Mold optimization design of metal powder injection product
USB interface based on Mold Flow analysis

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Abstract. Metal powder injection molding technology (metal injection molding, the MIM) can achieve a mass in the small and medium-sized complex shape product preparation, low cost, which is of great significance in promoting the production of products and applications. In this paper, taking the USB interface parts made of 17-4ph stainless steel as an example, through scheme verification, the optimized and reasonable die structure is obtained, the 3d modeling of the parts is carried out with UG, and MoldFlow software is used for MoldFlow analysis. The design cycle is shortened and the design quality is improved.

1. Introduction

Metal powder Injection Molding (Metal Injection Molding MIM) is a kind of suitable for small production, 3 d complex shape and near net forming technology with special performance products. MIM technology has unique advantages in the preparation of near-final parts with complex geometry, uniform structure and excellent performance.

The MIM process includes: Metal powder + Organic binder → mixing → forming → skim → The sintering → post-processing → The finished product [1].

The martensite precipitated hardening stainless steel of 17-4ph was developed by American Armco in 1948. It was originally used in the manufacture of aircraft and missile components. The emergence of MIM technology has effectively avoided the disadvantage that 17-4ph materials are difficult to be cold processed, and provide favorable conditions for manufacturing complex shape precision parts with high comprehensive performance requirements of 17-4ph [2].

High quality injection mould is closely related to material performance, forming process and product design. At present, most die designs rely on the personal experience of technicians or design manuals. However, due to the diversity, complexity and limitations of metal powder products and the experience of technicians, it is difficult to design a set of low cost, high efficiency and good product quality process plans. In this paper, taking the injection mold design of USB interface parts with material of 17-4ph as an example, the latest modern mold design concept and MoldFlow software are adopted for MoldFlow analysis, which can effectively solve the impact of limited experience of technical personnel, greatly shorten the mold design and manufacturing cycle, and improve enterprise efficiency and competitiveness [3].
2. Mold overall structure design
When designing the mould of this USB interface part, firstly, the 3d model of the part is established in UG, and then the 3d model is stored as IGS format file and imported into MoldFlow software for analysis to preliminarily determine the gate position of the part. The UG modeling picture of USB interface parts is shown in figure 1.

![UG modeling picture of USB interface part.](image1)

2.1. Establish the finite element mesh model
USB interface parts can be imported into MoldFlow software for automatic grid division after being stored as IGS format file through UG modeling. However, the automatically generated grid has many defects and needs to be modified manually. The total number of manually modified grids is 15104, the average aspect ratio of the grid is 1.56, the analysis results will be more accurate and reliable if the aspect ratio is less than 6. The system prompts that the grid matching rate reaches 93.5%, which can complete the follow-up work well. The resulting grid model is shown in figure 2.

![Finite element mesh division of USB interface parts.](image2)

2.2. Optimal gate location analysis
If the gate position is not selected properly, the formed parts will have defects such as air hole, weld mark and warping, which will affect the strength and rigidity of the parts. Therefore, the location of gate should be reasonably selected [4]. The analysis results of optimum position of gate are shown in figure 3.
2.3. Mold design
The location of the gate has been determined by MoldFlow analysis. Now, according to the actual production needs, the solution of the USB interface part mold is one mould with four cavities. When the mold design is made, the parting surface and the opening surface are not on the same plane. The outer surface of the part is formed by the cavity between the front and rear moving dies. The front and rear moving dies are located between the upper and lower formwork, and there are two pairs of cavity in each pair. Because of the material characteristics of metal powder injection molding parts, when part injection is completed, no ejection device is required. Only the upper template is moved up and the front and rear moving dies are moved for a certain distance. The 2d diagram of mold structure is shown in figure 4.

2.4. 3d mold assembly drawing design
Through the analysis of software and the determination of structure, the UG assembly module is used to generate the 3d assembly explosion diagram of mold components. The resulting 3d explosion diagram of the mold is shown in figure 5.
3. Analyze the flow of USB interface parts

In this paper, high pressure water atomized stainless steel powder of 17-4ph was used to study the material of USB interface parts. Its performance and chemical composition are listed in table 1 and table 2.

| Powder brands | The average particle size / \( \mu m \) | Apparent density /\( (g/cm^3) \) | Rock density /\( (g/cm^3) \) |
|---------------|---------------------------------|-------------------------------|-------------------------------|
| 17—4PH        | 8.22                            | 3.36                          | 4.74                          |

Table 2. Properties of alloy powder.

| Powder brands | C  | Si  | Mn  | Cr  | Ni  | Cu  | Nb  | Fe  |
|---------------|----|-----|-----|-----|-----|-----|-----|-----|
| 17—4PH        | 0.04 | 0.8 | 0.1 | 16.5 | 4.1 | 4.0 | 0.3 | remain |

USB interface parts molding process conditions for: mold temperature is 85 °C, the melt temperature of 2000 °C, open mould time is 5 s, injection pressure, cooling time sum of 25 s, filling control, speed/pressure control switch is automatically set, pressure control of filling pressure and the time relationship, using the default values. According to the mold structure determined by analysis, the finite element model of mold flow analysis is created as shown in figure 6, and according to the parameters of forming process conditions of USB interface parts, the results of mold flow analysis are shown in figure 7.

![Figure 6. Finite element flow analysis model.](image)

(a). Time of filling the cavity with molten material.  
(b). Heat removal efficiency of the loop.
(c). Time of filling the cavity with molten material. 

(d). Heat removal efficiency of the loop.

Figure 7. Results of flow analysis.

According to the analysis results, the total maximum deformation amount of the parts is 0.0486mm. According to the actual production needs of the enterprise, the dimension precision of this part is required to be ±0.05mm, and the maximum deformation amount of the parts is within the tolerance range. In addition, it can be seen from the analysis results that the number of air holes and trace shrinkage of the parts are relatively low, indicating that the location of the mold runner and gate is reasonable, that is, the overall design of the mold structure is feasible and can be put into actual production. The actual production site is shown in figure 8.

Figure 8. Actual production site diagram of USB interface parts.

4. Conclusion
Based on the UG software, the accurate USB interface components of the three-dimensional model is established, and by using MoldFlow software to analyze the components of the gate location, auxiliary mold structure is determined, at the same time using UG modeling and assembly module, generating the mould 3d assembly drawing, and the corresponding interference, and greatly shorten the mold design time. Finally by MoldFlow mold flow analysis function, based on the design of the mould structure, ph of metal powder injection molding of 17-4 USB interface components were analyzed, and according to the analysis results and the actual input into production, molding parts conform to the requirements of the enterprise, the mould optimization design is reasonable, the method for production of such parts and die after optimization design has reference significance.
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