Permanent Mould Casting (Gravity Die Casting)

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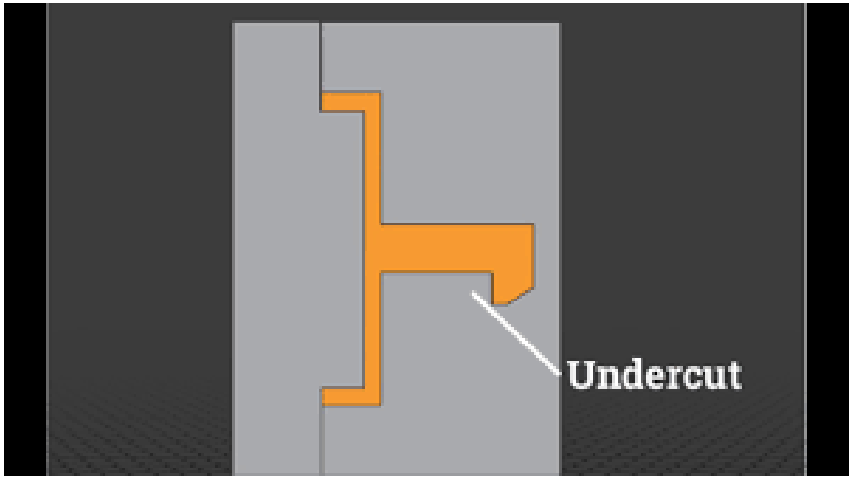
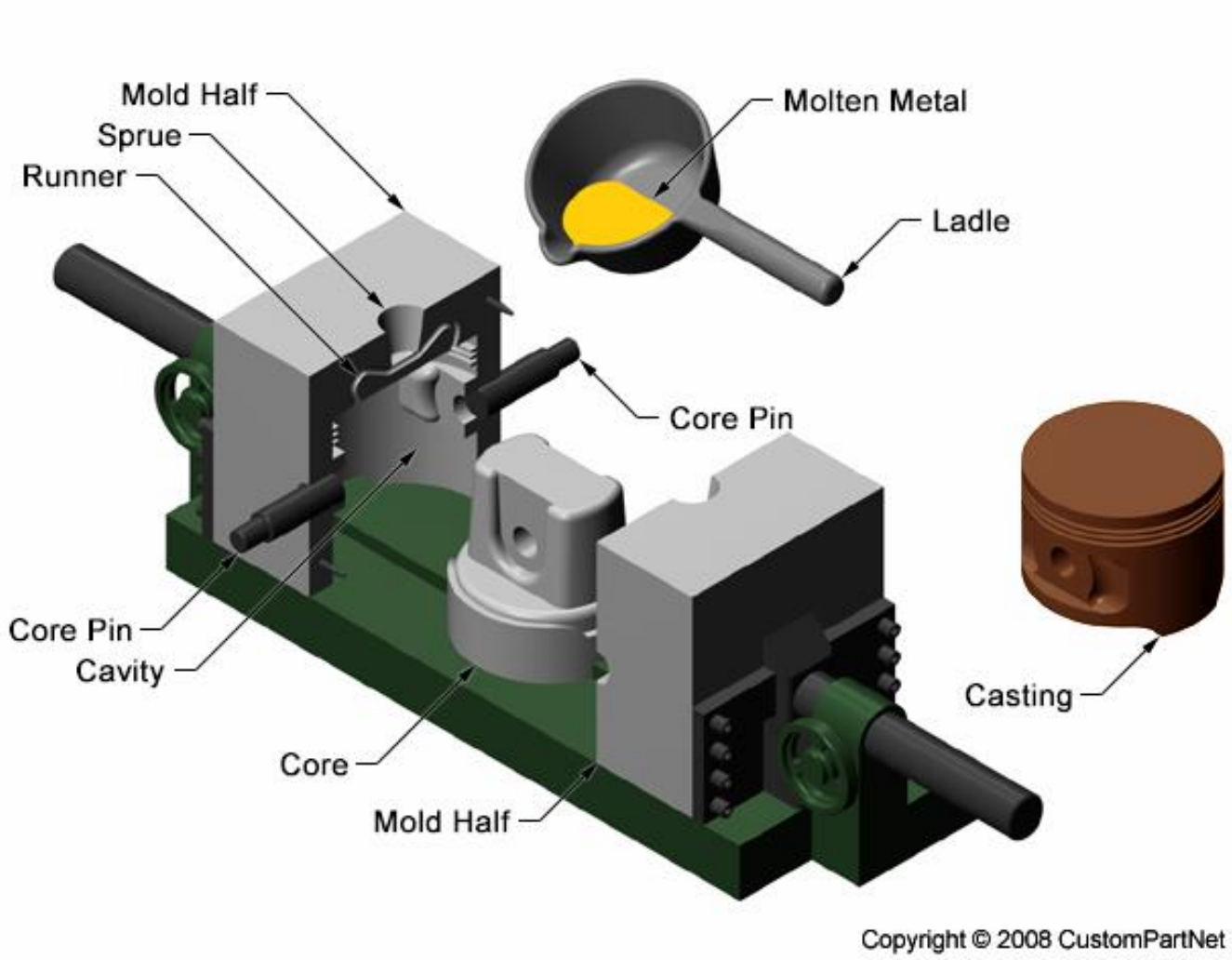
In permanent mould casting, sometimes referred to as gravity die casting, a metal mould consisting of two or more parts is repeatedly used for the production of many castings of the same form. The liquid metal enters the mould by gravity. Simple removable cores are usually made of metal, but more complex cores are made of sand or plaster. When sand or plaster cores are used, the process is called semi permanent mould casting.

