Mould and Die Basic Structure

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Injection moulding moulds and high pressure die casting dies are fabricated to a standard mould set. The standard mould set consists of two clamp plates, two cavity plates, guiding elements between them, an optional back plate, two risers and an ejector set. Ejector set consists of an ejector base plate, an ejector retaining plate and an optional set of buffer plates. Guiding elements are guide pillars, guide sleeves and centering sleeves in each corner of the mould. (See images.)


Mould is divided into two halves: fixed and movable. Movable half consists of one clamping plate, the ejector set, risers and one cavity plate. The fixed half consists of one clamping plate and one cavity plate. Guide pillars and guide sleeves lock the two halves together in vertical and horizontal directions. High pressure die casting and injection moulding machines have a mould closing mechanism, which press the mould halves tightly together.
The basic functional parts in a HPDC die or injection molding mould are:

- **Cavity and cores** (fixed and moving cores), which give the shape to the casting or molding
- **Runner system**, which leads the molten raw material from the machine injection / shot system to the cavities
- **Core moving mechanisms**, which will move the movable cores in in the beginning of the machine cycle and out along with the mould/die opening
- **Ejecting mechanism**, which removes the part from the cavity together with the machine ejection system
- **Cooling/tempering channels**, which keep the thermal balance during moulding or casting operations

The mould/die functional parts act together with the casting/moulding machine. In the machine there are parts for dosing the raw material into the mould/die, parts for producing the core moving forces (electrical, hydraulic or pneumatic), parts for producing the forces for ejection (electrical or hydraulic) and parts for circulating the cooling liquid inside the mould cooling/tempering channels. The system for circulating the cooling liquid may also be separate equipments like HPDC tempering devices.

The space inside the mould in which the part is shaped is called a mould cavity. The surface between the fixed and movable halves is called a parting surface. As the first choice the parting surface should be planar like in the image below. Only if it is absolutely necessary to make stepped or shaped parting surface, this option could be taken into consideration. The two mould halves need to fit tightly together. Otherwise the high pressure inside the mould cavity during moulding operation (or casting shot) will extrude the moulding material to the parting surface. It is more difficult to produce surface flatness to shaped or stepped surfaces than to planar surfaces. It is the surface flatness, which does the tightness between the mould halves.

![Image 3. Left: Mould fixed side with the cavity. The space inside which the part is shaped, is also called a cavity. Right: Mould movable side with a core. The surface between these mould halves is called a parting surface.](image)

A core is any extension in the mould. There are two types of cores: fixed and moving. Note that an extension in the mould is a recession or hole in the part. The fixed cores can be either separated parts or just machined extensions in the mould cavity plates (See image next page.). The part fastens around a core, because all injection mouldable plastics and high pressure die castable metals shrink during cooling. It is practical to place the part into the mould so that as many cores as possible are located in the moving side and as much of the cavity as possible in the fixed side like in the image above. This arrangement fastens the moulded part to the moving side and makes it possible to eject it in the right time.
As you can see in the image above, all cores are prepared with angled vertical surfaces. None of the vertical surfaces is perpendicular to the parting surface. The angle is called a draft. All moulded part or high pressure die casting vertical surfaces must be prepared with a draft angle. Otherwise it is not possible to eject the casting out of the mould. The angle size depends on the material of the part and in the case of injection moulded parts also on the surface texture. The deeper shapes there are in the texture the larger draft angle is needed. The draft angle in the outer and inner surfaces takes an opposite direction.

The parting surface is set to the line in the part where the draft direction changes. In the following example (Image 5 below) the part is cup-shaped and the parting surface is placed to the outer corner of the cup opening. If there was a collar around the cup, the parting surface would locate in the collar edge. If the part is flat there are two basic options: Place the parting surface to the middle of the part or on the other side of the part. The selection of the parting surface location has an influence on which corners in the part are rounded and which are not. (See images.)

Image 4. Different fixed core types: a separated core, a core pin and a machined core.

Image 5. Draft angles in a part. Pay attention to the draft angles in a holed boss. The wall thickness enlarges from top to bottom.

Image 6. The same shapes in a mould movable and fixed half. The draft angle enables the part ejection. If the surfaces were perpendicular to the parting surface, the ejection would need to be forceful and most likely there would be drag marks on the part surface. The corner between the part shapes and the parting surface is rounded in the movable (core) half. The corner in the fixed mould half is sharp. This will mean that the same corners in the part must also be rounded or sharp.

