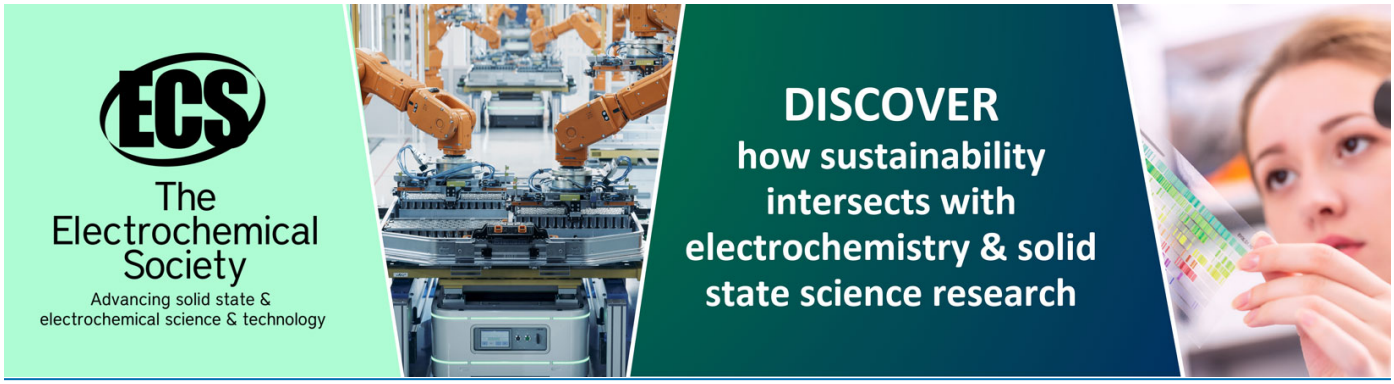
Pallet Stamping Die Design



Pallet Stamping Die Design

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Abstract - Nowadays, the level of stamping dies in the world has been greatly improved, and stamping technology has also developed greatly. Based on the analysis of the pallet parts, it is determined that the required processes are punching and blanking. The compound dying for punching and blanking was chosen for processing after the processing method was examined. Specific design process: analyze the material used for the part, calculate the required punching force, and select the required press according to the punching force, the closing height of the die, and the size of the die handle hole. The parts required by the die, such as convex and concave die, stripper plate, fixed plate, and other components, should also be designed so that the processing of the parts can be completed after the assembly is completed. In the design process, CAD drawing software, three-dimensional drawing software, etc., can be used to complete the drawing of two-dimensional and three-dimensional drawings of parts, improve the efficiency of our drawing, and can also quickly solve problems existing in the drawing, which makes the design process simpler.

1. INTRODUCTION

For existing die technology, the importance of this aspect of stamping is self-evident. A stamping die is a piece of special process equipment for processing metal or non-metallic materials into semi-finished products or parts in cold stamping [1]. At present, the development of foreign stamping technology is relatively rapid, and some fields are relatively advanced. The rapid development of the worldwide economy is inseparable from the contribution of the industrial field. The mold design of the pallet parts is a stamping die designed to aid workers in the mass production of pallet parts. This mold can improve the work efficiency of workers and speed up the production of parts. The processes required for this part include blanking and punching. To improve work efficiency, a blanking and punching composite die is selected [2]. Some researchers have combined blanking and punching processes to improve the production efficiency of parts. Combined with [1], [3], [6], and [9], these researchers use blanking and punching continuous dies and blanking and punching single-process dies to produce parts. Although the continuous die is easy to automate, it is suitable for the mass production of small and medium-sized parts that do not require high precision. The structure of the single-process mold is relatively simple,

but it is not suitable for the mass production of parts. Because the blanking and punching composite mold has the characteristics of high production efficiency and is suitable for mass production of parts, the composite mold is used in this design. After investigation, research, and communication among the research team, the feasibility of this mold design was confirmed. Using the assistance of CAD software and 3D software, draw the graphics of the mold. After some necessary calculations and the actual situation, the mold design is modified to complete the final mold design[3].

2. STAMPING PROCESS ANALYSIS AND PROCESS PLAN FORMULATION

2.1. Process Analysis

The part diagram is shown in Figure 1. From the two-dimensional CAD diagram of the part, it can be seen that the stamping process scheme and main process parameters are determined. The part is mass-produced, made of 08 steel, has a thickness of 2.00 mm, a precision of IT12, and a shear strength of 300 MPa. The processes required for the design of the workpiece this time include punching and blanking processes.

