Structural Design of 209 Type Fully Open Lid Mould

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\textbf{Abstract:} In this work SolidWorks software was used to design the mold structure of model 209 all-open easy open lid. Firstly, the high-speed forming process of basic lid and finished lid in model 209 all-open easy open lid was analyzed. Then the mold design for its auxiliary engraving line and stop-slip point was carried out, and the convex and concave die of the first station was theoretically analyzed. Finally, the 3D mold structure design for the basic cover, finished cover and pull ring was carried out, and 209 type fully open type easy open cover general assembly drawing was designed. Some practical problems such as interference and position relation were solved in die design. It has certain guiding significance to the design of easy opening lid.

\textbf{Keyword:} Fully open lid; SolidWorks; Analysis of high speed forming process; Mould design.

1. \textbf{Introduction}

At present, the development of the mold industry is attached great importance by the world. High precision and polymer nanomaterials are the trend of mold industry. Molds such as easy-open lids are used for high-speed stamping, and their shape is thin-walled, so the requirements for wear resistance, impact toughness and fatigue resistance of mold materials are very high. At the same time, because of their high precision, the processing shape is more complex, and the requirements for processing equipment are also high[1]. Easy to open the lid mold can not be produced by many domestic manufacturers independently, all are relied on imports. Therefore, it is urgent to enhance their independent research and development capabilities and accelerate the production of easy-open lid molds to increase economic benefits and improve market service conditions. SolidWorks software are used to carry out the mold structure design for the 209 type full-open easy-open lid.

2. \textbf{Molding process}

209PPT that is 209 type easy-open lid, rolled and sealed can top edge outside diameter of $2 + \frac{9}{16}$ inches fully open lid. Its production process can be divided into basic lid forming and finished lid forming[2][3]. The production process of the basic lid is roughly as follows: unrolling $\rightarrow$ rolling blank forming $\rightarrow$ rolling edge $\rightarrow$ gluing $\rightarrow$ packing composition. The production process of the finished lid can be roughly divided into: basic lid $\rightarrow$ bubble $\rightarrow$ button $\rightarrow$ button whole $\rightarrow$
auxiliary engraving line and stop slip point → engraving line basic forming and strengthening beam → pull ring assembly → leveling pull ring and sharp edge treatment.

2.1. Basic lid molding process analysis
The work piece diagram of the basic lid mold studied in this paper is shown in Figure 1. Firstly, the basic lid is stamped by the basic lid forming machine, then the edge is rolled by the edge rolling machine, and finally the glue is injected by the glue filling machine. Because the forming machine cannot complete 270° rolled edge at once, so this part is completed by the rolled edge machine instead. The process of curling is completed by rotating the entire curling process in a circular arc at high speed for one week. Basic lid forming process can be divided into ten detailed process descriptions: press material forming → reverse pressure head sidewall → roll sealing plane → close the mold, pull out the aluminum → lid roll sealing plane and roll sealing plane lip → basic lid pressure head sidewall roll sealing plane and roll sealing plane lip → pressure resistant basic lid forming → basic lid lifting → basic lid leaving the mold core ring → basic lid row lid machine send away and other processes. The glue injector is to inject sealant into the groove of the rolled edge of the basic lid to ensure a more effective sealing.

![Figure 1. Basic lid parts drawing.](image1.png)

2.2. Finished lid molding process analysis
The finished lid is completed with the pressing of the pull ring and the opening engraving. The assembly of the pull ring is assembled by rivets, and the forming of the rivets is its main process. Because the rivet deformation is too large when forming, it must be formed several times to ensure that the rivet does not break at the rivet and the forming is complete. For better molding, the molding process of the finished lid is therefore adjusted from the traditional molding process, as shown in Figure 2.

![Figure 2. Finished lid process drawing.](image2.png)
3. Mold Design

3.1. Basic lid molding mold design
The upper die and lower die are the most important parts in the design of the basic lid mold for easy-to-open lids\[4\]. The upper die consists of the upper die holder, the upper die core, the upper press ring and the upper knife. In the design of the mold structure, the upper mold base, upper mold core, upper compression ring and upper knife should be drawn out first. Lower die consists of lower die holder, lower die core holder, lower die core, lower compression ring and lower knife. The basic easy-open can cap assembly part is shown in Figure 3. This is the mold part, the mold is fixed on the high-speed back and forth movement of the press die base, when the need for which lid type only need to replace the whole set of mold can. The relative inching of the smaller modules is adjusted by the PLC for air pressure.

![Figure 3. Basic lid forming mold assembly drawing.](image)

3.2. Design of forming mold for finished lid
Among them, the technical indicators of the easy-open lid refer to table 1:

The pull ring material is 5182-H19 and the thickness is 0.473mm. The rest are the same as the basic lid, they have good plasticity and surface quality, the thickness tolerance of the sheet meets the standard requirements, and meets the material requirements of the stamping process.

