A aluminum alloy extrusion die structure on the large flat tube

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Abstract: The factors on premature failure of the traditional extrusion die for the big flat tube profiles were introduced. And the characteristics of the conventional structure was analyzed. Through an actual sample, a new type of hollow die structure for these profiles was presented. The composition elements of the new die structure were described. The selection of the main structural parameters was explained, and the characteristics of this new structure was described. In particular, the metal feeding way of this structure can greatly reduce the extrusion force. The new die structure has obvious advantages, which could greatly improve the die life. This is a type of die structure which is worth promoting.

1. INTRODUCTION
With the progress and development of modern manufacturing technology, the research and development of aluminum alloy materials have become more and more profound. The research and development of aluminum alloy materials have made great progress. The aluminum alloy materials have been widely used. Especially, aluminum alloy extruded profiles have been applied to various industries and fields as structural materials, and aluminum alloy profiles promote the trend or necessarily of aluminum replacing steel. As a large aluminum alloy flat tube extrusion profile, it is very common in civil and industrial applications. But the die of extruding and producing such large size profiles has been puzzling the enterprises. Because of the large cavity area of this type of profile, the die core size is larger. During the extrusion process, the pressure area of the die center is large and the extrusion rigid area is large. The deformation resistance and the metal friction force at high temperature are all large, and the working ring of the die is at high temperature, high pressure, high friction resistance and alternating stress. Under the circumstances, serious deformation will happen, which will easily lead to the early fracture of the diversion bridge, which will make the die premature failure and reduce the service life of the die. On the other hand, the thickness of the profile is usually thinner, and the ratio of the maximum width to thickness of the profile is more than 100, which leads to the increase of the extrusion deformation, the high pressure in the extrusion process, the increase of the pressure of the die and the decrease of the strength of the die. Therefore, how to improve the service life of large flat tube profiles has attracted the attention of engineers and technicians in the industry and has been researched.

2. DIE STRUCTURE

2.1 traditional die structure
Figure 1 shows a large flat tube aluminum profile with a section size of 215 mm by 115 mm, whose
wall thickness is 3.0 mm. It is a common tubular profile, and its maximum ratio of width to thickness is 71.7. Usually the extrusion machine is selected with capacity of 40MN, and the inner diameter of the container is 330 mm. It is calculated that the extrusion ratio is 44.

The traditional die structure is shown in Figure 2.

The main features of traditional mold structure include the following:

1. The die is composed of two parts of the male and female die.
2. There are 6 metal feeding holes in the male die, and the feeder ratio is 14.6.
3. The upper part of the intermediate bridge is narrower than the outer 4 corners of the bypass bridge, and the way of sinking bridge is used.
4. The thickness of the male die and female die is 280mm and 140mm respectively, and the dimension size of the die is 480mm.
5. A spread structure is used in the lateral feeder holes of male die.
6. The 6 bridges in the male die have used the chamfering way in the feeding port. The effect is to change the position of the central layer of the bridge section and reduce the tensile stress of the shunt bridge.
7. During the extrusion process, the practical data show that the maximum peak value of the extrusion pressure can reach 200MPa, and the wall thickness of the profile and the gap between the die are quite different for extrusion pressure, especially the wall thickness on both sides of the profile, and the maximum difference is up to 0.25mm. This indicates that during the extrusion process, the die has undergone large elastic deformation.
8. About the service life of dies, through the statistics of 10 sets of dies, the maximum life expectancy is 20tons, and the minimum is 16.3tons.
9. The main failure form of the die is the fracture of the bridge.

Through the analysis of extrusion process and die structure, it is found that the profile is produced on the extrusion machine with capacity of 40MN. The extrusion ratio is 44, and the deformation degree is not large. It is a suitable extrusion factor. However, in the traditional die structure, the structure of the feeder hole and the bridge make the bridge cut the metal into a few strands into the hollow hole, and each bridge is subjected to the maximum peak at the same time, so that the pressure of the whole die is maximum. At the same time, with the large compression area in the central part of the die, a large rigid zone of metal deformation is formed, and the deformation resistance of the metal extrusion deformation is greatly enhanced and the extrusion pressure rises sharply. In addition, due to the traditional die structure, in order to ensure the strength of the die, the thickness of the male die must be obtained very much. The disadvantage is that the male die is too thick so that the time what the male die bear the maximum pressure will extend, and the tension and pressure alternating stress is large. On the other hand, the over thickness of the die increases the processing difficulty of the die, and the parts of the local stress concentration increase, and the thickness is too large,
Fig. 2 the traditional die structure

which reduces the hardenability during the heat treatment process and reduces the toughness of the die, especially the impact toughness of the central part. As a result, extrusion pressure and die bearing force all will increase to result in the reduction of die strength.

2.2 the improved and optimized die structure

Aiming at the traditional die structure, the traditional structure is improved and optimized, and the structure obtained is applied to practice. The use shows that the effect is obvious. The structure is shown in Figure 3.

