PRODUCTION TECHNOLOGY

Th-1

3RD SEMESTER

BRANCH–AUTOMOBILE ENGINEERING

B.O.S.E., CUTTACK

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CHAPTER-1

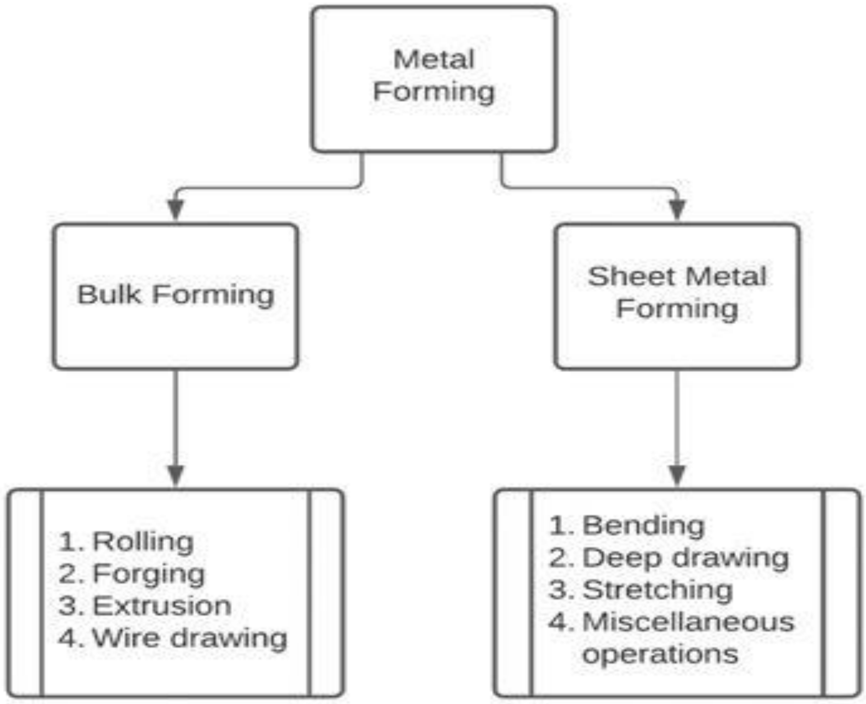
METAL FORMING PROCESS

What is Forming Process?

Metal forming is a process of manufacturing components of desired shapes by deforming the material plastically, by the application of compressive force, bending or shear force, tensile force, or combinations of these all forces together, without adding or removing material.

Types of Forming Process

Forming Process has been classified into two groups; **Bulk-forming and Sheet metal forming**.



Now we will get to know all types in detail.

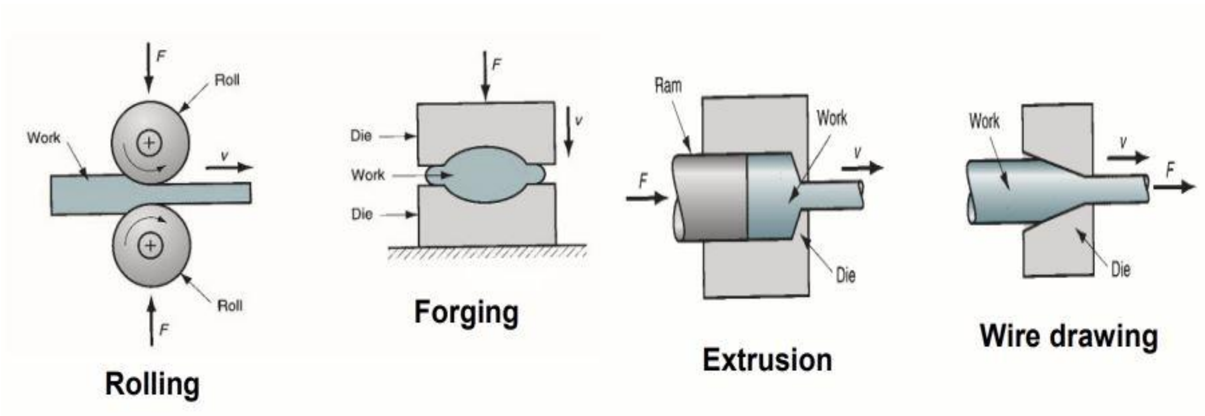
#1. Bulk forming

Bulk-forming is a method of producing materials large volumes of products whose surface area is less than the volume ratio.

Here, to accomplish the machining, tensile forces, compressive forces, shear forces, or a combination of any two is processed.

It is carried out in machinery which has a set of tools and dies. The use of a tool and the die itself makes us understand that the die has the same shape as the output to be produced and the tool is pressed against the die to generate the shape on the material.

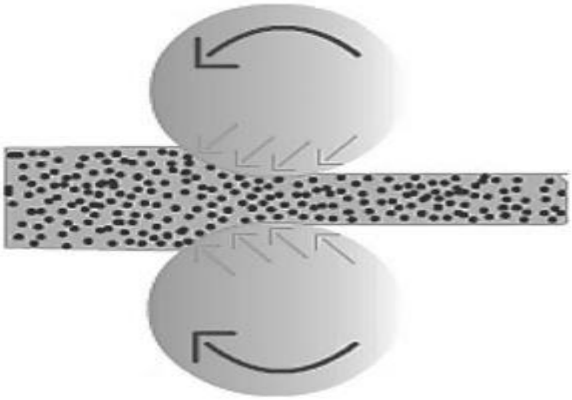
The bulk-forming involves processes named Rolling, Forging, Extrusion, and Drawing as its work processes.



Rolling

Rolling is a typical forming process used to manufacture semi-finished products such as rods, sheets, and plates, and finished products such as angles, U-profiles, and profiles. Rolling can be done both hot and cold.

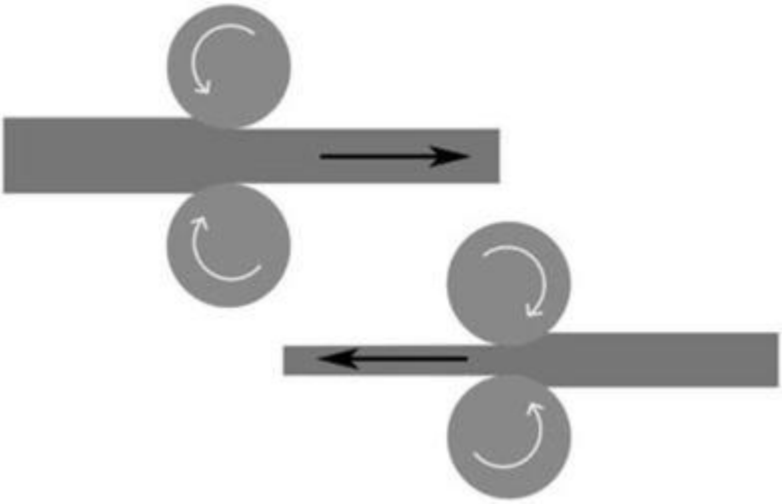
In this process, the billet in the form of a slab is compressed between two rolls that rotate in the opposite direction, thus reducing the thickness of the billet and fabricating it to a new shape. The rotating rollers pull the slab into space and compress it. The final product is the reduced size of the billet.



A variety of rolling mills have evolved over time for the production of different shaped articles. Each is described below

Two-High Rolling Mill

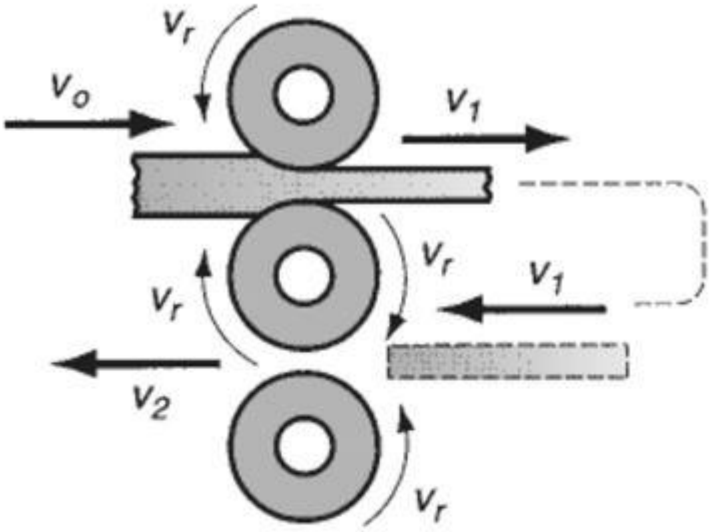
The Two-High Rolling Mill is constructed out of a three separate stand with two horizontal rolls stacked one on top of the other.



One or both rollers are adjustable in this type of mill. The metal is passed between two rollers that rotate at the same speed but in different directions during operation.

Three-High Rolling Mill

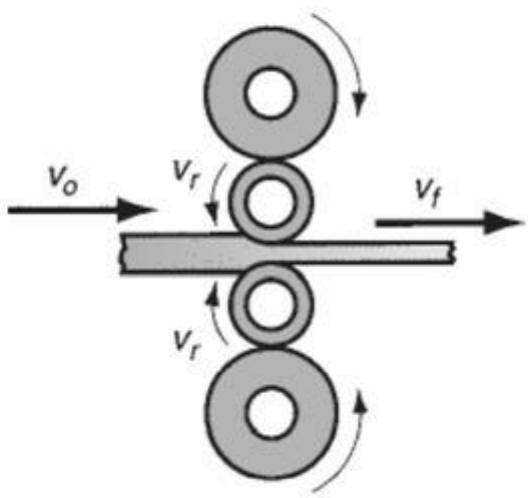
In the case of the Three-High Rolling Mill, there are three rolls, one on top of the other. Two rolls will be used at a time for a single pass. In this case, the roll direction will not be altered.



The sheet will be relocated to the bottom two rolls for a further reduction once the top two rolls have been used for the first reduction. This cycle is repeated until the desired decrease is achieved.

Four-High Rolling Mill

The Four-High Rolling Mill consists of two small rolls used to reduce thickness and two large backing rolls used to support the small rolls.

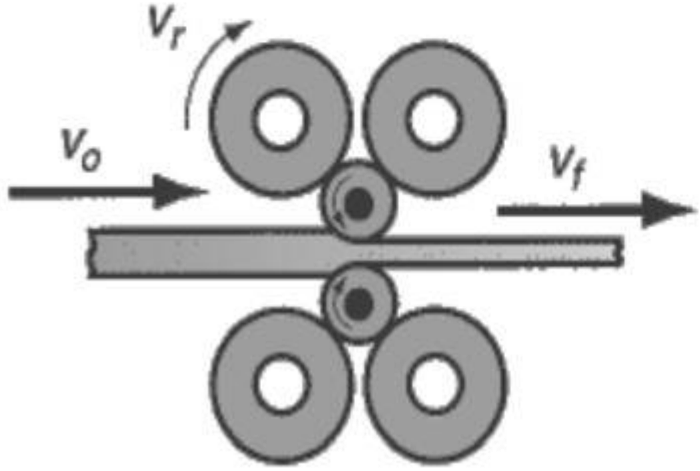


Because the roll-sheet contact area is reduced with short rolls, the roll force required is lowered.

The large backing rollers are needed to lessen the elastic deflection of the small rolls when the sheet is passed between them.

Cluster Mill

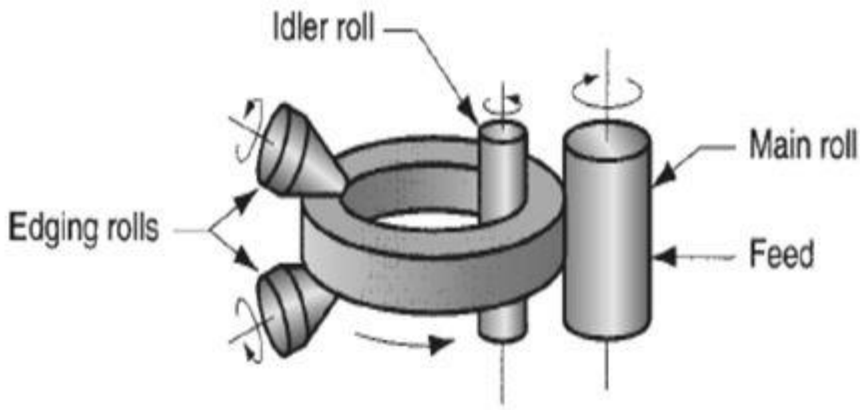
A Cluster Mill is comprised of two operating rolls and four or more backing up rolls.



The number of back-ups or supporting rolls necessary is determined by the amount of support needed for the working (small diameter) rolls. Cluster mills are normally employed in cold-rolling operations.

Ring Rolling

Ring Rolling is a forming method that involves rolling a thick-walled ring component of a lower diameter into a thin-walled ring of a greater diameter.



As the thick-walled ring is compressed, the deformed material elongates, causing the ring’s diameter to increase.

Forging

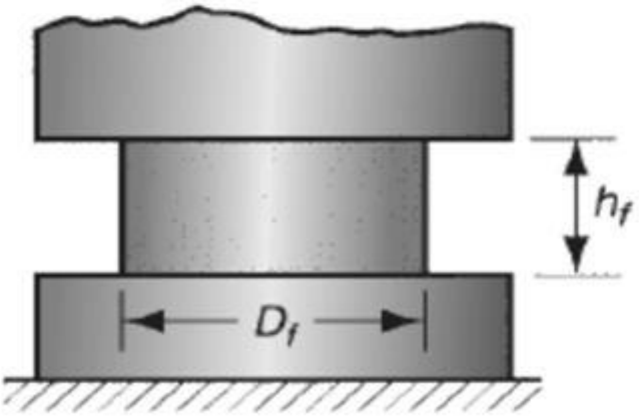
Forging is a bulk-forming method in which compressive and tensile forces are applied to a work piece or billet to fabricate it into a final product using a pair of tools called a die and punch.

Open or closed dies can be used for forging. In most cases, open die forging is used to shape raw materials into a shape suitable for later forming or machining.

In this process, the billet is compressed between two dies. The dies contain a shaped contour that is to be generated on the final product. On compression of the billet between a pair of dies, the shape is imparted on the billet, thus obtaining the final product.

Open Die Forging

For operations such as drawing out, thinning, and so on, Open Die Forgings are done with a pair of flat-facing dies.

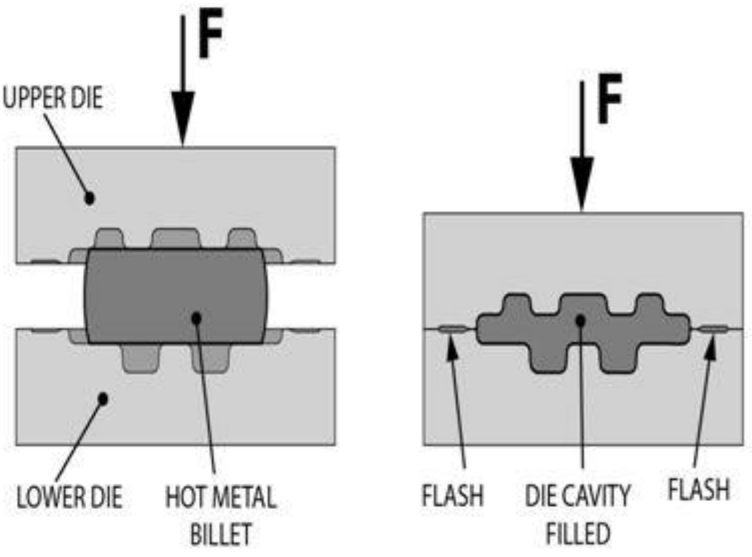


Open die forging is a vital technology in a variety of industries.

It enables the rough and finishing shape of metals, most notably steel and steel alloys. It necessitates a die with open sides that allows the workpiece to move freely in a lateral manner when hit. This design also enables the forging of very big workpieces.

Closed Die Forging

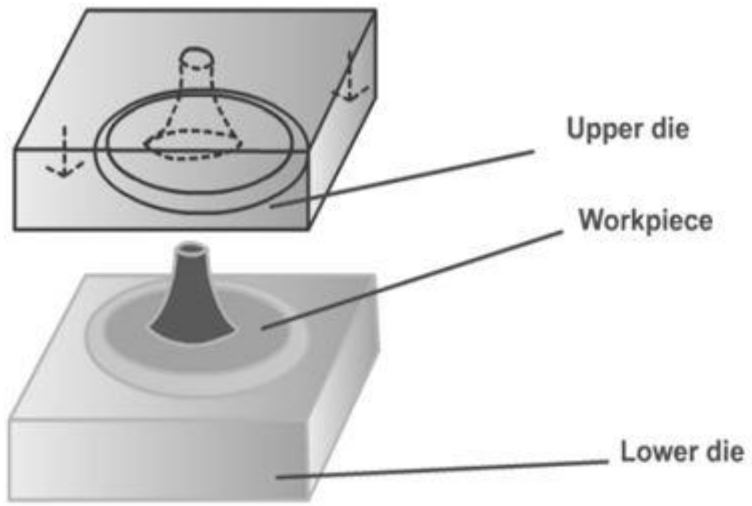
Closed Die Forging is accomplished by compressing a billet of raw material into a cavity produced between two shaped dies.



The shape of the die cavity is achieved by forming products. Closed die forming is used to make valve parts, pump parts, tiny gears, connecting rods, spanners, and other items.

Coining

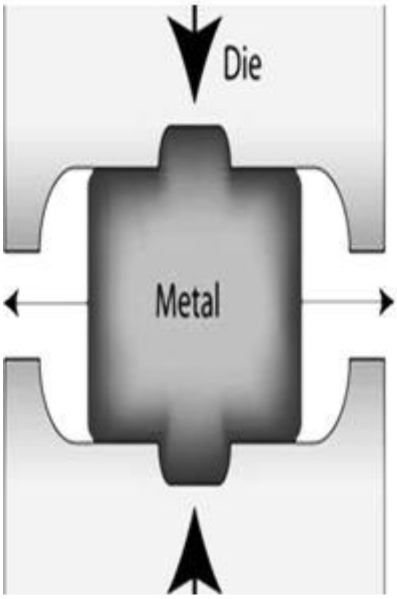
The process of coining is the application of compressive stress to the raw material's surface in order to impart unique shapes from the embossing punch.

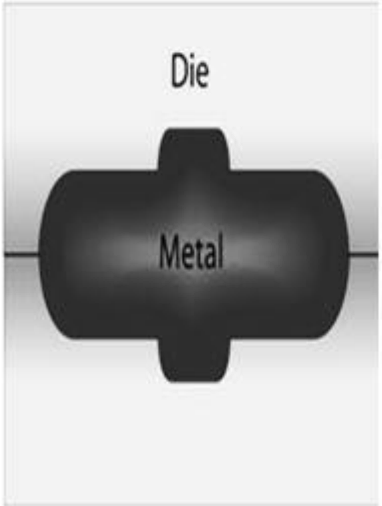


Examples are printed metal coins and medallions.

Impression Die Forging

In Impression Die Forging, the die surfaces have a form that is imparted to the workpiece during compression, greatly restricting metal flow. The additional distorted material outside the die impression is referred to as flash. This will be removed later.





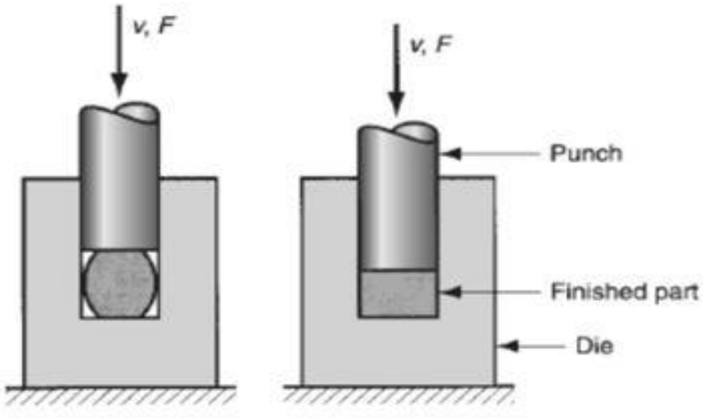
Impression dies forging is incapable of producing products with tight tolerances.

To attain the required accuracies, machining is usually required.

The forging process produces the fundamental shape of the item, with further machining performed on those parts of the part that require precision finishing, such as holes and threads.

Flash Less Forging

In the Flash Less Forging technique, the workpiece is totally limited within the die in flashless forging, and no flash is produced. The amount of initial workpiece utilized must be precisely managed so that it matches the volume of the die cavity.



This flash-less forging technique is appropriate for making basic and symmetrical part geometries, as well as working materials such as Al, Mg, and their alloys, due to the demands.

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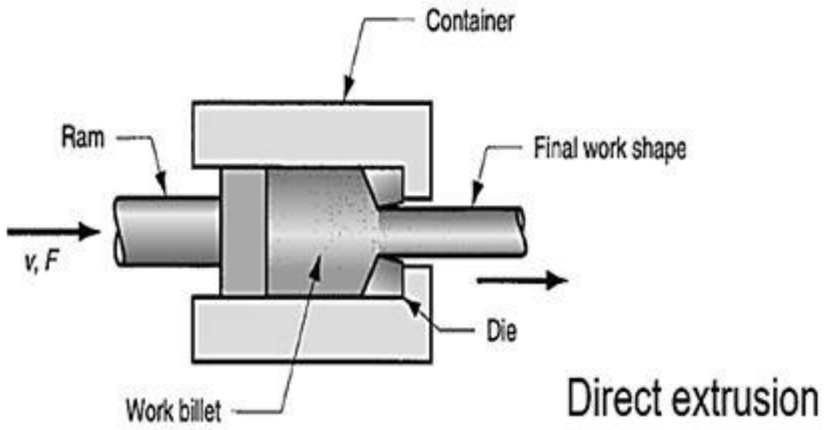
Extrusion

Extrusion is a bulk-forming procedure that involves forcing or compressing work metal through a die hole to produce a desired cross-sectional shape.

Extrusion is typically distributed into two work manners. One as Direct or forward extrusion and the other as Indirect or backward extrusion.

Direct or forward extrusion

In direct extrusion, a metal billet is first loaded into the container. The container has a die hole of shaped contour. A ram is then used to force the metal billet through the die hole to produce the article.

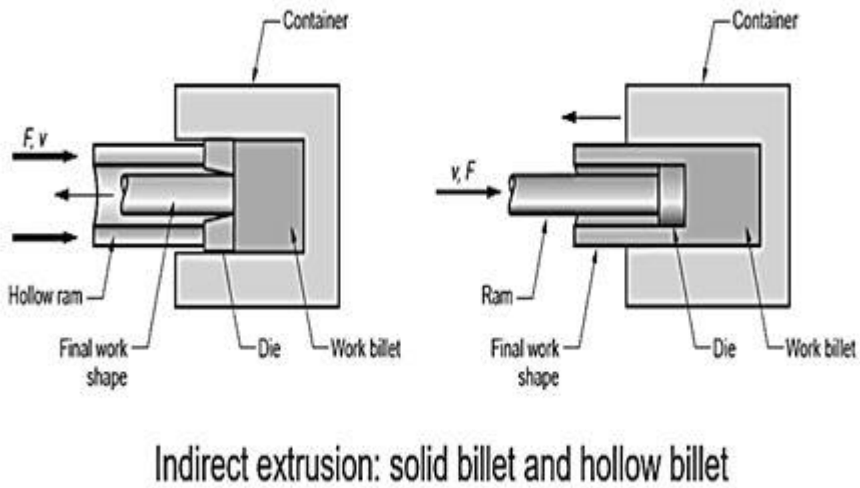


Extruded products include tubes, cans, cups, small size gears, shafts, etc.

Some portion of the billet always remains at the end of every extrusion and is called the butt.

Indirect or backward extrusion

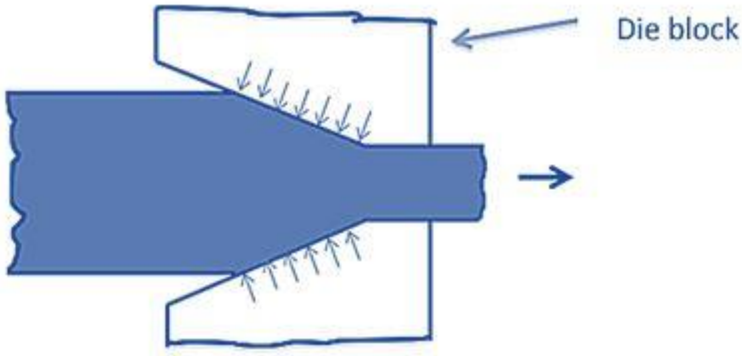
Instead of being mounted on the container, the die is mounted on the ram. The metal flows through the die hole on the ram side in the opposite direction of the ram's movement as it is compressed by the ram.



There is no friction at the contact since there is no relative motion between the billet and the container, hence the ram force is smaller than in direct extrusion.

Wire drawing:

The wire drawing process is used to make small diameter wires from rods by reducing their diameter and stretching their length with tensile force.

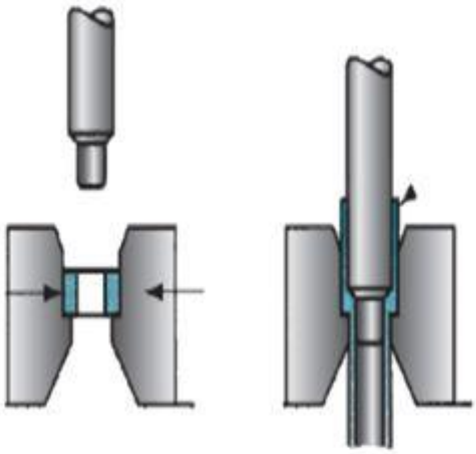


Wire drawing is used to make musical strings. Tube drawing can be used to create seamless tubes.

In this process, a rod, or bar is pulled through a die hole to form the desired thickness of wire, reducing their cross-section area.

Impact extrusion

Impact extrusion is always carried out in cold form. Backward impact extrusion permits for very thin walls. Manufacturing toothpaste tubes, for example, or battery boxes.



It is done at faster speeds and with shorter strokes. Impact pressure, rather than exerting pressure, is used to extrude the billet through the die. However, impacting can be accomplished by forward or backward extrusion or a combination of the two.

Hydrostatic extrusion

In the hydrostatic extrusion technique, the billet is surrounded by fluid within the container during the process, and the fluid is pressured by the ram's forward motion. Because of the fluid, there is no friction inside the container, and friction at the die hole is minimal. Special fluids and methods must be employed while working at high temperatures.

The ductility of a material rises when there is hydrostatic pressure on it and no friction. As a result, this approach may be utilized on metals that are too fragile for traditional extrusion procedures.

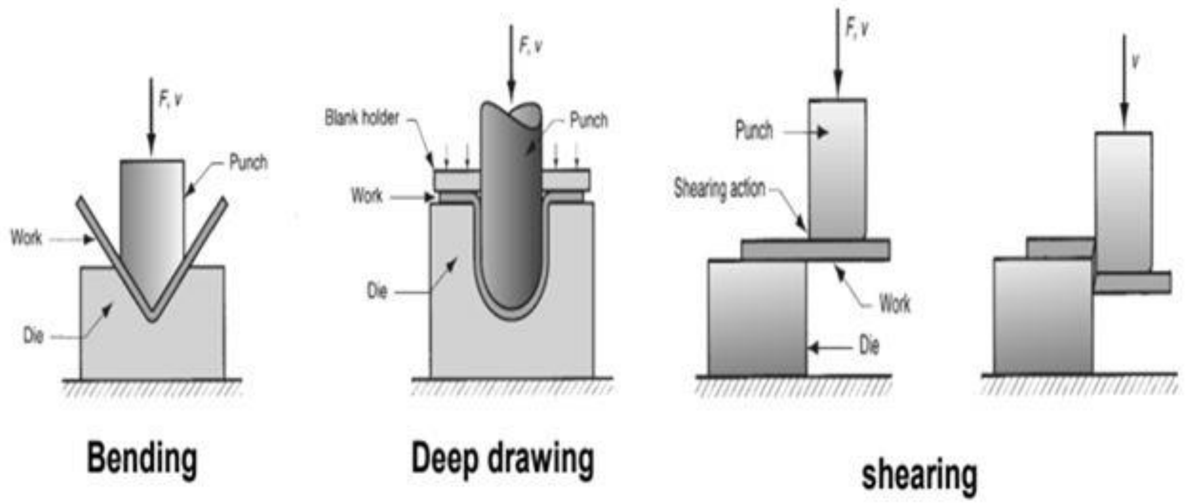
This method is used on ductile metals, with large reduction ratios conceivable.

Sheet metal forming

Sheet metal forming involves the application of tensile and shears forces to fabricate sheets, plates, and strips to a desired possible shape using a set of tools. The punch and die are used as tools in the fabrication process.

Sheet metal forming is associated with operations; Bending, Drawing, Shearing, Blanking, and Punching to produce the materials.

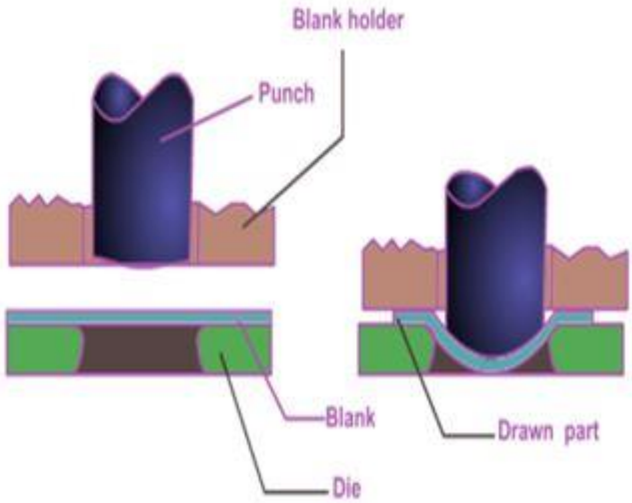
The sheet forming method uses plastic sheet deformation techniques such as Deep Drawing, Cutting, Bending, Hemming, Flanging, Curling, Stretch Forming/Stretching, Stamping.



Deep drawing:

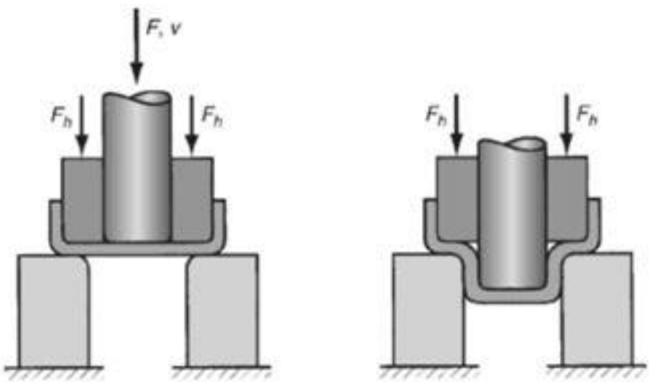
Deep drawing is a sheet metal process in which sheet metal is forced into a cup of hollow shape using tensile and compressive forces without changing its thickness.

In this process, the sheet is placed over the die opening and pushed into it with a punch. A blank holder is used to hold the sheet flat on the die surface.



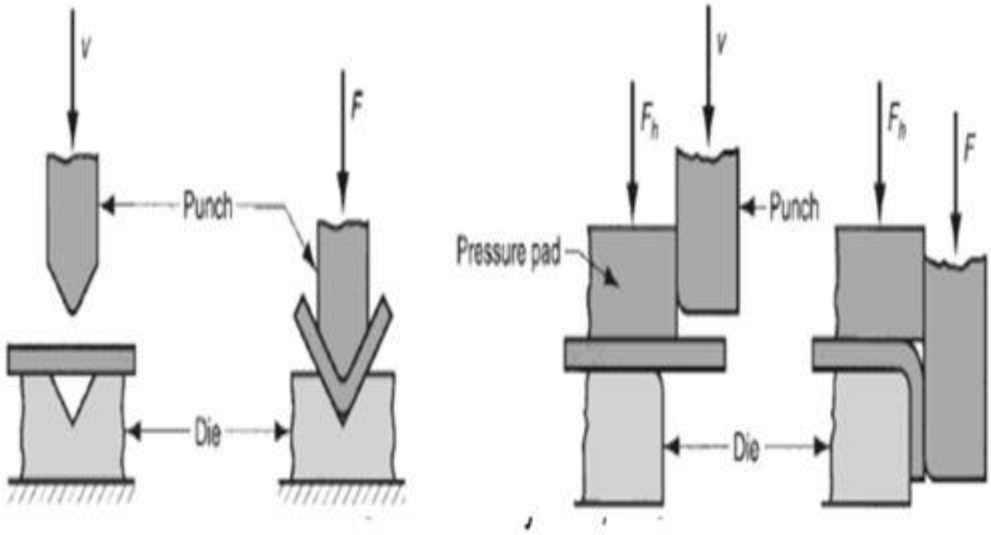
In many cases, the alteration required to create that part will be substantial (the drawing ratio is very high). In such cases, the part's complete forming necessitates more than one deep drawing step.

Any additional drawing steps required to complete the drawing operation are referred to as Redrawing.



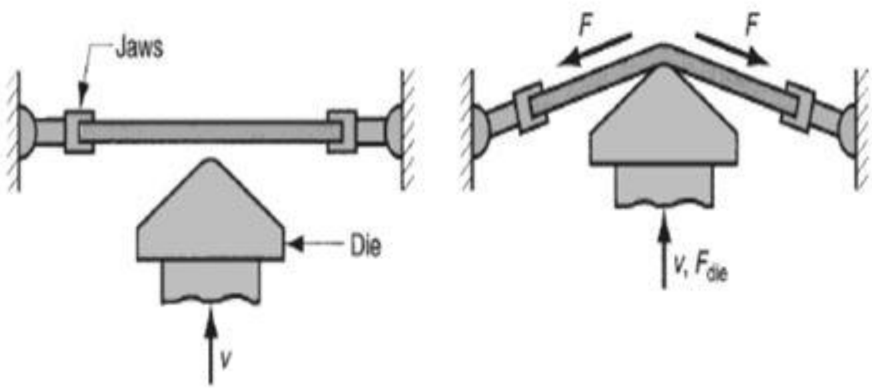
Sheet bending:

Sheet bending is defined as metal straining around a straight axis. The metal on the inner edge of the neutral plane is compressed while the metal on the outer edges of the neutral plane is stretched during the bending operation. The thickness of the sheet metal does not change as a result of bending.



