Ejector pins and sleeves

School of Technology and Management, Polytechnic Institute of Leiria

At the most basic level, moulds consist of two main parts: the cavity and core. The core forms the main internal surfaces of the part. The cavity forms the major external surfaces. Typically, the core and cavity separate as the mould opens, so that the part can be removed. This mould separation occurs along the interface known as the parting line. The parting line can lie in one plane corresponding to a major geometric feature such as the part top, bottom or centerline, or it can be stepped or angled to accommodate irregular part features. Choose the parting-line location to minimize undercuts that would hinder or prevent easy part removal. Undercuts that cannot be avoided via reasonable adjustments in the parting line require mechanisms (Slide Mechanisms) in the mould to disengage the undercut prior to ejection.

The mould base comprises the majority of the bulk of an injection mould. Standard off-the-shelf mould bases are available for most moulding needs. Typical moulds bases are outfitted with a locating ring and provisions for a sprue bushing in the stationary half (cavity) of the mould and an ejector assembly in the moving half. Both halves come with clamp slots to affix the mould in the press. The moving half has holes to accommodate bars that connect the press ejection mechanism to the ejector plate in the mould. Leader pins (guide pins) projecting from corners of the stationary half align the mould halves. Return pins connected to the ejector plate corners project from the mould face when the ejection mechanism is in the forward (eject) position. As the mould closes, the return pins retract the ejector plate (if not retracted already) in preparation for the next cycle.

When plastics products and their respective moulds are designed, the location of ejectors is important to ensure proper stripping from the core. By selecting suitable ejector components the visual appearance of the products can be considerably influenced, but it is even more important that the mould performance becomes more reliable and production improves. Usually ejectors are standard parts included in the CAD Standard Elements Software (CAD Library). Those items already suitable can be selected easily during the product design stage.

This document is focused on the design, material, assembling and operation of ejection systems.
Typically, moulds have ejector systems built into the moving half (see following figure). Ejector travel must be sufficient to clear the moulding from fixed members in the mould. Undercuts or "pick-up ribs" may be machined into mould members to insure that the moulded part remains on the ejection side of the mould. Pick-up sizes are determined for the type of the material being used. Parts may be removed from a mould using the common type of ejector or knockout system. Ejectors actuated by an ejector bar must contain push backs or safety return pins to reposition the ejector pins prior to the start of the injection or mould filling cycle.

The ejection unit of the moulding press activates these systems. Rods linking the press-ejector mechanism to an ejector plate in the mould enable the press controller to control the timing, speed, and length of the ejection stroke. Reverse injection moulds eject parts from the stationary side of the mould via independent ejection mechanisms operated by springs or hydraulic cylinders. This configuration facilitates direct injection onto the inside or back surface of cosmetic parts. The added complexity of reverse injection moulds adds to the mould cost. Specialized ejection components, such as knockout (KO) pins, KO sleeves, or stripper plates, project from the mould ejector plate to the part surface where they push the part out of the mould.

Many factors determine the amount of ejector area needed, including the part geometry, mould finish, material-release characteristics, and part temperature at the time of ejection. To prevent damage during ejection, thin-walled parts generally require larger ejectors and greater ejector area than comparable parts with thicker walls.

Draw polishing the mould steel in the direction of ejection generally helps ejection. Thermoplastic polyurethanes, exceptions to this rule, usually eject more easily from moulds with frosted finishes that limit plastic-to-metal contact to peaks in the mould texture.
Careful consideration is essential to decisions concerning the number and area of ejectors to be used and the type of system to be employed for the various types of materials. It must be understood that, in most cases, the part being ejected may, to some degree, be soft due to the high temperature at time of ejection. For lowest cost, moulding parts are ejected when they are just sufficiently hard to prevent distortion and in many cases, the mould itself is heated to achieve maximum feasible temperature at ejection. The following figure illustrates desirable knockout pin locations for soft materials such as polyethylene.

![Ejector pins](image)

**Figure 2 Knockout pin locations. Based on calculation to give minimum bending - shaded areas are preferable ejector pin locations for soft flexible plastics.**

Ejection marks may be styled into the part when desirable by adding design configuration in these areas. This is accomplished by decorating or adding a series of concentric rings on the ejector pin surface.

