Applied Mathematics, Modeling and Computer Simulation
C.-H. Chen et al. (Eds.)

doi:10.3233/ATDE221045

CAE Optimization Analysis and Design of Injection Mold Cooling System for Digital Camera Battery Cover

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Abstract. Moldflow is used to analyze the injection molding of the product. According to the analysis results, the gate position, quantity, size, cooling system, and pressure holding parameters are effectively optimized, and the warpage deformation is effectively reduced. It can reduce the late modification caused by the unreasonable mold design, obtain the best molding parameters, shorten the production cycle of the product, and enhance the competitiveness of the enterprise. This paper optimizes the filling, cooling and molding parameters of the mold cooling system of the digital camera battery cover based on the Moldflow software, so that the warpage deformation can be effectively controlled.

Key words. Moldflow, optimization, cooling system, molding parameters

1. Introduction

Moldflow software is widely used in injection molding simulation. Through the molding simulation, it is possible to know whether the thickness of the product is reasonable; whether the molding parameters are reasonable; whether the welding line position of the product exists in the area where the product strength is relatively weak; identify the area where the product air pockets are concentrated; the time to reach the ejection temperature; whether the warpage deformation is within the within tolerance, etc. Reasonable optimization for existing defects. Taking the battery cover of a digital camera as an example, this paper uses Moldflow software to analyze and optimize the warping deformation, optimize the position and number of glue ports through filling analysis, optimize the cooling system through cooling analysis, and optimize the cooling system through pressure-holding analysis. The packing parameters are optimized. [1]

2. Product Process Analysis and Pretreatment

The 3D model of the part is shown in figure 1, the size of the product is: 192.2mm*104.1mm*50.7mm, and the volume is 60.05cm^3. The average meat thickness is 2.2mm, and the meat thickness of the product is relatively uniform. The product has 5

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inner buckles, three of which need a large sloping top to form, and the other two need a small sloping top forming. There is an outer undercut on the measuring surface, which needs to be formed by the slider. Since the product is relatively large and the glue is fed through the gate, one mold and one cavity are used. Product dimensional accuracy and smoothness requirements are relatively high. The material is PC material, which has the characteristics of high strength and elastic coefficient, high impact strength, wide operating temperature range and dimensional stability. Because the product has some small features, such as rounded or beveled corners less than 0.5. The existence of these small features has a great impact on the quality of the mesh, and has no great impact on the analysis accuracy, so they can be deleted. It can be processed with CAD Doctor or 3D software. The processed model is exported in STL format, and then imported into Moldflow for meshing (dual-layer mesh) as shown in figure 2. The repaired mesh statistics are shown in figure 3. The number of meshes is 19277 triangular elements, the maximum aspect ratio is less than 10, and the matching rate is 94.4%, which fully meets the requirements of warpage analysis.

