Metal casting

Manufacturing of a machine part by melting (heating a metal or alloy above its melting point) and pouring the liquid metal/alloy in a cavity approximately of same shape and size as the machine part is called **casting process**. After the liquid metal cools and solidifies, it acquires the shape and size of the cavity and resembles the required finished product. The place, where castings are made is called foundry.

The casting procedure:

(*a*) Preparation of a pattern,

(*b*) Preparation of a mould with the help of the pattern, (*c*) Melting of metal or alloy in a furnace,

(*d*) Pouring of molten metal into mould cavity,

(*e*) Breaking the mould to retrieve the casting,

(*f*) Cleaning the casting and cutting off risers, runners etc., (this operation is called 'fettling'), (*g*) Inspection of casting.

MOULDING SAND AND ITS PROPERTIES

In foundries, river sand is used for making moulds. Sand is chemically SiO2 (silicon dioxide) in granular form. Ordinary river sand contains some percentage of clay, moisture, non-metallic impurities and traces of magnesium and calcium salts besides silica grains. This sand, after suitable treatment, is used for mould making.

Good, well prepared moulding sand should have the following properties:

(*i*) **Refractoriness** *:* it should be able to with stand high temperatures.

(*ii*) **Permeability** *:* ability to allow gases, water vapour and air to pass through it.

(*iii*) **Green sand strength** *:* when a mould is made with moist sand, it should have sufficient strength, otherwise mould will break.

(*iv*) **Good flowability** *:* when it is packed around a pattern in a moulding box, it should be able to fill all nooks and corners, otherwise the impression of pattern in mould would not be sharp and clear.

(*v*) **Good collapsibility** *:* it should collapse easily after the casting has cooled down and has been extracted after breaking the mould. It is particularly important in case of core making.

(*vi*) **Cohesiveness** *:* ability of sand grains to stick together. Without cohesiveness, the moulds will lack strength.

(*vii*) **Adhesiveness** *:* ability of sand to stick to other bodies. If the moulding sand does not stick to the walls of moulding box, the whole mould will slip through the box.

Properties like permeability, cohesiveness and green strength are dependent upon size and shape of sand grains, as also upon the binding material and moisture content present in sand. Clay is a natural binder. Chemical binders like bentonite are sometimes added if clay content in natural sand is not enough.

Generally fresh moulding sand prepared in the foundry has the following composition: Silica 75% (approx.), Clay 10–15%, Bentonite 2–5% (as required), Coal dust 5–10% and Moisture 6–8%

CORE

Whenever a hole, recess or internal cavity is required in a casting, a core, which is usually made up of a refractory material like sand is inserted at the required location in the mould cavity before finally closing the mould. A core, being surrounded on all sides by molten metal, should be able to withstand high temperature. It should also be adequately supported otherwise due to buoyancy of molten metal, it will get displaced.

Cores are made with the help of core boxes. Core boxes are made of wood and have a cavity cut in them, which is the shape and size of the core. The sand is mixed and filled in the core boxes. It is then rammed. A core box is made in two halves, each half contains half impression of core. Sometimes a core may need reinforcements to hold it together. The reinforcements are in the shape of wire or nails, which can be extracted from the hole in the casting along with core sand.

CASTING DEFECTS

Some of the common defects in the castings are described below:

1. **Blow-holes:** They appear as small holes in the casting. They may be open to surface or they may be below the surface of the casting. They are caused due to entrapped bubbles of gases. They may be caused by excessively hard ramming, improper venting, excessive moisture or lack of permeability in the sand.

2. **Shrinkage cavity:** Sometimes due to faulty design of casting consisting of very thick and thin sections, a shrinkage cavity may be caused at the junction of such sections. Shrinkage cavity is totally internal.

It is caused due to shrinkage of molten metal. Remedy is to use either a chill or relocation of risers.

3. **Misrun:** This denotes incomplete filling of mould cavity. It may be caused by bleeding of molten metal at the parting of cope and drag, inadequate metal supply or improper design of gating.

4. **Cold shut:** A cold shut is formed within a casting, when molten metal from two different streams meets without complete fusion. Low pouring temperature may be the primary cause of this defect.

