

Fastener Product Cold Heading Process Formulation and Precision Die Design

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Abstract

The stamping and forming process of the flat-head cross stainless-steel bolt was formulated and finite element simulation analysis was carried out, and the forming pressure required for the forming of cold heading stainless steel fasteners was obtained. On the basis of the results of the finite element analysis, two-dimensional and three-dimensional CAD aided design tools were used the double-station cold heading dies for screw punches are carried out. According to the two-dimensional general structure diagram, the overall structure of the die base is designed and determined, the design purpose of each part of the die is analyzed, and the elements such as the size and material of each part are determined. , Completed the design of the precision mold, the mold was successfully used in the enterprise, the production was good, and it created better benefits, providing a reference experience for the development of similar molds.

Keywords

Fastener; Forming Process; Precision Mold; Structure Design.

1. Introduction

Fastener products are a major category of hardware products[1-3]. Wenzhou Longwan is the largest fastener base in the country, with an annual consumption of several billion yuan. my country has become the world's largest fastener producer. Stamping dies for fastener products have harsh service conditions and harsh working environments. The dies work under high temperature, high pressure and high frequency conditions, and it is easy to fail in a short period of time. Frequent replacement of dies is required, which brings a lot of human and material costs to the enterprise. Reduced production efficiency. Cold heading (extrusion) is an important part of precision plastic volume forming technology. Cold heading (extrusion) refers to placing a metal blank into the mold cavity in a cold state, and under the action of strong pressure and a certain speed, the metal is forced out of the mold cavity to obtain the desired shape, size and characteristics. Extrusions with certain mechanical properties[4-5]. Obviously, the cold heading (extrusion) process relies on the die to control the metal flow, and the parts are formed by a large amount of metal volume transfer. Cold heading (extrusion) technology is an advanced production technology with high precision, high efficiency, high quality and low consumption, and is mostly used in the large-scale production of small and medium-sized forgings. Compared with hot forging and warm forging, it can save material by 30% to 50%, save energy by 40% to 80%, and can improve the quality of forgings and the working environment.

With the development of refined production of small and medium-sized fasteners and the popularization and application of cold extrusion and warm extrusion processes, multi-station cold heading presses, precision presses and special opportunities for design and manufacture of certain forgings have been vigorously developed[6-8].

(a). High requirements for molds. During cold heading, the blank is subjected to three-dimensional compressive stress in the mold, which increases the deformation resistance

significantly, which makes the stress on the mold much larger than that of the general stamping die. When cold heading (extrusion) steel, the stress on the mold often reaches 2000MPa ~2500MPa. For example, to manufacture a low-carbon steel cup with a diameter of 38mm, a wall thickness of 5.6mm and a height of 100mm as an example, when the drawing method is used, the maximum deformation force is only 17t, while when the cold heading method is used, the deformation force is 132t. At this time, the unit pressure acting on the cold extrusion punch is above 2300MPa. In addition to high strength, the mold also needs to have sufficient impact toughness and wear resistance. In addition, the strong plastic deformation of the metal blank in the mold will increase the mold temperature to about 250°C to 300°C. Therefore, the mold material needs a certain tempering stability. Due to the above conditions, the life of cold heading (extrusion) dies is much lower than that of stamping dies.

(b) Presses requiring large tonnage. Due to the large deformation resistance of the blank during cold heading (extrusion), a press of hundreds or even thousands of tons is required.

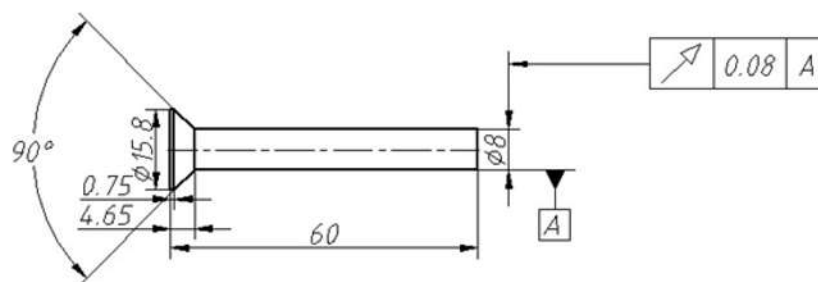
(c) Due to the high cost of cold heading (extrusion) molds, it is generally only suitable for mass-produced parts. Its suitable minimum batch is 50,000 to 100,000 pieces.

