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Class notes of the production engineering (Th 1) for the 3rd semester ME/AE.

Chapater - 1.0

Metal forming processes

1. INTRODUCTION

Metal forming processes, also known as mechanical working processes, are primary shaping processes in which a mass of metal or alloy is subjected to mechanical forces. Under the action of such forces, the shape and size of metal piece undergo a change. By mechanical working processes, the given shape and size of a machine part can be achieved with great economy in material and time..

Metal Extrusion

Metal extrusion is a forming process in which we force a metal (either hot or cold) through a die. This imparts the die shape to the extruded metal as it passes through the cavity. The material emerging from the die is known as "extrudate".

The metal endures compressive and shear stress to achieve the die shape. The nature of these forces and the elevated temperatures enable us to form materials with otherwise brittle properties using this process.

Key features

Extrusion is a low-cost process due to reduced wastage and has a high rate of production.

It can form brittle materials as it applies only compressive and shear forces on the billet.

The resultant products have an excellent elongated grain structure in the material direction.

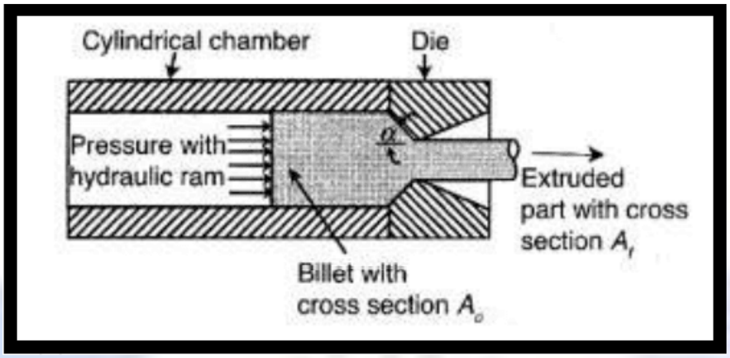
The products also have a smooth surface finish that reduces the amount of post-treatment.

Extremely thin wall thickness can be achieved through extrusion (~3mm for steel and ~1mm for aluminium).

Extrusion can create extremely complex cross-sections with a uniform wall thickness throughout the product.

Classification of the Extrusion Process

The Extrusion Process Is Divided Into ClassesExtrusions can be done in a variety of methods depending on the ductility of the material.



Temperature at work

- Cold extrusion
- Hot extrusion

By physical configuration

- Forward or Direct extrusion
- Backward or Indirect extrusion

The hot metal billet is put into a container in direct extrusion (forward extrusion).

-The material is compressed by a ram, pushing it to flow through perforations in a die at the container's opposite end.

-The metal is plastically deformed, slides along the container's walls, and is forced to flow through the die aperture.

-A little piece of the billet lingers as the ram reaches the die and cannot be driven through the die aperture.

The butt, or superfluous piece, is detached from the result by cutting it slightly beyond the die's exit.

The high friction that arises between the work surface and the walls of the container as the billet is forced to move toward the die hole is one of the challenges with direct extrusion.

In direct extrusion, this friction generates a significant increase in the ram force required.

The existence of an oxide layer on the surface of the billet exacerbates the friction problem in hot extrusion.

This oxide layer has the potential to induce flaws in the extruded product.

A fake block is frequently utilised between the ram and the work billet to alleviate these issues.

The dummy block has a diameter that is somewhat smaller than the billet diameter.

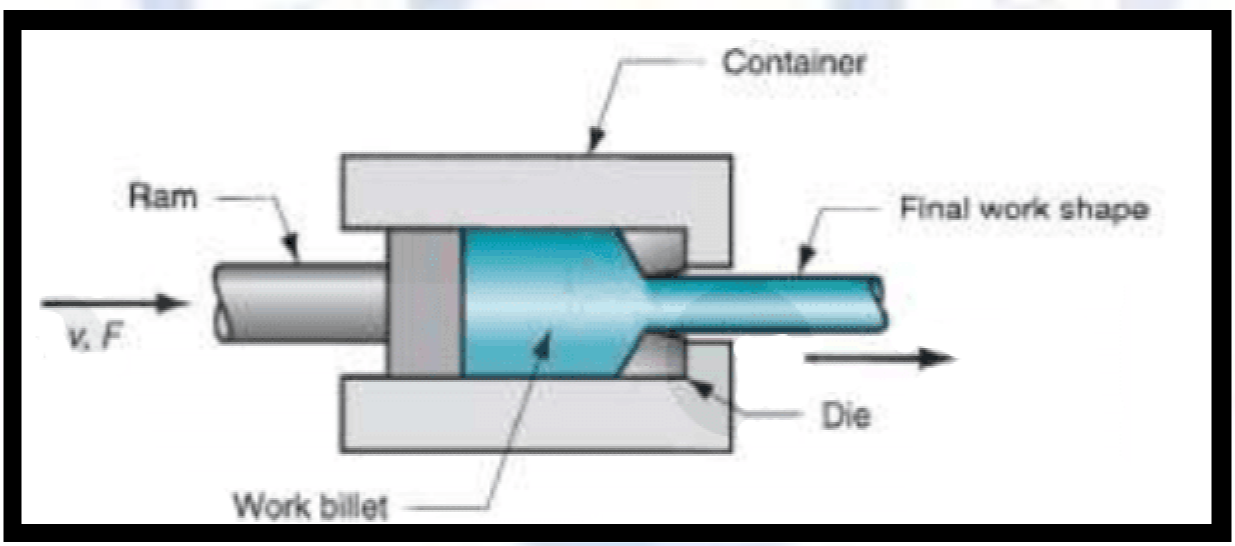
As a result, the container is left with a thin cylindrical shell (skull) made mostly of the oxidised layer.

The oxides are thus removed from the extruded result, and the skull is afterwards removed from the chamber.

A hole parallel to the axis of the beginning billet is drilled.

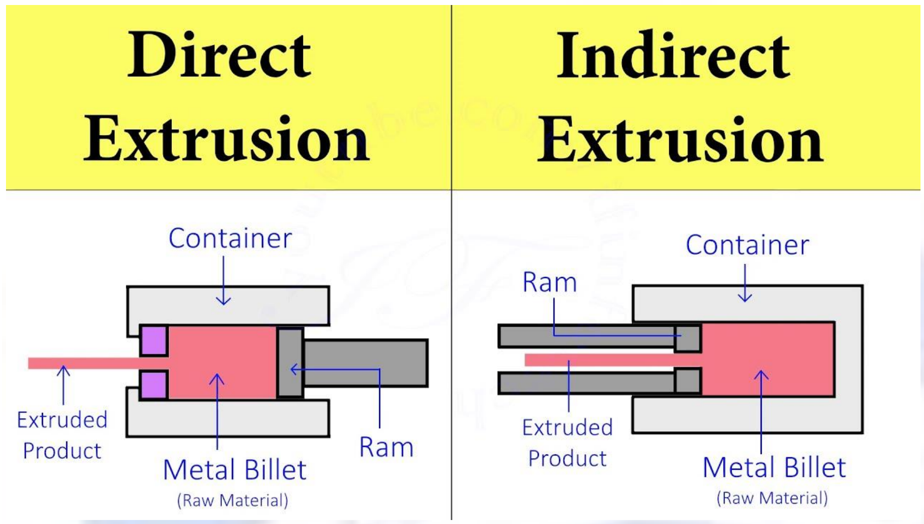
This allows a mandrel attached to the dummy block to pass through.

The material is forced to flow through the clearance between the mandrel and the die aperture when the billet is squeezed.



Indirect extrusion

In the indirect method, the ram carries the die and applies pressure on to the stationary billet, in the opposite direction of extrusion. ... As such, there is no billet to container friction influence, and the force during extrusion remains relatively constant from the front of the extrusion to the rear.



The process

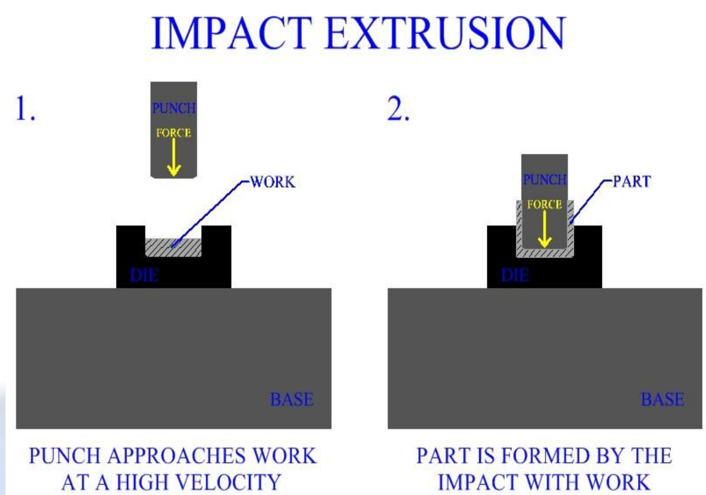
The working material consists of a preheated ingot placed in a pressure chamber A hollow plunger with a hollow die mounted on the end is pressed against the ingot with an applied pressing force which forces the ingot through the center of the die in the opposite direction to the pressing force. The ingot then assumes the same shape as the die cross section and is pushed out as a solid axially symmetric rod .

