Analysis and design of injection mold structure for car door handle frame

Wen Genbao[1], Fang Xin[1], Xiong Lijun[2]

(1. China Aviation Industry Aerospace Life-saving Equipment Co. LTD., Xiangyang 441007, Hubei, China;
2. Hubei Hangyu Precision Technology Co. LTD., Xiangyang 441007, Hubei, China)

Abstract: This article conducts a feasibility analysis of the form elements of the handle skeleton, identifying the lateral grooves, lateral bosses, and arcuate high barriers present on its form. It also clarifies the elements such as grooves, holes, and cylinders that meet the requirements for mass production and appearance.For the lateral grooves, bosses,and the molding surfaces on both sides of the handle skeleton's parting surface I-I, as well as the arcuate high barriers at the front end, an oblique guide pin slider core-pulling mechanism is adopted. For other holes and grooves parallel to the mold opening and closing direction, an insert structure is used, and the mold opening and closing motion is utilized to complete the forming and core-pulling process. As long as the manufacturing accuracy of the joint surface between the injection mold parting surfaces I-I meets the standards, no mold structure marks will be left. The ejector pins are set at both ends of the handle skeleton, so after molding, any visible and hand-contactable parts will not show any mold structure marks. The mold adopts a one-shot two-cavity structure. The implementation of these measures not only ensures the smooth progress of the injection mold parting, core-pulling, and demolding movements but also guarantees that the shape and dimensions of the handle skeleton meet the drawing and appearance requirements.

Key words: form analysis; lateral groove; boss; arcuate high obstacle; appearance

Classification number: TQ320.6 **Article number:** 1009-797X(2026)04-0013-06

Document code: B **DOI:**10.13520/j.cnki.rpte.2026.04.004

The door handle of a car consists of large and small handle covers, a handle frame, etc. A car has four doors, each with a door handle. The handle frame is the most critical component of the door handle. It is worth noting that the curved surface and two sides of the handle frame's back must not have any traces of mold structure, nor should there be burrs or fins. The presence of mold structure marks not only affects aesthetics but also causes a painful sensation when grasping the door handle with the hand during opening. Therefore, in the structural design of the injection mold for the handle frame, in addition to ensuring that its shape and dimensions meet the drawing requirements, it is also necessary to ensure the appearance requirements of the curved surface and two sides of its back.

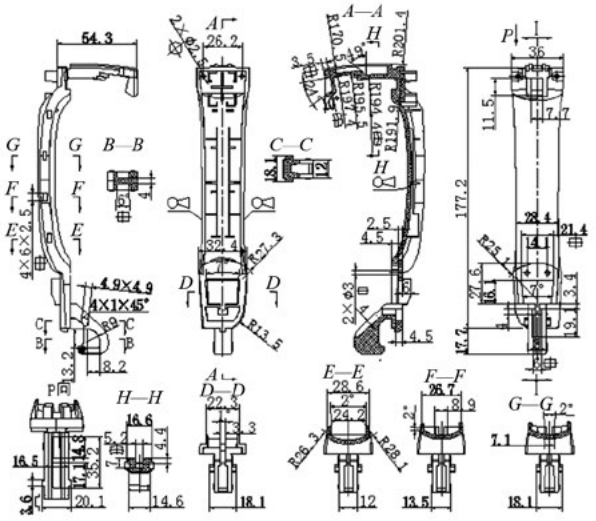
1 Analysis of the physical elements of the handle frame

The 2D drawing and parting surface I-I of the handle skeleton are shown in Figure 1(a). The 3D model of the handle skeleton is shown in Figure 1(b). The material is 30% glass fiber reinforced polyamide 6 (black) QYSS08—92, with a shrinkage rate of 1.5% to 2.5%.

