

Analysis of the physical elements and expected defects of the cover shell and structural design of the injection mold

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Abstract: Through the analysis of the physical elements of the cover shell, it is found that it possesses grooves, protrusions, and appearance elements. The cover shell is placed vertically in the injection mold, with the parting surface set on the bottom. If the gate is also set on the bottom, according to the expected analysis of defects, the plastic melt will produce countercurrent filling, resulting in defects such as insufficient filling, bubbles, overheat marks, flow marks, and silver streaks. Therefore, it is necessary to adopt concurrent filling, and the latent point gate of the mold should be set on the upper part of the cover shell. In this way, the above-mentioned defects can be eliminated and the appearance requirements can be met. The plastic melt injected into the latent runner enters the mold cavity through the point gate on the ejector pin. The condensed material in the main runner can be pulled out of the mold by the ejector pin, and the condensed material in the branch runner and latent runner can be pushed out by the ejector pin. While the ejector pin pushes out the cover shell, the condensed material attached to the point gate in the ejector pin can fall off by itself. This gating system shortens the length of the gating system, avoids the use of hot runners, and has universal application value.

Key words: cover shell; form factor; downstream filling; latent flow channel; defect prediction analysis

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0 Introduction

The design of an injection mold for a cover shell requires not only an analysis of the physical elements of the cover shell, but also a defect anticipation analysis. Only when the structural design of the injection mold meets the molding requirements of the physical elements of the injection molded part and does not produce molding defects that lead to non-conforming injection molded parts and injection molds, can the structural design and manufacturing of the injection mold proceed.

1 Analysis of the physical elements of the cover shell and defect prediction analysis

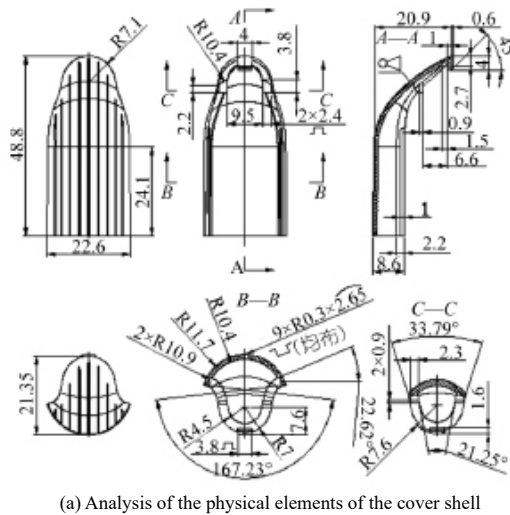
Before conducting a feasibility analysis of the injection mold structure for the cover shell, it is essential to perform

an analysis of the physical elements and anticipate potential defects. This is because the injection mold structure is determined by the physical elements of the injection molded parts, and defects arising from the injection molded parts must be primarily prevented and only secondarily rectified. Therefore, the mold requires repeated testing and repair, which may even result in scrap.

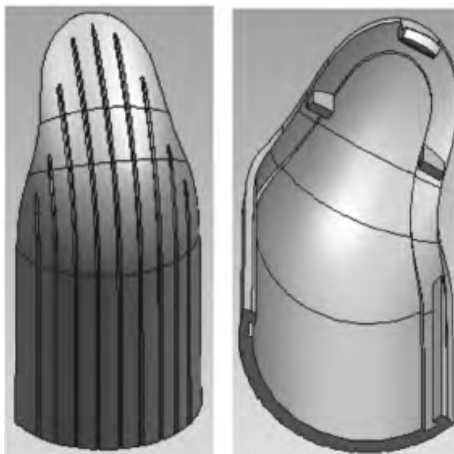
The analysis and parting surface I-I of the cover shell body are shown in Figure 1(a), and the three-dimensional modeling of the cover shell is shown in Figure 1(b). On the body of the cover shell, there are $9 \times R0.3 \text{ mm} \times 2.65 \text{ mm}$ groove elements parallel to the mold opening and closing direction,

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and there are 2×2.4 mm×3.8 mm×2.2 mm×R10.4 mm×0.9 mm×9.5 mm and 3.8 mm×1 mm×4 mm×0.6 mm×2.7 mm×45° boss elements parallel to the mold opening and closing direction . The material is ABS+30% PC, with a shrinkage rate of 0.3% to 0.6%.