5. **Mismatch:** This defect takes place when the mould impression in the cope and drag do not sit exactly on one another but are shifted a little bit. This happens due to mismatch of the split pattern (dowel pin may have become loose) or due to defective clamping of cope and drag boxes.

6. **Drop:** This happens when a portion of the mould sand falls into the molten metal. Loose sand inadequately rammed or lack of binder may cause this defect.

7. **Scab:** This defect occurs when a portion of the face of a mould lifts or breaks down and the recess is filled up by molten metal.

8. **Hot tear:** These cracks are caused in thin long sections of the casting, if the part of the casting cannot shrink freely on cooling due to intervening sand being too tightly packed, offers resistance to such shrinking. The tear or crack usually takes place when the part is red hot and has not developed full strength, hence the defect is called "hot tear". Reason may be excessively tight ramming of sand.

9. **Other defects** include scars, blisters, sponginess (due to a mass of pin holes at one location) and slag inclusions etc.

Advantages of casting

- Parts of complex shape can be made easily.
- Extremely large as well as extremely small objects can be made.
- The only way to making parts from cast iron is casting
- Casting parts having high strength to compressive forces.
- Melting of metal is required high energy.
- Labour- intensive process
- Time taking process. After finishing each step only we can start next step.(without pattern mould cannot be made.)

DIE CASTING

A sand mould is usable for production of only one casting. Die is essentially a metal mould and can be used repeatedly. A die is usually made in two portions. One portion is fixed and the other is movable. Together, they contain the mould cavity in all its details. After clamping or locking the two halves of the dies together molten metal is introduced into the dies. If the molten metal is fed by gravity into the dies, the process is known as **gravity die casting** process. On the other hand, if the metal is forced into the dies under pressure (*e.g.*, a piston in a cylinder pushes the material through cylinder nozzle), the process is called "**pressure die casting**". The material of which the dies are made, should have a melting point much higher than the melting point of casting material. A great number of die castings are made of alloys of zinc, tin and lead, and of alloys of aluminium, magnesium and copper. Hence dies are made out of low alloy steels. The dies are usually water or air cooled.

Since most materials contract on cooling, extraction of castings from dies becomes important otherwise they will get entangled in the die as they cool. Therefore, in the design of dies, some arrangement for extraction of casting is incorporated.

Forging

Forging is the process in which, metal and alloys are deformed to the specified shapes by application of repeated compressive force from a hammer. It is usually done hot (hot forging); although sometimes forging is done at room temperature (cold forging). The raw material is usually a piece of a round or square cross-section slightly larger in volume than the volume of the finished component.

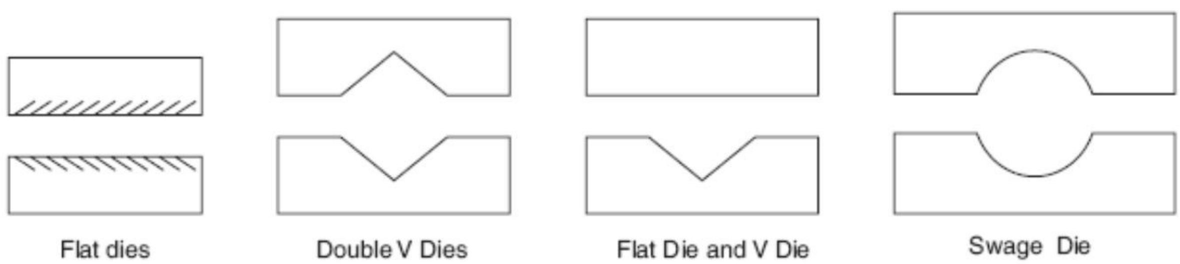
Components produced by forging are bolts, spanners, crane hooks, crankshaft etc

Open-die forging

Open-die forging is also known as ***smith forging***. In open-die forging, a hammer strikes and deforms the work piece, which is placed on a stationary anvil.

Open-die forging gets its name from the fact that the dies do not enclose the work piece, allowing it to flow except where contacted by the dies. Therefore the operator needs to orient and position the work piece to get the desired shape.

The dies are usually flat in shape, but some have a specially shaped surface for specialized operations. For example, a die may have a round, concave, or convex surface or be a tool to form holes or be a cut-off tool.



Closed die forging

In closed-die forging metal is placed in a die resembling a mold, which is attached to the anvil. Usually the hammer die is shaped as well. The hammer is then dropped on the work piece, causing the metal to flow and fill the die cavities.

