HANSER

Selecting Injection Molds

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Weighing Cost vs Productivity

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Leseprobe

4 Mold Selection

4.1 Selection of an Appropriate Mold

Once a good product design has been achieved and it is decided where the product will be made and how many cavities are required, we must consider the available alternatives for the molds.

4.1.1 Dedicated Mold, Universal Mold Shoe

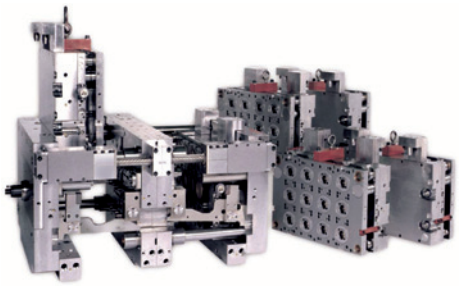

Figure 4.1 A 4-level mold designated to quickly switch to different sets of inserts (Courtesy: Stackteck)

Dedicated molds are usually preferred. However, the use of a common mold shoe with different sets of stacks can often be more economical

"Dedicated mold" means a complete mold that is used for one purpose only. After use, the mold is put into storage until it is used again. This is the most common type of mold. Occasionally, especially with molds with 2–8 cavities, the same mold shoe can be and often is used for more than one set of cavities and cores. In principle, there is nothing wrong with this concept, provided the molding shop is well organized (good record keeping and proper storage facilities for the loose stack parts) and the personnel is capable of making the switch from one product to another without the need for high-priced mold makers. It may take a few hours to switch from one set of stacks to another and there is always the risk of damage to the mold components in handling and during assembly. The question is whether it is worthwhile to switch molds, especially if it is done frequently. If the mold shoe is quite simple, it would be better (safer and more economical) to have a dedicated mold. But there are cases where the mold shoe is large, complicated, and relatively expensive; if the stacks for the various (preferably similar) products are designed from the beginning so that they can be easily interchanged, this is a very good and economical solution.

Typical examples are 4- or 6-cavity molds for a series of round containers, with none or only small differences in diameters, but with large differences in height, as would be the case with small tubs for dairy products, e.g., in sizes from 0.25 liter to 1 liter capacity. Such molds can be designed and built with all the advantages of a dedicated mold, but saving the cost of several mold shoes.

For small products and low quantities, universal molds can often be the most economical solution

"Universal mold shoes" are used mainly for low production runs, for which only small numbers of cavities are required. They are based on the principle that stack inserts can be easily and quickly interchanged by the molding technicians or setup personnel, often even without removing the mold shoe from the machine. The stacks do not necessarily have to be for the same or even similar products. They are usually designed for one cavity per insert. If there is space, two or more cavities and cores could well be placed within one insert. The disadvantage is that, because the stacks are designed for easy interchangeability in the mold shoe, it may not be possible to provide them with the best cooling layouts (facilitating faster cycles) of a dedicated mold. In addition, the product requiring the longest cooling time governs the cycle

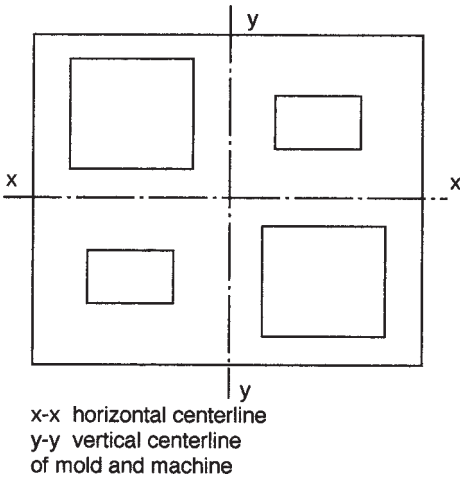

Figure 4.2 Schematic of symmetrically balanced cavities in relation to the centerline of the clamp

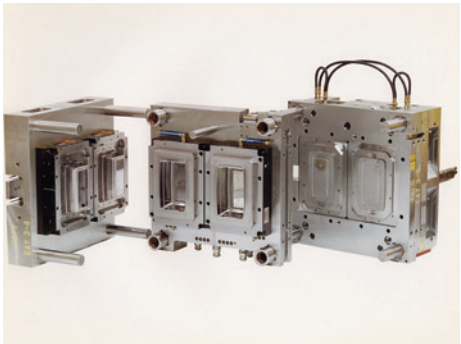

Figure 4.3 Stack family mold for container and lid (Courtesy: Husky)

