Viser Technology Pte. Ltd.
Mechanical Engineering Science
DOI: 10.33142/mes.v6i2.15054

Research Article Open Access

Design of Plastic Injection Mold with Support Strip Based on CAD/CAE

Wenwu ZHANG, Guangchen XU*

Yingkou Institute of Technology, Yingkou, Liaoning, 115017, China

***Corresponding Author:** *Guangchen XU, E-mail: kanu012@163.com*

Abstract

The structural characteristics of plastic parts containing support strips were analyzed, and Moldflow software was used to simulate and analyze the pouring position and cooling system of the plastic parts to determine the optimal solution. The UG-Moldwizard module was used to complete the mold base design of the injection mold, which reduced the potential risks in the design of the injection mold, improved the quality of the mold, and reduced the number of mold trials. It fully demonstrated the role of CAE technology in the design of the pouring system and the development process of the injection mold. The outstanding role it plays in the process can provide reference value for the design of injection molds similar to plastic parts.

Keywords: *CAD; CAE; injection mold; support strip*

1 Introduction

With the widespread application of injection molded products, their shapes and structures are becoming more and more complex, and their appearance requirements are also increasing.Traditional two-dimensional mold design and processing methods cannot meet the needs of modern and integrated production. The use of advanced mold CAD/CAE technology can assist in determining the gating system,predicting product defects,and optimizing process parameters during processing. It can shorten the molding cycle and reduce the defective rate of plastic parts[1].Siemens' large-scale interactive CAD/CAM software UG NX is widely used in the mold industry. Its injection mold wizard module Mold wizard provides a professional injection mold design platform. The mold parting tool is powerful and easy to operate[2]. Autodesk's Moldflow software can realize injection molding process analysis. This software has been dominating the plastic molding analysis market with its powerful CAE analysis capabilities. It can realize data exchange between systems with UG NX through standard output formats such as IGES and STL.

Plastic parts containing support strips are increasingly used in automotive,military, aerospace and other fields. This type of parts can improve the strength and stiffness of the parts while reducing the overall mass to meet lightweight requirements. Currently, there is little literature on the design of injection molds for plastic parts with support strips. Therefore, this article takes the mold design of support strip plastic parts as the main line, combines injection molding CAD/CAE technology, and explains the molding process analysis and mold design method of support strips.Its design ideas can provide useful reference for similar molds.

This article uses the UG Mold wizard module and Moldflow software as assistance to optimize injection mold design and process parameters, solving the production method of only obtaining the final result through repeated trial and error, mold repair, and parameter adjustment in the design and manufacturing process of support bar injection molds, and improving the quality and production efficiency of plastic products.

2 Plastic Part Structure Analysis

The three-dimensional model of the plastic part is shown in Figure 1. Its overall size is 150mm×50mm×65mm, the volume is $48cm^3$, the average wall thickness is 2mm, and The material used is acrylonitrile butadiene styrene copolymer (ABS) from Kumho company in Moldflow database, with the grade HFA 700 and a shrinkage rate of 0.5%. There are support strips in the middle of the plastic part, and their position distribution meets the requirements of structural mechanics; There are concavities at the

Received on September 23, 2024; Accepted on November 5th, 2024

round cones on both sides, and a side core-pulling structure needs to be designed.There are precision requirements for the fitting of plastic parts, requiring mass production, and the surface must be free of shrinkage holes, flash and burrs.

Figure 1 3D model of plastic part

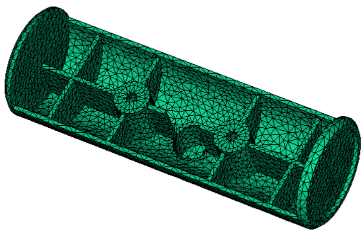

Figure 2 Finite element model

3 Gating System and Cooling System Design

3.1 Mesh subdivision

The CAD model was transformed into STL format in UG NX and imported into Moldflow software.Firstly, the two-layer mesh is used for meshing. The finite element mesh is composed of three-node triangles, which are created on the outer surface of the model. The grid side length is set to 2mm, the number of nodes is 5378, and the number of grid elements is 10612.Because there are triangles with large aspect ratio in the meshing and the matching degree is less than 90 %, the subsequent analysis results will be affected. Therefore, it is necessary to use the grid repair tool to re-divide the long and narrow grid cells. The repaired finite element mesh is shown in Figure 2. The average aspect ratio is 1.751, the maximum aspect ratio is controlled within 6, and the matching percentage is 92.3%.The mesh orientation is consistent, non-crossed and non-overlapping, which can be used for the next simulation analysis.

