Injection Molding

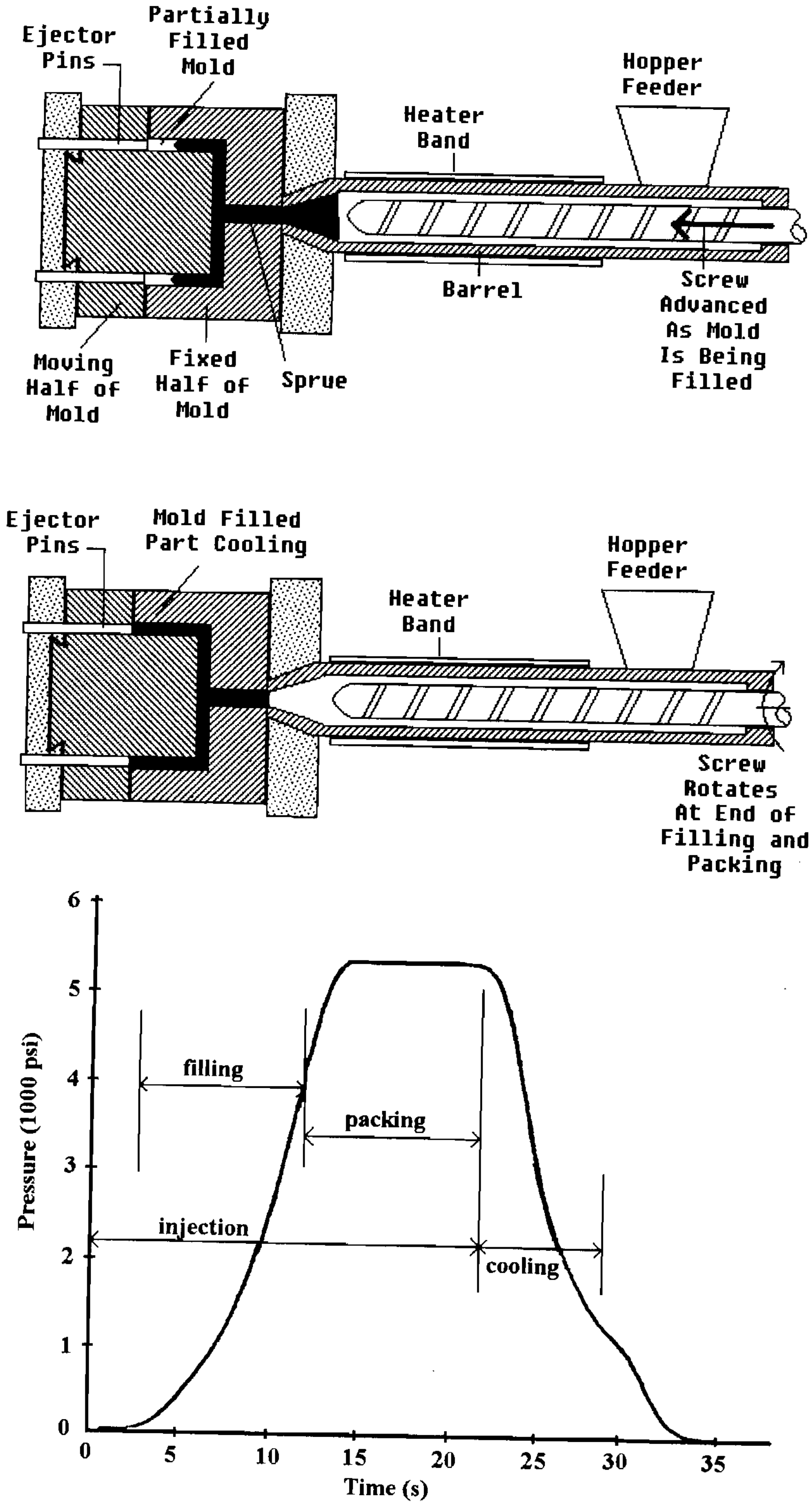


FIGURE 3.1 *Screw-type injection-molding machine.*

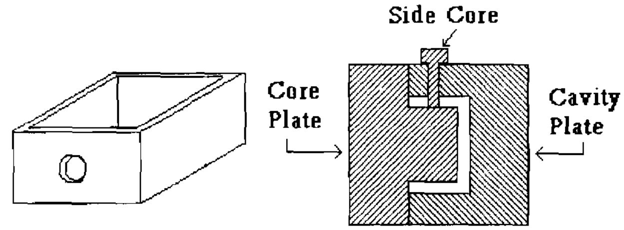


FIGURE 3.2 *Example of a part with an external undercut.*

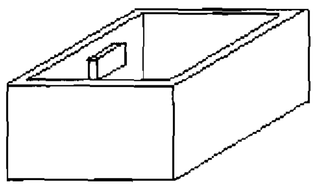


FIGURE 3.3 *Example of a part with an internal undercut.*

A through-hole feature in the vertical wall, such as the one shown in Figure 3.2, is referred to as an external undercut. To produce it requires a relatively costly side core to form the hole; the core is made to slide out of the way to permit ejection of the part. In general, external undercuts are features that will, without special provisions, prevent the part from being extracted from the cavity half of the die.

An internal undercut, such as the one caused by the projection that exists on the inner wall of the boxed-shaped part shown in Figure 3.3, is one that prevents the core mold half of the part from being extracted. In general, internal undercuts require even more costly molds than external undercuts.

Undercuts and their effect on tooling and processing costs for injection-molded parts are discussed in more detail in Chapter 4, "Injection Molding: Relative Tooling Cost," and Chapter 5, "Injection Molding: Total Relative Part Cost."