(d) The blank needs to be surface treated before extrusion. This not only increases the number of processes, takes up a larger production area, but also makes it difficult to automate production.

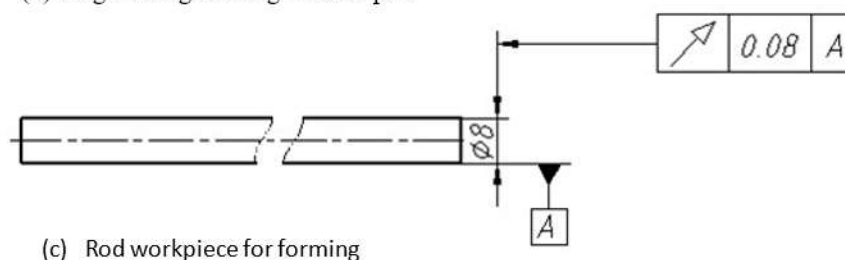
2. Product Analysis of Cross Stainless Steel Fasteners



(a) 3D Shape of Screws



(b) Engineering drawing of screw part



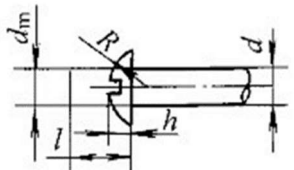
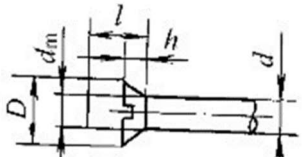
(c) Rod workpiece for forming

Fig. 1 Fastening screws product and rod blank

The product comes from the actual needs of fastener molding process and mold development of Kaisheng Mould Co., Ltd., a fastener supporting mold enterprise in Wenzhou region. . Part name: flat head Phillips screw (not rolled); production batch: large batch; material: 1Cr18Ni9Ti; blank diameter: 8mm.

According to the allowable deformation degree and the ultimate deformation degree, considering that the top upsetting will not produce defects such as cracking, bending, folding, dust inclusion, etc., the number of impacts necessary for the top upsetting forming is generally based on the free height of the unclamped part of the wire and its diameter. The ratio is determined as shown in Fig 2.

Table 1. Calculation table of blank length required for cold heading screw head

	$L = \frac{4h^2}{d_m^2} \left(R + \frac{h}{3} \right)$
	$L = \frac{h}{3d_m^2} (D^2 + Dd + d^2)$

