LECTURE NOTES ON

PRODUCTION TECHNOLOGY

DIPLOMA-3RD SEM

NAME-MANAS RANJAN SAHU

BRANCH-MECHANICAL

GIACR RAYAGADA

1.0-METAL FORMING PROCESS

Metal forming processes are used to produce structural parts and components that have widespread applications in many industries including automobile, aerospace, appliances. Metal forming processes include a wide range of operations which deform sheet or tube metal to form the component with the desired geometry. Deep drawing is one of the most popular metal forming processes used to produce a cup like cylindrical component by radially drawing metal blank into the die cavity with the help of a punch. The cup shaped part thus produced has the depth greater than half of its diameter. The change in cross-section is achieved by plastic deformation of the initial blank. Commercial applications of this metal shaping process often involve complex geometries with straight sides and radii. In such a case, the term stamping is used in order to distinguish between the deep drawing (radial tension-tangential compression) and stretch-and-bend (along the straight sides) components.
Hydroforming is a forming technology for semi-finished goods like: tubes and sheets that aims to produce relatively small quantities of drawn parts or parts with asymmetrical or irregular contours that do not lend themselves to stamping. By hydroforming, high strength parts and to manufacture complex geometries can be obtained in one step. Even the material straining caused by fluid pressure leads to a uniform rise in yield strength in the used materials, resulting in a lower need necessary for high wall thicknesses. Hydroforming allows to overcome some of the limitations of conventional deep drawing increasing the drawing ratio and minimizing the thickness reduction of the formed parts. Some of the advantages introduced by hydroforming are: a greater flexibility and a remarkable reduction of tooling costs. Tube hydroforming is an unconventional metal forming process that uses the internal hydraulic pressure and tube end axial load to avoid rupture of the blank. Tube hydroforming is one of the most popular unconventional metal forming processes which is widely used to form various tubular components. By this process, tubes are formed into different shapes using internal pressure and axial compressive loads simultaneously to force a tubular blank to conform to the shape of a given die cavity.
In metal forming analysis, a large number of process and geometrical parameters need to be optimized in order to promote the industrial performance measures such as productivity and cost by improving formability, reducing tool wear and reducing scrap percentage. Examples of the studied parameters are the blank shape, sheet dimensions, blank holding force or pressure, feed, lubrication and punch/die design need to be controlled and optimized.

EXTRUSION PROCESS- Extrusion is a metal forming process in which metal or work piece is forced to flow through a die to reduce its cross section or convert it into desire shape. This process is extensively used in pipes and steel rods manufacturing. The force used to extrude the work piece is compressive in nature. This process is similar to drawing process except drawing process uses tensile stress to extend the metal work piece. The compressive force allows large deformation compare to drawing in single pass. The most common material extruded are plastic and aluminum.

Working Principle:

Extrusion is a simple compressive metal forming process. In this process, piston or plunger is used to apply compressive force at work piece. These process can be summarized as follow.

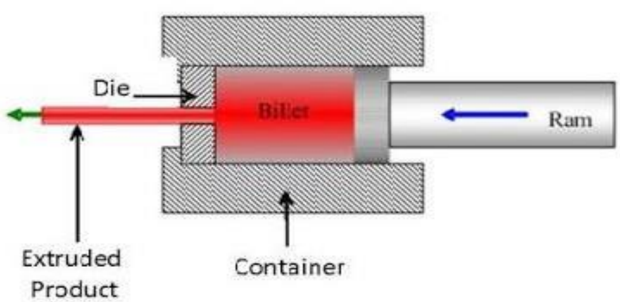
- First billet or ingot (metal work piece of standard size) is produced.
- This billet is heated in hot extrusion or remains at room temperature and placed into a extrusion press (Extrusion press is like a piston cylinder device in which metal is placed in cylinder and pushed by a piston. The upper portion of cylinder is fitted with die).
- Now a compressive force is applied to this part by a plunger fitted into the press which pushes the billet towards die.
- The die is small opening of required cross section. This high compressive force allow the work metal to flow through die and convert into desire shape.
- Now the extruded part remove from press and is heat treated for better mechanical properties.

Types of Extrusion:

Extrusion process can be classified into following types.

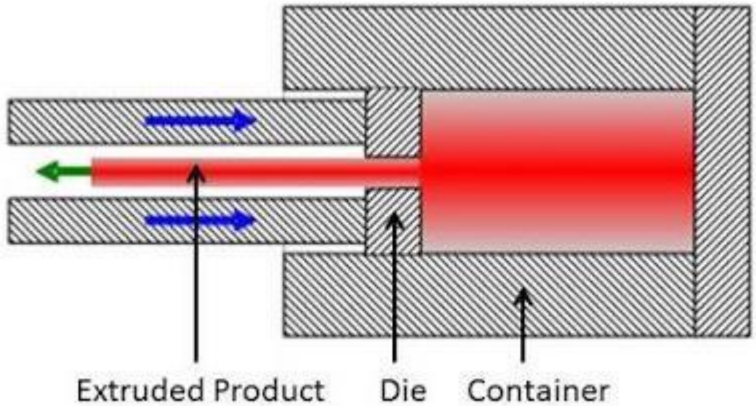
According to the direction of flow of metal

1) **Direct Extrusion:-** In this type of extrusion process, metal is forced to flow in the direction of feed of punch. The punch moves toward die during extrusion. This process required higher force due to higher friction between billet and container.



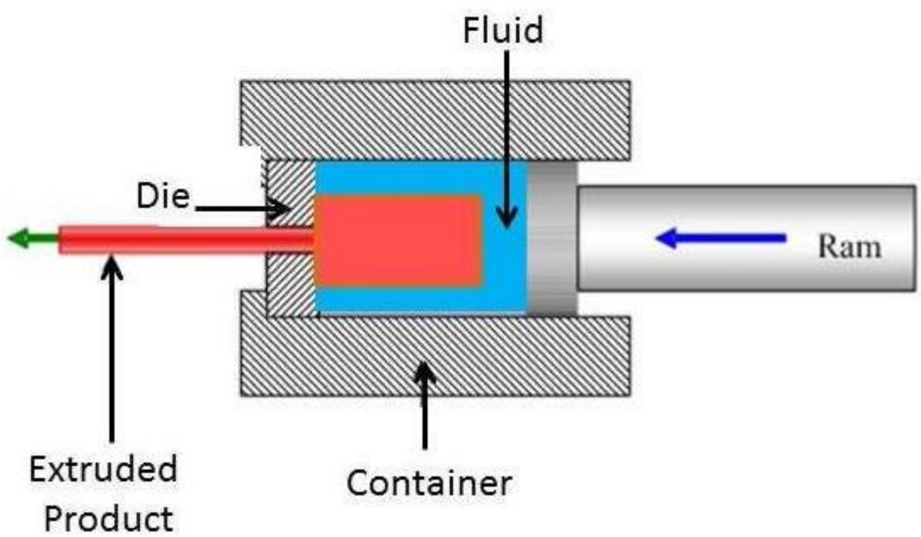
Direct Extrusion

2) <u>Indirect Extrusion</u>:- In this process, metal is flow toward opposite direction of plunger movement. The die is fitted at opposite side of punch movement. In this process, the metal is allowed to flow through annular space between punch and container.



Indirect Extrusion

3) <u>Hydrostatic Extrusion:-</u> This process uses fluid to apply pressure on billet. In this process, the friction is eliminated because the billet is neither contact with cylinder wall or plunger. There is a fluid between the billet and plunger. The plunger applies force on fluid which further applied on billet. Normally vegetable oils are used as fluid. This process accomplished by leakage problem and uncontrolled speed of extrusion.



Hydrostatic Extrusion

According to the working temperature

Hot Extrusion:

If the extrusion process takes place above recrystallization temperature which is about 50-60% of its melting temperature, the process is known as hot extrusion.

Advantages:

- Low force required compare to cold working.
- Easy to work in hot form.
- The product is free from stain hardening.

Disadvantages:

- Low surface finish due to scale formation on extruded part.
- Increase die wear.
- High maintenance required.

Cold Extrusion:

If the extrusion process takes place below crystallization temperature or room temperature, the process is known as cold extrusion. Aluminum cans, cylinder, collapsible tubes etc. are example of this process.

Advantages:

- High mechanical properties.
- High surface finish
- No oxidation at metal surface.

Disadvantages:

- High force required.
- Product is accomplished with strain hardening.

Application

- Extrusion is widely used in production of tubes and hollow pipes.
- Aluminum extrusion is used in structure work in many industries.
- This process is used to produce frames, doors, window etc. in automotive industries.
- Extrusion is widely used to produce plastic objects.

ADVANTAGES

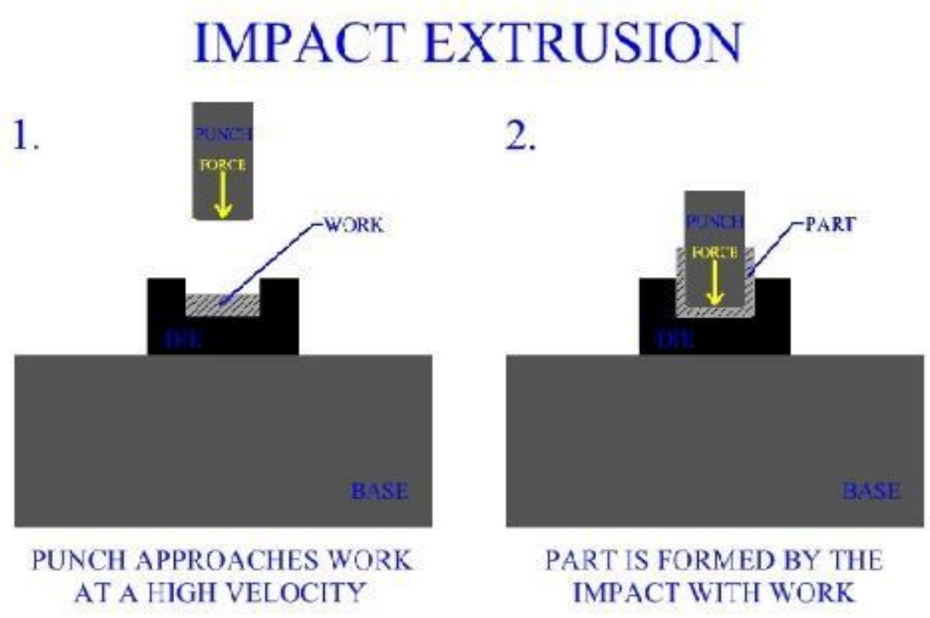
- High extrusion ratio (It is the ratio of billet cross section area to extruded part cross section area).
- It can easily create complex cross section.
- This working can be done with both brittle and ductile materials.
- High mechanical properties can achieved by cold extrusion.

DISADVANTAGES

- High initial or setup cost.
- High compressive force required.

IMPACT EXTRUSION PROCESS

Impact extrusion is a discrete manufacturing process, in which a metal part is extruded through the impact of a die with the work stock. The part is formed at a high speed and over a relatively short stroke. In standard metal extrusions, the force to extrude the work is commonly delivered by way of a hydraulic press. In impact extrusions, mechanical presses are most often employed. The force used to form standard extrusions is usually delivered over a horizontal vector, producing a long continuous product. Force used to form impact extrusions is usually delivered over a vertical vector, producing a single part with each impact of the punch. Impact extrusion is most often performed cold. Occasionally with some metals and thicker walled structures, the work is heated before impact forming it. This process is best suited for softer metals, aluminum is a great material for forming by impacting.



