Cam fine blanking technology and die design

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Abstract

The fine blanking technology of cam were analyzed, its blank layout was designed, the fine blanking force was calculated and stamping equipment selected, the fine blanking die clearance and rounded edge were determined. The fine blanking compound die structure were designed, the materials and heat treatment specifications of fine blanking mold work parts were selected and the gear plate structure designed. Practice shows that the process program used was reasonable, mold design proper and equipment selection reliable. By adopting fine blanking technology, not only improve product quality, but also significantly reduce the mechanical processing time. Thus the product cost would be lowered and the production efficiency increased. Fine blanking technology will have broad application prospects.

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Key words: cam; fine blanking technology; fine blanking compound die

1. Introduction

Fine blanking technology developed on the basis of ordinary blanking is an advanced technique, it can be obtained that good quality fine blanking components than conventional blanking part of small dimensional tolerances, high geometric accuracy, punching surface smooth, smooth surface and good vertical and interchangeability in a press trip. It is a high quality, high efficiency and high value-added processes[1]. The cam part is shown in figure 1(a), its material is 20 steel, thickness 5mm, dimensional accuracy and surface roughness requirements higher. Cam is one of the key components in the automation equipment. Traditional processing method was machining all shape of a cam, or punching in the ordinary
blanking and then finish turning round hole and grinding cam profile in a special fixture devices and so on. The disadvantage of these processes was low production efficiency, unstable product quality and poor consistency. To this end, the fine blanking process of cam was studied and the fine blanking compound die used in the general press based on conventional blanking process designed. Part after forming is no longer needed to grind outer surface and finish turning round hole, the dimensional accuracy and surface roughness can meet the technical requirements, production efficiency and product quality are greatly improved.

Fig. 1  (a) cam part ; (b) cam layout

### 2. Cam process design of fine blanking compound mold

2.1. Layout design[2]

Layout refers to arrangement of the work piece on the sheet, layout is closely related to part quality and economy. Therefore, when layout is made not only to consider the utilization of materials, but also consider the feasibility of achieving fine blanking process.

The boundary of layout map is an important factor influential on fine blanking part section quality, it has the right size. If its value is too large, it can help to improve the section quality of fine blanking part, but the material utilization is low. Too small, it can not play a role. The factors of influence on the size of the boundary value are mechanical properties of materials, material thickness, shape and size of parts, layout form, the way of sheet transporting or stopping and so on. For the cam part, considering the above factors and refering to relational reference, take the boundary of a=5mm, b=6mm. The cam layout is shown in figure 1(b).

2.2. Fine blanking pressure calculation and press selection[3]

Total pressure of fine blanking is the total pressure needed for completing parts fine-blanking, the main basis for the election of fine blanking presses, and also necessary data of fine blanking die design. It is included of fine blanking force, binder force and anti-stress.

2.2.1. Determination of blanking force

Fine blanking material is three-time state of stress, the deformation resistance is larger than ordinary blanking, the blanking force can be estimated according to the following empirical formula.

\[ P_f = Ltt \cdot 0.9LtR_m \]  

(1)
Where, \( L \) - circumference of fine blanking parts, including the outer perimeter \( L_1 \) and the inner \( L_2 \):
\[
L = L_1 + L_2 = 69.8 + 32.73 = 102.52 \text{mm};
\]

\( t \) - sheet thickness of fine blanking part, \( t = 5 \text{mm} \);

\( R_m \) - the tensile strength limit, 20 steel \( R_m = 500 \text{MPa} \).

Therefore, \( P_1 = 0.9LtR_m = 0.9 \times 102.52 \times 5 \times 500 = 230.67 \text{KN} \)

2.2.2. Determination of binder force

The size of binder force of the gear plate directly affects the quality of cut section. If it is too small, it is prone to tear defects; too large, the friction increases, the punch would cause damaged, which affects the life of fine blanking dies. The binder force \( P_2 \) can be calculated according to the following formula.

\[
P_2 = 4LhR_m
\]  
(2)

Where, \( L \) - the total length of the workpiece outer and inner cutting edge, \( L = 102.52 \text{mm} \);

\( h \) - ring gear tooth height, the main function of ring gear is to prevent the metal outside the shear zone flow with the punch in the process of shear, thus generating compressive stress in the shear zone. Double-ring gear tooth surface is used, refering to relational references, \( h_1 = 0.4 \text{mm} \), \( h_2 = 0.5 \text{mm} \).

\( R_m \) - the tensile strength limit, \( R_m = 500 \text{MPa} \).

Therefore, \( P_2 = 4LhR_m = 4L(h_1+h_2)R_m = 4 \times 102.52 \times (0.4+0.5) \times 500 = 184.54 \text{KN} \).

2.2.3. Determination of anti-stress

Fine blanking anti-stress is the main factor influential on part smooth. If it is smaller, it will affect the dimensional accuracy, flatness and section quality, and increases the load on the die, thereby reducing the service life of the die. More large, it can not only increase the flatness of the workpiece, but also have different degrees of improvement on the dimensional accuracy of parts, blanking angle and section quality. But too much anti-stress can cause mold damage. Under normal circumstances, it take 20\% of blanking force.