Draft angle

Different parting surface and draft angle options
Image 7. Parting surface in a cup-shaped part with a collar. The draft angles are the same. Pay attention that there must be draft angle also in all the collar faces.

Image 8. The same shapes in a mould movable and fixed half. Note that the corner in which the parting surface is located is sharp in the movable half, but rounded in the fixed half with the cavity.


Image 10. A sliding core mechanism. The basic components in this system are: angle pins, slides, guiding rails and slide locking components. The idea is to move cores out of the part during the mould opening movement. After the cores are removed, the ejection is possible.
Sometimes the part has shapes which block the mould opening and/or part ejection. These shapes are called back drafts or counterdrafts. Typical example of such shape is a hole in the side of the moulded part. Back draft requires a moving core to the mould. There are three basic structures: a slide mechanism, a pulling cylinder and a string loaded pulling mechanism.

The part is removed from the mould cavity with standard mould parts called ejectors. Ejectors are round, flat or cylinder shaped pins with a collar on one end. The ejectors are fastened with this collar between the ejector set plates, ejector base plate and ejector retaining plate. (See image 2.) The ejector set is guided with strong ejector pins, ejector returning pins or with special guiding components. The ejector set is fastened to the injection moulding or high pressure die casting machine ejection system. A high pressure die casting mould is fastened with four ejection bars. An injection moulding mould is typically fastened with one ejector pushing component which is placed into the middle of the ejector set plates. Typically the high pressure die casting die ejection set needs only a light guiding system or no guiding at all.

It is possible to produce one, two or several parts with the same mould. A mould with more than a one cavity is called a multi-cavity mould. A mould with only a one cavity is called a single-cavity mould.

Image 11. Ejector pins. The part is removed from the mould cavity with round, flat or cylinder shaped ejectors.

Image 12. A single cavity mould. This type of injection moulding mould can be filled with a very simple runner and gating system, but the sprue bushing must be located in the middle. If it would be more preferable to fill the cavity from the side, single cavity mould is not practical any more. Injection moulding mould sprue and ejector set fastening must locate opposite to each other and both in the center of the plates.
Image 13. Multiple cavity mould. This type of mould gives more freedom in selecting the filling point. In injection moulding moulds there are two types of runner systems: cold runner and a hot runner. Cold runner must be placed to the parting surface and it is removed from the mould cavity together with the part. Hot runner system is placed inside the fixed cavity plate.

There are two different options in injection moulding mould runner and gating systems: Hot runner and cold runner. Cold runner is rather simple. It consists of a gate and a runner. The gate is specially machined and shaped hole to the mould cavity. The runner guides the moulded material to the gate. The hot runner system consists of nozzles and of a specially designed heated channel system, hot runner. Both nozzles and the hot runner are placed inside the fixed cavity plate above the mould cavity.

Image 14. Left: Cold runner in a single cavity mould. Cross section of the mould core plate. Right: The same structure with the moulded part

Image 15. A complete hot-runner system with round nozzles. With this type of runner system the mould can be filled from top of the part, not from the parting surface like with the cold runner system.

High pressure die casting die runner system is completely different from the injection moulding mould runner systems. The runner and gates are always located in the parting surface. There are two basic high pressure die casting machine types: a hot chamber machine and a cold chamber machine, but the runner systems are much alike. The high pressure die casting die gating system consists of bisquit or sprue, runner, gate, overflows and vents. (See images next page.)
Image 16. Left: Runner and gating system for a cold chamber high pressure die casting machine. Right: Runner and gating system for a hot chamber high pressure die casting machine. The main difference is the sprue vs. bisquit and the runner shapes near the sprue.

The injection moulding mould has a tendency either to heat up or cool down during operation. The high pressure die casting dies always have the tendency to heat up too much if nothing is done to maintain the thermal balance. The thermal balance is maintained by circulating heated oil or heated water through mould tempering channels. Injection moulding mould is usually insulated thermally from the machine with insulating plates. High pressure die casting does not need such equipment. The main focus is on cooling the mould down.

Tempering channels can be simple straight drilled holes or they can be shaped according to the mould/die cavity shapes and contain special components which function is to bring turbulence into the cooling agent flow.