

# Numerical Simulation Research on the Deformation and Solidification of Corrosion Protection Shell Casting

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**Abstract.** The temperature and stress field in the deformation and solidification process of the corrosion protection shell casting was simulated based on the ProCAST software to predict the possible defect area and prevent the deformation. According to the simulation results, the qualification rate of products could be improved and the parts which are more qualified could be produced by optimizing the process parameters, then analyzing the simulation results and optimizing the optimal process parameters in the end.

## 1. Introduction

Traditional casting forming process of the filling and solidification process of liquid metal in the cavity is invisible for technical personnel on the spot. If the qualified products are purely produced by operation workers' experience and repeated trial, not only the low production efficiency but also the high cost and time-consuming are not conducive to the long-term development and economic benefits of the enterprise [1, 2].

The advent of computer numerical simulation technology in casting field technicians make it possible for technical personnel to predict the location and size of areas where are easy to form shrinkage, dispersed shrinkage and deformation during the process of casting deformation and solidification without actual operation [3]. The temperature and stress field in the deformation and solidification process of the corrosion protection shell casting was simulated based on the proCAST software to predict the possible defect area and prevent the deformation in this paper, in order to optimize the process parameters. And thus the qualification rate of products was improved at last.

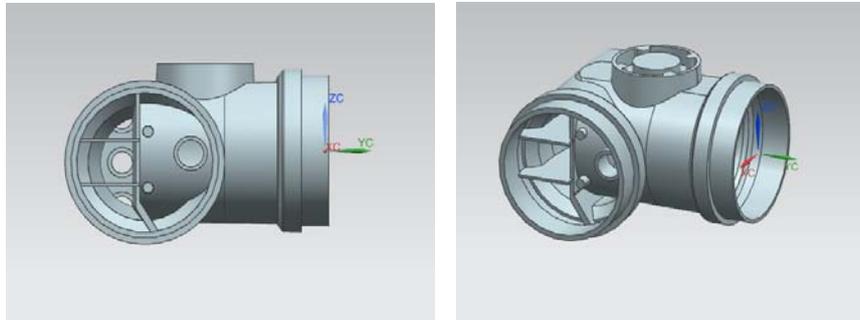
## 2. Designing and analysis

### 2.1. Structure and system designing

*2.1.1. Structure designing.* Shown in the Fig.1 is the Corrosion protection shell castings used in this paper, which is made by 304 stainless steel and consist of three circular interface. The diameter of the

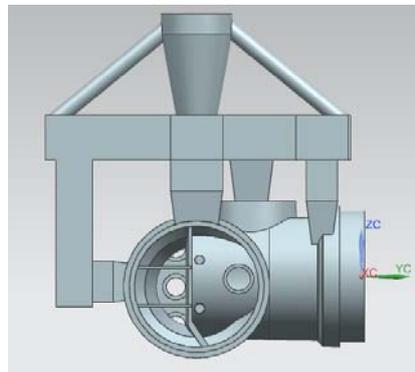


interface on the boss is 76mm, and the diameter of remaining two interfaces with a wall 5 is 130mm. The thickness of the whole casting is 6mm, inside there are a lot of complicated structures including some of the holes, rib and convex, so the casting itself is prone to appear defects.



**Figure 1.** 3D model of shell casting.

*2.1.2. Filling system designing.* The construction of the filling system was designed, combined with the gating system design principles and components of the structure shape. The shell structure is complex, with two circular interface and there are a lot of blocks inside. The parts where solidification occurs at first needs timely feeding to avoid the appearance of defects, so that gating system must be able to ensure that the liquid metal can finish filling in a very short time. Then there is a need to set large sprue cups to feeding the parts after solidification. At the same time, based on the casting's irregular shape, the feed of individual parts must be carried on to avoid the formation of shrinkage and dispersed shrinkage and ensure the quality of casting. In addition, the gate should be set to ensure that each part of the liquid metal in the casting have a balanced flow to make heat conduction smooth and avoid deformation defects such as cracking stress concentration [4]. What's more, the design should take the possibility of casting rejection resulting from exhaust and slag discharge into consideration.