Stretching or Stretch forming:

Stretch forming is a sheet metal forming process in which the sheet metal is intentionally stretched and bent at the same time to change its shape.



The sheet is held at both ends by jaws or draw beads and then stretched by punch, causing the sheet to be stressed above its yield strength and fabricating it to the desired shape.

The metal has been plastically distorted when the strain is released. The combined impact of stretching and bending causes the part to have a lower spring back.

Applications of Metal Forming Process:

The metal forming technique is used to produce seamless tubes, rods, and turbine rings. It is also used to create cement kilns.

This forming process can be used to create bearings, plates, steel sheets, and numerous components for an automobile.

This method is also used to make missile and aircraft components and also used to make hinges, bolts, and nails.

Advantages of Metal Forming Process:

The following advantages of **forming processes are** as follows:

- Articles with increased strength.
- Very less material wastage.
- A smaller components with high strength can be manufactured.
- Articles produced are accurate in dimensions.
- Uniform rate of forming.
- Great surface finish.
- Less machining time compared to conventional metal removal method.
- Improved mechanical properties.

Disadvantages of Metal Forming Process:

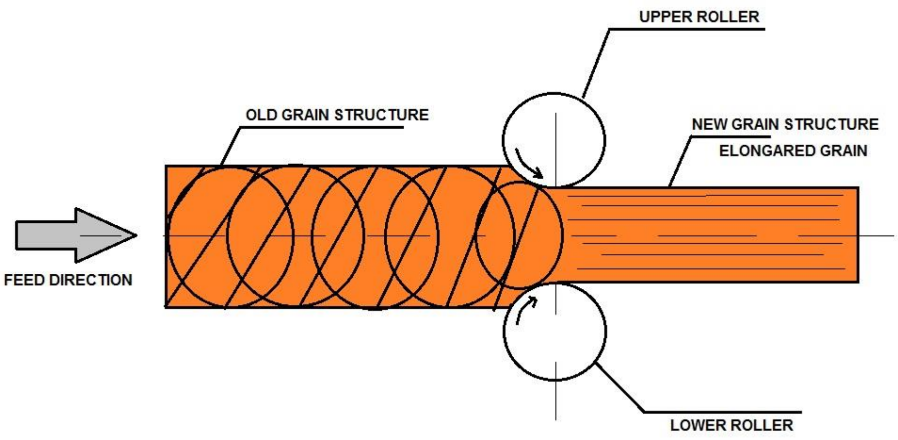
The following disadvantages of **forming processes are** as follows:

- The requirement of Power is high.
- There is high mechanical forces requirement.
- Strain hardening of the work material is a limit to the amount of forming.
- The brittle material cannot be manufactured in this process.
- There is also use of heat treatment process in metal forming some times.

What is Hot-working Process?

Hot-working Process is a type of metal forming process and this distinction is based on the particular temperature at which the deformation is carried out. The minimum temperature at which plastically deformed metals form new grains or crystals within a specified time is recrystallization temperature.

Most of the metals have a recrystallization temperature that is one-third or one-half of the melting point of the metal. If the deformation of metal is carried out above the recrystallization temperature.



HOT WORKING PROCESS

Method of Hot Working Process:

Various Methods of Hot Working Process are follows:

- **Hot Rolling**
- **Hot Forging**
- **Hot Extrusion**
- **Hot Piercing Or Rotary Piercing**
- **Hot Drawing Or Cupping and**
- **Hot Spinning.**

Hot Rolling:

Hot rolling is the process of metal forming in which metal is heated above the recrystallization temperature and then passed through pair of rollers, rolling in the opposite direction but with the same speed to flatten it, lengthen it, and reduce cross-sectional area and obtain uniform thickness.

In other words, we can say hot rolling is the process in which metal is plastically deformed above the recrystallization temperature in the working or rolling operation.

Hot Forging:

This is a very important metalworking process, which is of great commercial importance as it is used by many industries for producing a variety of products.

It is the metal forming manufacturing process involving the shaping of metal through localized compressive forces. It includes heating, deforming, and providing shape to the piece of metal. These localized forces are delivered through a manual hammer or hammer machine and dice.

This hot forging process is useful in manufacturing many industrial components like crane hooks, crank, crankshaft, and wrenches.

Hot Working Process In Detail:

The process of hot working with metal involves the deformation of a metal at certainly high temperature (above recrystallization point of metal). During this process, recrystallization happens simultaneously with the deformation of the metal.

The phenomena that occur at sufficiently high temperature is called recrystallization, it accelerates the growth of grains in the metal structure, resulting in metal consisting of entirely new grain.

The temperature for hot working of metal depends on the temperature of recrystallization, for example, carbon steel requires a temperature more than 1000 degrees celsius.

Formation of the new grain structure(due to recrystallization) rapidly eliminates the distorted grain structure and strain hardening that is produced due to the deformation of metal during hot working.

50 degrees is the maximum temperature of the metal. Below its melting point. The metal will crumble if the process is done at or near the melting point.

There are various steps for carrying hot working of metal. Firstly the metal is heated to its recrystallization temperature thereafter the intermediate and maximum temperature is fixed to obtain the metal consisting of the maximum number of fine grains.

The finishing temperature is held just above the recrystallization temperature. And the deformation created in the last step is relatively large to maintain fine recrystallized grain size.

Hot Working Process Advantages:

The following **advantages of Hot Working Process** is:

- Hot-working is Suitable for bulk production work.
- The shape and size of metal can be easily changed.
- As the material is above the recrystallization temperature any work can be performed on metal without any stress of hardening.
- As the material is at a high temperature so it has a higher amount of ductility, which means there is no limit on hot-working of metal.
- Due to hot working metals have a refined grain structure. Thus improved mechanical properties.
- Porosity is considerably reduced.
- If there are no errors, hot-work won't affect strength, hardness, corrosion, etc.
- Higher temperature results in reducing the shear stress, so much less force is required for necessary deformation.
- As the metal is in the plastic state, larger deformation can be accomplished.
- It can improve mechanical, physical & chemical properties.
- This is fast, economic & reliable.

Hot Working Disadvantages:

The following **disadvantages of Hot Working Process** is:

- Due to oxidation, it leads to a poor surface finish.
- Due to oxidation, there is a loss in carbon sometimes leads to a weaker strength.
- Maintaining and handling the hot working setup is not easy.
- Requires expensive units like a gas furnace or induction heater.
- Dimensional accuracy is difficult to achieve due to the thermal expansion of the metal.
- It is not suitable for all types of metals.

Hot Working Application:

The **hot working process is used to manufacture different types of products like tubes, pipes, metal sheets,** etc. Different types of products we encounter daily are manufactured using this method like the many types of equipment of automobile, aerospace, architecture, home decor, etc.

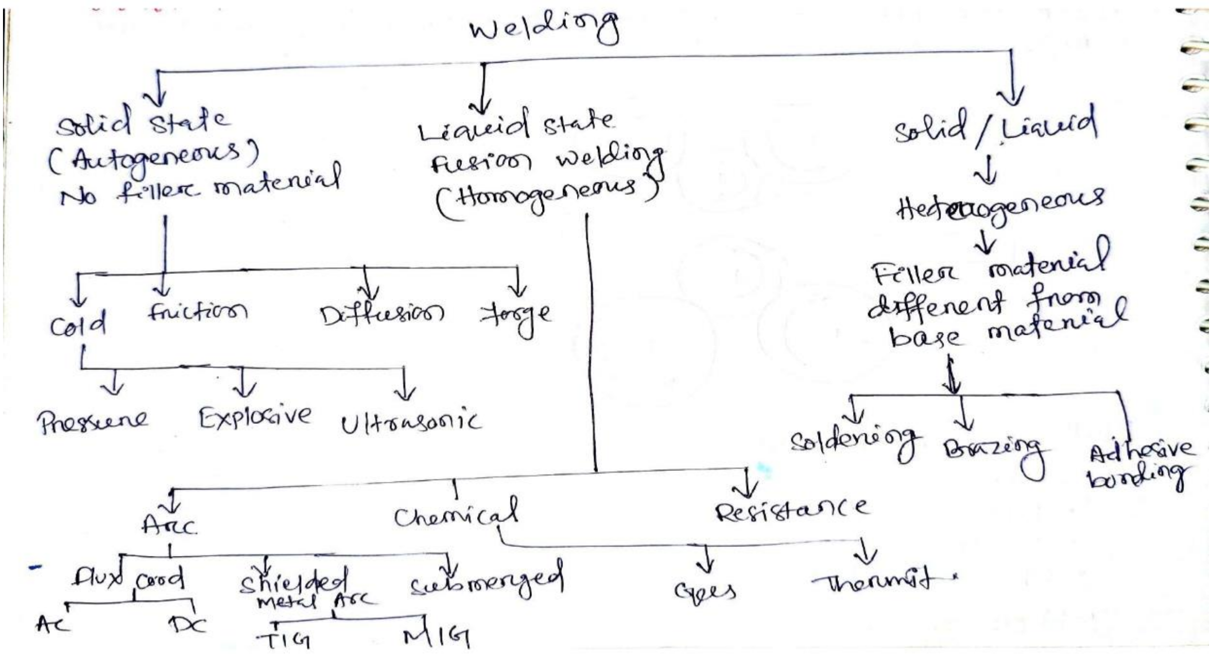
Mainly it is used in forging, hot rolling, and extrusion.

CHAPTER-2

WELDING

Joining

- The **joining is the process** used to assemble different parts to obtain the desired complex parts or geometry which is either too difficult or impossible to obtain by using only the manufacturing processes.
- The joining process is either temporary (Bolted joints) or permanent (Welding, riveting, coupling, etc.).
- Different joining processes are classified below:



Welding is the process of joining together two pieces of metal with or without the application of heat or pressure or both is applied and with or without addition of filler metal for formation of metallic bond.

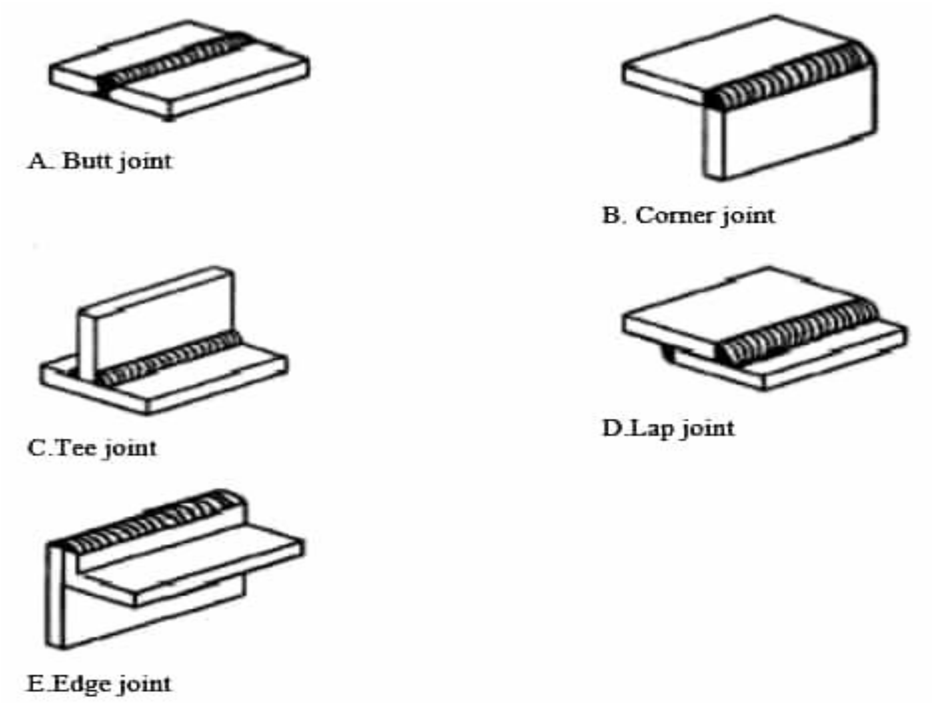
Classification of the welding processes: Welding process based on composition of filler material are as follows:

(i). Autogenous Welding: In this type, no filter material is required. All types of solid phase welding and resistance welding are the examples of this category.

(ii). Homogenous: Here, the filler material provided to the joint is the same as the parent material. Arc, gas, and thermit welding are examples of this category.

(iii). Heterogenous Welding: Here the filler material has different composition from the parent material. Soldering and brazing are two such joining processes. The insoluble materials, for example iron and silver, can be welded using the heterogeneous process.

Types of joints: Different types of joints according to their configuration are butt, lap, corner, tee and edge joints. The contact area plays an important role in tensile strength of butt joints. In case of lap joint, the bonding area is taken as per the strength requirement but the main disadvantage is that the thickness of joint increases due to overlapping of the parts.



Welding Accessories

(1). Non consumable electrodes:

- They are made of tungsten or carbon and do not melt during the welding thus called non-consumable electrodes.
- Generally non-consumable electrodes are used in TIG welding processes.

(2). Coated consumable electrodes:

- With these type of electrodes, no additional filler metal and flux are required.
- These electrodes have core of mild steel and coating over them of flux material.
- Coating on the electrode performs many functions:
  (i). It develops a reducing atmosphere and prevents oxidation.
  (ii). It forms separable slag from metal impurities.
  (iii). It establishes arc and provides necessary alloying elements to the weld pool.
  Examples: Manganese oxide and potassium silicate are the alloying elements and stabilizers.

(3). Welding cables: These are needed to carry the current from the power source to different elements of Arc welding process equipment i.e. the arc, Electrode, the workpiece and finally return to the welding power source. These are insulated copper or aluminum cables.

(4). Hand screen: It protects the eyes during Arc welding process.

(5). Chipping hammer: It is used for removing the slag from the weld bead region by striking on it.

(6). Wire Brush: A wire brush is generally used to clean the surface before and after the welding process.

(7). Protective clothing: The clothing such as apron which is used to protect from the direct exposure of heat to the body. Example: Gloves is necessary before touching any item in the workshop.

(8). Filler Metal: Filler metal is provided separately to improve properties of weldment especially with non consumable electrodes. Filler metal is selected based on the metal to be welded. Common filler metals used are are discussed below.

(i). Coated filler metal: Rods of this type of filler metal consists the coating of flux-material.
(ii). Bare filler metal: No coating of flux is there, it is supplied additionally as per the requirement.

Examples: The alloy of chromium and vanadium are most commonly used for stainless steel and alloy steels. Phosphorous mixed copper is the main filler metal for the welding of the copper and its alloys.

What Does Weld Flux Mean?

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

Flux is an important agent in most welding consumables, it is a coating outside and sometimes inside of welding consumables that helps in promoting the fusion of metals during the welding process. It is a chemical purifying agent that helps to join the workpiece. The main purpose of the flux is to prevent the welded area from getting oxidized. Different ingredients are used to make flux, it can differ from process to process and manufacturer to manufacturer. Materials that are generally used to make flux consist of Zinc chloride, Ammonium chloride, Hydrochloric acid, Borax, etc. One can add extra alloying elements etc through flux.

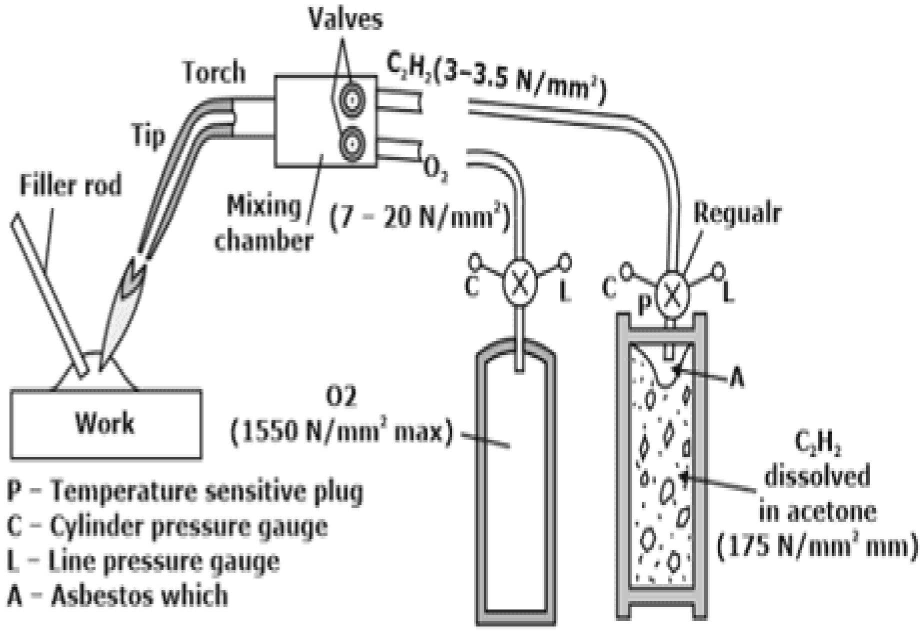
During the welding process when the arc is generated flux keeps the atmospheric gases away from the molten pool, flux does this by generating CO_2 gas at the same time when the arc is formed. Flux keeps oxygen, nitrogen, and moisture away from the weldment, without flux the welded area will contain porosity due to oxidation and can get brittle which can lead to hazards.
Flux has the ability to clean the metal surface & remove the impurities, it forms a protective layer of slag which helps in giving shapes to the weld, flux reduces the surface tension of the molten pool, flux helps in increasing mechanical properties by infusing alloys and help to join the base metal with filler metal which provides the strength.

Flux is an agent that helps the metal to get prepared for the welding, once the welding process is done and the metal/workpiece has cooled down the excess flux can be easily removed with the help of a brush. Sometimes warm water is also used to remove the slag. The remaining layer will give extra protection to the weld from getting oxidized or to get rusted. Hence, flux is a very important and inseparable part of the welding process, even in some of the gas welding processes the flux coated wire is used for the basic protection.

Oxyacetylene welding (Gas welding):

- It can used for welding of wide range of metals and alloys.
- In this welding, Acetylene and oxygen mixture are burnt under a controlled environment which releases a large amount of heat resulting in high temperature rise.
- Carbon dioxide is also produced which prevents the oxidation of metals being welded.
- Highest temperature obtained in this welding is 3200°C. The chemical reaction involved in burning of acetylene is:

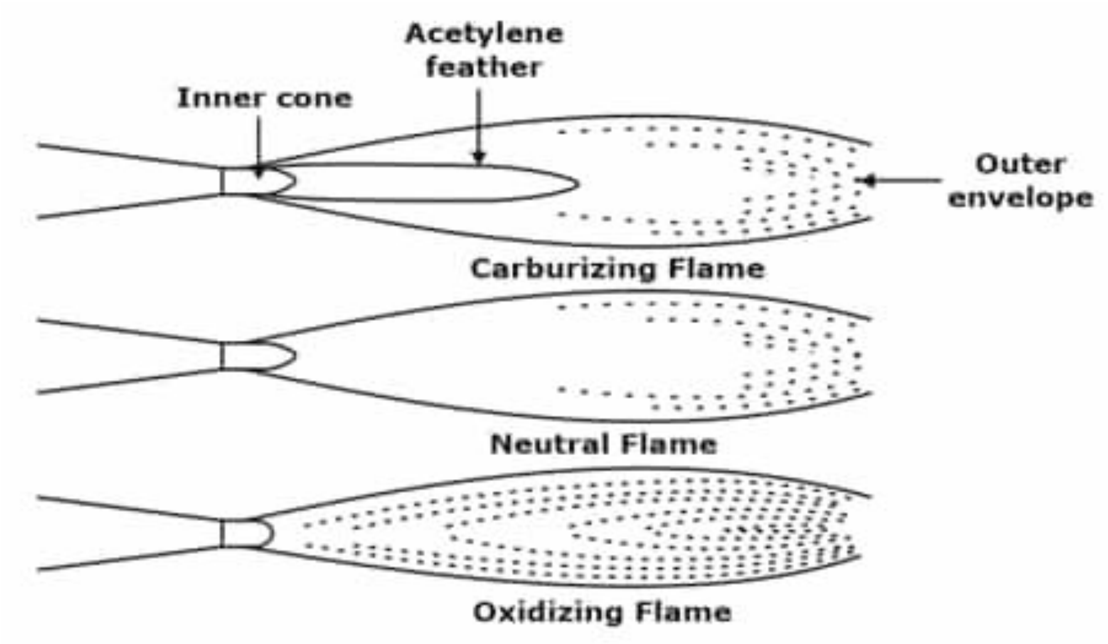
$$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O + Heat$$



- Oxygen cylinder valves are made of Brass and Acetylene cylinder valves are made by Steel. Brass valve does not corrode so easily and that is why brass valves are used in oxygen cylinder.
- Acetylene is a very dangerous gas because it can explode under its own weight. So, calcium silicate is filled in the cylinder and then acetone is poured. Acetylene is absorbed in acetone.

Flame Formation and its Types

Based on the proportion of acetylene and oxygen, flames are divided into three categories named neutral flame, carburizing flame and oxidizing flame. These are explained below:



1). Neutral flame:

- It consists of 1:1 ratio of acetylene and oxygen by volume. It has two parts namely the inner cone and the outer envelope.
- It produces hissing sound on burning and is used for welding low Carbon steels & Aluminum.
- The temperature of neutral flame is 3200°C.

(2). Carburizing flame:

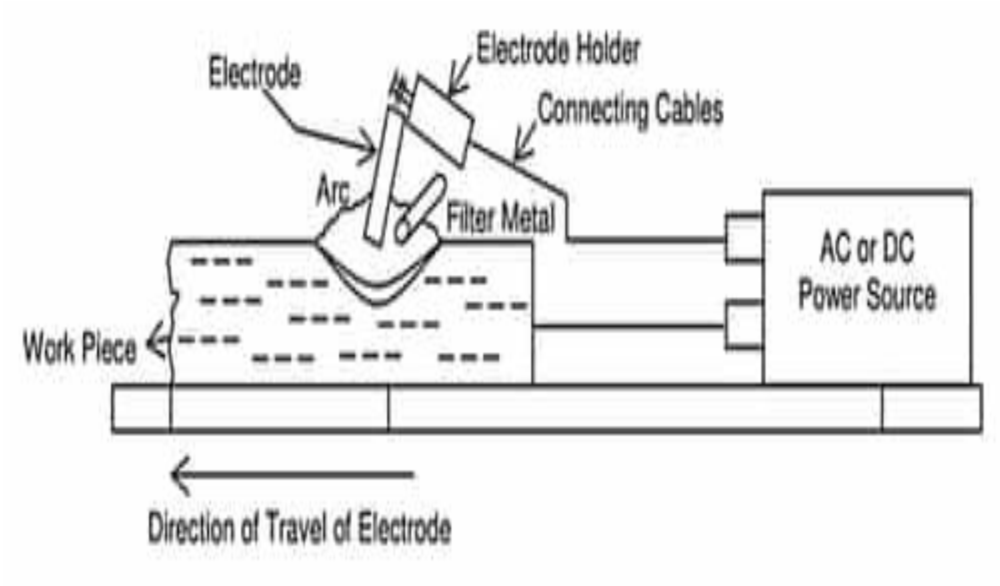
- In this flame, there is excess of volume of acetylene over oxygen and thus it is white in color due to excess acetylene.
- Its temperature generation range is 3100 °C to 3300 °C.
- It is used for the welding of metals where risk of oxidation at elevated temperature is more like aluminum, its alloys and lead and its alloys.

(3). Oxidizing Flame:

- This flame has an excess volume of the oxygen over the acetylene. It is the hottest flames and produces roaring sound.
- It consists of a very short pointed white inner cone and a shorter outer envelope. The reduction of length of the inner cone is a measure of excess oxygen.
- These flames are used to weld alloys of Copper and Zinc. In welding these metals, the oxidizing flame produces a base metal oxide layer to protect the evaporation of low point alloying elements.

- The temperature of these flames is around 3480°C.

Arc welding: It is the liquid state joining process in which coalescence of the metal is achieved with the application of the heat from an electric arc generated between an electrode and workpiece.

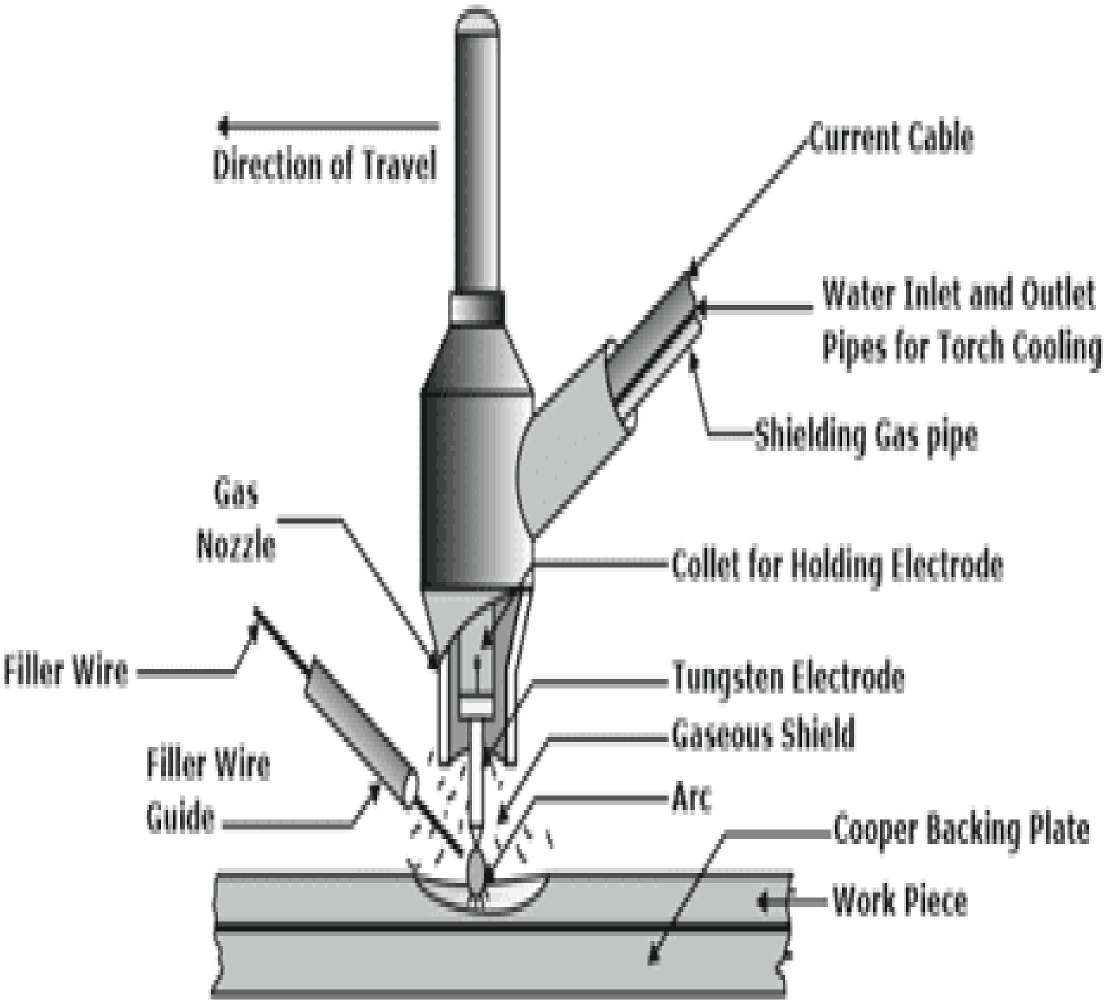


- Electric arc is generated when electrode is brought into contact with the work and is then quickly separated by a short distance approximately 2 mm.
- The circuit operates at low voltage and high current, so arc is established in the gap due to thermionic emission from electrode (Cathode) to workpiece (Anode).
- The arc is sustained due to continuous presence of a thermally ionized column of gas. This arc produces at temperature of the order of 5500°C or higher.

TIG Welding

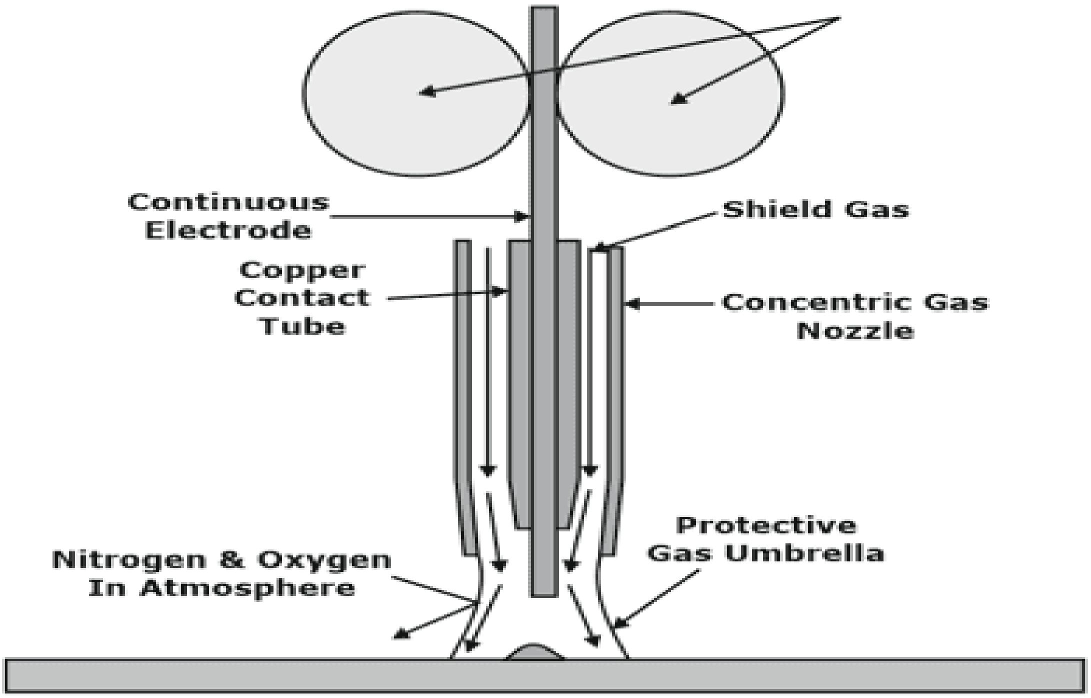
- A non consumable is used in TIG welding process and its objective is only to create an arc.
- A separate metal rod is supplied as filler material during welding.
- TIG welding is mainly used to weld Aluminium and Magnesium allloys. Aluminium is very difficult to weld because as soon as it is exposed to atmosphere it forms a layer over it. Thus, work piece is given negative polarity and electrode positive polarity to avoid this problem. With such polarity, electrons flow from workpiece to electrode and peels of oxide

layer and fresh Aluminum comes in contact with the arc. This phenomenon of self cleaning is known as cathodic cleaning.



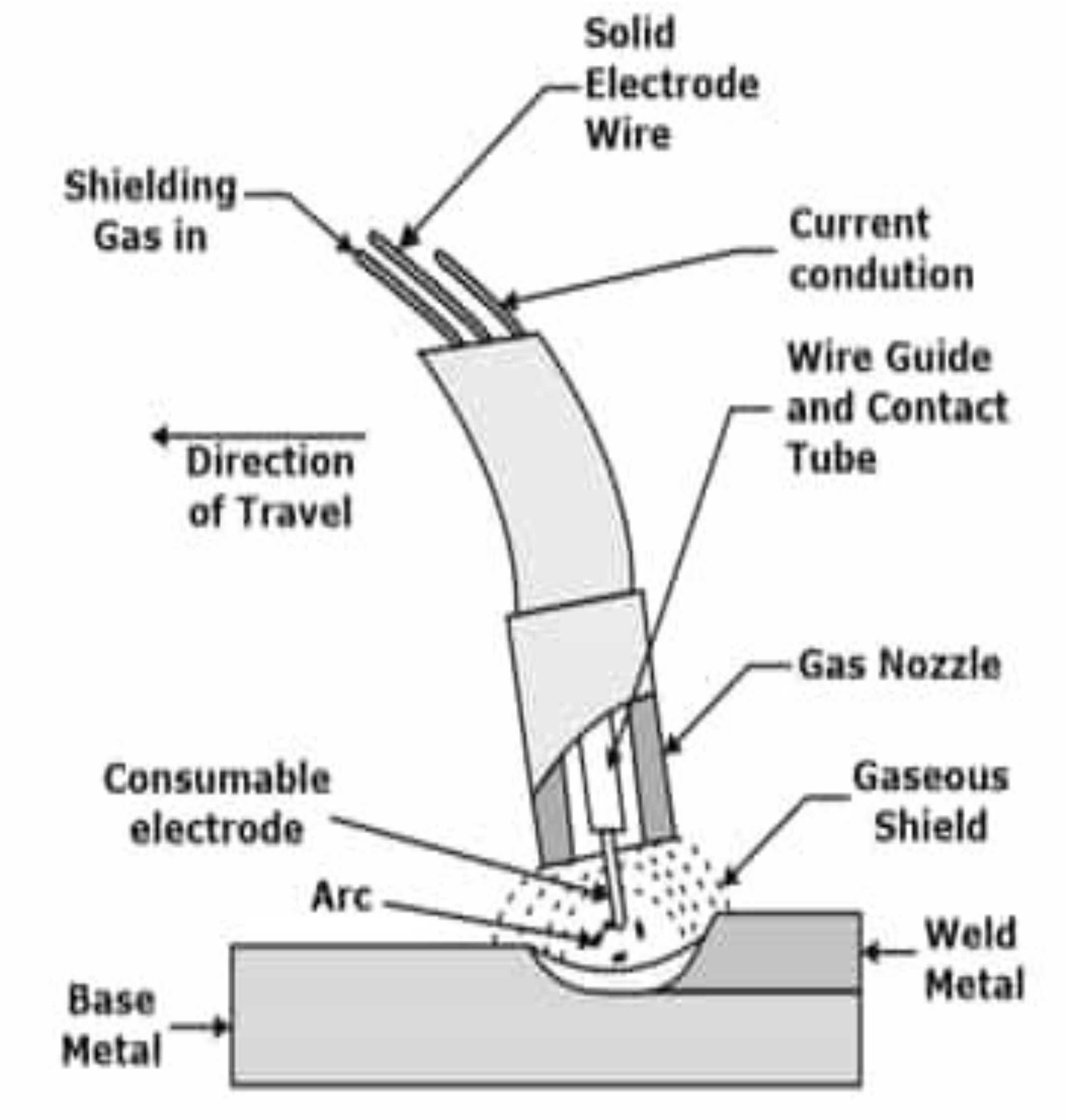
MIG Welding

- MIG works on same principle of TIG or arc welding.
- It utilizes the heat generated due to electric arc for the welding process. The heat generated is used to melt consumable electrode and parent metal workpieces which make a strong joint together on the solidification.
- The shielded gases are used to protect the weld zone from other reactive gases. This welding results in good surface finish of the welded parts and a stronger joint.