1.3 ROLLING:- Rolling is the most important and widely used metal forming process because of its lower cost and higher productivity. The rolling process is best defined as the shaping of metals into semi-finished or finished forms by passing between rollers rotating in opposite direction. Just like any other metal forming process, rolling works in the same way. The deformation takes place when a compressive force is applied by a set of rolls on ingot or any other product like billets, blooms, sheets, slabs, plates, strips, etc. This deformation decreases the cross-section area of the metal and converts it into the required shape. The main purpose of rolling is to decrease the thickness of the metal. Steel, magnesium, aluminum, copper, and their alloys are the materials commonly rolled. As a result of the friction between the rolls and the metal surface, the metal is subjected to high compressive stresses. High production rate, grain structure, and surface-finish are obtained, which makes it a most suitable metal forming process for large length cross-section workpieces like plates and sheets of steel and aluminum for other works and structure.

Types Of Rolling The types of the rolling process can be classified into the following ways-

- Thread/Gear Rolling
- Shape Rolling
- Ring Rolling
- Tube Piercing
- Transverse Rolling/Roll Forging
- Skew Rolling
- Roll Bending
- Flat Rolling
- Controlled Rolling

A) Thread/Gear Rolling:-The thread/gear rolling is a cold-forming type of rolling process used to cut gear or threads on a cylindrical blank. In this process, the threaded dies are fitted on cylindrical rollers of the rolling machine. The cylindrical blank presses the threaded roller and roll against the faces, which displace the material and form threads on the cylindrical blank. The thread-rolling process has the benefit of generating threads with high strength (due to cold working), without any material loss (scrap) and good surface finish. The thread/gear rolling is used for the production of screws, bolts, etc. in mass quantities.

B) Shape Rolling/Structural Shape Rolling/Profile Rolling:-The shape rolling is used to cut different shapes on the metal work piece. It does not involve any significant change in thickness. It’s a special type of cold rolling that is suitable for producing molded sections such as irregular shaped channels and trim. It's used to roll construction shapes such as I-beams, L-beams, and U channels, rails for railroad tracks, and round and square bars and rods, etc. The applications of shape rolling are -

- Construction materials
- Ceiling panel
- Metal furniture
- Household appliances
- Partition beam
- Steel pipe
- Automotive parts
- Roofing panels
- Door and window frames and other metal products

C) Ring Rolling:-Ring rolling is a type of hot rolling that increases the diameter of a ring. Two rollers i.e. main and idler are arranged and rotated in the same direction to each other in this process. Due to the rotation of the roller, the ring rotates and the rollers then start moving close to each other, with a decrease in ring thickness and hence this results in an increase in its diameter. To maintain the height of the ring, a pair of edge rollers are used, which does not allow metal flow in the direction of height. This process gives material finish and high accuracy. Common applications of ring rolling include -

- Large bearings
- Turbines
- Airplanes
- Gears
- Rockets
- Pipes
- Pressure vessels

D) Tube Piercing:-Tube piercing is another rolling process in which you can find a stationary mandrel at the center of tube and cavity form, due to tensile stress in a cylindrical rod when subjected to external compressive stress. Two rolls are rotated in the opposite direction in this process which compresses the tube and feeds it against mandrel which creates a hollow cavity in it. This process is used to make seamless hollow tubes of a thick wall.

E) Transverse Rolling/ Roll Forging:-Also called cross rolling, which is used to produce table knives, leaf springs, tapered shafts, and hand tools. In this process, both rollers rotate in the same direction and the heated bar is cut to length and is fed transversely between rolls. Usually, circular wedge rolls are used in the transverse rolling.

F) Skew Rolling:-This is a process similar to roll forging. Typically used for making ball bearings. In this process, round wire or bar is fed directly into specially designed rollers which continuously form spherical balls by rolling action. Used for the mass production of small size spherical balls.

G) Roll Bending:-In roll bending, a cylindrical shaped product is produced from plate or steel metals. The rolls change shape during rolling because of the forces acting on them, which tends to bend the elasticity of the rolls during rolling. If the elastic modulus of the roll material is high, then the roll deflection would be smaller. Compared to its edges, the rolled strip tends to be thicker at the center. We can avoid this problem by grinding the rolls in such a way that their diameter at the center is slightly larger than at their edges.

H) Flat Rolling:-This is the most basic form of rolling in which the starting and end material both have a rectangular cross-section. The material is fed in between two rollers, that rotate in opposite directions. The two rollers in flat rolling are called working rolls. The gap between the two rolls is less than the thickness of the starting material, which causes the deformity of it. The material, which is pushed through due to the friction at the interface between the material and the rolls, even elongates due to the decrease in material thickness. However, the friction between the rolls limits the amount of deformation possible in a single pass. The rolls just slip over the material and do not draw it in if the change in thickness is too great.

I) Controlled Rolling:-It's a type of thermo-mechanical processing which combines heat treating and controlled deformation. The work piece is brought above the recrystallization temperature with the help of heat, which performs the heat treatments to avoid any subsequent heat treating. Controlling the nature, size, and distribution of various transformation products; production of a fine grain structure; controlling the toughness; inducing precipitation hardening are some of the types of heat treatments included. The entire process must be closely monitored and controlled, to achieve this. The deformation levels, cool-down conditions, starting material composition and structure, the temperature at various stages are the common variables in controlled rolling. Better mechanical properties and energy savings are the benefits of controlled rolling.

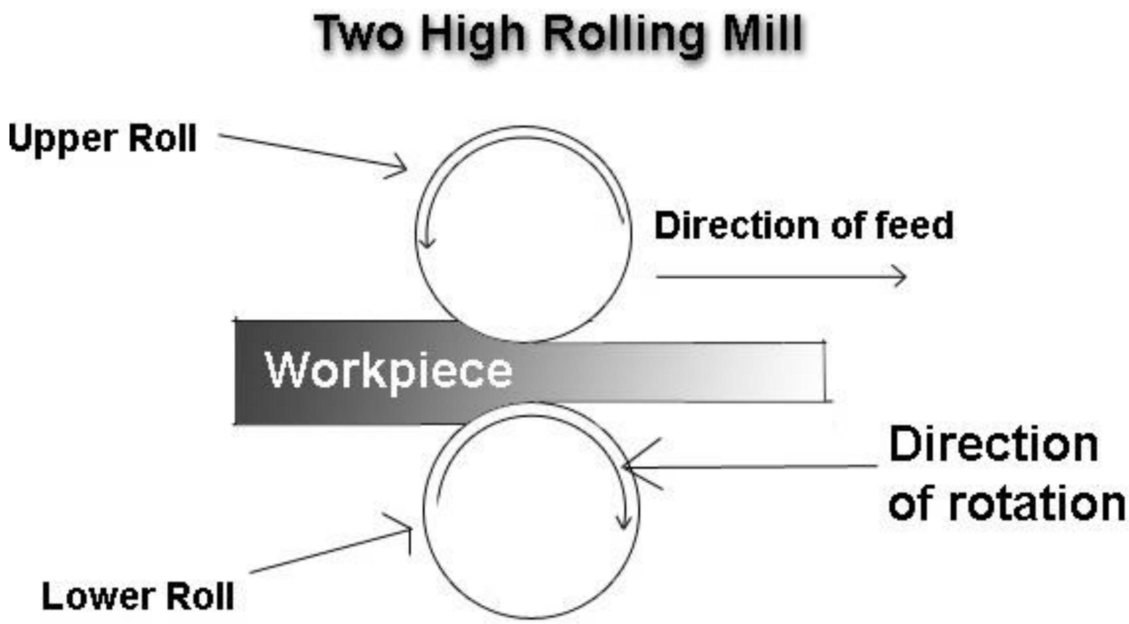
1.4 <u>DIFFERENCE BETWEEN HOT ROLLING AND COLD ROLLING PROCESS</u>:-

HOT ROLLING	COLD ROLLING
• Process is carried out at above recrystallisation temperature.	• Process is carried out at below recrystallisation temperature.
• Pressure applied is less due to high temperature.	• High pressure is applied.
• Coarse grain becomes fine grains.	• The grains becomes longer and distorted.
• No residual stresses are generated.	• Residual stresses are generated.
• Tool handling cost is more.	• Tool handling cost is less.
• Improves ductility.	• Ductility reduces.
• Surface finish and accuracy is less.	• Surface Finish and Accuracy is more.

1.5 <u>TYPES OF ROLLING MILLS USED IN ROLLING PROCESS</u>:-Rolling mills are classified based on the number and arrangement of the rolls in it. Rolling is a metal forming process in which metal stock is passed through one or more pair of rolls to reduce its thickness and make the thickness uniform.

Now the main types of rolling machines are :-
i) Two high rolling mills .
ii) Three high rolling mills .
iii) Four high rolling mills.
iv) Tandem rolling mills.
v) Cluster rolling mills.

<u>i) Two high rolling mills</u> :-This type of mill has two rollers arranged as shown in figure below. Both the roller revolves at same speed but in opposite direction. The space between the rollers can be adjusted by raising or lowering the upper roll which is adjustable. To reduce the thickness of work piece, it can be feeded from one direction only. However, there is another kind of two high rolling mills in which work piece can be feeded from both direction.



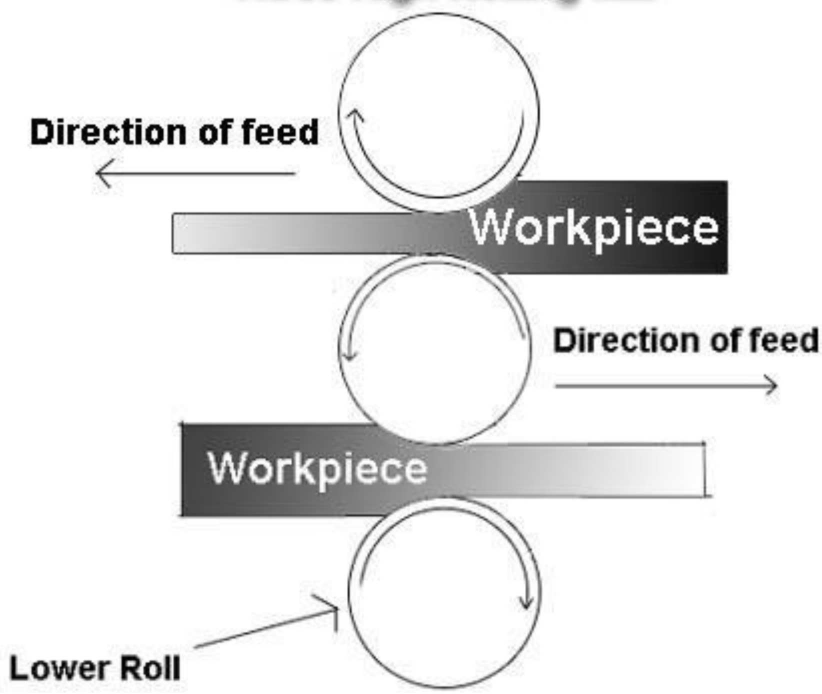
Based on the direction of feed available, two high rolling mills are further divided into types :-

a) Non -Reversing two high rolling mill:-In this type of rolling mill, the rolls can rotate in one direction only and hence the work piece can be feeded from one direction only.

b) Reversing two high rolling mill:-In this type of rolling mills, the rolls can rotate in both direction forward and reverse and hence the workpiece can be feeded from both the direction.