3.2 Gating system design

Gating system design is an important part of mold design. The quality of the design can directly affect the quality and service life of the mold. In order to optimize the mold gating system, CAE analysis software can be used to perform preliminary simulation analysis to avoid the failure of mass production or scrapping of the mold due to improper design of the gating system[3]. When analyzing the optimal gate position, it is mainly based on the geometric characteristics and technical requirements of the plastic part,taking into account factors such as the balance of the melt flow, the flow resistance in the cavity and the exhaust conditions[4].Figure 3 shows the simulation results of flow resistance and gate matching. The area indicated in the figure is the area with the smallest flow resistance and the best gate matching. Therefore, the gate position should be designed in the area marked in the figure[5].

Since the cavity layout is symmetrically balanced, in order to save system and analysis time, a partial pouring system model as shown in Figure 4 was designed in Moldflow. Its main technical parameters are:The main channel cone angle is $\alpha = 2°$; The diameter of the circular cross-section of the shunt is d=8mm;The cross-sectional size of the side gate is 2mm×1mm, and the number of occurrences of the runner and gate is set to 2.

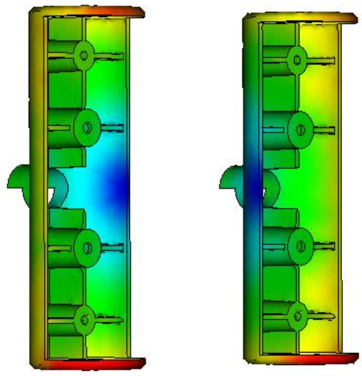

Figure 3 The best gate location

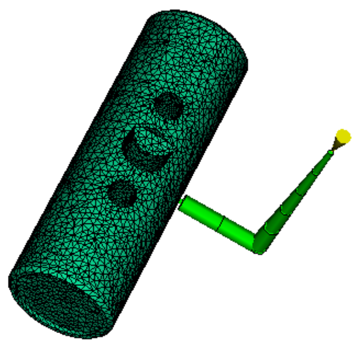

Figure 4 Gating system

3.3 Filling analysis

After the design scheme of the gating system is preliminarily determined, the filling process parameters need to be set. Among them, the mold temperature, melt temperature, injection speed, holding pressure, holding time, cooling time and other variables are very important[6-7].The molding process parameters were set in Moldflow software: the mold temperature was 55 ℃, the material temperature was 235 ℃, the mold opening time was 5s, and the total time of injection, pressure holding and cooling was 30s.

In this paper, the maximum warpage deformation is taken as a reference, and the parameters such as holding pressure and holding time are adjusted many times in combination with the results of flow, holding pressure and warpage analysis.When the maximum warpage deformation of the plastic part is less than 0.5mm, the final combination of process parameters is: the mold temperature is 55 ℃, the material temperature is 235 ℃, the holding pressure is 40MPa, the holding time is 10s, and the speed/holding pressure switching time is taken when the filling volume is 100 %. The whole filling process is completed within 1.04 s, and the round table at both ends is the final filling position. The whole plastic part can be filled in a short time, the flow balance is good, and the filling condition is reasonable[8].

Figure 5 shows the temperature simulation results of the flow front. It can be seen from the figure that the temperature difference at the front of the model is less than 1 ℃, and the color transition is relatively soft, indicating that the melt temperature changes slowly during the filling process, and the melt filling condition is good. It proves that the design of the above gating system is reasonable.

Air pockets may cause the plastic part to be incompletely filled and there will be pores in the part; it may also cause the plastic part to burn and cause scorching. Figure 6 shows the distribution of air pockets. The circles in the figure indicate the locations of air pockets. It can be seen that air pockets are distributed on the boundaries of plastic parts.Parting surfaces, core inserts and ejector pins can be used to connect the gap between the holes is used to achieve the exhaust effect.

Weld lines can cause surface cracks and may also reduce the strength of plastic parts. Figure 7 marks the location of the weld marks on the plastic part. As can be seen from Figure 7,the number of weld marks is small. Combined with the melt flow front temperature analysis results in Figure 5, it can be seen that the temperature difference at the weld marks is small and the fusion is good. The surface quality and mechanical properties of plastic parts are guaranteed.