The shape of both sides of the parting surface I-I of the handle skeleton is basically symmetrical left and right, with 4×6 mm×2.5 mm×(28.6—26.7)/2 mm×2° and 13.2 mm×8.2 mm×R9 mm×(12—4)/2 mm×6° lateral groove elements on

Biography: Wen Genbao (1946-), senior engineer, who is primarily engaged in research on mold design and manufacturing.

each side; 4.9 mm×4.9 mm×4×1 mm×45°×(18.1−12)/2 mm and 3.6 mm×(20.1−16.5)/2 mm lateral boss elements; the front end has a 5.2 mm×7 mm×17.1 mm×R194.4 mm×4.4 mm×14.8 mm×R197.4 mm arcuate high barrier lateral groove element; the lower end has a 28.4 mm×27.6 mm×16.1 mm×7°×3 mm×3.4 mm×6 mm×19.1 mm groove element; the upper end has 3.5 mm×24°×11.5 mm×7.7 mm and 2×Φ2.5 mm×26.2 mm parallel mold-opening and -closing direction hole elements. The lower end has 2×Φ3 mm×4.5 mm×14.1 mm mold-opening and -closing direction cylindrical elements and numerous reinforcing ribs. The handle skeleton is a part of the car door handle, and cars themselves are produced in large batches, plus each car has 4 doors, so it belongs to a very large batch product. In order to make the handle skeleton beautiful and non-prickly, it is required that the forms visible to the eyes and touchable by the hands should meet certain appearance requirements.



Note: —denotes a slot element; —denotes a hole element; —denotes a cylindrical body; —denotes a boss "obstacle"; —denotes an arcuate high obstacle lateral slot element; —indicates that the surface of the injection molded part should meet "appearance" requirements.

(a) Feasibility analysis of the form elements of the handle skeleton

(b) 3D modeling of the handle frame

Figure 1 Feasibility analysis of the form elements of the handle skeleton

2 Analysis of feasible structural schemes for injection molding of handle skeletons

Based on the feasibility analysis of the form elements of the handle skeleton, there are lateral slot elements, lateral boss elements, and arcuate high barrier elements on the handle skeleton. There are slot, hole, and cylindrical elements, as well as numerous reinforcing ribs. It also requires high volume and appearance requirements. The injection mold structure scheme should adopt mold structure measures corresponding to the form elements of the handle skeleton.

2.1 Feasibility analysis of the handle frame structure scheme

For the lateral slot elements and the mold surfaces on both sides of parting line I-I, an oblique guide pin and slider core-pulling mechanism should be employed. Given that the mold surfaces on both sides of the handle frame are nearly 200 mm long, to enhance the strength and rigidity of the oblique guide pins, two oblique guide pins are required on each side. The core-pulling distance on both sides should exceed 36 mm, and the unilateral core distance should be greater than 18 mm. Therefore, the injection mold can adopt a left and right oblique guide pin and slider core-pulling structure. At the front end, there is an arcuate high obstacle lateral slot element, which cannot adopt an insert like a straight slot in the direction of parallel mold opening and closing. Instead, the mold opening and closing motion is utilized for slot formation and core-pulling. For such arcuate high obstacle lateral slots, an oblique guide pin and slider core-pulling mechanism must be employed. For other mold holes and slots in the direction of mold opening and closing, an insert structure can be used. For cylindrical elements and numerous reinforcing ribs, it is sufficient to machine corresponding slots on the fixed and movable mold surfaces. Considering the large batch requirements for the handle frame, the symmetry of the injection mold structure, and the reduction of the length of the runner, the mold needs to be designed as a two-cavity structure for the first mock examination.

2.2 Feasibility analysis of the optimal optimization scheme for the handle frame structure

There are two forms of injection mold structure schemes based on the handle skeleton parting surface I-I. One is the scheme with the parting surface I-I as the left and right core-pulling surface, and the other is the scheme with the parting

surface I-I as the fixed and movable mold parting surface. The first scheme requires the design of left, right, and front mold core-pulling structures. As long as the manufacturing accuracy of the injection mold parting surface I-I joint surface is in place, no marks will be produced. The ejector pins are set at both ends of the handle skeleton, so that after molding, the visible and hand-contactable parts will not show any mold structure marks. For the second scheme of forming the handle skeleton, the mold cavities of the injection molds at the left and right ends of the handle skeleton are designed as fixed and movable mold cores, which can be used to form and open the handle skeleton through the opening and closing of the fixed and movable molds. The original upper and lower direction mold slots and the front arcuate high-obstacle lateral mold slots require the use of core-pulling mechanisms. The demolding must be designed for the left or right side, which will inevitably produce ejector pin demolding marks, affecting the appearance of the handle skeleton. Therefore, the first mold structure scheme should be selected as the optimal optimization scheme for the handle skeleton structure.

