Introduction to the injection mold at MÜHLBEYER Werkzeug- und Formenbau GmbH for trainees

Tool design

Most mold plates are divided into the nozzle side and the ejector side. In both halves the negative contour of the casting is present as a cavity. The casting machine separates these two mold halves, after the casting process (injection) and solidification. The casting remains in the ejector side and is ejected with the separate ejection device. The contour of the injection molding does not allow undercutting in the opening direction. If the contour still needs undercutting, additional slides are installed, which are retracted before the ejection process.

Parts of a typical form are:

- clamp plate
- mold plate gate
- mold plate ejection side
- spacer strips for the ejector plates
- ejector plates with the ejector tappets
- clamp plate
- connections for the cooling holes
- hot runner or cold runner nozzle
If necessary, sliders are added.

For high numbers of pieces, permanent molds are made of steel for injection molding (plastic) or die casting (metal). This is also referred to as steel forming, which is closely related to tooling.

There are also so-called "master forms" and the corresponding inserts call themselves "changeable inserts", which can be exchanged. There are also tools with fixed inserts.

Wear-resistant molds generally consist of hardened or tempered tool steel or hard metal. The mostly very precise shape contours are incorporated by means of different machine tools according to design drawing and NC data, some of them also by hand. This makes the manufacture of a mold expensive, but for the manufacture of components in large quantities, this is more cost-effective and faster than the part production without molds (for example with CNC milling) from a certain batch size (minimum number of pieces).

When a mold is used, a deformed material is brought into the desired shape by the tool. The material can be, for example, soft mats, a granulate or a melt. The material is introduced into the tool (i.e. the mold) by different methods:

- Mineral casting
- Injection moulding (processing of plastics) (thermoplastic, thermoset, elastomer)
- Die casting (processing of non-ferrous alloys, e.g. aluminium, magnesium and zinc)
- Injection moulding
- Fibre Syringes
- Compression moulding
- Extrusion
- Drop forging (metal processing)

These processing methods can be combined with each other. Also, completely different or similar materials can be combined in successive processes.

Tempering

The mold must usually be brought to a temperature adapted to process and material. When processing thermoplastics, the mold must be colder than the melt to cool and solidify in the mold. The cooling of a mold essentially determines the cycle time in production and thus the cost of the serial part to be produced. The better the cooling, the shorter the cycle time.

For duroplastics and elastomers, the tool must be warmer than the molding compound so that it crosslinks in the mold.

In order to achieve a temperature control, bores are generally introduced into the tool in as many as possible complicated circuits, as uniformly as possible and close to the mold part. A liquid medium (e.g. cold water or warm oil) flows through it during the production of the injection molded parts. The interface is usually solved via quick couplings. In doing so, a uniqueness of the feed and return flows as well as a permanent and reliable process should be selected.
The following can be influenced with a tool temperature control:

- cycle time (and thus the cost of the molded part to be produced)
- part warping or shrinkage behavior (quality of the sprayed part to be produced)
- surface finish of the injection molding (e.g. gloss or matt in the plastic injection molding or in Al alloys)
- quality at the point of the injection point
- tool life

A special form is inserts for continuous temperature control by means of cooling channels and a cooling medium to further reduce cycle times.

**Gate system**

In DIN 24450 the term "gate" refers to the part of the injection which is not part of the molded part. The gate system of the mold serves to receive the molten molding material coming from the plasticizing cylinder and to feed it into the mold cavity. The gate, in particular its shape, its dimension and its connection to the injection mold, influences the tool filling process and thus, to a large extent, the quality of a molded part. The interpretation according to purely economic aspects (for example fast freezing and short cycle times) counteracts the quality requirements in many cases, in particular with regard to technical parts.

The gate or the gate system usually consists of several segments. This is particularly evident with multiple tools. The gate system consists of: Stefan Dürr,

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a) The gate cone, also known as a gate pin or gate rod, which takes the plastic molding compound directly from the nozzle which closes the plasticizing cylinder and which leads to the tool on which it is generally perpendicular. In simple tools, it often forms the entire gate system alone. One then speaks of the so-called rodang.

b) The gate or channels, also called gate gate or gate distributor, which connects the gate cone to the gate web or gate web. The essential task, therefore, is to distribute the melt, particularly in the case of multiple tools, in such a way that material of the same state (equal pressure and temperature) simultaneously fills the cavity cavities.

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c) and the gate web, the cross-section of which is mentioned at the beginning of the forming test (DIN 24450). The term “connection” is also used for this purpose.