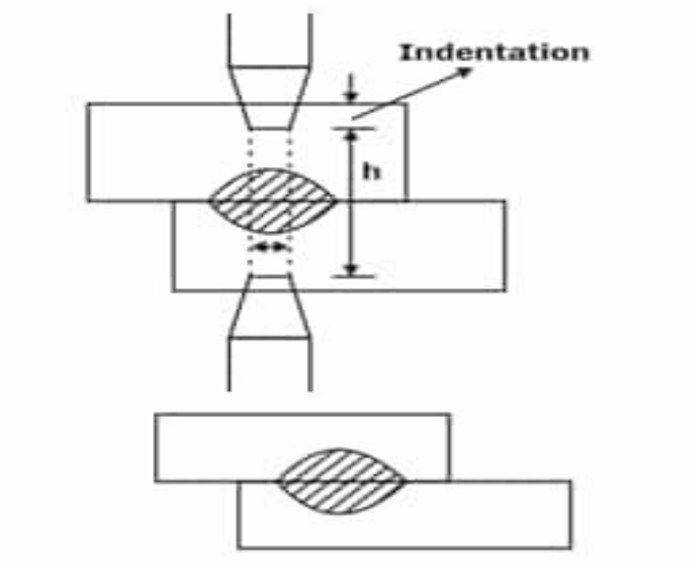
SUBMERGED ARC WELDING (SAW)

- This is semi-automatic version of SMAW process which can produce long weld runs.
- The electrode used is in the form of spool of having copper coating (to increase the conductivity of wire) and granular flux.
- The powdered flux is poured in to the welding area not only helps in maintaining the arc but also minimizes the Spatter of liquid metal and suppresses the intensity ultraviolet radiation.
- Flux is fed on weld zone by gravity through flow nozzle, a long continuous weld can be performed.
- This process is mainly suitable for down hand welding position.



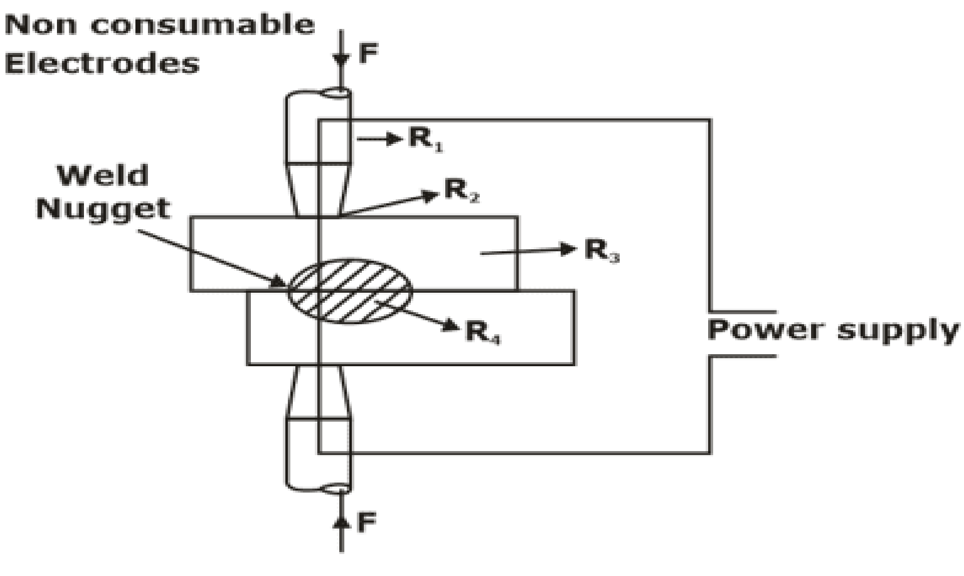
Resistance Welding

- Resistance welding is a fusion welding process that also utilizes pressure in welding operation.
- In Resistance welding whatever the heat required for melting and joining of plates is obtained due to electrical resistance circuit, so the name given as resistance welding operation.



Resistance Spot Welding:

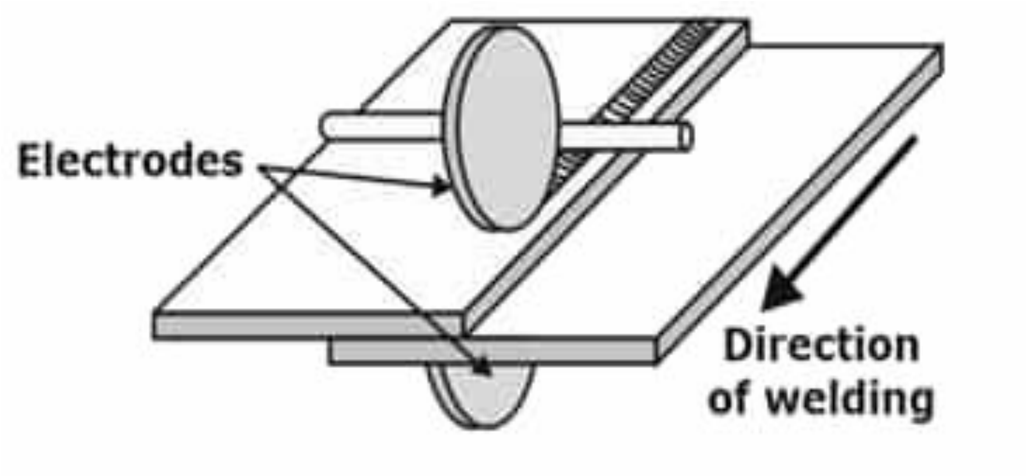
- It is a resistance welding process in which contacting metal surface are joint at different points by the heat obtained from resistance to electric current.



Seam welding:

- It is resistance welding process where continuous series of spots is obtained to join the metal with the application of heat from resistance and pressure by electrodes.
- Here disc electrodes are continuously rotated and the workpiece is advanced underneath them while at the same time the pressure on the

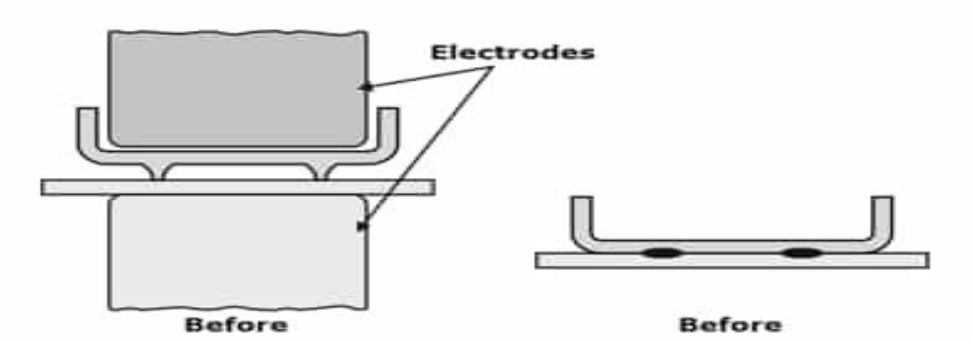
joints is maintained. The electrodes pressure is relieved after solidification of molten metal.



- This process is used for air tight joints.

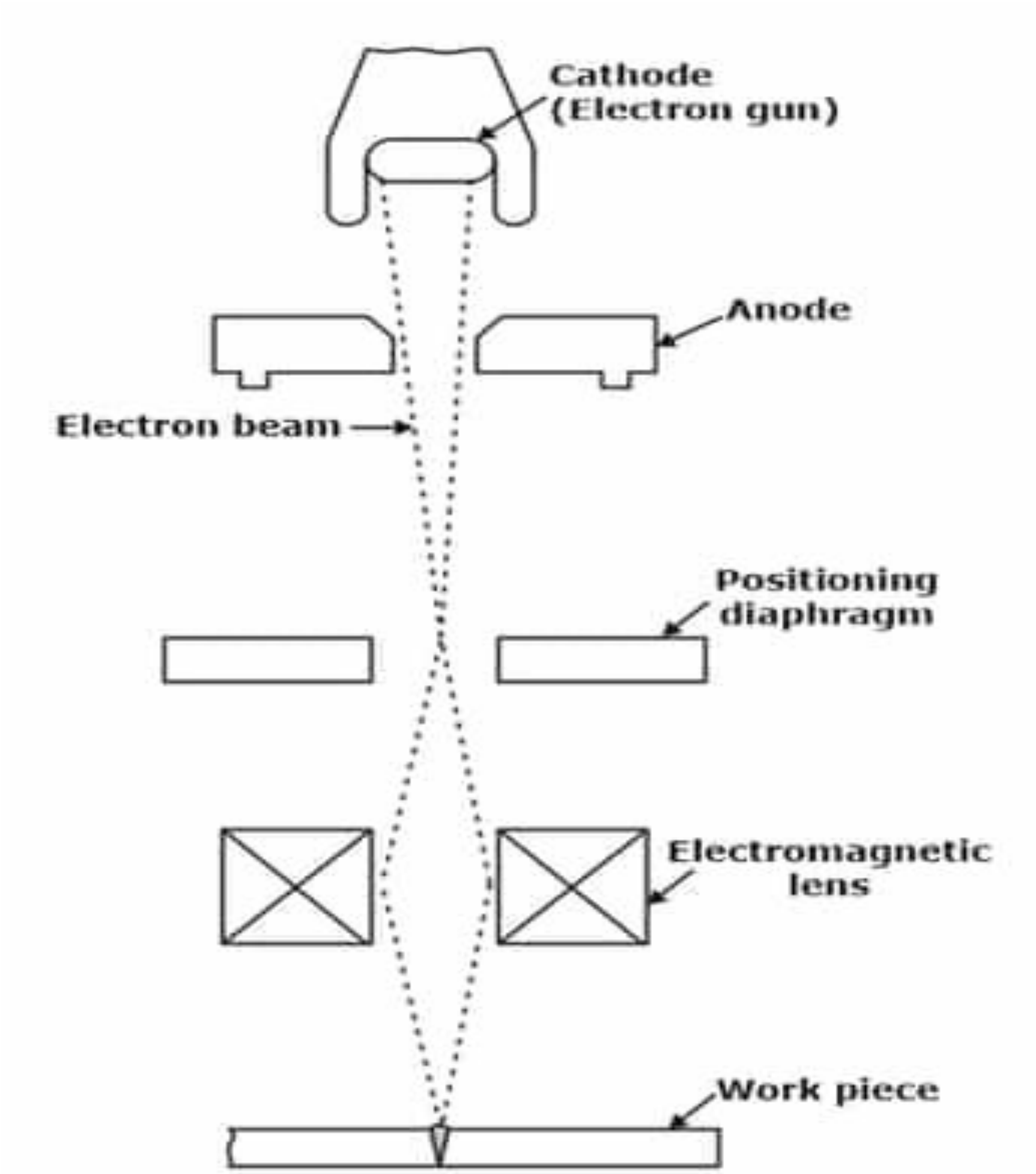
Projection welding:

- The method of joining a projected component on a flat component by using resistance welding is called resistance projection welding.
- In projection welding, the shape of the electrode remains same as the shape of components to be joined.



Electron Beam Welding

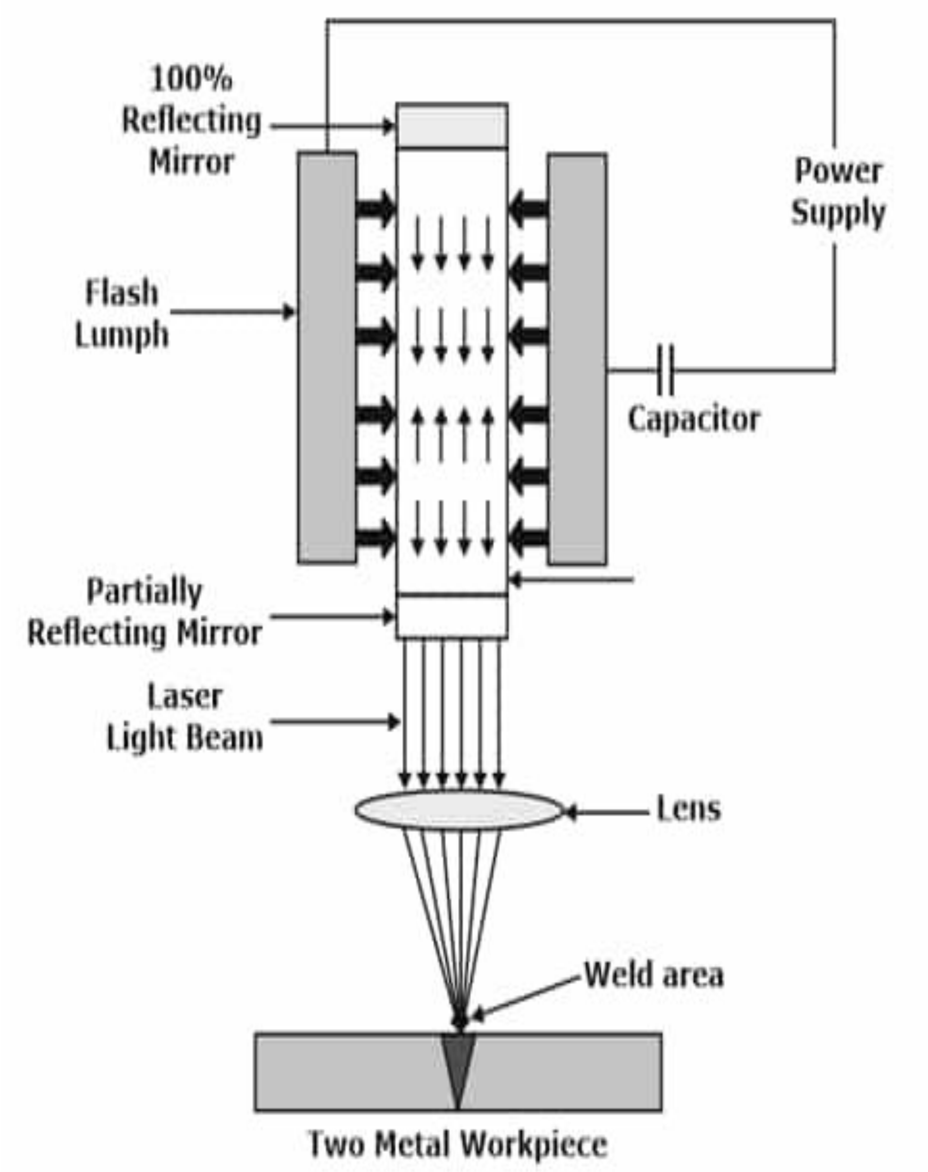
- Electron Beam Welding (EBW) is a fusion welding in which coalescence is produced by heating the work piece due to impingement of the concentrated electron beam of high kinetic energy on the work piece.



- Electron beam welding process is done under the vacuum condition.
- Molten metal fills into the gap between parts to be joined and subsequently it gets solidified and forms the weld joint.

Laser Beam Welding

- In the LBM process, the laser beam is directed by flat optical elements, such as mirrors and then focused to a small spot (for high power density) at the workpiece using either reflective focusing elements or lenses.



- Inert gas shielding is generally employed to prevent oxidation of the molten puddle and filler metals may be occasionally used.
- The Lasers which are predominantly being used for industrial material processing and welding tasks are the Nd-YAG laser and 1.06 µm wavelength CO2 laser, with the active elements most commonly employed in these two varieties of lasers being the neodymium (Nd) ion and the CO2 molecules respectively.

Gas Cutting

For thicker plates and contour, oxy-fuel cutting is used. The difference in oxyacetylene gas cutting and acetylene welding is a torch tip which is used for preheating the plate as well as providing oxygen jet.

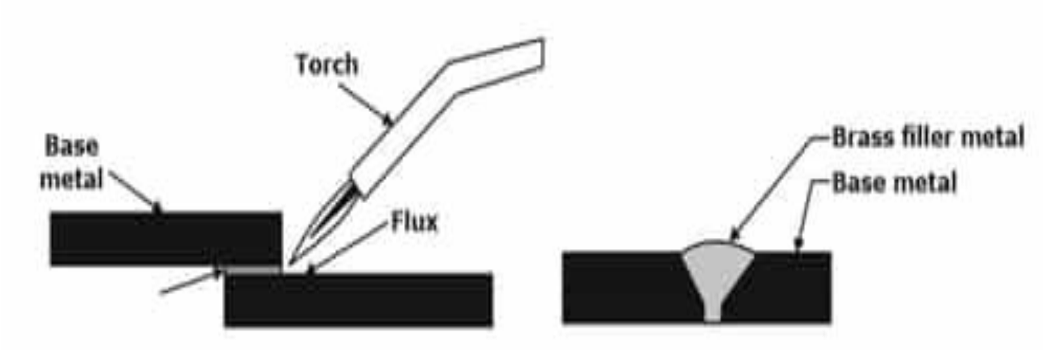
- The tip has a central hole for oxygen jet and surrounded holes for preheating flames.
- When high-pressure oxygen jet with a pressure of order 300 kPa is directed against a heated steel plate, the oxygen jet burn the metal and blows it away causing the kerf(cut).
- Larger the size of the orifice, wider is the kerf width and larger is the volume of the oxygen consumed.

Arc Cutting

- In arc cutting, the metal is melted with the application of heat of arc and then blown away using any gases such as air or shielding gases.
- The torch holds the electrode and supply high pressure gas where needed. There are different types of arc cutting based on heat source:
  (i). Carbon arc cutting- The process carries a carbon electrode to obtain the required arc. The metal that is cut is blown away by arc force and gravity.
  (ii). Air carbon –arc cutting: Here, Arc is generated between copper coated graphite or carbon electrode and the work piece with molten metal being forced out by means of a compressed air at pressure of 550 to 690kPa.
  (iii). Oxygen arc cutting: It carries a hollow tubular electrode to obtain the arc. Compressed oxygen is forced through a hollow portion so that metal is oxidized and blown in a similar manner as oxy fuel gas cutting (OFC).

Brazing

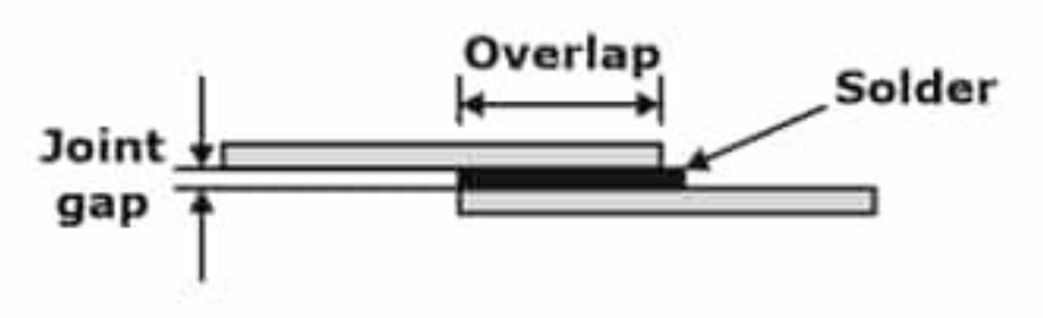
- In this welding, the coalescence of a joint is obtained using the filler metal whose liquidus temperature is above 450°C and is below the solidus temperature of the base metal.
- In brazing, the base metal is not melted. Dissimilar metals can be joined by brazing. Except for aluminum and magnesium, brazing can join almost all metals.



- Here the filler metal in the joint, is filled by capillary action. Thus, it is necessary to control the clearance between two parts.
- Since too much clearance doesn't allow the capillary force to draw the filler metal into the joint and also insufficient clearance may be too small to allow the filler metal to give rise to an effective strength.

Soldering

- It is used tp join similar or dissimilar metals by means of a filler metal whose liquidus temperature is below 450°C.



- The joint design used for soldering is similar to that of brazing as in both cases filler metals enter the joint by capillary action.
- Like brazing, soldering also needs solvent cleaning, acid pickling and mechanical cleaning of the joint surface. In order to remove the oxides from the joint surface for avoiding filler metal from oxidizing, fluxes are generally used in soldering.

Differences between MIG and TIG welding

SL.NO	MIG WELDING	TIG WELDING
	Metal inert gas (MIG) welding utilizes a consumable electrode that is continuously fed into the welding zone from a wire pool	Tungsten inert gas (TIG) welding utilizes a non-consumable electrode (so it remains static and intact during welding).
2.	The electrode itself melts down to supply necessary filler metal required to fill the root gap between base metals. So electrode acts as filler metal (no additional filler is required).	If required, filler metal is supplied additionally by feeding a small diameter filler rod into the arc. So filler metal is supplied separately.
3.	Composition of electrode metal is selected based on parent metal. Usually, metallurgical composition of electrode metal is similar to that of base metal.	Electrode is always made of tungsten with small proportion of other alloying elements (like thorium).
4.	It is suitable for homogeneous welding. It cannot be carried out in autogenous mode welding as filler is applied inherently	It is particularly suitable for autogenous mode welding. However, it can also be employed for homogeneous or heterogeneous mode by supplying additional filler.
5.	The electrode-cum-filler for MIG welding comes in the form of a small diameter (0.5 – 2 mm) and very long (several hundred meters) wire that is wound in a wire-pool.	TIG welding filler typically comes in the form of small diameter (1 – 3 mm) and short length (60 – 180 mm) rod
6.	Due to very large length, the filler electrode can be fed for a longer duration without replacement.	Due to short length, frequent replacement of filler is required. This interrupts the welding process unintentionally.
7.	MIG welding is commonly carried out either in AC or in DCEP polarity so that electrode can be melted and deposited at a faster rate.	TIG welding is commonly carried out either in AC or DCEN polarity to increase electrode life.
8.	Filler deposition rate is very high, so the process is highly productive.	Filler deposition rate is low. In this sense, it is not very productive.
9.	MIG welding usually produce spatter. This causes loss of costly filler metal	TIG welding is mostly free from spatter.
10.	Quality and appearance of weld bead are not very good.	It can easily produce defect-free reliable joint with good appearance.
11.	It does not lead to tungsten inclusion defect.	TIG welding sometimes leads to tungsten inclusion defect (occurred when a melted/broken part of the tungsten electrode gets embedded into weld bead).

WELDING DEFECTS

What Is A Weld Defect?

In short, a weld defect is any flaw or imperfection that compromises the intended use of a weldment.

A weld must be strong enough for the intended purpose at the most basic level, and many defects can weaken a joint.

There are many types of welding defects, but in general, the most common weld defects are:

1. Cracks
2. Inclusions
3. Lack of fusion
4. Porosity
5. Undercut
6. Poor penetration
7. Burn through
8. Under-fill
9. Excess reinforcement
10. Spatter
11. Over-roll/Overlap
12. Whiskers
13. Mechanical damage

Irregular welds include too wide or too narrow, those with an excessively convex or concave surface, and those with coarse, irregular ripples. These characteristics may be caused by poor torch manipulation, a speed of travel that is too slow, current that is too high or low, improper arc voltage, improper stick out, or improper shielding gas.

But when a particular defect occurs, you want to know which parameter needs adjusting so you can fix it. Therefore, a list by defect type, along with how to correct the problem, is helpful.

1. Cracks

We may as well start with one of the most obvious and serious defects in a weld – cracks. These weaken a weld, and even worse, cracks tend to grow at a rapid rate making the problem worse.

So, it goes without saying you do not want any cracks in your welds. But it can be a challenge, and there are three main types of cracks:

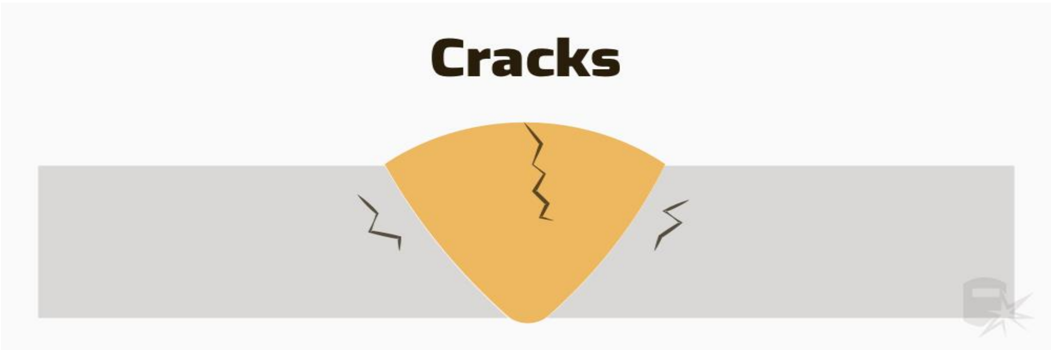
- Longitudinal cracks run along, or are parallel, to the length of the weld.
- Transverse cracks run across the width of a bead.

- Crater cracks usually occur at the end of a weld when the arc is terminated. They are often star-shaped and form when a dent or “crater” is formed at the end of a weld.

Cracks can further be categorized as hot or cold cracks.

Welds can be heated to over 10,000°C, and hot cracks occur as the weld cools and transitions from the liquid to the solid phase. Hot cracks tend to occur when the wrong alloy filler material is used.

Cold cracks occur after the weld has cooled. They can occur hours or days after the joint is made. This defect usually occurs when welding steel and is often caused by deformities in the base metal.



How to prevent cracks

- Use the correct alloy filler material for the metal being welded.
- Avoid welding high sulfur and carbon steel.
- Preheat your joint.
- Ensure the joint is filled and avoid a convex-shaped bead.
- Use sound, defect-free base metal.
- Avoid low currents coupled with high travel speeds.
- Do not use hydrogen shielding gas with ferrous metals.
- Keep a good depth to width ratio for your joint.
- Avoid craters at weld termination by placing adequate filler material when ending a bead.
- Allow for expansion and contraction of a weld joint during the weld and cool down.

2. Inclusions

Impurities can become trapped inside a weld, and these are referred to as inclusions. Contaminants trapped inside a weld dramatically weaken the joint.

Slag often forms when flux is used, such as brazing and stick, flux-cored, and submerged arc welding. The slag must be allowed to float to the top of the puddle and not become trapped inside the bead. That means the molten pool should not be allowed to cool too fast.

But it can occur with MIG welding as well. Bits of rust and even tungsten can be counted as slag and can cause contamination in your welds. So, MIG and TIG welding is not immune to inclusions.

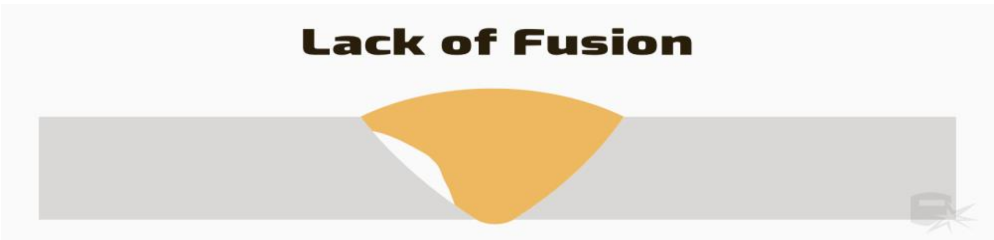
How to prevent inclusions in your welds

- Prep and clean the base metal well.
- Avoid low amperage settings (prevent the weld pool from cooling too fast).
- Keep a proper torch speed (the welding and slag pools should not mix).
- Maintain a proper torch angle.
- Clean slag from previous welds between passes.

3. Lack Of Fusion

It may seem obvious, but the filler material must be well bonded to the base metal on both sides and to welds underneath during multiple passes.

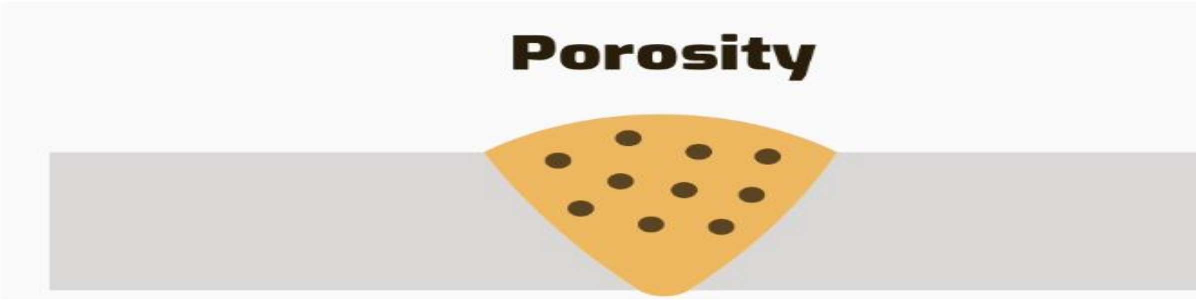
If there are voids, gaps, or poor adhesion, the joint will be structurally impaired.



How to prevent a lack of fusion

- Clean your base metal well and remove all impurities.
- Use the correct size electrode.
- Select the right electrode alloy for the metal being welded.
- Don't move the torch too fast.
- Prevent the arc from getting too short.
- Keep the amperage high enough for the job.

4. Porosity

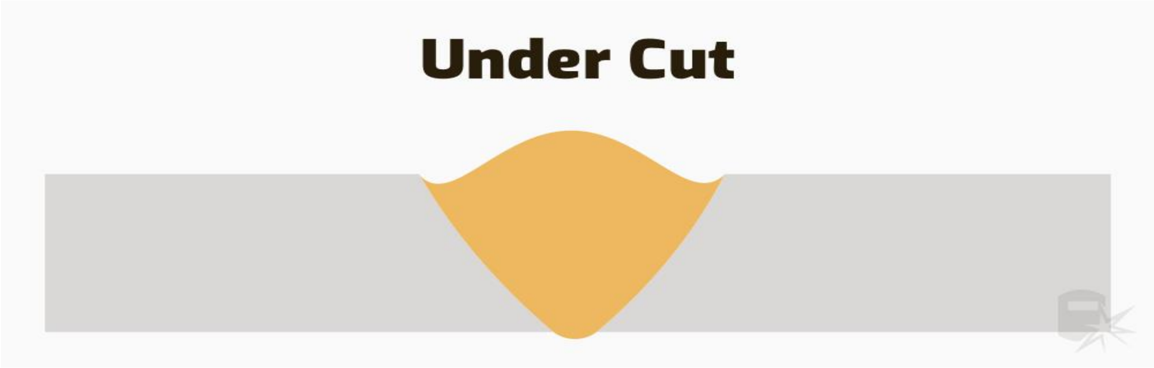


Weld porosity (also known as wormhole weld) is where gas bubbles accumulate and get trapped inside a weld. This is also said to be porous. A cross-section of a porous weld bead will resemble a sponge with all the air bubbles trapped inside. As you weld, gases like steam, hydrogen, and carbon dioxide can be generated, and they normally bubble out of the molten bead. But if the gas bubbles are trapped, they can weaken your joint, and the work is ruined.

How to avoid porous welds

- Properly clean and prepare the base metal.
- Make sure the joint is dry.
- If used, set your shielding gas flow correctly (too low or high can create issues).
- Keep the amperage from getting too high (i.e., too "hot").
- Use the correct electrode alloy for the job.
- Ensure the electrode coating is not damaged if it has one.
- Move your torch slow enough to keep a molten puddle, allowing the gas to bubble out.
- Avoid a long arc.
- Use low hydrogen electrodes.

5. Undercut



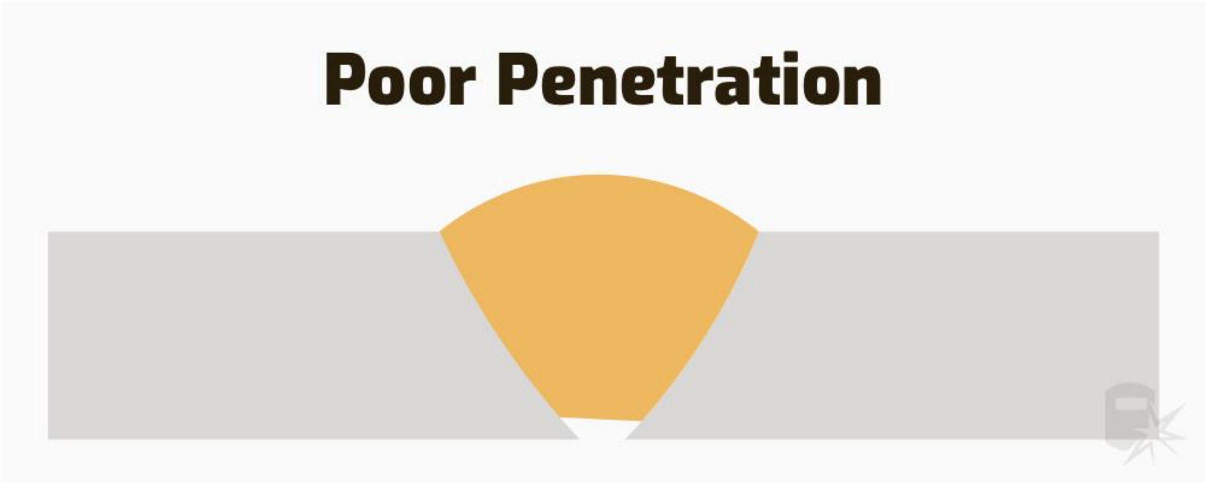
When the welding process results in spots or sections being less than the original base metal, the defect is referred to as an undercut. This will often appear as a "notch" at the edge of a weld, either on the top or bottom of the weld.