Based on the above analysis, the single-cavity injection mold structure features three oblique guide pillar slider core-pulling mechanisms, with dual guide pillars employed for both left and right core-pulling. Conversely, the dual-cavity injection mold structure should incorporate six oblique guide pillar slider core-pulling mechanisms.

3 Design of the left and right oblique guide pillar slider core-pulling mechanism for the injection mold of the handle frame

Based on the analysis of the injection mold structure scheme for the handle skeleton, the lateral slot elements and the molding surfaces on both sides of the parting surface I-I of the handle skeleton should adopt an oblique guide pillar slider core-pulling mechanism.

3.1 Closed mold state of handle frame injection mold

As shown in Figure 2(a), when the fixed mold and the movable mold are closed, the left oblique guide pin 7 and the right oblique guide pin are inserted into the oblique holes of the left slider core and the right slider core, respectively. By pushing the left slider core and the right slider core, the limit pin compresses the spring and enters the hole, achieving the reset of the left slider core and the right slider core. Once the plastic melt enters the injection mold cavity and cools down, the handle skeleton 14 can be molded. At this time, the oblique surfaces on both ends of the fixed mold plate 12 wedge the oblique surfaces of the left slider core and the right slider core, preventing the left slider core and the right slider core from retracting under the action of large injection force and holding pressure. This can prevent the parting surface of the handle skeleton from failing to close, resulting in leakage of plastic melt.

3.2 Opening and core-pulling state of the handle frame injection mold

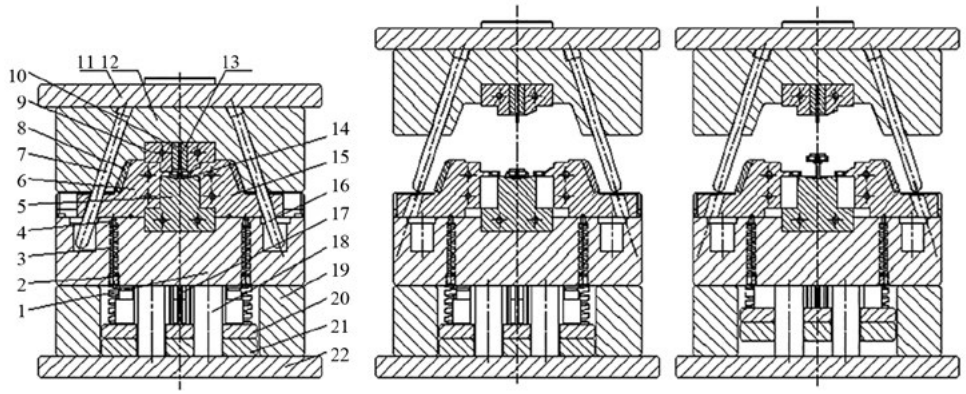
As shown in Figure 2(b), after the fixed and movable molds are opened, the left and right oblique guide pillars 7 and 8 respectively drive the left and right slider cores, enabling the core-pulling movement of the left and right slider cores. When the hemispherical pits on the bottom surfaces of the left and right slider cores move to the position of the limit pins, under the action of the spring, the limit pins enter the hemispherical pits and lock the left and right slider cores respectively. This prevents the left and right slider cores from escaping from the T-slot of the movable mold plate 1 due to the inertia of movement. At the same time, it also ensures that the oblique holes of the left and right slider cores align with the positions of the left and right oblique guide pillars. When the fixed and movable molds are closed, it ensures that the left and right oblique guide pillars are accurately inserted into the oblique holes of the left and right slider cores. The opening of the fixed and movable molds and the core-pulling of the left and right slider cores facilitate the demolding of the handle skeleton.