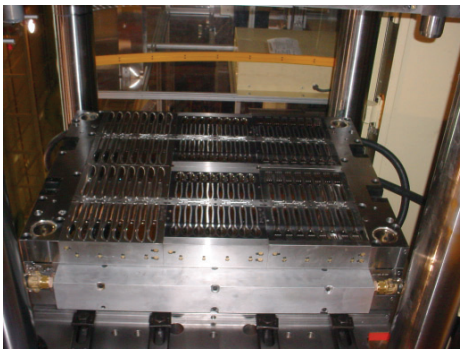

Figure 4.4 Cavity view of 72-cavity cutlery mold; 24 forks, 24 spoons, and 25 knives are molded every shot (ca. 8–10 s)

time; however, for low production, short cycle times are not as significant for the unit cost as is the lower mold cost.

4.1.2 "One-Product" Molds or "Family" Molds?

"One-product mold" is a mold built for one specific product. The best layout for minimum mold size, space (stack location), cooling, ejection, etc., can be achieved with a dedicated (one-product) mold.

A "family mold" is a dedicated mold, in which more than one shape of product is made during the same injection, which will be of the same material and color. A very serious disadvantage of all family molds is that the cycle time of the mold is governed by the product (and the mold stack) that is most difficult to cool. This difference can be substantial, and should be seriously considered, particularly with products as described in Section 4.1.2.1 and 4.1.2.2. For all family molds producing pieces of different size, we must make sure that the mold is laid out so that the clamp forces are balanced as well as possible, i.e., that the sum of all projected areas is about equal in each of the 4 mold quadrants. In other words, the projected areas of the cavities above and below the horizontal center line of the mold must be nearly equal and so must be the sum of the projected areas to the right and the left of the vertical center line of the mold (see Fig. 4.2).

4.1.2.1 Family Molds for Composite Products

For composite products, such as toys and games, it may be desirable to make all the components of the toy in one shot. Often, the various pieces are kept on the runner system of a 2-plate mold and are packed and shipped together with the runner; it is left to the user to take the pieces off the runner during assembly of the toy. The production runs are usually relatively small; therefore, this is a most effective method of producing with low cost molds (don't forget to include the cost of the runners in the cost of the product).

Occasionally, a product, e.g., a toy car, may have two or more colors. It could be a car with a blue body, red wheels, and yellow bumpers, etc. By molding equal production runs of first blue, then red, then yellow parts, 3 sets of cars can be produced, in the three combinations of colors. In this case, the runners are not shipped with the product. This method is also used occasionally for technical products.

4.1.2.2 Family Molds for Small or Medium-Sized Technical Products

Family molds for small or medium-sized technical products are used when a number of different sizes of similar, rather small products, such as washers or seals, are molded in one mold. But such molds can also be used for larger products, which are required as a "set" in production, as they are used, e.g., for home appliances, among others. Any type of mold can be used (hot runner

or cold runner, 2-plate or 3-plate). There are two main disadvantages of this type of mold:

(1) Except for edge-gated 2-plate molds, the products fall out of the mold all mixed together and must be separated before storage or use.

(2) Stock and production control can have serious problems when some of the products are used up (e.g., wear) faster than others, and must be available as spare parts. It may then be necessary to run the mold to produce the full shots while only some of the items are required. This problem can be overcome by blocking off the runner system ahead of the unwanted cavities and running the mold only for the products required; this means to run the mold less efficiently.