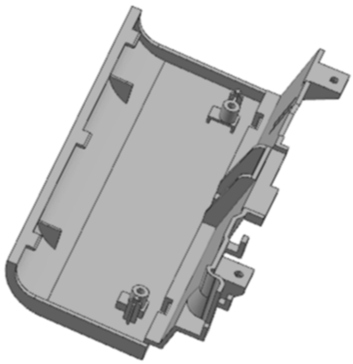


Figure 1. 3D model of the part

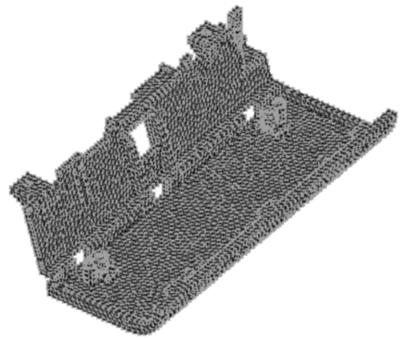


Figure 2. Finite element mesh model

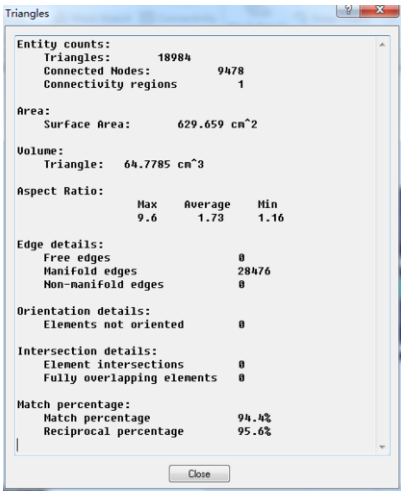


Figure 3. Grid statistics

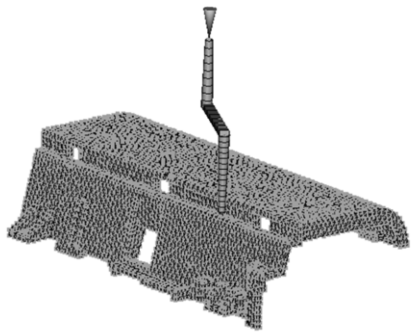


Figure 4.one point gate

3. Molding Process Optimization Steps

(1)Filling analysis: Establish a gating system to check whether there are short shots, hysteresis, trapped air, etc., check whether the welding line position is in an area with weak product strength, and whether the shear rate is within the allowable range of the material. By comparing the two schemes, determine the number, size and location of point gates used.
(2)Cooling analysis: Uneven cooling is an important factor causing warpage deformation, so cooling optimization is an important measure to ensure product quality. By comparing the results of two different cooling schemes, the best cooling method is determined.
(3)Packing analysis: The optimization of packing parameters can effectively reduce the warpage deformation of the product. If the holding pressure is too small, it may cause the shrinkage of the product. If the holding pressure is too large, it may cause the overpressure and even the appearance of flash. Through different pressure-holding schemes, the pressure-holding parameters are optimized to effectively reduce the warpage deformation. [2]

4. Fill Analysis

Filling analysis simulates the process of plastic melt entering the mold cavity from the gating system and filling the cavity, and the main function is to obtain the best gating system. [3]Through product function analysis, it can be known that the first-level appearance surface of the product cannot have any gate. Spot gates can be set on the step surface of the product. One scheme is one point gate as shown in figure 4, and the other scheme is two point gates as shown in figure 5. The diameter of the point gate is 1.8mm. Comparison of analysis results: the filling time of one gate is 1.86 seconds, and the shear rate is: 2.133E+05S $^{-1}$, as shown in figure 6(a); the filling time of two gates is 1.52 seconds, and the shear rate is 29009S $^{-1}$,as shown in figure 6(b). Through the analysis results, it can be known that the shear rate of a gate exceeds the maximum shear rate of the material 40000S -1 too much, which may lead to material degradation during the injection molding process. It is better to use two point gates to feed the glue.

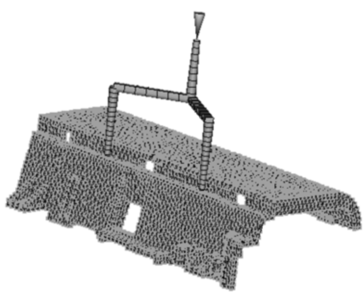
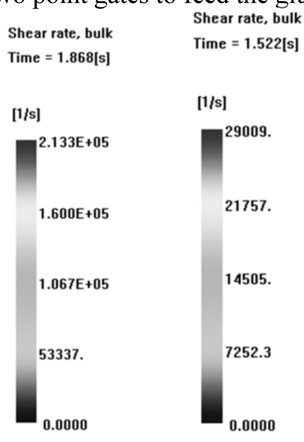


Figure 5. Two point gates



(a) (b)

Figue 6. Shear rate

5. Cooling Analysis

Since the cooling time of the product accounts for 80% of the entire molding cycle, to improve the molding efficiency and shorten the molding cycle, an effective cooling system must be designed. The cooling system also has a great influence on the warpage deformation of the product. Uniform cooling can greatly reduce deformation and improve product quality. [4]Two cooling schemes are developed here for comparative analysis. The first scheme is that the fixed mold part has four cooling water paths, and the movable mold has two "U"-shaped water paths; the second scheme also has four cooling water paths for the fixed mold, and six cooling water paths are designed for the movable mold, including two cooling water paths for the inclined roof. waterway. The total deformation of scheme 1 is 1.116mm, as shown in figure 7. The total deformation of scheme 2 is 0.7767mm, as shown in Figure 8. It can be clearly seen from the analysis results that the deformation amount of scheme 2 is significantly reduced under the same molding parameters. If the denaturation factor is separated, the deformation amount caused by uneven cooling in scheme 1 is 0.6917mm, as shown in Figure 9, and the deformation amount caused by uneven cooling in scheme 2 is 0.3068mm, as shown in Figure 10. It can be clearly known from the analysis results that the cooling scheme 2 is the best cooling scheme.