Depending on the size and complexity of the part the hammer may be dropped multiple times in quick succession. Excess metal is squeezed out of the die cavities, forming what is referred to as *flash*.

The flash cools more rapidly than the rest of the material; this cool metal is stronger than the metal in the die so it helps prevent more flash from forming. This also forces the metal to completely fill the die cavity. After forging the flash is removed.

Net-shape forging

This process is also known as *precision forging*. This process was developed to minimize cost and waste associated with post forging operations. Therefore, the final product from a precision forging not needed final machining.

Cost savings are gained from the use of less material, and thus less scrap, the overall decrease in energy used, and the reduction or elimination of machining. The downside of this process is its cost; therefore it is only implemented if significant cost reduction can be achieved

Rolling

In this process, metals and alloys are plastically deformed into semi finished or finished products by being pressed between two rolls which are rotating.

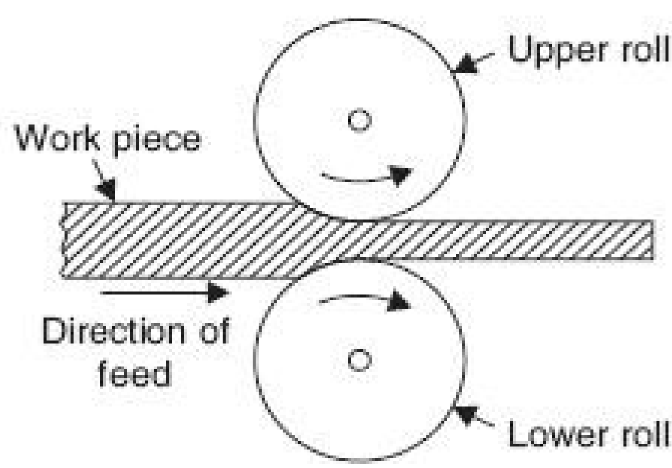
The metal is initially pushed into the space between two rolls, thereafter once the roll grips the edge of the material, the material gets pulled in by the friction between the surfaces of the rolls and the material.

The material is subjected to high compressive force as it is squeezed (and pulled along) by the rolls. This is a process to deal with material in bulk in which the cross-section of material is reduced and its length increased

TWO ROLL PROCESS:

It comprises of two heavy rolls placed one over the other. The vertical gap between the rolls is adjustable. The rolls rotate in opposite directions and are driven by powerful electrical motors. Usually the direction of rotation of rolls cannot be altered, thus the work has to be fed into rolls from one direction only.

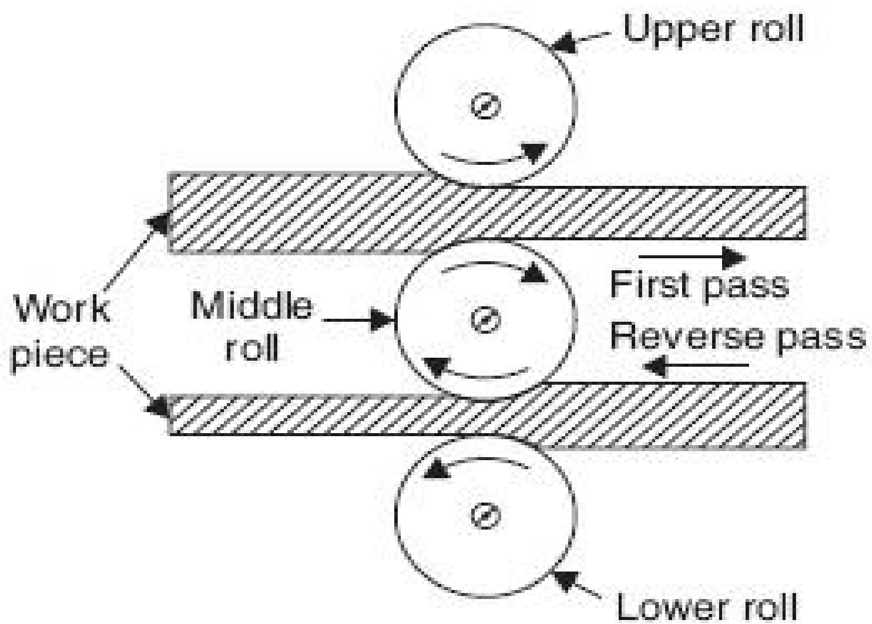
Since transporting material (which is in red hot condition) from one side to another is difficult and time consuming (material may cool in the meantime), a ‘‘two high reversing mill’’ has been developed in which the direction of rotation of rolls can be changed.



