A Covering Type Extrusion Die with Twin Cavities for Semi-Hollow Al-Profiles

Rurong Deng¹,a, Xuemei Huang¹,b*
¹Guangzhou Vocational College of Science and Technology, Guangzhou, 510550, China
*sqf6410@163.com, b41784402@qq.com
* corresponding author

Abstract. A new structure named covering type with twin cavities in a die for the semi-hollow aluminum profiles was present. The determination of structure parameters was introduced in detail. Mainly including the selection of the machine, the arrangement of portholes, the structure design of chamber and the selection of bearing. The method of checking the die strength was introduced. According to the extrusion results, the structure of the traditional solid die, the porthole die with single cavity and the covering type structure with twin cavities were compared. The characteristics of the latter structure were simple and easy to process. The practical application shows that the new die structure can enhance the die life, improve the production efficiency and reduce the cost. The high precision and the surface brightness of the profiles were obtained. The structure is worth promoting. The aim is to provide reliable data and reference for the further research and development of this technology on the extrusion die with multi-cavities in a die.

1. Introduction
With the progress and development of modern manufacturing technology, and in-depth understanding and research on aluminum alloy, the aluminum alloy profile has been widely used. Because of a huge market demand, Enterprises are pursuing certain production capacity in order to meet the needs of the market and be in a favorable position in the fierce market competition. The traditional approach is to rely on investment to build more production lines to expand the scale. But in the case of human resource costs and energy use costs to continue growing and land supply not to adequate to the demand is not realistic. The best way is to rely on technological innovation to increase production efficiency of extrusion machine by a big margin. The extrusion technology of multi cavities in a die is undoubtedly one of the best ways. This paper introduces a covering type extrusion die with twin cavities in a die for semi hollow profiles for reference.

2. The die structure of covering type with twin cavities
The covering structure is a hollow die structure used to covering type in replace of the traditional solid die structure used in the extrusion of semi hollow profiles. The die structure is to use the centre part of male die to cover the cantilever, so that the cantilever can not bear the positive pressure of the metal directly during the extrusion process, and the cantilever is protected. In the female die, the cantilever part will protrude upward with no contact with the male die, a space named stress gap between the protruding top and the male die is set so that the male die can not touch the cantilever and do not impose force to the cantilever in the extrusion process when the male die is bent downward. Thus, the force state...
of the cantilever is changed, and the cantilever is protected to improve greatly the strength of the die. For the new structure of twin cavities, the hollow bridge will be made full use as the protection of the cantilever. In view of the extrusion pressure gradient exists in the container, the reasonable hole arrangement can avoid the cantilever, especially the end of the cantilever, to bear the positive pressure during the metal extrusion, and the die strength can be improved while the extrusion efficiency can be improved.

3. Determination of die structure parameters

3.1 The arrangement of die holes

Figure 1 shows a civil building door and window profile, a typical semi hollow profile.

![Fig.1 the signal of profile section](image)

Its section area is 221mm$^2$, and the ratio of tongue is 6.5. When single cavity extrusion is used, the extrusion machine of 8 MN is selected, and twin cavities extrusion can be used in machine of 18MN, its inner diameter of container is 185mm. By calculation, the extrusion coefficient is 66.5, and the extrusion press is 670MPa. On the one hand, the arrangement of the die holes is beneficial to the extrusion forming, which can give full play to the potential of the container, on the other hand, it is necessary to make the structure of the die simple and compact, conducive to processing and saving materials. The arrangement of the die holes can be of two forms in the machine of 18MN, as shown in figure 2.

![Fig.2 the signal of die hole arrangement](image)

Figure 2- (a) is a symmetrical arrangement, so the benefit is that there are no contact with the surface of the two profiles, the profiles can be in contact with the sliding table, it is easy to achieve smooth extrusion, the deficiency is that the characteristics of container cannot be make full use, the die holes everywhere can be in the central region as far as possible to achieve the forming velocity easily tend to be the same everywhere. The die hole wall edge distance from the container is small, on the one hand, the spreading structure will be used, which will increase the complexity of the metal flow; on the other hand, the size of the die must be increased to ensure the strength of the mold. Figure 2- (b), on the contrary, a arrangement of the upper and lower symmetry, while the two profiles of the upper and lower have a surface contact during extrusion, the surface may be slight friction, however, with the final surface treatment and the automatic pulling device considered, the influence of this contact on the surface quality of the profile can not be considered, so it is more appropriate to choose 2- (b).
3.2 The Arrangement of porthole holes

The arrangement of diversion holes consists of determining the feeder ratio, the size of the hollow holes and the structure of the bridge. This is the key for the die of twin cavities. The structure is designed according to the layout of figure 2- (b). The first, based on personal experience, a preliminary program is designed with the aid of CAD software, there are two mature layout program to be selected. As shown in figure 3. The second is to build the three dimensional model in the UG software environment and save it as a fixed format in the software environment. The third is to use the extrusion simulation software HyerXtrude to carry out the simulation and observation. Finally, the results are analyzed and compared, and combined with the personal experience, the necessary amendments, simulation, analysis and comparison may be carried out to get the best program.