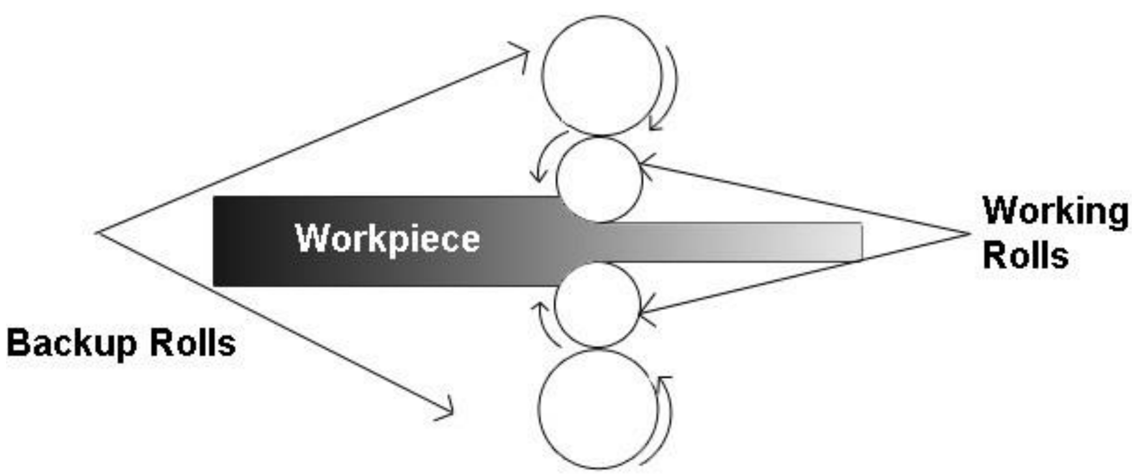
ii) Three High Rolling Mills :-This type of rolling mills consists of three rolls arranged one above other as shown in figure. The direction of rotation of upper and lower rolls are same but the middle roll rotates in the opposite direction. This type of rolling mills are used for rolling of continuous passes in a rolling sequence without reversing the drives. This results in a higher rate of production then the two-high rolling mill.

Three High Rolling Mill



iii) Four High Rolling Mill :-

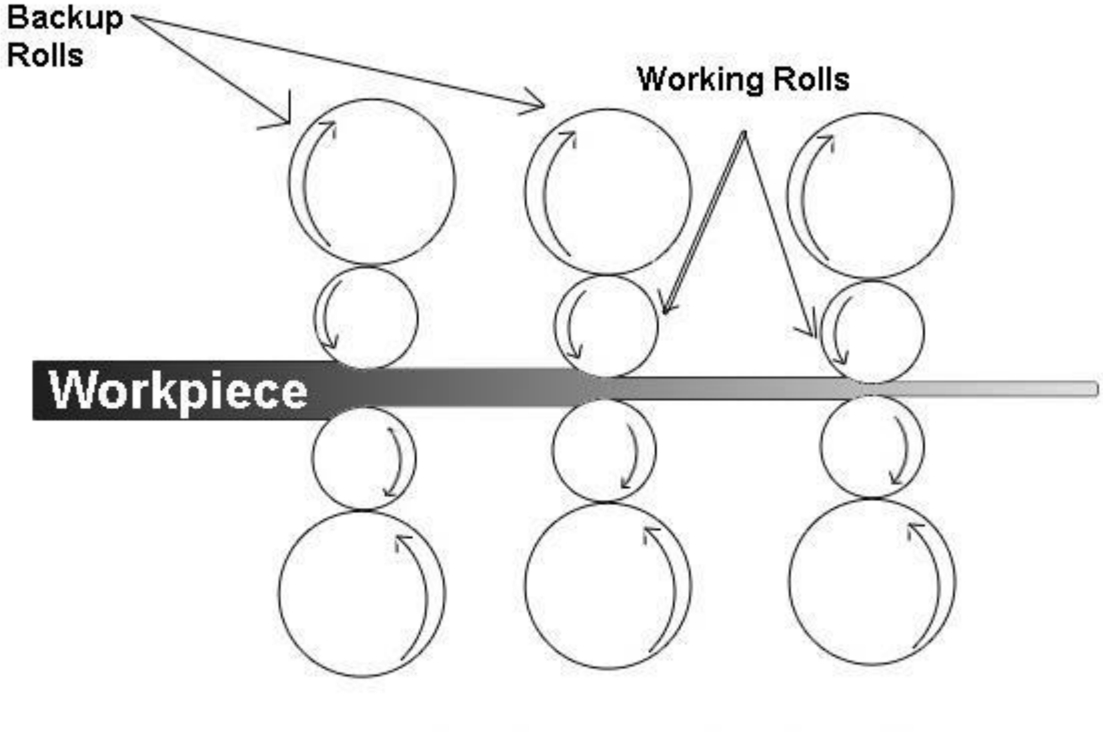
In this type of rolling machine, two rolls are in direct contact with the work piece and the other two rolls are used as backup rolls. The two rolls which are in direct contact with the work piece are smaller than backup rolls and are called working rolls. Backup rolls are used to prevent the deflection of the smaller rolls, which otherwise would result in thickening of rolled plates at the centre.



Four High Rolling Mills

iv) Tendem or Continuous rolling Mill :-

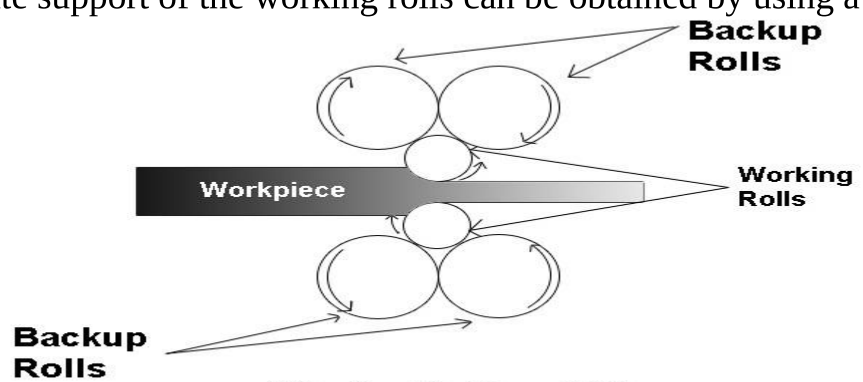
It consists of a number of non reversing two-high rolling mills arrange one after other. So that the material can be passed through all of them in sequence. It is suitable for mass production work only, because for smaller quantities quick changes of set up will be required and they will consume lot of labor and work.



Tendem or Continuous Rolling Machine

iv) Cluster Rolling Mill :-

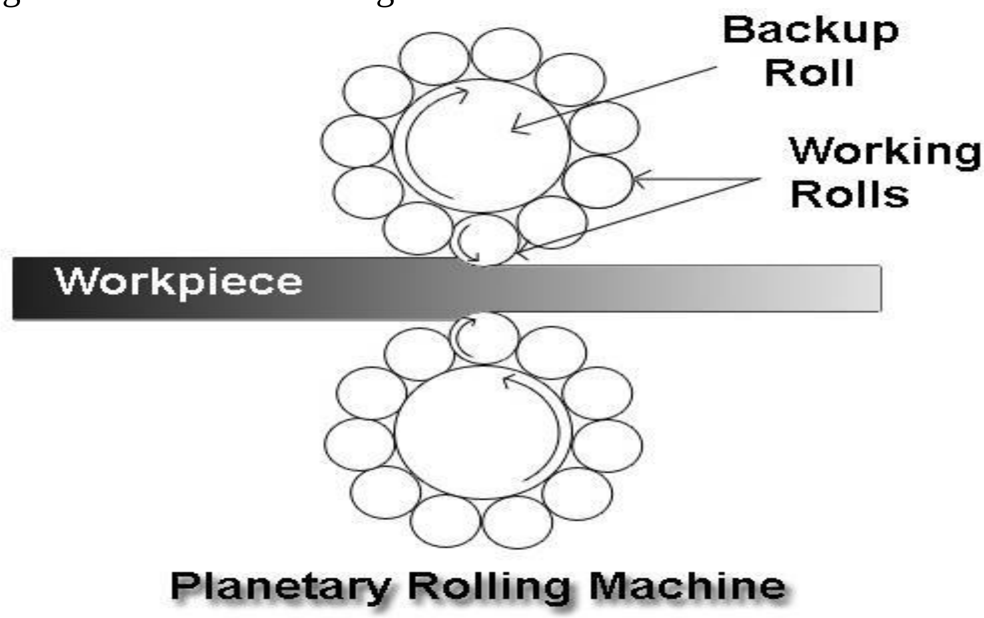
In this type of rolling mill, each of working roll is backed up by two or more larger backup rolls. These rolls are arranged as shown in figure. This rolling mill are used in rolling hard thin materials. For rolling hard thin materials, it may be necessary to employ work rolls of very small diameter but of considerable length . In such cases adequate support of the working rolls can be obtained by using a cluster-mill.



Cluster Rolling Mills

v) Planetary Rolling Mill :-

In this type of rolling mill, a large backup roller is surrounded by many planetary working rolls. Each planetary rolls gives constant reduction. It is used to reduce large thickness of single pass of steel strip. Its rolling capacity is more than cluster rolling mill but less than rolling mill.

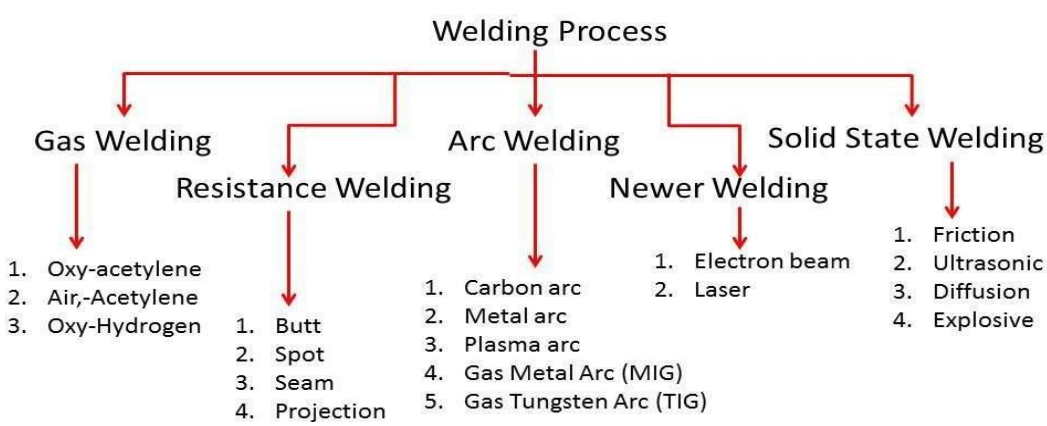


2.0 WELDING

2.1 WELDING AND ITS CLASSIFICATION PROCESS

WELDING:- Welding is a process of permanently joining two parts by the application of heat and (or) pressure. Filler metal may be added into the joint depending upon the welding process and the type of joint.