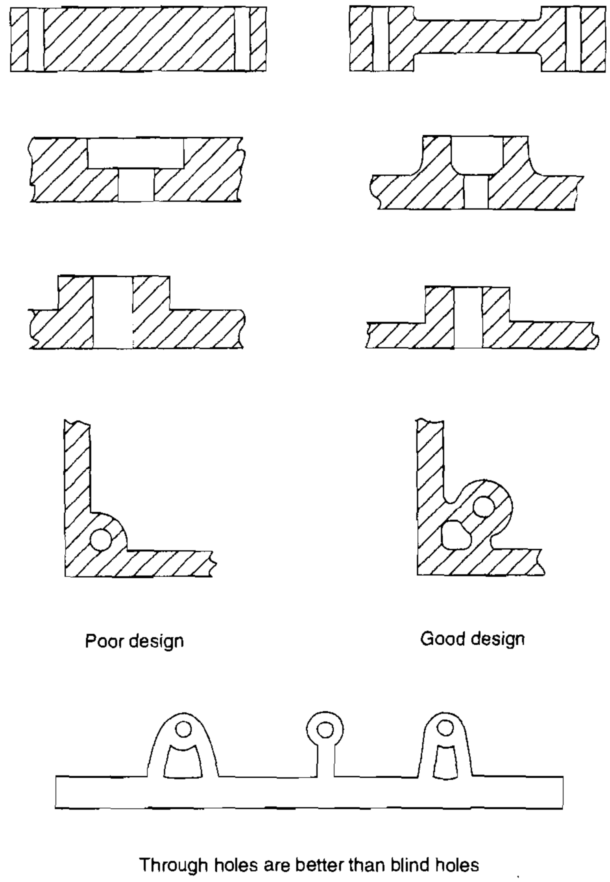
Per-part processing time (or cycle time) for an injection-molded part is primarily dependent on the time required for solidification, which can account for about 70% of the total cycle time. Solidification time in turn depends primarily on the thickness of the thickest wall. Typical solidification times for thermoplastic parts range from 15 seconds to about 60 seconds. Other part features that also influence cycle time are discussed in Chapter 5, "Injection Molding: Total Relative Part Cost."

3.4 COMPRESSION MOLDING

Compression molding for forming thermoset materials uses molds similar to those for injection molding. The mold (Figure 3.4), mounted on a hydraulic press, is heated (by steam, electricity, or hot oil) to the required temperature. A slug of material, called a charge, is placed in the heated cavity where it softens and becomes plastic. The mold is then closed so that the slug is subjected to pressures between 350 kPa (50 psi) to 80,000 kPa (12,000 psi) forcing the slug to take the shape of the mold.