Permanent mould casting is particularly suitable for the high-volume production of castings with fairly uniform wall thickness and limited undercuts or intricate internal coring.



The process can also be used to produce complex castings, but production quantities should be high enough to justify the cost of the moulds. Compared to sand casting, permanent mould casting permits the production of more uniform castings, with closer dimensional tolerances, superior surface finish, and improved mechanical properties.


Mold Half
Sprue
Runner
Molten Metal
Ladle
Core Pin
Core Pin
Cavity
Core
Mold Half
Casting
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Permanent mould casting has the following limitations:

- Not all alloys are suitable for permanent mould casting.
- Because of relatively high tooling costs, the process can be prohibitively expensive for low production quantities.
- Some shapes cannot be made using permanent mould casting, because of parting line location, undercuts, or difficulties in removing the casting from the mould.
- Coatings are required to protect the mould from attack by the molten metal.

Metals that can be cast in permanent moulds include the aluminium, magnesium, zinc, and copper alloys and hypereutectic gray iron. Practical sizes of permanent mould castings differ according to materials cast, part configuration, and number of parts needed.

Aluminium Alloys. In high production, permanent mould castings weighing up to 70 kg have been made from aluminium alloys in casting devices. However, much larger castings can be produced. For example, aluminium alloy engine blocks with a trimmed weight of 354 kg have been produced in a four-section permanent mould having a vertical parting line.

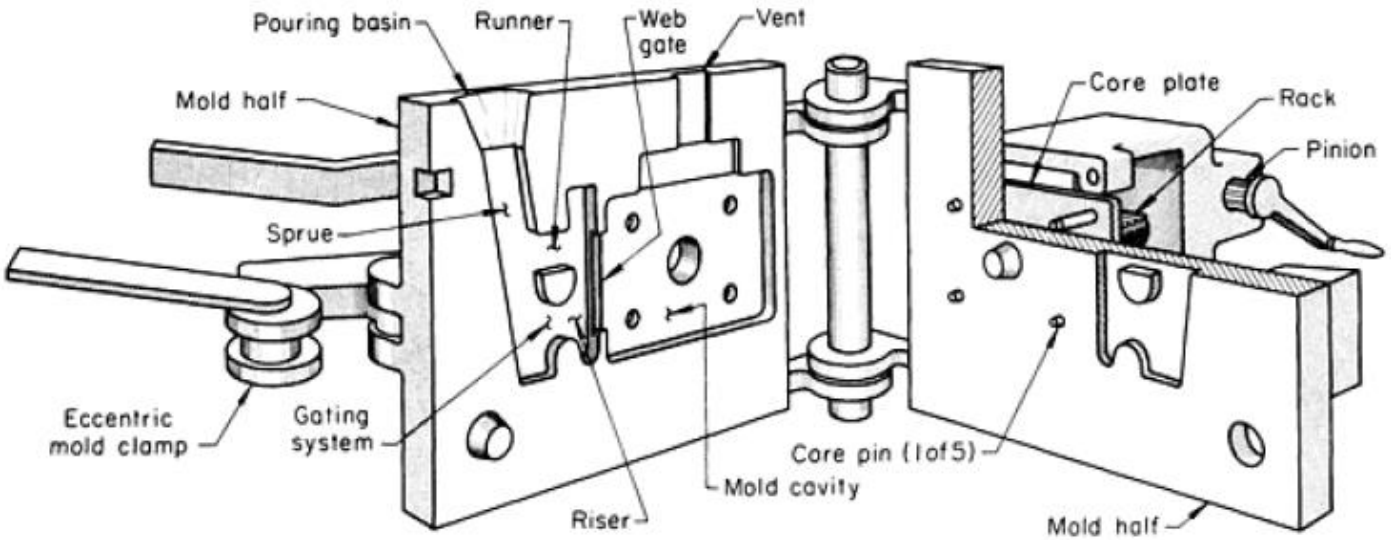
Magnesium alloys, despite their comparatively low castability, have been cast in permanent or semi permanent moulds to produce relatively large and complex castings. For example, an 8 kg housing for an emergency power unit was poured from alloy AZ91C in a semi permanent mould. In another application, 24 kg spoolhead castings 760 mm in diameter were produced from alloy AZ92A in a two-segment permanent mould with vertical parting.