(a) Analysis of the physical elements of the cover shell



(b) Cover shell design

Figure 1 Analysis of the physical elements of the cover shell

Note: — indicates a raised element; — indicates a recessed element; — indicates that the surface of the injection molded part should meet "appearance" requirements.

1.2 Defect expectation analysis

Due to the upright placement of the cover shell in the injection mold, the injection mold's gating system can be designed in two ways: countercurrent filling and concurrent filling. Different filling methods can result in various molding defects or no defects. Injection molded parts with defects are considered scrap, and naturally, the injection mold is also considered unqualified.

1.2.1 Countercurrent filling state of plastic melt

As shown in Figure 2(a), due to the placement of the lateral gate 1 at the parting surface I-I, the plastic melt fills in a countercurrent manner, meaning that the melt enters the mold's moving and stationary mold cavities from the lateral gate 1, filling from bottom to top. The bottom-to-top filling of the plastic melt causes the gas in the mold cavity to be squeezed to the upper layer of the enclosed mold cavity, where it cannot be discharged, resulting in bubbles and insufficient filling. Under the pressure of the injection force and holding pressure of the plastic melt, the gas will eject from a certain point. Due to the high temperature generated during the compression and ejection process, the cover shell body may overheat and lose its mechanical properties. Furthermore, during the bottom-to-top filling process of the plastic melt, the temperature of its front edge decreases layer by layer, forming condensed molecular clusters. These condensed molecular clusters are scattered throughout the filling process of the plastic melt, resulting in defects such as flow marks and silver streaks. At the same time, due to the excessively long lengths of the main runner and branch runners, the temperature of the plastic melt is too low, causing poor welding. Clearly, the countercurrent filling of plastic melt is not suitable for the filling method of the cover shell body.

1.2.2 Plastic melt downstream filling state

As shown in Figure 2(b), in order to achieve downstream filling of the plastic melt, the mold gate should be set on the upper part of the cover shell. Since the inner and outer surfaces of the cover shell have "appearance" requirements, a point gate set on the upper part of the inner shape of the cover shell can be adopted. This can only utilize the position of the injection mold ejector pin to set the point gate, and design a latent runner compound gating system in the moving mold core. The plastic melt fills downstream from top to bottom, and the gas in the mold cavity is discharged from the parting surface I-I from top to bottom, thus avoiding problems such as insufficient filling and bubbles. If a cold slug well is set on the parting surface I-I, the front condensed material and gas of the plastic melt enter the cold slug well, and the length of the gating system is short, naturally, defects such as overheat marks, poor welding, flow marks, and silver streaks will not occur.

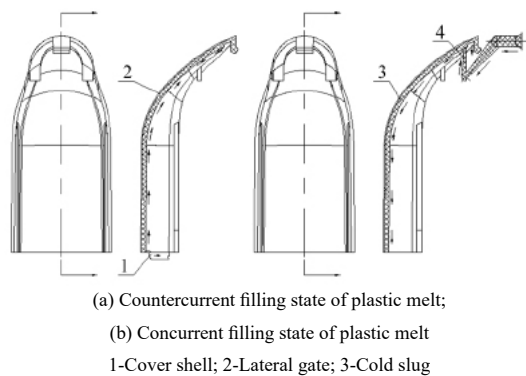


Figure 2 Expected analysis of defects in the cover shell

2 Analysis of feasible structural schemes for injection molds for cover shells

The cover shell is placed in an upright position in the injection mold. For the internal shape of the cover shell, a movable mold core can be used for molding, and the external shape can be molded using a fixed mold cavity. This injection mold adopts a four-cavity design, with parallel opening and closing mold directions featuring bosses and grooves. Cavity and groove molding can be performed on the movable and fixed mold cores. The cover shell is molded after the plastic melt injected during the closing of the fixed and movable molds cools down. For mold structures with "appearance" requirements and where defects are not allowed, a structure with latent pin gates at the position of the injection mold ejector pin can be adopted.

