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Optimization Design of Injection Mould for External Barrel of Washing Machine Based on Moldflow

Min Zhang
National Local Joint Engineering Laboratory of Intelligent Manufacturing Oriented Automobile Die & Mold
Tianjin University of Technology and Education, Tianjin，Chnia

Quan Wang
National Local Joint Engineering Laboratory of Intelligent Manufacturing Oriented Automobile Die& Mold
Tianjin University of Technology and Education，Tianjin，China

Abstract: **In this paper, external barrel of washing machine of injection process analysis was presented. Mould process of the External barrel was analyzed under two kinds of gates and cooling channels by Moldflow. The paper compares the differences between the two designs, such as air traps, welt line, warping, mould temperature. By Moldflow analysis, the more reasonable mould process conditions and design were obtained, the quality of part can be promoted maximally and molding period is reduced more. The results show that the CAE analysis mould has a strong guiding effect on the injection process.**

Keywords: External Barrel, Moldflow, Optimization, Mould Design.

I. INTRODUCTION

In the age injection mould has become an important industry. The traditional method of optimizing product through artificial experience has been unable to meet the needs of the market. Moldflow, as finite element analysis software, can be used for defect analysis before injection process. It improved the efficiency of production greatly [1-3].

With the improvement of human life, automation was well known by more and more familiar. Full-automatic washing machine has the advantage of a high degree of intelligence with less need manual operation, weak on clothing damage, and the advantages of small noise[4]. Compared traditional washing machines, increased demand for full-automatic washing machine is being met in our daily life. So the market competition is particularly fierce. External barrel is an important part of the automatic washing machine, however parts manufacturing is difficult due to the larger volumes and higher costs in injection molding process. The efficiency of the full-automatic washing machine is directly affected by the quality of the external barrel. In terms of external barrel injection process, optimized molding condition was discovered based on analysis. This research is designed according to the design standard of the mould and use the Moldflow software to analyze the structure design [5].

II. MOLDING PROCESS ANALYSIS

A. Comprehensive Analysis of external barrel

The external barrel plays a decisive role in the automatic washing machine. It is an important structure according to the washing machine. The material PP was used in the simulation analysis. Its structure is more complex with more grooves at the bottom. In order to guarantee the mould reliability and improve product quality, it needs a good shape to ensure assembly of products. The hole in the middle of part is to be made to plug through, the materials is P20 that made in China. The external barrel component is shown in Figure (1).

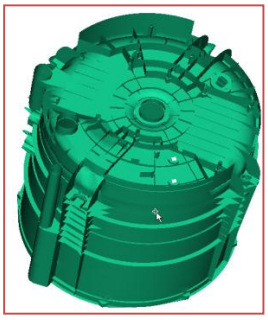

Fig. (1). External barrel of washing machine.

B. Design of External Barrel Products

The outside of the external barrel of washing machine is provided with reinforcing ribs, the smoothness of the external barrel should be ensured in production. there is a round hole at the bottom which connects with the stirrer to make it rotate. Therefore the bottom rib of the slope increased to 2° unilateral. All stiffeners need to be rounded. The Angle is not suitable for stripping mould and the products always were broken in the mould. In order to improve the quality and reduce the injection time, the design of external barrel and the injection process parameters optimization in the next paper.

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III. SIMULATION ANALYSIS

A. Gate Position

The gate is used in the mould system to connect the runner system and mould cavity. The time of melt filling cavity is usually determined by gate quantity. The layout of gate will influence the surface quality of the products and filling balance. In the design of the gate, Multi gate layout is used in order to fill mould cavity quickly, evenly to ensure the production quality.

Taking into account the surface quality of the product, product underside having no impact on the surface of products is the best area to place the gate. Dealing with products structure analysis, the product is symmetry, the four points gate are designed at the bottom of the outside. The runner system is designed by using hot runner. The small end diameter of the main channel is 8mm and the main end diameter is 16mm. The diameter of subchannel is 16mm. The distribution of gate is shown in Figure (2).

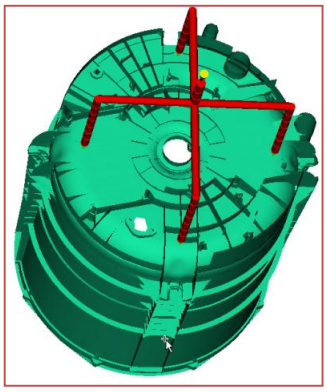

Fig. (2). The distribution of gate.

Process parameter set as follows. Mold temperature is 45℃ The melting temperature is 210℃ The cooling time is 20 s, and the packing pressure is setting 80% of the injection pressure. The packing time is 10s.The molding material of the product is the PP material. The mould material is the domestic p-20. The injection molding machine is 1500 or 1700 tons.

