Design of Injection Mold for Support Bar Based on CAD/CAE

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ABSTRACT

Application of Mold flow and UG Mold wizard in the injection mold design were introduced. Using the design of support bar as a model, the technology of injection mold design and analysis with CAD/CAE was elaborated in details. By means of CAD/CAE tool, the optimized process parameters could be obtained, the injection mold design cycle could be induced and the quality could be increased greatly.

KEYWORD: Injection mold; CAD; CAE; Optimization design; Support bar

GENERAL INSTRUCTIONS

With the wide application of injection molding products, its shape and structure more complex, the appearance of the requirements are increasing, the traditional 2D mold design and the traditional mold processing method can not adapt to modern and integrated production requirements. Using the advanced mold CAD/CAE technology to improve the quality of the mold design, shorten the cycle of mold design and manufacture, improve the quality of plastic products, for the development of injection molding technology has important significance[1-2].

Siemens company's large interactive CAD/CAM systems UG NX is widely applied in the mold industry, the injection mold Wizard module Moldwizard provide the professional injection mold design platform, parting tool powerful and easy to operate[3]. Autodesk's Moldflow software enables realize the injection molding process analysis, the software with its powerful CAE analysis capabilities have dominated the plastic molding market analysis, and UG NX data can be exchanged between systems through IGES, STL and other standard output format. In this paper, to support the main line of the mold design, injection molding combined CAD/CAE technology, elaborate molding process analysis and die design methods for supporting the strip.

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STRUCTURAL ANALYSIS OF PLASTIC PARTS

Three-dimensional solid model of the support bar shown in Fig.1, the overall size of 150mm×50mm ×65mm, a volume of about 4.8×10⁴mm³, the thickness is uniform, and the average thickness of 2mm. The center of the plastic parts provided with reinforcing ribs, in line with the position of the distribution of structural mechanics requirements; there are concave on both sides at the round table, the need to design the side core pulling structure. Department has plastic parts with precision, high-volume production requirements, the surface without shrinkage, flash and burrs.

Moldflow material selection database Kumho's acrylonitrile - butadiene - styrene copolymer (ABS), the designation HFA 700, a shrinkage of 0.5%. Working conditions as follows, mold temperature: 40~60°C, material temperature: 200~240°C, the top temperature: 89°C.

Figure 1. 3D model of plastic part.                                     Figure 2. Triangular mesh model.

DESIGN OF GATING SYSTEM AND COOLING SYSTEM

Pretreatment Grid

In UG NX import the CAD models into STL file format, then import the model into MPI2010, divided into two-level grid. Finite element mesh by a three-node triangular composition, created on the outer surface of the model. Mesh side length is set to 3mm, the number of nodes triangle is divided after 5378, grid cell number is 10612. The presence of relatively large triangular aspect and matching automatic division of the grid unit is less than 90%, it will affect subsequent analysis results, therefore, need to use the mesh repair tool to narrow re-divided grid cells. After the restoration of the finite element mesh shown in Fig.2, the average aspect ratio is 1.751, the maximum aspect ratio is 6 or less in control, matching also increased to 91.3%, consistent with the grid, do not cross, do not overlap, fully meet the analytical conditions. The result is shown in Fig.2,

Gating System Design

Cavity layout intends to adopt a two cavity mold, gate open position open or not has a great impact on the quality of plastic parts. When analyzing the best gate location, mainly based on the geometry of the characteristics of plastic parts and
technical requirements, considerations melt flow balance, the cavity and the flow resistance of the exhaust gas conditions[4].

Fig.3 shows the results of analysis for the best gate location, it can be seen that as dark areas in the middle of the best gate region, for the feed side. Therefore, using the common side gate.

Since the cavity layout symmetrically balanced, in order to save time calculation and analysis system, created in part in Mold flow gating system model shown in Fig.4, the main technical parameters are: the sprue cone angle $\alpha=2^\circ$; shunt circular cross-sectional diameter $d=8\text{mm}$; side gate-sectional dimension taken $2\text{mm}\times1\text{mm}$, the number of occurrences of the runner and the gate is set to 2 times.

![Figure 3. The best gate location.](image)

![Figure 4. Gating system.](image)

**Filling Analysis**

Initially identified gating system design, the need to set the filling process parameters, mold temperature, melt temperature, injection speed, holding pressure, protect the value of time, cooling time and other variables are very important[5-6]. Moldflow window molding system recommended molding process parameters: a mold temperature of $55^\circ\text{C}$, material temperature of $235^\circ\text{C}$, mold opening time 5s, injection pressure and cooling time total protection for 30s.