The friction force between the ingot and the pressure chamber is small when the ingot is pushed into and back through the die.

Impact extrusion

It is a manufacturing process similar to extrusion and drawing by which products are made with a metal slug. The slug is pressed at a high velocity with extreme force into a die or mold by a punch.

To perform impact extrusions, manufacturing companies need either a mechanical or hydraulic press. The metal slug is positioned between a punch and a die. When activated, the press will move the punch down onto the metal slug, thereby forcing the metal slug through the die. The metal slug will then take the physical properties of the die. After the metal slug has been forced through the die, it's removed via an ejector.



Rolling Process

Rolling Process is a deformation process in which Metal(s) in its semi-finished or finished form is passed between the two opposing rollers, which reduces the metal's thickness through the compression process. The rollers rolls around the metal as it squeezes in between them.

Types of Rolling Mills

Rolling mills consist of set-up that rotates the roller and helps in initiating and completing the Rolling Process. It consists of one or more roller stands, reducing gear, the main drive motor, Stand Pinion, Flywheel, and Coupling gear between the Units. These Components equipped together to help in the Completion of the Rolling Process.

Rolling mills are classified on the basis of the number and arrangement of rolls in a stand. There are commonly six types of Rolling mills that are used, they are as follows:

(i) Two-High Rolling Mill:

It Consists of two High stands, and two rolls placed exactly one over the Other. In this type of Rolling Mill, the Rollers rotates in Opposite direction and their direction changes after each Metal pass. The Metal (Ingot) is passed continuously and approximately 25-30 passes are required to convert Ingot to Bloom.

(ii) Three-High Rolling Mill:

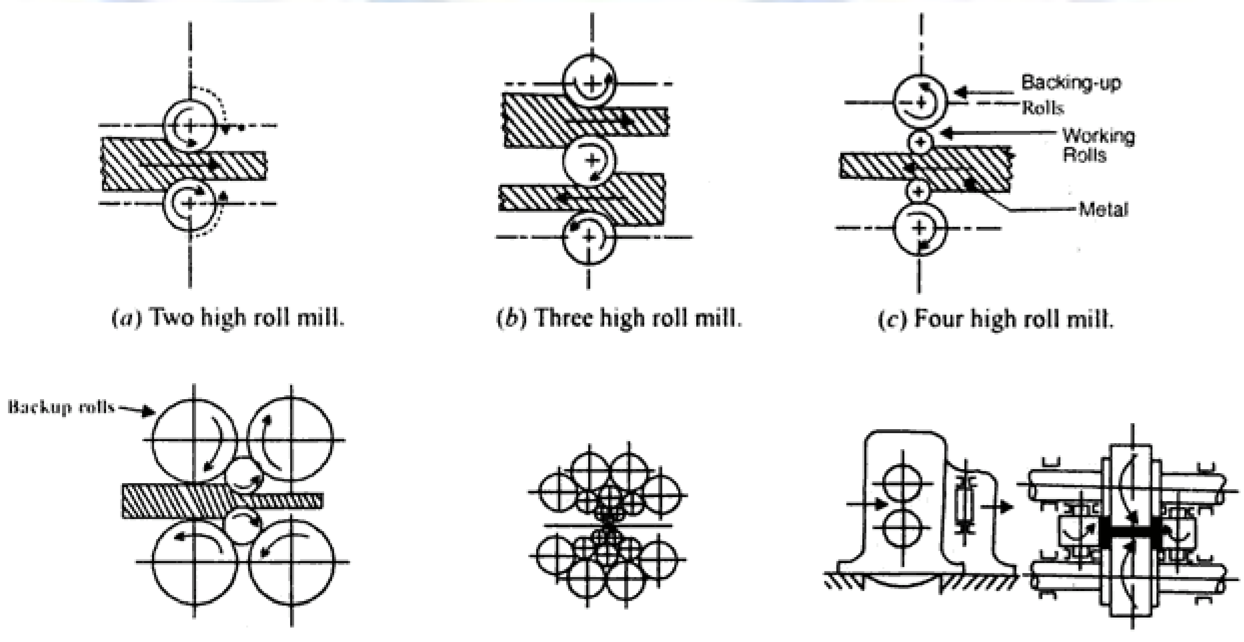
It consists of three high stands and three Rollers present in the same vertical plane. The Top and bottom roller rotate in the same direction, and the middle roller rotates in

the Opposite Direction. In this type of Rolling mill, the Direction of the drive is not changed after each pass. It is more Productive and easier with respect to the two-High Rolling Mill.

(iii) Four-High Rolling Mill:
It Consists of two backup rollers and two Working rollers, arranged One over the Other in the same Vertical Plane. The Diameter of Backup rollers is always greater than the Working rollers. This type of rollers is mainly used in Sheet Rolling.
The Two Working Rollers of small diameters are used to reduce the power demands, but it increases the chance of bending of working rollers, and as a result, non-Uniform compression of sheets. This is the reason we use Backup rollers for reducing the bending of Working rollers.

(iv) Cluster Mill:
It consists of Two Working rollers and two or more backup rollers. The number of Backup rollers depend upon the amount of support required for working. It is mostly used in Cold rolling Operations.

(v) Universal Rolling Mill:
It consists of two vertical rollers and two Horizontal rollers. The Vertical rollers are arranged between the bearing of horizontal rollers in the vertical plane. It is widely used to produce blooms from Ingot, and for rolling wide flange H-Section beams.



(a) Two high roll mill. (b) Three high roll mill. (c) Four high roll mill.

(d) Cluster rolling mill. (e) Multi high roll mill. (f) Universal roll mill.

Fig. 2.9. Types of rolling mills.

Diffrence between cold rolling and hot rolling

Hot Rolling

The process of rolling consists of passing the hot ingot through the two rolls, rotating in opposite directions, at a uniform peripheral speed.
To confirm the desired thickness of the rolled section, the space between the rolls is adjusted and is always less than the thickness of the ingot being fed.
When the metal passes through the rolls, there is a change in its grain structure.
Due to squeezing, the grains are elongated in the direction of rolling and the velocity of material at the exit is higher than that at the entry.
After crossing the stress zone, the grains start refining.

Cold Rolling

Cold rolling is used for producing bars of all shapes, rods, sheets, and strips.
Cold rolling is generally employed for providing a smooth and bright surface finish to the previously hot rolled steel.
It is used to finish the hot rolled components, to close tolerances and improve their hardness and toughness.
Before cold rolling, the hot rolled articles are cleaned through pickling and other operations.
The same types of rolling mills, as in hot rolling, are used for cold rolling.
The part being rolled is generally annealed and pickled before the final pass is made, so as to bring it to accurate size and obtain a perfectly clean surface.

Chapter 2
Welding

Welding

Welding is a fabrication process whereby two or more parts are fused together by means of heat, pressure, or both forming a join as the parts cool. Welding is usually used on metals and thermoplastics. The completed welded joint may be referred to as a weldment.

Types of Welding processes

Arc welding:

- Carbon Arc Welding;
- Shielded Metal Arc Welding (SMAW);
- Submerged Arc Welding (SAW);
- Metal Inert Gas Welding (MIG, GMAW);

- Tungsten Inert Gas Arc Welding (TIG, GTAW);
- Electroslag Welding (ESW);
- Plasma Arc Welding (PAW);

Resistance Welding (RW);

- Spot Welding (RSW);
- Flash Welding (FW);
- Resistance Butt Welding (UW) ;
- Seam Welding (RSEW);

Gas Welding (GW);

- Oxyacetylene Welding (OAW);
- Oxyhydrogen Welding (OHW);
- Pressure Gas Welding (PGW);

Solid State Welding (SSW);

- Forge Welding (FOW);
- Cold Welding (CW);
- Friction Welding (FRW);
- Explosive Welding (EXW);
- Diffusion Welding (DFW);
- Ultrasonic Welding (USW);

Thermit Welding (TW);

Electron Beam Welding (EBW);

Laser Welding (LW).

Weld Flux

Weld flux is a chemical purifying agent, flowing agent or cleaning agent. It is commonly used in metal joining and metallurgy. It is a material used to promote the fusion of metals and is employed in welding. The primary purpose of weld flux is to prevent oxidation of the base and filler materials during the welding process.

Some examples of flux materials include:

- **Ammonium chloride**
- **Zinc chloride**
- **Hydrochloric acid**
- **Borax**

The main function of weld flux is to oxidize the base and filler materials during the welding process. Weld flux is a substance that is almost inert at average room temperature but can be intensely reducing when exposed to higher temperatures to prevent metal oxide formation.
Flux dissolves the metal surface oxides that facilitate the molten metal wetting and acts as a barrier to oxygen and minimizes oxidation. Fluxes are used to generate a surface for wetting the solder.