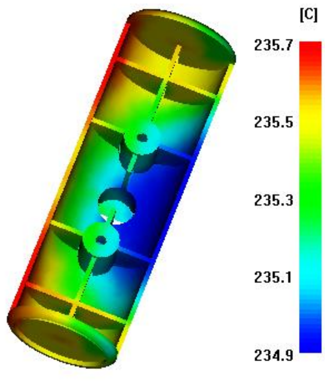

Figure 5 Temperature at flow front

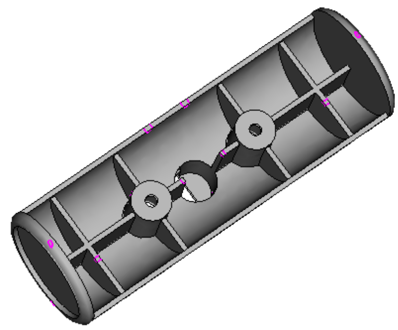

Figure 6 Air traps

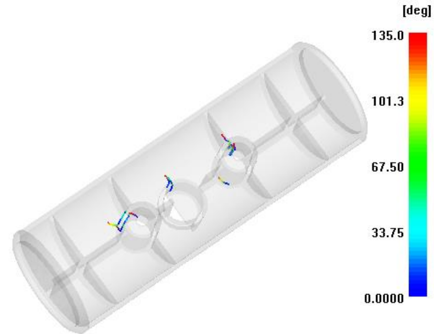

Figure 7 Weld lines

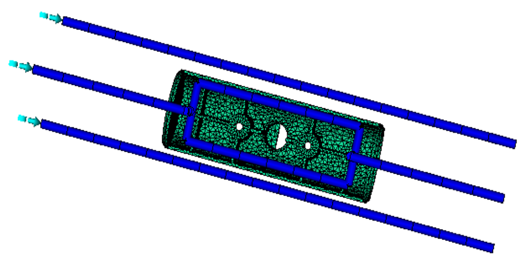

Figure 8 Coolant system

3.4 Cooling system design

First,analyze the structural characteristics of the plastic part. The fixed mold part needs to avoid the central boss.Therefore,a straight-through waterway is distributed on both sides of it, and the distance from the surface of the cavity is kept equal;The intersection of the reinforcing ribs of the movable mold part it is easy to accumulate heat.In order to reduce the temperature difference between the surface of the movable and fixed mold cavities and to avoid structural parts such as push rods, a parallel connection is used to cool the inner surface of the plastic part.The cooling system layout created in Moldflow is shown in Figure 8, and the diameter of the cooling water pipe is 7mm.

3.5 Cooling analysis

Set the cooling medium to water and the inlet water temperature to 25 ℃. Analyze the above cooling scheme and the results show:

(1) The temperature difference between the outlet

and inlet of the three cooling water channels is less than 1℃;

(2) The extreme temperature difference of the mold is controlled at 30 ℃, and most temperatures are close to the set mold temperature;

(3) As shown in Figure 9, the round cones on both sides reach the ejection temperature first, and the cooling time at the intersection of the stiffeners is the longest. The time for most areas to reach the ejection temperature is concentrated in about 10 seconds.

To sum up, the flow channel design and flow parameter settings of the cooling system can meet the cooling requirements of the main body of the plastic part.

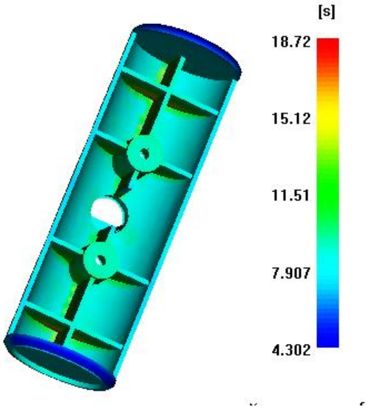

Figure 9 Time to freeze

4 Mold Structure Design

From the perspective of molding, plastic parts can be divided into two parts: the middle part and the two ends. The middle part is more complicated. Considering the processing cost and maintenance and replacement during the life of the mold, combined with the air pocket distribution shown in Figure 6, the three stepped holes are planned to be formed by partial inserts. The two fixed mold inserts and the cavity insert are combined to form the cavity shown in Figure 10, and then the whole is embedded into the fixed mold template; The core structure is shown in Figure 11; Both ends of the plastic part have undercuts. The circular cone of the structure can be formed separately through two side cores.Figure 12 is a schematic diagram of the side core pulling structure.