Usually, the gate system is hardened to withstand temperatures, pressure and abrasion. Often it is also coated to ensure better flow properties.

The material in the gate normally solidifies with the molded part and must be removed mechanically. It is either waste or is recycled. Furthermore, the material volume to be provided per casting process increases by the gate volume, which entails an increased demand for machine capacity. According to the geometry one differentiates between:

- Rod or cone: see above
- Tape or film casting: In this case, the entire width of the molding is cast to minimize stress and distortion.
- Shielding: In the case of rotationally symmetrical forces are usually applied over the entire end face, so that a likewise rotationally symmetrical, shield-like gate is produced.
- Ring or disk inlet: Cylindrical components are often filled from the inside via a disc-shaped gate.

The following gate types are separated independently:

a) Tear-off point: The gate is designed in such a way that a thin deflection point is created at the gate, which tear itself when it is demoulded.

b) Tunneling: Here, a cutting edge separates the gate from the molded part when the tool is opened.

It is also possible to cast without casting. This prevents a solidification of the material in the gate, so that it can be pressed into the cavity and used for the next mold part. In the case of thermoplastics, the melt in the gate system must be kept above the mold temperature so that it remains liquid (hot runner system). For duroplastics and elastomers, the gate system must have a lower temperature than the tool to slow the crosslinking reaction (cold runner system).
By means of needle closing nozzles in the gate area, it is possible to close the gate system during demoulding, but there are also open nozzle systems.

**Ejector**

The ejector unit, or the ejector package, serves to demould a molded or cast part. It essentially consists of an ejector base plate and an ejector holding plate as well as the number of parts depending on the part contour, usually round ejectors. The ejector pins held by the retaining plate by means of a collar are pushed forward by means of ejector pins which is connected to the base plate and the hydraulics of the machine, in order to eject or eject the part from the mold.

For more complex contour contours, the ejector pin can also include more complex functions such as oblique ejectors, contour ejectors, sleeve ejectors or flat ejectors. The ejector package is generally secured by back pressure bolts, which force the package back by force when closing the tool, if it has not been retracted in order to prevent errors in the program sequence and thus to damage the expensive mold parts. Limit switches are also used which check the end position of the package before the closing process.

**Pusher**

Slides are used to remove parts which cannot be removed in the normal demoulding direction. That is, the injected or cast part cannot be released from the mold by the sole opening of the mold in the so-called separation plane. These are called undercuts.

Such undercuts on the mold part can make a mold massively more expensive, even if they are only very small. The position of the undercut, which indicates the direction of demoulding, is also responsible for the expenditure for producing a tool.

Sliders are either mechanically actuated by helical bolts during the opening of the mold or hydraulically to free the molded part or cast part at the undercut.
**Stretching**

In order to secure a mold in the casting machine, a clamping plate is generally used on both sides. This is usually provided with clamping grooves which are adapted to the corresponding machine type.

Today's production requires ever more rapid product changes and thus smaller series that are produced (just-in-time). In the associated frequent changes of the mold on the production machine, a quick-clamping system can be useful. This simplifies the clamping and quick connection of cooling, hydraulics or pneumatics.

The 4 main tasks of an injection molding tool are thus:

- Transfer plastic compound
- Form plastic material
- Cool plastic material
- Eject the molded part
Tool with core pull

A core train is generally understood to be an apparatus which moves tool elements on an injection molding machine. These tooling elements can be cores, slides, jaws, etc. A mostly hydraulic core pull is used whenever an element (core) has to be pulled out of the tool and this does not move mechanically through the opening movement.

Example: Before the tool opens, a core must be pulled out of the article, such as on a backrest of a chair.

The hydraulic lines for controlling the moving parts in and on the tool can be connected and controlled directly at the injection molding machine. The medium oil and the adjustable pressure and times / delays can be adjusted on the injection molding machine. Stefan Dürr, Grundlagen_Spritzgießwerkzeuge.doc

The core train can be moved to specific paths or times in the cycle and is controlled via the machine control. This device can also be actuated pneumatically on the injection molding machine.

The signals for "open / extended" or "retracted" are passed on to the machine control via limit switches. That is, if the core pull control is activated on the machine, the cycle only runs when the limit switches are switched according to the programming.

The hydraulic cylinder is usually fastened by screwing in or inserting it into a groove when some clearance of the piston rod is required.

MÜHLBEYER Werkzeug- und Formenbau GmbH
Raiffeisenstr. 4
D-74177 Bad Friedrichshall
Tel. +49 7136 9460-156 Fax: -19
www.muehlbeyer.de info@muehlbeyer.de