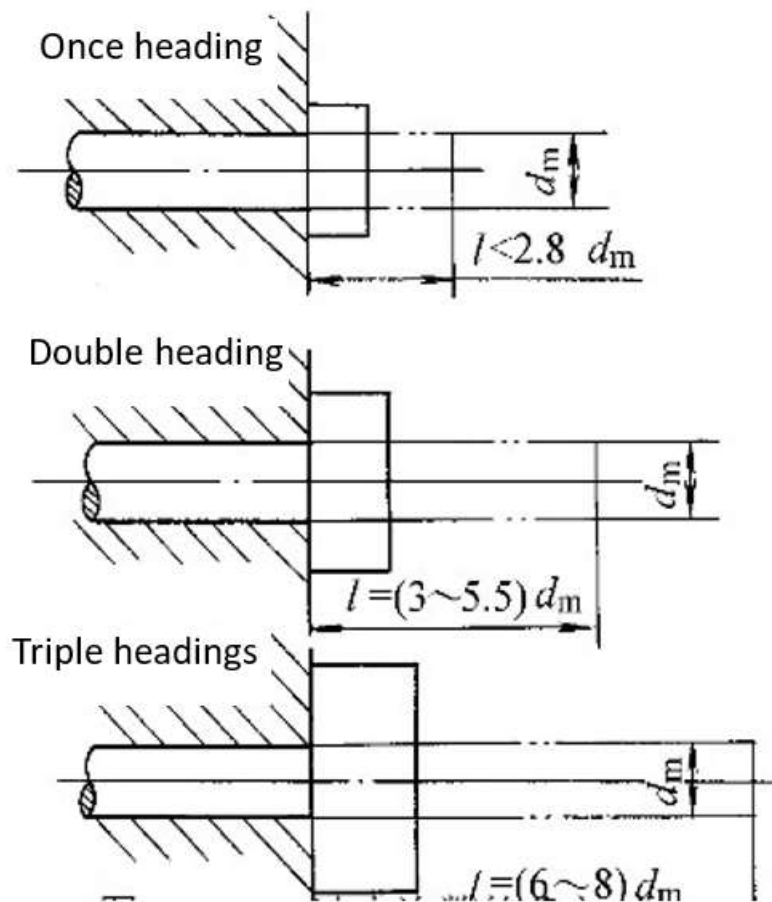


Fig. 2 The number of times of screw impact cold heading

3. Cold Heading form Simulation

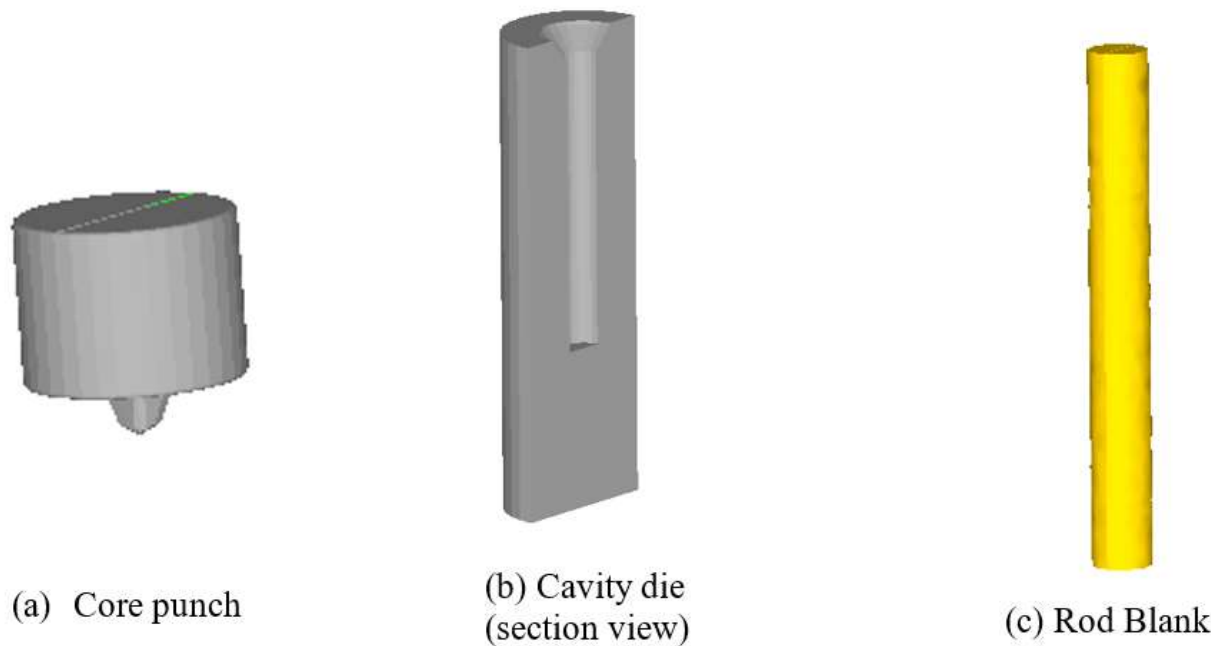


Fig. 3 Deforming simulation critical parts setup

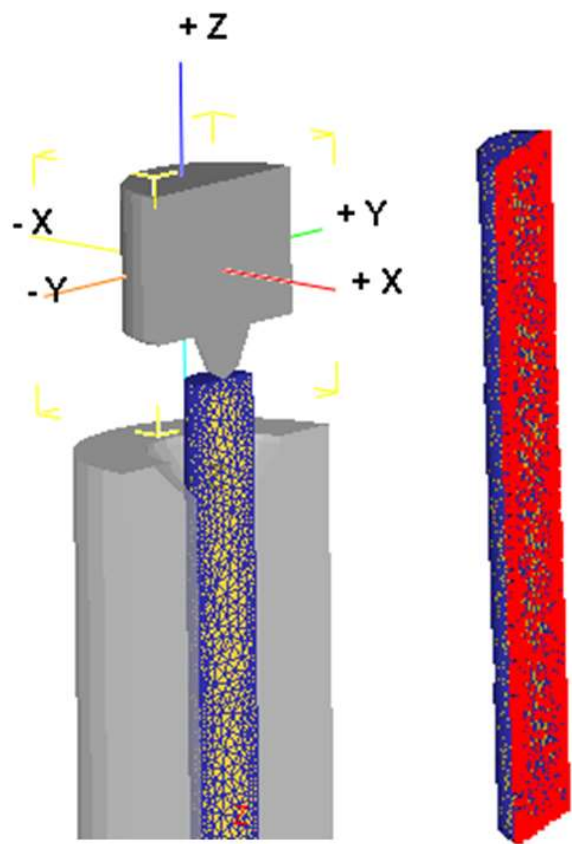


Fig. 4 Boundary conditoinis setup

Simulation key parameter analysis:

1) Punch load: According to the simulation data in Figure 20, it can be concluded that the maximum pressure on the blank is 70.1kN, which is consistent with the calculation results of the relevant literature, that is, within the error range.

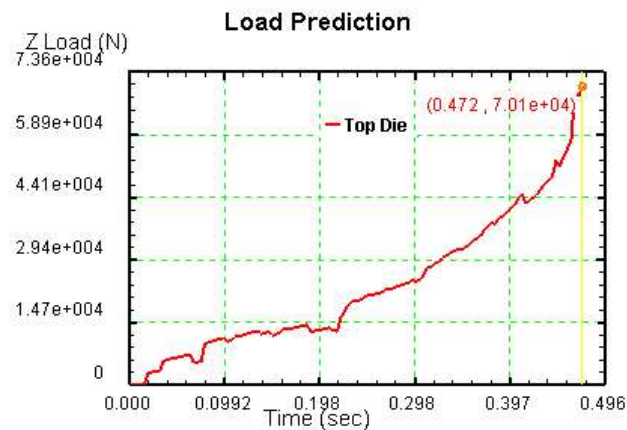


Fig. 5 Time-load relation

2) Punch displacement: According to the simulation data in Figure 21, it can be concluded that the die displacement diagram has moved a total of 12mm.

