3.2.4. Pressure Casting, Die Casting and Centrifugal Casting

♦ Pressure casting

In the **pressure casting process** the molten material is forced upward by gas pressure into a graphite mould or metallic mould Fig 3.8. The pressure is maintained until the melt has completely solidified in the mould. The molten material may also be forced upward by a vacuum, which also removes dissolved gases ahead of the rising melt and produces a casting with lower porosity.

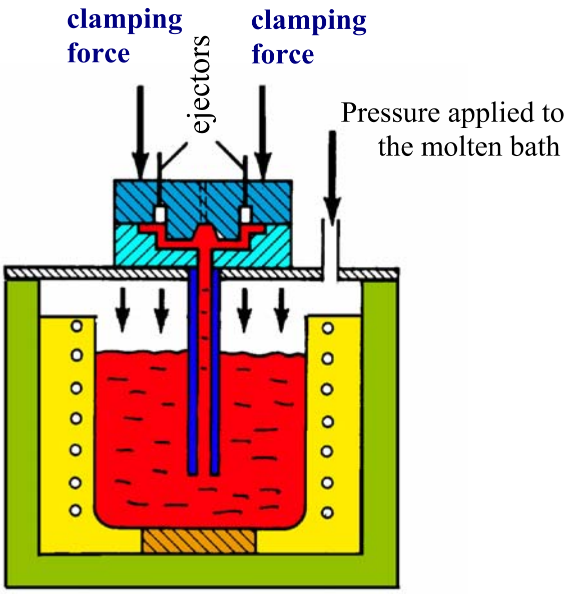

Fig 3.8: Pressure Casting Process [530, 575]

Variations of this method include Vacuum Riserless Casting (VRC) and Pressure Riserless Casting (PRC). These techniques are capable of producing a range of structural and high performance castings exhibiting excellent mechanical attributes and microstructure refinements in an economical manner. While VRC process uses vacuum to draw the liquid material up into a mould cavity, PRC uses pressure applied to a molten bath to force melt into a mould cavity. Yet another approach combines both techniques to achieve appropriate casting conditions.

Squeeze casting developed in the 1960s, involves solidification of the molten material under high pressure Fig 3.9. Thus it is a combination of casting and forging. The machinery includes a die, punch, and ejector pin.

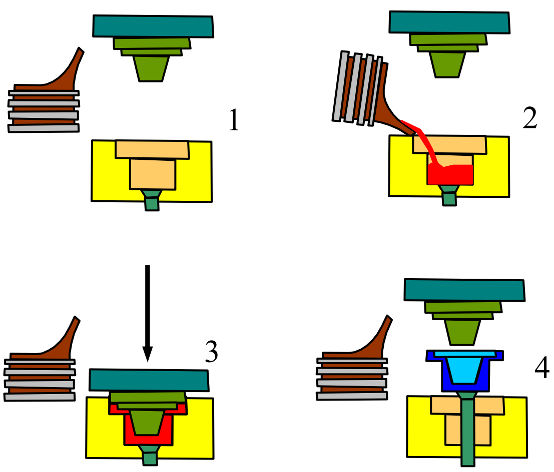

Fig 3.9: Sequence of operations in squeeze-casting:

1. Bring a ladle filled with liquid material close to the dies
2. Pour liquid in the bottom die cavity
3. Close dies and apply pressure
4. Open dies and eject the solidified product

[29, 229, 575]

The pressure applied by the punch keeps the entrapped gases in solution, and the high-pressure contact at the die-product interface promotes rapid heat transfer, resulting in a fine microstructure with good mechanical properties.

Parts can be made to near-net shape, with complex shapes and fine surface detail, from both nonferrous and ferrous alloys. Typical products: automotive wheels and mortar bodies (a short-barreled cannon). The pressures required in squeeze casting are lower than those for hot or cold forging.