Oxyacetylene welding

It is commonly referred to as gas welding, is a process which relies on combustion of oxygen and acetylene. When mixed together in correct proportions within a hand-held torch or blowpipe, a relatively hot flame is produced with a temperature of about 3,200 deg.

Oxy-fuel welding basic equipment includes the following:

Cylinders:
Steel pressurized cylinders contain oxygen and the fuel gas.

Regulators:
The flow of gas needs to be controlled. Regulators take high pressure and reduce it to a lower working pressure.

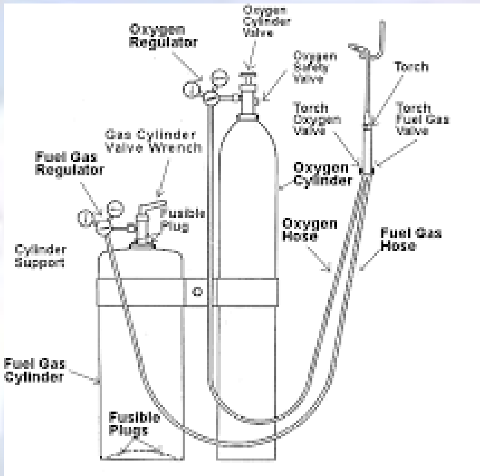
Hoses:
A nonporous hose is used to move the oxygen and fuel gas to the torch. To prevent the wrong hose from being installed or set up incorrectly, the oxygen hose is usually green and the fuel gas hose is usually red.

Hose fittings:
Siamese hoses are one piece with hoses that have been molded together. Hoses can also be taped together. Oxygen hoses have right-hand threaded fittings. Fuel-gas hoses have left-hand threaded fittings. Hose connections shouldn’t leak after they’re tightened. Regulator-mounted and torch-mounted flash arrestors should be used on oxygen hoses and fuel hoses. Regulator-mounted flash arrestors stop flashbacks and backfires from entering the hoses and, potentially, the cylinders.

Safety valves:
Safety valves keep the flow of gas going in one direction, preventing gas from flowing back into the wrong line or cylinder. They also reduce the possibility of a flashback.

Torches:
Torches may vary in design, but all are made to provide complete control of the flame.

Tips:
Because there's not an industrial standard system for identifying tip sizes, welders need to master various tip sizes. Tip sizes are comparable to numbered drill sizes. There are some torch sets where each tip has its own mixing chamber.



Gas Welding

Types of flames:

There are three basic types of oxy-acetylene flames viz., carburising or reducing flame, neutral or balanced flame and an oxidising flame. Apart from the chemical nature, these flames also differ in structure and shape.

The carburising or reducing flame has excess of acetylene and is char-acterised by three stages of combustion instead of two stages applicable to other two types of flames. The additional combustion stage is called the inter-mediate feather that can be adjusted by controlling the flow rate of acetylene.

Such a flame is usually quoted by the length of this intermediate feather in terms of the inner cone length. For example, a 2X carburising flame would have the intermediate feather 2 times as long as the inner cone and so on as shown in Fig. 16.14. As a carburising flame contains unburnt carbon its temperature is lower than a neutral or an oxidising flame.
If this excess carbon finds its way to the molten metal the weld puddle appears to be boiling. On solidification such a weld will have pitted surface all along its length and the weld bead attains higher hardness and becomes extremely brittle due to

exces-sive amount of carbon in it. Such a flame, however, is quite suitable for weld-ing high carbon steel and cast iron.

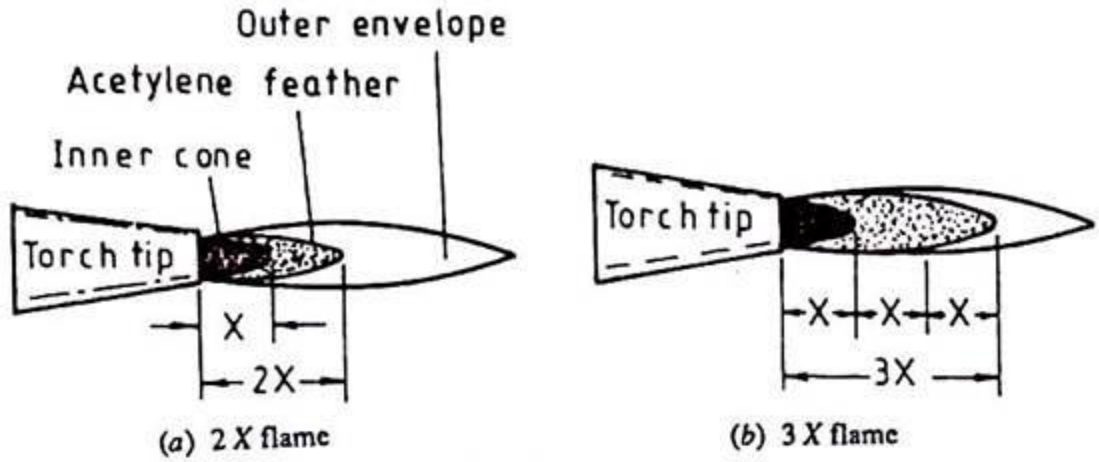


Fig. 16·14 Representation of a carburising flame in terms of inner cone length.

The neutral flame has nearly one-to-one ratio of acetylene and oxygen by volume. Structurally it consists of two parts namely the inner cone and the outer envelope as shown in Fig. 16.15. It has a clear, well defined or luminous inner cone indicating that the combustion is complete. Such a flame makes a hissing sound and is the most used type of flame for welding of metals.

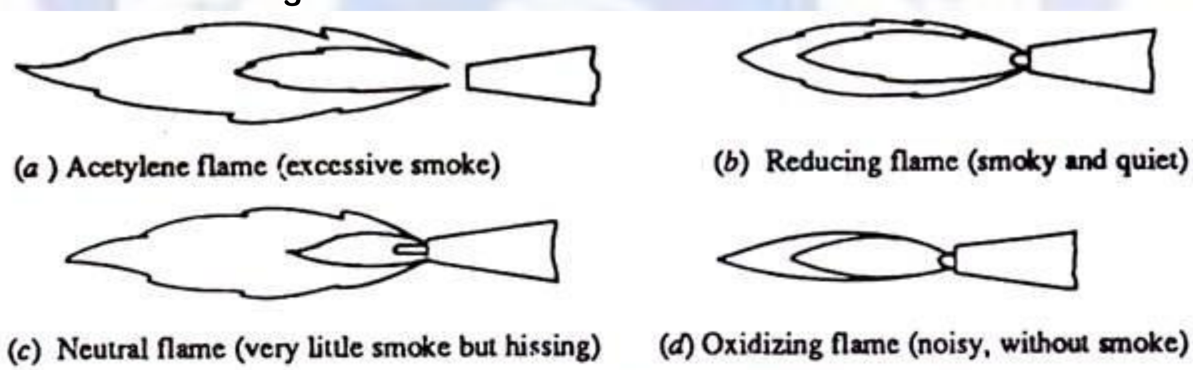


Fig. 16·15 Structures of different types of oxy-acetylene flames.

The oxidising flame has an excess of oxygen over the acetylene. It consists of a very short pointed white inner cone and a shorter outer envelope. Such a flame makes a loud roaring sound. The reduction in length of the inner cone is a measure of excess oxygen..

Arc welding

Arc welding is a type of welding process using an electric arc to create heat to melt and join metals. A power supply creates an electric arc between a consumable or non-consumable electrode and the base material using either direct (DC) or alternating (AC) currents.

Arc welding process

Arc welding works by using an electric arc from an AC or DC power source to generate a staggering heat around 6,500 degrees Fahrenheit at the tip, to melt the base metals, and to create a pool of molten metal and join the two pieces.

The arc is formed between the work piece and the electrode, which is moved along the line of the joint either mechanically or manually. The electrode can either be a rod that carried the current between the tip and the work piece, or it can be a rod or wire that conducts current as well as melts and supplies filler metal to the joint.

Arc welding Electrode

The carbon electrode is a non-filler metal electrode used in arc welding or cutting, consisting of a carbon graphite rod that may or may not be coated with copper or other coatings. The tungsten electrode is defined as a non-filler metal electrode used in arc welding or cutting, made principally of tungsten

Non-Consumable Electrodes

Types

There are two types of non-consumable welding electrodes.

The carbon electrode is a non-filler metal electrode used in arc welding or cutting, consisting of a carbon graphite rod that may or may not be coated with copper or other coatings.

The tungsten electrode is defined as a non-filler metal electrode used in arc welding or cutting, made principally of tungsten.

Resistance welding

It is the joining of metals by applying pressure and passing current for a length of time through the metal area which is to be joined. The key advantage of resistance welding is that no other materials are needed to create the bond, which makes this process extremely cost effective.