Classification of welding processes:



There are about 35 different welding and brazing process and several soldering methods, in use by the industry today. There are various ways of classifying the welding for example, they may be classified on the basis of source of heat(flames ,arc etc.)

In general various welding processes are classified as follows.

1: Gas Welding

(a) : Air Acetylene

(b) : Oxy Acetylene

(c) : Oxy Hydrogen Welding

2: Arc Welding

(a): Carbon Arc welding

(b); Plasma Arc welding

(c): Shield Metal Arc Welding

(d): T.I.G. (Tungsten Inert Gas Welding)

(e): M.I.G. (Metal Inert Gas Welding)

3: Resistance Welding:

(a): Spot welding

(b): Seam welding

(c): Projection welding

(d): Resistance Butt welding

(e): Flash Butt welding

4: Solid State Welding:

(a): Cold welding

(b): Diffusion welding

(c): Forge welding

(d): Fabrication welding

(e): Hot pressure welding

(f): Roll welding

5: Thermo Chemical Welding

(a): Thermit welding

(b): Atomic welding

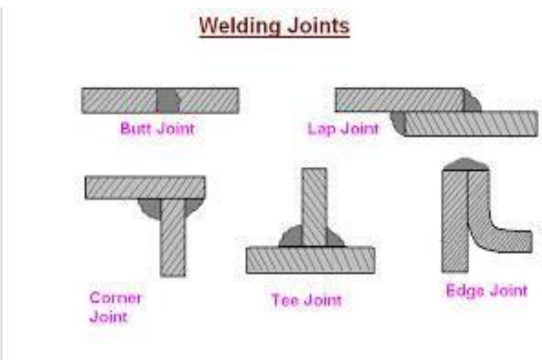
6: Radiant Energy Welding

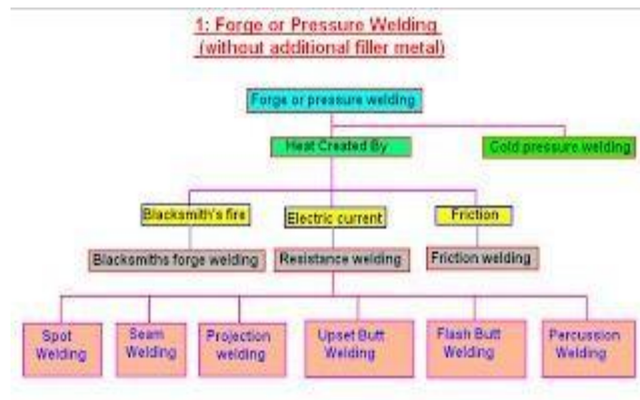
(a): Electric Beam Welding

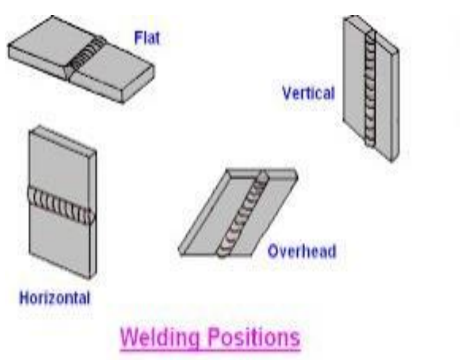
(b): Laser Beam Welding

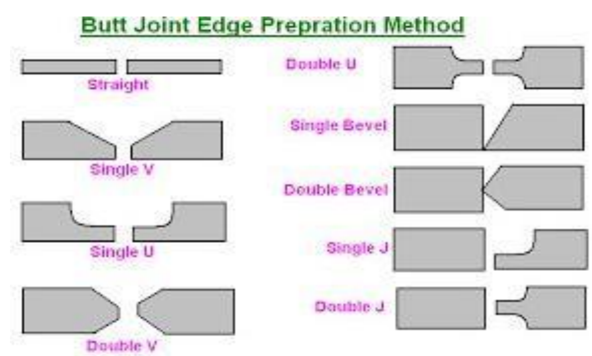
Welding Joints

Different types of welding joints are classified as Butt, Lap , Corner, Tee and edge joints which are shown in figure









2.2 FLUXES USED IN WELDING:-A flux is a substance used to Prevent the formation of oxides and the other unwanted contaminations, or to dissolve them and facilitate removal .During welding the flux melts and becomes a liquid slag, Covering the operation and protecting the molten weld metal. The slag hardens upon cooling and must be removed later by Chipping or brushing.

Types of Fluxes

1. Halide Fluxes (CaF_2-NaF)
2. Oxide Fluxes (MnO-SiO_2 , FeO-MnO-SiO_2)
3. Halide -Oxide Fluxes (CaF_2-CaO-Al_2O_3)

Functions of Flux in welding.

1. Provide protective atmosphere for welding.
2. Stabilize the arc and control arc resistivity
3. Reduce spattering.
4. Permit Use of different types of current and polarity.
5. Promote slag detachability.

2.3 Oxy-acetylene welding :- Oxy-acetylene welding is a very common welding process. The combination of oxygen and acetylene produces a flame temperature over 6000 degrees Fahrenheit making it ideal for welding and cutting.

Characteristics of the oxy-acetylene welding process:-

- The use dual oxygen and acetylene gases stored under pressure in steel cylinders,
- Its ability to switch quickly to a cutting process, by changing the welding tip to a cutting tip,
- The high temperature the gas mixture attains,
- The use of regulators to control gas flow and reduce pressure on both the oxygen and acetylene tanks,
- The use of double line rubber hoses to conduct the gas from the tanks to the torch,
- Melting the materials to be welded together,
- The ability to regulate temperature by adjusting gas flow.

Advantages of Oxy-Acetylene Welding :

- It's easy to learn.
- The equipment is cheaper than most other types of welding rigs (e.g. TIG welding) The equipment is more portable than most other types of welding rigs (e.g. TIG welding)
- OA equipment can also be used to "flame-cut" large pieces of material.

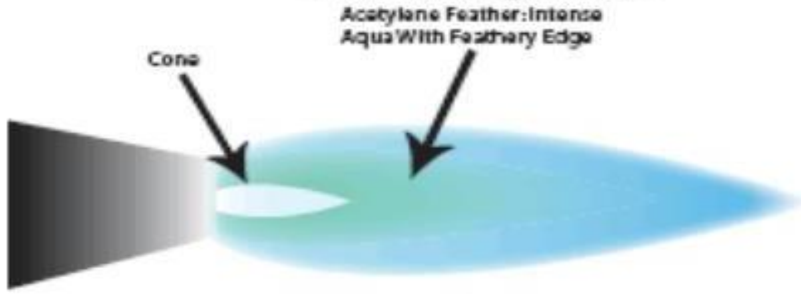
Disadvantages of Oxy-Acetylene Welding :

- OA weld lines are much rougher in appearance than other kinds of welds, and require more finishing if neatness is required.
- OA welds have large heat affected zones (areas around the weld line that have had their mechanical properties adversely affected by the welding process).

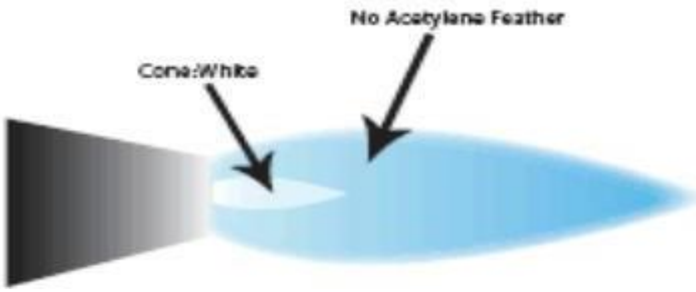
Adjusting the flame:-The blue flame will be divided into 3 different color regions - a long yellowish tip, a blue middle section, and a whitish-blue intense inner section. There are three types of flames as described below :

- **Neutral** - This type of flame is the one you will use most often in the metalwork room. It is called "neutral" because it has no chemical effect upon the metal during welding. It is achieved by mixing equal parts oxygen and acetylene and is witnessed in the flame by adjusting the oxygen flow until the middle blue section and inner whitish-blue parts merge into a single region.
- **Reducing / Carburising flame** - If there is excess acetylene, the whitish-blue flame will be larger than the blue flame. This flame contains white hot-carbon particles, which may be dissolved during welding. This "reducing" flame will remove oxygen from iron oxides in steel.
- **Oxidizing flame** - If there is excess oxygen, the whitish-blue flame will be smaller than the blue flame. This flame burns hotter. A slightly oxidizing flame is used in brazing, and a more strongly oxidizing flame is used in welding certain brasses and bronzes.