A loss in thickness reduces the strength of the weldment and makes the joint susceptible to fatigue. This defect is often the result of too high a current or moving the torch too fast.

How to prevent undercutting

- Do not move the torch too quickly.
- Use the proper amperage and avoid too high a setting.
- Keep the torch at the correct angle (and angle the heat to thicker areas when possible).
- Use a correctly sized electrode.
- Keep a shorter arc.
- Ensure you have the right shielding gas flowing at the correct rate.
- Use proper welding techniques.
- Employ multiple passes.

6. Poor Penetration

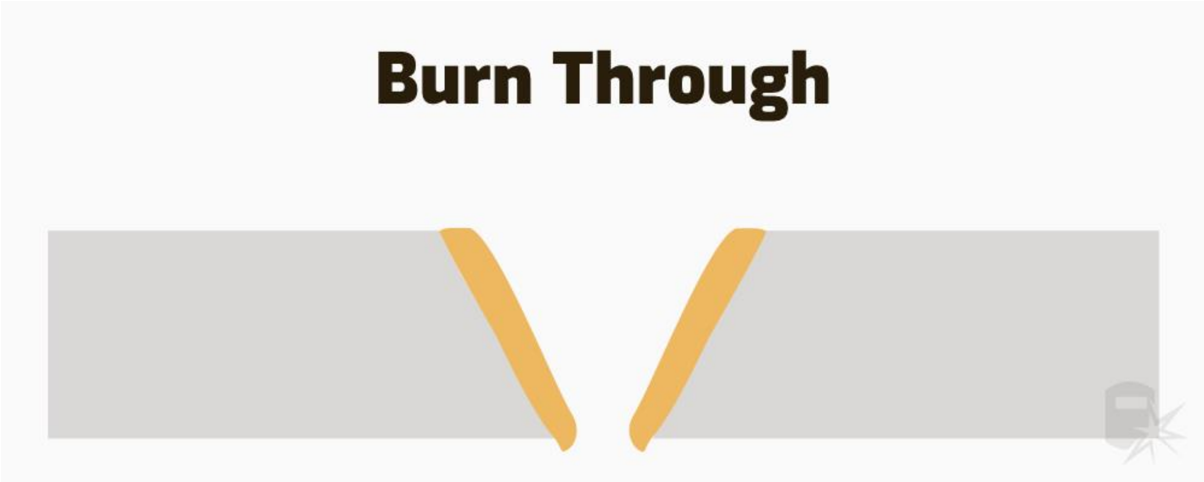


When the bead does not fill a butt joint all the way to the bottom, the weld achieves poor penetration. It is also referred to sometimes as incomplete penetration. Whatever you call it, this form of defect also compromises the integrity of a joint.

How to get good penetration

- Use a properly sized electrode for the weld (avoid an oversized electrode).
- Don’t move the puddle too fast.
- Prepare V grooves for butt joints with 60 to 70 degree sloped sides.
- Align the workpieces, so there are no large or irregular gaps to fill.
- Keep your amperage, or heat, at an optimum setting and avoid too low a current setting.

7. Burn Through



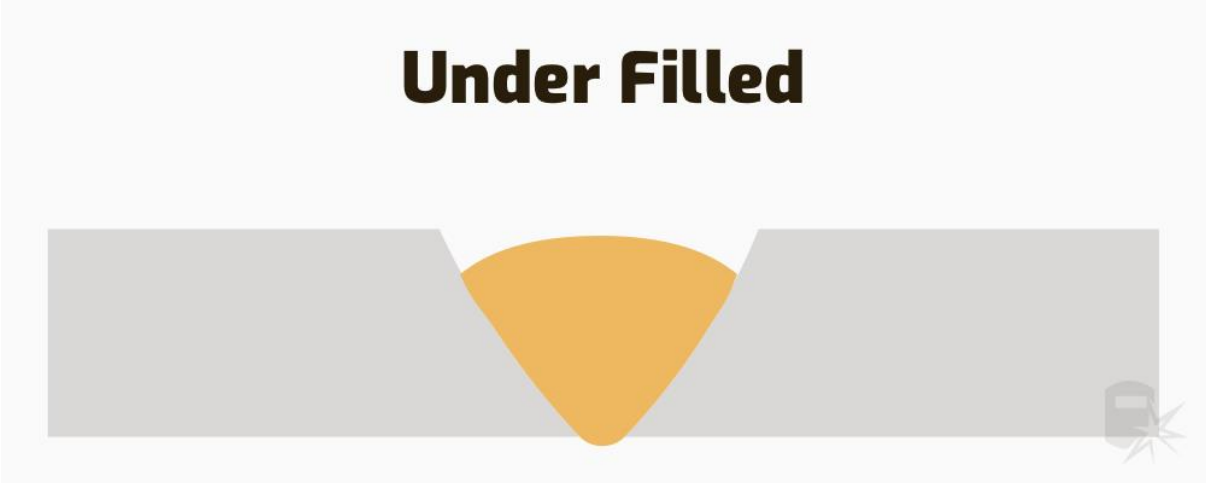
If too much heat is applied during the weld, you can actually blow a hole through the metal. This defect is referred to as burn through, but sometimes it is also called melt through. Of course, creating a hole defeats the purpose of a weld and destroys the joint.
This type of defect is usually encountered with thin stock, material less than 1/4 inch thick. But it can occur with thicker stock if your welder settings are too high, if the gap between pieces is large, and/or you are moving the torch too slow.

How To prevent burn through

- Do not let the current get too high.
- Avoid excessive gaps between plates.
- Ensure your travel speed is not too slow.
- Stay away from large bevel angles.

- Ensure the nose is not too small.
- Use the correct wire size; too small accentuates the problem.
- Provide adequate metal hold-down and/or clamping.

8. Under-Fill

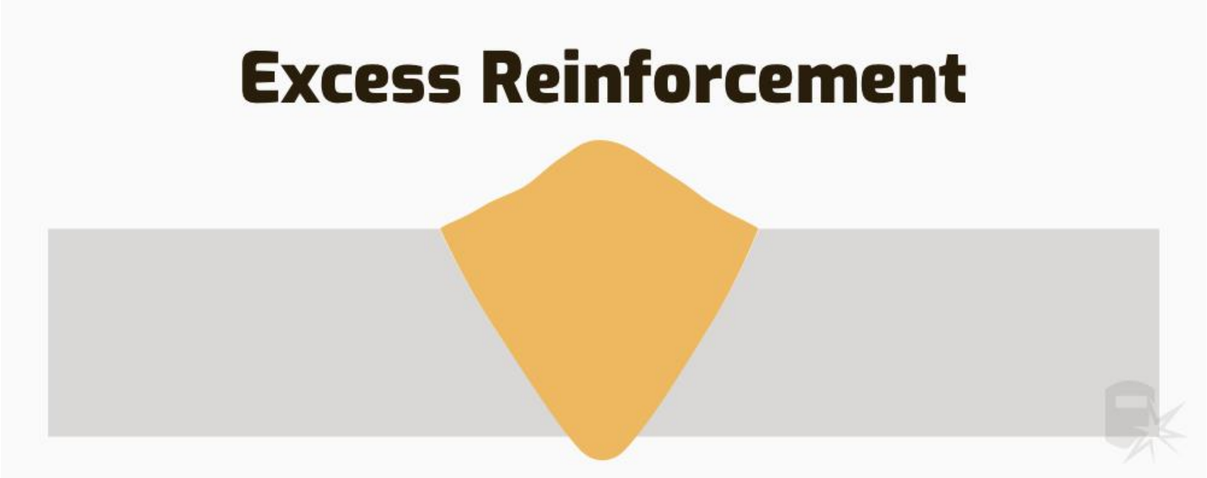


When the weld bead sits below the surface of the base metal, the weld is said to be under-filled. The bead itself is thinner than the base metal, which weakens the joint. This condition often appears as a "rut" that runs the length of the bead and is sometimes called a convex joint.

How to Prevent under-filled welds

- Avoid moving too fast.
- Use the right current setting.
- Use the correct size electrode/filler wire.

9. Excess Reinforcement



In contrast to an underfilled joint, a defect results when there is too much filler material in the joint. This is known as excess reinforcement or a “high” crown. Project specifications and codes often regulate what is considered too high.

At times, excess reinforcement may even come out the bottom of the joint. This is sometimes referred to as excess penetration.

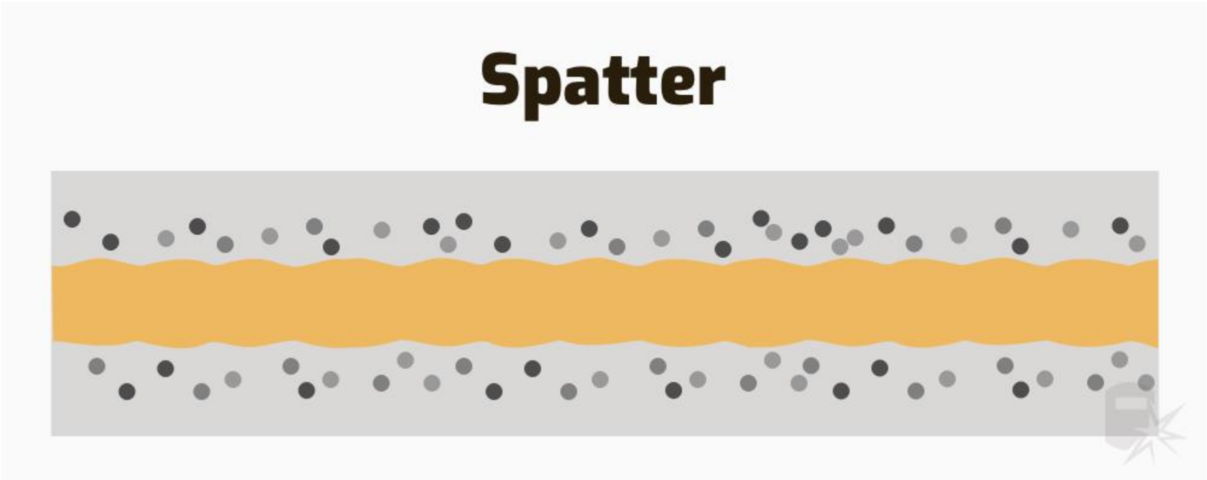
Other variations of the defect include narrow, steep-sided beads caused by an insufficient coating of flux on your feed wire or low voltage.

Also, when excess reinforcement is uneven and ragged, it may be called “mountain range” reinforcement, and this is caused by excess flux on the feed wire or fast/uneven travel speed.

How To Avoid excess reinforcement

- Keep the torch moving at a proper speed. Too slow, and excess filler will be placed. Too fast, and the bead becomes erratic.
- Set your amperage correctly and avoid excess heat.
- Adjust your voltage so that it is not too low.
- Align the pieces so that the gap is not too large.

10. Spatter



While usually not a threat to structural integrity, spatter can be considered a defect. The aesthetics of a weld are sometimes as important as the weld’s strength. But nothing makes welded pieces look sloppy, like spatter stuck all over the surrounding metal.

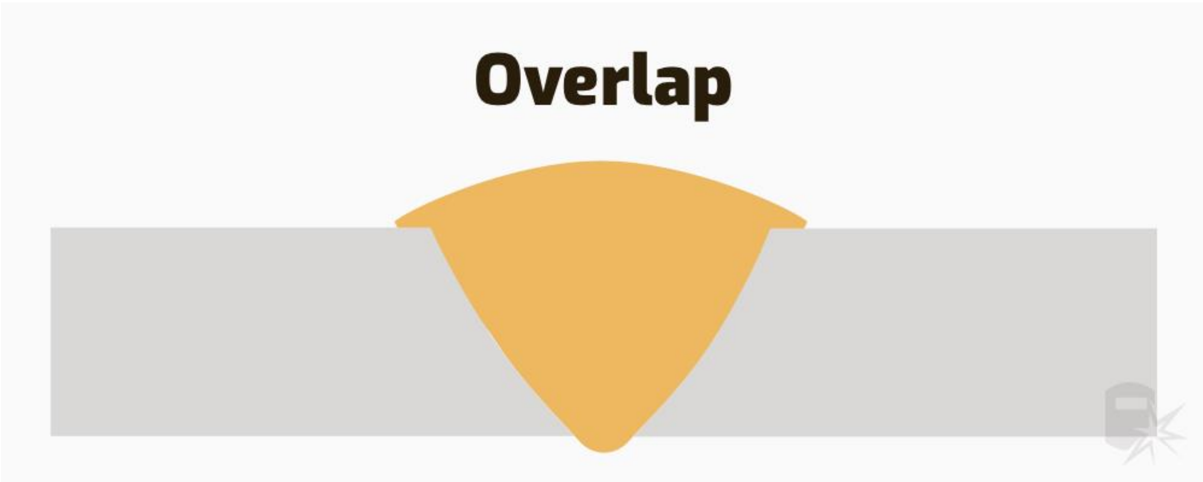
Spatter frequently occurs with MIG welders but can occur with other welding processes, too.

How to reduce spatter

While you can never eliminate all spatter, there a few things you can do to minimize it:

- Clean the base metal well.
- Use the correct amperage, and avoid "hot" settings.
- Use the correct voltage, and avoid low settings.
- Ensure the polarity is set correctly.
- Keep a short arc.
- Increase the electrode angle.
- Check the feed wire to ensure it is unimpeded.

11. Over-Roll/Overlap



When the filler material at the weld's toe covers the base metal without bonding, an over-roll or overlap defect occurs.

How to Prevent Overlap

If you want to avoid this condition:

- Avoid letting your travel speed get too slow.
- Keep the correct torch angle.
- Do not use oversized electrodes.
- Set the correct amperage, avoid a high setting.

12. Whiskers

When MIG welding, whiskers are short lengths of electrode wire sticking through the weld on the root side of the joint. They are caused by pushing the electrode wire past the leading edge of the weld pool.

These protruding wires look bad, but they can also cause problems. For starters, whiskers are considered inclusions and weaken the joint. In pipes, they can even inhibit the flow or even break off inside and cause equipment damage downline.

Whiskers can be prevented by

- Reducing your wire-feed speed.
- Keep an optimum travel speed, avoid going too fast.
- Increase the wire stick-out distance.
- Weaving the torch.

13. Mechanical Damage

Once the perfect bead is installed, you are not out of the woods. Damage can be caused by chipping hammers, grinders, and other tools. Not surprisingly, the term used for this type of defect is mechanical damage.

Common sense guides you to prevent mechanical damage with cautions like:

- When removing slag or cleaning a joint, do not get too aggressive
- Avoid heavy hammer blows
- Do not let other large pieces of metal impact or grind over your welds

CHAPTER-3

CASTING

What is the Definition of the Casting Process?

The casting process is the manufacturing process in which molten material such as metal is poured into the casting cavity or mold of the desired shape and allowed to harden or solidify within the mold, after solidification the casting is taken out by ejecting or by breaking the mold.

This is one of the oldest and widely used methods of the manufacturing process used to make many types of equipment, tools, materials that would be rather difficult or expensive to make using any other method. Major Parts like a bed of the Lathe machine, milling machine bed & IC engine equipment are made by using this method.

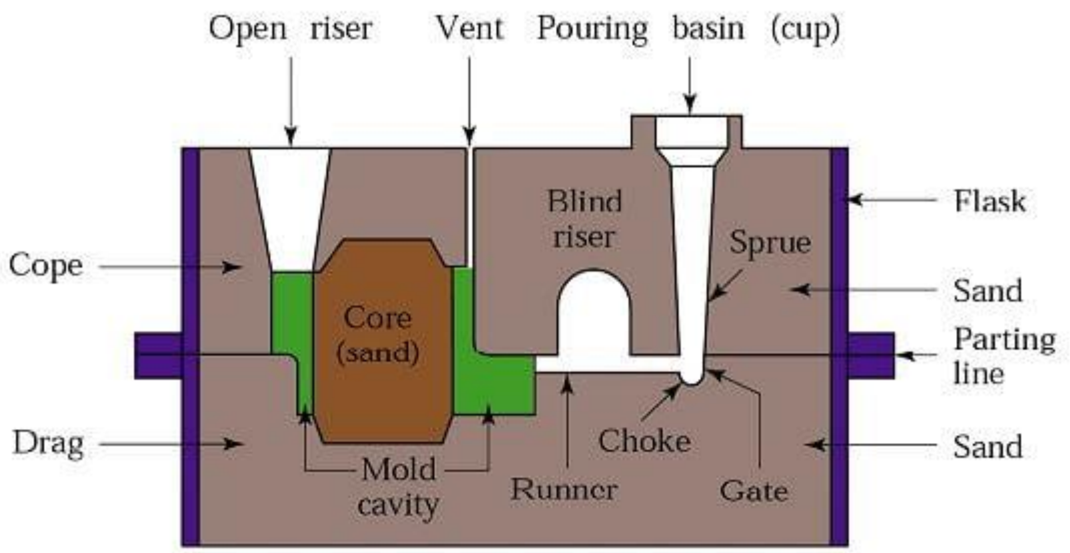
Casting Process Working Principle in Detail:

In this part, we will learn the detailed working process and Basic terminologies of Casting.

Basic Terminologies of Casting Process:

- **Flask:** A metal or wood frame in which mold is formed.

- **Cope:** The upper half of the flask is called cope.
- **Drag:** The lower half of the flask is called drag.
- **Core:** Core is used to create an internal hollow cavity in the final product.



- **Vents:** These are the places created in the mold to carry off-gases produced when the molten metal comes in contact with the sand.
- **Mold cavity:** This is the hollow space in the mold where the metal part is formed.
- **Riser:** It is the reservoir of molten metal that supplies additional metal in case of any reduction.
- **Runner:** It is the passage from where the molten metal can be regulated before reaching the mold cavity.
- **Pouring Cup:** It is the cup or basin from where molten metal is poured in the metal.
- **Pattern:** It is the duplicate of the shape needed to form.
- **Sprue:** It is the cavity through which molten metal flows downward.
- **Parting Line:** This is the line that separates the cope and drag.

Steps Involved in Casting Process:

There are **five steps involved in the casting process**:

- **Pattern Forming**
- **Core Forming**
- **Mold Making**
- **Pouring Process** and
- **Solidification Process**
- **Pattern Forming:**

Expendable Mold Casting:

This is the type of casting process molds are made of sand and cannot be reused. This method is used to produce expensive parts or equipment at less cost. These are also called temporary mold. As this is a temporary mold so, the surface finish & accuracy is not so clean.

Permanent Mold Casting:

In this type, the mold is made of metal and it can be reused again & again. This process is used for the bulk production of the product. In this process, the product produced has a smooth & accurate finish. The product produced has more strength. The cost of the die will be more.

Composite Mold Casting:

This casting is the combination of the permanent and expandable mold casting where some part of the mold is made up of sand that is temporary and some part is made up of permanent metal.

Types Of Casting Process In Detail:

Here I will explain all the types of the casting process:

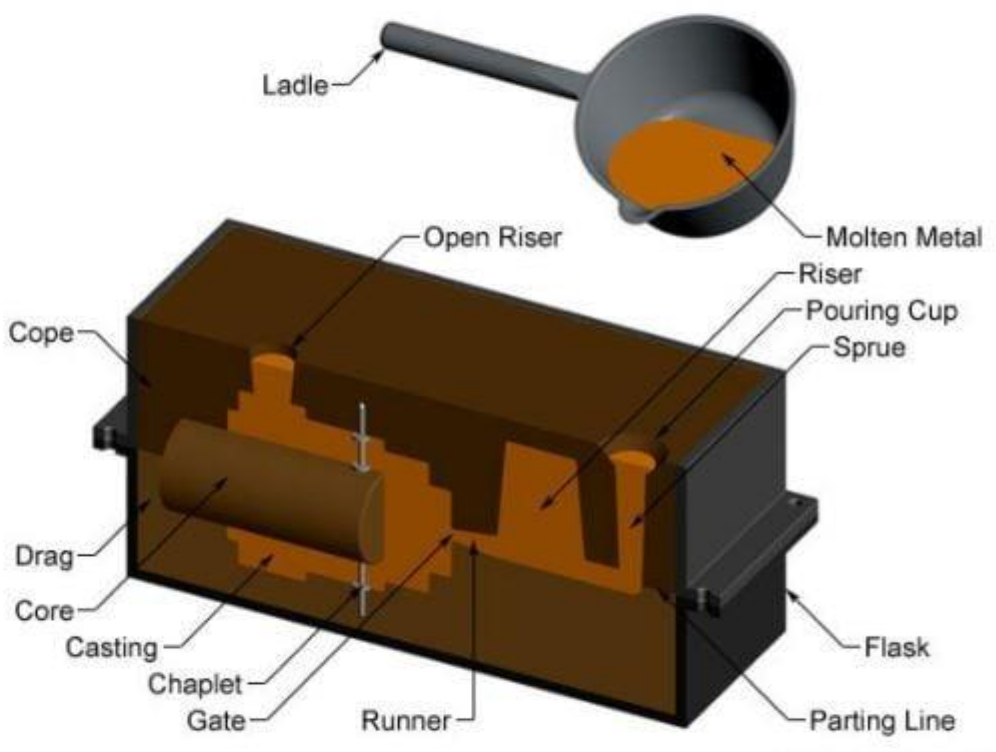
- **Shell Casting**
- **Investment Casting**
- **Full Molding**
- **CO2 Molding**
- **Sand Casting**
- **True Centrifugal Casting**
- **Gravity Die Casting**
- **Pressure Die Casting**
- **Hot Chamber Die Casting**
- **Cold Chamber Die Casting and**

- **Slush Casting**

Shell Casting Process:

Shell molding is the casting process that uses mold like a shell made up of material like fine-grain silica, thermosetting resin, and alcohol. In this method, the pattern is heated up to 250-degree celsius.

This mold has high strength and light-weighted. The mold is suitable for automatic casting. This method can be used for both ferrous and non-ferrous metals.



Merits of Shell Casting:

- This process can be performed by semi-skilled labor.
- The products have a smooth finish.
- Higher-dimensional Accuracy is obtained.
- Easily Automated

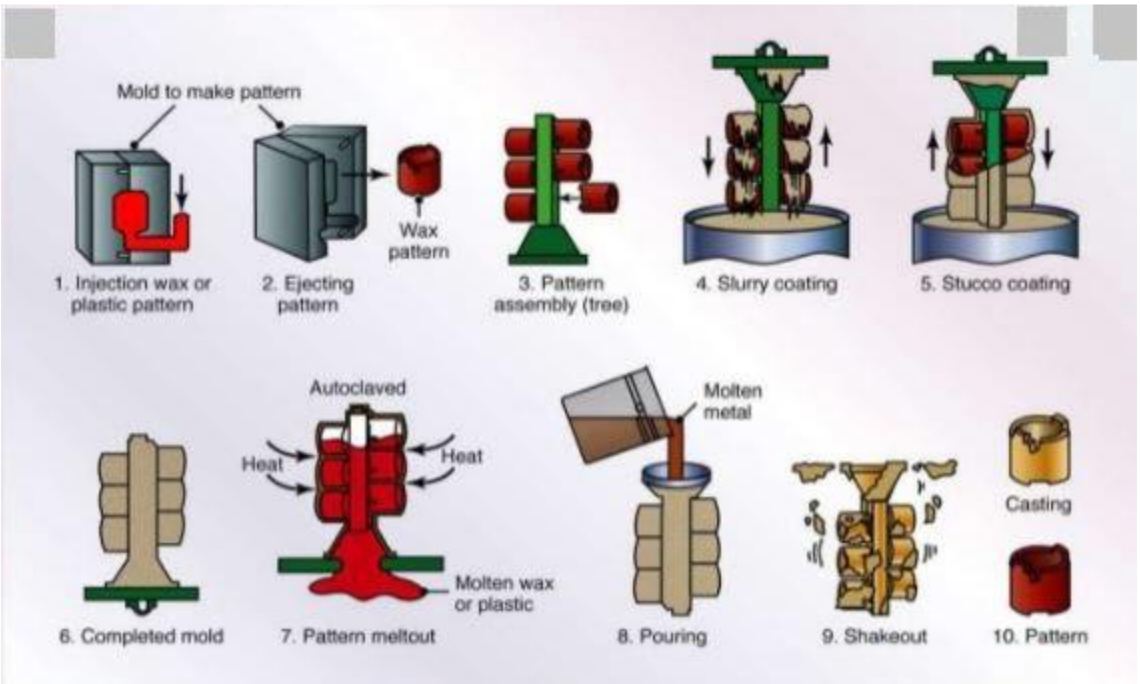
Demerits:

- Shell casting is more permeable so the chances of gas defect increases.

- It is not suitable for a small batch of production.

Investment Casting Process:

This is the type of casting process in which casting is formed around a pattern made of wax or similar material. In this casting, the pattern is used is made up of wax and the casting is formed around the pattern by dipping it into the slurry made of silica flour, ethyl silicate & water.



This method of forming a casting around a pattern is called stuccoing. After the casting formed the pattern is melted this process is called dewaxing. And this forms the hollow cavity and molten metal is poured into the cavity for products.

Merits:

- Fine surface finish
- Complex & intricate material can be formed.
- Higher-dimensional Accuracy is obtained.
- Low wastage of material.

Demerits:

- High Cost.
- Parts having a core are difficult to cast.

Full Molding Process:

This method is also known as cavity-less molding or evaporative pattern technique. In this process, the pattern used is made up of plastic, Pvc, polystyrene, foam, etc.

And when the hot liquid metal is poured into the mold the pattern placed inside the mold starts evaporating and gets converted into gases forming the hollow cavity.

Then the molten metal is poured into the cavity to form a product. It is generally used in making a motor casing.

Merits of Full Molding:

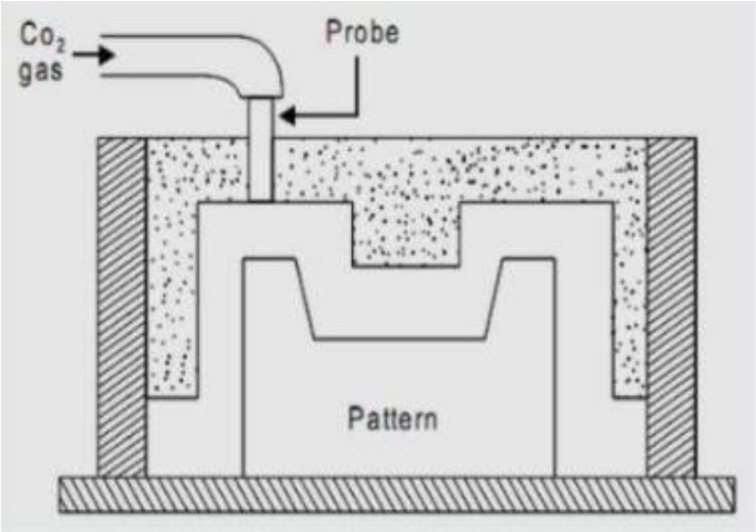
- Can cast lightweight parts
- Complex & intricate material can be formed without core or cast.
- Higher-dimensional Accuracy is obtained.
- It offers high smoothness.

Demerits of Full Molding:

- High costing if the die to create the pattern is large.
- Cost of the pattern if the finished product to be produced is big increases.

CO2 Molding:

This method is used to increase the strength & hardness of the large-size molding. In this technique, the strength of the casting is increased by passing CO_2 gas through the mold.



While preparing the mold we add a special type of additive called sodium silicate. This is added about 2%-6%. And when CO2 gas is passed through the mold this additive reacts with CO2 and forms silica gel.

And this silica gel has better bonding properties which further increases the strength & hardness of mold. Hence CO2 molding is used to produce a casting of the larger shape which requires good strength.

Merits of CO2 Molding:

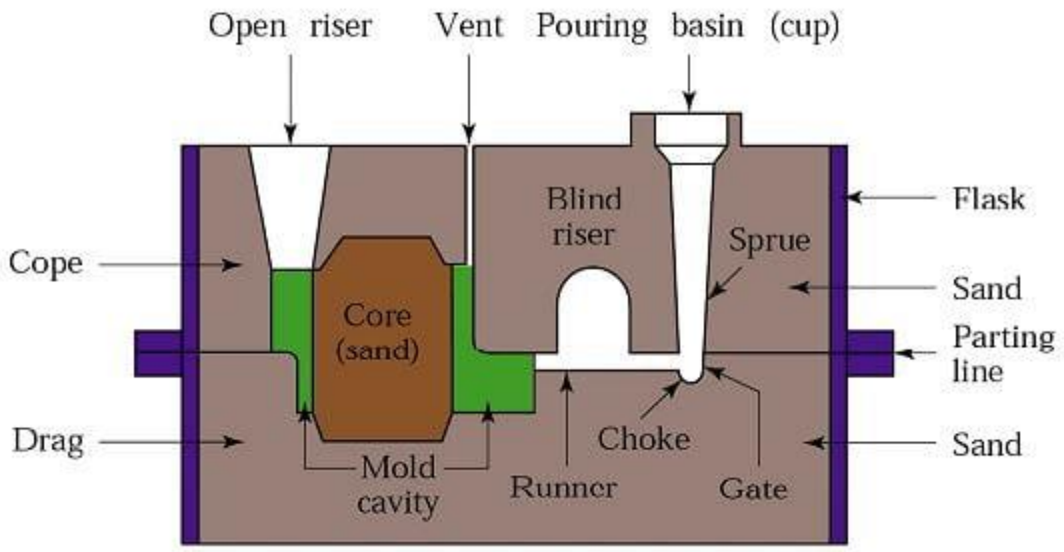
- The cost of raw material is less.
- Can be performed by semi-skilled labor.
- Can be mechanized easily.
- Faster production rate

Demerits of CO2 Molding:

- Not suitable for non-ferrous material.
- The minor fault can lead to gas defects and poor surface finish.

Sand Casting Process:

Sand casting is the widely used method of casting. This method is known as sand casting. In this technique, the pattern is placed in the drag and filled with sand.



In addition to sand certain bonding agents are mixed like clay. More than 60% of metal casting is done using the sand casting method.

Merits:

- Wider choice of material as any kind of metal alloy can be cast.
- The cost of tools & equipment needed to perform the process is certainly lower than other metal casting processes.
- As it has a short lead time so, it is perfect for production in the short-run.
- It can be used to create complex & intricate shapes.

Demerits:

- It cannot produce large casting as it has low strength.
- Poor surface finish.
- Increases the efforts as requires post-production finishing.
- Chances of occurring defects as tools & equipment are of low cost.

Centrifugal Casting Process:

Centrifugal or roto casting works on the principle of centrifugal force to produce hollow cylindrical parts or products. During this casting operation, a cylindrical mold revolves at a high velocity around its central axis as melted metal pours into it.

This rotation of the cylindrical mold creates centrifugal force, which pushes the molten metal to the circumference of the mold. Resulting in forming hollow cylindrical parts & products.

Merits:

- The high-density object will be produced.
- No chances of the gas defect.
- Due to fast rotation, the object obtained is of fine grain structure.
- No riser & No gating system required

Demerits:

- Skilled labor is required.
- This expensive process.
- Only some shapes can be formed by this process
- The inaccurate diameter of the inner surface of the product.

Gravity Die Casting Process:

Gravity die casting is a type of permanent casting in which the molten metal is poured into the die with the ladle. While filling the mold with the melted metal no force will act other than gravity force. The material that has high fluidity is made by gravity die casting.

Merits:

- The surface finish of the material produced is high.
- Excellent accuracy of the product produced.
- Mechanical & physical properties are higher than other types of casting.
- Parts can be made of internal inserts and core.

Demerits:

- Certain alloys have a lower production rate.
- Tools and equipment required are of higher cost.

Pressure Die Casting Process:

Pressure die casting is the type of permanent casting in which the molten metal is poured into the mold under high pressure. In this, technique force is applied to the melted metal using a plunger. There are generally two types of die casting-

Hot Chamber Die Casting:

This method is only applicable for the metal like zinc & other alloys that have a low melting point. In this process, the furnace is attached to the gooseneck.

Cold Chamber Die Casting:

The difference between a hot chamber and a cold chamber is in the cold chamber gooseneck is not attached to the furnace. And molted metal is poured with the help of a ladle through the hole in the gooseneck. generally, stell casting along with copper & aluminum is done through a cold chamber.

Merits of Cold Chamber:

- Produces high-volume equipment with higher accuracy.
- Excellent accuracy of the product produced.
- Molten metal solidifies in the second of time even milliseconds.
- Suited for large production in long run.

Demerits of Cold Chamber:

- Complex equipment used.
- Tools and equipment required are of higher cost.
- Not suited for individual products in the short run.

Slush Casting Process:

Slush casting is the type of permanent casting used to produce objects that are thin-walled and hollow. This technique is commonly used to produce decorative objects, components, and ornaments

In this method, the molten metal is not allowed to solidify completely. When the desired thickness is achieved the remaining molten metal is poured out.

Merits:

- A wide range of ornaments and decorative products can be produced.
- Preferred thickness can be easily achieved by pouring excess molten metal.
- Good surface finish.

- Faster cooling rates.

Demerits:

- Requires manual labor.
- The thickness of the material can vary.
- Time-consuming.

Advantages of Casting Process:

The following advantages of Casting Process is:

- Complex and intricate shapes can be formed.
- We can cast any type of material.
- The tools and equipment used in the casting process are inexpensive.
- It is possible to make the casting of any shape and size.
- The casting of any size can be performed up to 200 tons
- It is the cheapest way to produce shapes and sizes with different mechanical properties.

Disadvantages of Casting Process:

The following disadvantages of Casting Process is:

- High chances of defects.
- The dimensional accuracy of casting is not so good.
- Generally, sand casting the popular technique of casting is labor-intensive.
- In some cases, it is not possible to overcome defects.

Application of Casting Process:

The casting process is used to manufacture different products in industries like a cylindrical hollow cylinder, piston used in automobiles, pulley, engine manifolds, valves, nuts, defense equipment, etc.

