A Hollow Extrusion Die for Big Square Tube Profiles of Al-alloy

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Abstract. The factors on premature failure of the traditional extrusion die for the big square tube profiles were introduced. And the characteristics of the conventional structure were analyzed. A new type of hollow die structure for these profiles was presented. And the composition elements of the new die structure were described, including its advantages. According to the comparison conventional with new die structure in use, it was shown that the new die structure has obvious advantages, it could greatly improve the die life; this is a type of die structure which is worth promoting.

1. Introduction
When the section of aluminum profile is square and the dimension is larger than 100×100mm, the profiles are called big aluminum square tube. The big square tube is a kind of common structural material, widely used in industrial and civil construction. But the extrusion dies used in extrusion of large square tubes have been a difficult problem for production. This is because the inner cavity of profiles are relatively large so that the core area of the male die becomes bigger, in the extrusion process, the metal deformation resistance and friction of metal produced by the rigid region in the center of die become huge, it will cause serious deformation of die under the condition of high temperature, high pressure and high friction resistance, which will lead to the premature rupture of the porthole bridge, lead to premature failure of the die and a low die life. On the other hand, the wall thickness of these profiles are usually thin, which increases the extrusion deformation degree, makes the extrusion pressure increase so as to increase the endurance of the die and reduce the strength of the die. In fact, in practice, when the traditional structure used, the hollow bridge will appear crack, the die scrap rate is very high, it not only greatly increase production costs, but also delays delivery cycle so that it is difficult to meet the requirements of production and market. Therefore, it has attracted the attention of the engineering and technical personnel in the industry to reduce the extrusion force in the extrusion process through the die structure of improving the die life of the big square tube profiles. This paper introduces a new die structure through practical example, the structure is different from the traditional structure, it can significantly reduce the extrusion pressure of extrusion process, improve the strength and life of the die with simple process and applicable to a wide range of characteristics.

2. Die Structure Introduction

2.1 The traditional mold structure
As shown in Figure 1, a big aluminum profile of square tube of 160×160mm, with a wall thickness of 2.0mm, is a common specification.

![Fig.1 the diagram of big square tube](image1)

Its traditional die structure is shown in figure 2. The main features are as follows:

![Fig.2 the diagram of traditional die structure](image2)

1. The die is a porthole die composed of two pieces of male and female die.
2. The male die adopts the feeding way of 4 porthole holes.
3. The die is used in an extrusion machine of 30MN or 35MN, and the diameter of container is from 260 to 285mm.
4. The male die uses a moderately extended form.
5. In the extrusion process, the maximum extrusion force can reach 190MPa, and the final wall thickness of the profile is different from the die gaps of the male and female, and the value is greater than 0.15mm. This shows that the elastic deformation of the die is greater in the extrusion process.
6. The service life of the die, the maximum extrusion output, shall not exceed 12×10³Kg.
7. The main form of die failure is the fracture of the porthole bridge.

2.2 The improved and optimized die structure

In view of the fact that the extrusion force of the traditional structural die is high and the die premature failure occurs in the extrusion process, the traditional structure is improved and optimized. The new structure is shown in figure 3. The main features of this structure are as follows:
Fig. 3 the signal of the improved die structure

(1) The traditional structure of two pieces is changed, and the structure of three pieces is used. A front feeder plate is arranged at the front end of the male die.

The advantage is that the thickness of the male die is reduced, the processing difficulty is reduced, and the hardenability of the heat treatment process is improved, which will improve the strength of the die. For metal forming, after a preforming, the first deformation can be selected larger to the metal to flow into the front feeder plate, which will greatly reduce extrusion pressure. As we know the reason, the greater the hollow ratio is, the lower the extrusion force will be.

(2) With 4 portholes in the front plate, and 8 portholes are used in the male die. But a slope of 10 degree is designed in the feeder end of the front feeder plate, and 20 degree taper is designed in the feeding end of hollow bridge, the bridge width of the front feeder plate was selected 35 ~ 40mm. This has the advantage of reducing the rigid region of the feeding center in extrusion process and the compression area of the front feeder plate. The tapered bridge is like a sharp axe, which reduces the force of the first shearing of the aluminum billet, which greatly reduces the shear area. At the same time, the oblique feeding type can make the maximum shearing force not appear at the same time, but form a certain pressure gradient, when the billet is sheared, which will greatly improve the stress state of the die, thereby enhancing the strength of the die. The structure of the front feeder plate as shown in Figure 4.

Fig. 4 the signal of the front feeder plate

(3) A stress space of 0.8 ~ 1.2mm is designed in the joint of male die and the front plate. The gap value is designed on the exit plane of the front plate. The advantage is that the center stress of male die is lighten, the die stress is mainly bore by the the front plate, it will reduce the deformation of male die in the extrusion process, improve the strength of the mold, it can also make the wall thickness change decrease to zero.
(4) 8 hollow holes are used in the male die. The metal of one porthole from the front feeder plate will be split again, when the metal flows into the male die. The bridge width of male die is 30mm, and the width of jointing is 20mm. The advantage is that the metal will be shunted again in the male die, and the split ratio can be greater to reduce the extrusion force. At the same time, the reduction of the width of the porthole bridge can greatly reduce the metal flow in the central position of die, so that the velocity of the metal forming in the extrusion process tends to be more consistent, and the profiles with higher accuracy are obtained.

(5) The expansion mode of porthole holes in the male die is different from the traditional, which will reduce the span of the intermediate hollow bridge, which is beneficial to the improvement of the die strength.

(6) The auxiliary holes are respectively designed in the centre position of the male die and the front feeder plate. The purpose is to improve hardenability of heat treatment, so as to improve the toughness and strength of the die. The structure of male die is shown in figure 5.

![Fig. 5 the signal of the male die](image)

(7) When the male die is damaged with a failure, the front feeder plate and the female die can be repeatedly used, which can improve the utilization rate of the material and reduce the cost of die

3. Conclusions

This is a concrete example of big square tube of 160×160mm. The traditional die structure is improved and optimized. The result shows that the life of the die is greatly improved after the optimization, and the processing of the die is simpler. This shows that the selection of the die structure and the structure parameters are the key. It is the key and important factor to effectively improve the life of the die.

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