Copper alloy permanent mould castings weighing more than 9 kg can rarely be justified.

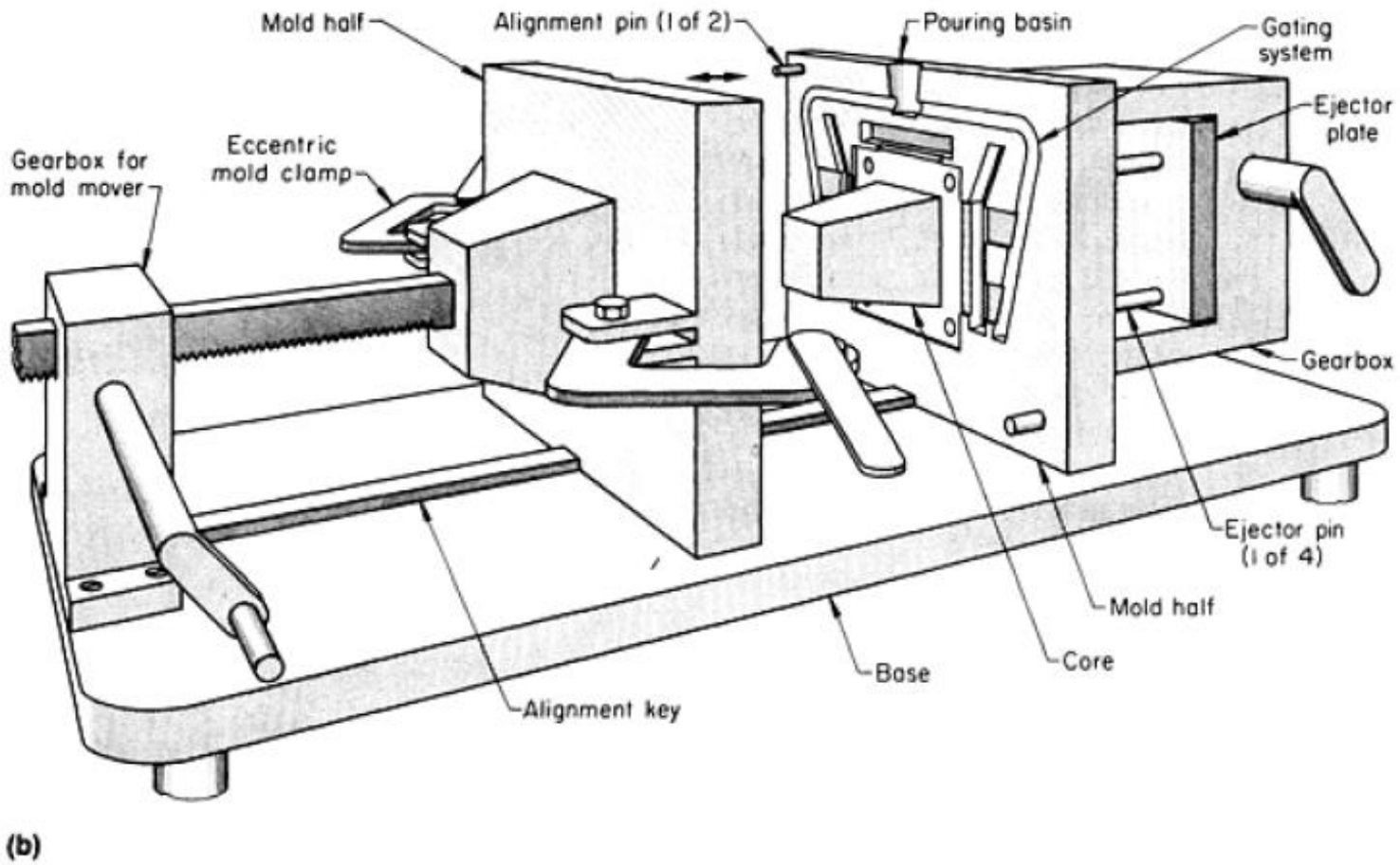
Gray Iron. The production of gray iron castings in permanent moulds is seldom practical when the castings weigh more than 13.6 kg.