Injection Molding

FIGURE 8.8
Examples of poor and good designs of bosses in injection-molded parts



Provide appropriate draft. As is the case with forging, it is important to provide a draft of 1° so that the product can be injected from the mold.

Avoid heavy sections when designing bosses. Heavy sections around bosses lead to wrappage and dimensional control problems. Figure 8.8 shows poor and good designs of bosses.

Compression Molding

Compression molding is used mainly for processing thermosetting polymers. The process involves enclosing a premeasured charge of polymer within a closed mold and then subjecting that charge to combined heat and pressure until it takes the shape of the mold cavity and cures. Figure 8.9 shows a part being produced by this process.

Although the cycle time for compression molding is very long when compared with that for injection molding, the process has several advantages. These include low capital cost (because the tooling and the equipment used are simpler and cheaper) and the elimination of the need for sprues or runners, thus reducing the material waste. There polymer melt can solidify. The thicker the walls of a product, the longer the product cycle, and the higher its cost. Consequently, a designer has to keep the thickness of a product to a minimum without jeopardizing the strength and stiffness considerations. Also, thickness must always be kept uniform; if change in thickness is unavoidable, it should be made gradually. It is better to use ribs rather than increase the wall thickness of a product. Figure 8.7 shows examples of poor design and how they can be modified (by slight changes in constructional details) so that sound parts are produced.

Provide generous fillet radii. Plastics are generally notch-sensitive. The designer should, therefore, avoid sharp corners for fillets and provide generous radii instead. The ratio of the fillet radius to the thickness should be at least 1.4.

Ensure that holes will not require complex tooling. Holes are produced by using core pins. It is, therefore, clear that through holes are easier to make than blind holes. Also, when blind holes are normal to the flow, they require retractable core pins or split tools, thus increasing the production cost.