Therefore, \( P_3 = 0.2P_1 = 0.2 \times 230.67 = 46.13 \text{KN} \).

Total pressure of fine blanking \( P = P_1 + P_2 + P_3 = 230.67 + 184.54 + 46.13 = 461.31 \text{KN} \).

2.3.4 press selection

To reduce costs, the fine blanking is carried out in general presses. According to the total blanking force, JB21-63 of Two Column Fixed Bench Press Open is used.

2.3. Determination of clearance[4]

Fine blanking die clearance is one of the main parameters to ensure parts achieve the fine blanking comprehensive technical indicators. The significant difference of fine blanking and conventional blanking is that the clearance of fine blanking is very small. Size of the clearance and its uniformity along the peripheral edge are the main factors that affect the section quality of fine blanking parts and mold life. It is related to the nature of material, material thickness, the shape of workpiece and other factors. The larger for the better plastic material, the smaller for the low. refering to relational references, Blanking clearance is \( t \times 1\% = 5 \times 1\% = 0.05 \text{mm} \), punching clearance is \( t \times 0.625\% = 5 \times 0.625\% = 0.031 \text{mm} \).

3. Design of the fine blanking die structure

The fine blanking die is the main technology equipment used in precision stamping production, the quality of fine blanking parts is directly related to the quality of mold design. It has a close relationship to the quality and accuracy of fine blanking parts, fine blanking processing productivity and economic
efficiency, mold life and operational safety and so on. Therefore, must design the mold reasonably and properly.

3.1. Design of the fine blanking mold work parts

Punch, die and punch and die are work parts of fine blanking die and key pieces to ensure the quality of the fine blanking parts. Its shape and dimension accuracy directly affect the fine blanking die clearance and fine blanking parts section quality and its intensity the life of fine blanking die, they must be reasonably designed, a reasonable choice of mold material and heat treatment specifications be made. In this design, the cam dimension is not too much, its structure is relatively simple, Cr12MoV which has good hardenability, wear resistance and high strength and small quenching deformation are used in punch, die and punch and die, all vacuum harden, heat treatment of punch hardness 60 ~ 62HRC, die and punch and die hardness 62 ~ 64HRC.

3.2. Design of gear plate[5]

The most significant difference between fine blanking die and common die is that the former has a gear plate, which is a major part of high-precision and high-intensity. It is made of triangular-shaped convex ring gear revolved the blanking circle certain distance on blank holder. In the fine blanking process, the triangular-shaped convex ring gear was pre-pressed into the sheet to increase the three-dimension stress, limit the material outside the shear zone flow, in order to prevent the materials teared and make pieces smooth. Then, it is played the role of discharge after the fine blanking. Based on actual experience and searched to relevant information, when the material thickness is 5mm, the plate should be double-sided ring gear, double ring gear structure is shown in Figure 2(a). In order to increase the strength and hardness of gear plate, the material of 9SiCr is selected to use, the heat treatment hardness 58 ~ 60HRC.

![Fig. 2 (a)double ring gear plate structure; (b) cam fine blanking die structure](image)

1-die  2- gear plate

3.3. Die structure design[6]
The blanking and punching compound die is adopted to meet the structure and dimension requirements of the part. According to die locations in the mold, compound mold can be divided into right and inverted. Mold strength and production efficiency are two important factors to consider to design compound mold structure. According to the cam structure, we can see strength of punch and die enough. The inverted compound mold is adopted on the premise that the punch and die strength and part requirements is ensured in order to operate safely and conveniently and improve productivity. Cam fine blanking compound die structure is shown in figure 2(b). In order to prevent the workpiece into the waste cavity when slide return to scratch section, ensure the section quality of fine blanking parts, the pushing lagging body is designed, which consists of a hard rubber ring 9, the spherical joints 14, adjusting pads 15 and disc spring 7. When the upper mold returns, the hard-rubber ring make the mold handle bounce, disc springs is relaxed, pushing block is stock-still. The upper model continues upward, pushing block pushes parts out by playing the role of the pushing rod 11. Note that the putter travel and the depth of punch into die should be strictly controlled when this structure is used, otherwise it will damage the pushing block and disc springs.

4. Summary

The fine blanking technology of cam were analyzed, its blank layout was designed, the fine blanking force was calculated and stamping equipment selected, the fine blanking die clearance and rounded edge were determined. The fine blanking compound die structure were designed, the materials and heat treatment specifications of fine blanking mold work parts were selected and the gear plate structure designed. Practice shows that the process program used was reasonable, mold design proper and equipment selection reliable. By adopting fine blanking technology, not only improve product quality, but also significantly reduce the mechanical processing time. Thus the product cost would be lowered and the production efficiency increased. Fine blanking technology will have broad application prospects.

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