Numerical Simulation Analysis for ABS Bracket Based on MPI Technology

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Abstract. Numerical simulation for ABS bracket based on Mold Plastic Insight (MPI) technology was carried out to analyze the injection process of ABS bracket, and its injection system was also established correspondingly. In accordance with the structure characteristics of plastic part, the perimeter cooling system was optimized. The molding parameters such as melt front temperature, shear rate, weld lines and plastic deformation were systematically analyzed in order to shorten the mold manufacturing cycle and increase the relative efficiency. The objective of this paper is to assess the accuracy of numerical simulation results, and forecast the internal defects of plastic parts.

1. Introduction
Plastic injection molding is a kind of complicated molding process. Along with the diverse and complex plastic parts used in the daily life, it adjoins the higher requirements for plastic molding design. Owing to the complexity of injection molding process as well as various parameters, it is difficult to predict the material properties. Moreover, the ties bind the quality of products and the molding process together in the modern mold enterprises. Generally, Computer-Aided Engineering (CAE) technology for numerical simulation is used to investigate the molding process, products quality and the molding parameters, in order to establish the relationship between process model and the quality of products, as a result, to control the quality of injection molding products [1-4].

In this paper, MPI technology was used to investigate the numerical simulation analysis for ABS bracket, in order to determine the suitability of gating system, cooling system, and the optimization of molding process, so as to shorten the development cycle.

2. Mold setup
The bracket model was imported into MPI software with the *.STL file format, with the overall dimension of 320 mm in length, 8 mm in height, and 2.5 mm in wall thickness. Remesh the plastic grid, free edge and repair the overlapping surface defects, maximum aspect ratio was less than 10, grid matching rate reach 91.4%, and the grid number of final model is 24437. Figure 1 exhibits the material viscosity and pressure, volume, temperature (PVT) performance, MONKAS ABS grade TFX-210 was selected as the injection materials. Its molding parameters contain 50 ℃ of setting temperature, 230 ℃ of melt temperature, 88 ℃ of top temperature, and 12000 s⁻¹ of the maximum shear rate.
Figure 1. Rheology and PVT properties of ABS plastics

Figure 2 illustrates the plastic thickness measured after meshing. It can be seen that wall thickness is uniformly distributed in the plastic part. To analyze the plastic’s structural machinability and precision, a mold with two cavities was selected for injection molding of plastic parts, in accordance with the best gating location analysis and design. The analysis result is illustrated in Fig.3. The side gate molding is used, injection delay by 1.4 s, using a circular runner, gate size is 8 mm*6 mm*10 mm*1.2 mm, while the diameter of sprue size is 10 mm.

The disqualification plastics in the production include plastic deformation, size variation, surface defect etc., about 60% of plastic quality problems is the outcome of the inappropriate cooling system design, which highlights the importance of cooling system. According to the plastic parts with the long, thin features and previous design experience, the cooling system design is intended to fix the mold cooling system for fixed half and moving half, in order to reduce the deformation, strengthen the gate cooling, with the 8 mm diameter of cooling channel. The final results are shown in Fig.9.

3. Molding analysis
Melt filling status has a great influence on the plastic injection, different filling stages of the plastics are illustrated in Fig.4. According to the filling analysis, the model can be fulfilled successfully, and there is no structural defects presented in the model.

Bulk temperature is a velocity-weighted average temperature when the polymer is flowing and a simple average temperature when the flow stops. For each element, a plot of bulk temperature versus time shows that the switch-over from bulk temperature to average temperature gives a smooth curve.
In the process of filling, there has volumetric shrinkage, as a result, it is necessity to supply the lack in order to ensure the integrality of ABS bracket. The V/P switchover time is restricted within 2 s. When the part is filled about 98.13vol%, the V/P pressure is 43.03 MPa, so as to ensure the sufficient switch time from filling stage to packing stage, and improve the overall properties of bracket part.

**Figure 4.** Different filling status

**Figure 5.** Flow front temperature
In Fig. 5, the difference in the temperature of flow front is about 6.4°C, that is, the maximum temperature at flow front is 253.9°C, while the minimum temperature at flow front is 247.5°C. The temperature difference in the flow front is very small, and the main body temperature is kept within the recommended temperature range for the material.

The maximum shear stress at wall is 32.69 MPa. The shear stress is maximum recommended for the material database 0.28 MPa, regions above this limit (0.28 MPa) could be subjected owing to the stress crack during the ejection or in service.

**Figure 6.** Shear rate

**Figure 7.** Air trap’s distribution
Figure 8. Weld lines

The areas highlighted in pink are the places where air traps might be happened. When designing a mold, these areas should be paid more attention. Air traps will cause a burn mark if the air is under enough pressure, causing the air to ignite and burn the plastics. If an air trap is not vented, or it is not compressed fast enough to cause a burn mark, it may cause a short shot, or leave bubbles of air or gas in the part. Even if an air trap does not cause a burn mark or short shot, it can still leave a surface blemish on the part.

Some weld lines might be seen by human eyes. Weld lines can cause structural problems, and it can also make the part visually unacceptable. However, some weld lines are unavoidable, so it is necessary to check the processing conditions and the weld lines position to decide if the weld lines will be of a high quality. The cohesion strength in the weld lines is highly influenced by the temperature when the weld line is formed. Overflow well is not effective for weld lines.

The maximum shrinkage at ejection is about 7.537%. The minimum shrinkage at ejection is 0.9551%. The results exhibit that the packing process should be improved. Smaller packing pressure lead to the bigger volumetric shrinkage. The difference of the coolant temperature is 0.88 °C, which can be acceptable. Warpage deformation is a major factor affecting the quality of plastic parts [6, 7], so it is necessary to take the warp value for assessment target into consideration. Deformation causing factors include uneven cooling, uneven contraction and molecular orientation, affect the uneven shrinkage of plastic parts directly. Overall deformation of plastic is 4.914 mm, where X direction for 1.286 mm, Y direction for 2.351 mm, Z direction for 3.704 mm. When compared to the plastics, it is relatively small deformation, and their unique morphology can be maintained. When the stiffener adds to the lower surface, the overall properties of bracket will be better.
4. Conclusion

Based on the MPI technology, numerical simulation analysis for ABS bracket, the gating system and cooling system of plastic parts were established correspondingly, and then the melt front temperature, shear rate, plastic parts, surface temperature, cooling system temperature distribution were analyzed systematically. The total deformation of plastic parts, assess the balance condition of plastic flow, products shrink mark and cavitation tips, weld line distribution. It is realized to assess the theoretical prediction of molding and control, and improve the efficiency of mold design greatly.

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