A summary of standardised ejector pins and sleeves is shown in the table on next page. They are available in two steel grades: (1) tool steel, through-hardened with a hardness of ~60HRC, and (2) hot work steel, with a core strength of ~45HRC and a nitrided surface of ~950HV 0.3. All ejectors made of tool steel have a bright appearance on the shaft, and only the forged head is dark, from the annealing treatment. Depending on the nitriding treatment, the pin surface looks either bright or dull gray. Ejectors that undergo the bath nitriding process (Tenifer treatment) show the typical dull gray surface. For certain applications, e.g., in die-casting molds, this type of surface is most suitable, because the lubricating film adheres better to the surface. Gas-nitrided ejectors have a bright surface because regrinding is required after nitriding. In some cases these pins are subsequently treated by a special sulfating process to obtain a visual appearance similar to that of bath nitrided pins. Plasma-nitrided ejectors also have a bright surface, but the same mechanical properties apply as for Tenifer-treated ejectors. Because a certain amount of wear on ejectors can never be avoided, for a new mold the designer should consider selecting a relatively smaller pin diameter. If worn, this pin can then be replaced by a larger one. For this purpose the suppliers of standards offer oversize ejectors. Remachining of nitrided pins and sleeves in the radial direction is not recommended, because this would remove the ~0.1-mm-thick nitrided layer. Repeating the nitriding treatment is not advisable.
Ejector sleeves are of excellent help in ejecting complex areas of mouldings without the need to reinforce the product with special bosses or ribs. They are available in the same steel grades as ejector pins. For special applications, stepped sleeves are also available as standards. For long ejectors, extension rods (Figure) can be applied to provide stability to thin pins and sleeves. They fit standard ejector components and eliminate the need for expensive custom-made oversize items.

Figure 3 Extension for injector pins and sleeves: 1) screw cap; 2) extension; 3) looking tab; 4) groove; 5) ejector sleeve

On the basis of resistance to buckling, a certain maximum diameter-to-length ratio has been established for all ejectors; therefore, suitable ejector pins with small diameters for large moulds are not available. When extension rods are used, and when ejectors are worn, only the standard ejector, which is mounted to the sturdy rod (2) with a screw cap (1), needs to be replaced. A locking tab (3) pressed into the groove (4) prevents loosening of the screw cap (1). For use with ejector sleeves (5), the extension must be drilled through to suit the core pin diameter \( d \). In every case, the bore in the screw cap must be machined to suit the shaft diameter \( d \) of the pin or sleeve.

For special ejection applications under thin ribs or extremely narrow contours, blade ejectors are available.
<table>
<thead>
<tr>
<th>Drawing</th>
<th>Designation Standard</th>
<th>Material</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="2D Drawing" /></td>
<td>Ejector pin with cylindrical head DIN 1530-A ISO 6751</td>
<td>Hot Work Steel 1.2343</td>
<td>Nitrided ≥ 950 HV 0.3 Core strength ≥ 1400 n/mm²</td>
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<tr>
<td><img src="image2.png" alt="3D Drawing" /></td>
<td>Tool steel 1.2516</td>
<td>Through hardened 60±2 HRc</td>
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<td><img src="image3.png" alt="2D Drawing" /></td>
<td>Shouldered ejector pin with cylindrical head DIN 1530-C ISO 8694</td>
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<td><img src="image4.png" alt="3D Drawing" /></td>
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<td>Through hardened 60±2 HRc</td>
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<td>Ejector pin with conical head DIN 1530-D</td>
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<td>Blade ejector DIN 1530-F ISO8693</td>
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Figure 4 Special blade ejector example: 1) ejector blade; 2) guide bushing; 3) guide shell halves; 4) split guide

The very thin ejector blade (1) is solidly held by the guide bushing (2) and is supported along its entire length by the guide shell halves (3). This design prevents buckling and ensures reliable ejection. To facilitate assembly, a split guide bushing is available, which can be mounted in a bore just below the cavity. Difficult machining of the blade slot through the cavity block can thus be eliminated.

Figure 5 Assembly example of ejector pins.

Undercuts, part features that prevent straight ejection at the parting line, tend to increase mould complexity and lead to higher mould construction and maintenance costs. Whenever feasible, redesign the part to avoid undercuts.