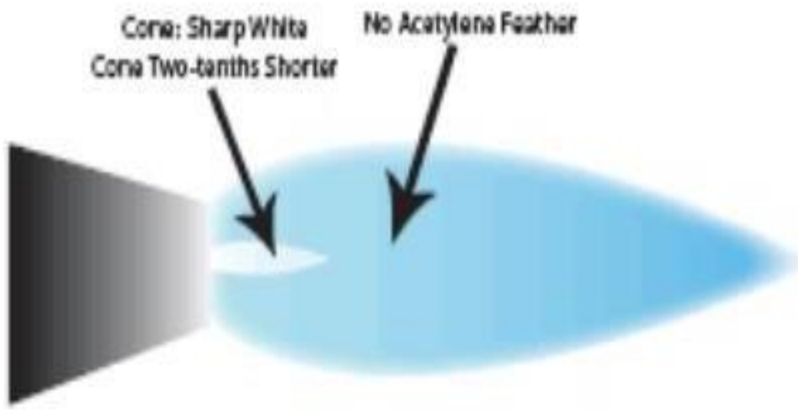
Carburizing Flame



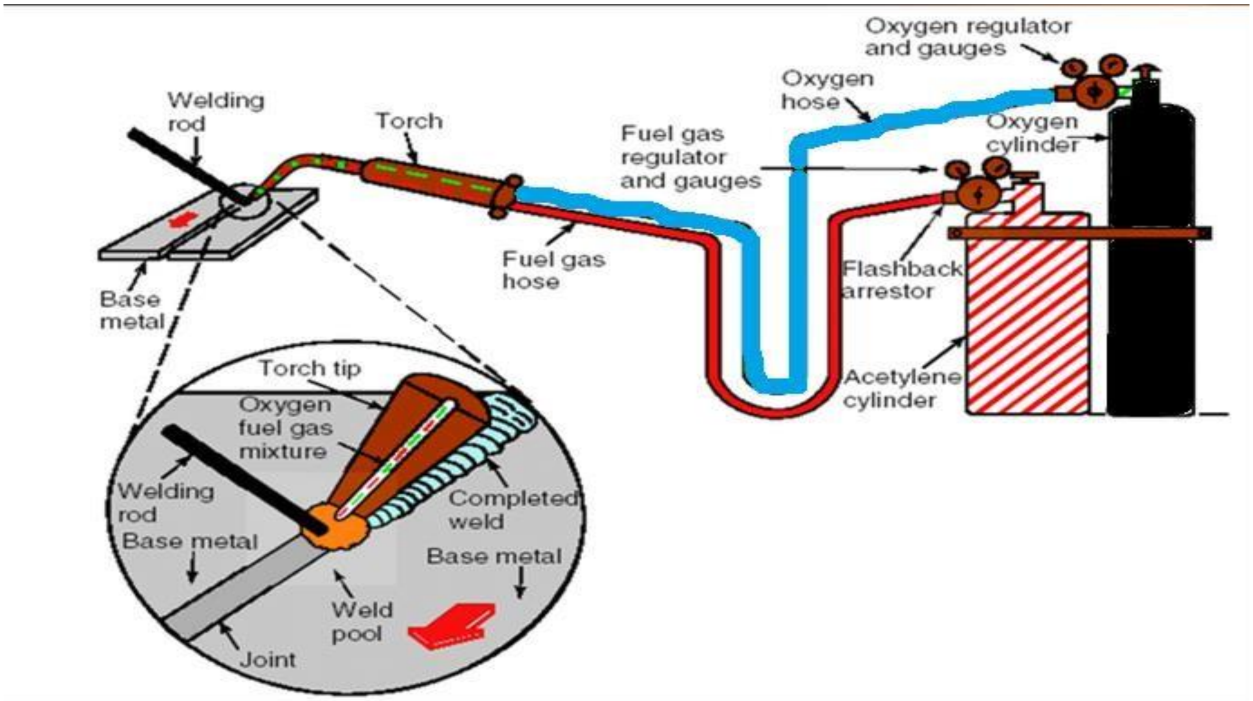
Neutral Flame



Oxidizing Flame



TYPICAL OXY ACETYLENE WELDING STATION



2.5 ARC WELDING PROCESS :- The definition of arc welding is a welding process which is used for welding the metals with the help of electricity to generate sufficient heat for softening the metal, as well as when the softened metal is cooled then the metals will be welded. This kind of welding uses a power supply to make an arc among a metal stick & the base material to soften the metals at the end of the contact. These welders can utilize either DC otherwise AC, & electrodes like consumable otherwise non-consumable. Generally, the welding location can be defended with some kind of shielding gas, slag, otherwise, vapor. This welding process could be manual, fully or semi-automated.

Working Principle of Electric Arc Welding

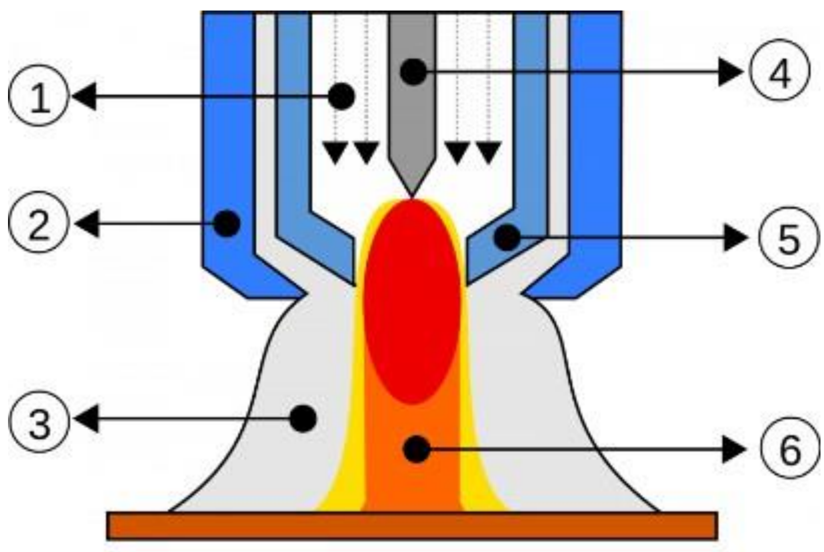
The working principle of arc winding is, in a welding process the heat can be generated with an electric arc strike among the workpiece as well as an electrode. This is glowing electrical discharge among two electrodes throughout ionized gas. The arc welding equipment mainly includes AC machine otherwise DC machine, Electrode, Holder for the electrode, Cables, Connectors for cable, Earthing clamps, Chipping hammer, Helmet, Wire brush, Hand gloves, Safety goggles, sleeves, Aprons, etc.

Types of Arc Welding:-The arc welding is classified into different types which include the following.

1. Plasma Arc Welding
2. Metal Arc Welding
3. Carbon Arc Welding
4. Gas Tungsten Arc Welding
5. Gas Metal Arc Welding
6. Submerged Arc Welding

1) Plasma Arc Welding

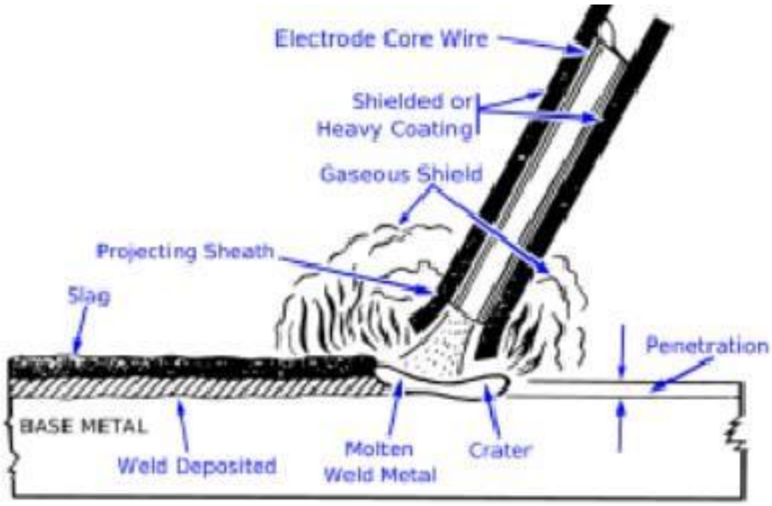
The Plasma arc welding (PAW) is similar to GTAW or gas tungsten welding. In this kind of welding process, the arc will generate among work part as well as the tungsten electrode. The major dissimilarity among plasma arc welding and gas tungsten welding is that the electrode is located within the torch of Plasma arc welding. It can be heated the gas at the temperature of 30000oF & changes it into the plasma to attack the welding region.



Plasma Arc Welding

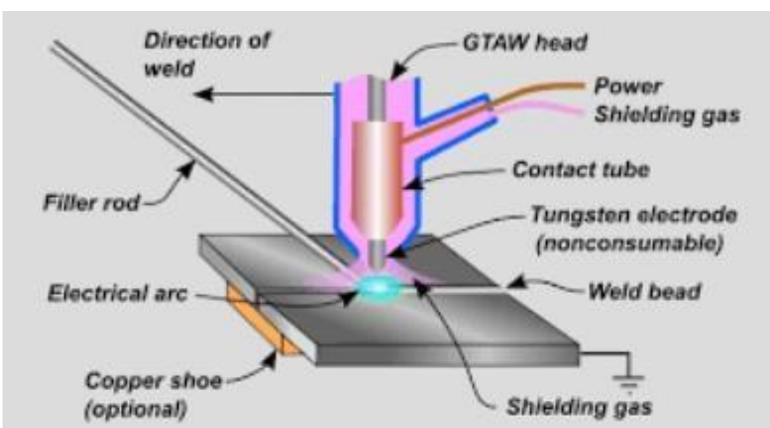
2) Metal Arc Welding

The metal arc welding (MAW) process mainly uses a metal electrode for the welding process. This metal electrode can be either consumable otherwise non-consumable based on the requirement. Most of the used consumable electrode can be covered with flux, and the main benefit of this type of welding process is that it requires low temperature compared with others.



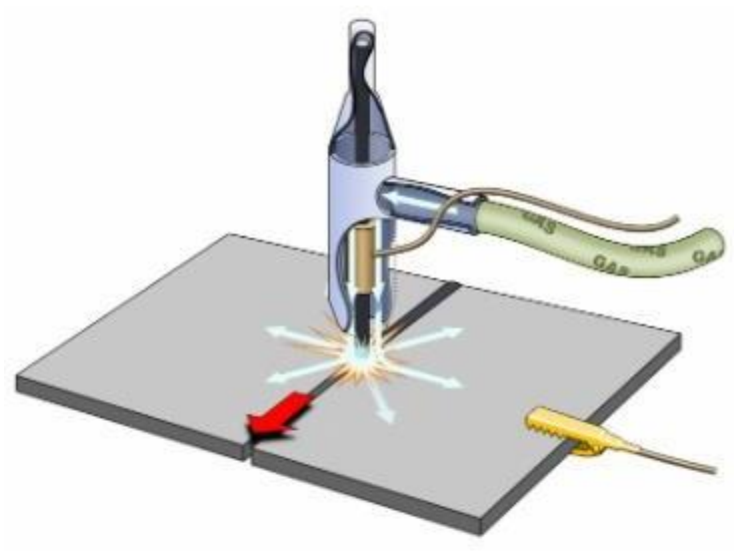
<u>3) Carbon Arc Welding</u>:-The Carbon arc welding (CAW) process mainly uses a carbon rod like an electrode for welding the metal joint. This kind of arc welding is the oldest arc welding process and requires high current, low voltage for generating the arc. In some cases, an arc can be generated among two carbon electrodes which are named as twin carbon arc welding.

<u>4) Gas Tungsten Arc Welding</u>:-The gas tungsten arc welding (GTAW) is also called as Tungsten inert gas welding (TIGW). In this type of welding process, a tungsten electrode which is non-consumable can be employed for welding the material. The electrode which is used in this welding can be enclosed with gases such as argon, helium, etc. These gases will guard the weld region against the oxidization. This kind of welding can be used for welding thin sheets.



Gas Tungsten Arc Welding

5) Gas Metal Arc Welding:-The Gas metal arc welding (GMAW) is also called as Metal inert gas welding (MIGW). It uses a fresh metal electrode which is protected by the gas like helium, argon, etc. These gases will protect the join area from oxidation and generates multiple welding material layers. In this type of arc welding process, a filler wire can be fed constantly using a non-consumable metal electrode for welding the metal.



Gas Metal Arc Welding

6) Submerged Arc Welding:-The Submerged arc welding (SAW) can be extensively utilized within an automatic welding method. In this kind of welding process, an electrode is completely submerged by the granular coating of flux, and this flux can be an electric conductor which will not oppose the electric supply. The solid coating of flux stops the melted metal to ultra-violate radiation and atmosphere.

Advantages of Arc Welding:-The advantages of Arc welding mainly include the following.

- Arc welding has high speed as well as welding efficiency
- It includes a simple welding apparatus.
- It is simply moveable.
- Arc welding forms the physically powerful bond between the welded metals.
- It provides reliable welding quality
- Arc welding offers superior welding atmosphere.
- The power source of this welding is not costly.
- This welding is a quick and consistent process.
- The welder can utilize ordinary domestic current.

Disadvantages of Arc Welding:-The disadvantages of Arc welding include the following.