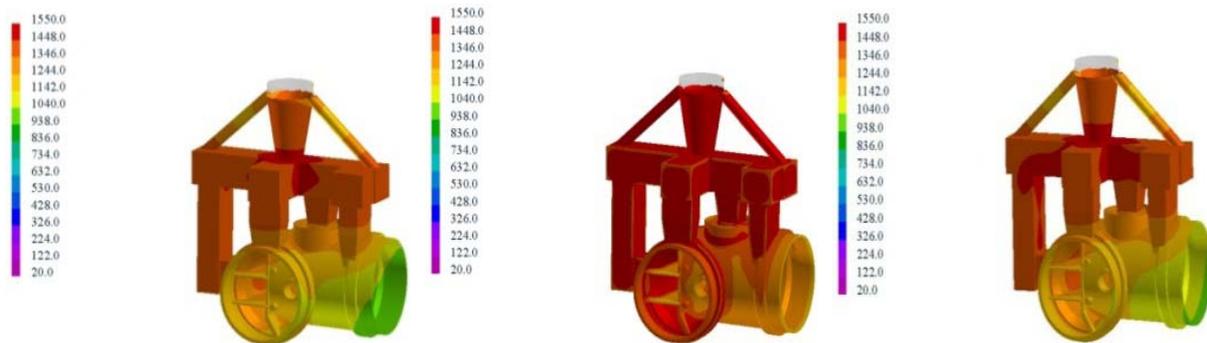


**Figure 2.** The note - side note type gating system.

The simulation design of gating system in this paper is the top note - side note type hybrid gating system. As showed in the Fig.2, it has four pouring gates, and two of them are set in the two interfaces section of the castings because of thin and nonuniform wall thickness of the two parts. The pouring gate set makes good feeding to the solidification of this part and avoids defects such as deformation. Gates also set in the convex part of the casting, enabling the metal to flow smoothly full of cavity, and the interface part of the casting can be feeding. Top note way design is aim to make the liquid metal solidification in order, which means the liquid metal can gradually in the bottom of the shell to the top of the gating system part of the solidification, so that the follow-up supplement of liquid metal can make a good feeding effect [5].

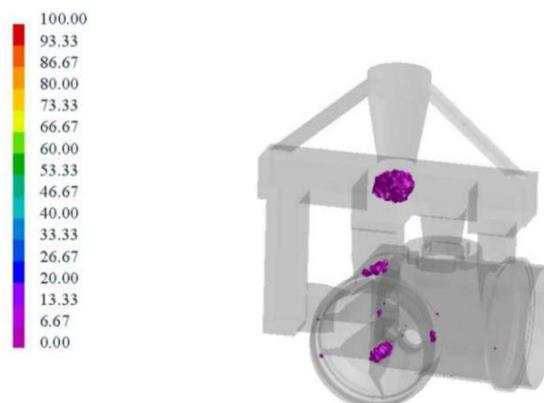
## 2.2. Project analysis

The first string of pouring process is simulated and analyzed by using the ProCAST software, and simulation conditions follows: mold-filling velocity is 200mm/s, mold shell temperature is 1000°C, the preheating temperature of casting is 1500°C. The Fig.3 is the casting solidification process diagram of the first string, it shows that the solidification is processed in order from top to bottom, and it begins from the lower shell with a comparatively fast speed, then occurs on the boss with a relatively slow speed. The whole process lasted about 1688.9s.



**Figure 3.** Top note - side note type solidification process.

Shown in the Fig.4 is the casting shrinkage porosity defect diagram under following simulation condition: mold-filling velocity is 200mm/s, mold shell temperature is 1000°C and the preheating temperature of casting is 1500°C. The result shows that the most massive shrinkage porosity defect ratio is 35.606%, next is 18.331%. There is less shrinkage porosity defect under this condition, which mainly occur in the gating system and slightly occur in the casting, especially in the middle of the thin-wall circular interface and the upper part of interface.



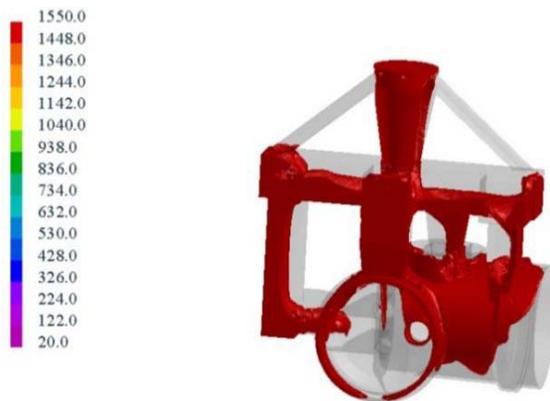
**Figure 4.** Top note - side note type shrinkage porosity defect.

## 3. Analysis and optimization

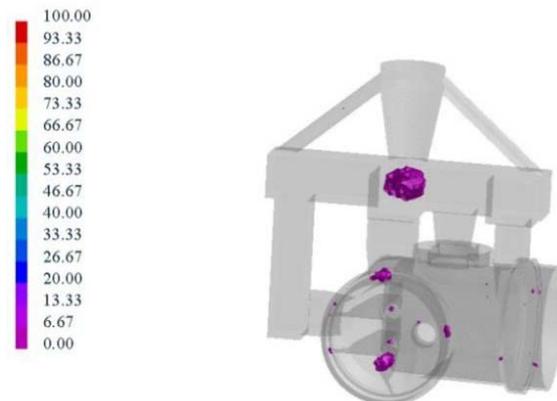
### 3.1. Temperature field parameters simulation optimization analysis