Three high mills:

It *consists* of three rolls positioned directly over one another as shown. The direction of rotation of the first and second rolls are opposite as in the case of two high mill. The direction of rotation of second and third rolls are again opposite to each other.

The advantage of this mill is that the work material can be fed in one direction between the first and second roll and the return pass can be provided in between the second and third rolls. This obviates the transport of material from one side of rolls to the other after one pass is over.



rusion

Extrusion

Extrusion is a process in which the metal is subjected to plastic flow by enclosing the metal in a closed chamber in which the only opening provided is through a die. The material is usually treated so that it can undergo plastic deformation at a sufficiently rapid rate and may be squeezed out of the hole in the die. In the process the metal comes out as a long strip with the same cross-section as the die-opening. The process of extrusion is most commonly used for the manufacture of solid and hollow sections of nonferrous metals (Mg,Al,Cu,Ni etc)and polymers etc . However, some steel products are also made by extrusion.

Extrusion processes can be classified as followed:

(A) **Hot Extrusion**

(*i*) Forward or Direct extrusion.
(*ii*) Backward or Indirect extrusion.

(B) **Cold Extrusion**

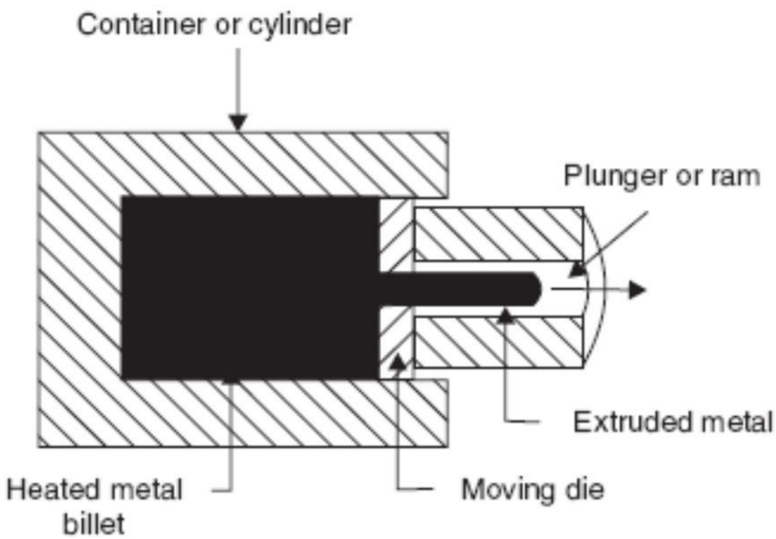
(*i*) Hooker extrusion.
(*ii*) Hydrostatic extrusion.
(*iii*) Impact extrusion.
(*iv*) Cold extrusion forging.

Forward or direct extrusion process:

The material to be extruded is in the form of a block. It is heated to requisite temperature and then transferred to a chamber. This block kept between the ram and die. In the front portion of the chamber, a die with an opening in the shape of the cross-section of the extruded product, is fitted. The block of material is pressed from behind by means of a ram and a follower pad. As the ram moves forward, pressure develops and metal plastically deforms. Since the chamber is closed on all sides, the heated material is forced to squeeze through the die-opening in the form of a long strip of the required cross-section.

Backward or indirect extrusion:

The block of heated metal is inserted into the container/chamber. It is confined on all sides by the container walls except in front, where a ram with the die presses upon the material. As the ram presses backwards, the material has to flow forwards through the opening in the die. The ram is made hollow so that the bar of extruded metal may pass through it unhindered. This process is called backward extrusion process as the flow of material is in a direction opposite to the movement of the ram. In the forward extrusion process the flow of material and ram movement were both in the same direction.



