation here the flow velocity of the molten liquid is made to parametrized and the count of number of the air traps are made as the result the material that is made to flow in the mold is Aluminum *AlSi7Mg* grade. This is generally known as the cast aluminum thixo. the mold material used was the green sand

Table- 1: The properties of the AlSi7Mg material are given in following table.

Si. No	Material property	Value
1	Solidification shrinkage	0.8 (minimum)
2	Melting temperature	582 ^{0}C (Maximum)
3	Thermal expansion	22e-6 K
4	Density	2650 Kg/m^3

4. RESULTS AND CONCLUSION

The simulation is made to run in transient state and the total time needed for the converging the solution is automatically by the solver. Since the study is parametric in nature the flow velocity is constantly changed and the number of air traps are counted.

Table- 2: the parametric study table, which illustrates the number of air, taps as function of velocity

Si no	Flow velocity (m/s)	Number of air traps
1	0.5	10
2	1	14
3	1.5	6
4	2	6
5	2.5	7
6	3	3
7	3.5	4
8	4	3

It is observed form the table -2 as the flow velocity increases the number of the air traps in the final casted product is also increases, the velocities are based on the normal hand based casting.

Figure -3: the simulation results showing the number of air traps for the flow of 0.5 m/s

Figure-4: the simulation results showing the number of air traps for the flow of 1

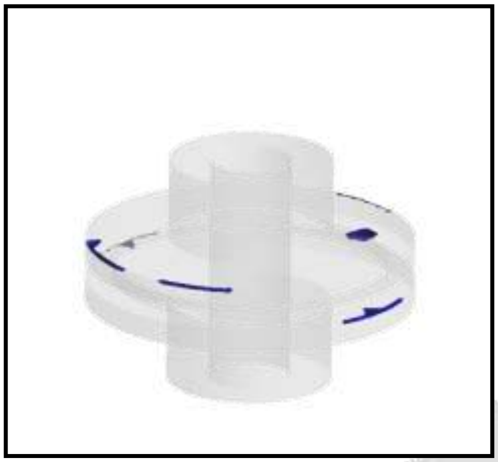

Figure -5: the simulation results showing the number of air traps for the flow of 1.5 m/s

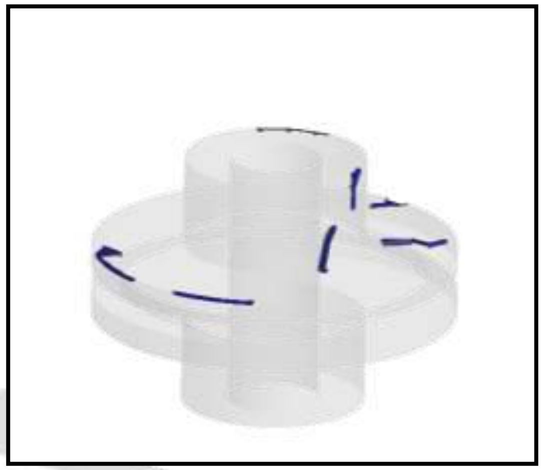

Figure -6: : the simulation results showing the number of air traps for the flow of 2 m/s

Figure -7 : the simulation results showing the number of air traps for the flow of 2.5 m/s

Figure -8 : the simulation results showing the number of air traps for the flow of 3 m/s

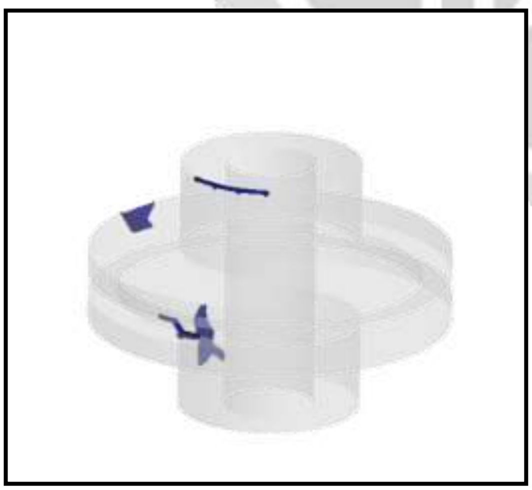

Figure -9: the simulation results showing the number of air traps for the flow of 3.5 m/s

Figure -10: the simulation results showing the number of air traps for the flow of 4 m/s

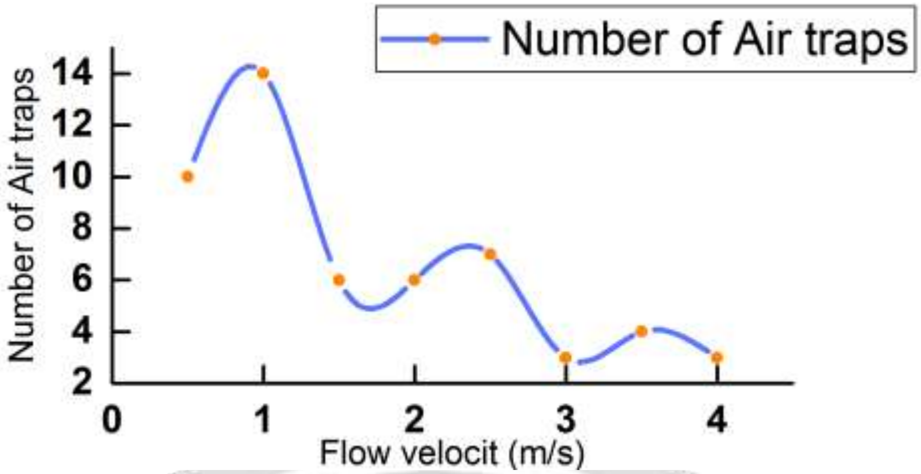

Figure -11: the nonlinear response of the number of the air traps as the function of the flow velocity

The response of the air traps v/s the flow velocities is fitted in to the concave function using the Gauss-Newtonian function which is given in following equation.

Let the number of the air traps be "B" and the let the flow velocity be "V" then the nonlinear equation is framed as

$$B - 0.196785\,BV = 1 \quad \text{...} \quad (1)$$

So from the equation (1) it has been observed that the non-linearity of the number of the air traps follow. So the optimum solution for reducing the number of air traps is said to be if the velocity reaches either 3 m/s and 4 m/s but the solution bonds to be a further case study.

6. REFERENCES

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