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Warpage Simulation of Manhole Cover using AutoCAST-X Software

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Abstract - *Designing an appropriate gating/risering system, some defects can be minimized such as cracks, distortion, shrinkage porosity, warpage, sink, and shrinkage cavity by simulating the directional solidification using casting software. In this study, the component from industry i.e. manhole cover is leading to premature failure of warpage or distortion. Hence, there is requirement of optimizing the appropriate gating/risering system. In this paper, the actual gating/risering system is simulated to minimize the warpage defect occurring in the industry while manufacturing. Hence, the simulation for optimizing better gating/risering system is done by using AutoCAST-X software which is based on Vector Gradient Method (VGM) for defect minimization.*

Keywords— *Autocast–X software, warpage, solidification, simulation, gating/risering system design.*

I. INTRODUCTION

Casting solidification phenomenon consist of volumetric contraction leading to defects i.e. distortion or warpage, shrinkage porosity. Casting solidification includes two phases i.e. short freezing range alloys and long freezing rang alloys. Generally short freezing range alloys poured in permanent molds, where the focus tends to shrinkage porosity and last solidifying region i.e. hot spots, while long freezing range alloys poured into sand molds and entire shrinkage distributed all over the casting during solidification process. Defect of casting such as warpage can be minimized by predicting the gating/risering location with the help of identified regions of high temperature i.e. hotspot and shrinkage porosity level with low gradient (short feeding distance). In this paper, the objective is to reduce warpage, occurring after ejecting from the mold which is further actually predicted due to the undesired location of gating/risering system. During solidification process some internal stresses were developed because of unequal distribution of molten metal which can be detected while doing solidification simulation by considering the temperature gradient factor i.e. hotspot (last solidifying region) and shrinkage porosity levels. By optimizing the shrinkage porosity factor, last solidifying region i.e. hotspot can be shifted into the risers which is actually the better gating/risering system for getting defect free component.

Simulation can be able to predict the actual location of gating/risering for optimizing defect minimized component with the help of AutoCAST-X software.

II. LITERATURE REVIEW

Behera Rabindra [1] suggested the computer aided methoding application and minimizing the bottlenecks in foundries by using casting simulation, also the development in casting by reducing the number of trials and non-value added lead time. Fras [2] discussed about mathematically and experimentally the transition from gray to white during solidification for various casting sizes i.e. for plate or wedge shape and further concluded that modulus of casting heat flow through mold depends upon the solidification rate. Hosseini [3] studied the effect of cooling rate on the solidification parameters, microstructure and composition of LM13 alloy. Therefore obtaining different mold configuration and cooling rates were parameters were determined by using computer-aided thermal analysis method. Rao Prabhakara [4] discussed about improving yield of casting, optimizing gating system design, mold filling and simulation.

III. PROBLEM IDENTIFICATION

The problem is inspected from the industry i.e. NECO Heavy Engineering & Castings Limited (NHECL). It produces castings catering to the needs of heavy engineering sector including integrated steel plants and also produces refractory items for steel and cement plants. Figure 1 show the manhole cover which is subjected to warpage. The ultimate objective is to reduce this warpage by changing the existing gating system.

Figure 1 Distortion occurs at the edge of cover plate

Figure 2 shows the actual gating system with the sprue, runner, riser etc. It can be seen that warpage or distortion is occurring at the edges of the cover frame which get bend at any one of the edge which has to be reduced for obtaining desired quality of casting.

Figure 2 Actual gating system of manhole cover

Further, figure 3 shows the CAD model of manhole cover with actual gating/risering system. Its volume is 900*600*40 mm^3 and the material is ductile iron grade (500/7). The entire simulation is done on this part by following the steps provided in AutoCAST.

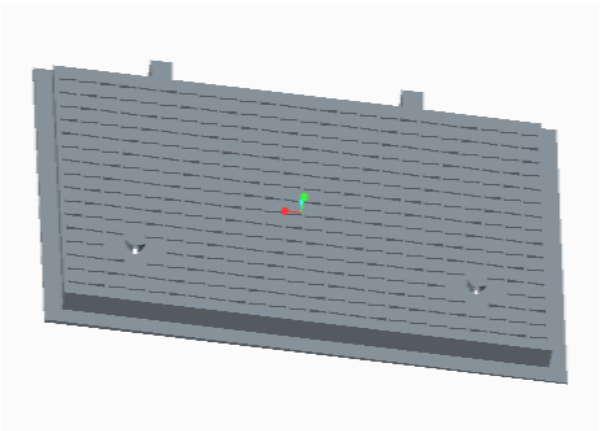

Figure 3 CAD model of Manhole cover

IV. SIMULATION OF MANHOLE COVER PLATE

According to the dimensions of the component, first the mold cavity is prepared. After preparing the mold cavity the existing gating system is incorporated for carrying out the simulation process. The Further, this simulation results are actually inspected by the position of hotspots which helps to optimize the predictable location of gating/risering with minimum defect. Simulation helps to minimize the defect by adjusting the riser location according to the last solidifying area i.e. hotspot and the shrinkage porosity levels i.e. micro and macro porosity levels. If both the shrinkage porosity level showing 100% quality then and then it can be predicted that entire hotspot is shifted at the center of the riser which helps in minimization of warped or distorted kind of defect. Now, simulation is carried out by using AutoCAST-X software in which the results are taken by considering solidification, thickness, mold cavity, hotspot and shrinkage porosity levels.