The working principle of resistance welding is the generation of heat because of electric resistance. The resistance welding such as seam, spot, protection works on the same principle. Whenever the current flows through electric resistance, then heat will be generated. The same working principle can be used within the electric coil. The generated heat will depend on material's resistance, applied current, conditions of a surface, applied the current time period

This heat generation takes place because of the energy conversion from electric to thermal. The resistance welding formula for heat generation is

$$H = I^2RT$$

Where

'H' is a generated Heat, and the unit of heat is a joule
'I' is an electric current, and the unit of this is ampere
'R' is an electric resistance, and the unit of this is Ohm
'T' is the time of current flow, and the unit of this is second
The generated heat can be used to soften the edge metal to shape a tough weld joint with fusion. This method generates weld with no application of any flux, filler material, and shielding gases.

Types of Resistance Welding
Different types of resistance welding are discussed below.

Spot Welding:
Spot welding is the simplest type of welding where the work portions are held jointly below the force of anvil face. The copper (Cu) electrodes will make contact with the work portion & the flow of current through it. The work portion material applies a few resistances within current flow which will cause limited heat production. The resistance is high at the edge surfaces because of the air gap. The current begins to supply through it, then it will reduce the edge surface.
The current supply & the time must be enough for the correct dissolving of edge faces. Now the flow of current will be stopped however the force applied with electrode continued for a second, whereas the weld quickly cooled. Later, the electrodes eliminate as well as get in touch with new spot to create a circular piece. The piece size mainly depends on electrode size (4-7 mm).

Seam Welding:
This type of welding is also known as continuous spot welding where a roller form electrode can be utilized to supply current throughout work parts. Initially, the roller electrodes are getting in touch with the work part. High current can be supplied through these electrode rollers to melt the edge surfaces & shape a weld joint.At present, the electrode rollers will begin rolling on work plates to make a permanent weld joint. The weld timing & electrode movement can be controlled to guarantee that the weld overlap & work part doesn't acquire too warm. The speed of the welding can be about 60 in per min within seam welding, which is used to make airtight joints.

Projection Welding

Projection welding is similar to spot welding apart from a dimple can be generated on work parts at the place wherever weld is preferred. At present the work parts held among electrode as well as a huge quantity of current flow through it. A little quantity of pressure can be applied throughout the electrode on welding shields. The flow of current throughout dimple which dissolve it & the force reasons the dimple level & shape a weld.

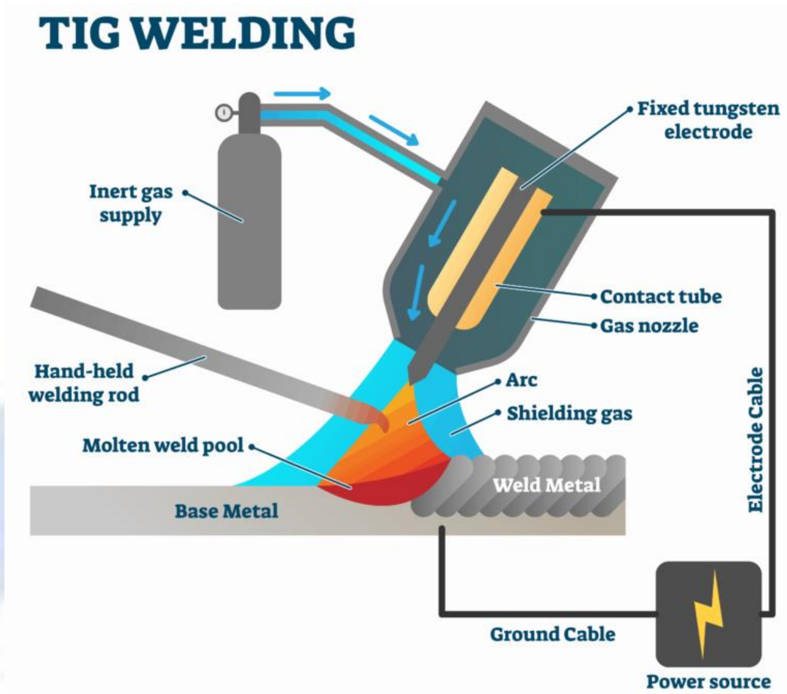
Flash butt Welding

The flash butt welding is a form of resistance welding, used for welding tubes as well as rods within steel industries. In this method, two work parts are welded which will be held tightly during the electrode holders as well as a high pulsed flow of current within the 1,00,000 ampere range can be supplied toward the work part material.In the two electrode holders, one is permanent & other is changeable. At first, the flow of current can be supplied & changeable clamp will be forced against the permanent clamp because of the get in touch with the two work parts at high-current, the spark will be generated. Whenever the edge surface approaches into plastic shape, the flow of current will be stopped as well as axial force can be improved to create joint. In this method, the weld can be formed because of plastic deformation.

TIG Welding:

TIG—i.e., tungsten inert gas—welding is highly versatile, enabling industry professionals to join a wide range of small and thin materials. It uses a non-consumable tungsten electrode to heat the metal and can be used with or without a filler.

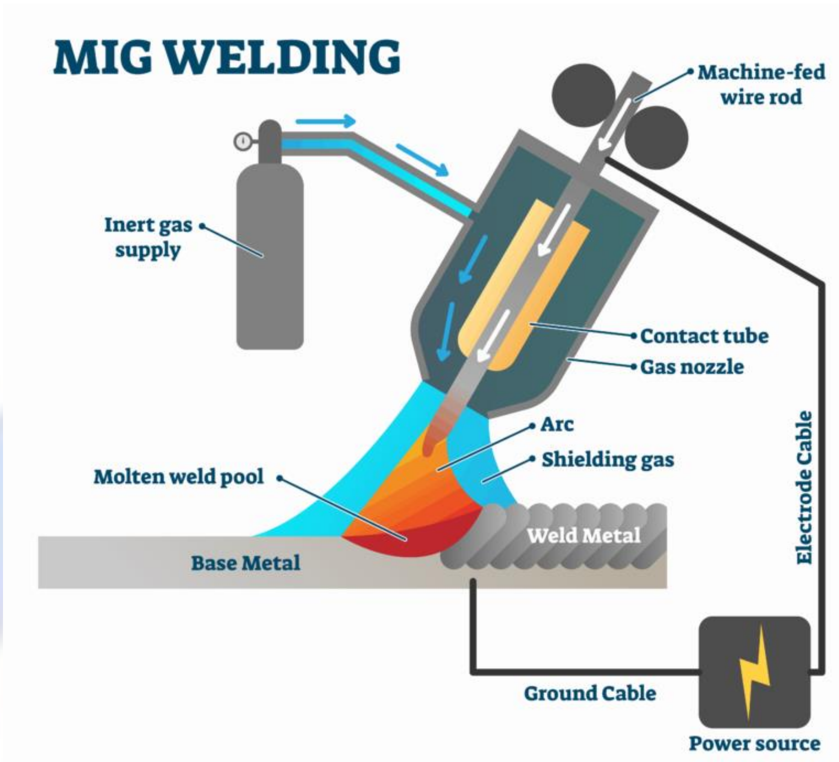
Compared to MIG welding, it is much slower, often resulting in longer lead times and greater production costs. Additionally, welders require highly specialized training to ensure they achieve proper precision and accuracy. However, it also offers greater control during the welding operation and produces strong, precise, and aesthetically pleasing welds.



MIG Welding

MIG—i.e., metal inert gas—welding is generally used for large and thick materials. It employs a consumable wire that acts as both the electrode and the filler material.

Compared to TIG welding, it is much faster, resulting in shorter lead times and lower production costs. Additionally, it is easier to learn and produces welds that require little to no cleaning and finishing. However, its welds are not as precise, strong, or clean as those formed by TIG welding operations.



common weld defects

- Lack Of Penetration or Incomplete Penetration.
- Lack Of Fusion or Incomplete Fusion.
- Undercut.
- Spatter.
- Slag Inclusions.
- Cracks.
- Porosity.
- Overlap

Chapter 3
Casting

Casting:

Casting is defined: the casting method has a certain shape, microstructure and mechanical properties of metal parts. Castings, cast in a variety of methods for metal forming objects, namely the smelting good liquid metal, with casting, injection,

inhaled, or other casting methods into the prepared mold, after cooling the shakeout and cleaning, and post-treatment of a certain shape, size and properties of objects.

Classification of Casting:
Casting has a variety of classification method: according to the different metal materials used, divided into steel casting, iron casting, copper casting, aluminum casting, magnesium castings, titanium zinc castings, castings, etc. And each type of castings can be according to their chemical composition or the microstructure is further divided into different kinds. Such as iron castings can be divided into grey iron castings, ductile castings, malleable pieces, vermicular casting, alloy casting, etc.

According to cast molding method is different, can be divided into ordinary sand mold casting, the casting metal mold casting, die casting, centrifugal casting, continuous casting parts, investment casting, ceramic type casting, electroslag casting pieces, double metal castings and so on.