♦ Die casting

The **Die-casting** process is a typical example of permanent-mould casting. The molten material is forced into the die cavity at pressures ranging from 0.7 to 700 MPa. Typical products are carburettors, motor housings, business machine and appliance components, hand tools and toys. The weight of most castings ranges from less than 90 g to about 25 kg.

The **Hot-chamber process** involves the use of a piston, which traps a certain volume of melt and forces it into the die cavity through a gooseneck and nozzle Fig 3.10.

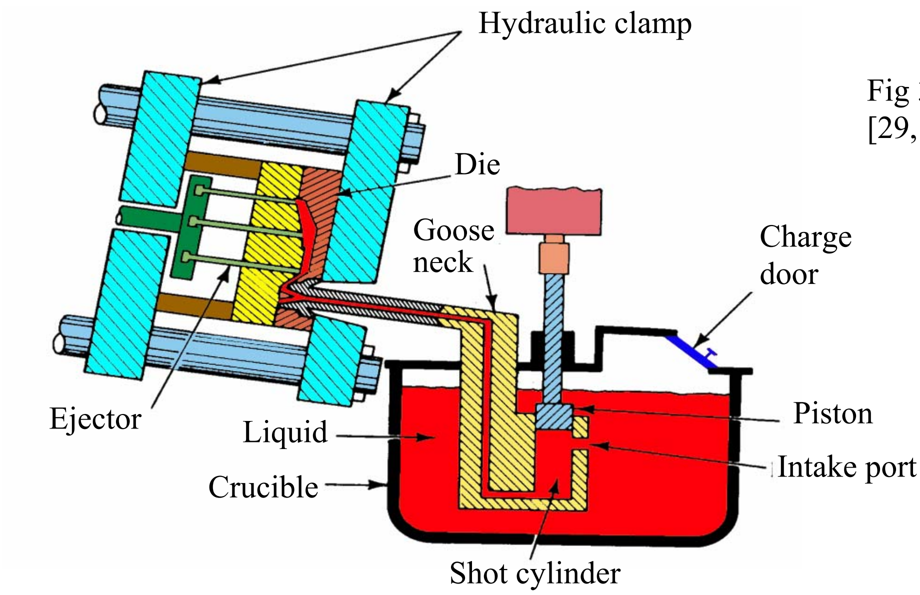

Fig 3.10: Hot-chamber process [29, 229, 326]

The pressures range up to 35 MPa. The melt is held under pressure until it solidifies. To improve die life and to aid in rapid heat transfer, thus reducing the cycle time, dies are cooled by circulating water or oil through passageways in the die block. Cycle times usually range up to 900 shots per hour for zinc, (very small components such as zipper teeth can be cast at 18,000 shots per hour). This process commonly casts low-melting-point alloys of metals such as zinc, tin, and lead.

In the **Cold-chamber process** molten metal is poured into the injection cylinder with a ladle Fig 3.11. The shot chamber is not heated. The melt is forced into the die cavity at pressures ranging from 20 MPa to 70 MPa, (in extremes 150 MPa). The machines may be horizontal or vertical.

Process capabilities and machine selection: High-melting-point alloys of Al, Mg, and Cu are cast by this method; ferrous alloys can also be cast in this manner. The dies have a tendency to part unless clamped together tightly. Die casting machines are rated according to the clamping force and range from 25 t to 3000 t. A further factor in the selection of die-casting machines is the piston stroke which delimits the volume of fluid injected into die cavity.