B. Air Traps and Welt Line

As the melt fills the cavity, air pocket is pushed out through the exhaust system. The bubbles are basically at the bottom of external barrel products, especially the bubbles mainly focus on the parting surface of mould. Therefore, the gas is easy to be exhausted through the mould parting surface. The distribution of air traps are shown in Figure(3).Because of the complexity of the product structure, air traps in the external barrel is inevitable, the overall quality of the products is not affected seriously because the air traps most in outside the bottom of the barrel, but the stiffener position should be enhanced by exhaust. The stiffeners near the exhaust gases will cause other defects of products.

As shown in Figure (4), the simulation analysis of Moldflow showed that the number of weld line at the bottom of the outer barrel is greater than that on the side wall. Thin wall weld line distribution mainly appeared on the wall reinforcement due to the steel structure. An outer barrel with more stiffeners is easy to fuse when two strands of polymer are polymerized. Because of the outside barrel in the washing machine, the appearance of the product was not almost affected.

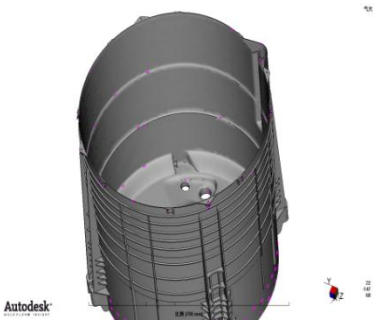

Fig. (3). Air traps.

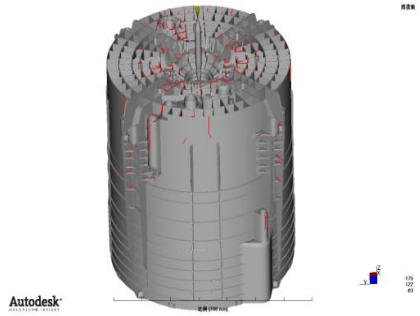

Fig. (4). Welt line.

C. Simulation Analysis

The maximum warping deformation for one gate is 15.21 mm in Figure (5), the maximum amount of warping that the red area is shown in the diagram which occurs at the end of the filling. The maximum warping deformation with four gate numbers is 18.78 mm in Figure (6).The maximum warping deformation also occurs at the end of the filling according to the customer standards that the maximum under 12 mm, The position and quantity of the gate have a great influence on the deformation degree of the plastic parts, but in this analysis the maximum warping is not affected by the number of gates, so warping may be related to reasonable process parameters and cooling water passage.

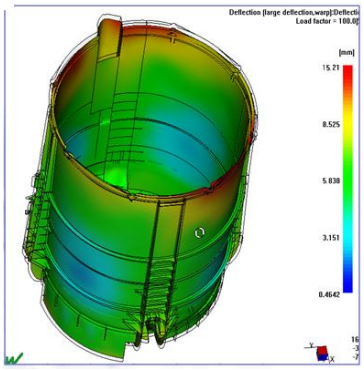

Fig.(5).One gate.

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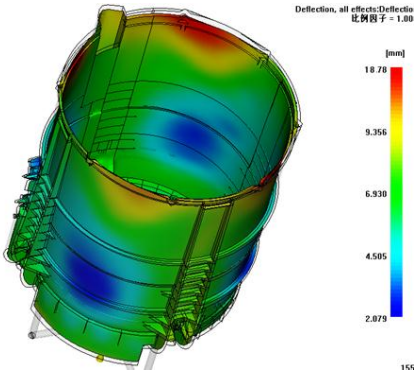

Fig.(6).Four gate.

IV. OPTIMIZATION OF PROCESS PARAMETERS AND COOLING CHANNEL

A. Optimization of Process Parameters

According to the flow analysis and the result of warp analysis, we can see that the main factors influencing the deformation of the large warps are the shrinkage of the parts. Reset injection process parameters in simulation analysis, mould temperature is 45℃Melting temperature is 210℃ The cooling time is adjusted for 24 s. The packing pressure to 85% of the injection pressure, pressure maintaining time extended to 20 s. Packing time is maintained first 10s with the constant packing pressure, the rest of the time will attenuate to 0, the analysis process parameters for the warping deformation is small.

It simulate the results after modify the process parameters as shown in Figure(7), the product of warping deformation under the comprehensive factors is 11.78mm, it has been greatly improved comparing the original data analysis, one of the possible reason is that the polymer melt slows down into the cavity when the mold temperature is relatively low, The melt of polymer can solidify and hinder the flow velocity. Packing pressure is an important parameter for the amount of warpage, the optimized pressure is more reasonable, because the higher pack pressure forces more polymer melt into the cavity in a shorter time frame.