3 Injection mold structure design

The injection mold structure for the cover shell consists of a mold frame, a gating system, a cooling system, a mechanism for removing the cover shell and condensed material from the gating system, a return mechanism, molding components (including fixed and movable mold cores), and guiding components. The injection mold for the cover shell adopts a four-cavity design with parting surface I-I, as shown in Figure 3.

3.1 Mould base

As shown in Figure 3, the mold base consists of the moving platen 1, hexagonal socket screws 2 and 7, the fixed platen 5, the sprue bushing 6, the fixed mold cushion plate 8, the locating ring 9, the ejector rod 10, the mold feet 11, the mounting plate 12, the stripper plate 13, the bottom plate

14, the ejector pins 15 and 25, the guide sleeve 18, the guide post 19, the return rod 20, and the spring 21. The mold base serves as the platform and foundation for assembling various mechanisms, systems, and components of the injection mold.

3.2 Cooling system

As shown in Figure 3, during the continuous processing of the cover shell 17, the plastic melt transfers heat to the mold forming components, causing the temperature of the mold to continuously rise. This results in the cover shell overheating, losing its mechanical properties, and becoming scrapped. Therefore, it is necessary to install a cooling system in the fixed and movable mold plates and forming components. The cooling system involves machining cooling water flow channels in the fixed and movable mold plates and cores of the mold. Pipe threads are machined at the ends of the flow channels, and screw plugs 23 and 27, as well as cooling water connectors 22 and 26, are installed. Grooves for installing "O" rings 24 and 28 can be machined at the joints between the fixed and movable mold plates and cores, with the purpose of preventing leakage of cooling water.

3.2.1 Fixed mold cooling system

As shown in Figure 3, cooling water flows in from the cooling water connector 22, passes through the flow channel in the mold, and then flows out from the cooling water connector 22, thereby carrying away heat and achieving the effect of cooling.

3.2.2 Dynamic simulation cooling system

As shown in Figure 3, cooling water flows in from the cooling water connector 26, passes through the flow channels in the mold, and then flows out from the cooling water connector 26, thereby carrying away heat and achieving the effect of cooling.

3.3 Condensate removal mechanism

As shown in Figure 3, it consists of a pull rod, a ejector pin, a mounting plate, and a stripper plate. When the fixed mold part is opened, the zigzag hook of the pull rod can pull off the condensed material in the sprue bushing of the main runner and the condensed material in the runner of the parting surface of the fixed mold core. When the ejector pin of the injection machine pushes the mounting plate, stripper plate, pull rod, and ejector pin, it can push off the condensed material in the main runner and the condensed material in the runner of

the parting surface of the moving mold core.

3.4 Return mechanism

As shown in Figure 3, it consists of a return rod, a spring, an installation plate, and a push plate. When the ejector pin of the injection molding machine retracts, the elastic force of the spring restores the installation plate, push plate, return rod, and pull rod 10, ejector pin 15, 25 to their initial positions. However, after prolonged use in injection molding, the spring may fail, preventing the demolding mechanism from fully returning to its original position, resulting in interference during the movement of the injection mold. When the fixed and movable molds are clamped together, the fixed mold plate 5 pushes the return rod, ensuring the demolding mechanism fully returns to its original position and acting as a safety mechanism, thereby enabling the injection molding process to automatically cycle indefinitely.

3.5 Formed components

As shown in Figure 3, it includes both a fixed mold core and a movable mold core. Due to the characteristics of plastic expansion and contraction, all molding dimensions should be: the drawing size of the cover shell 17 + the drawing size $\times$ ABS + 30% of the average shrinkage rate of PC, which is 0.45%. All molding surfaces facing the demolding direction should have a demolding slope of 1.5 to 2 degrees.

