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# Analysis of Injection Molding for Sensor Back Cover with Metal Insert based on Mold Flow

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## Abstract

**Moldflow simulation analysis software was used to analyze the mold flow of the sensor back cover, studying the setting and optimization of process parameters such as filling time, clamp force, and injection pressure. Possible defects of the plastic part during the injection process were analyzed, such as: Air traps, weld lines, and warping deformation are timely proposed for modification measures, reducing the frequency of mold testing and repair, and improving the quality of plastic parts. Finally, the feasibility of model flow analysis was verified through experiments, and the produced sensor back cover met the requirements.**

## Keywords

**Moldflow; Sensor Back Cover; Process Parameters.**

## 1. Introduction

The development of industrial intelligence has increasingly increased the demand for sensors, which has put forward higher requirements for the production efficiency of sensors. In traditional solutions, the PCB board and quick plug connectors are fixed by manual welding. This approach not only consumes time but also increases labor costs. In order to achieve intelligent production, a sensor back cover with metal inserts is designed, which fixes the PCB board and sensor front cover on the base through ultrasonic welding [1, 2].

Injection molding with metal inserts often results in inaccurate positioning, damage to the inserts, overflow around the inserts, and poor or even cracked plastic appearance around the inserts. This article takes the sensor back cover containing metal inserts as the research object, uses Moldflow simulation to analyze its mold flow situation, provides theoretical basis for determining mold design and forming parameters, provides guidance for discovering forming defects, thereby reducing the number of mold repairs, and improving production efficiency [3, 4].

## 2. Process Analysis of Plastic Parts Containing Metal Inserts

The axonometric diagram of the sensor back cover is shown in Fig. 1. The main body size is 49.5 x 15 x 14 mm, with a thickness of 1.5 mm. The bottom of the plastic part is a threaded quick connect plug. The plastic material is POLYLAC PA-765A, with a melt density of 1.0964 g/cm3 and a solid density of 1.2082 g/cm3. The recommended injection molding temperature parameters for this material are shown in Table 1.

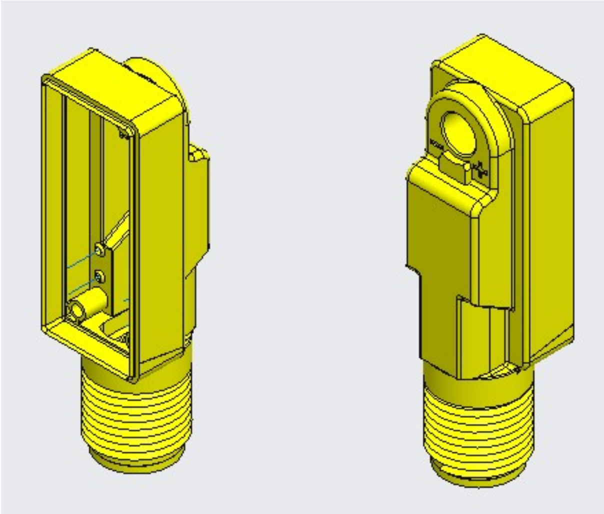

**Fig. 1** Sensor back cover

**Table 1.** Processing characteristic parameters recommended for plastic parts

| Processing parameters | Mold surface temperature | Melt temperature | Mold temperature range | Melt temperature range | Absolute maximum Melt temperature |
|---|---|---|---|---|---|
| Data | 50 °C | 230 °C | 25 ~ 80 °C | 200 ~ 280 °C | 320 °C |

The four metal inserts are shown in Fig. 2. The diameter is 1mm and the material is phosphorous copper. The process parameter settings include: the initial temperature is 18 °C.