- A high expert operator is necessary to perform arc welding.
- The rate of deposition can be incomplete as the electrode covering tends to burn and decrease
- The length of the electrode is 35mm and needs electrode changing for the entire production rate.
- These are not clean for reactive metals such as titanium & aluminum

SPECIFICATION OF ARC WELDING ELECTRODES:-

An electrode is a tool used in arc welding to produce electric arc. It may be used as a positively charged anode or as a negatively charged cathode.

Arc welding Electrodes of various forms and sizes are used in practice. The most common forms are wire electrode and rod electrode.

Types of Arc Welding Electrodes:

Based on their characteristics, arc welding electrodes can be broadly classified into two types. They are:

1. Consumable electrode
2. Non-consumable Electrode

Consumable Electrode:-If the melting point of an arc welding electrode is less, it melts and fills the gap in the work piece. Such an electrode is called consumable electrode. In arc welding, to produce deep weld, consumable electrode is connected to the positive terminal of the power supply (i.e., it is made as anode) while work piece is connected to the negative terminal of the power supply (i.e., it is made cathode).This is because, heat concentration is always higher in the anode than in cathode. When consumable electrode is made as anode, it melts faster and easily fills the gap in the work piece.

Consumable electrodes are usually coated with a flux material. This is done to protect the arc and the weld from the external atmosphere. Metal inert gas welding is an arc welding technique that uses a consumable electrode.

Non-consumable electrode:-

If the melting point of the arc welding electrode is high, it does not melt to fill the gap in the work piece. Such an electrode is called non-consumable electrode.

If a non-consumable electrode is used, either the work piece should have a low melting point or a filler metal with low melting point should be used, to fill the gap in the work piece. As non-consumable electrodes do not melt, heat concentration should be high in the work piece. Hence, in non-consumable electrode processes, to produce deep weld, the electrode is made cathode and work piece is made anode. Tungsten is a non-consumable electrode whose melting point is 3422 °C. It is used in tungsten inert gas welding.

2.7 RESISTANCE WELDING AND ITS CLASSIFICATION

Resistance welding-Resistance welding can be defined as; it is a liquid state welding method where the metal-to-metal joint can be formed within a liquid state otherwise molten state. This is a thermoelectric method where heat can be generated at the It is a thermo-electric process in which heat is generated at the edge planes of welding plates because of electric resistance and a weld joint can be created by applying low-pressure to these plates. This type of welding uses electric resistance to generate heat. This process is very efficient with pollution free but the applications are limited because of the features like equipment cost is high, and material thickness is limited.

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

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

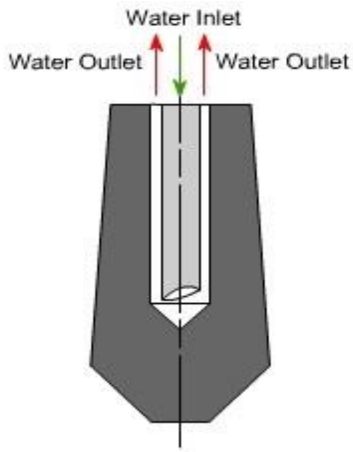
$$H = I^2RT$$

- Where ‘H’ is a generated Heat, and the unit of heat is a joule
- ‘I’ is an electric current, and the unit of this is ampere
- ‘R’ is an electric resistance, and the unit of this is Ohm
- ‘T’ is the time of current flow, and the unit of this is second

The generated heat can be used to soften the edge metal to shape a tough weld joint with fusion. This method generates weld with no application of any flux, filler material, and shielding gases.

Types of Resistance Welding

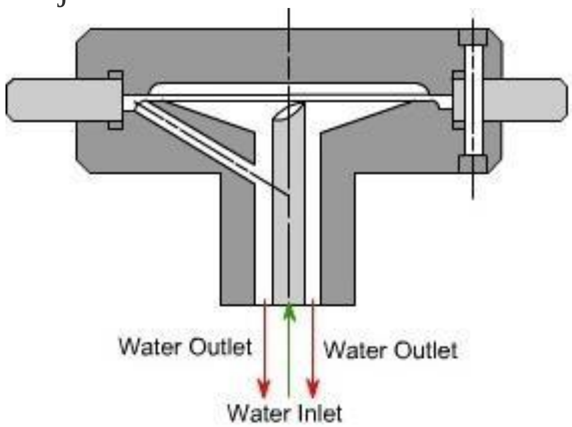
1) **Spot Welding:-**Spot welding is the simplest type of welding where the work portions are held jointly below the force of anvil face. The copper (Cu) electrodes will make contact with the work portion & the flow of current through it. The work portion material applies a few resistances within current flow which will cause limited heat production. The resistance is high at the edge surfaces because of the air gap. The current begins to supply through it, then it will reduce the edge surface.



Spot Welding

The current supply & the time must be enough for the correct dissolving of edge faces. Now the flow of current will be stopped however the force applied with electrode continued for a second, whereas the weld quickly cooled. Later, the electrodes eliminate as well as get in touch with new spot to create a circular piece. The piece size mainly depends on electrode size (4-7 mm).

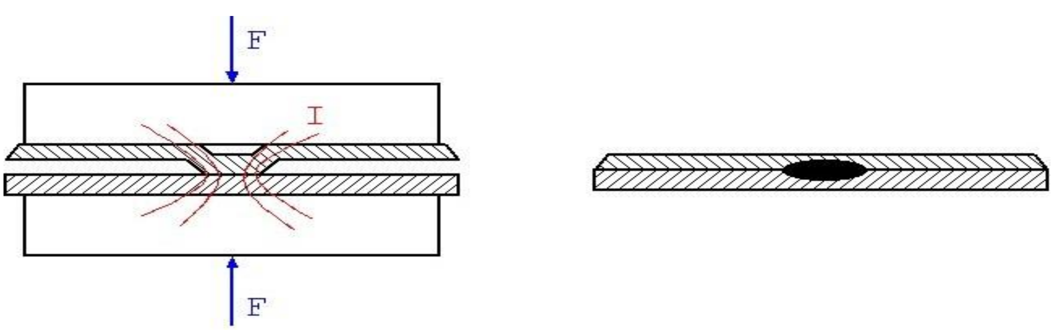
2) Seam Welding :- This type of welding is also known as continuous spot welding where a roller form electrode can be utilized to supply current throughout work parts. Initially, the roller electrodes are getting in touch with the work part. High current can be supplied through these electrode rollers to melt the edge surfaces & shape a weld joint.



Seam Welding

At present, the electrode rollers will begin rolling on work plates to make a permanent weld joint. The weld timing & electrode movement can be controlled to guarantee that the weld overlap & work part doesn't acquire too warm. The speed of the welding can be about 60 in per min within seam welding, which is used to make airtight joints.

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



Projection Welding

4) Flash butt Welding:-The flash butt welding is a form of resistance welding, used for welding tubes as well as rods within steel industries. In this method, two work parts are welded which will be held tightly during the electrode holders as well as a high pulsed flow of current within the 1,00,000 ampere range can be supplied toward the work part material.

Flash Butt Welding

In the two electrode holders, one is permanent & other is changeable. At first, the flow of current can be supplied & changeable clamp will be forced against the permanent clamp because of the get in touch with the two work parts at high-current, the spark will be generated. Whenever the edge surface approaches into plastic shape, the flow of current will be stopped as well as axial force can be improved to create joint. In this method, the weld can be formed because of plastic deformation.

Resistance Welding Applications

The applications of resistance welding include the following.

- This type of welding can be widely used within automotive industries, making of nut as well as a bolt.
- Seam welding can be utilized to generate leak prove joint necessary within little tanks, boilers, etc.
- Flash welding can be used for welding tubes and pipes.

Resistance Welding Advantages and Disadvantages

The advantages & disadvantages of resistance welding include the following

Advantages

- This method is simple and does not necessary high expert labor.
- The resistance welding metal thickness is 20mm, & thinness is 0.1 mm
- Automated simply
- The rate of production is high
- Both related, & different metals can be weld.
- Welding speed will be high
- It does not need any flux, filler metal & protecting gases.

Disadvantages

- Tools cost will be high.
- The work section thickness is limited because of the current requirement.
- It is less proficient for high-conductive equipment.
- It consumes high electric-power.
- Weld joints contain small tensile & fatigue power.

TIG WELDING PROCESS:- TIG welding is an arc welding process that operates at high temperatures (over 6,000 degrees Fahrenheit) to melt and heat metals. While it is more expensive than stick welding, it is cleaner and more versatile (works on steel, aluminum, brass and many other metals).It also results in high-quality welds. On the downside, the equipment is more expensive and the process is slower than other welding processes. The arc is started with a tungsten electrode shielded by inert gas and filler rod is fed into the weld puddle separately. The gas shielding that is required to protect the molten metal from contamination and amperage are supplied during the TIG welding operation.TIG welding is a slower process than MIG, but it produces a more precise weld and can be used at lower amperages for thinner metal and can even be used on exotic metals. TIG welding is a commonly used high quality welding process. TIG welding has become a popular choice of welding processes when high quality, precision welding is required. The TIG welding process requires more time to learn than MIG.

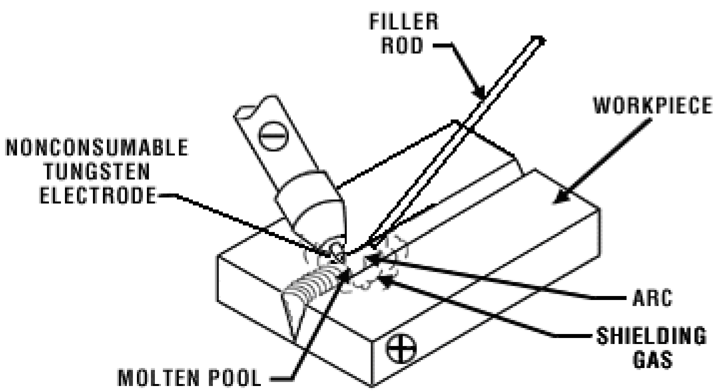
Characteristics of the TIG welding process

- Uses a non-consumable tungsten electrode during the welding process,
- Uses a number of shielding gases including helium (He) and argon (Ar),
- Is easily applied to thin materials,

- Produces very high-quality, superior welds,
- Welds can be made with or without filler metal,
- Provides precise control of welding variables (i.e. heat),
- Welding yields low distortion,
- Leaves no slag or splatter.

In TIG welding, an arc is formed between a non-consumable tungsten electrode and the metal being welded. Gas is fed through the torch to shield the electrode and molten weld pool. If filler wire is used, it is added to the weld pool separately.

The illustration that follow provide a schematic showing how the TIG welding process works.

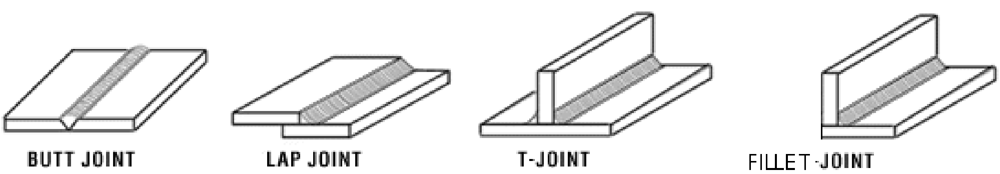


TIG WELDING PROCESS

The most common TIG welds are illustrated below. They include the:

- butt joint,
- lap joint,
- T-joint, and
- Fillet weld.