Types and Classification of Casting Process

1. Green Sand Mould Casting:

The material for a green sand mould is a mixture of sand, clay, water, and some organic additives, e.g., wood flour, dextrin, and sea coal. The percentage of these ingredients on weight basis is approximately 70-85% sand, 10-20% clay, 3-6% water, and 1-6% additives. This ratio may vary slightly depending on whether the casting is ferrous or non-ferrous.
Sand is an inexpensive refractory material, but natural sand may not have all the desirable qualities of a moulding material. For example- it normally has higher clay content than desired. The sand used as a moulding material should have a specified clay, water, and additive content in addition, it must have a specific grain size distribution

2. Dry Sand Mould Casting:

The dry sand mould casting uses expendable moulds, i.e., each mould is used only once. A dry sand mould is basically a green sand mould baked in an oven at 100-250°C for several hours. The sand-mix contains 1-2% of pitch. The oxidation and polymerization of pitch increases the hot strength of the mould. As the water is driven out from the sand-mix by heating, the defects caused by the generation of steam, e.g., blows and porosity, are less frequent in dry sand mould casting.

3. Shell Mould Casting:
The shell mould casting is a semi precise method for producing small castings repetitively in large numbers. The mould material contains phenolic resin mixed with fine, dry silica. These are mixed either dry or in the presence of alcohol; no water is used. Normally, a machined pattern of gray iron, aluminium, or brass is used in this process. First, the pattern is heated to 230-260°C, and then the sand-resin mixture is either dumped or blown over its surface.

4. Die Casting:
In the die casting process, unlike in gravity casting, the liquid metal is forced into the mould cavity under high pressure. The process is used for casting a low melting temperature material, e.g., aluminium and zinc alloys. The mould, normally called a die, is made in two halves, of which one is fixed and the other moving. Medium carbon, low alloy tool steel is the most common die material. The die is cooled by water for an efficient cooling of the casting. This also increases the die life.

5. Centrifugal Casting:
The centrifugal casting process is normally carried out in a permanent mould which is rotated dining the solidification of a casting. For produc-ing a hollow part, the axis of rotation is placed at the centre of the desired casting. The speed of rotation is maintained high so as to produce a centripetal acceleration of the order of 60g to 75g. The centrifuge action segregates the less dense nonmetallic inclusions near the centre of rotation. It should be noted that the casting of hollow parts needs no core in this process.

Types of Moulding Sand:
According to the use, moulding sand may be classified as below:

1. **Green Sand:**
   The green sand is the natural sand containing sufficient moisture in it. It is mixture of silica and 15 to 30% clay with about 8% water. Clay and water act as a bonding material to give strength. Molds made from this sand are known as green sand mould.

2. **Dry Sand:**
   When the moisture is removed from green sand, it is known as dry sand. The mould produced by dry sand has greater strength, rigidity and thermal stability. This sand is used for large and heavy castings.

3. Facing Sand:

A sand used for facing of the mould is known as facing sand. It consists of silica sand and clay, without addition of used sand. It is used directly next to the surface of the pattern. Facing sand comes in direct contact with the hot molten metal; therefore it must have high refractoriness and strength. It has very fine grains.

4. Core Sand:

A sand used for making cores is known as core sand. It is silica sand mixed with core oil (linseed oil, resin, mineral oil) and other binding materials (dextrine, corn flour, sodium silicate). It has remarkable compressive strength.

Pattern:

For making the casting product in casting process, a pattern is used to making a mold cavity in the sand.

A pattern is a similar to the casting product but not exactly the same size given some allowance because of the shrinkage property of cast metal.

The pattern materials can be made of wood, metal, plastic, compound, or wax. Usually, the patterns are made of wood only because they are cheap, and they are also easy to make.

Pattern Allowance:

A pattern is a replica of casting which is used to making a mold cavity but it has slightly large dimensions.

This change in the pattern is due to when the cast solidifies, it shrinks at some limit due to metal shrinkage property at the time of cooling.

Types of Pattern Allowance

There are the following types of pattern allowances are used in the casting process.

- Shrinkage Allowance
- Draft Allowance
- Machining Allowance
- Deformation or Camber Allowance
- Shake or Rapping Allowance

Shrinkage Allowance:

Shrinkage is defined as the reduction during the cooling or solidification process. This is a common property of all materials.

The magnitude of shrinkage varies from material to material, but each and every material has to shrinks.
For avoiding this, the pattern is made larger than the required size of the casting product Then the difference between actual pattern size and required casting size is known as shrinkage allowance.
The shrinkage allowance is given in the pattern in mm/m (millimeter/meter). Which is different for different materials.

Shrinkage Allowances For Different Materials

- There are following some shrinkage allowance given inside the pattern for different materials are used in casting.
- For grey cast iron shrinkage allowance is given from 6.95 to 10.5mm/m.
- For white cast iron and steel, it is given up to 20.8 mm/m.
- For Aluminium shrinkage allowance given 17 mm/m and for aluminum alloy given from 12.5 to 15 mm/m
- For brass, it is given up to 15.3 mm/m.

Draft Allowance:
During removing the pattern from the mold cavity, the parallel surfaces in the direction in which the pattern is withdrawn are slightly damaged and also converted into slightly tapered surfaces.
To compensate for these changes, these parallel surfaces on the pattern are slightly tapered by about 1 to 2 degrees.

Machining Allowance:
As we know that the product of the casting process gives a very poor surface finish, so the surface of the final product of casting always is rough.
But we required a product that is polished and has a good surface finish.

Deformation or Camber Allowance:
When the metal is in the cooling process, stress is developed during the solidifying of this metal due to uneven metal thickness in the casting process.
This stress can cause deformation or bend in the casting.

Shake or Rapping Allowance:
When the pattern is to be removed from the sand of the casting, a slight shake is required to remove the pattern from the sand and this will increase the dimension of the casting slightly.

To avoid this increase in the dimension of the casting, the pattern is made slightly smaller than the casting.
These small changes in the dimensions of the pattern in the casting process are called the shaking or rapping allowance.

Core:
Core is an obstruction-which when positioned in the mold, naturally does not permit the molten metal to fill up the space occupied by the core. In this way a core produces hollow castings. • Cores are required to create the recesses, undercuts and interior cavities that are often a part of castings. • A core may be defined as a sand shape or form which makes the contour of a casting for which no provision has been made in the pattern for molding. • core as a sand shape is generally produced separate from the sand mold and is then baked (hardened) to facilitate handling and setting into the mold. • Cores may be made up of sand, metal, plaster or ceramics

TYPES OF CORES
Cores may be classified according to
A. The state or condition of core
1. Green sand core
2. Dry sand core
3. No bake sand core

Green sand cores
Green sand cores are formed by the pattern itself. • A green sand core is a part of the mold. • A green sand core is made out of the same sand from which the rest of the mold has been made i.e., the molding sand

Dry sand cores •
Dry sand cores (unlike green sand cores)are not produced as a part of the mold. • Dry sand cores are made separately and independent of the mold. • A dry sand core is made up of core sand which differs very much from the sand out of which the mold is constructed. • A dry sand core is made in a core box and it is baked after ramming. • A dry sand core is positioned in the mold on core-seats formed by core-prints on the patterns.

No-bake sand cores •
The sand used for preparing no-bake core is similar to that used for making no-bake sand moulds. • Synthetic resins like phenol or urea formaldehyde are used as binder for bonding silica sand.

Cupola furnace:

It is one of the furnace where we melt different types of metal some are cast iron, some are maybe bronze.

So today we discuss the working principle of Cupola Furnace as well as see the construction, advantages, disadvantages, and applications of Cupola Furnace.

Construction of Cupola Furnace:

The Cupola Furnace is consists of:

- Legs
- Slag Hole
- Sand Bed
- tuyers
- Preheating Zone
- Melting Zone
- Charging Door
- Brick lining
- Spark Arrester

Legs:

Legs are provided for supporting purposes.

Slag Hole or Slag spout:

The slag hole is used for removing or extracting the slag from the melting iron.

Sand Bed:

This is in taper form and from this, the melted iron comes out easily.

Tuyeres:

By tuyeres, we enter the gas to the proper burn of fuel.

Preheating Zone:

In the Preheating zone, the heating process started and heats the metal charge about 1090 degrees Celsius.

Melting Zone:

In the melting zone, we do not provide much heat to melt the metal charge because it’s already melted in the preheating zone with a temperature of about 1090 degrees Celsius.