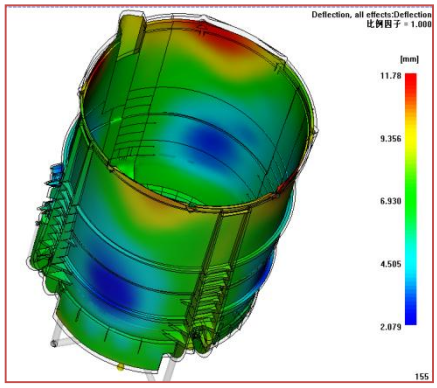

Fig. (7). Warping after optimizing parameters.

In the current study, it was found that packing pressure appear to have foremost effect on warping deformation. In generally, the warping deformation decreases with the increasing packing pressure. Melt temperature is also important. So it focuses on adjusting the two injection process parameters, that warping deformation can meet the reasonable requirements.

B. Optimization of Cooling Channel

The production quality is always the main objective in injection molding production, The simulation analysis will focus on distribution of cooling channel. The quality of molding efficiency is influenced by the quality of cooling channel.

As shown in Fig. (8). The highest temperature of the external surface is 121.6℃, the minimum temperature is 38.26℃, the average temperature is 77.69℃. The mould needs 35s when it reaches the cooling temperature. The original cooling waterway can't cool the product very well so it need optimize the cooling system.

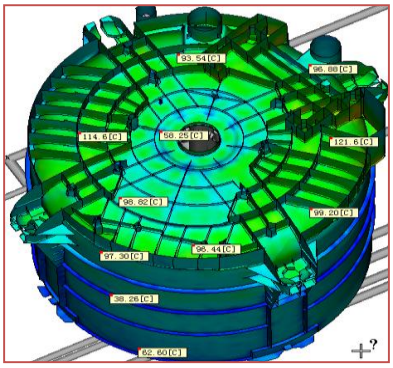

Fig. (8). Temperature of the original data.

As shown in Fig. (9).the cooling waterways need to be increased from 4 to 6, and the cooling is enhanced in an area with high temperature. The distribution of cooling water makes the product temperature more well-distributed.

As shown in Fig. (10). The overall temperature distribution is more uniform because the cooling system is optimized under the complexity product structure. we can try to adjust the cooling channel to achieve uniform temperature. The higher temperature in the reinforcing ribs does not affect the quality of the whole product. The design of cooling system can not only reduce production cycle, but also can control the warpage of product in the production. Thus the optimized cooling channel basically can accord the actual production requirement.

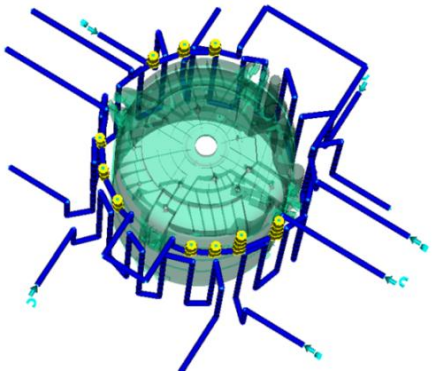

Fig. (9). Optimized cooling channels.

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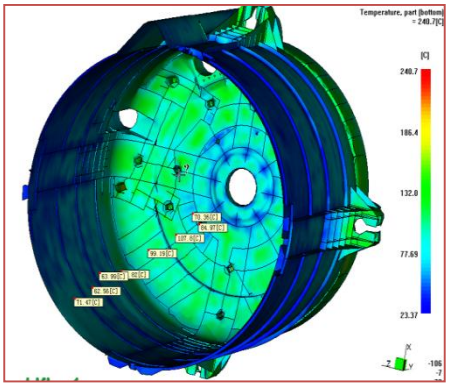

Fig. (10).The temperature of optimization.

Changing the injection molding process parameters, more melt was injected into the mould in the injection process. In order to ensure the normal size of the product, temperature of the product is uniformity under optimization the cooling waterway. But the cooling time must be considered in the actual injection process.

V . CONCLUSION

Different processing parameters were varied and it was found packing pressure appears to have the greatest effect on part quality at the current processing range. In addition to the process parameters, there are also the reasons for the mould design liking the cooling water channel. In the present study, the effects of these factors on the product are analyzed.

Thought optimizing the injection mould parameters and cooling water channel to product qualified products, the results indicate that packing pressure and packing time play a great role in injection mould process. Optimized the cooling water channel, the mould temperature is declined. By optimization, the warp deformation of the product is reduced and the temperature is uniformity. So it improves the quality of production.

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