3.3 Demolding state of injection mold for handle frame

As shown in Figure 2(c), when the ejector pin of the injection machine pushes the push plate 21, mounting plate 20, and ejector pin 17, the demolding mechanism can move in parallel along the guide of the push plate guide post 18 to protect the ejector pin, thereby facilitating the demolding of the handle skeleton.

Through the core-pulling and resetting movements of the left and right oblique guide pillar slider core-pulling mechanism, it is possible to ensure the forming and core-

pulling movements of the left and right lateral shapes of the handle skeleton after mold clamping, eliminating the influence of the left and right physical elements of the handle skeleton on its demolding.



(a) Closed state of the handle frame injection mold (b) Opening and core-pulling state of the handle frame injection mold (c) Demolding state of the handle frame injection mold

1—Moving template; 2—Plug screw; 3—Spring; 4—Limit pin; 5—Moving mold core; 6—Left slider core; 7—Left oblique guide pillar; 8—Left and right spacers; 9—Fixed mold core; 10—Fixed mold insert; 11—Fixed mold base plate; 12—Fixed template; 13—Round hole core; 14—Handle skeleton; 15—Right slider core; 16—Right oblique guide pillar; 17—Top rod; 18—Push plate guide pillar; 19—Mold foot; 20—Installation plate; 21—Push plate; 22—Base plate

Figure 2 Design of the core-pulling mechanism with left and right oblique guide pillar sliders for the injection mold of the handle frame

4 Design of front and rear core-pulling mechanisms for injection molds of handle skeletons

Based on the analysis of the injection mold structure for the handle frame, there exists a lateral mold slot element with an arcuate high obstacle at the front end. This arcuate high obstacle lateral mold slot requires the use of an oblique guide pillar slider core-pulling mechanism to eliminate its impact on the demolding of the handle frame.

4.1 Closed mold state of injection mold for handle frame

As shown in Figure 3(a), when the fixed and moving molds are closed, the front and rear oblique guide pillars 9 are inserted into the oblique holes of the front and rear slider cores 6, and the front and rear slider cores are pushed to force the limit pin 5 to compress the spring 3 and exit the hole, thus achieving the reset of the front and rear slider cores. Once the plastic melt enters the injection mold cavity and cools down, the handle skeleton 12 can be molded. At this time, the oblique surfaces on both ends of the fixed mold plate 10 wedge the oblique surfaces of the front and rear slider cores, preventing the front and rear slider cores from retracting under the large injection force and holding pressure, which could lead to the depth of the lateral groove of the arcuate high barrier body failing to meet the drawing requirements.

4.2 Opening and core-pulling state of the handle frame injection mold

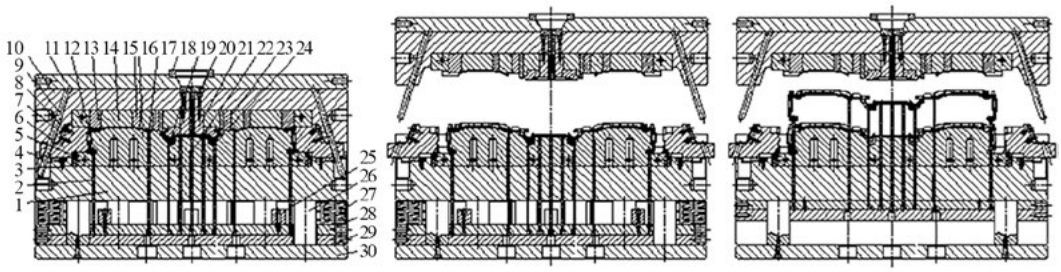
As shown in Figure 3(b), after the fixed and movable molds are opened, the front and rear slide cores can achieve core-pulling movement by being actuated by the front and rear inclined guide posts. When the hemispherical pits on the bottom surfaces of the front and rear slide cores move to the position of the limit pins, the limit pins enter the hemispherical pits under the action of the spring, locking the front and rear slide cores. This prevents the front and rear slide cores from escaping from the T-slot of the movable mold plate 1 due to the inertia of movement. At the same time, it also ensures that the inclined holes of the front and rear slide cores align with the positions of the front and rear inclined guide posts. When the fixed and movable molds are closed, it ensures that the front and rear inclined guide posts are accurately inserted into the inclined holes of the front and rear slide cores. The opening of the fixed and movable molds and the core-pulling of the front and rear slide cores are beneficial to the demolding of the handle skeleton.