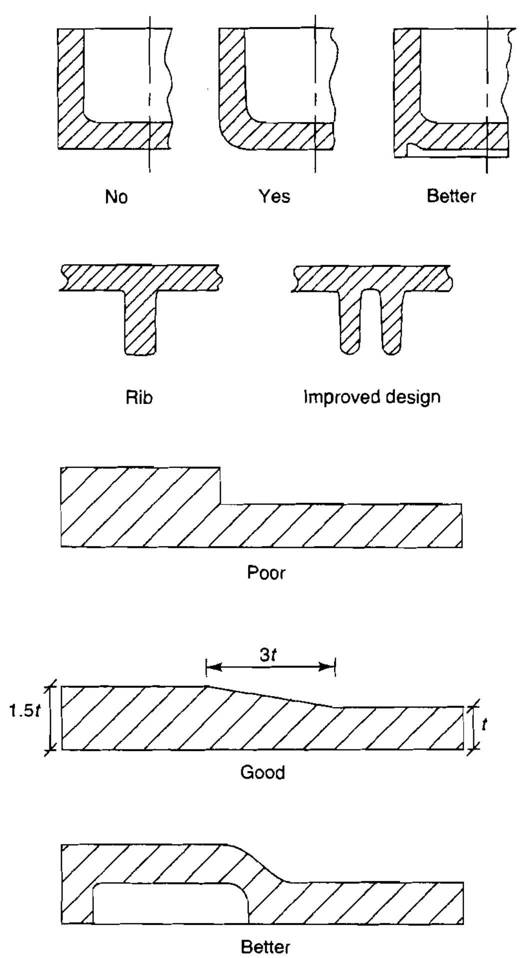


FIGURE 8.7 Examples of poor and good designs of walls of plastic products

