Permanent mold casting

Sand casting has two disadvantages:–a new mold is necessary for each casting and dimensional variations from one casting to another.

In permanent mold casting, the two halves of the mold are made of metal, usually cast iron, steel, or refractory alloys. The cavity, including the runners and gating system are machined into the mold halves. For hollow parts, either permanent cores (made of metal) or sand-bonded ones may be used, depending on whether the core can be extracted from the part without damage after casting.

The surface of the mold is coated with clay or other hard refractory material – this improves the life of the mold. Before molding, the surface is covered with a spray of graphite or silica, which acts as a lubricant. This has two purposes – it improves the flow of the liquid metal, and it allows the cast part to be withdrawn from the mold more easily. The process can be automated, and therefore yields high throughput rates. Also, it produces very good tolerance and surface finish.

It is commonly used for producing pistons used in car engines, gear blanks, cylinder heads, and other parts made of low melting point metals, e.g. copper, bronze, aluminum, magnesium, etc.

Mold is a form of cavity into which molten metal is poured to produce a desired shape. **Die** is a metal block used in forming materials by casting, molding, stamping, threading, or extruding.

For nonferrous permanent mold casting, the gravity is used to introduce the metal and the molds are made from steel or cast iron. For casting steel or cast iron, graphite molds are used.

Die casting Processes

Die casting is a very commonly used type of permanent mold casting process. Molten metal is forced into the die by pressure and held under pressure during solidification. It is used for producing many components of home appliances (e.g rice cookers, stoves, fans, washing and drying machines, fridges), motors, toys and hand-tools. Surface finish and tolerance of die cast parts is so good that there is almost no post-processing required. Die casting molds are expensive, and require significant lead time to fabricate; they are commonly called dies.

Advantages of die casting processes:

- Very excellent details and fine sections can be obtained while extending die-life.
- Mostly non-ferrous metals and alloys are cast.
- It is also possible to cast ferrous metals
- Excellent accuracy
- Smooth surface finish
- Low labor cost
- High production rate.

Dies used in Die Casting

- Dies with at least two pieces are made from alloy steel.
- Die sections include cooling water passages and knock-out pins.
- When necessary, metal cores are used in the dies.
- Mechanisms are utilized to retract them before opening the die for removal of the casting.
- Small vents or overflows may be used to discharge trapped air from the cavity.

Common uses: components for rice cookers, stoves, fans, washing-, drying machines, fridges, motors, toys, hand-tools, car wheels.

There are two common types of die casting: hot- and cold-chamber die casting.

1- Hot chamber die casting (Referred to as Gooseneck type machines)

In a hot chamber process (used for Zinc alloys, magnesium) the pressure chamber connected to the die cavity is filled permanently in the molten metal.

Some specifications of the process:

- Metal is melted within the machine.
- Fast operation.
- Cannot be used for higher melting-point metals above 450C (e.g. brass, bronze, magnesium (Mg)).
- Mainly used for low mp e.g. zinc (Zn), tin (Sn) and lead (Pb) base alloys.
- When used with aluminum, there is a tendency to pick up some iron from the equipment.
- Lower injection pressures and speed can be achieved, so castings may be less dense.
- Higher maintenance costs.

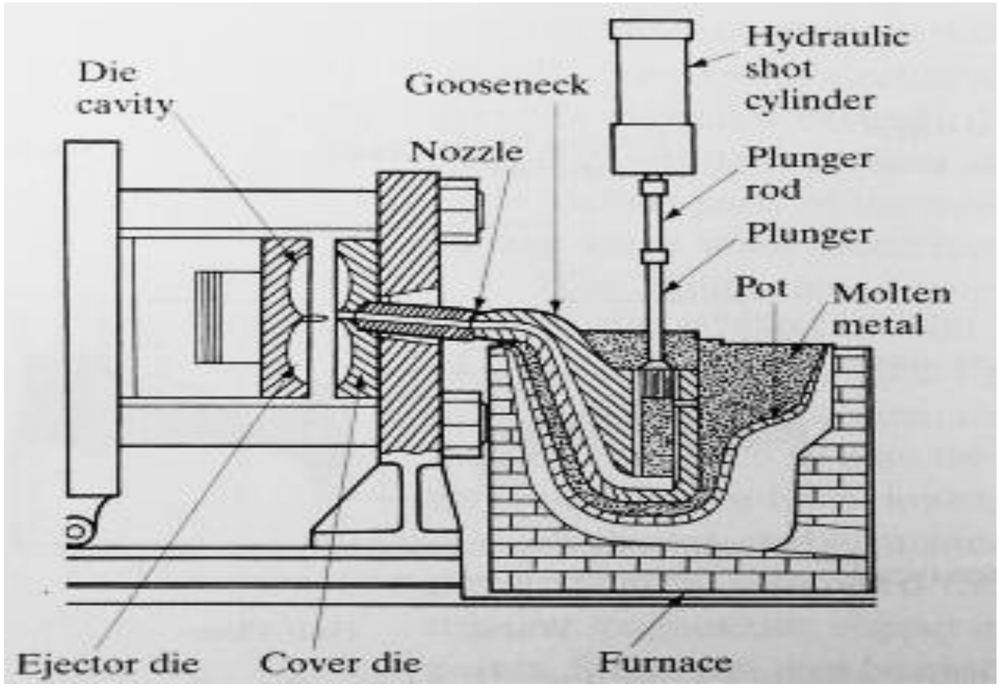
The basic cycle of operation is as follows:

(i) Die is closed and gooseneck cylinder is filled with molten metal.