3.6 Guiding components

As shown in Figure 3, the guidance of the opening and closing motion between the fixed mold and the movable mold relies on the precision of the fit between the guide sleeve and the guide pillar.

4 Design of demolding mechanism for injection mold gating system

The injection molding pouring system consists of the main sprue, runner, sub-runner 9, pin gate 10, and cold slug well. The demolding mechanism can be divided into the mechanism for removing the molded parts and the mechanism for removing the condensed material from the pouring system.

4.1 Design of the injection mold feeding system

As shown in Figure 4, according to the injection mold structure plan, the submerged pin gate should be set on the

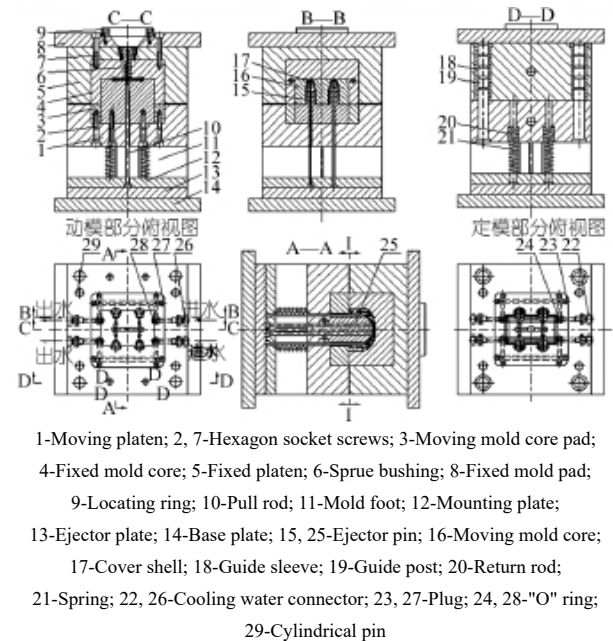


Figure 3 Structural design of injection mold for cover shell

inner surface of the upper part of the cover shell 5. In this way, the plastic melt can enter the pin gate 10 made on the upper end of the square ejector pin 11 through the submerged runner, and then enter the mold cavity to cool and form the cover shell 5.

4.2 Injection mold opening status

As shown in Figure 4, when the fixed mold is opened, the condensed material in the sprue and the runner on the parting surface of the fixed mold core is pulled out under the pulling force of the zigzag hook of the pull rod 13. The cavity of the fixed mold core 4 is opened, which facilitates the demolding of the cover shell 5.

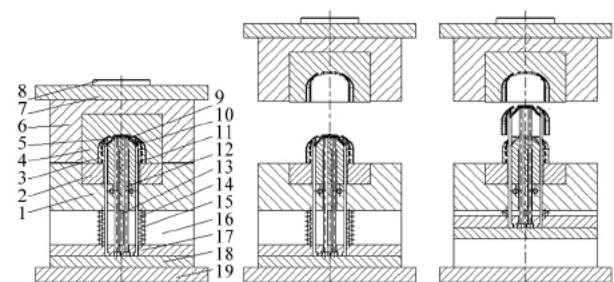


Figure 4 Design of the injection mold pouring system and demolding mechanism for the cover shell

4.3 Demolding status of cover shell

As shown in Figure 4, when the injection machine ram pushes the mold mounting plate 17, the stripper plate 18, and the square ram 11, it can eject the cover shell. The cylindrical ram 12 can eject the condensed material in the runner and the latent sprue 9 on the parting surface of the mold core 3.

6 Conclusion

The gating system of the injection mold for the cover

shell adopts a latent point gate, which conforms to the principle of downstream filling of plastic melt. It not only eliminates molding defects but also meets the appearance requirements of the cover shell. Additionally, it shortens the length of the gating system and avoids the need for a hot runner structure due to the cooling of the plastic melt. This gating system and demolding structure have universal application value.