Fig. 3 the improved die structure

The main features of the die structure are as follows:

1. Unlike the traditional die structure, a three piece die structure is adopted, and a diffuser plate named front feeder plate (FFP) is added at the front end of the male die. The metal is pre-assigned in the FFP first, and the metal predistribution function is made full use with the FFP, so that the metal can use the larger feeder ratio to enter the FFP and carry out multiple metal predistribution through a number of larger feeder ratio in the FFP. The pressure is greatly reduced. On the other hand, the thickness of the male die can be reduced, the machining difficulty of the die can be reduced, and the hardenability of the die in heat treatment can be improved. All these will help to improve the strength of the die.

2. The step type feeding method is used. The metal first enters the FFP, after the metal is cut from the outer edge of the feeder hole of the FFP, the metal enters the hollow hole with a metal and contact the first stage bridge after the distance 30mm, the bridge cut the metal flow second times, and the metal is divided into two strands of metal in the FFP, and the two strands of metal flow forward for 60mm, the two strands of metal are formed after third shearing of the second stage bridge, and at this
point, after two times of shunt, four strands of metal are eventually formed into the feeder holes of the male die. The advantage of this is that from a metal to a four strand of metal, the feeder ratio can be larger and formed a certain gradient in turn than the traditional one, so that the pressure acting on the bridge can also form a certain gradient. As a result, the peak value of maximum extrusion pressure of bridge does not appear at the same time, so that the maximum peak value of extrusion pressure is avoided. On the other hand, such a stepped feeding way can effectively reduce the rigid area of the center part of the die, thereby reduce the deformation resistance of the metal during extrusion. The final result is to greatly reduce the bearing capacity of the bridges and improve the strength of the die. The metal feeding mode of FFP is shown in Figure 4, the metals were sequentially fed from a, b, c to d.

(a) - billet  (b) first level feeder hole  (c) two stage feeder hole  (d) three stage feeder hole

Fig.4 the feeding type of metal through the front feeder plate(FFP)

(3) 6 feeder holes are used in the male die. This indicates that after the four metal flows of the FFP enter the male die, 6 strands of metal flow will form. As can be seen from the die structure, the two strands of metal in the FFP will turn into three pieces of metal in the male die. This process will lead to the rewelding and fusion of metal and the partial rediversion. The advantage of this is to ensure that the metal supply in the part that it is difficult to be formed, so that the metal flow in each place tends to be consistent, so that the precision of the profile can be ensured. At the same time, metal is changed from four strands to six strands, which is more consistent with the similarity between metal distribution and profile shape, making the distribution of metals more reasonable. On the other hand, with the use of the FFP, the feeder ratio is increased. In the case of 6 feeder holes in the male die, the final feeder ratio is 23.5, which is 53.4% of the extrusion ratio, which is also significantly higher than the traditional shunt ratio.

(4) In order to reduce the elastic deformation of the male die during extrusion process and maintain uniformity of the wall thickness of the profile, the pressure at the center of the male die should be reduced as much as possible. Therefore, we should mainly let the FFP bear most of the extrusion pressure. At the same time, the deflection or elastic deformation of the central part of the FFP is transferred to the male die as small as possible and affects the male die. Therefore, the stress gap is set on the contact surface of the FFP and the male die, and the experience indicates that the stress gap of from 1 to 1.5 mm or from 1/3 to 1/2 of the thickness of the section is more suitable, and the clearance is easier to be machined on the FFP. The structure of the FFP is shown in Figure 5.
The way of spreading is used in FFP and male die. On the one hand, we can give full play to the potential of the extrusion machine, and on the other hand, we can ensure that the welding chamber in female die has enough metal to ensure the welding performance of extrusion. At the same time, in order to improve the hardenability of the die during the heat treatment process, one process holes are opened in the center of the FFP and the core of male die respectively. The diameter of the process hole is 30mm, and its depth is 60mm. The male die structure is shown in Figure 6.

The choice of bearing in the female die is in the traditional way. But the width of the profile is larger. The pressure gradient is considered in the radial direction of the container. Therefore, in order to ensure that the flow of metals in each place tends to be consistent, metal flow blocking blocks are set at the center of the length and width of the die hole. The height and width of the blocks are 6mm. The welding room and the bearing of female die are shown in Figure 7.
3. CONCLUSIONS

In view of the improvement and optimization of the die structure of a large flat tube aluminum extrusion die with a specification of 215mm by 115mm by 3.0mm, the practice shows that the effect is obvious and the life of the die is greatly improved. It can be fully explained that those methods are quite critical for the extrusion die of large section profiles. Those methods include the selection of the die structure, the structure of the feeding holes and the reduction of the extrusion pressure etc. These structural parameters are the key and important links to effectively improve the life of dies. The structure mentioned above can be used for reference other large section profiles.

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