(ii) Plunger pushes molten metal through gooseneck passage and nozzle and into the die cavity; metal is held under pressure until it solidifies.

(iii) Die opens and cores, if any, are retracted; casting stays in ejector die, plunger returns, pulling molten metal back through nozzle and gooseneck.

(iv) Ejector pins push casting out of ejector die. As plunger uncovers inlet hole, molten metal refills gooseneck cylinder.



Hot chamber die casting machine

2- Cold chamber die casting

The molten metal is poured into the cold chamber in each cycle. Metal is forced into the die by a plunger. Injection pressures over 70 MPa can be obtained from this type of machine. This process is particularly useful for high melting point metals such as Aluminum, and Copper (and its alloys). There is little tendency for iron pick-up.

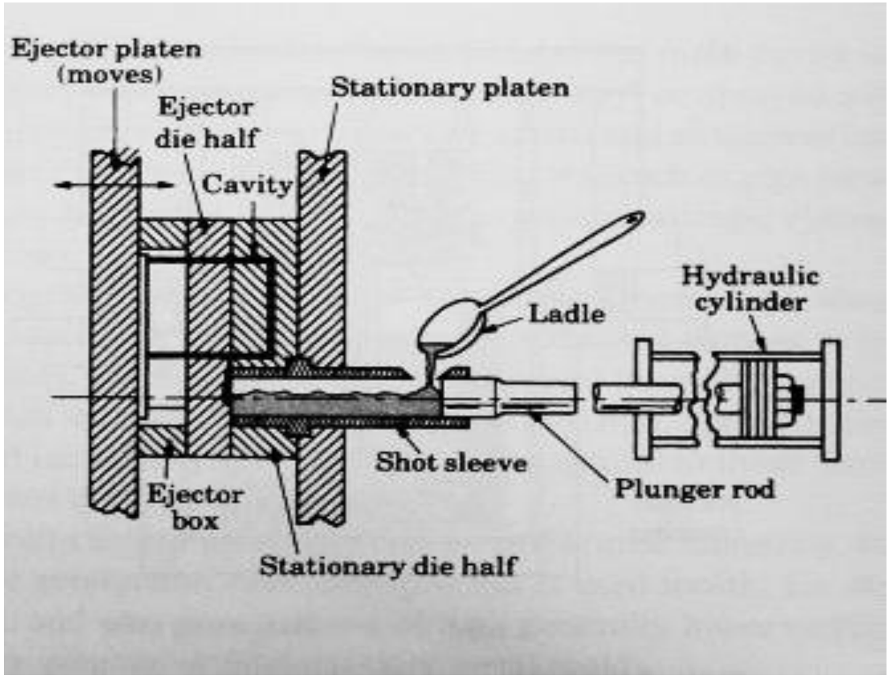
The operating cycle is:

(i) Die is closed and molten metal is ladled into the cold chamber cylinder;

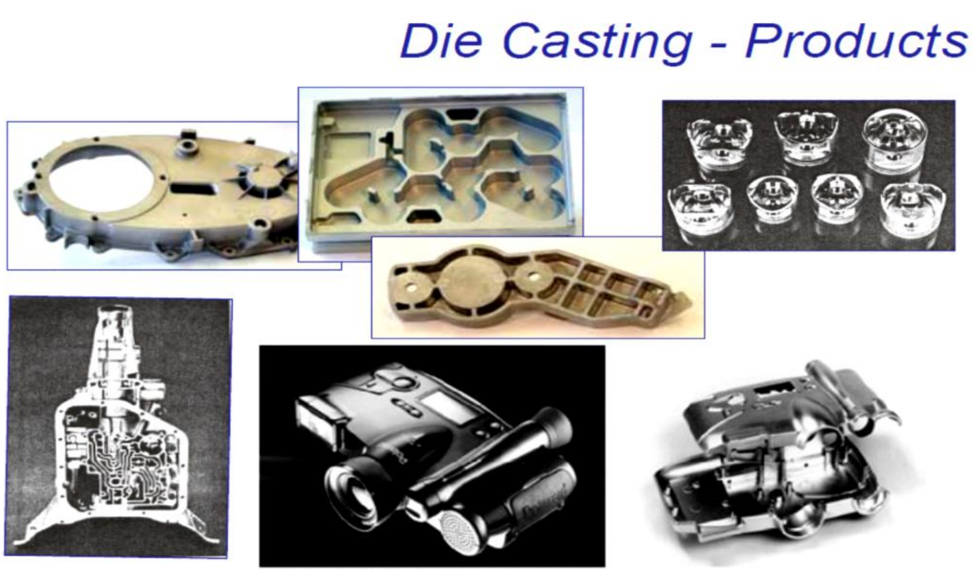
(ii) Plunger pushes molten metal into die cavity; the metal is held under high pressure until it solidifies;

(iii) Die opens and plunger follows to push the solidified slug from the cylinder, if there are cores, they are retracted away;

(iv) Ejector pins push casting off ejector die and plunger returns to original position.