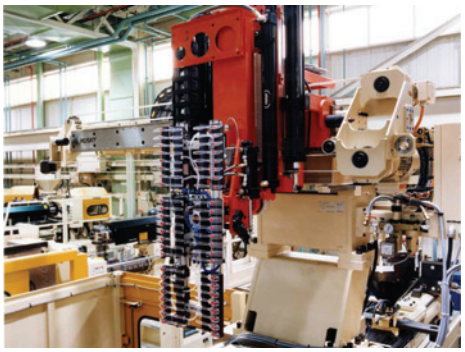

Figure 4.5 View of ejected array in robot end of arm tooling

4.1.2.3 Family Molds for Perfect Color Matching

Perfect color matching can easily be achieved with family molds

Any plastic, and especially colored plastic, whether colored in-house or bought already colored from the supplier, comes in batches. Within each batch, the plastic can be considered uniformly mixed and colored. These batches are supplied in bags, or in large carboys, or in truckloads, etc. Even though the specifications to make the batches were identical, there are mixing tolerances in manufacturing and small variations from batch to batch are unavoidable. It is better to work with large batches, which will yield large numbers of matching-colored pieces, but this is not always practical or economical. If a product pair (or assembly) must have a *perfect* color match, the answer is to make the matching pieces in *one* shot, which is of course supplied by the same injection unit, at the same time. A typical application for this is a "lady's compact", consisting of a base (for the face powder) and a matching lid (for the mirror). But there are other applications, some of them in the technical field. It is quite common to build molds that have the same number of each of the products that require the perfect color match. If the pieces are required in pairs and their projected areas are about the same, a mold layout is rather easy and the stacks can be laid out symmetrically. A problem is that the pieces are ejected together and must be separated after molding; also, they must also be stored so that the matching colors are kept together and are not mixed with products from another color batch (this can also add costs to the product).

Figure 4.6 Color matched parts for personal care products

4.1.2.4 Family Molds for In-Mold Assembly

Family molds for in-mold assembly are more sophisticated molds, usually for very high production volumes and are only rarely used. A multiple of two different but matching pieces is molded in the same mold; they are assembled during the ejection time, using special motions, which are part of the mold or during the mechanical removal (with synchronized take-offs or robots), so that already assembled pieces are ejected to a conveyor or carried away under controlled conditions. Such assembly methods may require longer ejection times but can save subsequent assembly equipment, and time.

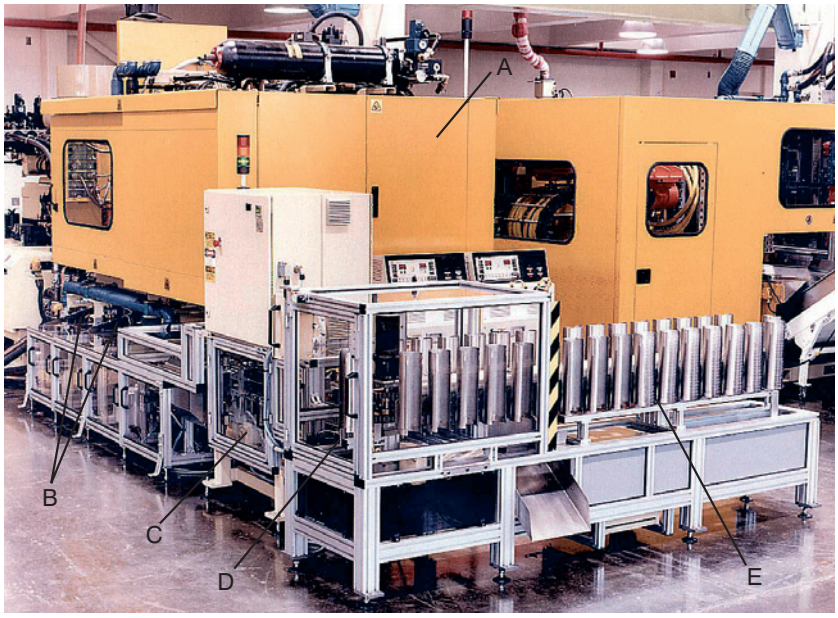

Figure 4.7 Petri dish system (Courtesy: Husky)

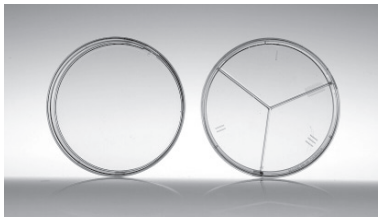

Figure 4.8 Petri dishes and CD jewel boxes are typically molded using family molds

Figure 4.9 Cutlery is also often molded in family molds

4.1.2.5 Family Molds Using Controlled Ejection for Subsequent Assembly

This method is almost exclusively used for products where the required annual quantities are very large and virtually no changes are expected for years. In these cases, a number of pairs of matching pieces, usually of the same projected area or with only small difference in area, are molded in one (single level or stack) mold and then removed either by take-off or by other methods, which maintain the orientation of the matching pieces so that they can be easily assembled in a specially designed machine or mechanism, usually adjacent to the molding machine. Typical examples are Petri dishes, video and audio- cassettes, CD "jewel boxes," and so forth.