Minor part design changes can often eliminate problematic undercuts in the mould. For example, adding throughholes can give access to the underside of features that would otherwise be undercuts. Undercut features that cannot be avoided through redesign require mechanisms in the mould to facilitate ejection. These types of mechanisms include side-action slides, lifter rails, jigger pins, collapsible cores and unscrewing mechanisms. The remainder of this section discusses these options.

Side-action slides use cam pins or hydraulic (or pneumatic) cylinders to retract portions of the mould prior to ejection. Cam-pin-driven slides retract as the mould opens (see following figure). As the mould closes, the cam pins return the slides to their original position for the next injection cycle. Slides driven by hydraulic or pneumatic cylinders can activate at any time during the moulding cycle, an advantage in applications requiring the slides to actuate prior to mould opening or closing.
Shallow undercuts can often be formed by spring-loaded lifters or lifter rails attached to the ejector system. These lifters move with the part on an angle during mould opening (see following figure a) or ejection until the lifter clears the undercut in the part. A variation on this idea, the “jiggler” pin (see following figure b), has angled surfaces to guide the pin away from the undercut during ejection, then return it to the moulding position as the ejector system retracts.

Figure 6 Slide mechanisms: a) and b) motion activated by guided pillars c) motion activated by non-circular geometries d) e) motion activated by springs f) interior slide mechanism g) motion activated by hydraulic or pneumatic systems.

Figure 7 Lifter rails attached to the ejector system: a) angled lifters; b) lifter rail with angled surfaces.
Features such as internal threads, dimples, slots, or grooves on the inside of holes or caps may require collapsible cores.

These complex cores are made in segments that collapse toward the centre as they retract during mould opening (see following figure). As soon as the inner core is retracted, the segments move inward, thereby releasing the product. Setting up of moulds is easy, because adjusting the collapsible cores is done during mould construction and mounting of additional devices is not required. The collapsible cores are hardened and ready to use, except for the grinding of the required threads or undercuts.
Figure 10  Collapsible cores for external moulding of part surfaces.

Figure 11  Collapsible cores for interior moulding of part surfaces: a) scheme of assembling and operation of an anterior collapsible core; b) collapsible core.
Small size cores are supplied with segments separated from each other by fixed ribs. Consequently, undercuts on the moulding, e.g., threads, also show an interruption on the circumference. During ejection there might be a danger that products will stick to the core, and it is suggested that an air blow off be used; in addition, infrared safety devices or weight check scales can ensure that all products have been ejected. Available in a variety of standard sizes from various mould-component suppliers, these specialty cores are typically modified to produce the desired undercut shape. The number and complexity of individual core components limit the minimum size of collapsible cores. Collapsible cores are rarely used for inside diameters less than 16 mm.

Using the same operation principle of both, lifters and collapsible cores, with the flexible core concept small undercuts can be easily released.

![Flexible cores](image)

**Figure 12** Flexible cores: a) operating; b) examples of several different geometries

For products with internal threads, special considerations are required when designing the unscrewing mechanism. A variety of devices can drive the rotation of the threaded cores, including rack-and-pinion devices actuated by mould opening (following figure a), motors, or hydraulic cylinders (following figures b and c); or motor-driven gear and chain mechanisms.

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**Flexible cores**

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**Unscrewing mechanisms**
The mould design should include provisions to lubricate the various moving parts of the unscrewing mechanism. Slides, cams, collapsible cores, and unscrewing mechanisms add to the cost and complexity of the mould, as well as the mould maintenance cost. It would be of advantage to integrate the unscrewing drive into the mould, where the rotation is initiated by a lead screw driven by the mould-opening motion. When the mould is installed, only a specified opening stroke needs to be set; therefore, such unscrewing moulds are also very suitable for automatic mould changing.

Figure 13 Application of unscrewing drive components: 
a) activation components using hydraulic or, pneumatic activated pistons; b) activation of rotation using the mould movement; c) actuation of rotation using the hydraulic machine ejector.
In some injected parts the ejection must be done using, accelerated ejector pins. The application of these systems turns possible, both the ejection of some undercut features and the ejection in one orientated direction.