Hydrostatic extrusion:

It is a type of cold extrusion process. In the hydrostatic extrusion process the billet is completely surrounded by a pressurized liquid, except where the billet contacts the die. The fluids commonly used are glycerin, ethyl glycol, mineral oils, castor oil mixed with alcohol etc. these fluids are helpful in reducing the friction between metal block and chamber surface. This is a direct extrusion process. Pressure is applied to the metal blank on all sides through the fluid medium.

The advantages of Hydrostatic extrusion process include:

- No friction between the container and the billet reduces force requirements. This ultimately allows for faster speeds, higher reduction ratios, and lower billet temperatures.

- Usually the ductility of the material increases when high pressures are applied.

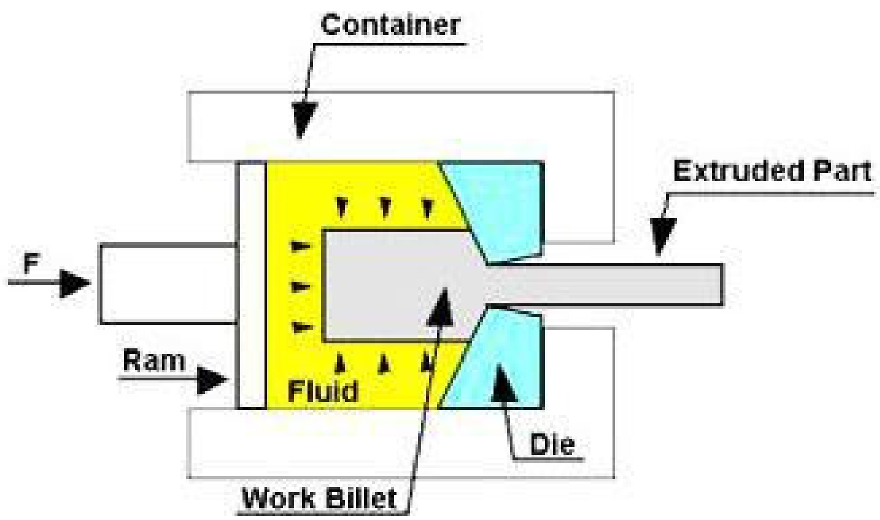
- An even flow of material.

- Large billets and large cross-sections can be extruded.

- No billet residue is left on the container walls.

The disadvantages are

- The billets must be prepared by tapering one end to match the die entry angle. This is needed to form a seal at the beginning of the cycle.
- Handling the fluid under high pressures can be difficult.



Welding

Welding means the process of joining two metal parts together to give strong joint . The welding process is subdivided into two main classes.

1. **Fusion welding:** which involves heating the ends of metal pieces to be joined to a temperature high enough to cause them to melt or fuse and then allowing the joint to cool. The join, after the fused metal has solidified will result in a strong joint.

2. Pressure welding: which involves heating the ends of metal pieces to be joined to a high temperature, but lower than their melting point and then keeping the metal pieces joined together under pressure for some time. This results in the pieces welding together to produce a strong joint

Based on the sources of heat, fusion welding is again classified to different type

Electric arc welding: electric arc is the source of heat

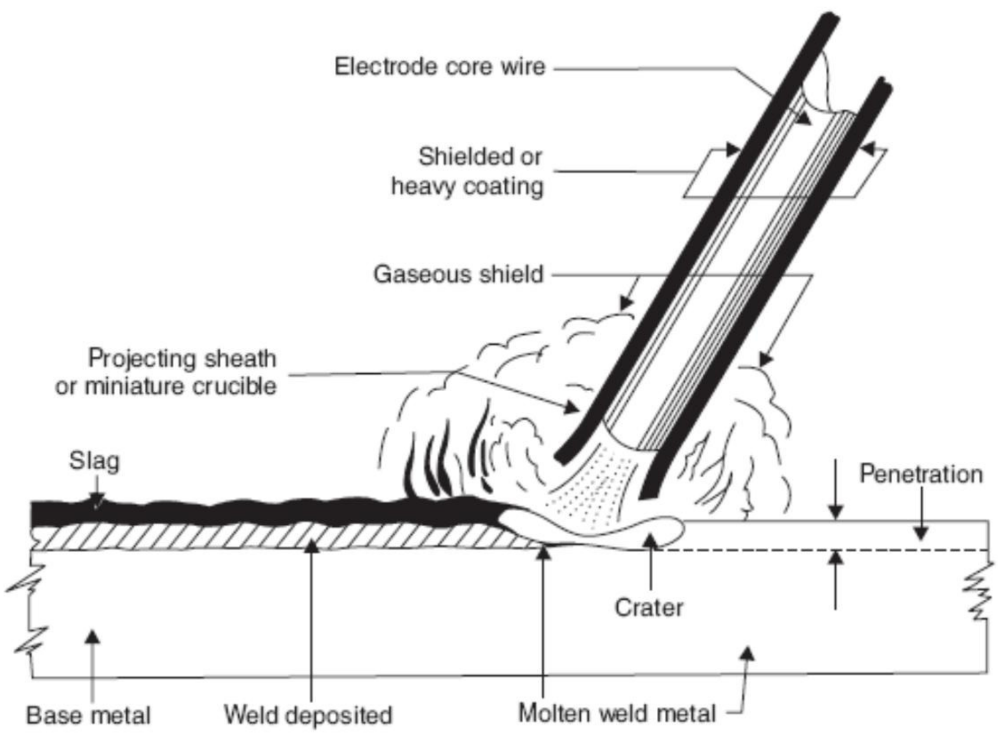
Gas welding: A burning gas is producing the heat. Normally acetylene is used.