Fig.3 The layout of feeder portholes

It is found by simulation that it is difficult to adjust the flow velocity of metal in figure 3- (a). It is difficult to determine the ratio of S1, S2 and S3. Due to manufacturing errors, the workload of die repair will inevitably increase. The simulation shows that the deformation degree of the cantilever is larger, and the change of the area of the porthole hole S2 has obvious influence on the deformation of the cantilever. Figure 3- (b) as shown in the program, because the number of holes is less, it is simple to only adjust the area of S4 and S5, after the determination of the area of the feeder hole S5, it will be easy to adjust flow of the feeder hole of S4 in order to make all velocity consistent, and it is the key that the change of the area of the porthole hole does not affect the cantilever. At the same time, to adjust the area of feeder holes without correction or change of bridge, and the cantilever also completely is placed under the protection of bridge. In particular, the end of the cantilever does not bear the direct metal pressure, so the strength of the cantilever is the best. After analysis and comparison, it is more appropriate to adopt the scheme of figure 3- (b). The main parameters are as follows:

1. The feeder ratio is 17.3 to the extrusion ratio (25~30)%.
2. The width of the bridge is 24mm, and the thickness is 85mm.
3. The area relationship between the feeder holes S5 and S4 are shown in Equation 1.

\[ S5 = 0.8S4 \]  

From the simulation, it is found that when the S5 meet the area relationship shown in Equation 2, the adjustment of metal flow velocity tends to be consistent everywhere.

\[ S5 = (0.75 \sim 0.85) S4 \]  

The structure of the bridge is designed according to the corresponding cantilever. The structure is shown in figure 4.
3.3 The welding chamber of female die and the bearing
In order to eliminate the effect of manufacturing errors on the extrusion synchronization and to avoid the rigid region of metal flow in the central part of the cavities to cause the coarse grain in the profile, the chamber of the female die must be designed to be independent respectively. A wall must be set between the chambers, without mutual interference and influence between the holes, its width of desirable is (6 ~ 8) mm, and the height is (8 ~ 10) mm.

Because of the covering structure, the cantilever raises upwards, and the size relation between the raised part and the die hole are shown in figure 5.

3.4 The structure composition of die
The die is composed of an male die and a female die. The die structure is shown in figure 7.
4. Conclusions

Through the use of the covering type structure with twin cavities in a die for the semi hollow sections shown in Figure 1, the results show that the die is successful, the die has been used many times after nitriding, and the extrusion output can reach 26.7 tons. It can be concluded that the adoption of the new die structure can greatly improve the life of the die, increase production efficiency and reduce costs. At the same time, it can be seen that the die hole layout, the design of feeder holes, the bridge structure and the chamber structure design and the bearing are very important for the die with twin cavities for the semi hollow section. In the design process, computer simulation can improve the efficiency and accuracy of the design.

![Image: Fig.7 The signal of die structure](image1)

**Fig.7** The signal of die structure

**Fig.8** The inner hole structure of special die support

**References**

[1] LIU Jingan. Die design, manufacture, application and maintains for aluminum profiles extrusion[M]. Beijing: Metallurgical Press, 1999: 181～183.

[2] XIE Jianxie, LIU Jingan. Die design, manufacture, application and maintains for aluminum profiles extrusion[M]. Beijing: Metallurgical Press, 2012: 133～138.

[3] WANG Liwei. Optimization design of extrusion die for the bigger slenderness ratio half hollow aluminum profile[J]. Die and Mould Manufacture, 2011(4): 61-64.

[4] YU Mingtao, LI Fuguo. Simulation extrusion process of the sketch hollow aluminum profile based on infinite volume method[J]. Die and Technology, 2008(4): 40-43.

[5] SUN Xuemei, ZHAO Guoqun. Fake porthole extrusion die structure design and strength analysis for cantilever aluminum alloy profiles[J]. Journal of Mechanical Engineering, 2013, 49(24): 39～44.

[6] KUANG Weihua, CHEN Biaobiao. Research on design and structure of extrusion die for...
cantilever aluminum profile [J]. Hot Working Technology, 2013, 42(21): 136-138.

[7] DENG Rurong, Huang Xuemei. Design of the extrusion die of semi-hollow aluminum profile [J]. Light Alloy Fabrication Technology, 2015, 43(4): 51-54.

[8] Xu Yongli, Huang Shuangjian, Pang Zugao, et al. Failure analysis of extrusion die and optimization of heat treatment process for aluminum alloy circular tube [J]. Forging & Stamping Technology, 2015, 40(2): 116-122.