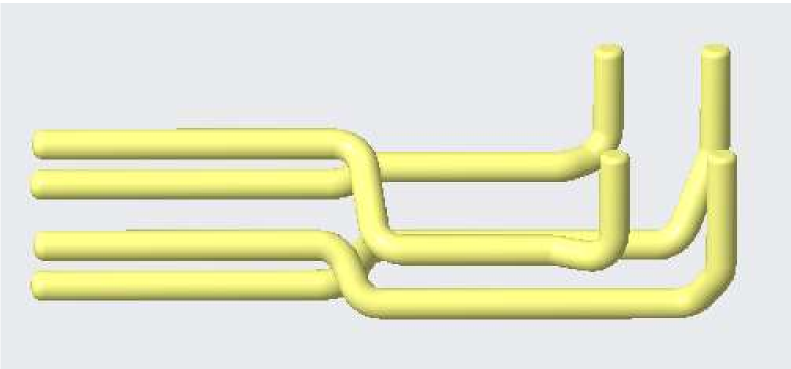

**Fig. 2** Mold insert

## 3. Analysis of Forming Process

### 3.1 3D Mesh Division

Due to the complexity of the sensor back cover model, to improve analysis accuracy, the model is imported into Moldflow CAD Doctor for preprocessing before grid division. The chamfers, threads, etc. in the parts are simplified, and then the model is imported into Moldflow for grid division. Firstly, it is divided into a double-layer mesh, and secondly, the double-layer mesh is converted into a 3D mesh. After division, a total of 247400 units are generated. Fig. 3 shows the 3D mesh model of the sensor back cover. Similarly, as a metal insert, the pin also needs to be divided into a 3D grid with a total of 5300 units, as shown in Fig. 4.

 

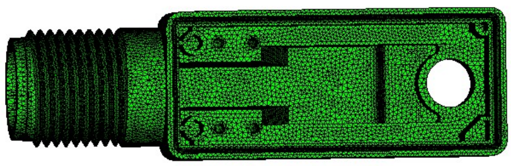

**Fig. 3** Sensor back cover mesh elements (3D)

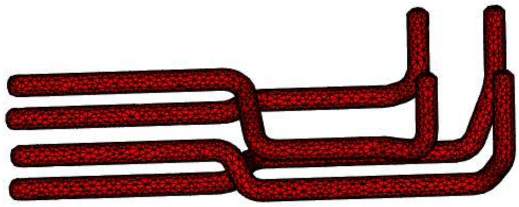

**Fig. 4** Mold insert mesh elements (3D)

### 3.2 Molding Process Settings

Although the volume of the back cover of the sensor is small, considering the need for an inclined core pulling mechanism and the actual production of a 60t injection molding machine, a one-mold with four cavities is adopted. The setting of the gating system is shown in Fig. 5. The injection molding process analysis sequence is set to Fill + Pack + Warp. The specific process parameters for plastic parts are set as follows: The melt temperature is 200 ℃; The mold opening time is 3 seconds, and the injection time is 1.3 seconds; Switch speed/pressure to 95% filling volume; The pressure control is to maintain the pressure for 3 seconds in the first stage, at a pressure of 45MPa, and for 0.7 seconds in the second stage, at a pressure of 25MPa.

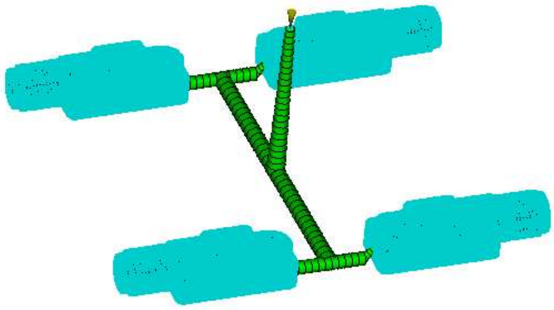

**Fig. 5** Feed system

## 4. Simulation Results and Analysis

### 4.1 Filling and Flow Analysis

The Fill time, Pressure at V/P switch, Pressure at injection location, and Clamp force of the sensor back cover are shown from Fig. 6 to Fig. 9, respectively. From Fig. 6, it can be seen that at 0.53 seconds, the melt can fill the entire cavity, which means it can fill the cavity in a relatively short time. The color transition from light to deep in the filling time chart is more uniform, and the flow balance is good. Fig. 7 shows the pressure during V/P switching, which can be used to observe whether the

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pressure distribution of the plastic part is balanced, at 0.53 seconds, the pressure during V/P switching is 40.08MPa. Fig. 8 shows the X-Y diagram of the pressure at the injection location: During the injection process, the pressure continues to increase, and then decreases uniformly, enabling a more balanced filling of the mold. From Fig. 9, it can be seen that its maximum clamp force is 8.5 tons. In actual operation, this can be used as a reference value, and selecting an injection molding machine with a locking force of 60 tons can meet the requirements [5].