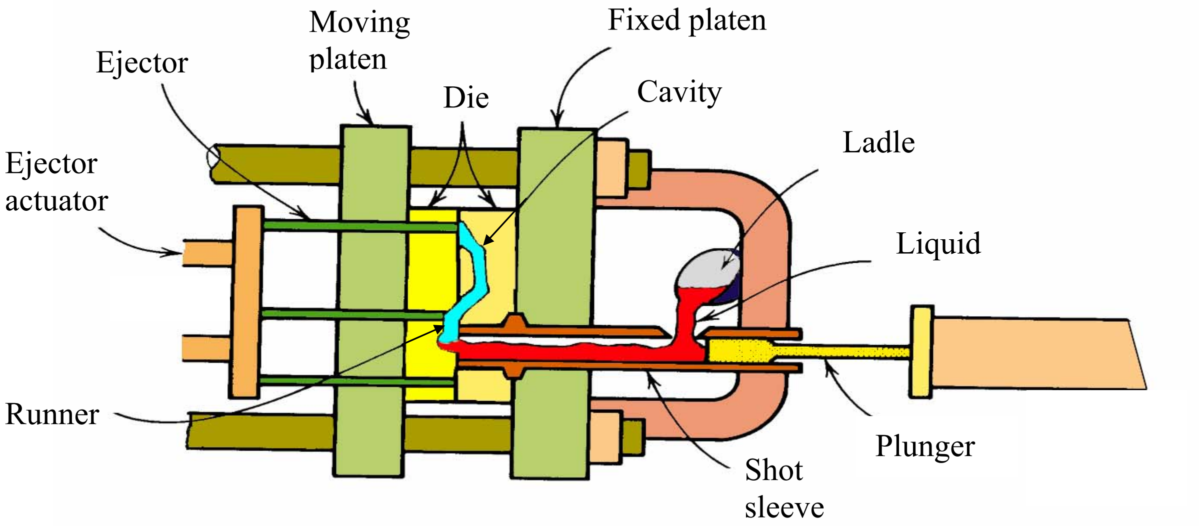

Fig 3.11: Cold-chamber process [530, 575, 576]

Dies may be made for single or multiple cavities. Dies wear increases with the temperature of the fluid. **Heat cracking** of the die surface from repeated heating and cooling can be a problem. However dies may last more than half a million shots before die wear becomes significant.

The entire die-casting and finishing process can be highly automated. Lubricants are applied, as parting agents on die surfaces. Alloys (except Mg alloys) generally require lubricants. Die-casting has the capability for high production rates with good strength, high-quality parts with complex shapes, good dimensional accuracy and surface detail, thus requiring little or no subsequent machining or finishing operations. Components such as pins, shafts, and fasteners can be cast integrally. Ejector marks remain, as do small amounts of **flash** (thin material squeezed out between the dies) at the die parting line.

Die-casting can compete favourably in some products with other manufacturing methods, such as metallic-sheet stamping or forging. Because the molten material chills rapidly at the die walls, the casting has a fine-grain, hard skin with higher strength than in the centre. The strength-to-weight ratio of die-cast parts increases with decreasing wall thickness. With good surface finish and dimensional accuracy, die-casting can produce bearing surfaces that would normally be machined. The cost of dies is somewhat high, but die-casting is economical for large production runs.

♦ Centrifugal casting

Centrifugal casting utilizes inertial forces caused by rotation to distribute the molten material into mould cavities. Variations of this manufacturing method include:
True centrifugal casting,
Semi-centrifugal casting, and
Centrifuging (also called **centrifuged** or **spin casting**).

In **true centrifugal casting**, Fig 3.12, hollow cylindrical parts, e.g. pipes and lampposts, are produced by pouring liquid into a rotating mould. The axis of rotation is usually horizontal but can also be vertical. Moulds are made of steel, cast iron, or graphite and may be coated with a refractory lining to increase mould life. Pipes with various outer shapes, (including polygonal) can be cast. The inner surface of the casting remains cylindrical because the molten material is uniformly distributed by centrifugal forces. Because of density differences, lighter particles such as dross and impurities tend to collect on the inner surface of the casting.