Injection Molding

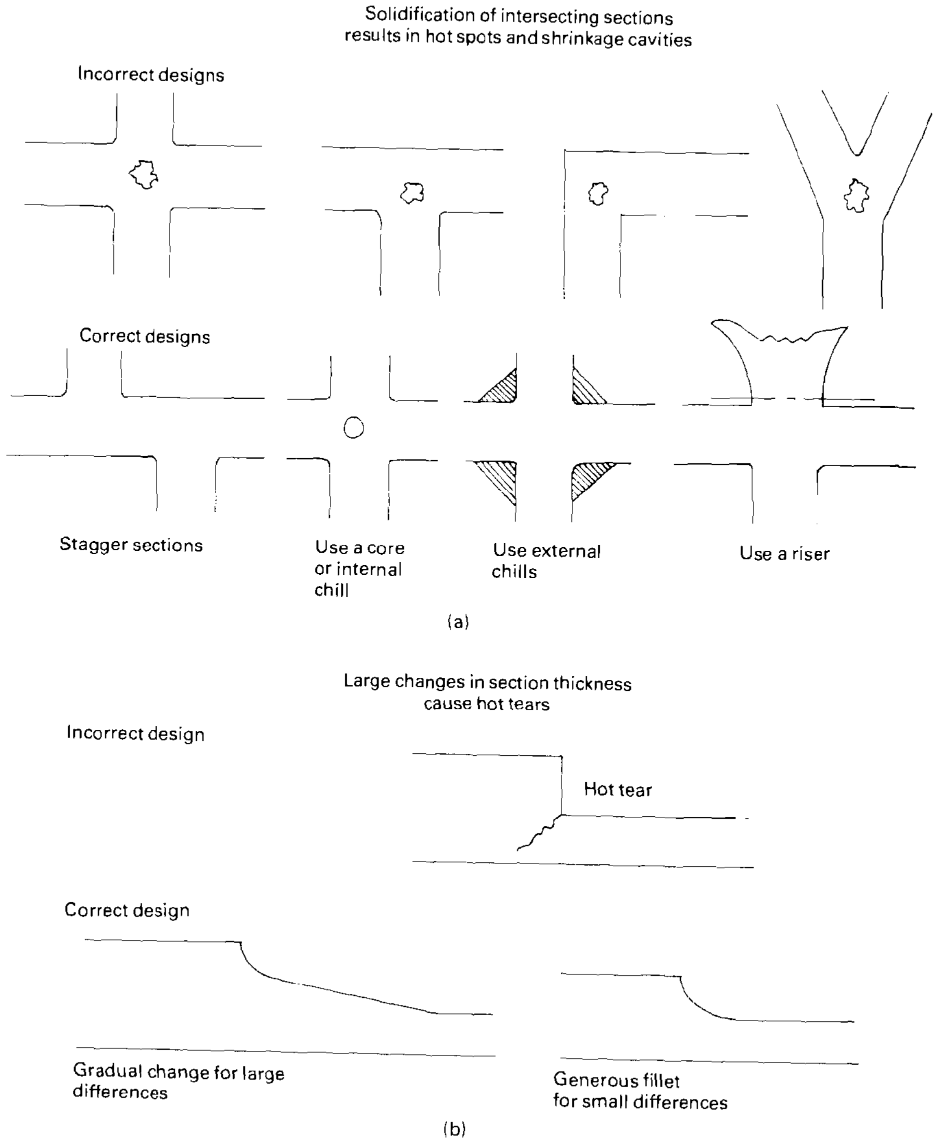
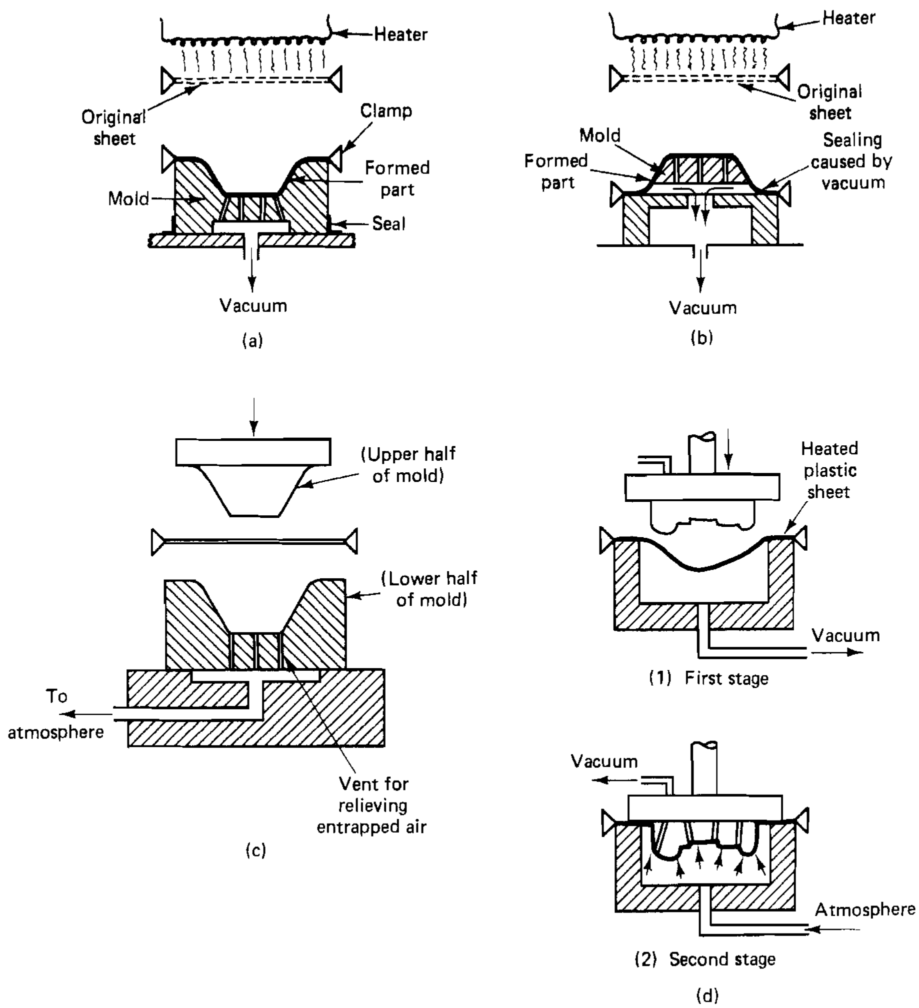