Charging door:

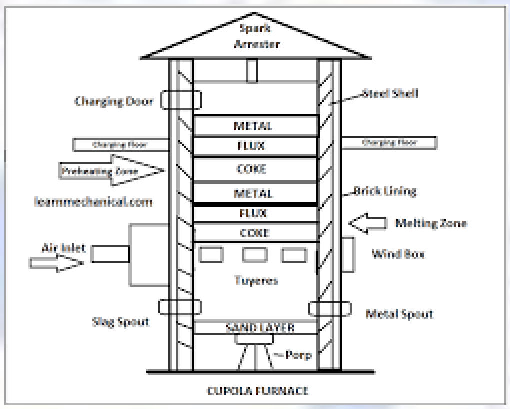
From here we supply the charge to the furnace. The various charges are for the cupola furnace are Pig Iron, Coke and limestone.

Brick lining and Steel shell:

The shell of the cupola furnace is being usually made of steel and it’s called a steel shell.

Spark Arrester:

This device used in the system for preventing the emission from the fireplace.



Working Principle of Cupola Furnace:

The Cupola furnace works on the principle where we generate heat from burning coke and when the temperature of the furnace is above the melting point of the metal then the metal is melt.

The charge introduced in the cupola consists of pig iron, scrap, casting rejection, coke, and flux. Coke is the fuel and limestone are added as a flux to remove undesirable materials like ash and dirt. The scrap consists of Steel and cast iron rejections.

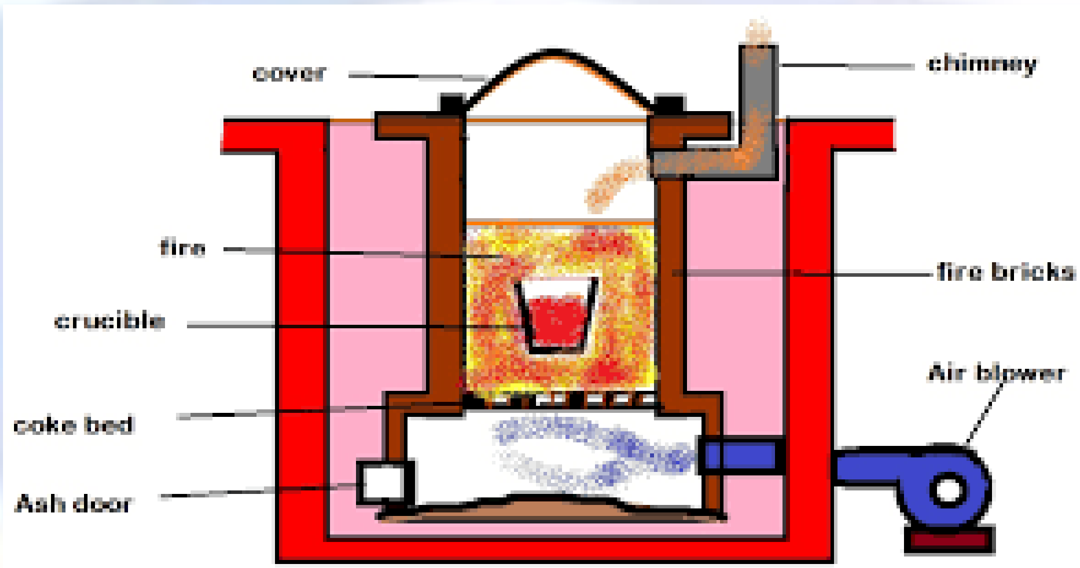
The working of Cupola furnace is, Over the sand Bottom, Coke in charged extending up to a predetermined height. This serves as the coke bed within which the combustion takes place.

Cupola operation is started by igniting the coke bed at its bottom. After the Coke bed is properly Ignited, alternate charges of limestone, pig iron, and coke are charged until the level of the charging Door.

Then the air blast is turned on and combustion occurs rapidly within the coke bed. Within 5 to 10 minutes after the blast is turned on the first molten cast iron appears at the tap hole.

Crucible furnance:

A crucible furnace is a simple and very old type of melting unit commonly used in foundry. The crucible furnace typically uses a refectory crucible with contains a metal charge. The actual crucible is a container that can withstand very high temperatures and is therefore used to melt materials such as metals.



Crucible furnace

Depending on the operating temperature and the type of metal to be melted / kept hot, the crucibles used are either graphite crucibles (additional glazing coat and containing clay), silicon carbide crucibles (SIC crucibles), or crucibles made of cast iron, special cast iron, cast steel, or sheet steel (particularly for magnesium and zinc alloys).

Crucible furnaces are classified by their design type and the method of heating:

Mobile and fixed crucibles: the latter form an integral part of the furnace and are predominantly used in crucible induction furnaces (s.a. induction melting furnace). These kinds of furnaces are emptied by tilting the entire furnace.

Crucible furnaces operated by means of resistance heat or fuel heat: In this case, the crucible is a separate unit and is inserted into the furnace. It may be replaced if required.

Crucible furnaces with exhaust gas venting through the crucible edge are only rarely used today; in these furnaces the flue gasses escape through a hood above the crucible. With this mechanism, there is a risk that the flue gasses come into contact with the melt, which may have a negative influence on the melt quality and, in addition the pollution load at the work-place is far greater.

Die Casting Method:

Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mould cavity. The mould cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mould during the process.

Functionality and Procedures:

In die casting, there are two different ways of manufacturing components: hot chamber and cold chamber die casting. In both manufacturing processes, the mold is sprayed with a release agent prior to the casting process in order to ensure that the subsequently cast part can be easily remover from the mold. However, the melt is not poured directly into the mold cavity, but is first filled into the casting chamber of the die casting machine. From there, the alloy is pressed into the mold by a piston (the so-called casting set) through one or more channels.

Die Cast Process

There isn't one single process that can suit every project. Each project is different which is why Dynacast offers multiple solutions for all die casting needs. This ensures the right process is always used for the right application. At Dynacast, we offer three different types of die casting processes.

Hot-Chamber

Used for zinc, some magnesium alloys, and other low-melting, hot-chamber die casting is a great option for alloys that do not readily attack and erode metal pots, cylinders, and plungers.

Cold-Chamber

Better suited for metals with high melting points such as aluminum, during cold-chamber die casting, metal is liquefied and then ladled into a cold chamber where a hydraulically operated plunger pushes the metal into the die.

Injected Metal Assembly

Over the past 50 years, we have developed and refined our innovative; one-step manufacturing solution, Injected Metal Assembly. IMA outperforms most adhesives used for small component joining and assembly production and reduces manufacturing costs.

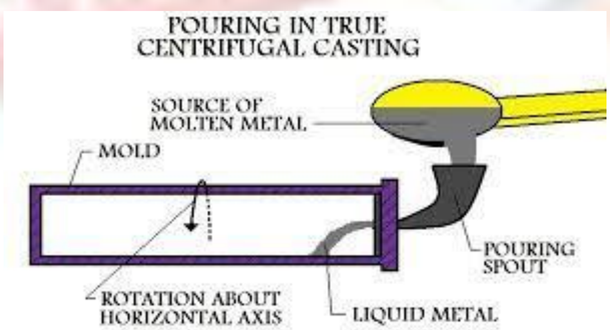
Centrifugal Casting:

Centrifugal casting is a process that delivers components of high material soundness. As a result, it is the technology of choice for applications like jet engine compressor cases, hydro wear rings, many military products, and other high-reliability applications. It has also proven to be a cost-effective means of providing complex shapes with reduced machining requirements and lower manufacturing costs as compared to forgings and fabrications.

The centrifugal casting process steps begin with molten metal being poured into a preheated, spinning die. The die may be oriented either on a vertical or horizontal axis depending on the configuration of the desired part.

True centrifugal Casting:

The manufacturing process of centrifugal casting is a metal casting technique, that uses the forces generated by centripetal acceleration to distribute the molten material in the mold. Centrifugal casting has many applications in manufacturing industry today. The process has several very specific advantages. Cast parts manufactured in industry include various pipes and tubes, such as sewage pipes, gas pipes, and water supply lines, also bushings, rings, the liner for engine cylinders, brake drums, and street lamp posts. The molds used in true centrifugal casting manufacture are round, and are typically made of iron, steel, or graphite. Some sort of refractory lining or sand may be used for the inner surface of the mold.



Properties of True Centrifugal Casting:

True centrifugal casting is a great manufacturing process for producing hollow cylindrical parts.

The metal casting's wall thickness is controlled by the amount of material added during the pouring phase.

Rotational rate of the mold during the manufacture of the casting must be calculated carefully based on the mold dimensions and the metal being cast.

If the rotational rate of the mold is too slow, the molten material for the casting will not stay adhered to the surface of the cavity. From the top half of the rotation it will rain metal within the casting cavity as the mold spins.

Advantages of True Centrifugal casting process :

i) Castings acquire high density, high mechanical strength and fine grained structure.
ii) Inclusions and impurities are lighter.
iii) Gates and risers are not needed.
iv) High output.
v) Formation of hollow interiors without cores.

Casting Defects?