The casting process is used in multiple industries like aerospace, defense, automobile, railways, construction, farming, mining, chemical, etc. It is also used in the manufacturing of home decor and ornaments.

What is Pattern?

A pattern is a replica of the object to be cast that is used in casting to prepare the cavity into which the molten material will be poured during the casting process. Sand casting patterns can be made of wood, metal, plastics, or other materials. Patterns are built to exact construction standards to last for a reasonable amount of time, depending on the quality grade of the pattern being built, and to provide dimensionally acceptable casting consistently.

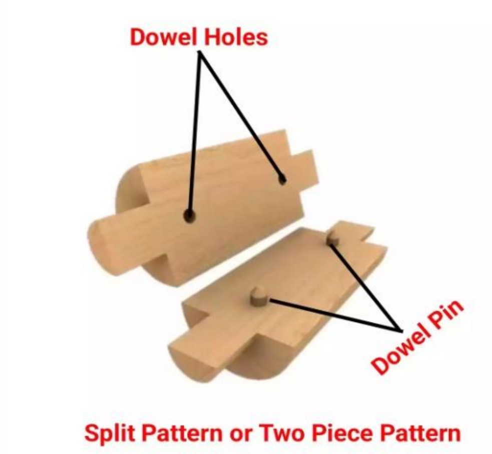
Typically, wood, metal, or plastics are used to create different types of patterns. Wax and Plaster of Paris are used only in limited circumstances. Investment casting is a casting technique that makes use of wax patterns. Plaster of Paris is commonly used to create master dies and moulds.

Types of Pattern in Casting

- As previously stated, casting objects are heavily reliant on types of patterns in casting. Patterns are ingle piece pattern
- Two-piece pattern
- Multi-piece pattern
- Match plate pattern
- Gate pattern
- Sweep pattern
- Skeleton pattern
- Loose piece pattern
- Cope and drag
- Shell pattern
- Follow board pattern
- Segmental pattern

Single Piece Pattern

The single-piece pattern is a type of pattern also known as the solid pattern. It is the most affordable casting pattern. It is ideal for simple processes and small-scale production, and large casting manufacturers prefer it because this type of casting pattern requires only simple shapes and flat surfaces, such as simple rectangular blocks. A single flat surface separates planes. It is used to make steam engine stuffing boxes.



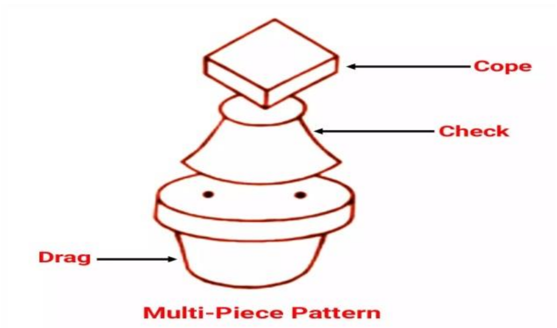
Two-Piece Pattern

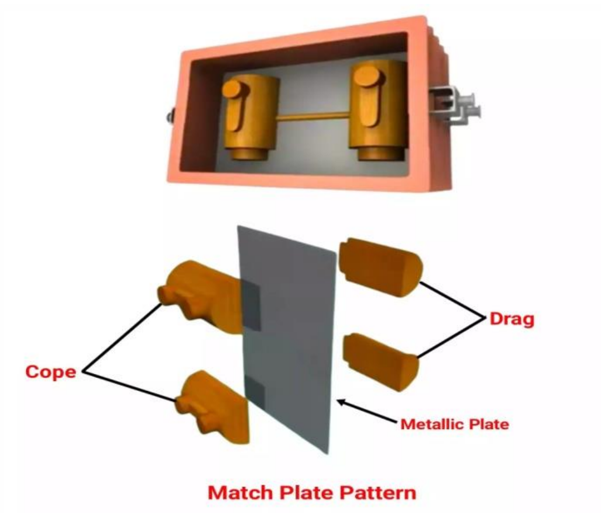
The two-piece pattern, also known as the split-piece pattern, is a popular casting pattern for intricate casting. Parting planes with flat or irregular surfaces are used in this pattern, and the exact position of the plane is determined by the shape of the casting. The split-piece pattern consists of two pieces. One of the parts is made of drag, while the other is made of cope. Dowel pins are always used in the cope part. The two halves of the split piece pattern can be aligned using dowel pins.

Multi-Piece Pattern

A multi-piece pattern is a good solution for difficult-to-make complex designs. This type of pattern consists of three or more patterns that aid in mould making.

As an example, consider the three-piece pattern. The pattern is divided into the top, bottom, and middle sections. The top part is called the cope, the bottom part is called drag, and the middle part is called the check box.



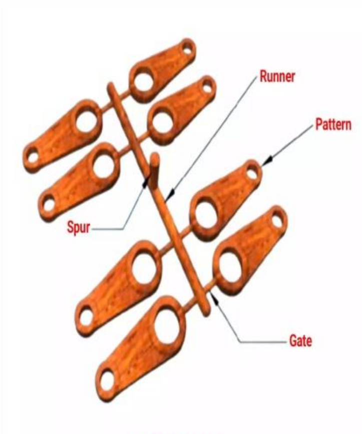


Match Plate Pattern

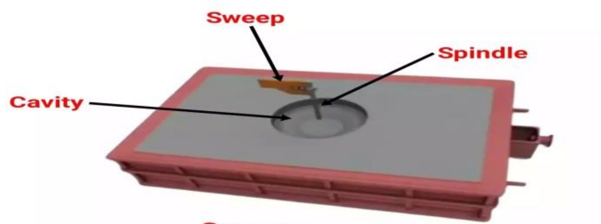
This type of pattern is made in two halves and is mounted on opposite sides of a match plate, which is made of wood or metal. The plate also holds the gates and runners. In machine moulding, this type of pattern is used. It is widely used in manufacturing and typically has a high yield, precise casting, and a high cost. And this type of casting pattern is commonly used in metal casting, such as aluminium.

Gate Pattern

Multi cavity moulds are used in the mass production of casings. The figure shows that such moulds are created by connecting some patterns and gates and providing a common runner for the molten metal. These types of patterns are made of metals, and metallic pieces are attached to the pattern to form gates and runners.



Gated Pattern



Sweep Pattern

Sweep Pattern

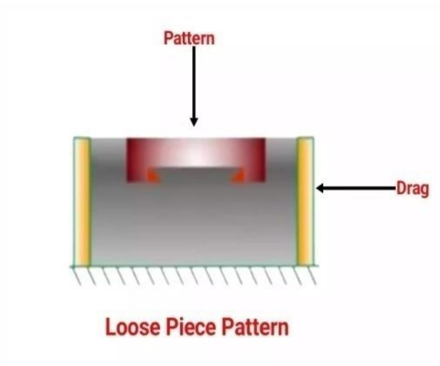
The sweep type of pattern shapes the cavity by rotating a wooden board along one edge. This type of casting pattern creates a cavity in the vertical direction, and the base of it is attached with sand. It also creates casting in a very short time, and it has three parts: spindle, base, and sweep, which is also known as a wooden board.

Skeleton Pattern

Skeleton patterns are large in size, and they are a good choice for castings with simple size and shape. This type of casting pattern is costly and unadaptable. It is not the most cost-effective option, but it is very effective at removing extra sand. This type of pattern is widely used in pit or floor welding industries.

Loose piece pattern

This type of pattern can assist manufacturers in removing one piece of the solid pattern that is above or below the mould's parting plane. Because this pattern necessitates additional skilled labour, it is an expensive casting pattern in casting.



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Cope and Drag

The cope and drag parts of the mould are prepared separately in this case. This occurs when the entire mould is too heavy for one operator to handle. The pattern is divided into two halves that are mounted on separate plates. The figure displays an example of a standard match plate pattern.

Shell Pattern

The shell type of pattern is an excellent choice for creating hollow-shaped structures. It splits down the middle and dowels the resulting halves.

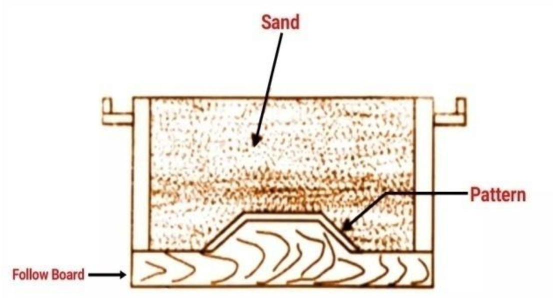
Follow Board Pattern

When solid or split patterns become difficult, a follow board is made with a contour corresponding to the exact shape of one-half of the pattern.

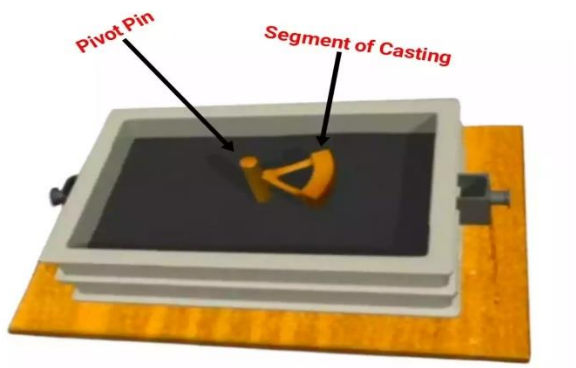
Segmental Pattern

This type of pattern is commonly used for circular castings such as wheel rims, gear blanks, and so on. Such patterns are sections of a pattern that are moved to form each section of the mould to form a complete mould. A central pivot guides the movement of the segmental pattern.

classified as follows based on the shape and size of the casting and the method of making the cavity.

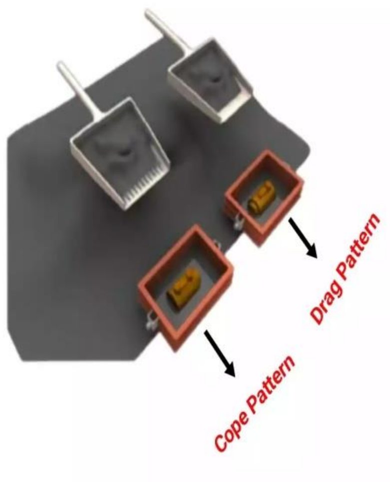


Follow Board Pattern



Segmental Pattern

Shell Pattern



Cope and Drag Pattern

Pattern Allowances - Explain Allowances in Casting and its Types

Pattern allowances play an important role in obtaining adequate patterns. The pattern size is never kept the same as that of the desired casting because the casting is subjected to various effects during cooling. Thus, corresponding pattern allowances are made in the pattern to compensate for these effects.

Pattern allowances include allowances for shrinkage, allowances for machining, allowances for the draft, allowances for rapping or shaking, and allowances for distortion. Here, we will discuss pattern allowances and types of pattern allowances in detail.

What is Pattern in the Casting Process?

The pattern is a replica of the device produced by the casting process. When molded in the sand, this forms a mold. Casting is formed after the molten metal is poured into the mold. Patterns are very important in casting because they determine the quality and perfection of a particular casting process. Gates and runners are the most important elements in many patterns.

The pattern is the fundamental requirement for mold creation and is always larger than the casting size. There should be a proper pattern selection to withstand rough handling. It creates a cavity in the mold for casting processes. Metals such as aluminum, brass, plaster, and wax can be used to create patterns.

What are the Pattern Allowances?

A pattern is a slightly larger version of a casting that is used to make a mold cavity. This pattern change is caused by the fact that when the cast solidifies, it shrinks to a certain extent due to the metal shrinkage property during cooling. As a result, a pattern is made slightly larger to compensate. Pattern allowances refer to these minor changes in the pattern.

Type of Pattern Allowances

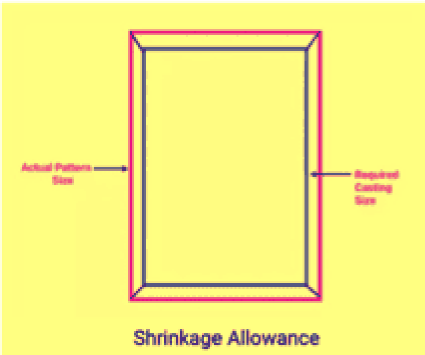
The art of designing patterns is known as pattern making. It is the first and most important step in the casting process. The patternmaker must account for the mold type and casting metal characteristics and make an exact replica of the shape they want to cast. For this pattern, allowances are provided. These provisions are built into the pattern:

- Shrinkage allowance
- Draft allowance
- Rapping or shake allowance

- Distortion allowance
- Machining allowance

Shrinkage Allowance

The dimensions of the patterns grow larger after the metal solidifies from further cooling (room temperature). As a result, the pattern size is larger than the finished cast product size. This pattern allowance is referred to as shrinkage allowance.



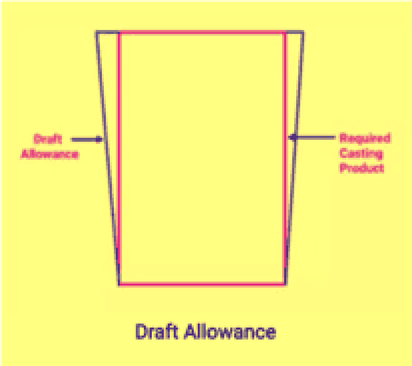
Shrinkage Allowance

Shrinkage allowances are three types:

- **Liquid shrinkage:** The contraction that occurs when liquid metal or alloy temperature falls from the pouring temperature to the liquidus temperature is referred to as liquid contraction.
- **Solidification shrinkage:** Contraction as a result of cooling from the liquid to the solidus temperature, also known as solidifying contraction.
- **Solid shrinkage:** Contraction that follows until the temperature reaches room temperature. This pattern allowance is referred to as solid contraction.

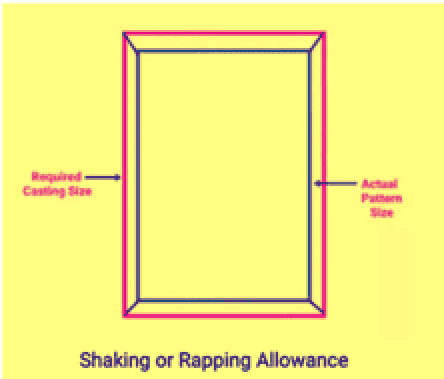
Draft Allowance

When the pattern is removed from the mold, the parallel surface to the withdrawal direction is slightly damaged and converted into slightly tapered surfaces. These parallel surfaces on the pattern are slightly tapered to compensate for these changes (nearly 1 -2 degrees). This allows for easy removal of the pattern from the mold while having no effect on the casting process. Draft allowances are the changes made to the pattern surface to protect it from damage.



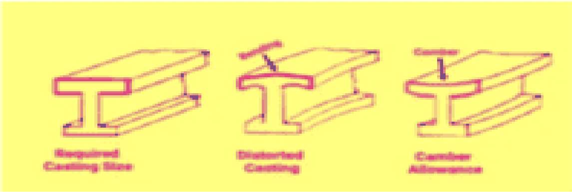
Rapping or Shake Allowance

When removing the pattern from the casting sand, it must be shaken slightly to remove it from the sand, causing a slight increase in casting dimension. The patterns are made slightly smaller from casting to compensate for the increased casting. Shaking or rapping allowances refer to this change in pattern dimension.



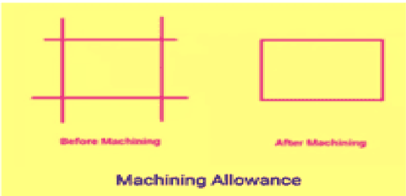
Distortion Allowance

Because of the uneven metal thickness in the casting process, stress develops in the solid metal during the cooling process. This stress may cause casting distortion or bending. To prevent bending or distortion in casting, a camber is provided in the opposite direction so that the casting becomes straight when bending occurs due to uneven metal thickness. Bending Allowances are the changes in pattern shape that compensate for bending while casting.



Machining Allowance

Because we know that the product of a casting process has a very poor surface finish, the surface of the final casting product will be rough. However, we require a polished product with a smooth surface finish. So, to achieve a good surface finish, the final product of casting is machined using processes such as turning or grinding.



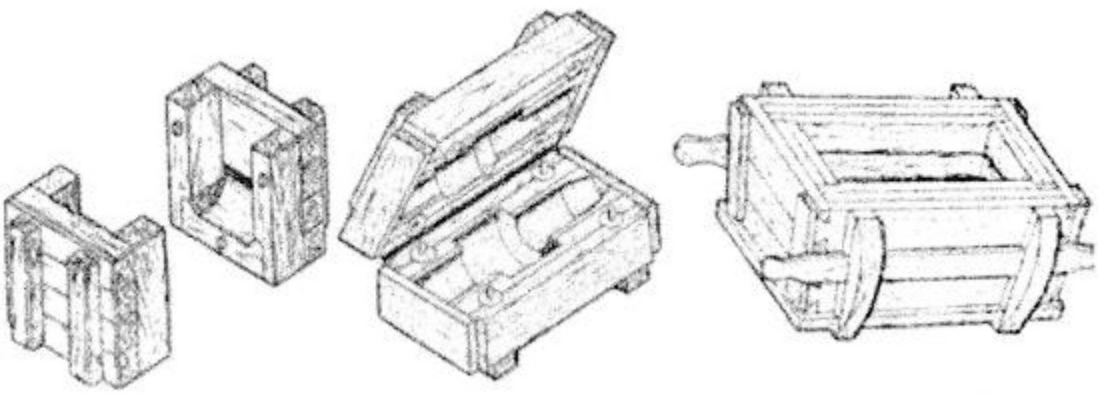
This post-casting machining results in a significant loss. The casting pattern includes machining or finishing allowances to compensate for this loss. This allowance is added to the basic pattern size. It varies from less than 2 mm to 15 mm, depending on the size and material of the part.

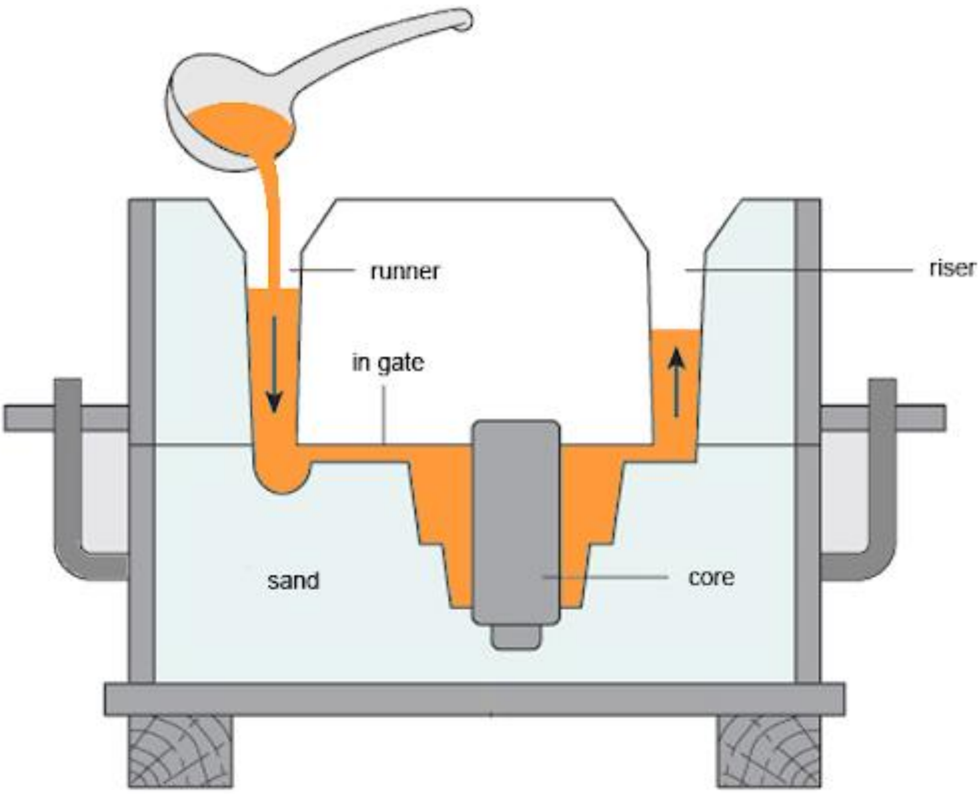
What is Core in Casting?

What is Core in Casting?
Core is defined as sand bodies which are used to form a hollow portion of cavities of desired shape and size in casting.

The cores are not molded with the pattern, but the separate core boxes are used to mould these sand cores.

You can see wooden core boxes for different shapes and sizes of sand cores (see below image).





In the casting process, the cores should be collapsible after the pouring of metal.

This property of collapsibility is present in the sand cores. Hence sand cores are widely used in casting.

Beside the formation of internal cavity, the sand cores also have few other properties.

1. Sometimes there may be some difficulty in making the molds of difficult shapes. In such cases, the cores are placed in the mould after the pattern is drawn from the mould.
2. The mold surface becomes strong by placing a core in the mold.
3. Cores also provides some benefits to the gating system of the casting.
    - Strainer core is used to prevent the entry of foreign materials.
    - Pouring basin core provides a cup or basin at the top of the mould for the entry of the molten metal.
    - Splash core is used to prevent the erosion in gates and runners of the mould.

The foundry sand core has to resist the extreme heat of the molten metal.

Hence it should have properties like high strength, high permeability, high refractoriness, collapsibility, etc.

When the cores are made up of molding sands in the moist state, they are known as **green sand cores**.

When the cores are made up by baking the mixture of sand and core binders, they are known as **dry sand cores.**

There are various sizes of sand available for manufacturing the core, but those sand selection depends upon the size of core as well as temperature of the molten metal.

If the cores are made up of small grain sand, then it will develop a smooth surface on the final casting.

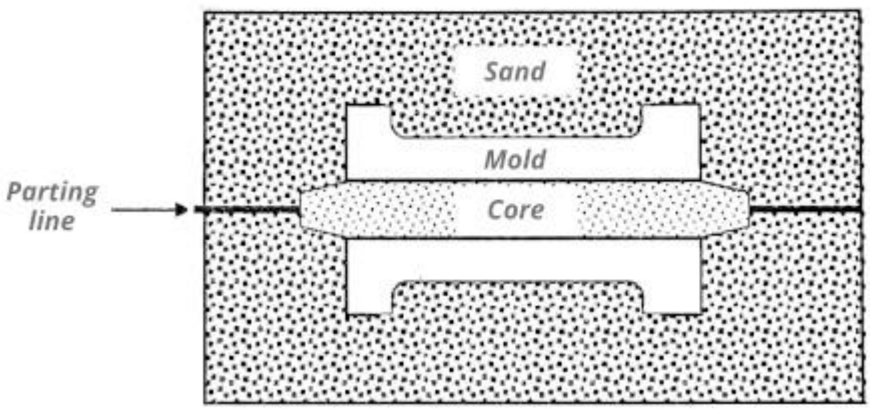
Types of Core in Casting

5 main types of cores in casting are mentioned below.

1. Horizontal core
2. Vertical core
3. Balanced core
4. Drop core
5. Cover core or hanging core

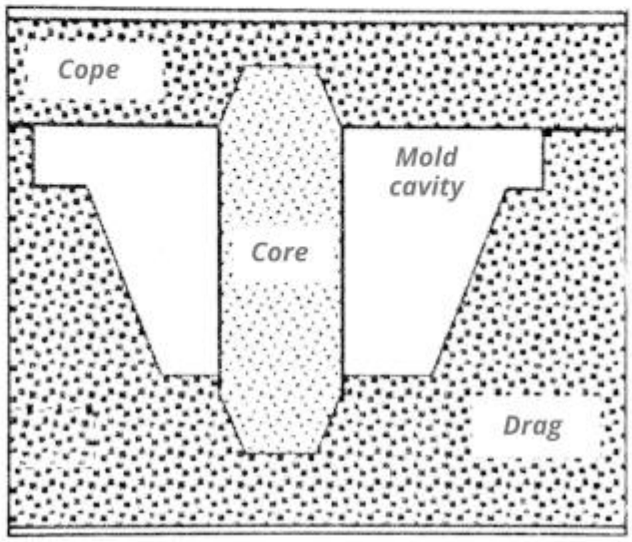
Let me tell you few things about each of these sand casting cores in brief.

#1) Horizontal core in casting



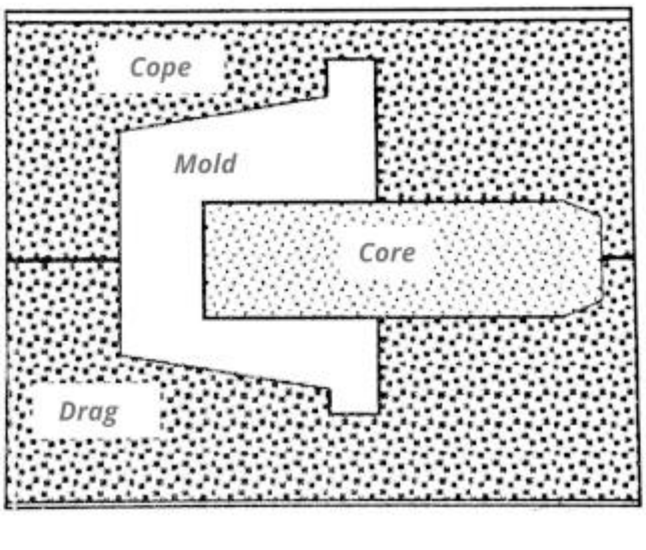
- Horizontal core is one of the simplest core in casting.
- As the name suggests, the horizontal core is placed in the horizontal direction in the core prints.
- The horizontal cores are mostly placed at the parting line of the mould in such a way that one half of the core remains in the cope and other half remains in the drag.
- The horizontal cores are generally in cylindrical shape, but other shapes are also prepared as per requirements. (Above image shows a horizontal core which is in cylindrical shape).

#2) Vertical core in casting



- Vertical cores are similar to horizontal cores, but the only difference is in their positions.
- The vertical cores are placed in vertical direction in the sand mould.
- The tapers are provided on the sand casting cores, so that it can be easily arranged without tearing the sand of cope and drag.

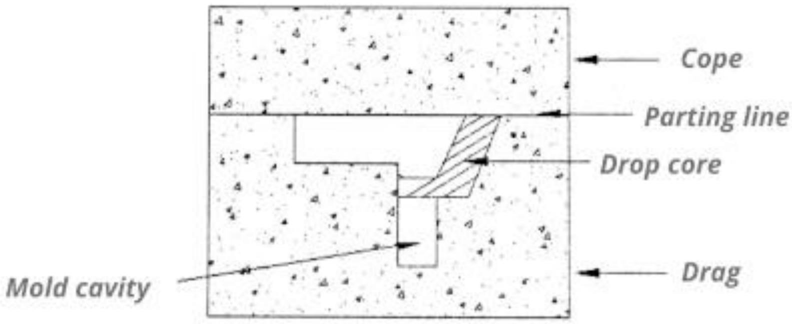
#3) Balanced core in casting



- In casting, the balanced cores are the cores which are supported only from the one end, and the other end of the core is hanging. (See above image).

- The limitations of balanced core is that it can be made of smaller lengths to avoid its breaking.
- Balanced cores are used to make holes in horizontal direction in the casting.
- If the balanced core is longer in length, then it is supported by using chaplets.

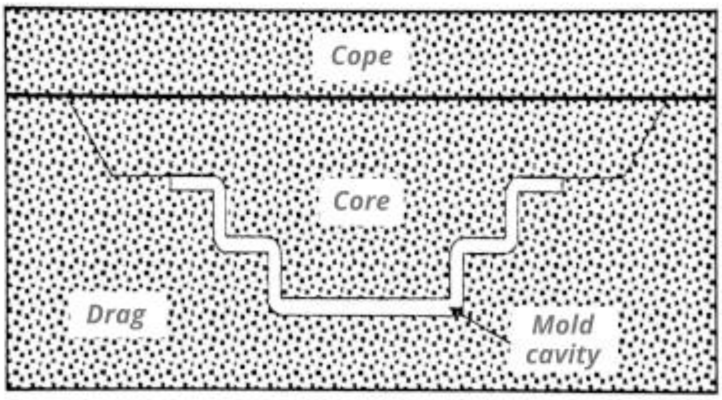
#4) Drop core



- Drop core (aka wing core or stop off core) are used when a cavity or a hole is not in line with the parting surface.
- Drop cores are kept either above the parting line or below the parting line.

#5) Cover core or Hanging core

- Cover core (also known as hanging core) is that type of core which is hanging vertically from the top and has no support from the bottom.
- Hanging core is used when the entire mould is prepared in the drag only.
- As shown in the image above, the entire mould is prepared by ramming the pattern in the mould and then the upper part of the mould cavity is covered using a hanging core.
- This type of core requires a passage from the top for the entry of the molten metal into the mould cavity.
- Cover core is also called as hanging core because it does not have any support from the bottom.



What is Centrifugal Force?

The Centrifugal force is a type of force felt by any object moving in a curved path and is directed radially outward.

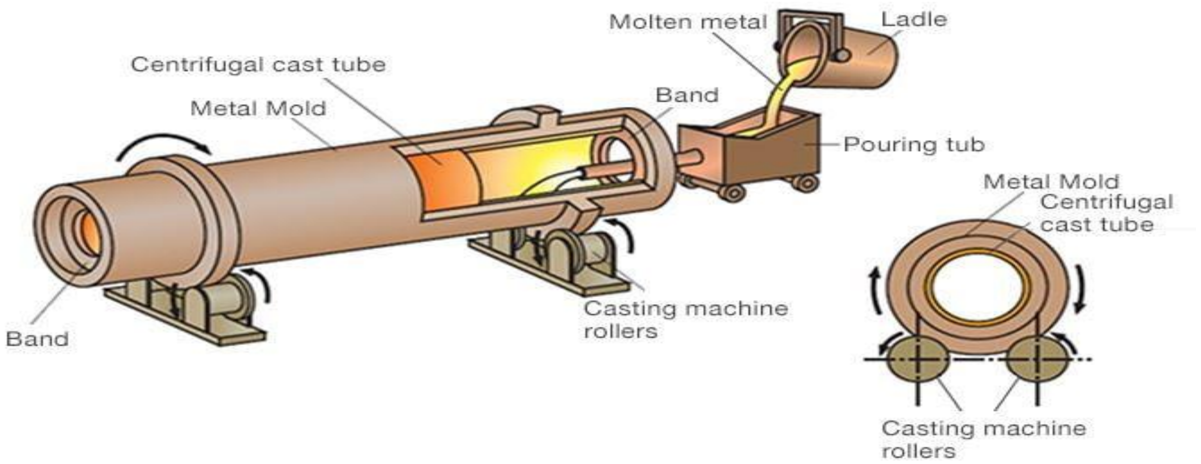
Centrifugal casting is also known as Roto Casting. It is a casting process in which centrifugal force is used and to cast thin-walled cylinders and materials such as metals, glass, and concrete.

- Centrifugal casting was invented by Alfred Krupp.
- High-quality products can be manufactured by the centrifugal casting process. It is mainly used to produce rotationally symmetric products.
- After obtaining the product from this manufacturing the product requires some machining for good finishing and material luster.

Centrifugal Casting Parts:

The following **parts of centrifugal casting** are:

- **Ladle**
- **Pouring Basin**
- **Core**
- **Rollers**
- **Motor and**
- **Metal Mold**



Pouring Basin:

Here the molten metal in placed by the ladle Now it is used to pour the molten metal into the metal mold.

Core:

A core is a preformed, bonded, sand insert placed into the metal mold to shape the interior of a casting. The Cores are used to create hollow sections or cavities in a casting.

Rollers:

Here The machine has four rollers and all of them are being used. Two rollers are at the bottom and two are at the top of the system. Two rollers that are in the bottom are connected to the motor and rotate with it. And the other two rollers which are in the top, provide support to the metal mold while rotating.

Motor:

The motor is used to provide rotary motion to the rollers.

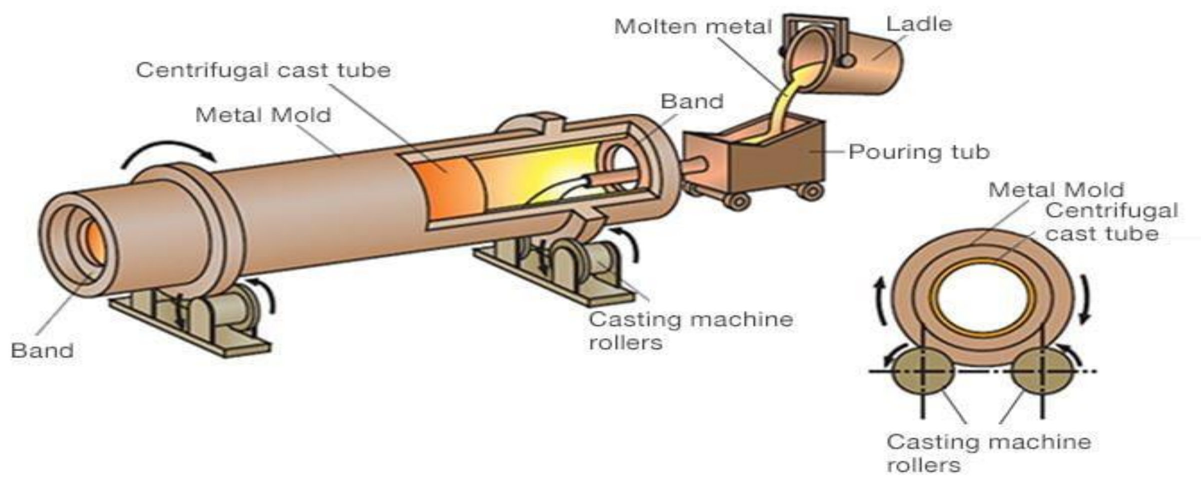
Metal Mold:

Here the molten material is placed with the help of a poring basin. Now with the help of motor and roller, it is being rotated and it rotates continuously at high speed when an operation is to perform.

Centrifugal Casting Material:

The material we use to cast by centrifugal casting is **cast iron, stainless steel, steel and aluminum, alloys of nickel, and copper**. In this casting, we can combine two materials and that introduces a second material during the process. A very good example is a cast iron pipe coated on the interior with cement.

