Applied Mechanics and Materials
ISSN: 1662-7482, Vol. 456, pp 354-357
doi:10.4028/www.scientific.net/AMM.456.354

Online: 2013-10-31

Casting Process Design and Simulation for Shaft Locking Pin

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Key words: shaft locking pin, casting process, simulation.

Abstract. Two kinds of methods of casting process for shaft locking pin were introduced. Simulated and analyzed the casting process by ANYCasting. Predicted the potential defects, resulted in a relatively optimized design. Replaced the traditional trial-and-error test with computer simulation, reduced design time and improved design efficiency.

Introduction

Casting process simulation software has been used by foundries to predict the potential defects and solve them before an actual casting is produced [1]. With the PC-Based casting solidification modeling software, the whole process of casting, such as filling, heat transfer and solidification can performed within a personal computer [2]. Computer modeling offers the potential of evaluating process designs in much less time, and at much less cost, than by producing sample castings.

Two kinds of casting process were presents in this paper, and then simulated with modeling software. By contrast, the relatively ideal solution obtained.

Initial casting process design

Shaft locking pin is the key parts of No. 13 couplers. It is the train connecting device for joint each railway carriage. Its quality seriously influences the safety of the whole vehicle and the goods in running process. Up lock be used for pilling coupler knuckle lock. In the locked position, up lock and lock pin rod shape into a bow for a prevent dropout function. Shaft locking pin is particularly important in the lock device, its quality is serious affects the whole couplers can connect, affects the safety of connection between cars.

The part is shown in Fig 1. Material: cast steel ZG25. After modeling, the quality of single entity is the 0.8kg.

Scheme 1. Cast method: sand casting process, use Non-pressurized gating system [3]. Each component area ratio for: ΣF ingate >ΣF runner>ΣF sprue, and use bottom gating system which is poured into the cavity form the bottom. It was found that the filling process was smooth, no pressure existing in the metal flow system and thus it helps to reduce turbulence. The advantage is not easy to produce porosity, but the disadvantage is not conducive to sequential solidification. The casting size is relatively small, so do not consider the riser to feed the casting.

Preliminary gating system design: Take the 6 part as a gating unit, the design scheme is shown in Fig 2.

According to the casting handbook, the gate size on casting was calculated: Through calculation: ΣF =11.2cm2.

Section size of each gate is 11.2/6=1.9cm2. Section area ratio of the inner gate to the runner is as follow:

$$\Sigma F\ ingate : \Sigma F\ runner : \Sigma F\ sprue = 1 : 0.8\sim0.9 : 1.1\sim1.2 \quad (1)$$

Where, ΣF ingate is ingate sectional area.

ΣF runner is runner sectional area.

ΣF sprue is sprue sectional area

According to the ingrate size 1.9cm2, can draw the ΣF runner =1.52~1.71, ΣF sprue =2.09~2.28

The runner, select h ≈a: a=13.5mm, b=10.5mm, h=13.5.
The ingrate, select h≈0.2a: a=33mm, b=30mm, h=6mm.
Spruce size =20mm, D1=32mm, l=600mm.
Pouring speed: 7~8m/s.

Fig. 1 The three-dimensional model of the casting

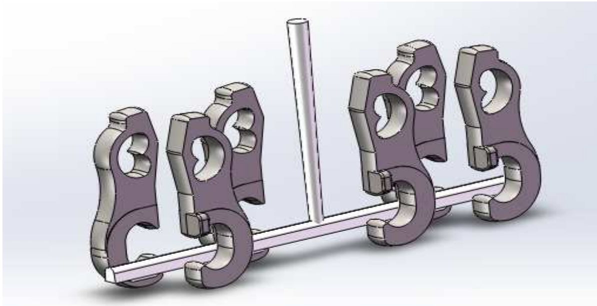

Fig. 2 The gating system

Scheme 2. Cast method: Using investment casting. Due to the solidification process will produce hot spots, so take the intermediate gating system, which has good feeding ability and can solve the problem of hotspots. The gating system is shown in Fig 3.