Firstly, the component i.e. manhole cover frame is inserted in software in .stl format where the volume of casting 900*600*40 mm^3 is shown and mold size can be adjusted according to the material properties given below.

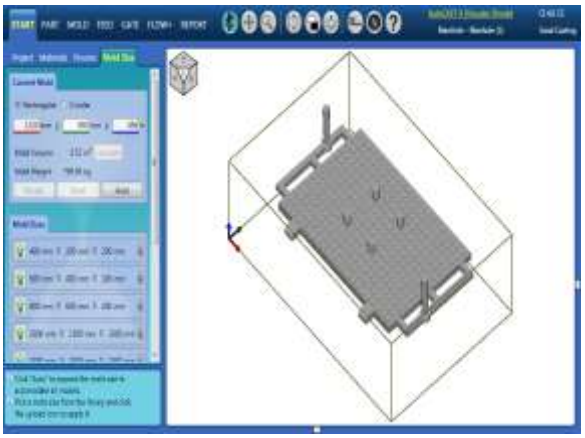

Figure 4 Manhole cover part

Now, further the simulation process is done by calculating the thickness map for each section considering the thickness of cover frame at each axis i.e. x, y, z axis. According to the thickness ratio the complexity of component can be simulated as shown in figure 5.

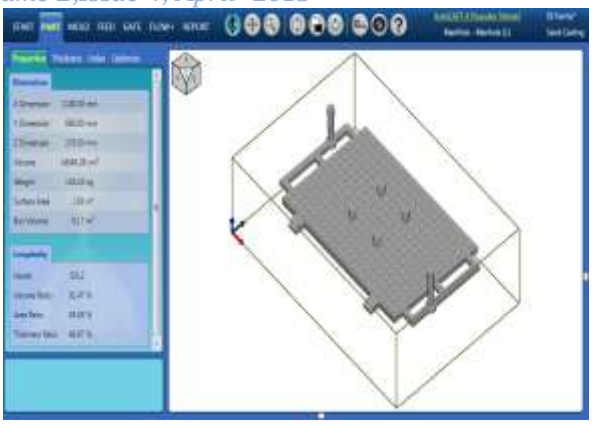

Figure 5 Thickness map for cover frame

Shape complexity of component can be identified by considering three ratios given below;
Volume ratio =
1 – (Volume of part / Volume of bounding box) =
Area ratio = 91.47%
1 – (Area of a sphere of equal volume / Area of part) =
Thickness ratio = 85.09%
1 – (Minimum thickness of part /Maximum thickness of part)
= 66.67%
From above, the indication of high value ratio is taken as more intricate shape.

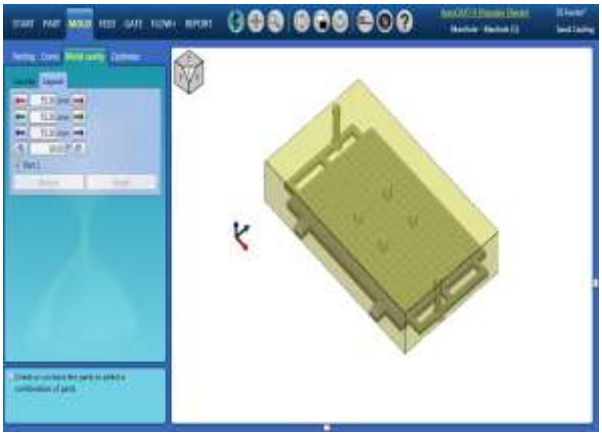

Figure 6 Mold cavity

From figure 6, the parameters of mold cavity i.e. the mold flow can be predicted during the simulation where the layout is shown with some orientation i.e. 90^0. All the parameters which take part while designing the mold cavity is further simulated in this software for defect minimization.

Figure 7 Hotspot detection

Figure 7 shows the last solidifying region i.e. hotspot and is detected in the risers. During solidification, it may be possible that unequal distribution of mold flow takes place due to which internal stresses are produced which leads to warpage. It is observed that the hotspots are found in the risers but not exactly at the centre. Hence it is required to change the position of riser so that the hotspot should get exactly at the centre.

Figure 8 Solidification simulation

Solidification of casting is takes place from casting surface to interior and to predict the casting defect such as shrinkage porosity, cracks and distortion, simulation is helpful. Solidification simulation enables to identify the location of gating/risering system which further helps to achieve desired quality of component.