In this paper, with reference to the maximum amount of warpage, combining flow, pressure and warpage analysis, repeatedly adjust holding pressure and dwell time and other parameters. When the maximum amount of warpage of plastic parts to meet less than 0.5mm, and ultimately determine the process parameters are: a mold temperature is $55^\circ\text{C}$, material temperature is $235^\circ\text{C}$, holding pressure is 40MPa, holding time is 10s, speed / pressure switching time taken to fill a volume is 100%. Filling the entire process is completed within 1.04s, both ends of the round table at the last filling position, the entire plastic parts can be filled in a relatively short period of time, flow balance is better, and filling reasonable condition.

Fig.5 is a flow front temperature simulation results, the model can be seen from the figure the forefront of the temperature difference is less than 1$^\circ\text{C}$, softer color transition, indicating that the filling process melt temperature changes more slowly melt filling good condition, thereby proof, reasonable gating system design described above.

Air traps may cause the plastic parts are not completely filled, stomata in the part; plastic parts can also cause burning, scorch phenomenon. Fi.6 shows the distribution of cavitation position, the figure at the circle indicates the location of cavitation, the cavitation can be seen in the distribution of the plastic parts of the border, you can take
advantage of parting surfaces, core and ejector and inserts the gap between the holes to achieve the effect of the exhaust gas.

Weld lines can cause surface cracks, may also lead to reduction in the strength of plastic parts. Fig.7 shows the weld lines on the plastic parts location. As can be seen from Fig.7, the number of welding marks are small, combined with the melt flow front temperature analysis Fig.5 shows that small temperature difference at the weld marks, good fusion. Ensuring the quality and mechanical properties of plastic surfaces.

Figure 5. Temperature at flow front. Figure 6. Air traps. Figure 7. Weld lines.

**Cooling System Design**

Firstly, analyze the structural characteristics of plastic parts, the fixed mold need to avoid the center of the boss. Therefore, on both sides of each distribution of a straight-through waterway, and the distance from the surface of the cavity remain equal;

To reduce the temperature difference between the dynamic model and the fixed mold cavity surface, ribs interchange of the dynamic mold portion easy to accumulate heat, taking into account to avoid the pusher structure. Therefore, in parallel way to achieve cooling of the inner surface of plastic parts. The cooling system was created in Moldflow arranged as shown in Fig.8, the cooling water pipe diameter is 7mm.

Figure 8. Coolant system.

**Cooling Analysis**

The cooling medium is water, water temperature is 25°C, analysis the cooling scheme mentioned above, the results show as follow:

1) The passageway of three cooling water circuit temperature difference is less than 1°C;
2) Extreme temperature difference mold control at 30°C, most of the temperature near the set mold temperature;

3) As shown in Fig.9, both sides of the round table reach the strip temperature firstly, the cooling time of ribs interchange are the longest, most of the region to reach the strip temperature time focused around 10s.

Comprehensive analysis shows that the cooling system and the flow of the design flow parameter are set to meet the cooling requirements of the plastic body.

**Figure 9. Time to freeze.**

**MOLD STRUCTURE DESIGN**

From the point of view of the molding, plastic parts can be divided into two parts in the middle and at both ends. The middle part is more complex, taking into account the processing costs and the repair and replacement within the die life, combined with the distribution of cavitation shown in Fig.6, three step hole intends to use local insert molding. A combination of two fixed mold inserts and cavity inserts into a cavity shown in Fig.10, and then embedded into the overall template fixed mold; mold core shown in Fig.11; Both ends of the plastic parts were frustum having undercut structure by forming two side cores respectively. Fig.12 is the oblique pin core pulling structure diagram.

**Figure 10 Fixed mold**  **Figure 11 Mold core**

**Figure 12. Core-pulling mechanism.**  **Figure 13. Mold structure.**
The push rod was chosen as launch mechanism of mold, release position is located the intersection of ribs. In order to ensure the effect of the exhaust gas and prevent overflow, must be adjusted assembly clearance between inserts, the push rod and holes. After the solid modeling structural design of each part of the mold, solid modeling was completed on Moldwizard module design platform, the mold structure shown in the Fig.13.

CONCLUSION

1) In this paper, the mold flow process of the support bar has been analyzed by the CAE technology, according to the results and analysis of the possible causes of defects to optimize the injection molding process scheme

2) At the design stage of molding parts, considering the possible defect products, spare parts processing and mold maintenance and other factors, mold structure has been designed rationally to ensure the quality of products;

3) The model set of mold has been designed quickly and easily by mold CAD technology, It not only shorten the design period, but also reduce the cost of product.

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