Casting Methods

Manually operated permanent moulds may consist of a simple book-type mould arrangement (Fig. a). For castings with high ribs or walls that require mould retraction without rotation, the manually operated device shown in Fig. b can be used. With either type of device, the mould halves are separated manually after releasing the eccentric mould clamps.

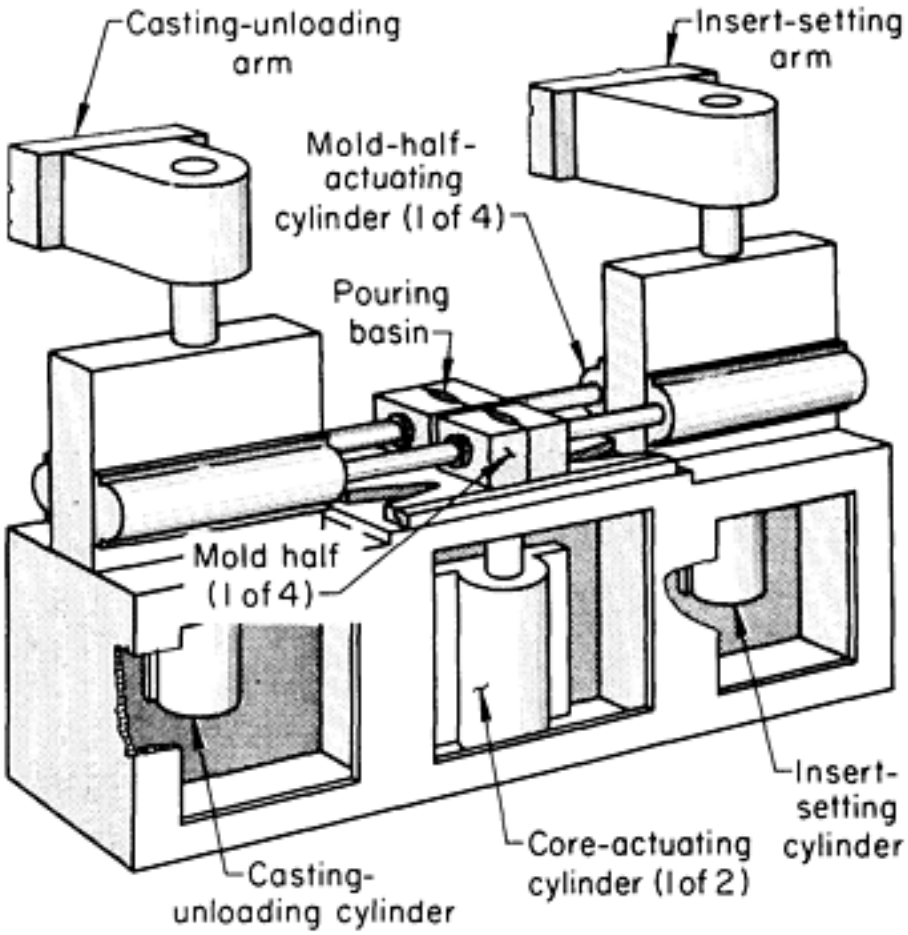


(a)