After doing solidification simulation it is found out that the time required for the solidification is 10.78 min. Figure 8 shows the solidification simulation of manhole cover.

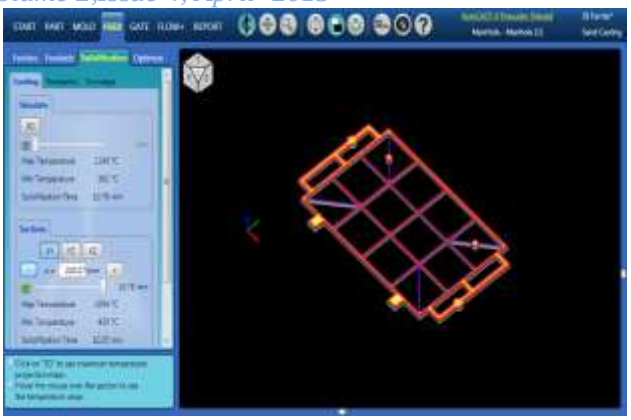

Figure 9 Solidification simulation of Ribs

Figure 9 shows the solidification simulation of Ribs. The ribs are the supporting parts of manhole cover which gives strength to it.

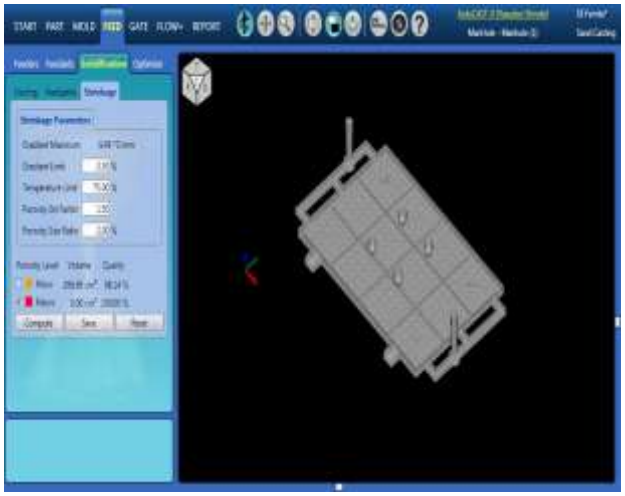

Figure 10 Shrinkage porosity

Shrinkage porosity consists of two porosity levels i.e. Macro porosity and Micro porosity. These two levels are the shrinkage parameter which helps to achieve the gradient temperature and porosity factors. Macro porosity level consists of red color while micro porosity level is shown by the orange color. Shrinkage porosity is identified as dots inside the component either in red or orange color with the quality percentage. Both the porosity level should be identified with 100% quality, then and then shrinkage can be shifted into the risers. In this simulation, macro porosity is identified with 100% quality while micro porosity obtained as 266.66 cm^3 volume with 98.34% quality. It can be seen that the hotspot s not exactly at the centre of the riser. Hence, possible trial runs have to take at different location of gating/risering system to shift the hotspot exactly at the centre to get the defect free component.

V. CONCLUSIONS

- Casting Simulation is very powerful tool which is used to identify the correct location of gating system so as to reduce defect.
- Solidification simulation provides iterative means of designing or modifying the feeding system. This reduces the overall cost of developing the method for new casting by minimizing the time as well as labor involved in it.
- After doing the simulation of gating system by AutoCAST software it is found that the hotspot is not exactly at the centre of the riser.
- In this simulation, macro porosity is identified with 100% quality while micro porosity obtained as 266.66 cm^3 volume with 98.34% quality. It can be seen that the entire shrinkage has not been shifted into the risers. Hence, possible trial runs have to take at different location of gating/risering system to shift the hotspot at the centre of the riser.

VI. REFERENCES

[1] Behera Rabindra, Kayal S., and Sutradhar G, " Solidification behaviour and detection of Hotspots in Aluminium Alloy castings: Computer Aided Analysis and experimental validation," International Journal of Applied Engineering Research, issue1, volume (4), pp: 715-726, 2011

[2] Fras, E., Gorny M., and Lopez, " The Transition from Gray to White Cast Iron During Solidification: Part I Theoretical Background,"Metallurgy and Materials Transactions A, 36A(11), pp: 3075-3082, 2005

[3] Hosseini, V.,A., Shabestari, S.,G., and Gholizadeh, R. "Study on the effect of cooling rate on the solidification parameters, microstructure and mechanical properties of LM13 alloy using cooling curve thermal analysis technique," Material Design, 50, pp: 7–14,2013

[4] Rao Prabhakara, P., Chakravarthy, Kumar and Srinivasa Rao, " Computerized simulation of sand casting process," 57th Indian Foundry Congress, Institute of India Foundrymen, Kolkata, 2009

[5] Prachi K. Tawele and Laukik P. Raut, " Warpage in casting: A Review," International Journal of Advanced Research in Engineering, Sceince and Technology, issue 2, volume 4, pp: 1-7, April 2015