4.3 Demolding state of handle frame injection mold

As shown in Figure 3(c), when the ejector pin of the

injection machine pushes the push plate 29, mounting plate 28, and ejector pins 2, 17, and 19, the demolding mechanism can guide and protect the ejector pins 2, 17, and 19 in parallel movement along the push plate guide post 26, thereby facilitating the demolding of the handle skeleton.

Through the core-pulling and resetting movements of the front and rear oblique guide pillar slider core-pulling mechanism, the core-pulling movement of the side-type groove core of the front and rear arcuate high-obstacle body of the molded handle skeleton can be ensured, thereby eliminating the impact of the side-type groove core of the front and rear arcuate high-obstacle body of the handle skeleton on its demolding.



(a)Injection mold closed state of handle frame (b)Injection mold opening and core-pulling state of handle frame

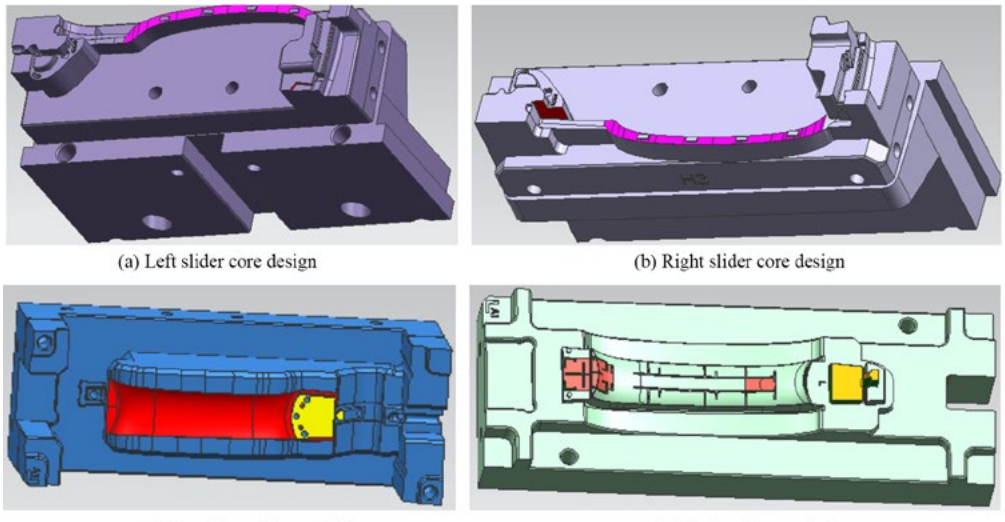
(c)Demolding state of injection mold for handle frame

1—Moving mold plate; 2, 17, 19—Ejector pins; 3, 27—Springs; 4, 7—Washers; 5—Limit pin; 6—Front and rear slide cores; 8—Countersunk head screws; 9—Front and rear inclined guide pillars; 10—Fixed mold plate; 11—Fixed mold washer; 12—Handle frame; 13, 15, 21, 23, 24—Fixed mold inserts; 14—Fixed mold core; 16—Moving mold core; 18—Locating ring; 20—Sprue bushing; 22—Pull rod; 25—Limit block; 26—Push plate guide pillar; 28—Mounting plate; 29—Push plate; 30—Base plate

Figure 3 Design of the front and rear oblique guide pillar slider core-pulling mechanism for the handle frame injection mold

