Structure optimization design of forging hydraulic press

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Abstract: In order to improve the centring and production efficiency of punching, we can add a centring structure to improve the centring of forgings in the punching process, which is mainly used to ensure the correct position of forgings during upsetting and punching, that is, to ensure the center of forgings and the center of hydraulic press to coincide. At the same time, a swing punch structure is added to clamp the replaceable punch, which is mainly used to ensure that the center of the hydraulic press coincides with the center of the punch, and there is no need for manual or auxiliary machine in the working process of the swing punch structure, which can greatly improve the production efficiency.

1. Introduction
Free forging is a blank production method for forging single piece, small batch forging and large forging. Upsetting process is to ensure that forging with larger cross section and smaller height is obtained [1]. As the preparation procedure before punching, the main function is to increase the cross-sectional area of the blank to facilitate punching [2]. The accuracy and quality of punching directly affect the quality of forgings after rolling forming or reaming of horse bar.

2. Punching process of ring forgings

2.1. Improve the process of punching before improvement
The punching of forging is to punch the forging after upsetting with a certain diameter punch on the free forging press. In practice, for the punch with smaller diameter, manual clamping punch is generally used to punch, and for the punch with larger diameter, auxiliary machine is used to assist punching [3].

If there is a connecting skin in the punching process, the workpiece shall be flipped and then punched again to remove the structure of the connecting skin. The punching process of the forging after upsetting is shown in Fig. 1.
2.2. Technological characteristics of punching

At present, the punching process is mostly carried out on the free forging press. Generally, the punching and upsetting are carried out by the same general forging press. Compared with the special punching equipment, the cost is greatly reduced\(^4\). However, from the above process, we can see that there are some problems in the punching process, which directly affect the accuracy and production efficiency of the punch.

(1) the process of punching, it is generally necessary for auxiliary machine or manual clamping punch to punch. When the auxiliary machine is used, if the clamping punch and the workpiece are turned over using the same auxiliary machine, more time will be wasted to replace the punch and the clamping workpiece\(^5\). The use of two or more auxiliary machines will increase the production cost. According to the production practice, it takes about 2-3 minutes to finish upsetting and punching, and the production efficiency is low.

(2) After upsetting, the blank is placed on the anvil by the manipulator, and there is a certain deviation between the placement position and the center of the hydraulic press\(^6\). Whether the punch is clamped manually or assisted by the manipulator, the alignment between the position of the punch and the center of the workpiece will be poor, as shown in Figure 2. The position accuracy of punching cannot be guaranteed, which will also prolong the time of subsequent rolling forming, and have a certain impact on the shape and position accuracy of ring forgings. It is found that the maximum deviation of punching center is about 20 mm, and the punching accuracy is low.

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**Figure 1** Punching process of forging after upsetting

**Figure 2** Position of parts during punching
(3) The equipment used in the production of heavy forgings is large and the working environment is poor. The punching process needs more workers to participate in the site, the labor intensity of workers is large and the labor consumption is large, and the production cost is also increased accordingly. And people work in the environment of noise and high temperature for a long time, which seriously endangers their health.

2.3. The improved punching process of ring forging

In order to solve the problems of hole deviation, low production efficiency and high labor intensity, the hydraulic press is improved. Solve the above problems without adding other auxiliary mechanical equipment.

(1) In order to improve the position accuracy of punching, a centering structure is added to the hydraulic press, which is mainly used to ensure that the center of the forging coincides with the center of the hydraulic press after the pier is thick and before punching[7]. And to ensure the position accuracy of the workpiece center relative to the hydraulic press center when the punching operation is carried out after the workpiece is turned over. It is expected that the offset of punching after structure optimization will be controlled at about 5mm.

(2) In order to improve the production efficiency and ensure the coaxiality of the punch center and the hydraulic press center, a swing arm punching structure is added to the hydraulic press, which is installed on the column of the hydraulic press, and the size accuracy and relative position accuracy of the mechanical structure itself are used to ensure the position accuracy of the punch. It is estimated that it will take about one minute to produce a blank. The improved punching process flow chart is shown in Figure 3.

![Figure 3 Punching process of improved forging](image)

The precision and efficiency of punching can be improved by optimizing the structure of forging press. The structure optimization is suitable for various types of three beam four column free forging press.

3. Optimal structure design of forging hydraulic press

In order to improve the centring and production efficiency of punching, we can add a centring structure to improve the centring of forgings in the punching process, which is mainly used to ensure the correct position of forgings during upsetting and punching, that is, to ensure that the center of forgings coincides with the center of hydraulic press. At the same time, a swing punch structure is added to clamp the replaceable punch, which is mainly used to ensure that the center of the hydraulic press coincides with the center of the punch, and there is no need for manual or auxiliary machine in the working process of the swing punch structure, which can greatly improve the production efficiency.

3.1. Scheme design of swing punching structure

When punching, the swing punching structure is required to swing into the center of the hydraulic press to complete punching, and then swing out, so the main motion form of the structure is swing.
Based on the analysis of the basic structure of the hydraulic press with three beams and four columns, it can be seen that the structure suitable for installing the swing in and swing out device between the upper anvil and the lower anvil is four columns, so the swing punching structure is fixed on one of the columns, and the cantilever beam structure is designed. At the same time, in order to reduce the force of the cantilever beam when punching, the swing punching structure is fixed on the movable beam, and it is used up and down with the movable beam when punching. In order to reduce the overall size of the swing punching structure, the punching pressure should be borne by the movable beam with larger size structure, and the punching pressure of the swing punching structure should be minimized. The schematic diagram of swing punching structure is shown in Figure 4, and the bold part in the figure is swing punching structure.

![Figure 4 Structure diagram of swaying punch of forging press](image)

### 3.2. Alignment structure design

Because the forgings are ring forgings and the outer surface is cylindrical, a pair of V-shape structures with high positioning accuracy are selected to center the forgings. The schematic diagram of the centering structure is shown in Figure 5, and the bold part in the figure is the additional centering structure.

![Figure 5 Centering structure diagram of forging press](image)

As shown in the figure, the centering structure is placed between the front and rear columns, and the structure is fixed on the front and rear columns. The connection with the column adopts clearance fit to ensure that the centering structure can move up and down along the column. The alignment structure is arranged in pairs, which requires smooth and accurate movement. Therefore, the hydraulic transmission
mode is selected to realize the alignment operation of forgings through the expansion and contraction of piston cylinder.

4. conclusion

According to the characteristics of the ring forging of the existing free forging equipment, the process improvement scheme is put forward. Then, according to the basic technical parameters and working requirements of the forging press, the structure optimization scheme of the hydraulic press is preliminarily determined. That is to say, on the basis of the structure of the hydraulic press, the swing punching structure and centering structure are designed. The scheme is feasible and practical.

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