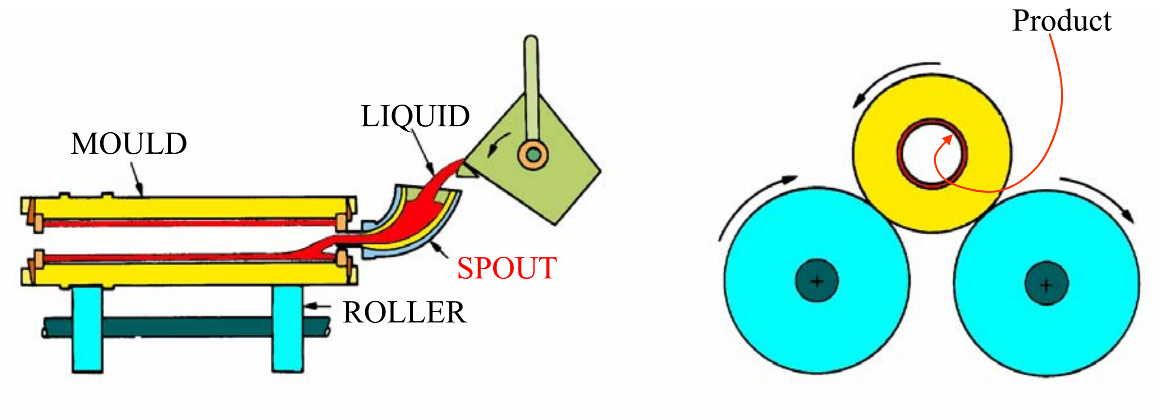

Fig 3.12: True centrifugal casting [531, 575]

Cylindrical parts ranging from ∅13 mm to 3 m in diameter and 16 m long can be produced with wall thickness ranging from 6 mm to 125 mm. The acceleration generated by the centrifugal force is high, as much as 150 g, and is necessary for casting thick-walled parts. This process enables good dimensional accuracy, and external surface detail. Typical products are pipes, bushings, engine cylinder liners, and bearing rings with or without flanges. Apart from metallic products some glass and ceramic products (e.g. TV picture tubes and ceramic membrane tubes) are also manufactured using this technique. (See Section 3.2.6.)

Semi-centrifugal casting is used to cast parts with rotational symmetry, such as wheels with spokes and central hub. This technique can be applied to most expendable and permanent moulds.

In **Centrifuging** mould cavities of odd shape are placed at a certain distance from the axis of rotation. The molten material is forced into the mould by centrifugal forces. The attributes within the castings vary with the distance from the axis of rotation, Fig 3.13.

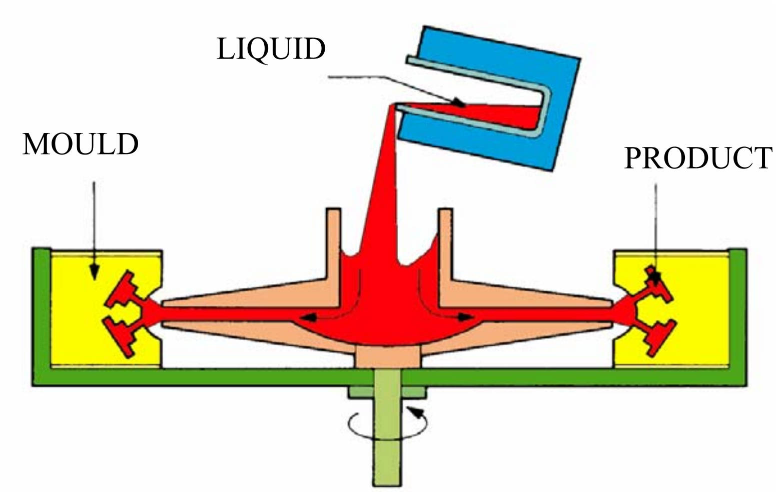

Fig 3.13: Centrifuging

Jewellery is spin cast by placing the investment mould at the end of a rotating arm. Crucible with the molten material is placed on the same arm but closer to, or at the centre of the rotation. The following 3-part clip shows all stages of centrifuged casting of the sterling silver jewellery:
(part 1) (part 2) (part 3)