Centrifugal Casting Working Process:



First, we prepare the molten metal which may be cast iron, steel, or stainless steel. Now we clean all the parts of the manufacturing and we will supply the power to the motor.

The motor starts get to rotate. Now the molten metal is now put into the pouring basin with the help of a ladle And from pouring basin, it is further put into the metal mold which is attached to the motor and it is rotating therefore the centrifugal force comes into play.

The dense material in the mold starts taking place at the wall of the spinning mold and simultaneously we supply the molten metal as per the requirement.

The mold rotates at a speed between 500 to 3000 rpm and here the pressure is created by the centrifugal force is 100 times gravity force.

Now this will run for some time and then we will get the product out from the pouring basin. The molten metal solidifies after cooling. The molten metal solidifies the outer diameter to the inner diameter.

And now this is further sent for the machining process where if any impurities are there it will be removed and the product gets a high luster and good mechanical properties.

The material gets a fine-grain microstructure that can easily resist atmospheric corrosion

Steps Involved in Centrifugal Casting:

The following **steps are involved in the Centrifugal Casting**:

1. **Mold Preparation**
2. **Pouring**
3. **Cooling Process**
4. **Removal of Casting and**
5. **Finishing Process**

Mold Preparation:

In the mold preparation steps, we prepare mold in a cup-shaped component before pouring the molten metal.

Pouring and Casting Removal:

Now the mold we prepared in the cup is poured directly into the rotating mold. Here we do not use a gate or runner system. The molten metal is poured into a high-speed rotating mold here the molten metal experiences the centrifugal forces inside it.

The pressure which is created by centrifugal force is 100 times the force of gravity and the mold cavity rotation speed around 500 to 3000 RPM

The high dense molten material is moving towards the wall of the spinning mold. And if any extra material comes on the upper surface we try to remove it if possible.

Now after some time, the poured metal gets a proper shape is being removed from the rotating machine with the use of tongs and all.

Cooling Process:

Now The mold is allowed to cool down evenly and gradually so that the metal does not get blistered and rendered.

Finishing Process:

After the cooling process now the product is sent to the finishing process where if any slugs are present it will be removed.

Further, the finishing process is done by machining, grinding and sand-blasting of the inside diameter to remove impurities of the product and make the inner and outer surface smooth and shiny.

Centrifugal Casting Types:

There are mainly two types of Centrifugal casting process:

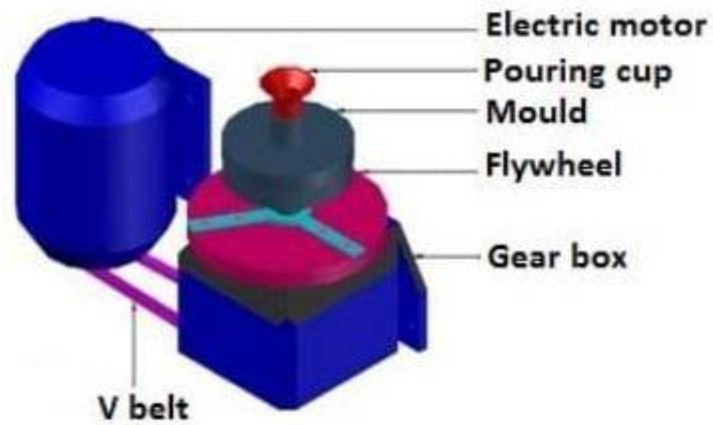
1. **Vertical Casting and**
2. **Horizontal casting.**

Vertical Centrifugal Casting:

From the vertical casting process, we get superior mechanical properties and a more uniform, fine grain structure of the manufactured component.

The vertical centrifugal casting process is used to cast cylindrical shapes whose diameter is more than the height or length of the cylinder.

For example rings and bearing, Balls for ball valves, Gear blanks, Short bushings, Flanges, and sprockets (Automobile component). It can also be used to cast non-cylindrical parts such as valves and propellers by using specialty castings.



(a)

Horizontal Centrifugal Casting:

In the Horizontal casting process, we preferred to manufacture the products with long cylindrical parts where the casting length is much longer than the outside diameter.

The horizontal casting process is a cost-effective method and it produces high-quality tubular components. Here In horizontal a mold, or die, spins about a horizontal axis and it casts parts having an axis of revolution.

And Centrifugal casting is further divided into three types: **True centrifugal casting, Semi-centrifugal casting, and Centrifuged casting.**

True centrifugal casting:

True centrifugal casting is a centrifugal casting process. The process is used for making symmetrical round hollow sections. Here there is no use of core and asymmetrical hollow section is created by pure centrifugal action.

In this casting process, a mold is rotated fast about its central axis as the metal is poured into it. With the use of Centrifugal force, we distribute liquid metal over the outer surface of the mold.

The Centrifugal force tends the poured metal and the freezing metal to fly outward, or away from the axis of rotation.

Now, this process creates high pressure on the casting material and the lighter slag or oxides being pushed towards the center.

Casting cools and solidifies from the outside therefore it results in good directional solidification. It is used to make hollow pipes, tubes, bushes, and son on which are axisymmetric with a concentric hole.

Semi-centrifugal casting:

The semi centrifugal casting is used to cast large size axisymmetrical objects. The mold is placed horizontally and is being rotated along the vertical axis and a core is inserted at the center that is used to cast a hollow section.

Now When the mold rotates, It is filled by purely centrifugal action, and as the liquid metal approaches the center, here the gravity component increases, and the centrifugal component decreases.

Therefore a core is inserted at the center to make a hollow cavity without centrifugal force. In this process centrifugal force is used for a uniform filling of axisymmetrical parts.

Some parts of automobiles like Gear blanks, flywheels, are manufactured from this process.

Centrifuged casting:

Centrifuged casting is used to manufacture only small objects and it is also used to cast object which is not axisymmetrical. The centrifugal force is used to obtain higher pressure on the metal and get more dense and high mechanical properties of castings.

In this process, there are several mold cavities connected with a central sprue with radial gates. This process uses higher metal pressure during solidification.

In Centrifuged casting process a group of small molds is arranged in a circle around the central vertical axis of the flask and the flask is rotated about the vertical axis, the process is known as centrifuged casting.

Centrifugal Casting Applications:

The following application is:

- Centrifugal casting is used to cast hollow cylindrical metal pipes.
- This casting process is used in the automobile industry for various product manufacturing like pistons, cylinder liners, and so on.
- This casting process is widely used in aircraft industries for casting flanges, compressors, and rings.
- It is also used to manufacture carriage wheels of railway and bearings.
- The centrifugal casting process is used in the electronic industry for manufacturing switchgear components.
- It is also used to create any parts whose shapes are symmetrical about an axis.

- This process is also used when a uniform grain structure is required.
- We also make Clutch plates Paper making rollers from this casting process.

The following advantages are:

- The centrifugal casting process has lower casting defects because of uniform solidification.
- The energy can be saved as it requires a lower pouring temperature.
- The impurities like oxide or any other slag particles are being segregated at one point and that can be easily removed from there.
- By centrifugal casting, a thin wall cylinder can be easily manufactured which is a very good advantage.
- This casting process can produce components with intricate geometries at a lower cost.
- The runner and gating system in this casting process is not there.
- For casting hollow shapes like tubes and other components we do not require cores.
  - The centrifugal casting process can be used for mass production.
  - The component we manufacture from the centrifugal casting process has high mechanical properties and dense metal.
  - Inclusions and impurities of the casting process are lighter.

Centrifugal Casting Disadvantages:

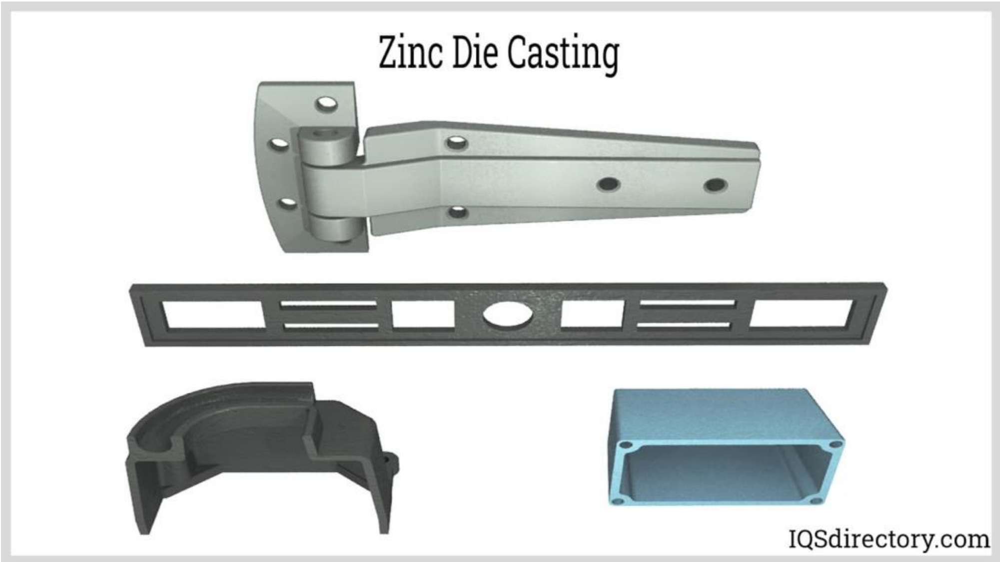
The following **disadvantages** are:

- In centrifugal casting, the temperature distribution and solidification time is difficult to determine.
- When we manufacture the small diameter pipe and if some impurities come in the internal diameter from this process it is very hard to remove which is a major disadvantage of centrifugal casting.
- It is good for manufacturing only cylindrical structures. When we manufacture other than cylindrical structure there is a loss in structural and purity benefit.
- More machining is required when we manufacture components other than cylindrical and there is more chance of making the process more costly.
- The size of components we manufacture here is limited.

- The centrifugal casting cast only symmetrical shapes therefore Limited design can be cast from this process.
- It is not suitable for manufacturing any type of material. The material is limited.
- More maintenance and skilled operator is required.

What is Die Casting?

Die casting is a high pressure metal casting process that forces molten metal into a mold. It produces dimensionally accurate precision metal parts with a high quality finish. Its ability to produce detailed parts makes it perfect for the mass production of products. Die castings are made from non-ferrous metals such as zinc, copper, aluminum, magnesium, lead, pewter, and tin.



The two methods of die casting are hot or cold chambers. The process that is used depends on the type of metal and the part. The cold chamber method is used with metals that have a high melting point such as alloys of aluminum, brass, or copper. Hot chamber die casting is limited to metals that won‘t dissolve when heated such as zinc, lead, and magnesium alloys.

The process of die casting is efficient, economical that offers a broad range of shapes and components. Parts produced have a long life and can be produced to be visually appealing giving designers significant advantages and benefits.

The high speed of die casting produces complex shapes with close tolerances requiring no after production processing. There is no need for additional tooling or shaping. Final parts are heat resistant with high tensile strength.

Depending on the feature and its size, tolerances of +/-.002" can be held in aluminum with tolerances of +/-.0005" in zinc.

Types of Metals Used in Die Casting

The type of metal used in die cast depends on its final use. Aluminum is used for automobile and truck parts because of its light weight and corrosion resistance, while medical instruments are made from stainless steel.

Metals for casting must be able to maintain their properties and characteristics during and after the melting process. The types are:

- Aluminum
- Zinc
- Brass
- Bronze
- Tin
- Lead
- Magnesium
- Silicon tombac
- Stainless steel
- Carbon steel

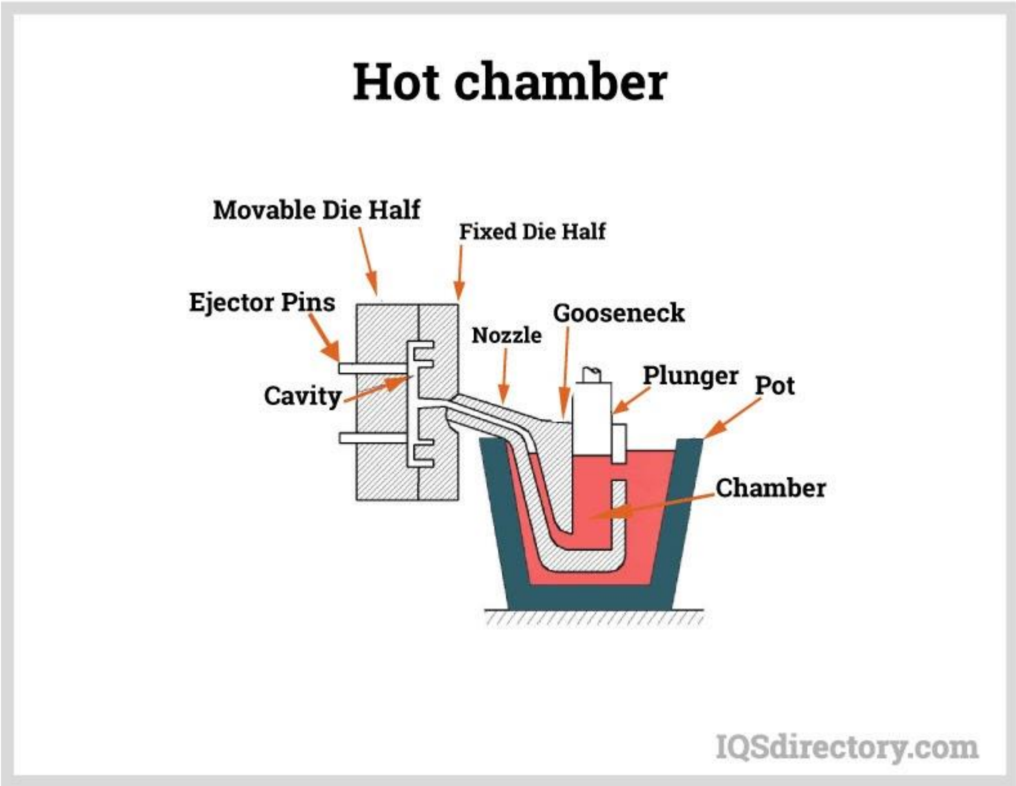
Die Casting – Hot and Cold

The most common types of die casting are hot and cold. The difference between them is that hot chamber die casting heats metals in the casting machine while cold chamber heats metal in a furnace and transfers the molten metal to the casting machine. The process produces complex shapes with close tolerances, heat resistance, and high tensile strength with little need for additional tooling and shaping.

Hot chamber

Hot chamber die casting uses alloys with a low melting temperature. Dies have two sections – movable and fixed. The fixed half is the covered die and is mounted on a stationary platen aligned with the gooseneck that connects to the chamber for inserting the molten metal. The movable die is the ejector die.

Molten metal is held in an open holding pot that is connected to the combustion area or furnace from which the molten metal enters the holding pot. With the plunger, that drives the molten metal up the gooseneck into the mold, in the up position the molten metal flows into the shot chamber. Once the metal is present, the plunger moves down forcing the molten metal up the gooseneck into the die.

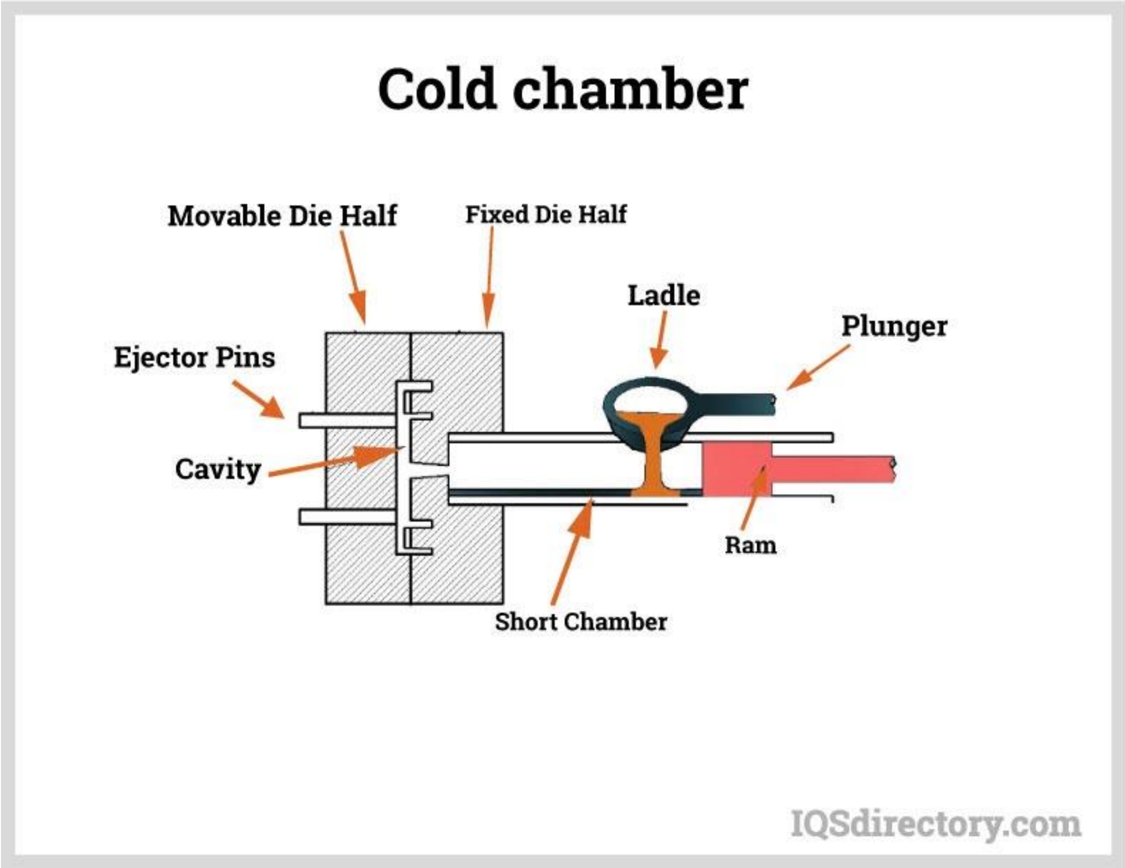


The two halves of the mold are forced together under great pressure to close the mold. The plunger remains down until the molten metal in the die cools. After solidification, an ejection system pushes the casting out from the two die halves.

Cold chamber

Cold chamber refers to the temperature of the chamber when the molten metal is introduced. With hot chamber casting, the chamber is filled with molten metal prior to beginning the casting process. In the cold chamber process, the chamber is at room temperature before the molten metal is poured.

High melting temperature metal alloys are used for cold chambered die casting. The molten metal is heated in a separate furnace and ladled or poured through a pouring hole into the shot chamber that encloses a ram for pushing the molten metal into the die. The parts of the die are the same with movable and fixed sections. The cold chambered method forces the molten metal in vertically.



As the ram moves vertically toward the die, the molten metal is forced forward at pressures between 2000 psi or 2 ksi to 20,000 psi or 20 ksi. The pressure is held by the ram until the molten metal cools and solidifies to be ejected.

Moulding Sand And Types

The **Moulding sand** is also known as foundries sand, this sand is commonly used for making moulds. Natural sand located on the bed and banks of rivers gives a larger source, although high-quality silica sand is also mined.

The sand is chemically Si02, silicon dioxide in a granular manner. Ordinary river sand contains a percentage of clay, moisture, non-metallic impurities and traces of magnesium and calcium salts besides silica grains. After appropriate treatment, this sand is used to make a mould.

Types of Moulding Sand

Following are the 8 different types of moulding sands:

1. Greensand
2. Dry sand
3. Loam sand
4. Facing sand
5. Backing sand
6. Parting sand
7. Core sand

1. Green Sand

Green sand is a sand or sandstone which has a greenish colour. it is a mixture of silica sand with 18 to 30% clay, having total water of 6 to 8%. It is soft, light and porous with clay and water furnishing the bond for green sand.

In green sand, It is slightly wet when squeezed by hand. It has the ability to maintain the shape and impression given to it under the pressure. The green sand can be easily available and it has a low cost. The mould that is prepared in this sand is called green sand mould. It is commonly used for the production of ferrous and non-ferrous castings.

2. Dry Sand

The Green sand that has been dried or backed after the mould is made is called dry sand. They are suitable for large castings. Moulds prepared in dry sand are known as dry sand moulds. If we talk about the physical composition of dry sand, it is similar to green sand except for water.

3. Loam Sand

The Loam sand with 50% of clay is called loam sand. They are also suitable for large castings. It is a mixture of sand and clay and water is present in such a quantity that it forms a thin plastic paste. In these types of sand, moulding patterns are not used.

4. Facing Sand

It forms the face of the mould. The facing sand is used directly next to the patterned surface and comes into direct contact with the molten metal when the molten metal is poured into the mould. It has high strength and refractivity as it comes in contact with molten metal. It is made of clay and silica sand in addition to unused sand.

5. Backing Sand

The backing sand is also called floor sand used to back up the facing sand. It is an old and frequently used moulding sand is used for backing purpose. It is sometimes called black sand because of the addition of coal dust and burning due to in contact with the molten metal.

6. Parting Sand

The parting sand is used to avoids sticking of green sand to the pattern. And also it allows in easy removal of cope and drag. This parting serves the same purpose as dust. It is pure clay free silica sand.

8. Core Sand

The core sand is the sand for making cores. It is also called oil sand because it is a mixture of silica sand and core oil. Core oil is a mixture of linseed oil, resin, light mineral oil and other binding materials. For the sake of economy, pitch or flour and water can be used to make large cores.

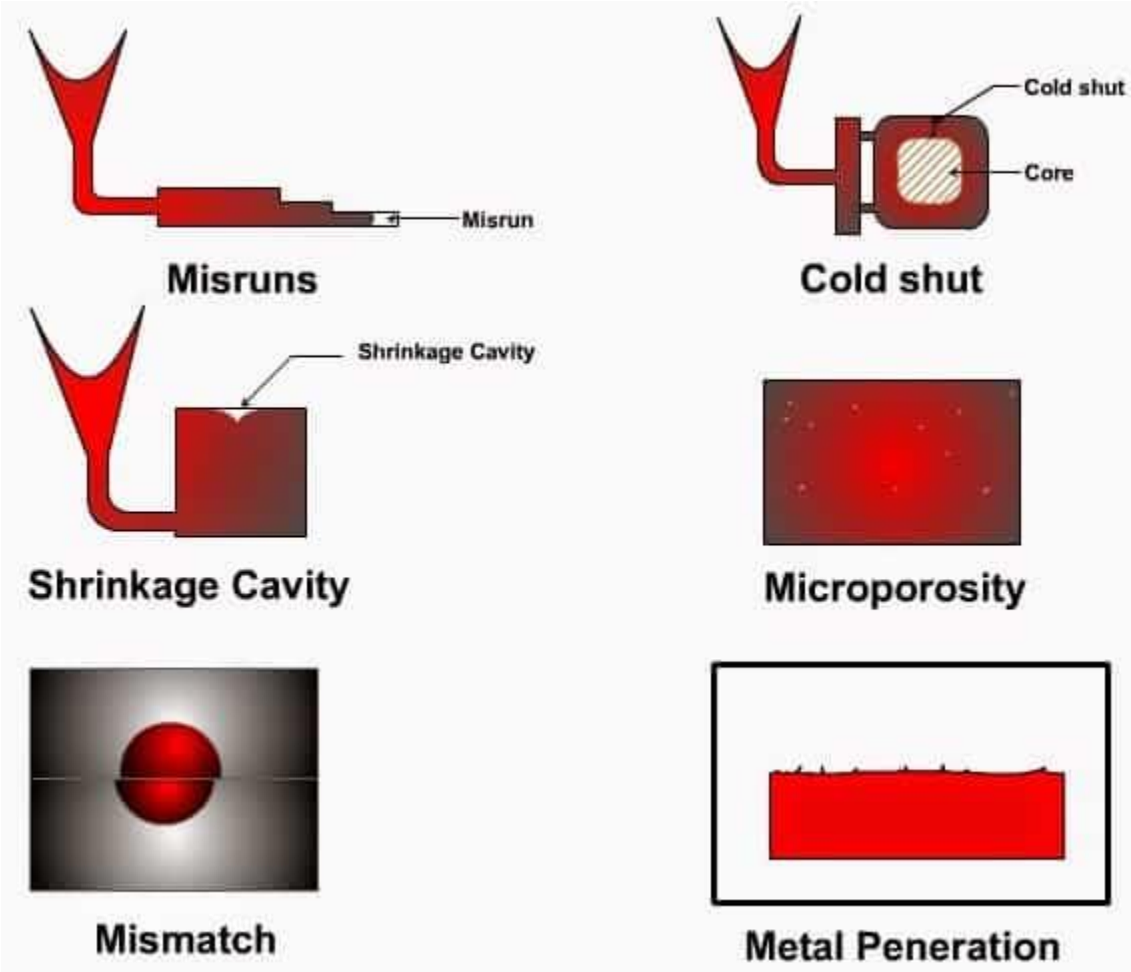
Properties of Moulding Sand

Good, well-prepared moulding sand must have the following properties:

1. **Refractoriness**– It should be able to withstand high temperature.
2. **Permeability**– Ability to allow gases, water vapour and air to pass through it.
3. **Greensand strength**– When the mould is formed of moist sand, it must have sufficient strength, otherwise, the mould will break.
4. **Good flowability**– When it is arranged around a pattern in a moulding box, it must be able to fill all nooks and corners, otherwise the impression of pattern in mould would not be sharp and clear.
5. **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 care making.
6. **Cohesiveness**– Ability of sand grains to stick together. Without cohesiveness, the mould will lack strength.
7. **Adhesiveness**– Ability of the sand to stick to other bodies. if the moulding sand does not stick to the wall of moulding box, the whole mould will slip through the box.

TYPES OF CASTING DEFECTS

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



Gas Defects

A condition existing in a casting caused by the trapping of gas in the molten metal or by mold gases evolved during the pouring of the casting. The defects in this category can be classified into blowholes and pinhole porosity. Blowholes are spherical or elongated cavities present in the casting on the surface or inside the casting. Pinhole porosity occurs due to the dissolution of hydrogen gas, which gets entrapped during heating of molten metal.

Causes

The lower gas-passing tendency of the mold, which may be due to lower venting, lower permeability of the mold or improper design of the casting. The lower permeability is caused by finer grain size of the sand, high percentage of clay in mold mixture, and excessive moisture present in the mold.

- Metal contains gas
- Mold is too hot
- Poor mold burnout

Shrinkage Cavities

These are caused by liquid shrinkage occurring during the solidification of the casting. To compensate for this, proper feeding of liquid metal is required. For this reason risers are placed at the appropriate places in the mold. Sprues may be too thin, too long or not attached in the proper location, causing shrinkage cavities. It is recommended to use thick sprues to avoid shrinkage cavities.

Molding Material Defects

The defects in this category are cuts and washes, metal penetration, fusion, and swell.

Cut and washes

These appear as rough spots and areas of excess metal, and are caused by erosion of molding sand by the flowing metal. This is caused by the molding sand not having enough strength and the molten metal flowing at high velocity. The former can be taken care of by the proper choice of molding sand and the latter can be overcome by the proper design of the gating system.

Metal penetration

When molten metal enters into the gaps between sand grains, the result is a rough casting surface. This occurs because the sand is coarse or no mold wash was applied on the surface of the mold. The coarser the sand grains more the metal penetration.

Fusion

This is caused by the fusion of the sand grains with the molten metal, giving a brittle, glassy appearance on the casting surface. The main reason for this is that the clay or the sand particles are of lower refractoriness or that the pouring temperature is too high.

Swell

Under the influence of metallostatic forces, the mold wall may move back causing a swell in the dimension of the casting. A proper ramming of the mold will correct this defect.

Inclusions

Particles of slag, refractory materials, sand or deoxidation products are trapped in the casting during pouring solidification. The provision of choke in the gating system and the pouring basin at the top of the mold can prevent this defect.

Pouring Metal Defects

The likely defects in this category are

- Mis-runs and
- Cold shuts.

A mis-run is caused when the metal is unable to fill the mold cavity completely and thus leaves unfilled cavities. A mis-run results when the metal is too cold to flow to the extremities of the mold cavity before freezing. Long, thin sections are subject to this defect and should be avoided in casting design.

A cold shut is caused when two streams while meeting in the mold cavity, do not fuse together properly thus forming a discontinuity in the casting. When the molten metal is poured into the mold cavity through more-than-one gate, multiple liquid fronts will have to flow together and become one solid. If the flowing metal fronts are too cool, they may not flow together, but will leave a seam in the part.

Such a seam is called a cold shut, and can be prevented by assuring sufficient superheat in the poured metal and thick enough walls in the casting design.

The mis-run and cold shut

defects are caused either by a lower fluidity of the mold or when the section thickness of the casting is very small. Fluidity can be improved by changing the composition of the metal and by increasing the pouring temperature of the metal.

Mold Shift

The mold shift defect occurs when cope and drag or molding boxes have not been properly aligned.

Casting Defects:

The defects in a casting may be due to pattern and moulding box equipment, moulding sand, cores, gating system or molten metal. Some of the defects are:

1: Mould shift

It results in a mismatching of the top and the bottom parts of the casting , usually at the parting line.

2: Swell

It is an enlargement of the mould cavity by molten metal pressure resulting in localized or general enlargement of the casting.

3: Fins and Flash

These are thin projections of the metal not intended as a part of casting. These usually occurs at the parting line of the mould.

4: Sand Wash

It usually occurs near the in the gates as rough lumps on the surface of a casting.

5: Shrinkage

It is a crack or breakage in the casting on the surface of the work piece, which results from un equal contraction of the metal during solidification.

6: Hot Tear

It is an internal or external ragged discontinuously in the metal casting resulting just after the metal has solidified.

7: Sand Blow or Blow Hole

It is smooth depression on the outer surface of the casting work piece.

8: Honeycombing or Slag holes

These are smooth depression on the upper surface of the casting. They usually occur near the ingates.

9: Scabs

These are patches of sand on the upper surface of the casting component.

10: Cold Shut and Misruns

These happens when the mould cavity is not completely filled by the molten and insufficient material or metal.

11: Run-outs and Bust-outs

These permit drainage of the metal from the cavity and result in incomplete casting.

What is the Cupola Furnace?

Cupola furnace is a melting device. We used this device in the forging operation where Cast Iron, Bronze, and other alloying elements are melted.

This is a very old device we used in manufacturing for melting because this system produces good cast iron from Pig Iron. The shape of this device is cylindrical but others size is also available.

While choosing a **cupola furnace** we keep some valid factors that are Melting Point Temperature, Shapes and many more.

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 Arreste

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:

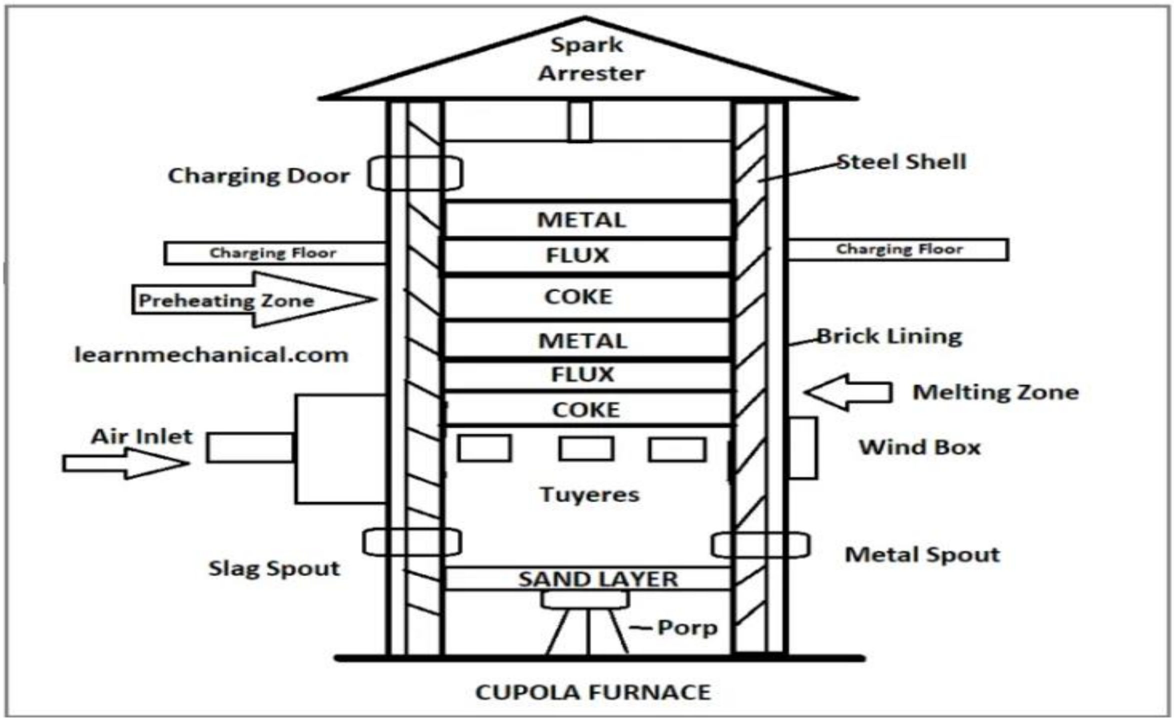
From here we supply the charge to the furnace. The various charges are for the cupola furnace are Pig Iron, Coke and limestone.

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.



Schematic Diagram of Cupola Furnace

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.

Usually, the first iron which comes out will be too cold to pour into sand molds. During the cupola operation, molten metal may be tracked every 10 minutes depending on the melting rate and the capacity.

All the oxygen in the air blast is consumed by the combustion, Within the combustion zone.

The chemical reaction takes place which is,

C + O2 (from the air) → CO2 + Heat

This is an exothermic reaction. The temperature in this zone varies from **1550 to 1850 degree Celsius**.

Then hot gases consisting principally of Nitrogen and carbon dioxide moved upward from the combustion zone, where the temperature is 1650 degree Celsius.