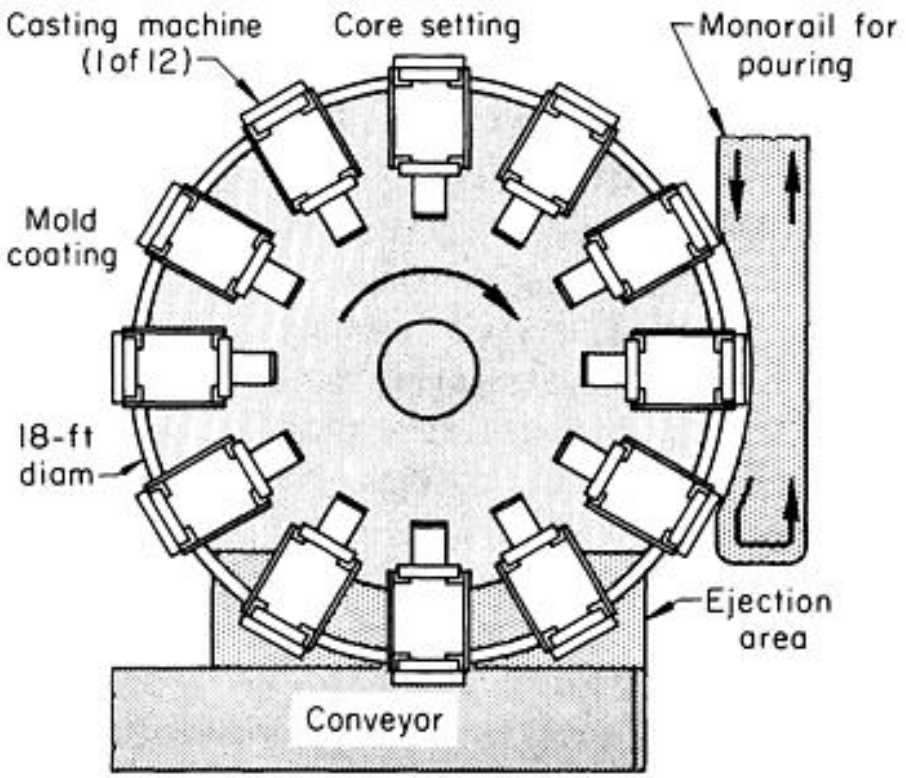


Two types of manually operated permanent mould casting machines. (a) Simple book-type mould for shallow-cavity castings. (b) Device with straight-line retraction for deep-cavity moulds.

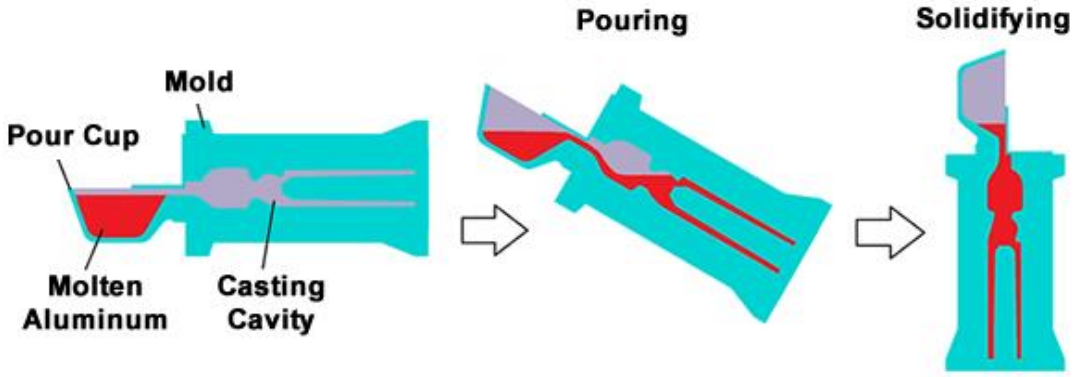
Semi Automatic Devices. For high-volume production, manual drives are replaced by two-way air or hydraulic mechanisms. These units can be programmed to open and close in a preset cycle. Therefore, the operation is automatic except for pouring of the metal and removal of the castings.



Turntables. Small, lightweight castings can be poured and removed manually, but manual handling becomes increasingly difficult as pouring temperatures rise and casting weight increases. The casting process must then be automated. This is often done by using casting machines mounted on a turntable.



Tilt pour type casting machines



Recommended permanent mould materials

Casting alloy	Number of pours		
	1000	10,000	100,000
For small castings (25 mm, or 1 in., maximum dimension)			
Zinc	Gray iron; 1020 steel	Gray iron; 1020 steel	Gray iron; 1020 steel
Aluminum, magnesium	Gray iron; 1020 steel	Gray iron; 1020 steel	Gray iron with AISI H14 inserts; 1020 steel
Copper	Gray iron	Gray iron	Alloy cast iron

Gray iron	Gray iron[a]	Gray iron[a]	Quantity not poured
For medium and large-size castings (up to 915 mm, or 36 in., maximum dimension)			
Zinc	Gray iron; AISI H11[b]	Gray iron; AISI H11[b]	Gray iron; AISI H11[b]
Aluminum, magnesium	Gray iron	Gray iron	Gray iron; AISI H11 or H14[c]
Copper	Alloy cast iron	Alloy cast iron	Alloy cast iron[d]
Gray iron	Gray iron[a]	Gray iron[a]	Quantity not poured

(a) Same composition as being poured.
(b) AISI H11 is used when polish is required on medium-size castings.
(c) For medium-size parts; recommended materials for large parts are gray iron with H11 inserts or solid H11 die steel.
(d) For medium-size parts; large parts are not poured in this quantity.