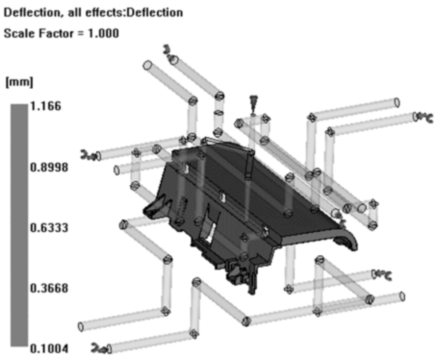


Figure 7. Deformation of scheme 1

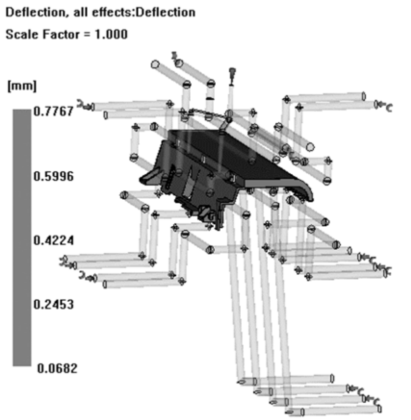


Figure 8. Deformation of scheme 2

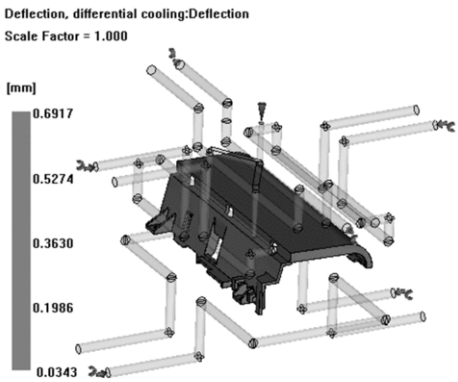


Figure 9. Deformation caused by uneven cooling in scheme 1

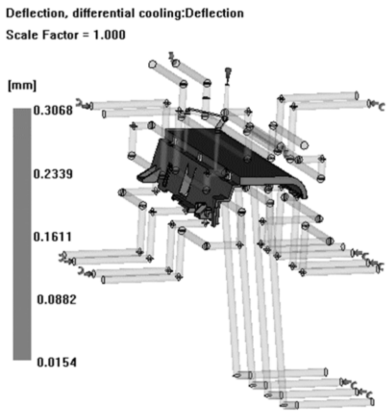


Figure 10. Deformation caused by uneven cooling in scheme 2

6. Packing Pressure Analysis

The packing analysis is to obtain the best packing parameters and effectively reduce the warpage deformation of the product. There are four types of pressure holding control methods: % filling pressure and time; holding pressure and time; hydraulic pressure and time; % maximum injection molding machine pressure and time. The default holding pressure method is: % filling pressure and time, and the default holding pressure is 80% of the filling pressure, and the holding pressure time is 10S. Generally, increasing the holding pressure properly can effectively reduce the warpage deformation of the product, but excessive holding pressure will cause the product to over-hold, the residual stress will increase, and a cloak will be formed.[5] The default pressure holding time is often not an effective pressure holding time. The accurate pressure holding time needs to be determined according to the analysis result of the cooling layer factor. The effective pressure holding time is the freezing time of the gate. You can create a new frozen layer factor: XY chart, click the gate location, click the result check button, and then click the first point where the frozen layer factor is 1, you can check that the freezing time of the gate is 8.174S, as shown in Figure 11.