It is an unwanted irregularities that appear in the casting during metal casting process. There is various reason or sources which is responsible for the defects in the cast metal. Here in this section we will discuss all the major types of casting defects. Some of the defects produced may be neglected or tolerated and some are not acceptable, it must be eliminated for better functioning of the parts

Types:

Casting defects can be categorized into 5 types

1. Gas Porosity: Blowholes, open holes, pinholes
2. Shrinkage defects: shrinkage cavity
3. Mold material defects: Cut and washes, swell, drops, metal penetration, rat tail
4. Pouring metal defects: Cold shut, misrun, slag inclusion
5. Metallurgical defects: Hot tears, hot spot.

The various casting defects that appear in the casting process are

1. Shift or Mismatch

The defect caused due to misalignment of upper and lower part of the casting and misplacement of the core at parting line.

Cause:

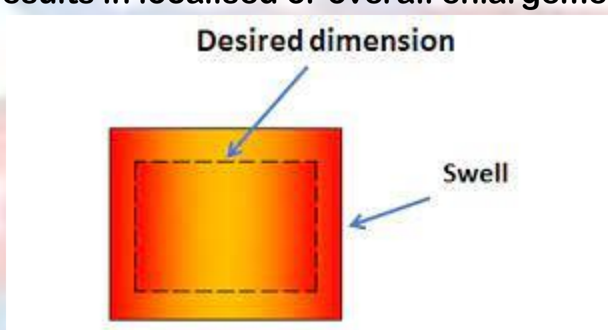
(i) Improper alignment of upper and lower part during mold preparation.
(ii) Misalignment of flask (a flask is type of tool which is used to contain a mold in metal casting. it may be square, round, rectangular or of any convenient shape.)

Remedies

(i) Proper alignment of the pattern or die part, molding boxes.
(ii) Correct mountings of pattern on pattern plates.
(iii) Check the alignment of flask.

2. Swell

It is the enlargement of the mold cavity because of the molten metal pressure, which results in localised or overall enlargement of the casting.



Causes:
(i) Defective or improper ramming of the mold.

Remedies

(i) The sand should be rammed properly and evenly.

3. Blowholes:
When gases entrapped on the surface of the casting due to solidifying metal, a rounded or oval cavity is formed called as blowholes. These defects are always present in the cope part of the mold.

Causes

(i) Excessive moisture in the sand.
(ii) Low Permeability of the sand.
(iii) Sand grains are too fine.
(iv) Too hard rammed sand.
(v) Insufficient venting is provided.

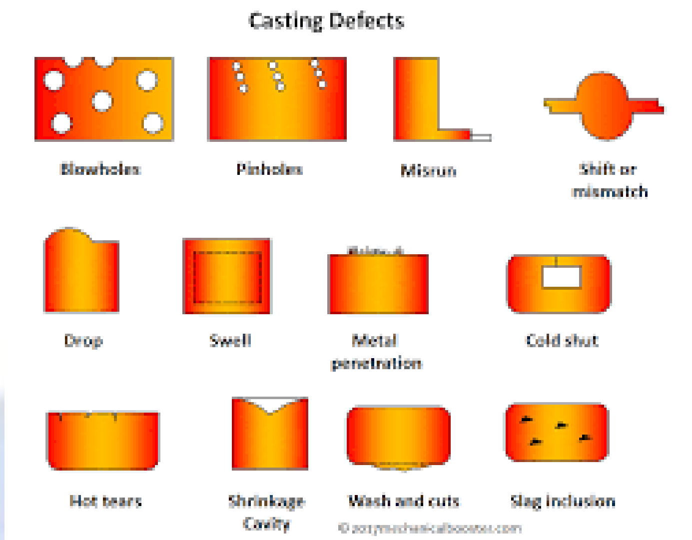
Remedies

(i) The moisture content in the sand must be controlled and kept at desired level.
(ii) High permeability sand should be used.
(iii) Sand of appropriate grain size should be used.
(iv) Sufficient ramming should be done.
(v) Adequate venting facility should be provided.

4. Drop
Drop defect occurs when there is cracking on the upper surface of the sand and sand pieces fall into the molten metal.

Causes

(i) Soft ramming and low strength of sand.
(ii) Insufficient fluxing of molten metal. Fluxing means addition of a substance in molten metal to remove impurities. After fluxing the impurities from the molten metal can be easily removed.
(ii) Insufficient reinforcement of sand projections in the cope.
(i) Sand of high strength should be used with proper ramming (neither too hard nor soft).
(ii) There should be proper fluxing of molten metal, so the impurities present in molten metal is removed easily before pouring it into the mold.
(iii) Sufficient reinforcement of the sand projections in the cope.



Chapter 4
Powder Metallurgey

Powder Metallurgy (PM) :
Powder metallurgy (PM) is a process for forming metal parts by heating compacted metal powders to just below their melting points. In other words, PM is a metal shaping process that creates near-net parts from powdered metal.
Powder metallurgy is the process of blending fine powdered materials, pressing them into a desired shape or form (compacting), and then heating the compressed material in a controlled atmosphere to bond the material (sintering).

The powder metallurgy process consists of four basic steps:

- Powder manufacture
- Powder blending
- Compacting
- Sintering

Advantages of Powder Metallurgy:
- Very little or no machining
- Minimal to no scrap or waste
- Close dimensional tolerances
- A wide variety of alloy systems
- Heat-treatable materials for increased strength or wear resistance
- The ability to combine multiple parts into one

Methods of producing component by powder matallurgey:

1.Powder Preparation

Properties of products produced using powder metallurgy are dependent on the characteristics and properties of the powder. One of the processes used to produce powder for powder metallurgy is melt atomization. In this process, liquid metal is broken into tiny droplets that cool and solidify into minute particles.

Though atomization is the most common method for producing powder, other processes include chemical reduction, electrolytic deposition, grinding, and thermal decomposition. Regardless of which process is used, all metals and alloys can be converted into a powder.

2.Mixing and Blending

In the mixing and blending process, powders are combined with other powders, binders, and lubricants to ensure the final part has the necessary characteristics. Blending and mixing can be completed wet or dry depending on the type of powder metallurgy process and the requirements of the part. The four most common blending and mixing techniques are rotating drum, rotating double cone, screw mixer on the interior of a drum, and blade mixer on the interior of a drum

3.Compacting

Compacting involves pressing and compressing the powder mixture into the desired shape or die. When done properly, compacting reduces potential voids and significantly increases the density of the product. The compressed and pressured form is referred to as a green compact, an indication that the part was formed by compacting.

4.Sintering

Though the green compact has been stressed and pressed at extreme pressure, it is not strong enough to be used. In order to produce a permanent bond between the metal particles, the green compact is sintered or heated at high temperature. In essence, sintering produces the final usable product or part.

Sintering:

Sintering is a heat treatment wherein large numbers of parts, in compacted form, are subjected to temperatures that are sufficient to produce enough pressure to cause the loose particles to unite and bond, forming a solid piece.

The required temperature fluctuates in accordance with the type of metal but is always slightly lower than the metal‘s melting temperature.

Economics of powder metallurgy:

1.Product size and weight

Although material utilisation is high in Powder Metallurgy, the powders used are a relatively expensive feedstock material compared with the steel bar or billet used in many competing processes.

2.Product geometry

Powder Metallurgy works best in making “prismatic” shapes with virtually die), but much more limited complexity in the third dimension, the axial or through-thickness direction.

3.Production quantity requirements

Powder Metallurgy requires large production runs in order to be viable. Firstly, the required forming tooling is generally complex and relatively expensive and the tooling cost needs to be amortised over a large number of products

Chapter 5
Press Work

Press Work:

Press working operations are also known as Sheet Metal Operations. The operations performed on the sheets to get the required shape is called Sheet metal operations. In the last article, we had discussed Types of dies and Types of fits which are performed on Sheet metal to get the required shape.

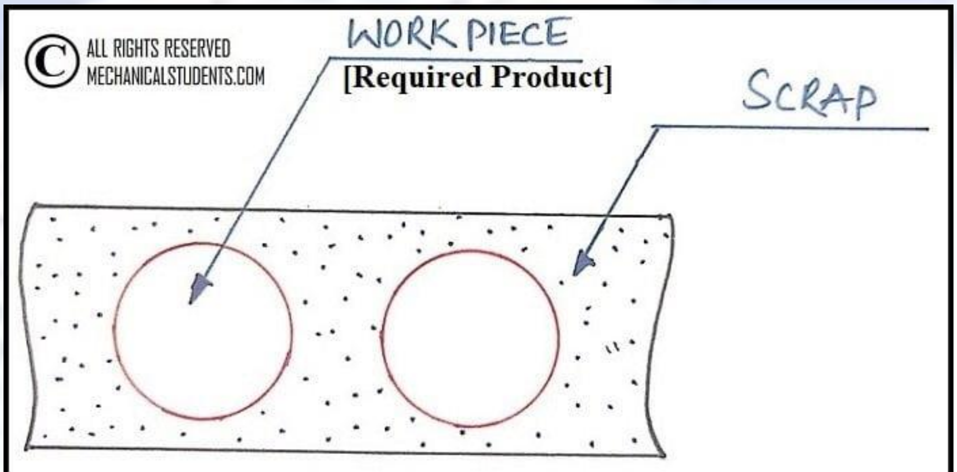
Blanking Operation:

When the force is applied by using the punch on to the sheet, the cutting or shearing action will be taking place in the sheet producing a piece/blank. In punch and die working, if the Piece/blank produced in the sheet is useful, it is called a Blanking operation.