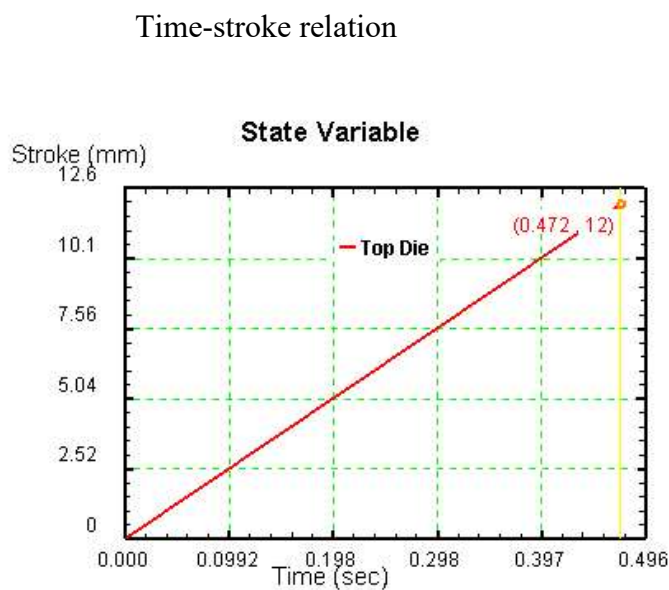


Fig. 6 Stroke-time relation

3) Equivalent stress of billet: According to the simulation data in Figure 22, it can be concluded that the maximum stress of billet is 942MPa.

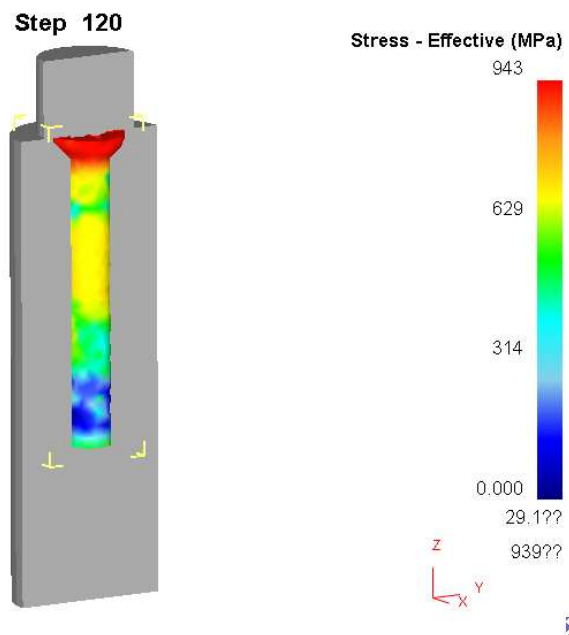


Fig. 7 Stress Effective Distribution

Forming punch and die design.

Flat head Phillips screw cold heading punch and die are specific with the detail screw dimensions, the geometry size should conform to the standard parts, which can be referenced by the the national or industrial standards.

1) Cold heading punch:

Drawing according to the national standard GB/T 4211.7-96. Its CAD two-dimensional drawing is as follows:

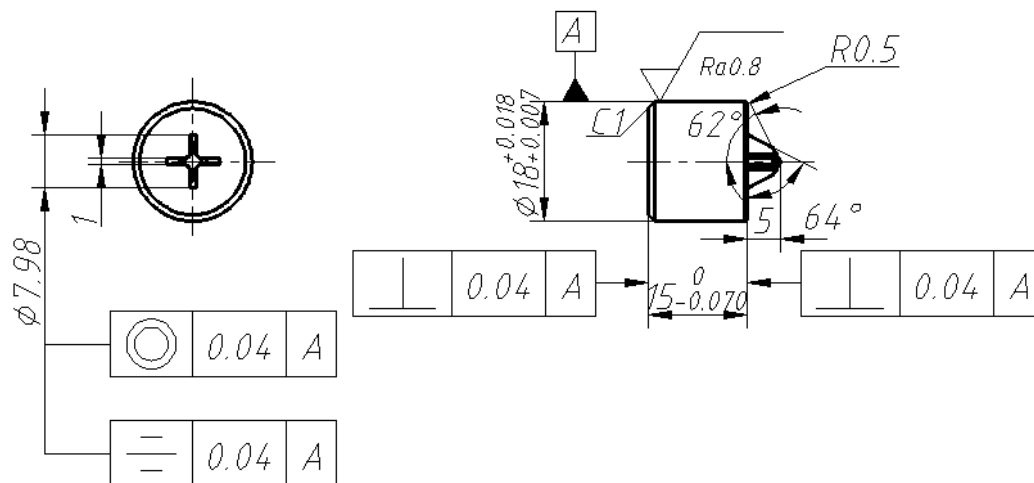


Fig. 8 Cold heading punch

2) Cold heading die:

Drawing according to the national standard GB/T 4211.10-96. Its CAD two-dimensional drawing is as follows:

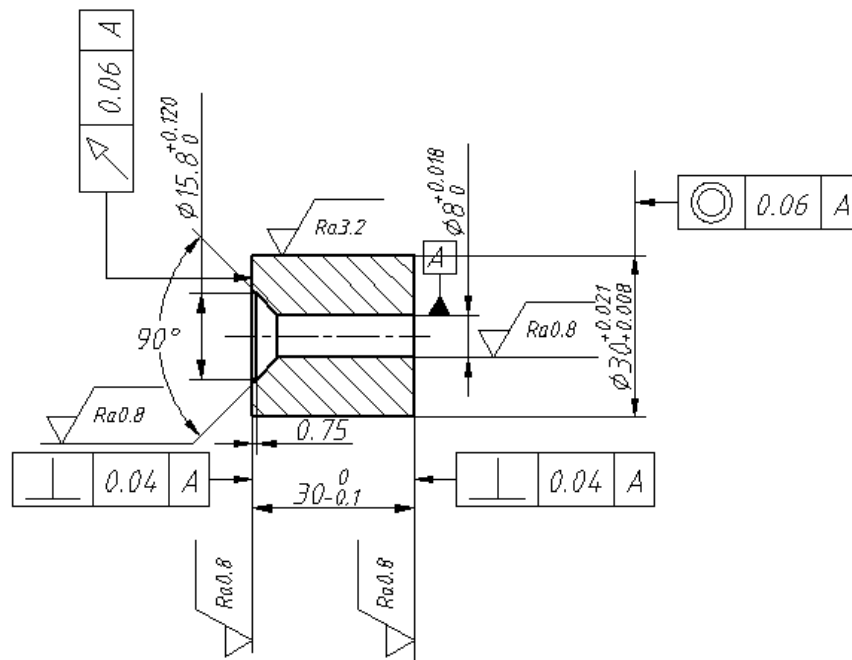


Fig. 9 Cold heading die

4. Design of Cold Heading Die

4.1. Determine the Stamping Die Operation Scheme

Option 1: Select 1Cr18Ni9Ti (ordinary stainless steel) steel wire with a blank diameter of 8mm, use a double-click cold heading machine, first cut it with a cutting die, and then use a cold heading machine for cold heading forming. Although the structure of the mold is simple in this process, at the same time, due to the use of an automatic feeding device, the operation is simple and the production efficiency is high, but the equipment is expensive. Although this part is produced in large quantities, the production cost is still high.

Option 2: Select 1Cr18Ni9Ti (ordinary stainless steel) steel wire with a blank diameter of 8mm, use a mechanical press, first cut the 66mm-long blank with a shearing die, and then cold heading on another mechanical press. Although the mold structure required by this process is relatively simple, it has many processes, inconvenient operation, and low production efficiency, so the production cost of the parts is relatively high.

Option 3: Select 1Cr18Ni9Ti (ordinary stainless steel) steel wire with a blank diameter of 8mm, use a continuous die for shearing and cold heading on a mechanical press, first cut the steel wire into a 66mm blank, and then cold heading forming. The structure is more complicated, but due to the automatic feeding device, the operation is simple, the production efficiency is high, and the production cost of the parts is low.

After the comparison and analysis of the three schemes, the third scheme is finally adopted.