The portion of the coke bed if the combustion zone is reducing zone. It is a protective zone to prevent the oxidation of the metal charge above and while dropping through it. As the hot carbon dioxide gas moves upward through the hot coke, some of it is reduced by the following reaction.

3Fe + 2CO → Fe3C + CO2

This is an endothermic reaction.

The first layer of iron above the reducing zone is the melting zone where the solid iron is converted into the molten state. A significant portion of the carbon is picked up by the metal also takes place in this zone.

The hot gas is passed upward from the reducing and melting zones into the preheating zone which includes all layers of charge above the melting zone up to the charging Door.

Since the layer of the charge is preheated by the outgoing gases which exist at the top of the cylindrical shell. this temperature is this zone is around 1090 degrees Celsius.

Advantages of Cupola Furnace:

These are the following advantages of Cupola Furnace:

- A wide range of materials can be melt.
- This device used for removing the slag present in the Iron.
- Comparison of electric furnace This is very less harmful.
- This is having high melting heat I.e 100 tones/hr.
- The floor space required is less and to perform the operation skilled operator not required.

Disadvantages of Cupola Furnace:

There are some disadvantages of Cupola Furnace and here is that:

- In cupola furnace, The main disadvantage is that sometimes unable to main the close temperature.

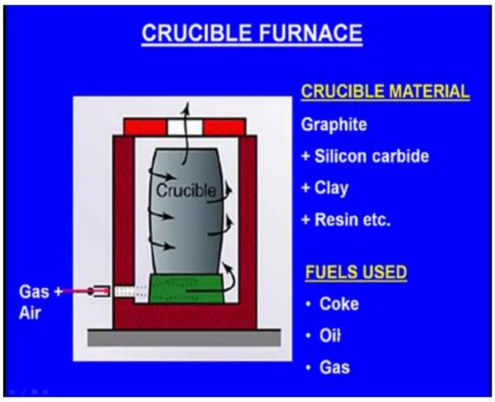
Applications of Cupola Furnace:

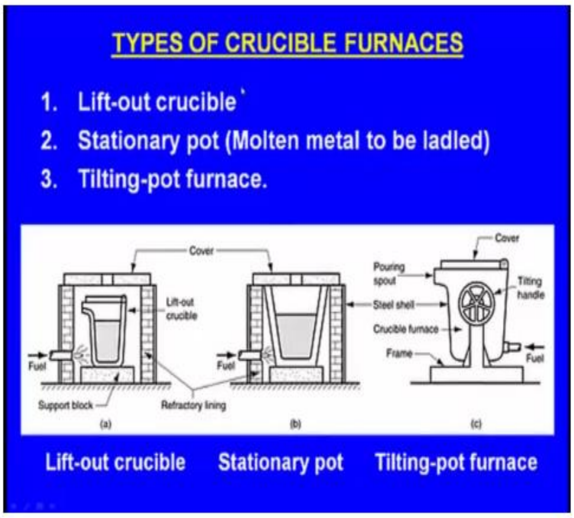
The **main application of Cupola Furnace** is different types of cast iron is produced from this device like Malleable, Grey cast iron, and the copper base alloy is also manufactured by this device.

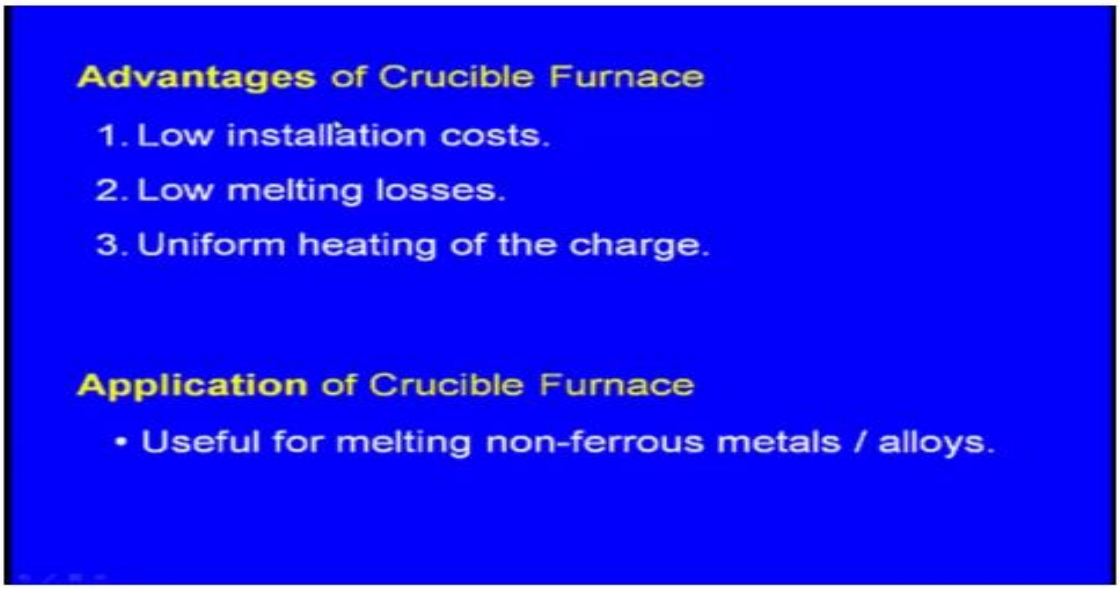
Crucible furnace construction and working

Crucible furnaces are one of the oldest and simplest types of melting furnace unit used in the foundry. The furnaces uses a refractory crucible which contains the metal charge. The charge is heated via conduction of heat through the walls of the crucible. The heating fuel is typically coke, oil, gas or electricity.

Now crucible furnace is the most simple furnace, there is a crucible we can see here inside this is the crucible. It is made up of graphite, plus silicon carbide, plus clay, plus resin, and some more binders will be there it say simple furnace. Now the fuel used in the crucible furnaces is it can most commonly it is the coke or oil and sometimes even gas is used. Now here we can see crucible is kept here, gas and mixture of gas and air will be passing here inside it will be burning and the charge will be kept inside the crucible after some time the charge will be melting and the molten metal is ready for tapping.







CHAPTER-4

POWDER METALLURGY

What is Powder Metallurgy?

Powder metallurgy is a manufacturing process that produces precision and highly accurate parts by pressing powdered metals and alloys into a rigid die under extreme pressure. With the development and implementation of technological advances, powder metallurgy has become the essential process for the production of bushings, bearings, gears, and an assortment of structural parts.

The key to the accuracy and success of powder metallurgy is the sintering process that heats parts to bond the powder particles. The temperature in sintering is slightly below the melting point of the primary metal such that the bonds of the powdered particles are bound together.

The Powder Metallurgy Process

The process of powder metallurgy is an ancient, unique method for forming shapes and designs from ferrous and non-ferrous metals. Powder metallurgy has been used for thousands of years as a way to produce household items and tools. It began as a method for mass producing products and parts in the middle of the first industrial revolution.

Until the early part of the 20th Century, the process was used sporadically but was not considered to be a viable production method. With the development of electricity and technological advances, powder metallurgy has found a place as a highly efficient and productive method for producing parts with high tolerances and minimal waste.

The four basic steps to the powder metallurgy process are powder preparation, mixing and blending, compacting, and sintering. These steps have been used over the centuries to produce a variety of products.

As with any manufacturing process, powder metallurgy has variations to accommodate the requirements of individual parts. The different methods and techniques have grown from the development of technological advances and engineering specifications. Four of the variations are conventional, injection molding, isostatic pressing, and metal additive manufacturing, which is the newest advancement.

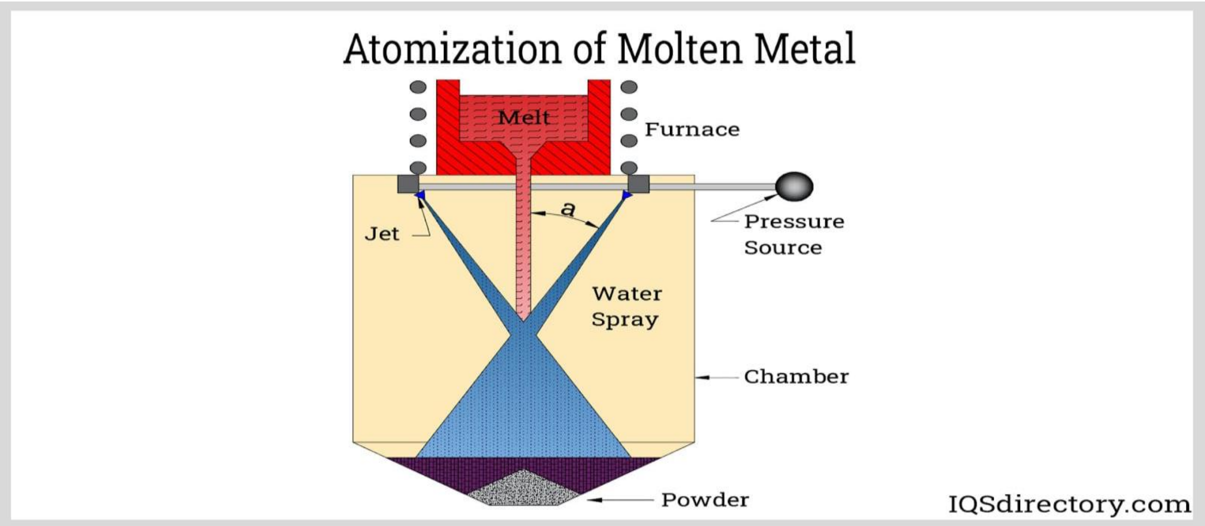
Four Basic Steps of Powder Metallurgy

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.

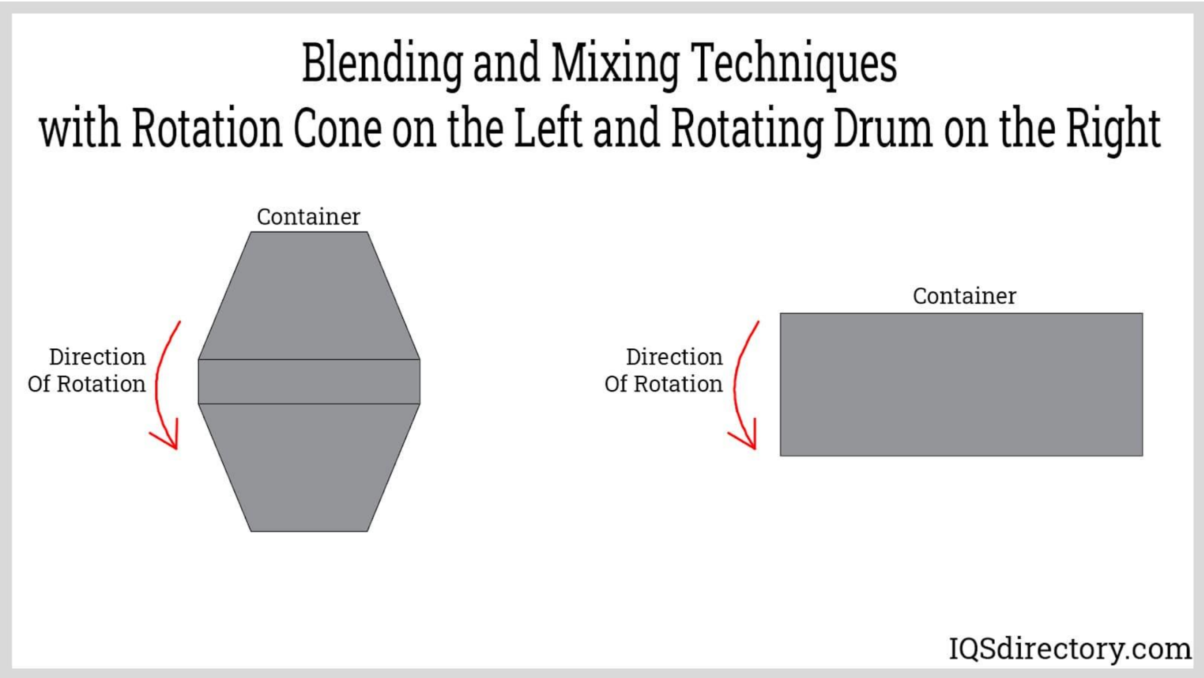
Prior to mixing and blending the powder, it is evaluated and tested for its appropriateness for the powder metallurgy process. The factors that are considered are flow rate, density, compressibility, and strength.



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. The image below shows a rotating double cone and rotating drum with three examples of blended powder below.

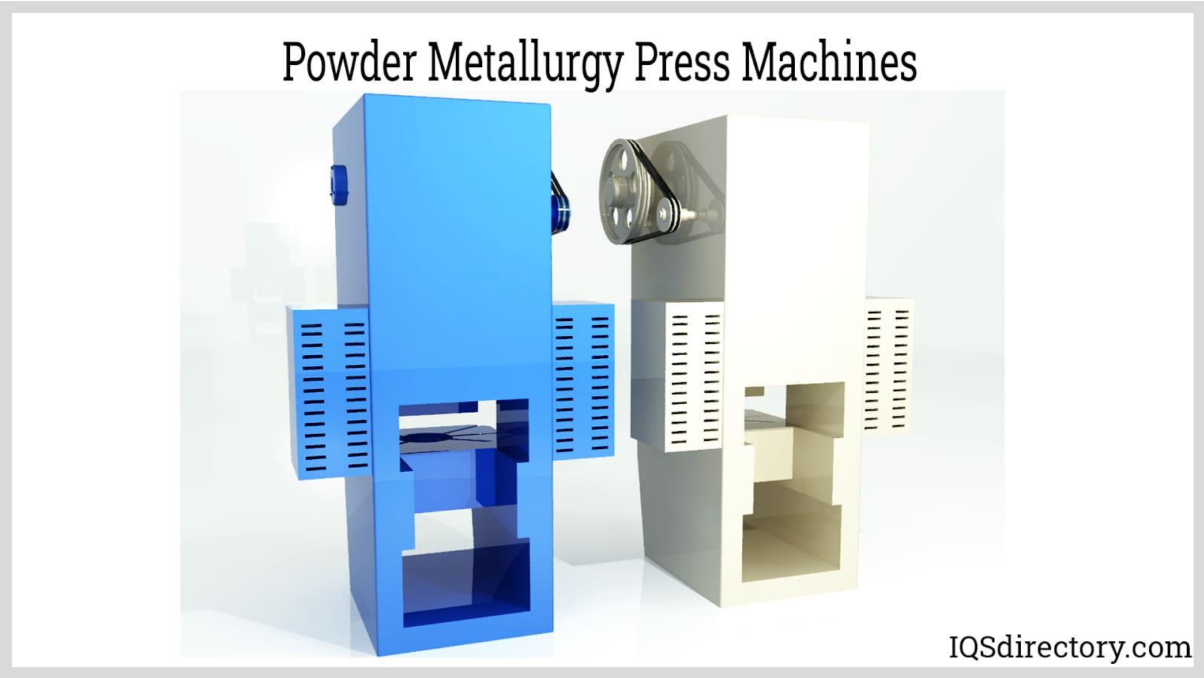


Compacting

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.

Compacting pressure is between 80 MPa and 1600 MPa. Each type of metal powder requires a different amount of compacting pressure depending on its properties.

In soft powder compacting, the pressure is between 100 MPa and 350 MPa. For more resilient and harder metals, such as steel and iron, the pressure is between 400 MPa and 700 MPa.



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. The atmosphere of the sintering is controlled such that it has a sufficient amount of carbon to produce a neutral or carburizing environment, which determines the properties of the sintered materials.

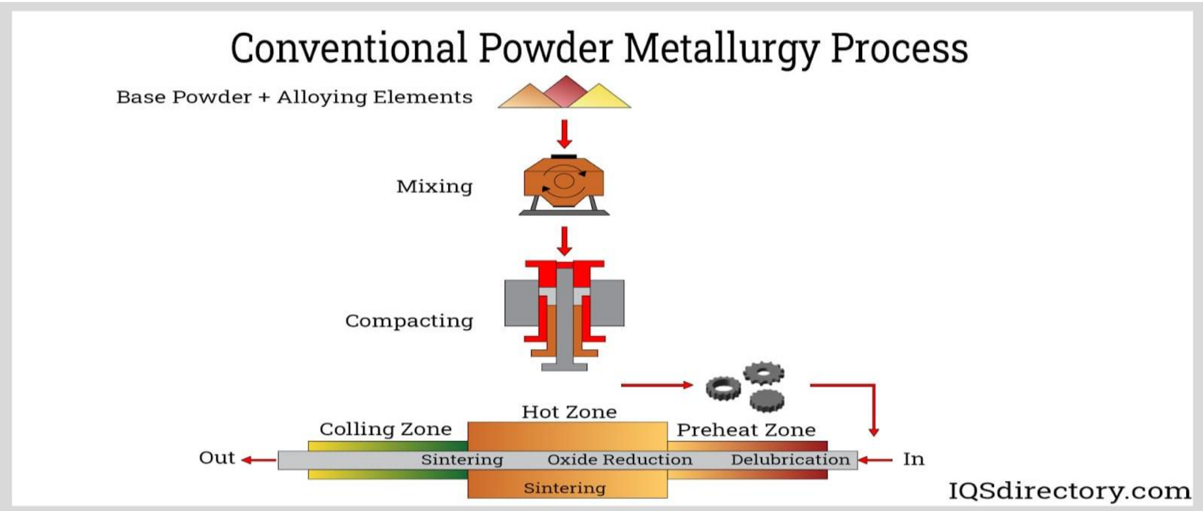
Sintering is a heat treatment wherein large numbers of parts, in compacted form, are subjected to temperatures that are sufficient to cause the loose particles to unite and bond, forming a solid piece. The required temperature fluctuates in accordance with the type of metal but is always slightly lower than the metal's melting temperature.

Compacting presses the particles of the green compact to form a shape. Regardless of the pressure applied during compacting, there are still minute porous spaces in the green compact. During sintering, the material is heated at high temperatures to close the porous spaces and strengthen the part.

Powder Metallurgy Processes

Conventional

Conventional powder metallurgy follows each of the steps of basic powder metallurgy where the powder and alloy are mixed, compacted, and sintered. It is much like the ancient method of powder metallurgy with the added benefit of modern technology.



ADVANTAGE OF POWDER METALLURGY

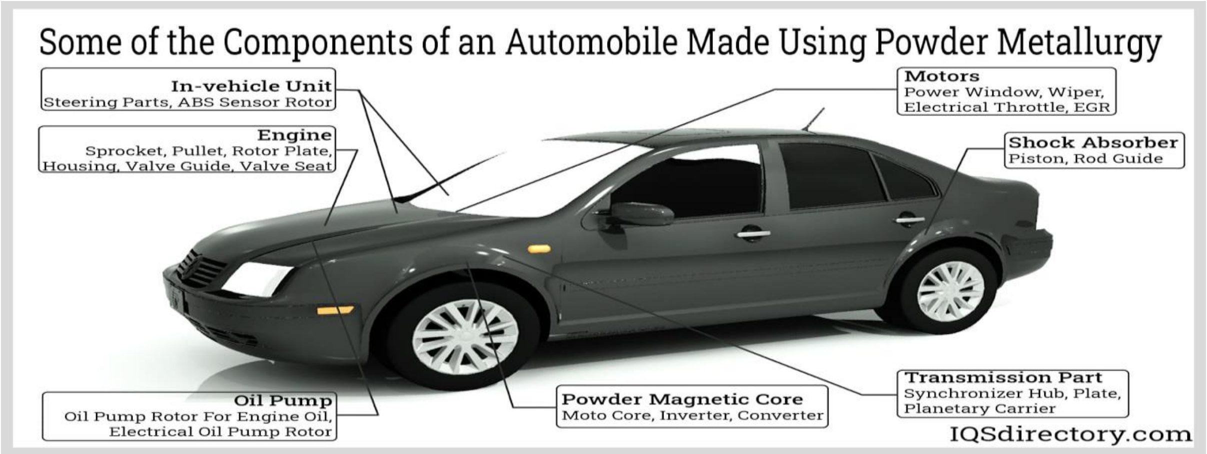
• Parts with closed dimensional tolerance (nearest shape) and good surface finish can be produced.
• It eliminates or minimizes scrap losses by more than 97% of the raw material in the finished part, unlike other process.
• Process can be fully automated hence unskilled labour can be employed which reduces labour cost.
• It eliminates or minimizes machining.

• It facilitates manufacture of certain parts by mixing different metals, metals and non metals, metals and ceramics etc to obtain desired properties which is impossible with other working processes.
• High production rates from 500-1000 parts/hour can be achieved.

• It facilitates manufactures of small and unique shape part which cannot be produce by any other manufacturing process
.
• Detect free component with uniform structure can produce.
• Non equilibrium composition possible e.g. cr. alloys.

LIMITATIONS OF POWDER METALLURGY

• The cost of material in powder form is quite high this cost is offset for Large volume production by absence of scrap and low labour cost.
• Products with intricate design are difficult to produce as there is little flow of metal powder during compaction.
• The residual porosity left in sintered parts makes then rough.
• This process is economically feasible for Large volume production due to high cost of dies and equipments.
• Producing parts of Large size and weight is quite expensive due to costly dies.
• It is difficult to compress some metal powders and also difficult to procure some metal powders.
• The density of compact is not uniform throughout.
• Some e.g. zr present explosion hazard.
• Parts produce by powder metallurgy have low impact and fatigue strength as compared to other method.
• Healt problems from atmospheric contamination of the work place.



Advantages

- Metal powders are high-purity materials.
- Close dimensional tolerances can be maintained.
- High-volume process with excellent reproducibility.
- Quality control is inherent in the process.
- Low labor input.
- Machining is eliminated or reduced.
- Scrap losses are eliminated or reduced.
- Segregation is avoided.
- Controllable porosity and density can be precisely controlled.
- Combines immiscible metals.
- Complex shapes can be produced.

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.

First go through it, so that you can understand the current topic must effectively. Around 10 Press Working Operations or Sheet Metal Operations can be performed on the sheet and they are as follows.

1. Punching
2. Blanking
3. Deep drawing
4. Bending
5. Notching
6. Perforating
7. Trimming
8. Shaving
9. Slitting

Press Working Operations or Sheet Metal Operations:

By physical removal of the material from the sheet, if the required shape of the component is obtained called as Cutting or Shearing operation.

Here, **Punching** operation and **Blanking** operation comes under Cutting or Shearing Operations whereas **Deep drawing** and **bending** operations come under Forming Operations.

Cutting Operations:

The cutting operations which come under Sheet Metal Operations are

- Punching Operation
- Blanking Operation

For both punching and blanking operations, the punch and die combination will be used as tools.

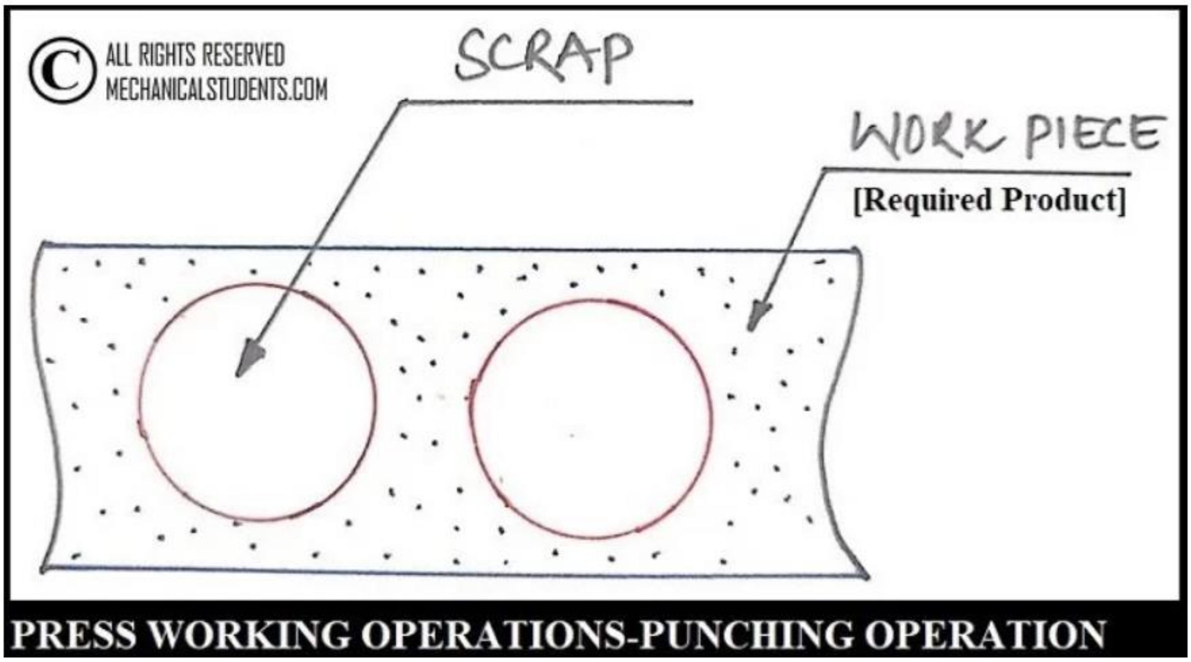
1 Punching Operation:

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.

To ensure that the cutting or shearing action is taking place on the sheet, the Punch size is always less than the Die size.

In punching operation, the punch size is made equal to hole size and clearance is provided on the die and also in punching operation, the shear is provided only on the Punch.



Note:

- Punch Size < Die Size(Basic Requirement)
- Punch Size = Hole Size. (Needed)
- Clearance → Die.
- Shear → Punch.

2 Blanking Operation:

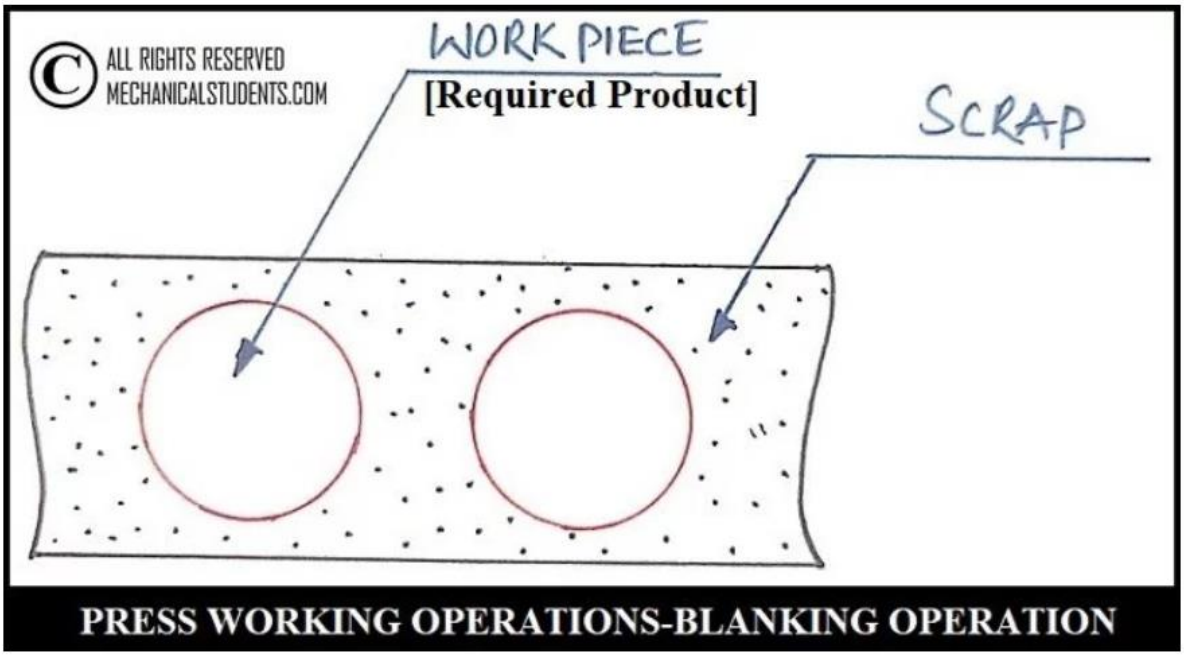
When the force is applied by using the punch on to the sheet, the cutting or shearing action will be taking place in the sheet producing a piece/blank.

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.

Note:

- Die Size = blank Size.
- Clearance → Punch.
- Shear → Die.



Application of Punching and Blanking Operations:

Punching Applications: Electronic Boards, Printed Circuit Boards, etc.

Blanking Operations: Coins etc.

Other Applications:

- Automobile industries.
- Kitchen appliances.

- Aerospace industries.
- Mass production of sheet metal components.
- What is die in manufacturing?

Dies is a machine tool used in many manufacturing industries to cut metal in the desired shape or for cutting threads on the outside surface on pipe, round rods, etc. Threads of proper size are cut in the dies which are chamfered from one side up to a certain length which facilitates to start of a thread.

The purpose of using die stock is because it is operated by hand. These are made of high carbon steel, high-speed steel, and alloy steel. These are made of circular and square shapes.

Generally dies are classified according to their use like stamping dies are used in press working, casting dies used in molding processes, and drawing dies are used in the manufacture of wires.

Types of Dies

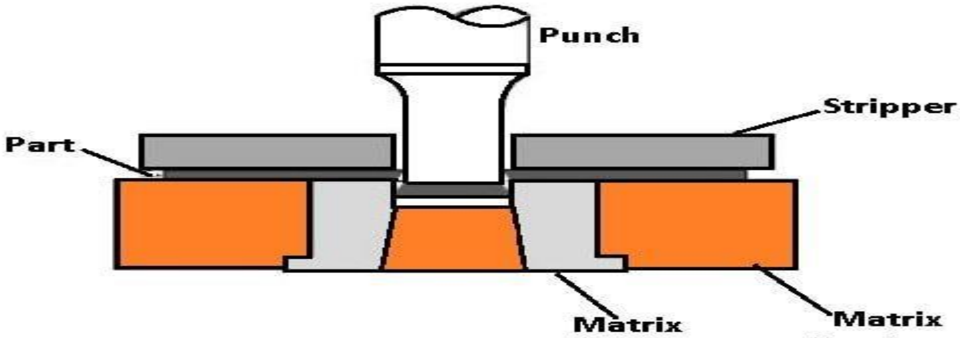
For different purposes, mainly the following **types of dies** are used:

1. Simple die
2. Compound Die
3. Progressive die
4. Combination die

1 Simple Die:

Simple die or single operation die designed to perform only a single operation of each stroke of the press slide. Simple die can be further classified according to the functions such as cutting and forming.

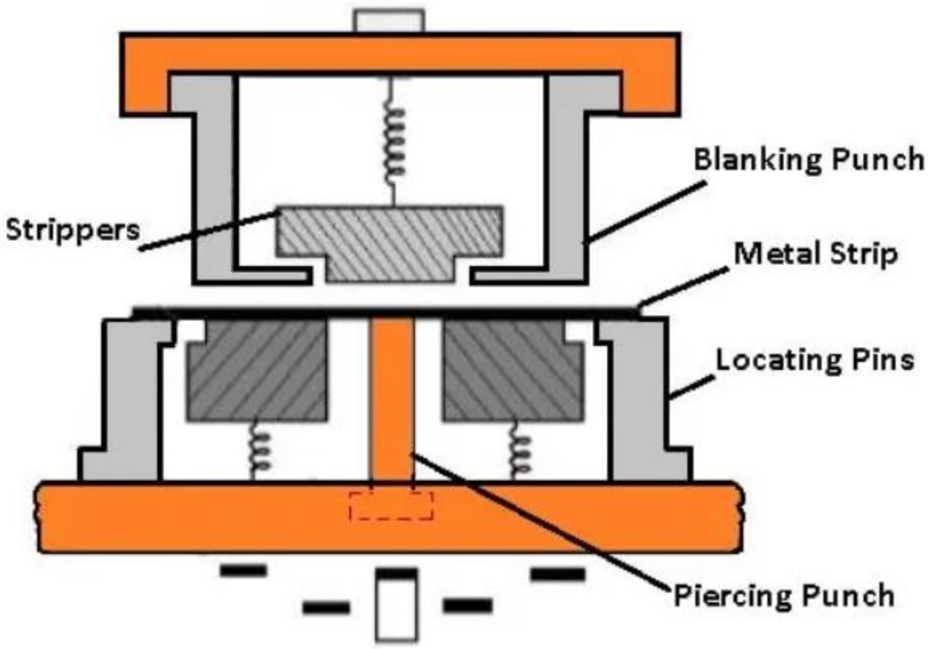
Cutting dies are used in operations like trimming, notching, blanking and more. The forming die used in bending, and curling etc.



Simple Die

2 Compound Die:

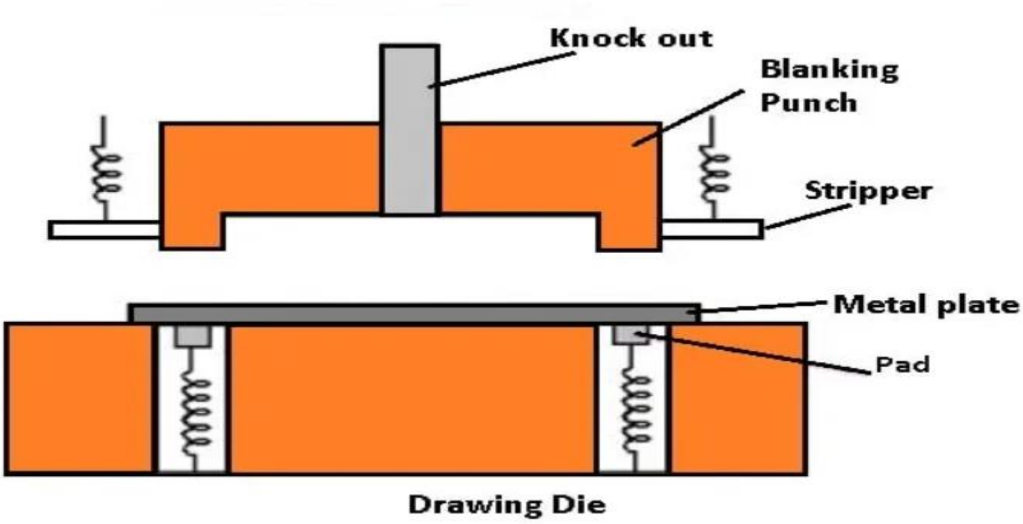
A compound die performs multiple operations like cut or punch can be done in one stroke. For example, it can perform cutting and forming operations simultaneously in one stroke. This very effective method for high-volume parts. Compound dies are used to stamp simple flat parts like washers.