Figure 4.7 shows a Petri dish system taken from the rear of the clamp, which is protected by guards (A). The bottoms and the tops of the Petri dish are molded on each face of a 2 × 4, 2 × 6, or 2 × 8 stack mold. *Guide rails* transport the molded parts by conveyor (B) to an assembly station (C); from there the assembled dishes move to a stacker (D) and the stacks of assembled Petri dishes are then moved to an (open) "sleeving" station (E) where plastic sleeves are manually pulled over the stacks for boxing and shipping to a sterilizer; cycle time: 3.5 s, productivity (with 2 × 8 mold): 8,200 assembled dishes/hour.

4.1.3 Where to Gate

The next issue to consider is the location of the gate. The gate is the point where the plastic enters the cavity space. In some cases, the *product designers* will indicate where *they* believe the gate should be. They may select this location because of the function and strength of the product and in some

cases, because any projecting gate vestige may be bad for appearance or even harmful to the user. However, such suggested location may not always be the best for filling the cavity space or for the best strength properties of the product. At this point of the development, the input by a molder or the *mold designers* could be very valuable and a dialogue between the product and mold designers should be encouraged to find the best location for the gate.

These days, computer aided mold filling simulation packages can accurately predict the fill patterns of any part. This allows for quick simulations of gate placements and helps finding the optimal location.

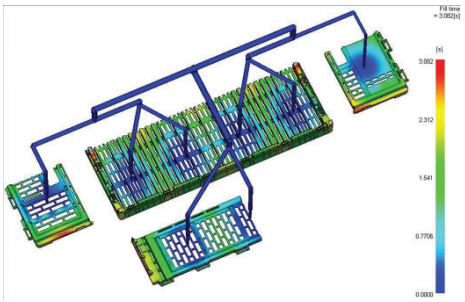

Figure 4.10 Mold filling analysis is very useful for finding the best gate location

4.1.3.1 Cup- or Box-Shaped Products

In general, for cup- or box-shaped products, outside center gating is most desirable, because it ensures more evenly distributed flow from the gate towards the rim or edge. However, center gating (except for single-cavity molds) implies the use of either 3-plate or hot runner molds, both of which are more expensive than 2-plate molds. Note that the gate area is always an area of inherent weakness; molding conditions such as higher melt temperatures, longer molding cycles, and higher cooling temperatures can improve the strength there and this must be considered as a factor affecting the cycle time and cost of the product. It should also be noted here that hot runner valve gating reduces the stresses in the gate area.

The foregoing does not imply that 2-plate molds cannot be used for cup- or box-shaped products; in fact, 2-plate molds are used for many such products, but usually only those with larger wall thickness.

Figure 4.11 Typical bottom center-gated parts

4.1.3.2 Flat Products

"Flat" in this context means *relatively* flat, as opposed to "cup-shaped." It includes really flat pieces (in one geometric plane) but also curved products, such as automotive panels, trays, etc. of all shapes. Flat products are preferably gated from the edge of the product, because the flow away from the gate (or gates) will result in a stronger product; it also ensures that there are no unsightly gate marks in the middle of the product. Here also, it is much better if the incoming stream of plastic will be directed against a solid portion of the core or at least a projection of the core and not to flow into an open space, such as a rib or an open surface. Thin-walled, round products, such as lids for containers and trays, should be center-gated for faster filling and to reduce possible distortion when ejected early to gain cycle speed; however, they can also be edge-gated when the center of the lid must not show a gate mark.

Figure 4.12 shows a selection of typical automotive products. The quantities are usually small compared with the huge numbers molded for packaging and medical products and the molds are usually small cavitations (1 or 2). But even so, most of these products are molded with hot runners, because it is easier and more effective to control the quality of the products and there is often less labor required than with cold runner molds. Also, the use of regrind is sometimes not possible, which makes the justification of a hot runner easier.

Figure 4.12 Selection of typical automotive products