A extrusion die structure with four cavities in a die of Al-alloy screen frame

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Abstract: The importance of extrusion die with multi-cavities in a die was introduced, and a new die structure with four cavities in a die for the frame in the screen window of Al-alloy was presented. The selection of the structure parameters for the die were described, including the selection of the machine, the arrangement of porthole and the die hole, the optimization of parameters, the design of the chamber and the bearing belt etc. The ways of optimizing these parameters were presented. The method of checking the die strength was introduced. It was shown by the results that the structure is effective and worth promoting, and the structure can greatly improve the production efficiency and reduce costs. The aim is to extend the technology and the structure, provide reliable and valid reference data for the designers.

1. Introduction

In the process of aluminum production, the die is the key. The problem of mould has been perplexing the enterprises. Since the aluminum production are mainly carried out in the form of the single hole in a die. If the multiholes extrusion is used, that is, a die can produce multiple times of extrusion at the same time, which will greatly increase production efficiency. The use of dies with multi-cavities in a die can make full use of large machines to produce small profiles, so as to solve the problem that large machines do not have enough orders to work. Because there is often such a real problem in the factory, the small machine has an unfinished task and order, and the big machines are set aside with no suitable products to do. With the continuous improvement of people's living standards, people's requirements for living environment are getting higher and higher. The aluminum alloy screen and the screen door are used more and more. The market demands of screen window and screen door profiles are very large. However, because the section area of this type of material is usually small, but in a very long period, the enterprises use small machine and single hole to make the production, its daily production is low, the energy consumption per unit output is large and the cost is quite high. A new die structure with four cavities in a die for the frame in the screen window of Al-alloy was presented in the paper, the die structure can greatly improve the efficiency and reduce cost. For reference.

2. The selection of extruding machine capability and determination of the types of being squeezed out

2.1. The selection of extruding machine capability

The size of the press is chosen to determine the extrusion coefficient and the maximum specific pressure of the machine on the cross section of the container. The extrusion coefficient is too large and the extrusion pressure will be large in the process of extrusion. It will form the difficulty of extrusion, which is not conducive to the smoothness of extrusion and the strength of the die, but the extrusion coefficient...
is too small, which will reduce the extrusion efficiency and influence the mechanical properties of the profile. The maximum specific pressure on the section of the container is too high, which indicates that the size of the inner diameter of the container is too small, which is unfavorable to the strength of the die, it will reduce the potential of the container, but the pressure value is too low and it is not good for the extrusion forming, and the force needed for the metal forming can not be met. Therefore, on the premise of determining the number of die holes, combining the actual conditions of the factory, the selection of the press capacity and the diameter of the inner diameter of the container will be more pertinent. The practical experience shows that the selection of extrusion coefficient of from 40 to 80 is the most suitable. The maximum specific pressure of the press on the section of the container is selected in the range of from 650 to 750 MPa, which not only meets the requirements of the force of the extrusion forming, but also gives consideration to the strength of the die and the life of the die. The Figure 1 shows a typical section of screen window section.

**Fig.1 the section of aluminum alloy window frame profile**

According to the characteristics of the profile and the related principles mentioned above, the press with a capacity of 18.0MN is selected, and its diameter of the container is 185mm. By calculation, the maximum pressure is 675MPa, if the profile shown in Figure 1 is extruded in the machine by way of four cavities in a die, the extrusion coefficient is 67, so that it can obtain the extrusion coefficient optimization. The size of the die is 185 by 160 mm (outer diameter by die thickness).

**2.2. The determination of the types of being squeezed out**

The determination of the types of being squeezed out is to determine the layout of die holes. This is the premise to ensure the smooth implementation of the extrusion. On the one hand, it is necessary to ensure that the four sections of the four cavities can not be interwoven and rubbed in the extrusion process. On the other hand, the metal supply and metal flow velocity adjustment in the extrusion process should be considered, and the more important is to ensure the strength and life of the die. The profile shown in Figure 1 has a small section size, especially the smaller size of the hollow part, which makes the core size smaller, and the hollow part contains step connections. In addition, the solid part also has a narrow and long cantilever, which is dangerous to break easily during the extrusion process. Therefore, it is necessary to consider the optimum selection of the design parameters in the layout of the die holes, so that the step part which is difficult for the metal to reach is fully supplied, and the force of the cantilever can be reduced, the force condition of the cantilever can be improved, and the purpose of improving the strength of the die is to be achieved. According to these principles, the layout of the die hole is shown in Figure 2.
The two ways in the picture, we choose the large plane of the section as the way of horizon, and adopt the type of the left and right symmetry of the die hole. In the two ways shown in Fig. 2, the Fig. 2 (a) is more reasonable, because the cantilevers are far away from the central part of the extrusion so as to reduce the force of the cantilever.

3. The optimization and determination of the structure parameters of the male die
The determination of structure parameters of male die mainly includes the layout of feeder holes, the determination of feeding ratio, the area relationship between the feeding holes, and the design of the core structure.

3.1. The design of feeding holes
The design of portholes is the key to the success of the extrusion die with multi-cavities in a die. The layout of the feeding holes can be arranged in a variety of ways. In order to improve the design efficiency, save the time of design and reduce the number of test, each scheme designed by CAD is used in the UG software environment, and the numerical simulation is introduced into the HperXtrude software, and the simulation results are analyzed, including the analysis and change of metal flow, the degree of shape, the temperature difference and the welding quality etc. Through the analysis and comparison, combined with experience, the portholes are arranged as shown in Figure 3.