Temperature field parameters simulation optimization analysis the simulation results are optimized by changing the process parameters in this paper, and the simulation conditions of the second string follows: mold-filling velocity is 200mm/s, the preheating temperature of casting is 1550°C and mold shell temperature is 1000°C. Provided are the situation of the filling metal figure, shrinkage porosity defect graph and solidification time line chart, as Fig.5, Fig.6 and Fig.7. According to the Fig.5, filling

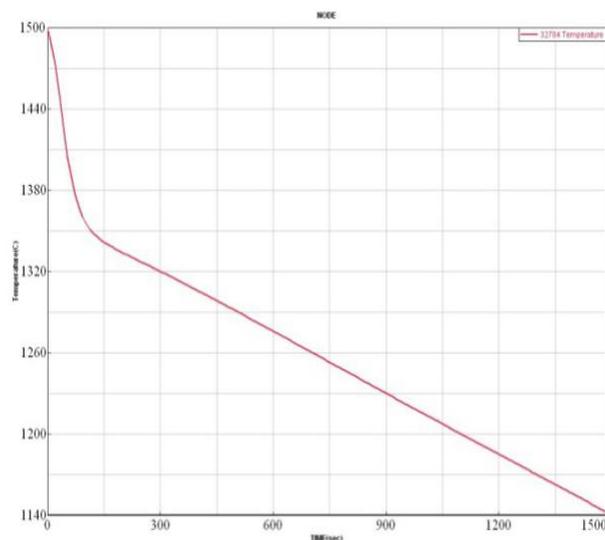
process becomes smoother under the condition where the mold-filling velocity is 200mm/s. The Fig.6 depicts that there is a big reduce in shrinkage porosity and shrinkage cavity. The Fig.7 show that the most massive shrinkage porosity defect ratio is 29.325%, next is 12.812%.



**Figure 5.** Situation of the filling metal figure.



**Figure 6.** Shrinkage porosity defect graph.

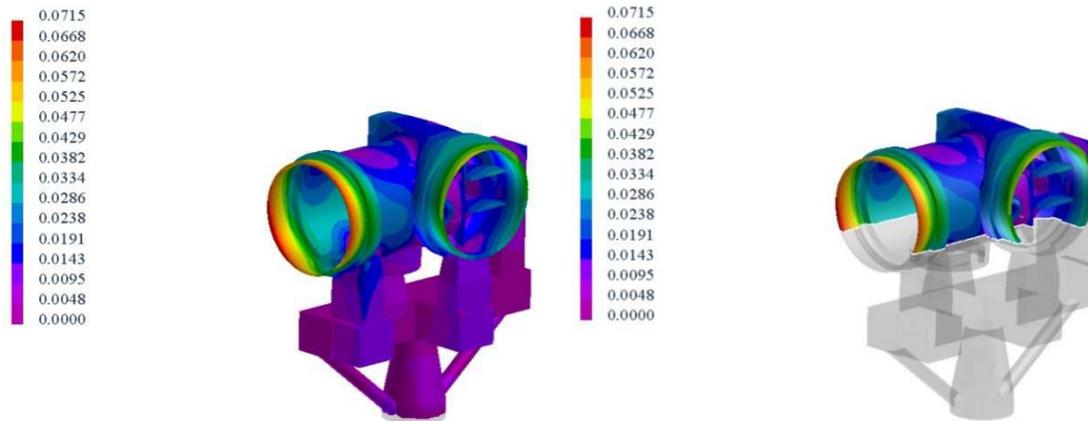


**Figure 7.** Solidification time line chart.

### 3.2. Stress field parameters simulation optimization analysis

After the solidification process of temperature field simulation, changing again a kind of process parameters of gating system of stress field simulation analysis according to the design of gating system, and the simulation conditions follows: mold-filling velocity is 200mm/s, the preheating temperature of casting is 1500°C and mold shell temperature is 1000°C. The simulation results are showed in the Fig.8.

According to the casting size deformation figure, the casting deformation of the gating system is mainly focused on the red circle outside the parts of circular interface thin wall casting, and the maximum size deformation is 0.715mm, followed by is the deformation in yellow of two ports with 0.668mm, which decrease from ports to inside. What's more, the figure of the green end is 0.382mm, the figure of the blue wall thickness of casting is 0.143mm, and the figure of the pink wall thickness of casting is 0.048. The result shows that the port is the area where happens the biggest size deformation, but it is smaller than that of the first string.



**Figure 8.** Casting size deformation figure.

#### 4. Conclusion

The qualification rate of products could be improved and the parts that are more qualified could be obtained by optimizing the process parameters to reduce the generation of defects, doing simulation analysis of gating system and optimizing the optimal process parameters of parts at last.

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