Dimensional structure analysis: this part has four 5 mm inner holes, the distance between two adjacent holes is 18 mm and 16 mm, respectively, and the part is an axisymmetric figure.

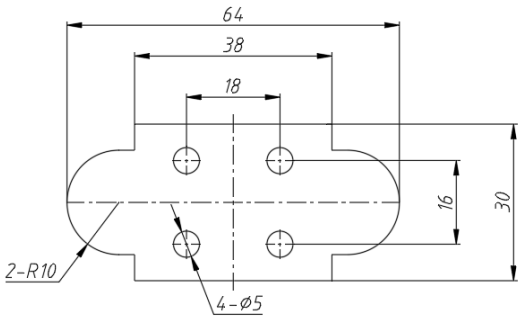

Figure 1: Part diagram

Accuracy analysis: the pallet parts have no special dimensional tolerance requirements, so the accuracy requirements are not high, and the machining accuracy of IT12 can be used.

2.2. Formulation of Process Plan

Through the analysis of the part, it is determined that the part needs two processes, namely blanking and punching. According to the analysis of the processing procedure, there are three different technological schemes to complete the processing of pallet parts [4].

Scheme one: blanking → punching continuous die;

Scheme two: punching → blanking single-process die;

Scheme three: blanking → punching compound die.

For scheme one, the continuous die is easier to automate, so its production efficiency is higher than that of the single-process die, and it is suitable for mass production of small and medium-sized parts with low precision requirements, but the production cost is high, and its structural form is complex [5].

For scheme two, the structure of a single process die is simpler, and the production cost is lower than that of a continuous die, but it is not suitable for the mass production of parts.

For scheme three, the service life of the composite die is longer than the above two dies, its production efficiency is the highest, and it is also suitable for the mass production of parts [6].

After comparative analysis, a scheme of three blankings and punching composite die was selected to produce the pallet parts.

3. CALCULATION OF THE FORCE

3.1. Calculation of punching force

According to the length of the punching edge of the pallet part and its selection of processing material thickness, shear performance, and other parameters to determine the punching force of the pallet parts stamping die, the first need to determine the various properties of the supporting plate parts of the material, the main parameters including the thickness of the material and shear strength [7].

According to formulas (1), (2), and (3), and putting all parameters into formulas (1), (2), and (3), the punching force, pushing force, and unloading force required by the stamping die can be obtained.

i) The calculation formula of punching force (kN):

$$F = KLt\tau \tag{1}$$

In the formula, $K$is the safety factor. Generally, the value is 1.3.L is the perimeter of the blanked part (mm), including the outer dimensions of the part and the perimeter of the four holes. t is the thickness of the material (mm). τ is the shear strength of the material (MPa). By substituting each parameter, we can figure out that F is 182.26 kN.

ii) The calculation formula of pushing part force (kN):

$$F_T = K_T Fn \tag{2}$$

In the formulaK_T is the safety factor of pushing force. Generally, the value is 0.05. n is the number of pieces left in the cavity of the concave die. By substituting each parameter, we can figure out that F_T is 27.34 kN.

iii) Calculation formula of unloading force (kN):

$$F_X = K_X F \tag{3}$$

In the formula, K_X is the safety factor of unloading force. Generally, the value is 0.05. By substituting each parameter, we can figure out that F_X is 9.11 kN. The total pressure F_{sum} is 218.71 kN.

3.2. Selection of Presses

Stamping equipment is also an indispensable part of stamping die processing. Whether the press is suitable or not will have a certain impact on the quality of the supporting plate parts, and even reduce the service life of the entire die [8]. Moreover, while selecting the press used for the stamping die, it is also necessary to ensure that the relevant performance parameters of the press can meet the design requirements of the stamping die.

According to formulas (1), (2), and (3), we have calculated that the punching force is 182.26 kN, the pushing force is 27.34 kN, and the unloading force is 9.11 kN. When selecting the press, we should ensure that the nominal pressure required by the press should be greater than the pressure required by the processing of the pallet parts [9]. After analyzing the parameters, such as the nominal pressure and the maximum closing height of each stamping equipment in Table 1, it was finally determined that the model J23-35 was selected.