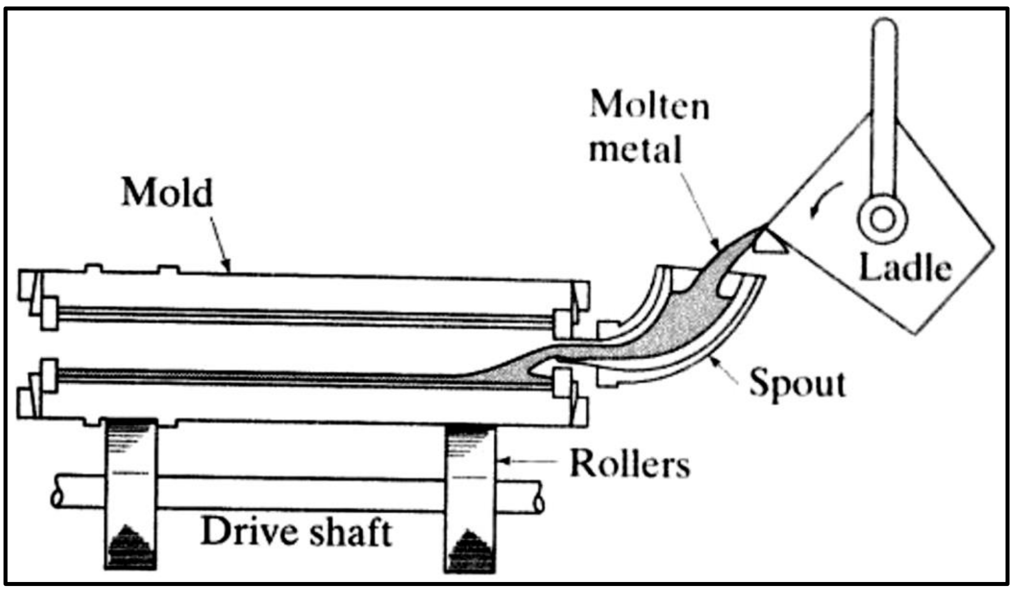


Cold chamber die casting machine

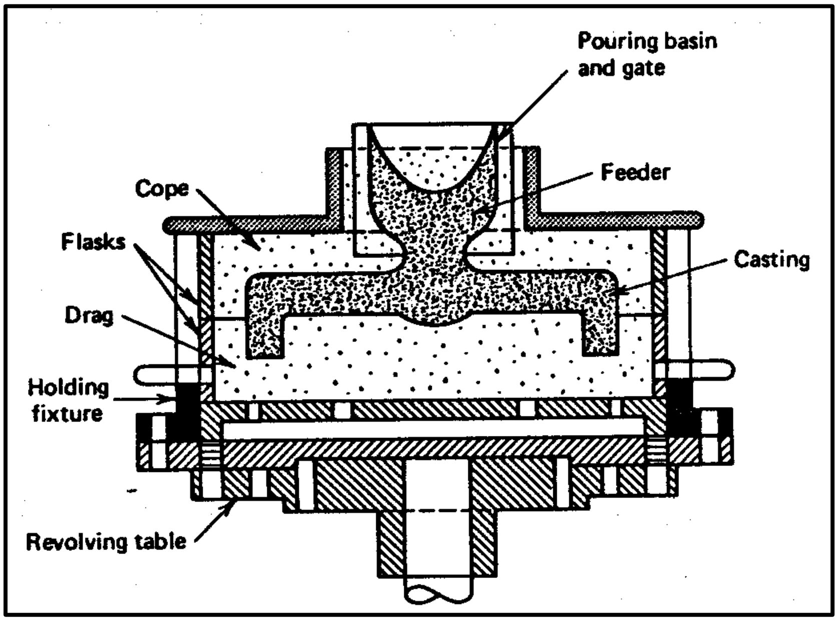


Centrifugal casting

Centrifugal casting uses a permanent mold that is rotated about its axis at a speed between 300 to 3000 rpm as the molten metal is poured. Centrifugal forces cause the metal to be pushed out towards the mold walls, where it solidifies after cooling. Parts cast in this method have a fine grain microstructure, which is resistant to atmospheric corrosion; hence this method has been used to manufacture pipes. Since metal is heavier than impurities, most of the impurities and inclusions are closer to the inner diameter and can be machined away. The surface finish along the inner diameter is also much worse than along the outer surface.



Centrifugal casting schematic [source: Kalpakjian & Schmid]



Centrifugal Casting - Vertical