4.2. Design Requirements of Cold Heading Dies

Fastener product stamping dies have harsh service conditions, harsh working environments, and dies work under high temperature, high pressure and high frequency conditions, which puts forward relatively high requirements on the structure, materials, and processing technology of the dies, so as to make them resistant to High pressure, impact resistance and friction resistance, etc., so that it can work normally under harsh working conditions, while ensuring a certain service life. Therefore, the designed cold heading mold should have the following requirements:

- 1). The mold should have sufficient rigidity and strength. Under the environment of hot and cold temperature and alternating stress, the material selected for the mold should ensure that it will not be damaged or deformed and fail. Therefore, mold parts such as upper and lower templates should be guaranteed to have sufficient thickness, and parts that work directly should be made of better materials.
- 2). The working part of the mold must have sufficient toughness and wear resistance, such as using special mold steel as the material for the upper and lower die.
- 3). The consumable parts should be disassembled and installed quickly and easily replaced. In the mass production process, the consumable parts should be guaranteed to have good interchangeability.
- 4). The convex and concave dies should have reasonable geometric shapes to avoid stress concentration, which is conducive to the plastic flow of the metal during the extrusion process, reduces the unit and pressure, and improves the bearing capacity of the die.
- 5). The mold should have a relatively accurate guiding device, so that the mold can have relatively good alignment and coaxiality during the whole process from the start of cold heading to the end of cold heading, so as to ensure that the cold heading that meets the requirements can be produced. pieces. Especially when the guide precision of the press is low and the product requires high precision, a suitable die guide device is more important.
- 6). It is necessary to ensure the safety of the operator during the production process of the mold, and try to simplify the process of installing and disassembling the mold and make it easy to operate.
- 7). On the premise of ensuring the use requirements and a certain service life, try to reduce the production cost of the mold. For example, the cost is strictly controlled in the selection of mold material, manufacturing process and machining accuracy.

Based on the above design requirements, combined with the actual situation of the specific mold, the flat head Phillips screw shearing and cold heading continuous mold base.

4.3. Overall Structure Design of Shear and Cold Heading Progressive Die

After the steel wire is sent to a certain position, the slider of the press goes down, and the wedge 6 fixed on the upper template 2 starts to contact the slider 9 and pushes the slider 9 to move to the left. The punch 25 and the cutting die 18 fixed on the guide base 15 work together to cut the steel wire. As the sliding block of the press gradually descends, the movable die 27 is kept at a position concentric with the punch 29 and does not move. When the sliding block of the press continues to descend, the punch 29 and the movable die 27 work together to perform cold heading forming on the blank. After finishing one cutting and cold heading work, the slider of the press goes up, and the slider 9 moves to the right under the action of the push-die spring 24. At the same time, as the slider of the press goes up gradually, the feeding device starts to push the steel wire upward. Feeding a certain distance, and at the same time of feeding, the workpiece that has been cold heading is ejected from the cavity of the movable die 27. The mold enters the next working cycle.

This stamping die has good guide and easy. It is easy to disassemble and replace the mold, and the mold parts are simple to manufacture, which basically meets the design requirements. The following figure is the mold assembly drawing:

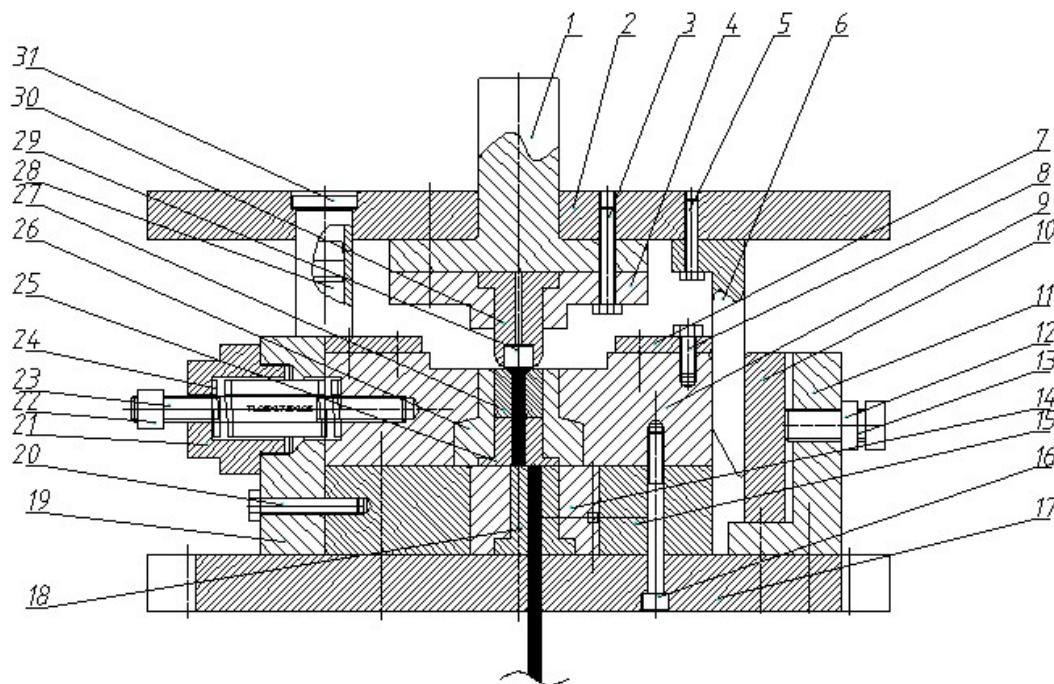


Fig. 10 Fastener forming 2-stations progressive die

01-die handle; 02-upper die seat; 03-hexagon head bolt; 04-punch fixing plate; 05-hexagon head bolt; 06- oblique wedge; 07-cover plate; 08-hexagon head bolt; 09-slider ;10-block;11-fixed block;12-hexagonal thin nut;13-hexagon head bolt;14-cut off die stress sleeve;15-guide seat;16-hexagon socket head bolt;17-lower template;18- Cut off die; 19- push plate; 20-hexagon bolt; 21- plug; 22- hexagon nut; 23- double-ended screw; 24- spring; 25- cut off punch; 26- die stress sleeve; 27- activity Die; 28-guide post; 29-punch; 30-punch stress sleeve; 31-guide sleeve.

4.4. Determination of Die Press and Closing Height

Selection of press: According to the required pressure, the spring return device of the mold needs a relatively large length and width, so the final selection of the press is J23-25. (1) The tonnage of the press should be equal to or greater than the cold heading force.(2) Select the type of press and the number of strokes according to the mold structure, and select an open double-column tilting press.

The closing height of the die: The closing height of the die refers to the distance H between the upper plane of the upper die seat and the lower plane of the lower die seat when the slider is at the bottom dead center, that is, the die is at the lowest working position. The closing height H of the die should be between the maximum die height and the minimum die height of the press. According to (3)-20, the relationship is obtained:

According to the parameters of the selected press J23-25, the final selection of the closing height of the mold is 260mm.

4.5. Verification of the Actual Production in the Collaborated Company

The mold design process is correct and the structure is reasonable, which has been highly recognized by the cooperative enterprises; at the same time, a variety of coating fixture design schemes have been proposed and optimized, and finally a reasonable scheme has been determined for physical production, and applied to the actual production. In the whole design process, students have strong independent learning ability and teamwork spirit, which not only improves the design level, but also learns engineering finite element analysis and advanced ion

coating technology, and also conducts product motion simulation, which has reached the level of technical talents. Cultivation requirements and goals.

5. Conclusion

In this paper, for the manufacture of flat head stainless steel screws, the cold heading forming process is used for design and finite element simulation analysis, and the geometric shape and mechanical parameters of the key punch and die for forming are determined. Combined with the intelligent production requirements of automatic stamping production, a 2-station progressive die set is designed, the overall structure of the die base is optimized, the shearing and forming composite die of cold heading forming is realized, and the continuous stamping forming production is realized. The die has been actually operated by the enterprise, and the effect is good. It meets the actual production needs of the industry, creates better economic and social benefits, and realizes a good industry-university cooperation relationship between enterprises in the higher vocational education service area.

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