Table 1 Press parameters

Model	J23-16	J23-25	J23-35
Nominal pressure/kN	160	250	350
Slider stroke/mm	55	65	100
Closing height adjustment/mm	45	55	60
Maximum closed height/mm	250	270	320
Slider centerline to bed distance/mm	160	200	200

Slider bottom surface size /mm	About	200	250	250
	Before & After	180	220	220
Die shank hole size/mm	Diameter	40	40	40
	Depth	60	60	60

3.3. Closed Height of Die

The closed height from the upper surface of the upper die base of the die to the lower surface of the lower die base:

The closed height of the die:

$$H = H_1 + H_2 + H_3 + H_4 + H_5 + H_6 + H_7 + H_8 + H_9 \quad (4)$$

In Formula (4), H_1 is the thickness of the upper die base(mm), H_2 is the thickness of the backing plate (mm), H_3 is the thickness of the punch fixing plate (mm), H_4 is the thickness of the unloading plate (mm), H_5 is the thickness of the concave die (mm), H_6 is the thickness of the lower die base (mm), H_7 is the thickness of the part material (mm), H_8 is the thickness of the rubber (mm), H_9 is the thickness of the convex and concave die fixing plate (mm).

Substitute the data to get H as 227 mm.

3.4. Check of Press

According to the closed height size calculated above, select the J23-35 press. The maximum die height of this press is 300 mm, and the die set adjustment is 45 mm.

Check formula:

$$H_{max} - 5mm \geq H \geq H_{min} + 10mm \quad (5)$$

According to the checking formula, it can be seen that the closing height size of the die is 227 mm, so the press meets the requirement.

3.5. Check the Total Pressure Required for Blanking

The check of press nominal force means that the nominal force of pressure must be greater than or equal to 1.3 times the total punching pressure of the die, and 1.3 times the total punching pressure of the die is a safe value.

In the previous calculation, we calculated the punching force, pushing force, and unloading force required by the stamping die [10]. It is also known that the total pressure required by the stamping die is 218.71 kN and the nominal pressure of the J23-35 press is 350.00 kN.

According to Equation 6, it can be seen that:

$$P = (1.1\sim1.3)F_{sum} \quad (6)$$

Substituting the total pressure of 218.71 *kN* into Equation 6, P is 240.58~284.32 kN.

Therefore, in the process of stamping die processing, the press was selected to meet the production requirements.

4. DIESTRUCTURE AND WORKING PROCESS

4.1. Design of Gasket Punch

For the fixing method of the four punches in the composite die design, we can design the punch fixing plate to fix the punches, so that the required punching process can be completed normally. A transition fit (H_7/m_6orH_7/n_7) can be used between the punch fixing plate and the punch, which can facilitate

disassembly and assembly. In order to strengthen the fixation of the punch and increase the relative stability of the stamping die, a stepped punch should be used[11]. With this stepped structure, it can be ensured that the punch will not be pulled out during the punching process. The punch material can be Cr12, the heat treatment hardness is 58~62 HRC.

Through the process analysis of the part, we can know that there are 4 circular holes with a diameter of 5 mm in the pallet part. Therefore, we should carry out the punching process for this pallet part. Since these four inner holes have the same shape, a standard round punch can be selected. The height of the punch can be calculated by Equation7:

$$L = H_1 + H_2 + H_3 + H_4 \tag{7}$$

In the formula, L is the height of the punch (mm); H_1 is the thickness of the punch retaining plate (mm); H_2 is the height of the concave die (mm); H_3 is the thickness of the plate (mm); H_4 is additional length (mm). Generally, the value is 0 ~ 10 (mm).

Substituting the above parameters into Equation 7, we can figure out that L is 58 mm.

According to the relevant parameters, the size of the punch can be determined, and its size is shown in Figure 2:

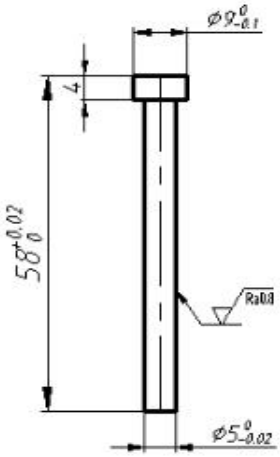

Figure 2: Punch

4.2. Design of Gasket Punch Retaining Plate

The thickness of the punch fixed plate can be calculated by Equation 8:

$$H_1 = 0.5H \tag{8}$$

We can figure out that H_1 is 20 mm.