The following illustration shows these TIG-welded joints:



TIG WELD JOINTS

The TIG welding process utilizes a number of shielding gases including:

- argon
- argon/helium, and
- helium

Argon is superior for welding metals. It operates at a higher arc voltage, makes the arc start more easily, and is commonly used to weld mild steel, aluminum and titanium. Helium is generally added to increase heat input (increase welding speed or weld penetration) and is used for high speed welding of mild steel and titanium. Helium offers a smaller heat affected zone and therefore, penetrates metals deeply. It also can increase the welding speed up to 40%. Helium is also commonly used to weld stainless steel and copper. The argon/helium combination gas is used for a hotter arc in welding aluminum and aluminum alloys. It is also used in automatic welding applications. Even though TIG is a commonly used welding process, there are a number of limitations. These include:

- TIG requires greater welder dexterity than MIG or stick welding,
- TIG yields lower deposition rates,
- TIG is more costly for welding thick metal sections.

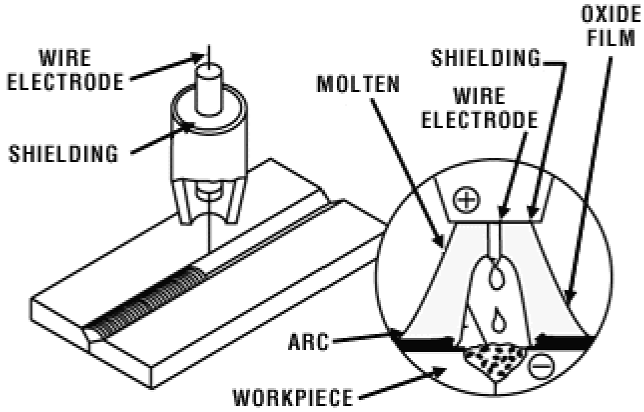
MIG WELDING PROCESS:- MIG welding is an arc welding process in which a continuous solid wire electrode is fed through a welding gun and into the weld pool, joining the two base materials together. A shielding gas is also sent through the welding gun and protects the weld pool from contamination. In fact, MIG stands for metal inert gas. The "Metal" in Gas Metal Arc Welding refers to the wire that is used to start the arc. It is shielded by inert gas and the feeding wire also acts as the filler rod. MIG is fairly easy to learn and use as it is a semi-automatic welding process.

Characteristics of the MIG welding process:-

- Uses a consumable wire electrode during the welding process that is fed from a spool,
- Provides a uniform weld bead,
- Produces a slag-free weld bead,
- Uses a shielding gas, usually – argon, argon - 1 to 5% oxygen, argon - 3 to 25% CO_2 and a combination argon/helium gas,
- Is considered a semi-automatic welding process,
- Allows welding in all positions,

- Requires less operator skill than TIG welding,
- Allows long welds to be made without starts or stops,
- Needs little cleanup.

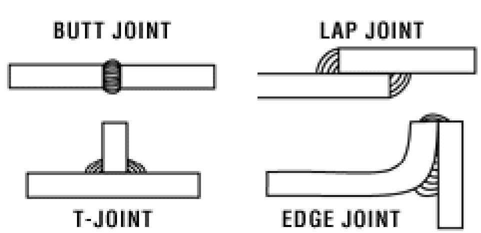
The illustration that follows provides a look at a typical MIG welding process showing an arc that is formed between the wire electrode and the workpiece. During the MIG welding process, the electrode melts within the arc and becomes deposited as filler material. The shielding gas that is used prevents atmospheric contamination from atmospheric contamination and protects the weld during solidification. The shielding gas also assists with stabilizing the arc which provides a smooth transfer of metal from the weld wire to the molten weld pool.



MIG WELDING PROCESS

The most common welds are illustrated below. They include the:

- lap joint
- butt joint
- T-joint, and the
- edge joint



MIG WELD JOINTS

MIG is used to weld many materials, and different gases are used to form the arc depending on the materials to be welded together. An argon CO_2 blend is normally used to weld mild steel, aluminum, titanium, and alloy metals. Helium is used to weld mild steel and titanium in high speed process and also copper and stainless steel. Carbon dioxide is most often used to weld carbon and low alloy steels. Magnesium and cast iron are other metals commonly welded used the MIG process.

Differences between MIG and TIG welding	
MIG Welding	**TIG Welding**
1. Metal inert gas (MIG) welding utilizes a consumable electrode that is continuously fed into the welding zone from a wire pool.	1. 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.	2. 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.	3. Electrode is always made of tungsten with 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.	4. It is particularly suitable for autogenous mode welding. However, it can also be employed for homogeneous or heterogeneous welding.
5. The electrode-cum-filler comes in the form of a small diameter (0.5 – 2 mm) and very long (several hundred m) wire wound in a pool.	5. TIG welding filler typically comes in the form of small diameter (1 – 3 mm) and short length (60 – 180 mm) rod.
6. MIG welding is commonly carried out in AC or DCEP polarity to increase filler deposition rate.	6. TIG welding is commonly carried out either in AC or DCEN polarity to increase electrode life.

www.difference.minaprem.com

<u>WELDING DEFECTS WITH CAUSES AND REMEDIES</u>

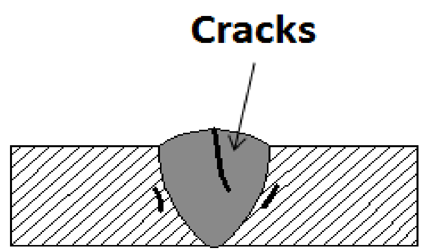
Defects are common in any type of manufacturing, welding including. In the process, there can be deviations in the shape and size of the metal structure. It can be caused by the use of the incorrect welding process or wrong welding technique. So below we'll learn about the 7 most common welding defects, their types, causes and remedies.

<u>1) WELD CRACK:-</u>

The most serious type of welding defect is a weld crack and it's not accepted almost by all standards in the industry. It can appear on the surface, in the weld metal or the area affected by the intense heat.

There are different types of cracks, depending on the temperature at which they occur:

1. Hot cracks. These can occur during the welding process or during the crystallization process of the weld joint. The temperature at this point can rise over 10,000C.
2. Cold cracks. These cracks appear after the weld has been completed and the temperature of the metal has gone down. They can form hours or even days after welding. It mostly happens when welding steel. The cause of this defect is usually deformities in the structure of steel.
3. Crater cracks. These occur at the end of the welding process before the operator finishes a pass on the weld joint. They usually form near the end of the weld. When the weld pool cools and solidifies, it needs to have enough volume to overcome shrinkage of the weld metal. Otherwise, it will form a crater crack.



Causes of cracks:

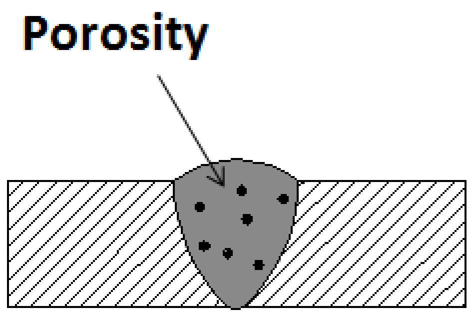
- Use of hydrogen when welding ferrous metals.
- Residual stress caused by the solidification shrinkage.
- Base metal contamination.
- High welding speed but low current.
- No preheat before starting welding.
- Poor joint design.
- A high content of sulfur and carbon in the metal.

Remedies:

- Preheat the metal as required.
- Provide proper cooling of the weld area.
- Use proper joint design.
- Remove impurities.
- Use appropriate metal.
- Make sure to weld a sufficient sectional area.
- Use proper welding speed and amperage current.
- To prevent crater cracks make sure that the crater is properly filled.

Porosity

Porosity occurs as a result of weld metal contamination. The trapped gases create a bubble-filled weld that becomes weak and can with time collapse.



Causes of porosity:

- Inadequate electrode deoxidant.
- Using a longer arc.
- The presence of moisture.
- Improper gas shield.
- Incorrect surface treatment.
- Use of too high gas flow.
- Contaminated surface.
- Presence of rust, paint, grease or oil.

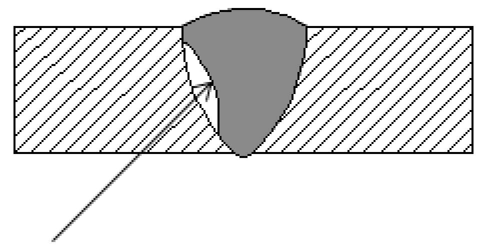
Remedies:

- Clean the materials before you begin welding.
- Use dry electrodes and materials.
- Use correct arc distance.
- Check the gas flow meter and make sure that it's optimized as required with proper with pressure and flow settings.
- Reduce arc travel speed, which will allow the gases to escape.
- Use the right electrodes.
- Use a proper weld technique.

Incomplete Fusion

This type of welding defect occurs when there's a lack of proper fusion between the base metal and the weld metal. It can also appear between adjoining weld beads. This creates a gap in the joint that is not filled with molten metal.

Causes:



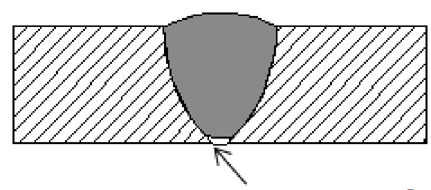
- Low heat input.
- Surface contamination.
- Electrode angle is incorrect.
- The electrode diameter is incorrect for the material thickness you're welding.
- Travel speed is too fast.
- The weld pool is too large and it runs ahead of the arc.

Remedies:

- Use a sufficiently high welding current with the appropriate arc voltage.
- Before you begin welding, clean the metal.
- Avoid molten pool from flooding the arc.
- Use correct electrode diameter and angle.
- Reduce deposition rate.

Incomplete Penetration

Incomplete penetration occurs when the groove of the metal is not filled completely, meaning the weld metal doesn't fully extend through the joint thickness.



Causes:

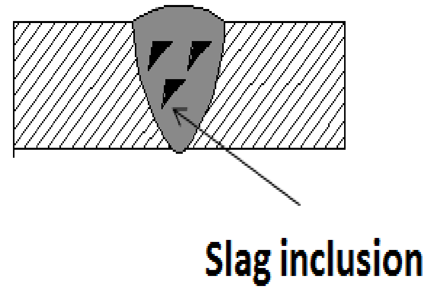
- There was too much space between the metal you're welding together.
- You're moving the bead too quickly, which doesn't allow enough metal to be deposited in the joint.
- You're using a too low amperage setting, which results in the current not being strong enough to properly melt the metal.
- Large electrode diameter.
- Misalignment.
- Improper joint.

Remedies:

- Use proper joint geometry.
- Use a properly sized electrode.
- Reduce arc travel speed.
- Choose proper welding current.
- Check for proper alignment.

Slag Inclusion

Slag inclusion is one of the welding defects that are usually easily visible in the weld. Slag is a vitreous material that occurs as a byproduct of stick welding, flux-cored arc welding and submerged arc welding. Is can occur when the flux, which is the solid shielding material used when welding, melts in the weld or on the surface of the weld zone.



Causes:

- Improper cleaning.
- The weld speed is too fast.
- Not cleaning the weld pass before starting a new one.
- Incorrect welding angle.
- The weld pool cools down too fast.
- Welding current is too low.