The advantage of this is that the solid part of the cantilever with a dangerous section can be placed under a larger bridge to protect the cantilever, which can avoid the direct impact of the metal on the cantilever, and improve the strength of the die. Taking into account that the width of the other two feeding bridges can be smaller, the flow of metal is provided by 3 portholes in each die hole. On the one hand, the welding quality of the metal can be improved, while the welding seam falls on the corner of the profile, and the surface quality of the profile can be improved. On the other hand, the metal of the step connecting part of the core can be supplied enough. In addition, placing the solid part under the shunt
bridge can reduce the metal flow velocity at that part. This is because the solid part is easy to form and tends to flow faster during extrusion. In this way, the flow rate around the die hole tends to be consistent.

In the two shared portholes, the form of "one divides into two" is used. After the metal enters the male die (20 to 25) mm from a feeding hole, it is divided into two strands of metal to enter two feeding holes respectively, and each of them supplies metal flow corresponding to the die hole. It is easy to grasp for the design and manufacture. More importantly, it can reduce the elastic offset of the die core in transverse direction during extrusion. However, it is important to note that in the radial direction, the portholes marked \( \textcircled{1} \) and \( \textcircled{2} \) cannot be merged into a common shunt hole, which will increase the uncertainty of the molding caused by the manufacturing error, especially the synchronism of the extrusion, which is shown by the simulation results and the practical application of other dies.

3.2. The key points of structural parameter design

(1) The selection of feeding ratio

The surface quality of the profile and the extrusion force during extrusion should be considered. Experience shows that the ratio of feeding to (25~35)% of the extrusion ratio is most suitable. The distance between the maximum circumscribed circle of the feeding holes and the inner diameter of the container is 8mm, and the feeding ratio is 22. On this basis, the design of the feeding holes is carried out.

(2) the width of the bridge: \( D_1 = 18 \text{mm}; D_2 = 14 \text{mm}; D_3 = 6 \text{mm} \);

(3) the distance between the feeding hole \( \textcircled{1} \) and \( \textcircled{2} \) is 6mm.

(4) the area relationship between the portholes is shown in Figure 4.

\[ S_1 = (1.1 - 1.2) \times S_2; \ S_2 = S_3 = 2S_4. \]

Fig.4 the signal of the area relationship between the portholes

(5) As the size of core is small, its rigidity will be small, and elastic deformation will occur during extrusion. Therefore, we must consider the variation of die wall thickness caused by elastic deflection of mold core. According to experience, a space of from 0.10 mm to 0.15 mm between the male die and the female die will be set for transverse clearance. As shown in Figure 5. The values of 0.92mm and 1.2mm in the figure are the wall thickness of the core offset, and the nominal wall thickness is 1.02mm.

Fig.5 the signal of thickness
The die assembly and the core structure

![Diagram of the die assembly and the core structure](image)

(b) die assembly           (d) the core structure

Fig. 6 the signal of die assembly and the core structure

4. The design of welding chamber and selection of bearing

In the die of multicavities, the design of the welding chamber is also crucial. The welding chamber should be designed in principle as an independent chamber with each die hole. Four independent chambers are adopted, so that the forming of each die hole is not interfered with each other, which is conducive to the stability of the forming. The width of the partition wall between the welding chamber is 6mm. In this way, the rigid zone of metal flow can be avoided at the center of the die hole, which leads to the increase of internal friction in the flow of metal and the influence of the surface quality of the profile, so as to avoid the serious chromatic aberration of the coarse grain and the profile. The shape of the welding chamber is based on the maximum contour of the shunt hole, and the piers are formed as a principle as far as possible, which is beneficial to the improvement of the overall strength of the bridge and the die. The depth of the welding chamber is 16mm, which is determined by the ability of the extruder and the rigidity of the core. The larger the depth of the welding chamber is, the greater the elastic deformation of the die core is.

The choice of bearing is carried out according to the principle of single hole. Selecting the bearing for a die hole, and the other die holes are the same.

The structure of chamber and bearing size are shown in Figure 7.

![Diagram of the structure of chamber and bearing size](image)

Fig. 7 the structure of chamber and the size of bearing

5. Conclusions

The die test and the use tracking show that the die is successful in one time, the extrusion output of the die is over 17.2 tons, the surface quality is good and all the properties meet the requirements. This shows
that the die structure of four cavities in a die is reasonable and effective. It can be concluded that the rational determination of the layout and extrusion mode of die holes and the selection of the capacity of the machine are the foundation of the die success, and the layout of the feeding holes, the size of the portholes, the distribution of metal flow between the feeding holes, the design of chamber and the selection of the bearing are the key points. The optimization of these parameters is the guarantee for synchronization and smooth extrusion, which is the guarantee for improving the strength and life of dies. With the aid of simulation software, the analysis and comparison of the scheme can greatly improve the effect and accuracy of the die design and the success rate. More importantly, it can greatly reduce the workload of the test link of die, and greatly shorten the cycle. This fully shows that the die structure with multi cavity in a die can greatly improve production efficiency, reduce the cost, which is a worthy of further research and promotion of technology.

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