Two pressure holding schemes are formulated based on experience: Scheme 1 is the default holding pressure method and holding pressure parameters, the holding pressure method is "% filling pressure and time", the holding pressure is 80% of the filling pressure, and the holding pressure time is the default 10 seconds. The pressure holding method of scheme 2 is "press holding pressure and time", the holding pressure time is set to two-stage holding pressure, the constant pressure section is 4 seconds, the pressure is 120MP, the time of the decaying pressure holding section is 4 seconds, and the pressure holding section is 4 seconds. The pressure curve is shown in Figure 12. The comparison table of the analysis results of the two pressure-holding schemes is shown in Table 1. The warpage deformation amount, volume shrinkage rate and sink mark of the scheme 2 are smaller than those of the scheme 1, so the pressure-holding scheme 2 is better.

Through the optimization of filling analysis, the optimization of cooling analysis, and finally the optimization of packing. The final warpage analysis results are shown in Figure 13. The maximum deformation of the product is 0.4506mm, which is within the allowable tolerance range of 0.5mm. Meet the product dimensional accuracy requirements.

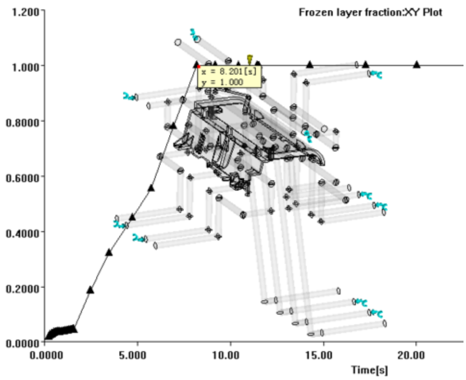


Figure 11. Freezing time of gate

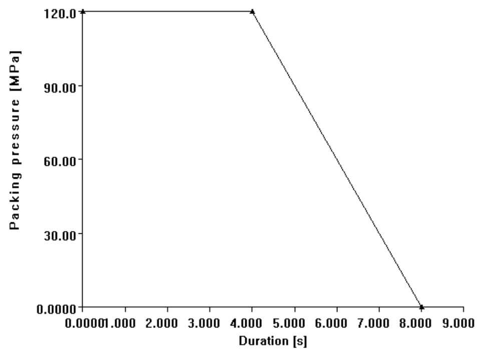


Figure 12. Holding pressure curve

Table 1. Comparison of the analysis results of the two pressure-holding schemes

Analysis results	Plan 1	Plan 2
Warpage deformation	0.7767mm	0.4506mm
Volume shrinkage during ejection	4.626%	1.950%
sink mark, index	2.262%	0.0052%

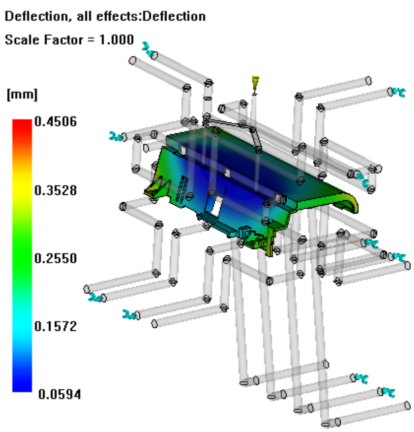


Figure 13. Warpage analysis results

7. Conclusion

The injection molding analysis of the electromagnetic cover of the digital camera was carried out by Moldflow software. First, the number of gates, the position of the gate, and the size of the gate were optimized through the filling analysis. Then, through cooling analysis, the cooling system is optimized. The fixed mold adopts 4 cooling water paths, and the movable mold includes two cooling water paths for the inclined roof, and a total of 6 cooling water paths are used. Under the premise of the optimization of the previous two, in order to ensure that the warpage deformation of the product is within the allowable dimensional tolerance range, the pressure holding parameters are optimized, and two stages of pressure holding are adopted. The first stage is a 120MP constant pressure for 4 seconds. Pressure holding, the second stage is a decaying pressure holding for 4 seconds, and the maximum warpage deformation of the final product is

0.4506mm, which meets the dimensional accuracy requirements within the allowable dimensional tolerance range. Through the molding simulation analysis, the mold structure design is optimized, the best molding parameters are obtained, the mold development cycle is shortened, and the enterprise competitiveness is improved.

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