5 The design of the left and right slide cores, the movable mold core, and the fixed mold core of the handle frame injection mold

The working parts of the injection mold for the shaped handle skeleton mainly include the left and right slider cores, the moving mold core, and the fixed mold core, as shown in Figure 4. The dimensions of the working surfaces of the working parts should be the corresponding drawing dimensions plus the drawing dimensions multiplied by the shrinkage rate of 2%. The surfaces parallel to the demolding direction should all have a demolding slope of 1°30′ and a roughness of Ra0.8



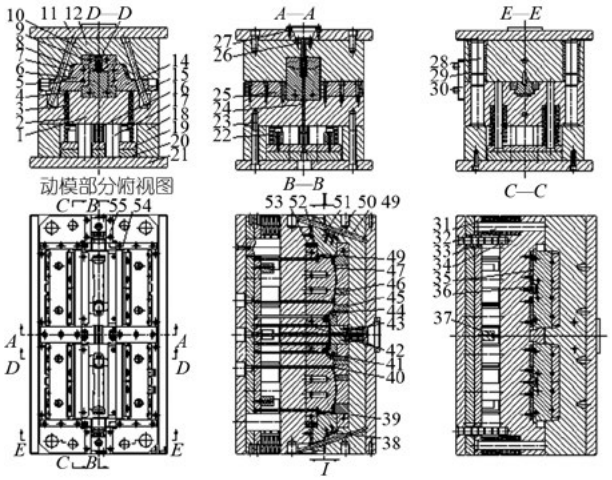
(a) Left slider core design (b) Right slider core design

(c) Movable mold core design (d) Fixed mold core design

Figure 4 Molding of left and right slider cores, moving mold core, and fixed mold core of the handle skeleton injection mold

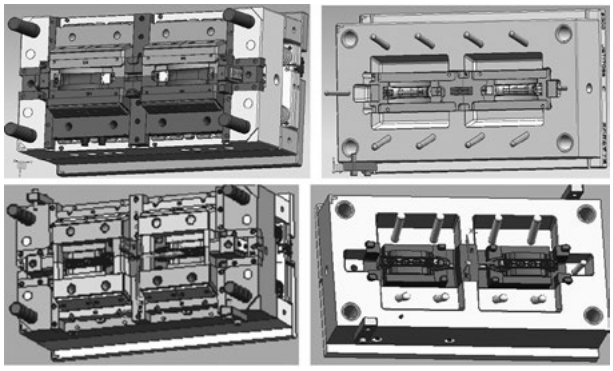
6 Design of injection mold structure for handle frame

As shown in Figure 5, the injection mold for the handle frame consists of a fixed mold, a movable mold part, a core-pulling mechanism, a demolding mechanism, a return mechanism, a mold frame, a gating system, a cooling system, and guiding components.



(a) 2D drawing design of injection mold structure for handle frame

1–Moving template; 2–Screw plug; 3, 31, 53–Spring; 4, 52–Limit pin; 5–Moving mold core; 6–Left slider core; 7–Left oblique guide pillar; 8–Left gasket; 9–Fixed mold core; 10–Fixed mold insert; 11–Fixed mold base plate; 12–Fixed template; 13–Round hole core; 14–Right slider core; 15–Right oblique guide pillar; 16, 39, 40, 41–Top rod; 17–Push plate guide pillar; 18 –Mold foot; 19–Installation plate; 20–Push plate; 21–Base plate; 22, 37– Limit block; 23–Hexagonal socket screw; 24, 42–Pull rod; 25–Middle slider pressing strip; 26–Sprue bushing; 27–Locating ring; 28–Guide sleeve; 29–Guide pillar; 30–Locating plate; 32–Return rod; 33–Push plate guide sleeve; 34–Push plate guide pillar; 35–Left and right slider gasket; 36–Guide strip; 38–Rear gasket; 43–Locating sleeve; 44, 45, 46, 48–Fixed mold insert; 47–Handle frame; 49–Front and rear oblique guide pillars; 50–Front and rear gasket; 51–Front and rear slider core; 54–Front and rear slider pressing strip; 55–Left and right slider pressing strip



(b) 3D modeling of the injection mold structure for the handle frame

Figure 5 Design of injection mold structure for handle frame

6.1 Formwork

The mold base consists of the moving platen 1, the fixed platen pad 11, the fixed platen 12, the mold feet 18, the mounting plate 19, the ejector plate 20, the bottom plate 21, the hexagonal socket screws 23, the sprue bushing 26, the locating ring 27, the guide sleeve 28, the guide pillar 29, the spring 31, and the return rod 32. The mold base serves as the installation platform for the entire mold.