Figure 7.1 Design considerations for cast components.

Injection Molding & Casting

FIGURE 8.12 Different thermoforming processes: (a) straight vacuum forming; (b) drape forming; (c) matched-mold forming; (d) vacuum snapback



conductivity. For low-volume or trial production, molds are made of wood or even plaster of paris.

Examples of the parts produced by thermoforming include containers, panels, housings, machine guards, and the like. The only limitation on the shape of the product is that it should not contain holes. If holes are absolutely required, they should be made by machining at a later stage.

Calendering

Calendering is the process employed in manufacturing thermoplastic sheets and films. This process is similar to rolling with a four-high rolling mill, except that the rolls that squeeze the polymer are heated. The thermoplastic sheet is fed and metered in the first and second roll gaps, whereas the third roll gap is devoted to gaging and finishing.

Extrusion

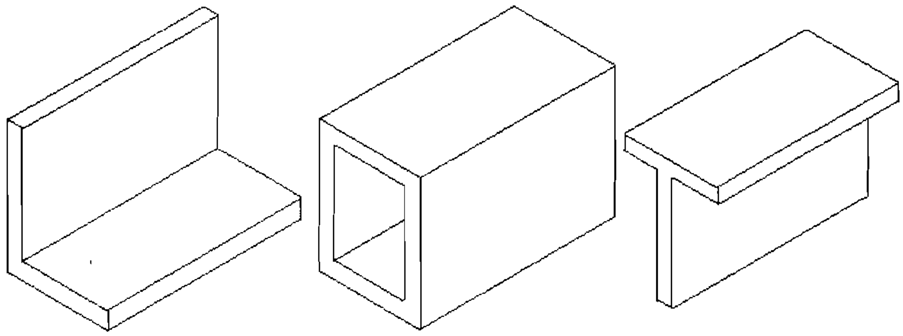


FIGURE 3.8 *Some common structural shapes produced by extrusion.*

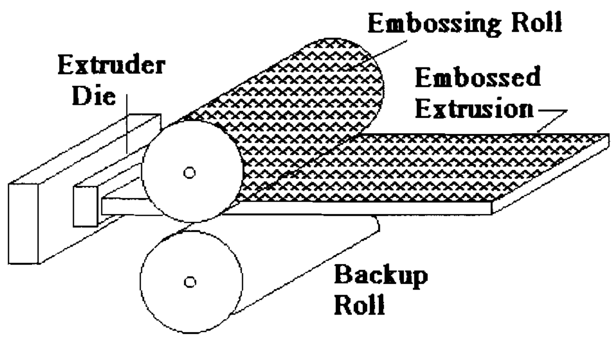


FIGURE 3.9 *Post-processing of extruded sheets.*

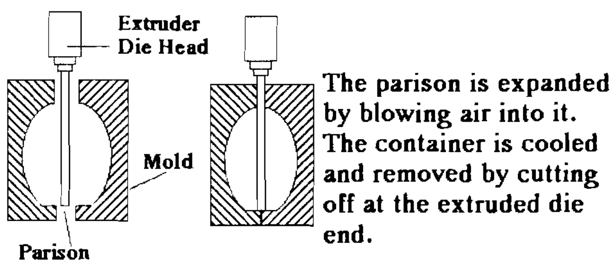


FIGURE 3.10 *Extrusion blow molding.*

Shapes formed by extrusion can be subjected to post-processing techniques by passing them through rollers (Figure 3.9) or stationary blades or formers that modify the shape of the (still hot and soft) extrusion. Sheets, for example, can be embossed to form patterns on them.

3.7 EXTRUSION BLOW MOLDING

Extrusion blow molding is a process used to form hollow thermoplastic objects (especially bottles and containers). The process (Figure 3.10) takes a thin-walled tube called a *parison* that has been formed by extrusion, entraps it between two halves of a larger diameter mold, and then expands it by blowing air (at about

Compression Molding

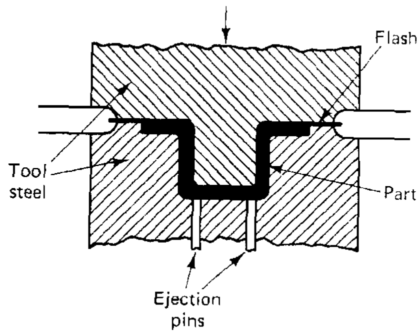


FIGURE 8.9 The compression molding process

are. however, limitations upon the shape and size of the products manufactured by this method. It is generally difficult to produce complex shapes or large parts as a result of the poor flowability and long curing times of the thermosetting polymers.

Transfer Molding

Transfer molding is a modified version of the compression molding process, and it is aimed at increasing the productivity by accelerating the production rate. As can be seen in Figure 8.10. the process involves placing the charge in an open. separate "pot," where the thermosetting polymer is heated and forced through sprues and runners to fill several closed cavities. The surfaces of the sprues. runners, and cavities are kept at a temperature of 280 to 300°F (140 to 200°C) to promote curing of the polymer. Next. the entire shot (i.e., sprues, runners, product, and the excess polymer in the pot) is ejected.

Rotational Molding

Rotational molding is a process by which hollow objects can be manufactured from thermoplastics and sometimes thermosets. It is based upon placing a charge of solid or liquid polymer in a mold. The mold is heated while being rotated simultaneously around two perpendicular axes. As a result, the centrifugal force pushes the polymer against the walls of the mold, thus forming a homogeneous layer of uniform thickness

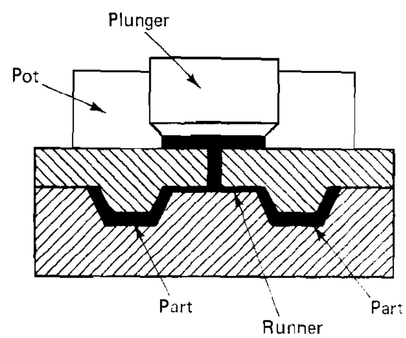


FIGURE 8.10 The transfer molding process

Transfer Molding
- Note can be use on Gr/Ep
(RTM)