Electric resistance welding: heat produced from the electric resistance of material

Thermite welding: chemical reaction is the source of heat. Etc

Laser welding: heat produced using Laser.

Arc Welding)



it is a manual arc welding process that uses a consumable electrode coated with flux. An electric current, welding power supply is used to form an electric arc between the electrode and the metal to be joined. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination

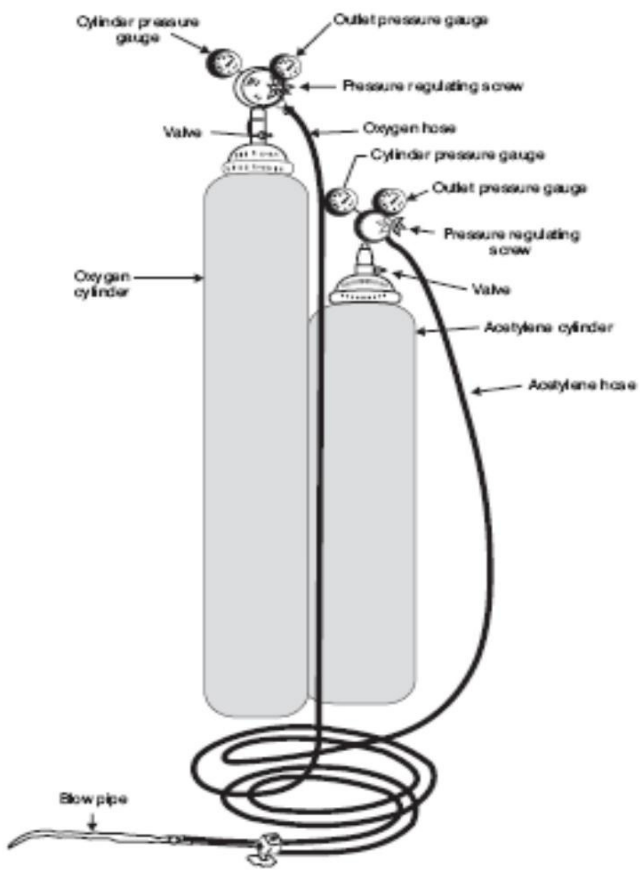
Gas welding

It is a welding process in which required heat is obtained by a combustion of a fuel gas. The heat used to melt the ends of work pieces to be joined an also to melt the filler metal rod(welding rod). Several gas mixtures are using but mainly acetylene is mostly used for welding as it produces high temp. of order of 3200°c. Acetylene gas is obtained by mixing calcium carbide with water

$CaC_2+2H_2O=Ca(OH)_2+C_2H_2$

$C_2H_2+O_2=4CO+H_2$

$4CO+ 2H_2+3\ O_2=4CO_2+2H_2O$



Acetylene and oxygen are stored separately in different cylinders as shown in fig. and these gases are mixed in the welding torch /blow pipe as shown below. Tube from oxygen cylinder and acetylene cylinder are connected to respective valves. These gases are mixed in the mixing chamber and mixture is sent out through the tip of head tube