The following figures show standards systems that have a very easy operation. Internally the system has a rack and rotates the wheel that gives an advance to the extractor pin assembled (following figure a). The acceleration of the central ejector pin is useful in order to prevent hanging of the injected part in the ejector pins. The application of these kinds of systems can avoid the intervention of a human or robot to remove the part from the mould.
Figure 14  Standard ejection accelerators (on left) and example of application and operation (on right)

The following figure shows a system for accelerating ejection developed by a Portuguese mould-making company.

Figure 15  Customised system for accelerating the ejection.

The release of large box-type shapes or similar products is substantially assisted with the use of air poppet valves or ejection pins pressurized with air. Ejection difficulties can arise if a vacuum forms between the part and mould during ejection. Typically, this difficulty develops in deeply cored, closed-bottom parts. Mould components such as air-poppet valves (see figure) can alleviate the problems. Air poppet valves relieve the vacuum and deliver pressurized air between the part and mould surface during ejection. The air poppet valves are built into the cores of the injection moulds. The spring-loaded conical seat is pushed forward by the application of compressed air at the same time as ejection starts. In some cases it is even sufficient for the poppet to open by itself during ejection to break the vacuum. Air poppet valves are mounted with press fit into the molding surface. To facilitate machining, auxiliary tools such as counter bores and reamers are available. Appropriate devices and fittings for air supply are offered by the suppliers of these standard components.
Figure 16  Ejection systems assisted by air pressure: a) Air puppet valves (left) and operation (right); b) Ejection pins assisted by air pressure (left) and operation (right); c) example of a mould with an air puppet valve.
Designs requiring thin walls or areas which have undercuts on the interior require one stage of ejection to remove the parts from the cams or the mould force forming the inner feature design and the second stage to remove the part from the mould. This double system permits the part to be freely ejected from the mould. This design maybe used for all materials. It is illustrated by the following figures. The ejection motion of the machine is automatically subdivided into two stepless adjustable strokes. The return travel is performed with either the hydraulic machine ejector or/and, in case of mechanical operation, the return pins of the mould.

**Figure 17**  Two-Stage ejection: concept (left) and application example (right).

Two-stage ejection can be supported by the application of latches devices (see last figure) however, latches are often used on injection molds with two mold parting levels. At least two latch assemblies are symmetrically mounted on the outside of the mould. During mould opening, one parting level opens first; after traveling a prede-termined distance, the locking mechanism of the latch is released and the second parting level opens. This kind of standard latch puller is used preferably with three-plate molds in which one parting level must open for the sprue and runners and the other parting level must open to allow the products to fall down. The classic design of a latch unit is shown in the following figure a). A hinged latch bar remains in its engaged position over a certain distance and then opens by the action of a cam. When the mould is closed, a leaf spring holds the hook in the locked position. Proper function of this spring must be checked when assembling this unit.
Another design of a latching unit is shown in following figure b). Both the housing and the base plate are mounted on the pulled plate. It is recommended to screw the latch bar on the movable mould half and the control bar on the fixed half. During mould opening, parting plane I opens first, until the slope S of the control bar (2) disengages the sliding lock (3). Parting plane II now starts to open. The stroke of the pulled plate is to be limited in this position, e.g., with shoulder screws. The length of the slope corresponds to the minimum stroke of the latch-locking unit. In this area, only low

During mould-opening movement, if there is another motion within the mould before the opening of parting plane I starts, a third parting plane must be provided as required. In this case the latch bar travels the delayed stroke \( H_c \) before the actual hooking starts.

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**Figure 18**  Standard latch pullers: a) latch puller with slide-hinged latch bar; b) Latch device; c) Latch locking unit and operating sequence: I, II, III – Mould parting lines 1- Latch bar 2- Control bar 3- Sliding bolt S- Slope Hv – Lost motion
Although the above-mentioned latching units are mounted from the outside, there are also round latching units available that are assembled in bores inside the mould. So-called friction pullers may be used to advantage for medium pulling forces and where positioning accuracy is not important. They transmit axial forces through friction between a plastic sleeve and the bore wall. The friction force is infinitely adjustable with a tapered, self-locking screw. These standard items can also be used effectively in three-plate molds; they can also be used as a "brake" to slow down a motion or as a "damper" to prevent shocks when plates collide. The stroke of the floating plate must be limited in the direction of pulling, e.g., by shoulder screws. Note that when the mould is being closed, the mould protection mechanism of the machine is affected by these frictional pullers. Lubrication of the pullers is not permissible.
References


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