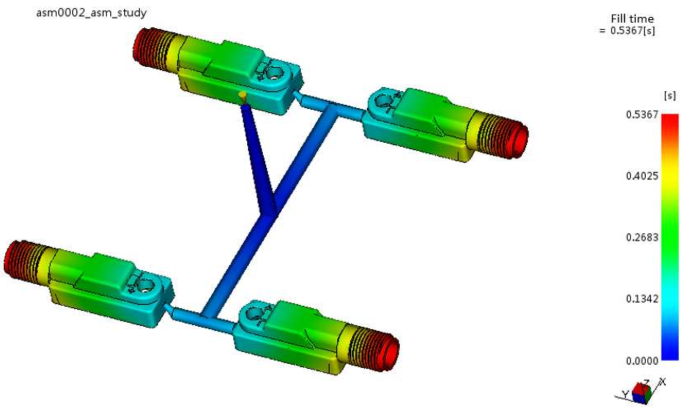


**Fig. 6** Fill time

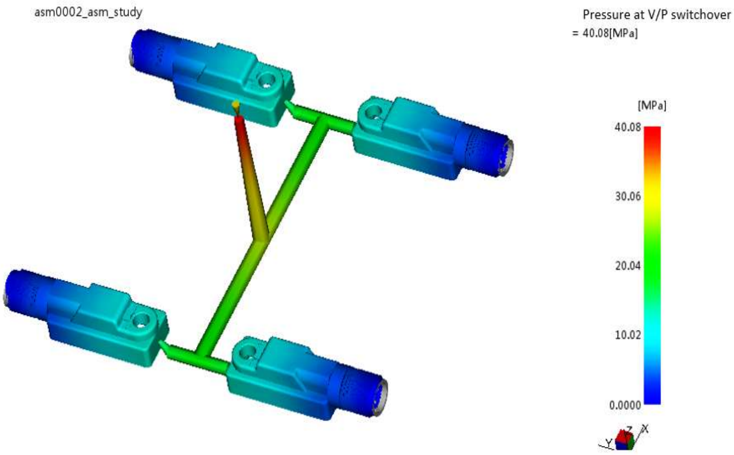


**Fig. 7** Pressure at V/P switch

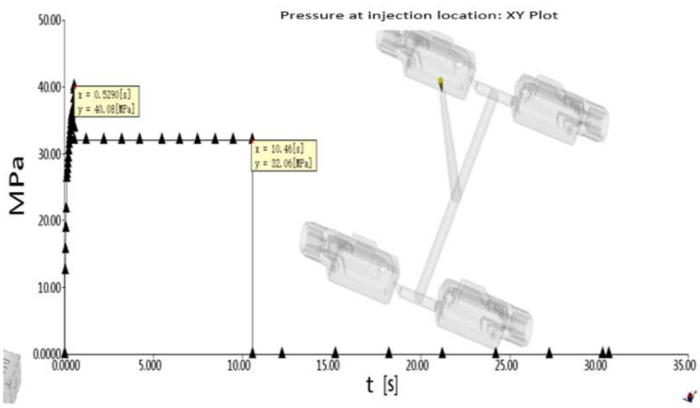


**Fig. 8** Pressure at injection location

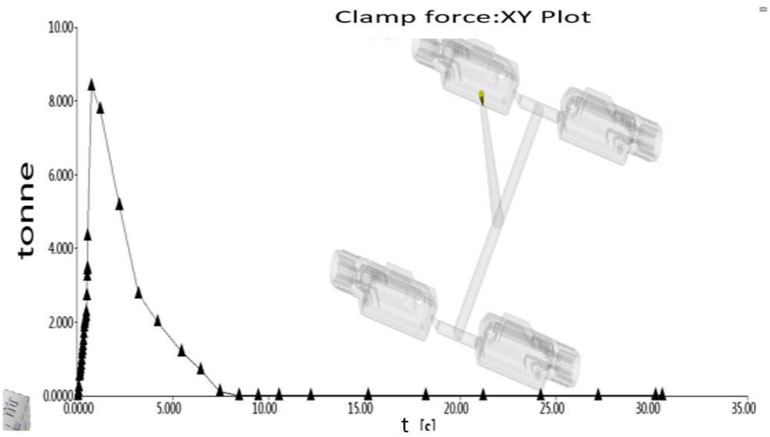


**Fig. 9** Clamp force

### 4.2 Surface Defect Analysis

The main surface defects considered for this plastic component are air traps, weld lines, and volume shrinkage. Fig. 10 ~ 12 show the analysis of surface defects in plastic parts. The volume shrinkage rate is shown in Fig. 10, and it can be seen that the average shrinkage rate of the sensor back cover is approximately below 4.9%; The distribution of air traps is shown in Fig. 11, and it can be seen that there are few and most of the air traps distributed at the edge of the plastic part, which can be discharged through the mold parting surface; Weld lines is an inevitable situation in injection molded parts, and its distribution is shown in Fig. 12. It can be seen that it is mainly distributed on the parting surface and connections and has little impact on the appearance of the entire injection molded part.