Mould Life

Mould life can vary from as few as 100 pours to as many as 250.000 pours (or even more), depending on the variables discussed later in this section. A mould for an aluminium piston, for example, can be expected to produce 250.000 castings before requiring repair. After the production of 250.000 more castings, the repaired mould will require a major overhaul. With repeated repairs and overhauls, the mould can produce as many as 3.5 million castings before being discarded. However, a piston mould, with its relatively simple design, will have a much longer life than a mould that requires elaborate internal coring and external inserts, such as a cylinder-head mould.

Major variables that affect the life of permanent moulds are:

- **Pouring temperature:** The hotter the casting metal is poured, the hotter the mould is operated, which leads to rapid weakening of the mould metal.
- **Weight of casting:** Mould life decreases as casting weight increases.
- **Casting shape:** Mould walls are required to dissipate more heat from castings having thick sections than from those having thin sections. When there is a significant variation in the section thickness of a casting, a temperature differential is set up among different portions of the mould. As the temperature differential increases, mould life decreases.

- **Cooling methods:** Water cooling is more effective than air cooling, but it substantially decreases mould life.
- **Heating cycles:** Generally, a continuous run, in which the mould is maintained at a uniform temperature, provides maximum mould life. Repeated heating and cooling over a wide temperature range will shorten mould life.
- **Preheating the mould:** This is done to operating temperature with a gas flame or electric heaters, and it greatly increases mould life. Thermal shock is one of the principal causes of mould failure.
- **Mould coating:** This protects the mould from erosion and soldering by preventing the metal from contacting mould surfaces, thus increasing mould life.

- **Mould materials:** See the table given above.
- **Storage:** Improper storage can lead to excessive rusting and pitting of mould surfaces, which will reduce mould life.
- **Cleaning:** The common practices for cleaning moulds are abrasive blasting, dipping in caustic solution, and wire brushing. Dipping in caustic can be hazardous to the operator. Wire brushing and abrasive blasting can cause excessive mould wear if not carefully controlled. Glass beads are the safest abrasive blast material; their use minimizes dimensional changes due to erosion from the abrasive blast.
- **Gating:** A poor gating system can greatly reduce mould life by causing excessive turbulence and washout at the gate areas.

- **Method of mould operation:** Although the same materials are used to make moulds and cores for both automatically operated equipment and hand-operated equipment, the life of the tool materials on hand operated equipment is shorter because of the abuse the tooling must withstand. Tools for automatic equipment may last up to twice as long as for hand-operated equipment.
- **End use of casting:** If the structural function of a casting is more important than its appearance, a mould can be used for more pourings before being discarded.

Mould Coatings

A mould coating is applied to mould and core surfaces to serve as a barrier between the molten metal and the surfaces of the mould while a skin of solidified metal is formed. Mould coatings are used for five purposes:

- To prevent premature freezing of the molten metal.
- To control the rate and direction of solidification of the casting and therefore its soundness and structure.
- To minimize thermal shock to the mould material.
- To prevent soldering of molten metal to the mould.
- To vent air trapped in the mould cavity.

Types. Mould coatings are of two general types: insulating and lubricating. Some coatings perform both functions. A good insulating coating can be made from (by weight) one part sodium silicate to two parts colloidal kaolin in sufficient water to permit spraying. The lubricating coatings usually include graphite in a suitable carrier.

Coating Requirements. To prolong mould life, a coating must be noncorrosive. It must adhere well to the mould and yet be easy to remove. It must also keep the molten metal from direct contact with the mould surfaces. A mould coating must be inert to the cast metal and free of reactive or gas-producing materials.

Coating Procedure. The mould surface must be clean and free of oil and grease. The portions to be coated should be lightly sand blasted. If the coating is being applied with a spray, the mould should be sufficiently hot (205 °C,) to evaporate the water immediately.

Video links

- https://www.youtube.com/watch?v=Q0xJMKH2Vxc
- https://www.youtube.com/watch?v=vYj_emJ3kOg
- https://www.youtube.com/watch?v=_A6KG010u3o
- https://www.youtube.com/watch?v=Fw4fpDSyXzU
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