Compound Die

The compound die is shown in the figure. It has a spring and punches at both ends. The upper part of the punch is connected to the ram and comes in contact between metal and pierce the hole. As punch moves downward the spring compresses after a certain range and the lower punch moves upward and cuts the hole.

3 Combination Die:



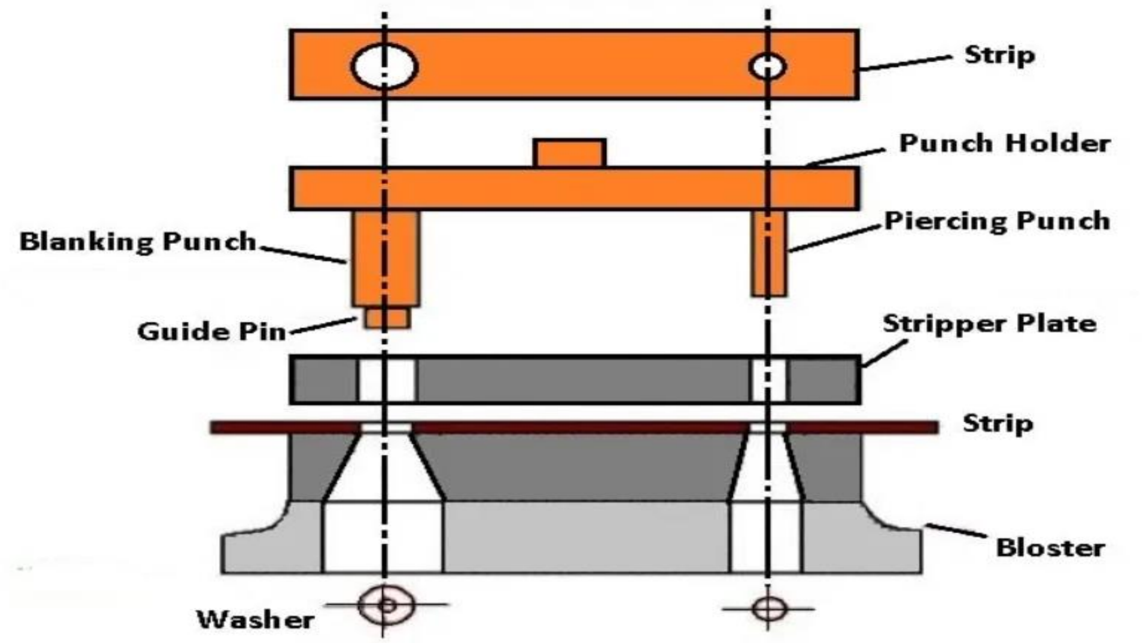
Combination Die

The diagram of the combination die is shown in the figure. In this type of dies, the cutting and bending operations are combined and carried out in a single operation. The cutting operation may include trimming, piercing, and blanking and is combined with noncutting operations like bending forming, etc.

4 Progressive Die:

Progressive die widely used in producing various industries parts, such as automotive and electronic. This type of die stamping consists of several individual workstations, each of which performs one or more different operations on the part. The work or part is transferred from station to station by the stock strip and is cut out of the strip in the final operation.

The progressive die has many unique benefits including a high-speed production rate with low labor cost, the minimum amount of scrape, and this dies required only one setup to work.



Progressive Die

Method of Using Die:

1. Before cutting outer threads, the end of the pipe or rod should be chamfered with a grinder or a file.
2. For cutting threads on a pipe, rod, or any other job, it should be firmly held in a vice.
3. Keep on moving the die forward and backward.
4. Equal pressure should be exerted on the die handle.
5. Jobs of large diameter, threads should be cut after adjusting two-three cuts.
6. Proper lubrication should be used while cutting threads.
7. After cutting the threads, it should be checked with a nut or ring gauge.
8. After using the drill. It should be properly cleaned and replaced in its proper place.

Benefits of Progressive Die Stamping

Progressive die stamping saves time and money by performing multiple operations simultaneously. Some of the notable advantages of progressive die stamping are that it has:

- Less setup time
- Low labour costs
- Minimal scrap
- Suitable for metal parts of complex geometries.
- Can produce large quantities of small parts with tight tolerances in a short period.

Disadvantages of Progressive Dies

- High setup costs, but these produce precise products in large quantities.
- Only mass-produced products are cost-effective.
- Not recommended for Large-sized components.

To summarise, progressive die stamping can quickly, affordably, and consistently produce parts with complex geometries. Progressive die stamping, however, necessitates the purchase of permanent steel tooling.

As the base material for progressive die stamping, manufacturers have the liberty to use a variety of metals such as steel, aluminium, copper, stainless steel, and brass

Benefits of Compound Die Stamping:

- Tooling that is less expensive than progressive die tooling
- Production of simple and small parts is quick and efficient.
- High repeatability of single-die cases.
- One stroke result in flatter parts.

Disadvantages of Compound Dies:

- Not suitable for metal geometries with medium to high complexity.

CHAPTER-6

JIG & FIXTURES

Jigs and Fixtures

jigs and fixtures are the devices which help in increasing the rate of identical parts and reducing the human efforts required for producing these parts, It has already been emphasized earlier that a center lathe is a suitable machine tool for producing individual parts of different shapes and sizes, but for producing similar articles in great number its use will not be economical.

Against this, a capstan and turret lathe can be easily adapted for repetition work on account of the multi-cooling arrangement and use of transverse stop this increases the rate of production.

However, every type of object cannot be machined on a capstan or turret lathe and may involve the use of drilling, milling, planning and grinding machines, etc. If such objects are to be produced in identical shapes and sizes on a mass scale, suitable devices have to be used for holding and locating purposes so that the repetition work can be done. These devices are the jigs and fixtures.

What is Jig?

A jig may be defined as a device which holds and located a workpiece and guides and controls one or more cutting tools. The holding of the work and guiding of the tool is such that they are located in true positions relative to each other.

In construction, a jig comprises a plate, a structure, or box made of metal or in some cases of non-metal having provisions for handling the components in identical positions one after the other, and then guiding the tool incorrect positions on the work in accordance with the drawing, specification, or operation layout.

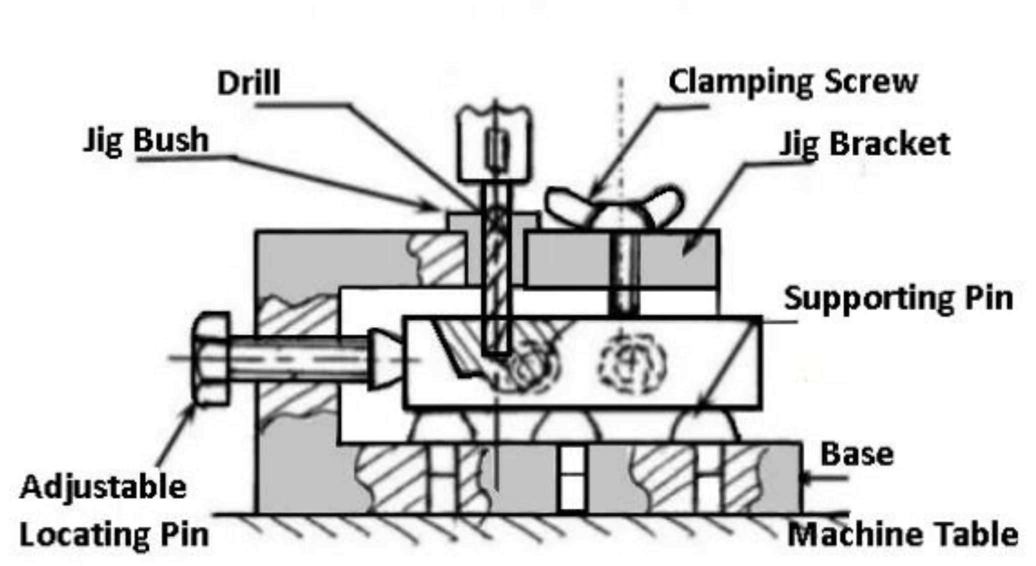
What is a Fixture?

A fixture is a device which holds and locates a workpiece during an inspection or for a manufacturing operation. The fixture does not guide the tool.

In construction, the fixture comprises a different standard or specially designed work holding the device, which is clamped on the machine able to hold the work in the position. The tools are set at the required positions on the work by using gauges or by manual adjustment.

The main elements of jigs and fixtures

Main elements of jigs and fixtures are:



Elements of Jigs and Fixtures

Body: It is a plate, box or frame type structure in which the components to be machined are located. It should be quite sturdy and rigid.

Locating elements: These elements locate the workpiece in a proper position in relation to the cutting tool.

Clamping elements: These elements firmly secure the workpiece in the located position.

Grinding and setting elements: These elements guide the cutting tool in case of jig and help in proper tool acting in case of the fixture.

Positioning elements: These elements include different types of fastening devices, which are used in securing the jig or fixture to the machine at the proper position.

Indexing elements: They are not provided always. But, many workpieces may have to be indexed to different positions in order to perform machining operations on different surfaces or different locations. In such cases, these elements will have to be incorporated in the jig or fixture.

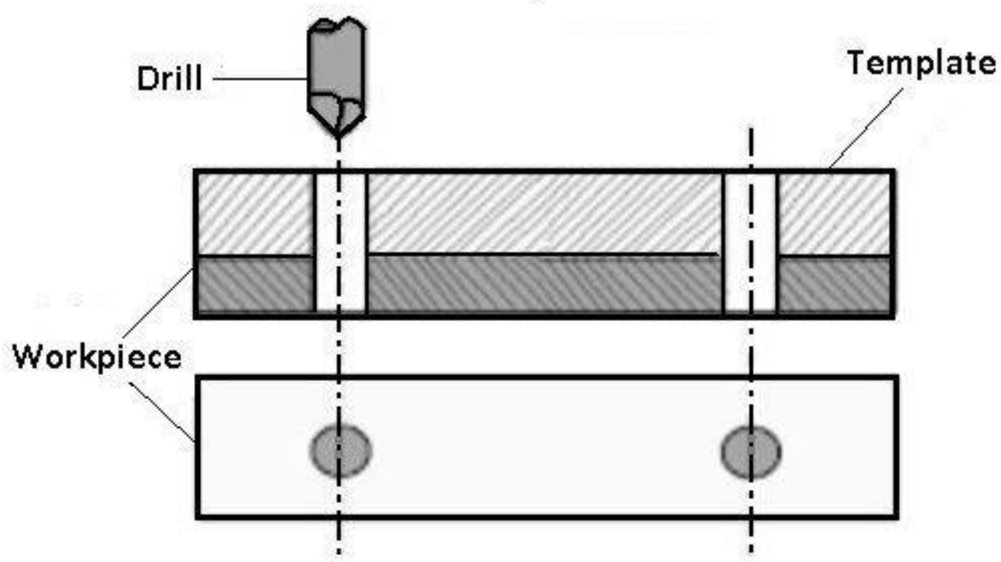
Types of Jigs and Fixtures:

Types of Jigs

Following are the seven different types of jigs.

1. Template jig
2. Plate jig
3. channel jig
4. Diameter jig
5. Leaf jig
6. Ring jig
7. Box jig

Template Jig



TEMPLATE JIG

The template jig is the simplest of all the types. A plate 2 having holes at the desired positions serves as a which is fixed on component 1 to be drilled. The drill 21 is guided through these holes of the template 2 and the required holes are drilled on the workpiece at the same relative positions with each other as on the template. A template jig is shown in the figure.

Plate Jig

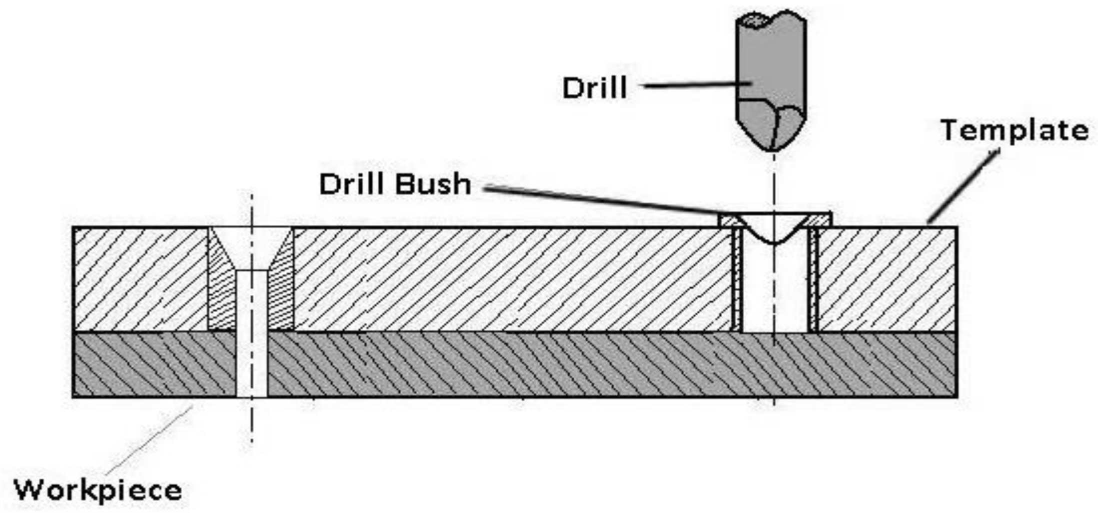
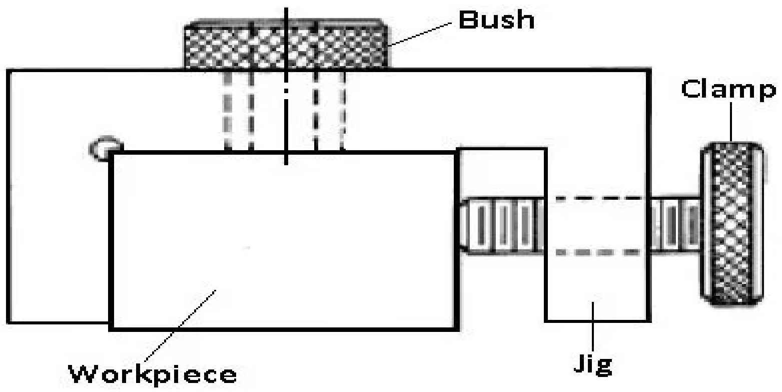


PLATE JIG

1. A fixture holds and positions the work but does not guide the tool. Whereas a jig holds, locates and as well as guides the tool.
2. The fixtures are heavier in construction and are bolted rigidly on the machine table. Whereas the jigs are made lighter for quicker handling, and clamping with the table is often unnecessary.
3. The fixtures are employed for handling work in milling, grinding, planing, or turning operations. Whereas the jigs are used for holding work and guiding the tool particularly in drilling, reaming or tapping operations.

A plate jig is an improvement of the template jig by incorporating drill bushes on the template. The plate jig is employed to drill holes on large parts maintaining accurate spacing with each other. A plate jig is shown in the above fig.

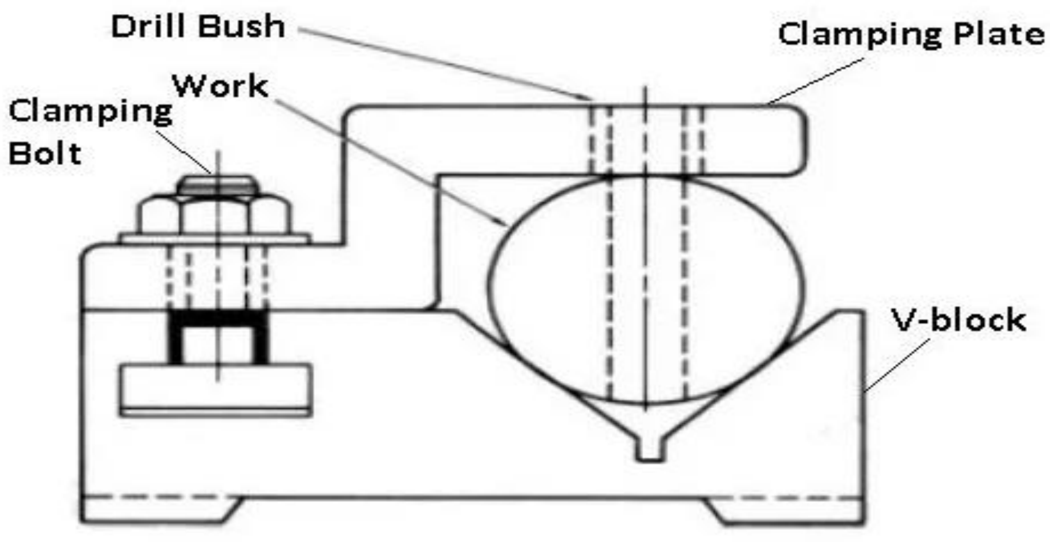
Channel Jig



CHANNEL JIG

The channel jig is illustrated in the fig. It is a simple type of jig having a channel-like cross-section. The component 1 is fitted within the channel 4 and is located and clamped by rotating the knurled knob 5. The tool is guided through the drill bush 3.

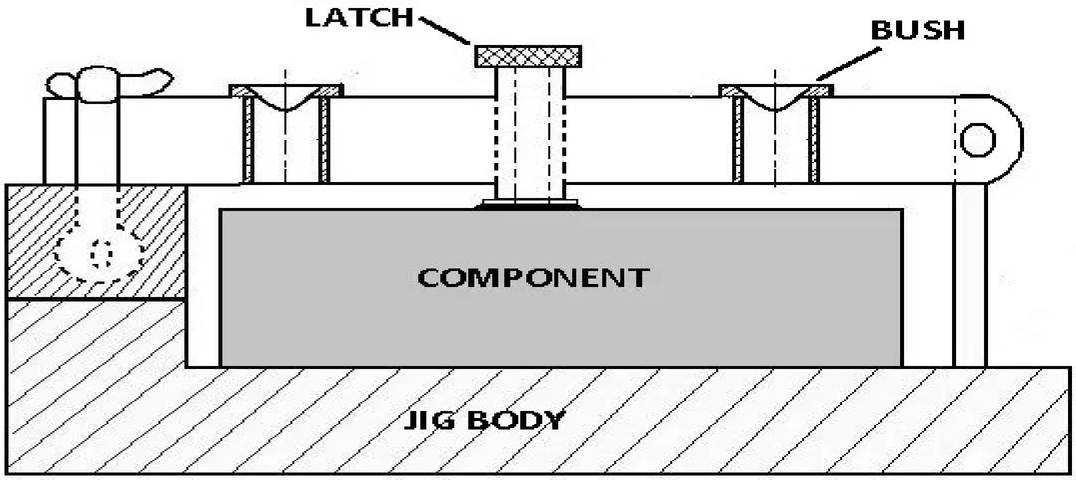
Diameter Jig



DIAMETER JIG

The diameter jig is shown in fig. It is used to drill radial holes on a cylindrical or spherical workpiece. The work 1 is placed on the fixed V-block 6 and then clamped by the clamping plate 7 which is also locate the work. The tool is guided through the drill bush 8 which is set radially with the work.

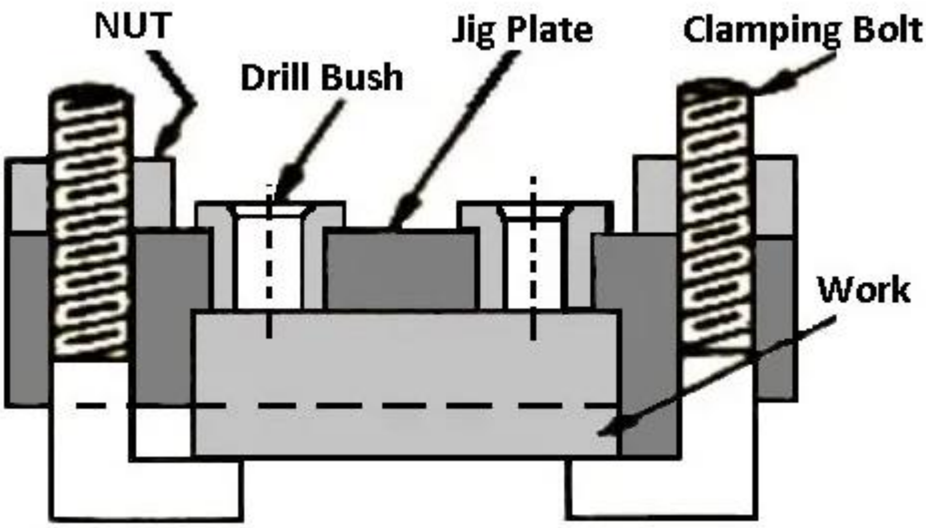
Leaf Jig



LEAF JIG

The leaf jig is illustrated in the above figure. It has a leaf or a plate 13 hinged on the body at 11 and the leaf may be swung open or closed on the work for loading or loading purposes. The work 1 is located by the buttons 10 and is clamped by set screws 12. The drill bush 3 guides the tool.

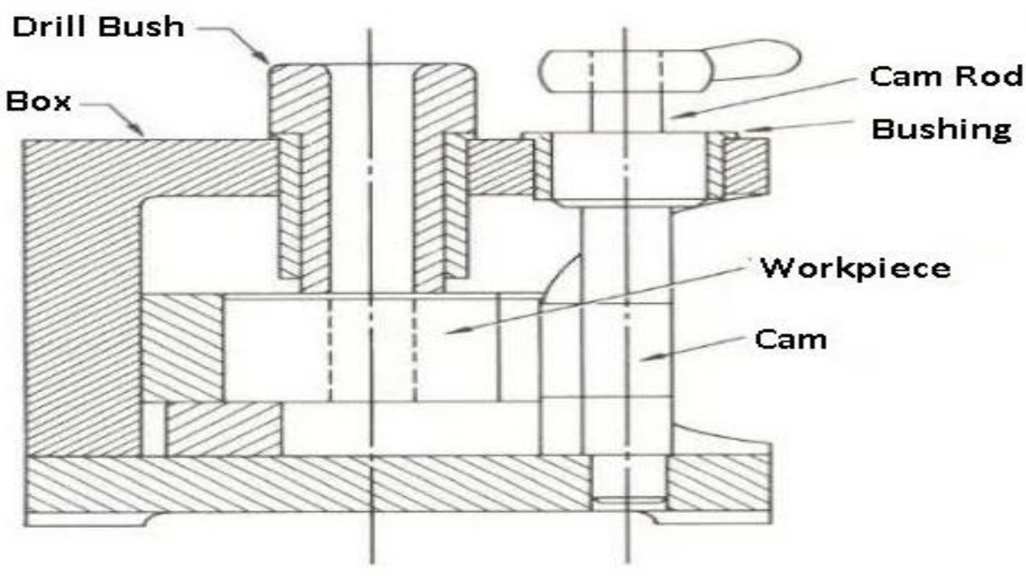
Ring Jig



Ring Jig

The ring jig is shown in the above figure. It is employed to drill holes on circular flanged parts. The work is securely clamped on the drill body and the holes are drilled by guiding the tool through drill bushes.

Box Jig



BOX JIG

The box jig is illustrated in the above figure. It is of box-like construction within which the component is located by the buttons 18. The work 1 is clamped by rotating the cam handle 19 which also locates it. The drill bush 3 guides the tool. The box jigs are generally employed to drill a number of holes on a component from different angles.

Types of Fixtures

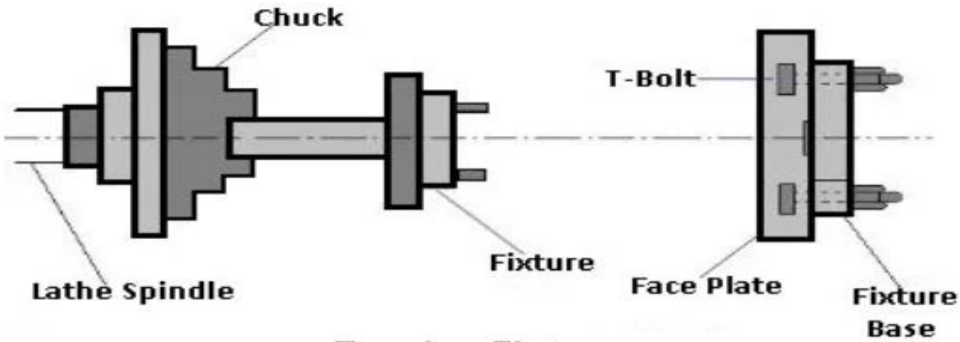
Following are the 10 different types of fixtures:

1. Turning fixtures.
2. Milling fixtures.
3. Broaching fixtures.
4. Grinding fixtures.
5. Boring fixtures.
6. Indexing fixtures.
7. Tapping fixtures.
8. Duplex fixtures.
9. Welding fixtures.
10. Assembly fixtures.

Fixtures are usually named after the type of machining operation for which they are designed and employed.

Turning fixtures

It is quite easy-to-hold regular workpieces on lathes in standard job holding devices like chucks and collects, between the centre and on mandrels or faceplates. But irregularly shaped components offer a lot of difficulties in holding them correctly.

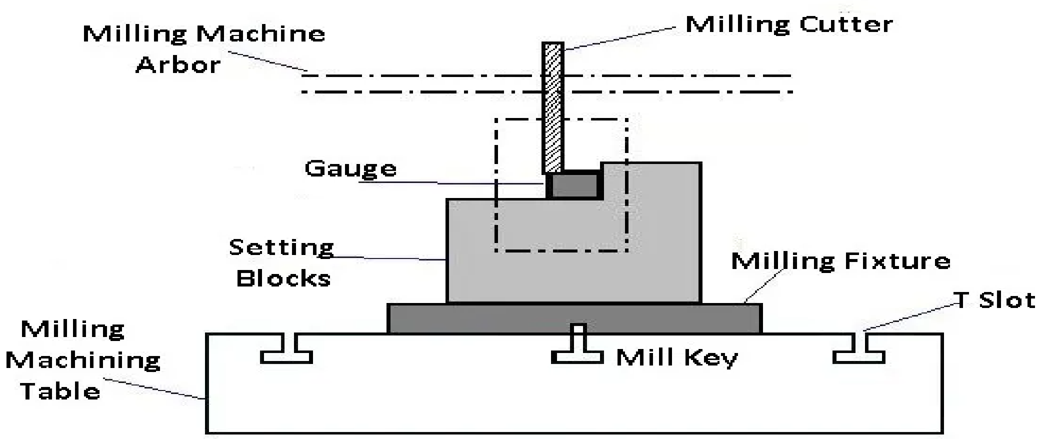


Turning Fixture

Simple odd shaped jobs can be held in chuck also, say by proper adjustment of jaws in a four-jaw chuck or by using shaped soft jaws. However, workpieces having complicated shaped have to be necessarily held in position with the help of turning fixtures. These fixtures are normally mounted on the nose of the machine spindle or on a faceplate and the workpieces held them.

Milling fixtures

These fixtures are used on milling for carrying out different milling operations on workpieces. The fixture is properly located on the table of the machine and secured in position by means of bolts and nuts.

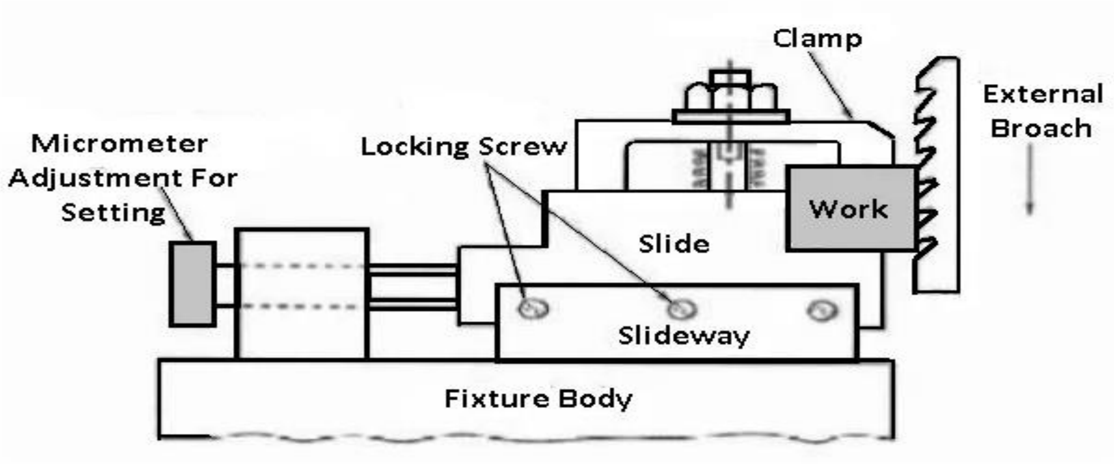


Milling Fixture

The table is shifted and set in the proper position, in relation to the cutter. The workpieces are located no the base of the fixture and clamped before starting the operation.

Since the cutting forces involved are quite high, and also intermittent, the clamping elements. Proper locating of the fixture on the machine table is usually achieved with the help of two tenons provided under the fixture base. These tenons enter a T-slot of the table to provide the required location. The fixture base can then be secured to the table by means of T-bolts and nuts.

Broaching Fixtures

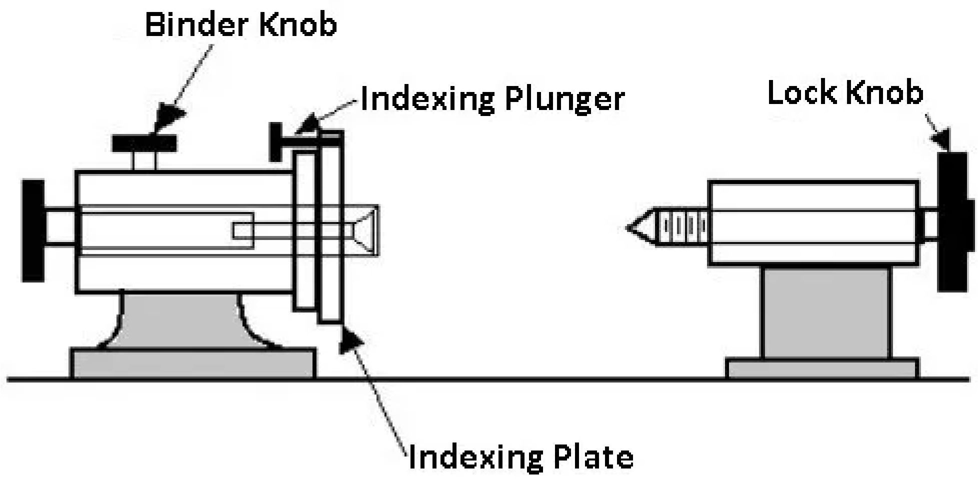


Broaching Fixture

These fixtures are used on different types of broaching machines to locate, hold, and support the workpieces during the operations, such as keyway broaching operations, such as keyway broaching, hole broaching, etc. The use of a clamping plate as a fixture for internal pull-type hole broaching.

Indexing Fixture

Several components need machining on the different surface such that their machined surface surfaces or forms are evenly spaced



Indexing Fixture

Such components are required to be indexed equally as many as the number of surfaces to be machined. Obviously, the holding devices (jigs or fixtures) used are made to carry a suitable indexing mechanism. A fixture carrying such a device is known as an indexing fixture.

Difference between Jigs and Fixtures

The following are the fundamental difference between a fixture with a jig:

1. A fixture holds and position the work but does not guide the tool, whereas a jig holds, locates and as well as guide the tool.
2. The fixtures are heavier in construction and are bolted rigidly on the machine table, whereas the jigs are made lighter for quicker handling and clamping with the table is often unnecessary.
3. The fixtures are employed for holding work in milling, grinding, planing or turning operations, whereas the jigs are used for holding the work and guiding the tool, particularly in drilling reaming or tapping operations.

Advantages of using jigs and fixtures in mass production work.

The following are the advantages of jigs and fixtures in mass production work.

1. Eliminates the making out, measuring, and other setting methods before machining.

2. It increases the machining accuracy because the workpiece is automatically located and the tool is guided without making any manual adjustment.
3. It enables the production of identical parts which are interchangeable. This facilitates the assembly operation.
4. It increases the production capacity by enabling a number of workpieces to be machined in the single set up, and in some cases, a number of tools may be made to operate simultaneously. The handling time is also greatly reduced due to the quick setting and locating of the work. The speed, feed and depth of cut for machining can be increased due to high clamping rigidity of jigs and fixtures.
5. It reduces the operator's labour and consequent fatigue as the handling operations are minimised and simplified.
6. It enables a semi-skilled operator to perform the operations as the setting operation of the tool and the work is mechanised. This saves labour costs.
7. It reduces the expenditure on the quality control of the finish products.
8. It reduces the overall cost of machining by fully or partly automating the processes.

Advantages of Jigs and Fixtures

The advantages of jigs and fixtures are:

1. Increases the machining accuracy because the workpiece is automatically located and the tool is guided without making any manual adjustment.
2. It increases the production capacity by enabling a number of workpieces to be machined in the single set up and in some cases, a number of tools may be made to operate simultaneously.
3. The handling time is also greatly reduced due to the quick setting and locating of the work.
4. The speed, feed and depth of cut for machining can be increased due to high clamping rigidity of jigs and fixtures.
5. Enables the production of identical parts which are interchangeable. This facilitates the assembly operation.
6. It eliminates the marking out, measuring and other setting methods before machining.
7. These devices reduce the operator's labour and consequent fatigue handling operations, are minimized and simplified.
8. It reaches the semi-skilled operator to perform the operation as the setting operations of the tool and the work are mechanized. This saves labour cost.
9. It reduces the expenditure on the quality control of the finished products.

10. Reduces the overall cost of machining by fully or partly automizing the processes.

Applications of Jigs and Fixtures

Applications of jigs are:

- Drilling
- Reaming
- Tapping

Applications of fixtures are:

- Milling
- Grinding
- Planing
- Turning
- Shaping

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