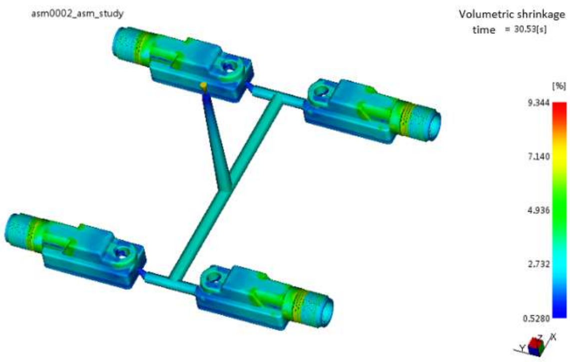


**Fig. 10** Volume shrinkage

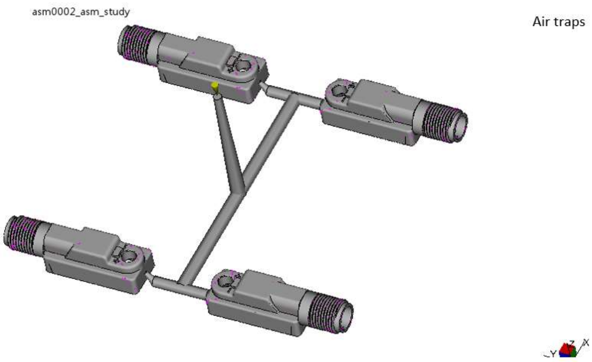


**Fig. 11** Air traps

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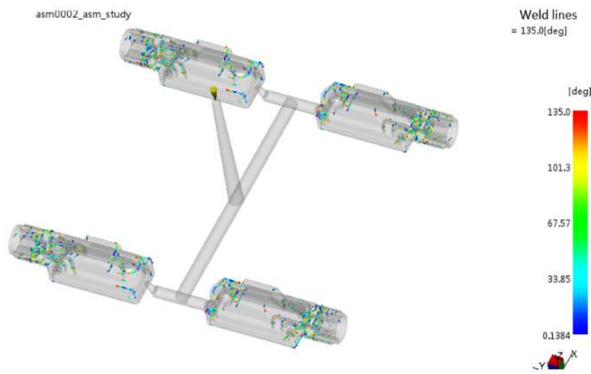


**Fig. 12** Weld lines

## 4.3 Warpage Analysis

Warpage analysis can predict whether the melt will deform during the forming process, which directly affects the qualification rate of the plastic part. Therefore, it is necessary to strictly control the amount of deformation. Fig. 13 ~ 16 show the total deformation, X-direction deformation, Y-direction deformation, and Z-direction deformation, respectively. It can be seen that the total deformation is 0.1456mm, and the deformation in the X direction is 0.0602mm, the deformation in the Y direction is 0.1454mm, the deformation in the Z direction is 0.0622mm, with relatively small warpage, meets the quality requirements of plastic parts [6].