3.2.1. Auxiliary scribe line and slip point mold design. At present, the easy-open lids on the market are all single-marked lines. With the improvement of people's consumption level, the easy-open lids are more widely used, and the consumers are not only young people, but more and more old people and children are using them. In this way, the requirements for easy opening of the lid are getting higher and higher.

In this paper, the easy-open lid adopts auxiliary engraving line, as shown in the figure 4. When the main engraving line is opened, the deformation of the auxiliary engraving line changes the direction of the force pulling the main engraving line, so that the pulling force becomes the vertical tearing force at the opening, and the material of the engraving line is reduced, which is easy to be broken. Reduce the initial opening force. The full opening force during the entire opening is reduced.

**Table 1.** Technical specifications of easy-open lid.

| Outside diameter of rolled edge (mm) | Rolled edge height (mm) | Can lid depth (mm) | Insertion depth of ring (mm) | Roll edge opening (mm) | Adhesive weight (mg) | 2 inch lid number (Pcs) | Conductivity value (mA) | water content (<14%) |
|----------------------------------|------------------------|------------------|-----------------------------|-----------------------|---------------------|------------------------|-------------------------|----------------------|
| 64.67~64.87                     | 1.90~2.10              | 4.75~4.85        | 1.10~1.30                   | >2.75                 | 40~50               | 25~26                  | Max<4, Avg<1            | <14%                 |
3.2.2. Mold assembly design. In order to improve production efficiency, the same machine will design multiple production lines. In this way, several times the number of easy-open lids can be produced in one molding to improve production efficiency. The following are the first four stations of the finished lid mold: blistering, buttoning, buttoning, auxiliary scoring and anti-slip points and the last four stations: scoring line, reinforcement beam, pull ring assembly, edge trimming, pull ring pressing and trimming upper and lower die assembly drawings and general assembly drawings for burrs and sharp edges are shown in Figure 5.

![Mold assembly drawings](image)

**Figure 5.** 1-4 station mold assembly drawing.

3.2.3. The Design of the Concave and Concave Die in the First Station. Refer to the 209 fully open lid parameter table [5] to know the required rivet diameter $d > 4.06mm$. Because the process of foaming is equivalent to the deep drawing of hemispherical parts, the drawing coefficient has nothing to do with the diameter of the part and is a constant. Its value is:

$$m = d/D = d/\sqrt{2}d = 0.71$$  \hspace{1cm} (1)
We study the process of foaming as the deep drawing of hemispherical parts, and tentatively set the drawing diameter as $0.8mm$. The unilateral gap between punch and die during deep drawing is generally taken as $Z = (1 \sim 1.1)t$. Here we take:

$$Z = t = 0.278mm$$

(2)

According to the literature [6], the manufacturing tolerance of punch and die is:

$$\delta_{\text{Concave}} = 0.015$$

(3)

$$\delta_{\text{Convex}} = 0.010$$

(4)

Calculate the diameter of the drawing punch as:

$$D_{\text{Convex}} = (D - 0.75\Delta - 2Z)^{\delta_{\text{Concave}}} = (8.0 - 0.75\times0.10 - 2\times0.278)^{0.015} = 7.369^{0.015}mm$$

(5)

The diameter of the deep drawing die is:

$$D_{\text{Concave}} = (D - 0.75\Delta)^{\delta_{\text{Convex}}} = (8.0 - 0.75\times0.10)^{0.010} = 7.925^{0.015}mm$$

(6)

3.3. Forming Die Design of Pull Ring

The forming of the pull ring is designed to be completed by selecting the progressive die and multi-process. The double-sided carrier is used in the layout. The arc space between the two adjacent products is used as the arrangement position of the guide pin, and the lap is arranged at the pressure point position of the pull ring. Pull ring forming consists of two parts: punching and metal deformation. Among them, metal deformation is the most critical, and its process and mold directly affect the forming quality and performance of the ring pull. In this paper, the design of the ring-pulling die adopts 209 ring-pulling die, and the drawn solid model is shown in Figure 6. (This drawing is provided by the engineer of Fujian Dingli Metal Products Co.)

4. Plastic forming verification

The 209 type full-open cover die designed in this paper has been stamped on an 80 t high-speed punching machine. The automatic superimposed plastic forming device and stamping work are in normal condition, and the working condition is good. The average number of strokes is 250 times per minute, and the sharpening life is more than 1.2 million times. The punched full-open cover has been inspected to meet the technical and dimensional requirements of the product drawings. The actual product is shown in Figure 7.

![Figure 6. Pull ring die assembly drawing.](image1)

![Figure 7. Real product.](image2)

5. Conclusions

SolidWorks software is used to carry out the mold structure design for the 209 type full opening lid in this paper. A series of designs were made for the mold by analyzing the molding process, auxiliary engraving and stop-slip points, and convex and concave dies for the basic cap, finished cap and pull ring of the easy-open cap. The 209 type fully open cover mold designed in this paper, compared with the original single-process punching and pressing using ordinary molds, greatly improves production efficiency, reduces labor intensity, meets the needs of mass production, and produces environmentally friendly covers with beautiful shapes and improved product performance.
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