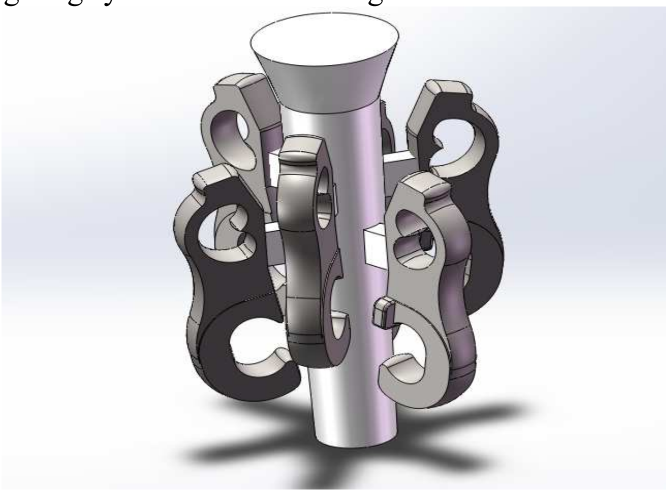

Fig. 3 Investment casting gating system

Gating system design using proportional coefficient method:

dg=k1Dc (2)

Ag=k2Ac (3)

where, Dc is the casting hot section diameter, Ac is section area of hot section, Dg is runner diameter, Ag is ingate sectional area, K1, K2 are the proportional coefficient respectively, K1 is 0.6 ~ 1, K2 is 0.4 ~ 0.9.

According to the analysis of casting, hot section area is 20mm * 55mm. And according to calculation of the thermal and section size, size of ingate and sprue size is as the follow:

Ingrate: H1=13mm, L1=24mm.
Spruce: D1=45mm, D=55mm.

Casting process simulation

Simulation of scheme 1. We can see from the graph, this gating system without riser for feeding during solidification. The final solidification area concentrates in casting internal. When the solidification completes, which without molten metal to feed the casting, so the shrinkage cavity was formed in the casting. Certainly there will be shrinkage or porosity defects in castings. So using this scheme, we can get unacceptable casting as shown in Fig. 4 and Fig. 5.

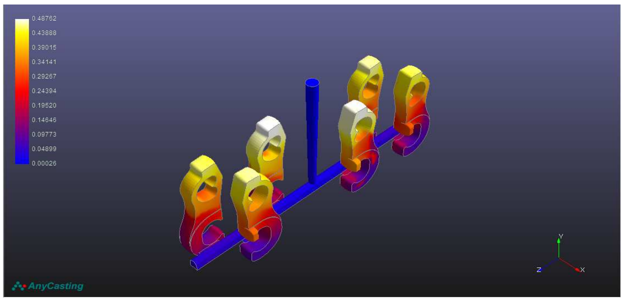

Fig. 4 Filling process diagram

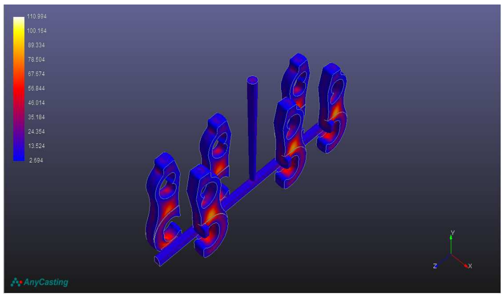

Fig. 5 Solidification sequence diagram

Simulation of scheme 2. Through the simulation, it can be seen from Fig. 6 and Fig. 7, the casting process using self-gating system for feeding, the final solidification area within the gating system, gating system is to feed the casting during solidification. So there is no shrinkage occur in the casting. With this scheme, we can get acceptable casting. Simulation results show that, this process is feasible.