The punch fixing plate can be made of 45 steel, with a length of 200 mm, a width of 130 mm, and a height of 20 mm. Other relevant dimensions are shown in Figure 3:

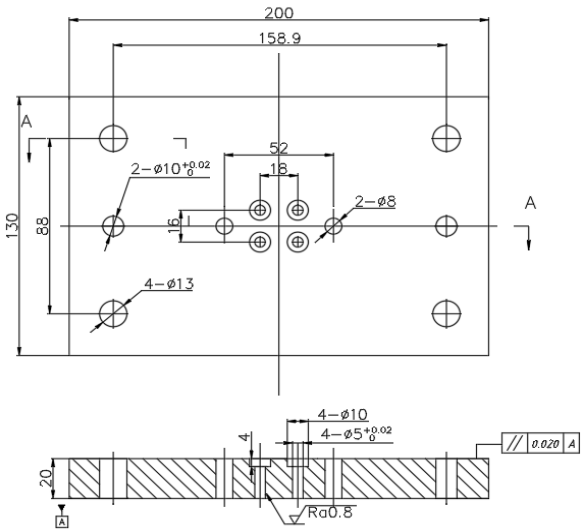

Figure 3: Punch retaining plate

4.3. The Working Process of the Die

As shown in Figure 4, The die is a blanking and punching compound die, which is mainly composed of upper and lower die bases, convex and concave dies, fixing plates, stripping plates, rubber, screws, and pins. Among them, the upper and lower mold bases use the rear guide column mold base. This mold base has good space and a wide field of vision and is suitable for small and medium-sized molds. The punching punch adopts a stepped structure to ensure that the punch cannot be pulled out during processing, and a transition fit (H_7/m_6orH_7/n_7) is used between the punch fixing plate and the punch. There are two different structural forms of the unloading device, which are: rigid unloading and elastic unloading. In this design, the elastic discharge device is selected. This time, the manual feeding method is adopted, and the strip can reach the designated position along the guide pin. The working process is that the strip enters the die along the guide pin. Under the action of the press, the die moves downward, and the push-piece is subjected to downward force. Under the action of the die, the push-piece, and the convex and concave die, the parts are formed, and then the punching process is completed under the action of punching punches and punching and concave dies. Finally, the rubber is restored to its original shape, the part is restored to its original position, and the remaining punching waste is pushed out of the convex and concave die to complete a working cycle [12].

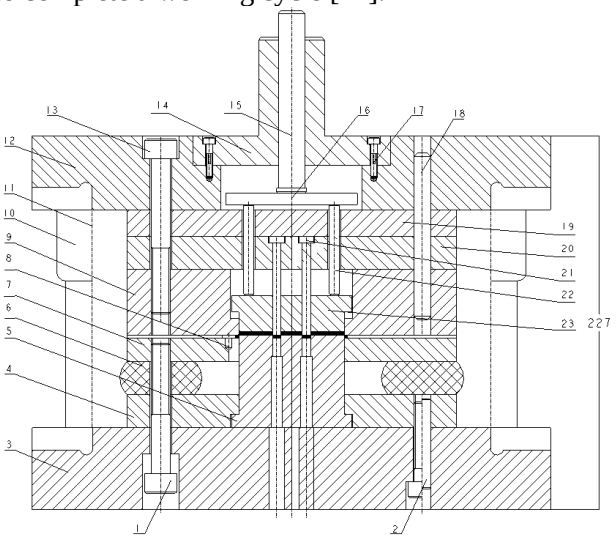

Figure 4: Assembly drawing

1. Screw; 2. Pin; 3. Lower die base; 4. Convex and Concave die fixing plate; 5. Convex and Concave die; 6. Rubber; 7. Unloading board; 8. Guide pin; 9. Concave die; 10. Guide bush; 11. Guide pillar; 12. Upper die base; 13. Screw; 14. Die handle; 15. Hit the rod; 16. Push board; 17. Screw; 18. Pin; 19. Plate; 20. Punch fixing plate; 21. Punch; 22. Push rod; 23. Push the pieced block.

5. CONCLUSION

In this paper, the stamping die for pallet parts is designed, which is a type of die processing. In this design, firstly, the process analysis of the pallet parts has been carried out. After the analysis, it is found that the parts need two processing procedures of blanking and punching. After comparing the process plans, the blanking and punching composite die is selected to process the pallet parts, which can not only complete the mass production of pallet parts but also improve production efficiency. Then, through various formula calculations, the size of the punching force, the unloading force, and the pushing force are obtained. Through the calculation of these forces and the comparison of the parameters, the press model J23-35 has been selected. After the above work was completed, various parts of the mold were designed. For the selection of the upper and lower die bases, combined with the characteristics of the parts and the model of the press, the upper and lower die bases with the rear guide column were selected. After the design of the parts used is completed, the overall design of the mold is also completed one after another. Finally, through some cutting-edge calculations, size calculations of each component, etc., the stamping die is more standardized.

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