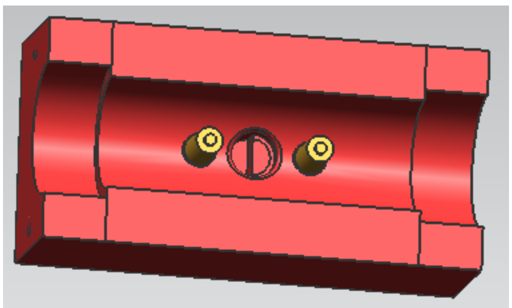

Figure 10 Fixed mold

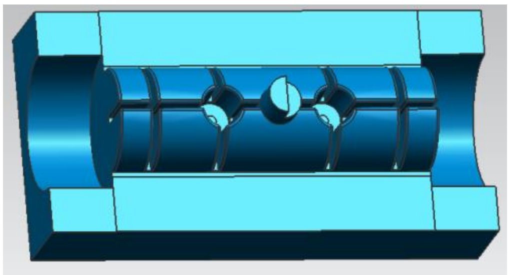

Figure 11 Moving mold

The pushing mechanism uses a push rod, and the pushing position is located at the intersection of the reinforcing ribs.Pay attention to adjusting the assembly clearance between the insert,push rod and hole to ensure the exhaust effect and prevent material spillage.After completing the structural design of each part of the mold, the solid modeling of the entire mold was completed on the Moldwizard module design platform.The mold structure is shown in Figure 13.

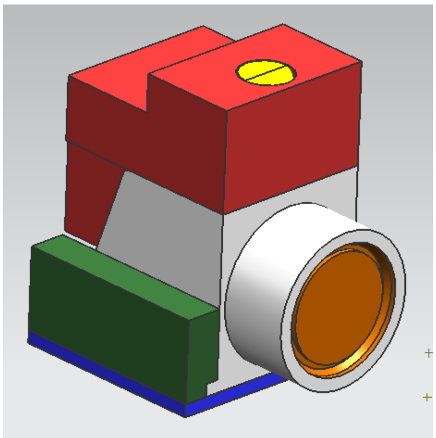

Figure 12 Core-pulling mechanism

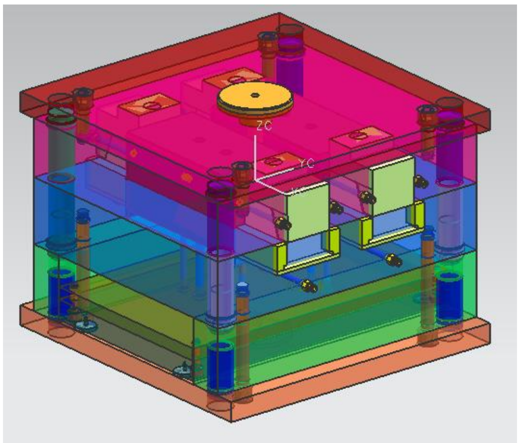

Figure 13 Mold structure

5 Conclusion

(1) Based on the structural characteristics of the plastic parts with support strips, the overall mold design was carried out through the UG-Mold wizard

module. The mold base is a side-pulling core-parting structure with one mold and two cavities.Production practice has proven that the mold structure is reasonable and meets production requirements;

(2) With the help of the mold flow analysis software Moldflflow, it is possible to achieve a substantial improvement in production efficiency, effectively save costs, complete the integration of theory and practice, and provide theoretical guidance and technical support to improve the quality of plastic parts and shorten the production cycle of products;

(3) Using mold CAD technology to quickly and conveniently realize the model design of the entire set of molds, shortening the product development cycle and reducing mold design costs.

Fund Projects: Research Project of Liaoning Provincial Department of Education: JYTMS20230066 — Application of Damping and Vibration Reduction Technology in Key Components of Machine Tools;Yingkou Institute of Technology school-level scientific research project(Grant: ZDIL202302).

Reference

[1] Zhang Liuwei,Gu Saijun,Hong Wei,et al.Design of Large Injection Mould for Automotive Front Frame with Inserts based on CAE Technology[J]. Engineering Plastics Application, 2023,51(2):91-98.

[2] Zhan Yougang. UG NX7.0 Mold Design Tutorial[M]. Bei Jing: Mechanical Industry Press, 2011.

[3] Li Chunling. CAE Technology Based on the Chassis Cover Inverted Injection Mold Design[J]. Plastics, 2020,49(4):50-54.

[4] Qu Huacang. Plastic molding process and mould design[M]. Bei Jing: Higher Education Press, 2005.

[5] Zhao Ertuan, Tian Yujing, Xu Kuan, et al. Injection Mold Design of Fan Cover and Optimization of FormingProcess Based on CAD/CAE[J]. Engineering Plastics Application, 2018,46(10):81-85.

[6] Zhang Jinbiao. Application of injection molding CAE and Moldflow software[M]. Bei Jing: Mechanical Industry Press, 2011.

[7] WU Menglin, ZHANG Long. Parameter Optimization for the Automobile Hood in Injection Molding Based on Orthogonal Method[J]. Plastics, 2009,38(1):5-8.

[8] Chen Hui, Li Mingyao, Wu Huachun. Development of CAD/CAE/CAM technology for mould and its software application[J]. Machinery Design & Manufacture, 2011(6):238-240.