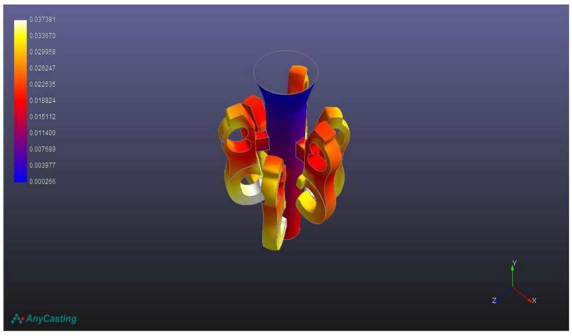

Fig. 6 Filling process diagram

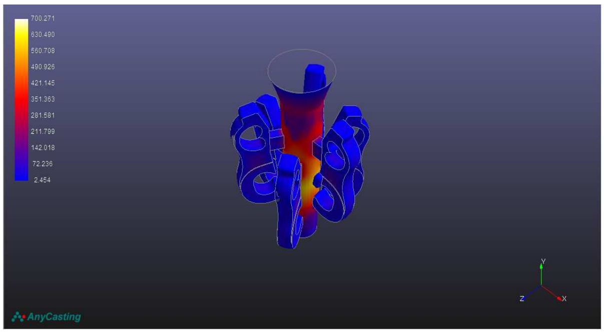

Fig. 7 Solidification sequence diagram

We can also analyzes the casting defect with the defects analysis module of the software, and can draw the defect probability of the filling process, solidification process (Fig. 8, Fig. 9).

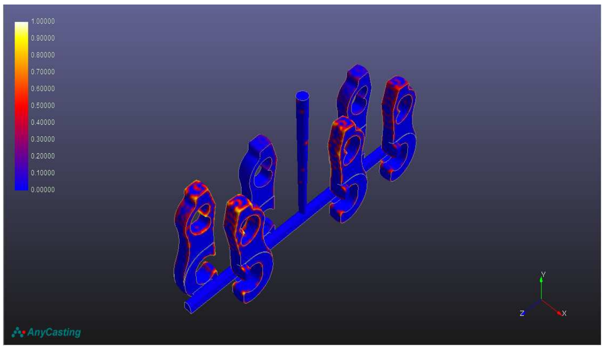

Fig .8 Solidification defect probability diagram of scheme 1

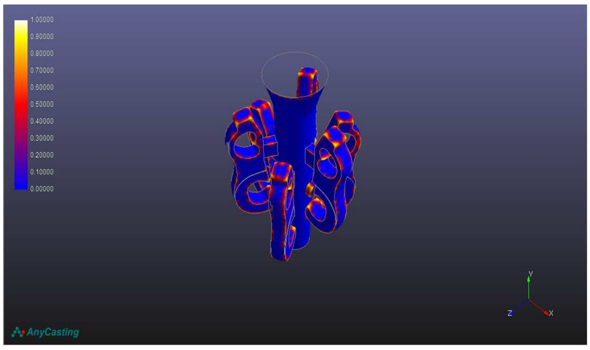

Fig .9 Solidification defect probability diagram of scheme 2

Results and Discussion

Through the simulation, the analysis result of two kinds of casting process is as the follow:

Scheme 1, in the process of solidification, hot section was formed within the casting which was proved by the diagram. So the probability of defects in castings is relatively large. Because of the hot section is in the casting internal, casting defects should be shrinkage cavities and shrinkage porosity.

Scheme 2, the simulation results show that the casting first solidification, finally solidification occurs in the gating system. The gating system is to feed the casting during solidification so that no shrinkage cavities are formed.

From the defect probability diagram also shows the key parts of casting defect probability is not high, only a small amount of defects formed in the surface. So use the second process schemes for casting, will get better quality of castings.

Conclusions

The uses of computer simulation software to verify the design process, which can predict the casting before the actual production, shorten the development cycle. With using casting simulation technology, make the casting production more scientific, avoid the defects of castings, thus improving the product quality and production efficiency, and reduce the cost of foundries.

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