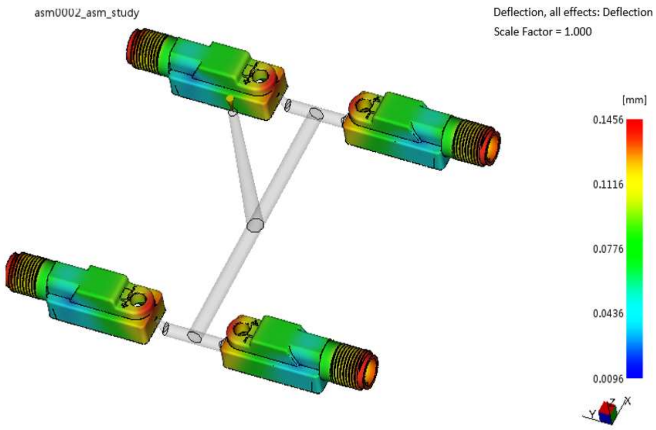


**Fig. 13** Total deformation


**Fig. 14** X-direction deformation

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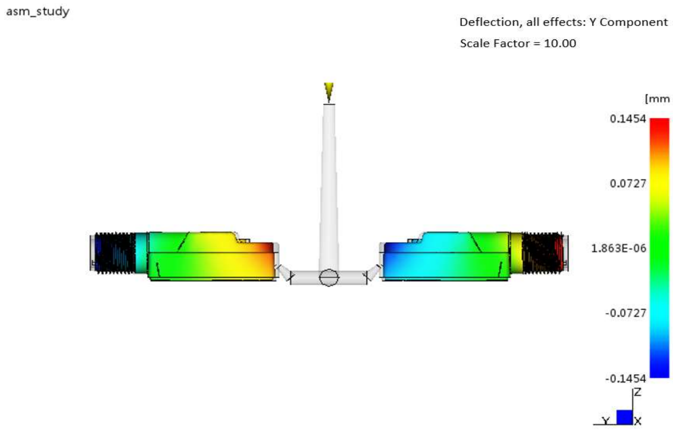


**Fig. 15** Y-direction deformation

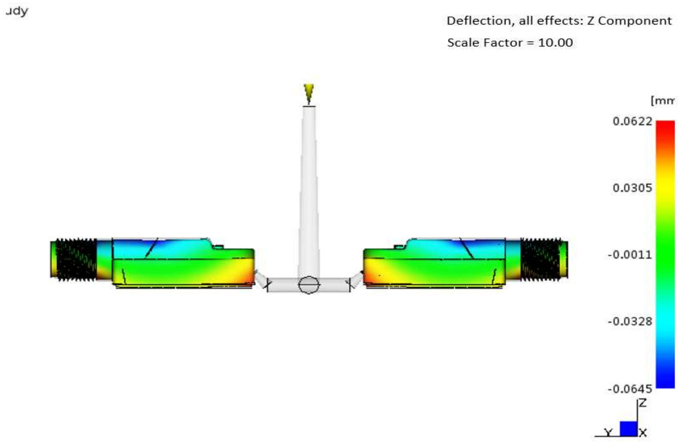


**Fig. 16** Z-direction deformation

## 5. Experimental Verification

Based on the above analysis and simulation of the process plan, actual experiments were conducted to verify the production of the sensor back cover, as shown in Fig. 17. After measurement and comparison, it was found that the results of injection molding simulation analysis were in good agreement with the actual experimental results, thus verifying the accuracy and effectiveness of Moldflow analysis, meeting the requirements of actual production, and having important theoretical guidance significance for the production practice of injection molded products.

**Fig. 17** Product diagram of the actual test

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