Simulation and Optimization for Casting of Boom Stand Based on AnyCasting

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Abstract. The AnyCasting software was used to simulate the filling and solidification of the casting technology of boom stand, therefore the type and location of the defect in the casting can be predicted based on the simulated result. According to the detect in the casting, the casting technology can be modified and simulated, then the casting technology can be optimized, and the detect in the casting can be minimized.

1. Introduction

Mining boom stand is an important component of the high-speed multifunction rescue engineering vehicle, it is the supporting part which connects mining boom with the truck frame, so it is possible to expand the excavation work area depends on the swing mining boom. High strength is required because of the working condition of the mining boom. The part material is ZG270-500, casting defects are not allowed at the position which machining a hole. Higher dimensional accuracy of castings and surface quality are required due to more non-processed contact surfaces during the mining boom stand, the mining boom and the truck frame [1-4]. The casting process is more difficult because of the complex structure, larger size and more mud core number, it will be deformed easily and the dimensional accuracy is difficult to guarantee, what's more, the large size riser result in a heavy workload to finish polish. 3D model of the mining boom stand is established by Pro/E in this paper. The AnyCasting software was used to simulate the filling and solidification of the casting technology of boom stand to solve the problems during forming and process of the mining boom stand castings, a reference can be provided for similar castings production [5-7]. The cycle process of design, verification and manufacture of products are shortening and the production costs are reduced by applying CAD technology.

2. Original casting process introduction

Mining boom stand is a large steel castings with complex structure whose weight is 230kg and the maximum size is 839mm. For the processing hole positions which cannot use riser feeding, in order to make its internal don't produce the defects such as shrinkage cavity, chill are used at both inside and outside positions which need processing hole to speed up the cooling ensure its solidification first, to ensure the inner quality of the parts.
3. The original process simulation
The 3D model of mining boom stand, riser, gating system and chill are established by Pro/E, STL format file is exported, then STL files of various parts are imported in AnyCasting. Pre-processing and each section attribute setting are carried out under AnyPRE environment, according to the AnyCasting meshing rules, non-uniform grid function is used to mesh the cast into 1,005,268 units. Sand casting is chosen as task setting, Analysis type Select. The analysis of filling and hot/solidification analysis before and after filling is chosen as analysis type. The process conditions are shown in Table 1, the heat transfer coefficient is shown in Table 2.

Table 1. Process conditions

| Casting material          | ZG270-500 |
|---------------------------|-----------|
| Pouring temperature       | 1580 °C   |
| Sand mold material        | Furan resin sand |
| Pouring time              | 32s       |
| Pouring liquid flow diameter | Ø 50mm   |

Table 2. Heat transfer coefficient

| Entity 1 | Entity 2     | Heat transfer coefficient\(\text{W/(m}^2\text{°K)}\) |
|----------|--------------|---------------------------------------------|
| air      | other        | 41.87                                       |
| casting  | chill        | 8374                                        |
| casting  | sand mould   | 4187                                        |
| chill    | sand mould   | 25122                                       |

3.1. Filling process simulation analysis
Since the original process plan to take a top gating, swirl may occur at the bottom of the cavity. Figure 1 is a filling process velocity field analysis. It is evident that swirl is generated at the beginning of the molten steel pouring at the bottom of the casting, likely to cause sand inclusion, air entrapment defects. AnyCasting also joined in the particle tracking analysis results in the numerical simulation of the filling. You can be more intuitive to see the stream flows into the cavity. The particle tracking analysis in the process of filling is shown in Figure 2.
3.2. Solidification process simulation analysis

The casting solidification process analysis diagram is shown in Figure 3. As it can be seen from the figure that in the final stages of solidification, orphaned liquid phase zones appeared at the massive hot section and waist circular riser of the casting. Orphaned liquid region in the non-riser area can easily produce Shrinkage defects. Figure 4 is a shrinkage defects figure according to the residual melt modulus criterion. You can see the shrinkage defects appeared at the root of the waist circular riser and the bottom hot section which will affect the casting quality.
4. Casting process optimization and simulation

According to the AnyCasting simulation analysis result of the filling process, the gating system solutions in the original process is easy to form vortex in the process of filling, cause sand inclusion and air entrapment defects. This paper argues that the gating system should be changed into bottom-pouring. Chill near the bottom gate is canceled in the improved process. New chill can be added to control the shrinkage defects at the bottom of the machined hole-location. The improved process is shown in figure 5.

The improved process simulation analysis for the filling process and solidification process are carried out. Found that the stream pours into the cavity and then rose slowly and filling stable when the bottom-pouring process is carried out. Sand inclusion and air entrapment defects are less likely to be caused. What's more, the shrinkage defects at the bottom of the machined hole-location has been controlled correspondingly. A small amount of shrinkage defects appears at the non-machined hole-location, and meet the needs of the casting to use.

The filling and solidification process simulation results and defects of casting obtained based on AnyCasting are in accordance with the actual production conditions, the cycle process of design, verification and manufacture of products are shortening and the production costs are reduced by applying CAD, CAE technology.

Figure 4 Main region of isolated liquid

Figure 5 Improved process
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References
[1] Mishra P, Ajmani S k, Kumar A, et al. Review article on physical and numerical modeling of sen and mould for continuous slab casting. Int [J]Engng Sci Tech, 2012, 4: 2234-2243.
[2] Wang L, Vitae A, Deng C, et al. Development of continuous casting technology of electrical steel and new products. [J] Iron Steel Res Int, 2012, 19: 1-6.
[3] Sindhya K, Miettinen K. New perspective to continuous casting of steel with a hybrid evolutionary multiobjective algorithm. Mater Manuf Proc, 2011, 26: 481-492.
[4] GanesanS,PoiricdrDR Conservation of Mass and Moment Umfor the Flow of Interdendritic Liquid During Solidification.MetTrans,1987,18:721-723.
[5] W.Wen.Simulation of an Automobile Wheel Casting Process’Proceedings of 61st World Foundry Congress, LiuBaicheng,ed.Beijing,1995:5-9.
[6] ChoiJK.Application of Mold Filling and Solidification Simultion to Aluminum Wheel Castings.Proceedings of the 61 st world Foundry Congress.Beijing,China,1995:13-27.
[7] ChiesaF Solidification Modeling of Cast Aluminum Wheels.Modern Casting 1991,(12):26-284.