In blanking Operation, the die size is made equal to blank size and clearance is provided on the Punch and also the shear is provided on the die.

Piercing Operation:

When the force is applied by using the punch on to the sheet, the cutting or shearing action will be taking place in the sheet producing a piece/blank leaving a hole. In punch and die working, if the hole produced in the sheet is useful, it is called Punching or Piercing operation.



PRESS WORKING OPERATIONS-BLANKING OPERATION

Trimming Operation:

It is a process of removing unwanted material from the surface of the workpiece called a Trimming operation.

Dies:

A die is a specialized machine tool used in manufacturing industries to cut and/or form material to a desired shape or profile. Stamping dies are used with a press, as opposed to drawing dies (used in the manufacture of wire) and casting dies (used in molding) which are not. Like molds, dies are generally customized to the item they are used to create.

Types of Dies:

- **Simple Dies**
- **Compound Dies**
- **Progressive Dies**

Types of Punch:

- **Centre punch.**
- **Prick punch.**
- **Solid punch.**
- **Transfer punch.**
- **Drive punch.**
- **Pin punch.**
- **Roll pin punch.**
- **Hollow punch**

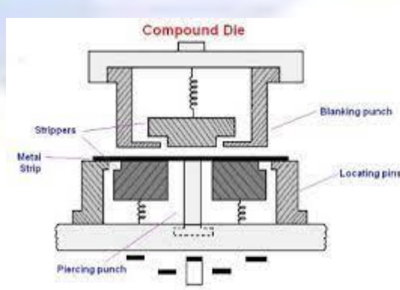
1. Simple Dies:

Simple dies are also known as single operation dies as a single operation is performed for each stroke of the die press. These are generally used for very simple operations listed under cutting or forming dies.

2. Compound Dies:

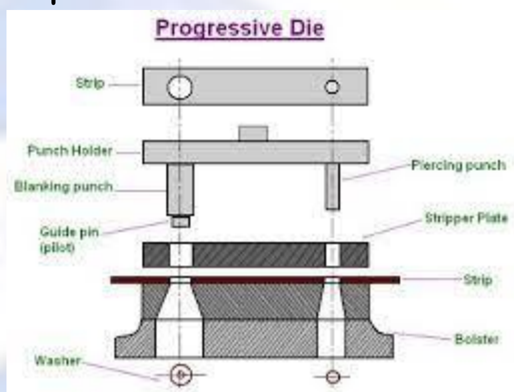
Compound dies are those dies wherein more than one operation takes place on a single station. These dies are mostly used for cutting operation and hence addressed as cutting tools. These dies allow simultaneous cutting of internal as well as external part features in a single stroke in some cases. Compound dies are always more accurate and economical as compared to single operation or simple dies.

The figure adjacent provides example of a compound die operation. In this operation a washer is prepared by one stroke of the press. This washer is manufactured by simulation blanking as well as piercing operations.



4. **Progressive Dies:**

Progressive dies also known as follow on dies have a series of operations. At every station on the work piece, an operation is performed during the stroke of press. However, in between the two presses, the work piece gets transferred to the next station and is worked there. In this operation thus, each press operation develops a finished piece.



Advantages of Progressive Dies:

- **Speed of production.**
- **Less scrap material.**
- **Quicker setup.**
- **Production of more geometries within a single tool.**
- **Longer production runs.**
- **High repeatability.**
- **Lower labor cost per part.**
- **Production of close tolerances.**

Advantage of Compound Dies:

- **Compound tooling is less costly and faster to build than progressive tooling**
- **Compound stamping will result in flatter parts because the part is made in one stroke**

Disadvantage of compound dies:

A disadvantage of building a compound blank die is the limitedspace which ends to leave die components thin and weak. This concentrates the load and shock on punches and matrixes resultingin tooling failures.

Chapter 6
Jig and Fixtures

Jig:

A jig is a work-holding device that holds, supports, and locates the workpiece and guides the one or more tools to perform a specific operation. In other words, this can also be defined as, used for holding the tools and also guiding the cutting tools.

The main purpose of a jig is to provide repeatability, accuracy, and interchangeability in the manufacturing of products.

Fixtures:

Fixtures are the work holding device, which holds, supports and locates the workpiece but not guides the cutting tool to perform a specific operation. In other words, the fixtures are only the work holding device that holds, supports and locates the workpiece in the desired position to perform any operation.

The main purpose of the fixtures is to hold and locate the workpiece during any machining operation and to provide repeatability, accuracy, and interchangeability in the manufacturing of products.

Advantages of Jigs and Fixtures

Jigs and Fixtures have made manufacturing processes less time consuming, more precise, and hassle-free from a human factor perspective. The benefits of jigs and fixtures including but not limited to, the following:

- Increase in production
- The consistent quality of manufactured products due to low variability in dimension
- Cost reduction
- Inter-changeability and high accuracy of parts
- Inspection and quality control expenses are significantly reduced
- The decrease in an accident with improved safety standards
- Due to relatively simple manoeuvrability, semi-skilled workers can operate these tools which reduce the cost of the workforce.

- The machine tool can be automated to a reasonable extent
- Complex, rigid and, heavy components can be easily machined
- Simple assembly operations reduce non-productive hours

Principal of location:

It is also known as six pin or six point location principle. In this, the three adjacent locating surfaces of the blank (work piece) are resting against 3, 2 and 1 pins respectively, which prevent 9 degrees of freedom.

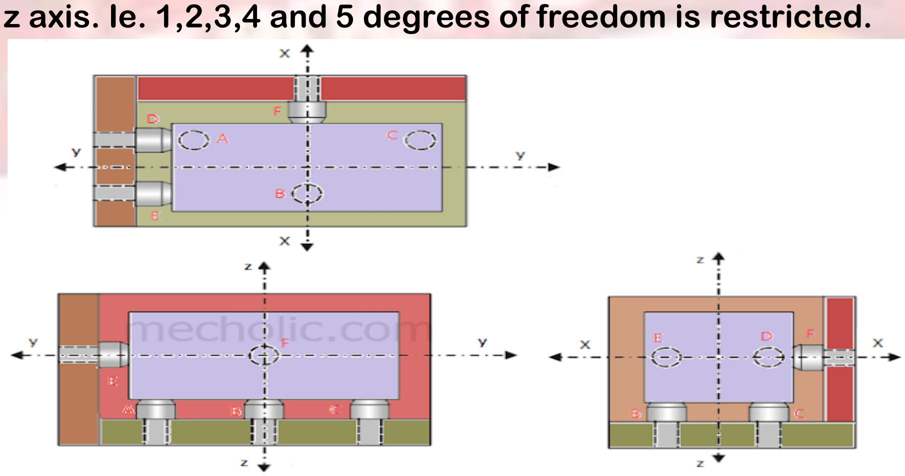
The rest three degrees of freedom are arrested by three external forces usually provided directly by clamping.

The 3-2-1 principle states that the six locators are sufficient to restrict the required degree of freedom of any work piece. In this, motion is restricted using clamps and locators. A three pin base can restrict five motions and six pins restrict nine motions

3-2-1 Principle of Location

The 3-2-1 principle of location (six point location principle) is used to constrain the movement of workpiece along the three axes XX, YY, and ZZ. This is achieved by providing six locating points, 3 pins in base plate, 2 pins in vertical plane and 1 pin in a plane which is perpendicular to first two planes.

Pins A, B, C on the base plane (a plane parallel to the plane which contains X and Y axis) restrict the rotation of component about X axis and Y axis. It also limit the downward movement of component along z axis. Ie. 1,2,3,4 and 5 degrees of freedom is restricted.



Types of Jigs:

- Template jig
- Plate jig
- Diameter jig
- Channel jig
- Ring jig
- Box jig
- Leaf jig
- Angle plate jig
- Indexing jig
- Trunion jig

Types of fixture:

- Plate fixture
- Angle plate fixture
- Vise-jaw fixture
- Indexing fixture
- Multistation fixture
- Profile fixture

Jigs	Fixtures
It holds and locates the work as well as guides the tool.	It holds and locates the work but does not guide the tool.
These are lighter in construction and clamping with the table is often unnecessary.	These are heavier in construction and bolted rigidly on the machine table.
Used for holding the work and guiding the tool in drilling, reaming or tapping operation.	Used for holding the work in milling, grinding, turning or planning operation
Gauge blocks are not necessary.	Gauge blocks may be provided for effective handling
The cost is more.	The cost is less as compared with the jigs.
Their designing is complex.	Their designing is simple as compared to jigs.