6.2 Fixed mold part

It consists of the left oblique guide post 7, the fixed mold core 9, the fixed mold insert 10, the fixed mold base plate, the fixed mold plate, the right oblique guide post 15, the sprue bushing, the locating ring, the guide sleeve, the guide post, the locating sleeve 43, the fixed mold inserts 44, 45, 46, 48, and the front and rear oblique guide posts 49.

6.3 Dynamic simulation part

It consists of a moving template 1, a moving mold core 5, a left slider core 6, a right slider core 14, front and rear slider cores 51, limit pins 4 and 52, springs 3, 31, and 53, a screw plug 2, mold feet 18, an installation plate 19, a push plate, a push plate guide sleeve 33, a push plate guide post 34, guide posts, hexagon socket screws, a return rod 32, ejector rods 16, 39, 40, and 41, pull rods 24 and 42, a base plate, front and rear slider pressing strips 54, and left and right slider pressing strips 55.

6.4 Demolding and condensation material removal mechanism of the pouring system

The demolding mechanism consists of the mounting plate, the ejector plate, the ejector plate guide post, and the ejector pins 16, 39, 40, and 41. The condensed material removal mechanism of the de-pouring system consists of the mounting plate, the ejector plate, the ejector plate guide post, and the pull rods 24 and 42.

6.5 Return mechanism

Consisting of an installation plate, a push plate, a return rod, and a spring, this mechanism can achieve demolding and resetting of the condensation material mechanism of the pouring system, facilitating automatic circulation in injection molding processes.

6.6 Pouring system

It consists of a sprue bushing, a main runner in the locating sleeve, a fixed mold core, a runner on the movable

mold core, and a point gate on the movable mold core. The plastic melt flows into the runner through the main runner, then into the point gate, and finally into the mold cavity. Due to the use of a two-cavity structure in the injection mold, the gating system can be symmetrically designed, shortening the length of the runner and avoiding many defects that may arise.

6.7 Cooling system

It consists of cooling water channels, screw plugs, "O" rings, and cooling water connectors in the fixed and movable mold parts, which are not shown in the figure.

6.8 Guide components

The positioning and guiding of the fixed and movable mold parts are composed of four sets of guide pillars 29 and guide sleeves 28. The positioning and guiding of the demolding mechanism are composed of four sets of push plate guide sleeves, push plate guide pillars, and push plate guide pillars 17. The component guiding component is the component for positioning and motion guiding of the fixed and movable mold parts.

The proper design and manufacturing of the various mechanisms, systems, components, and parts mentioned above are essential to ensure the accuracy of the injection mold for the handle frame, and ultimately, to guarantee the quality of the claw-shaped buckle box during the molding process.

7 Conclusion

Through a comprehensive and detailed analysis of the physical elements of the handle skeleton, and the measures adopted corresponding to these elements, the design of the injection mold structure for the handle skeleton can be accurately achieved. Only then can the qualification and appearance requirements of the injection molding process for the handle skeleton be ensured. It is evident that for both the design of the injection mold and the processing of the injection molded parts to succeed, the following design procedures must be followed: first, analyze the physical elements of the injection molded parts → then analyze the structural scheme of the injection mold → proceed with the demonstration of the injection mold structural scheme → carry out 3D modeling of the injection mold structure → convert the model into a 2D drawing of the injection mold structure → finally, convert the 2D drawing of the injection mold structural parts and formulate the manufacturing process specifications for the mold parts.