Remedies:

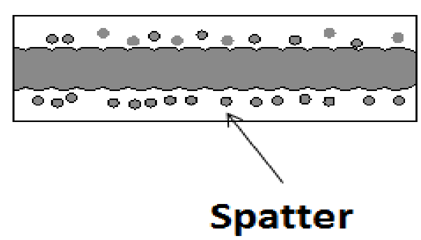
- Increase current density.
- Reduce rapid cooling.
- Adjust the electrode angle.
- Remove any slag from the previous bead.
- Adjust the welding speed.

Spatter

Spatter occurs when small particles from the weld attach themselves to the surrounding surface. It’s an especially common occurrence in gas metal arc welding. No matter how hard you try, it can’t be completely eliminated. However, there are a few ways you can keep it to a minimum.

Causes:

- The running amperage is too high.
- Voltage setting is too low.
- The work angle of the electrode is too steep.
- The surface is contaminated.
- The arc is too long.
- Incorrect polarity.
- Erratic wire feeding.



Remedies:

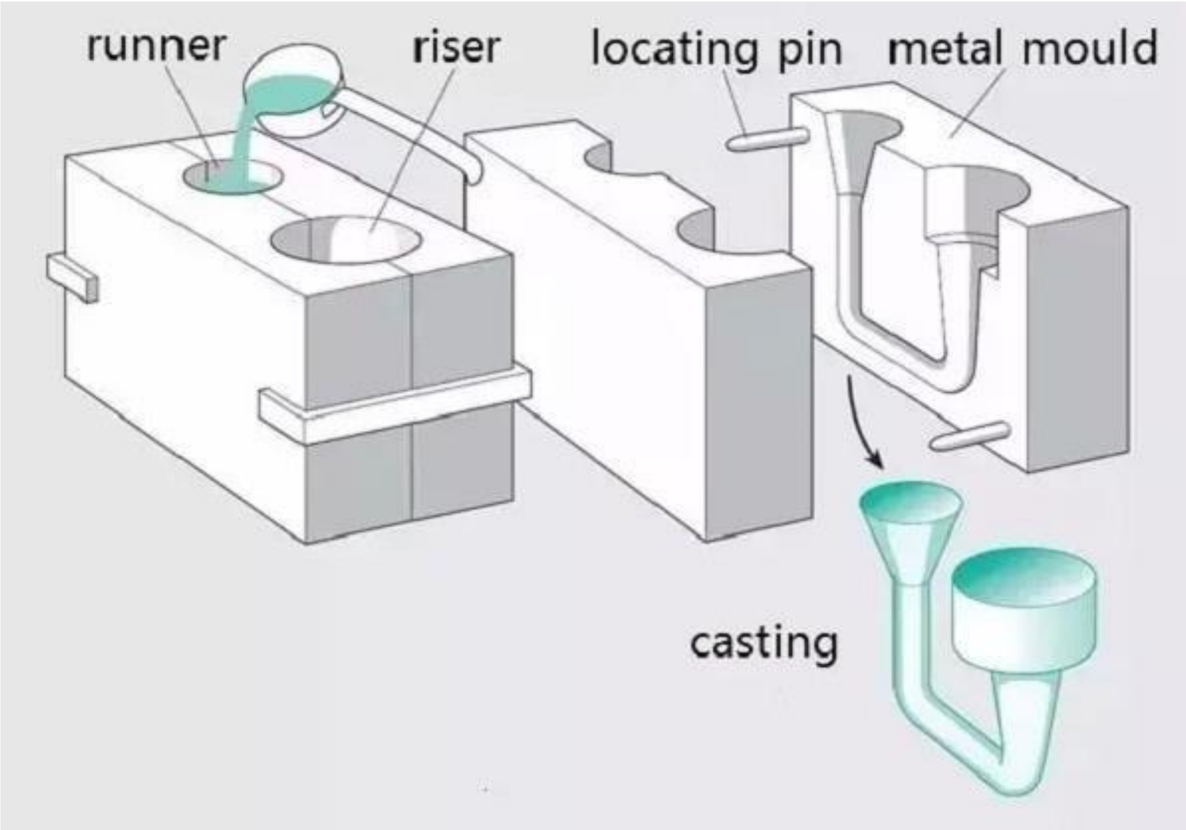
- Clean surfaces prior to welding.
- Reduce the arc length.
- Adjust the weld current.
- Increase the electrode angle.
- Use proper polarity.
- Make sure you don't have any feeding issues.

3.0 CASTING

CASTING:- Liquid metal is poured into a mold cavity that matches the shape and size of the part. The production method that waits for it to cool and solidify to obtain the blank or part is usually called metal liquid forming or casting.

TECHNOLOGICAL PROCESS:-

LIQUID METAL→FILLING→SOLIDIFICATION SHRINKAGE→CASTING



CHARACTERISTICS

1) It can produce parts with any complicated shape, especially those with complicated inner cavity shape.
2) Strong adaptability, unlimited alloy types and almost unlimited casting size.
3) Wide source of materials, waste can be remelted and equipment investment is low.
4) High scrap rate, low surface quality and poor labor conditions.

Selecting the Right Metal Casting Process

- For any Metal Casting Process, selection of right alloy, size, shape, thickness, tolerance, texture, and weight, is very vital.
- Special requirements such as, magnetism, corrosion, stress distribution also influence the choice of the Metal Casting Process.
- Views of the Tooling Designer; Foundry / Machine House needs, customer's exact product requirements, and secondary operations like painting, must be taken care of before selecting the appropriate Metal Casting Process.
- Tool cost.
- Economics of machining versus process costs.
- Adequate protection / packaging, shipping constraints, regulations of the final components, weights and shelf life of protective coatings also play their part in the Metal Casting process.

The Metal Casting or just Casting process may be divided into two groups:

Hot Forming Process

Examples are Centrifugal casting, Extrusion, Forging, Full mold casting, Investment casting, Permanent or Gravity Die casting, Plaster mold casting, Sand Casting, Shell Mold casting. The method to be used depends upon the nature of the products to be cast.

Cold Forming Process

Examples are Squeeze casting, Pressure die casting, Gravity die casting, Burnishing, Coining, Cold forging, Hubbing, Impact Extrusion, Peening, Sizing, Thread rolling.

Comparative Advantages, Disadvantages and Applications for Various Casting Methods :

Sand Casting		
Advantages	**Disadvantages**	**Recommended Application**
Least Expensive in small quantities (less than 100) Ferrous and non - ferrous metals may be cast Possible to cast very large parts. • Least expensive tooling	Dimensional accuracy inferior to other processes, requires larger tolerances Castings usually exceed calculated weight Surface finish of ferrous castings usually exceeds 125 RMS	Use when strength/weight ratio permits Tolerances, surface finish and low machining cost does not warrant a more expensive process
Permanent and Semi-permanent Mold Casting		
Less expensive than Investment or Die Castings Dimensional Tolerances closer than Sand Castings Castings are dense and pressure tight	Only non-ferrous metals may be cast by this process Less competitive with Sand Cast process when three or more sand cores are required Higher tooling cost than Sand Cast	Use when process recommended for parts subjected to hydrostatic pressure Ideal for parts having low profile, no cores and quantities in excess of 300
Plaster Cast		
Smooth "As Cast" finish (25 RMS) Closer dimensional tolerance than Sand Cast	More costly than Sand or Permanent Mold-Casting Limited number of sources	Use when parts require smooth "As Cast" surface finish and closer tolerances than possible with Sand or Permanent

		Mold Processes
• Intricate shapes and fine details including thinner "As Cast" walls are possible • Large parts cost less to cast than by Investment process	Requires minimum of 1 deg. draft	
Investment Cast		
Close dimensional tolerance Complex shape, fine detail, intricate core sections and thin walls are possible Ferrous and non-ferrous metals may be cast As-Cast" finish (64 - 125 RMS)	Costs are higher than Sand, Permanent Mold or Plaster process Castings	Use when Complexity precludes use of Sand or Permanent Mold Castings The process cost is justified through savings in machining or brazing Weight savings justifies increased cost
Die Casting		
Good dimensional tolerances are possible Excellent part-part dimensional consistency Parts require a minimal post machining	Economical only in very large quantities due to high tool cost Not recommended for hydrostatic pressure applications For Castings where penetrate (die) or radiographic inspection are not required.	Use when quantity of parts justifies the high tooling cost Parts are not structural and are subjected to hydrostatic pressure

	Difficult to guarantee minimum mechanical properties	

<u>SAND MOULD CASTING</u>:- Also known as sand molding casting, sand casting is a casting-based manufacturing process that involves the use of a sand mold. It's used to create metal products and components in a variety of sizes and shapes. To put its popularity into perspective, statistics show over half of all metal castings — about 60% — are produced using sand casting. Below, you'll learn more about the six primary steps of sand casting.

<u>Step -1) Place Mold Pattern in Sand</u>:-The first step of sand casting involves the placement of the mold pattern in sand. The size and shape of the casting is directly influenced by the mold. Therefore, manufacturing companies must create new molds to create metal products and components in specific sizes and shape.

<u>Step -2) Set Up the Gating System</u>:-Most casting processes involve the use of a gating system, and sand casting is no exception. Consisting of a pouring cup and tunnels or "gates" to the mold, it's used to funnel the molten mold into the mold cavity. After placing the mold pattern in sand, manufacturing companies will set up a gating system such as this.

<u>Step -3) Remove the Mold Pattern</u>:-With the gating system set up, manufacturing companies can then remove the mold pattern from the sand. The mold pattern is no longer relevant at this point. When the mold pattern is placed inside sand, the sand takes its shape. As a result, the mold pattern can be removed.

<u>Step -4) Pour Molten Metal Into Mold Cavity</u>:-Now it's time to pour the molten metal into the mold cavity. Sand casting supports a variety of different metals and alloys, some of which include iron, steel, aluminum, bronze, magnesium, zinc and tin. Depending on the specific metal or alloy used, manufacturing companies may need to heat it up to 3,000 degrees Fahrenheit. Once the metal or alloy has turned from a solid state to a liquid state, it's poured into the mold cavity.

<u>Step -5) Wait for Metal to Cool</u>:-After the molten metal has been poured into the mold cavity, manufacturing companies must wait for it to cool. Again, different types of metal take different lengths of time to cool. As the molten metal cools, it will revert from a liquid state back to a solid state.

Step -6) Break Open Mold to Remove the Metal Casting:-The sixth and final step of sand casting involves breaking open the mold to remove the newly created metal casting. While molds patterns are typically reusable, the actual molds are not. Therefore, manufacturing companies must recreate a new mold each time they want to create a new metal product or component using sand casting.

DIFFERENT TYPES OF MOLDING SANDS AND THEIR COMPOSITION

1: Green sand:- The sand in its natural or moist state is called green sand. It is also called tempered sand. It is a mixture of sand with 20 to 30 percent clay, having total amount of water from 6 to 10 percent. The mould prepared with this sand is called green sand mould, which is used for small size casting of ferrous and non-ferrous metals.

2: Dry Sand:-The green sand moulds when baked or dried before pouring the molten metal are called dry sand moulds. The sand of this condition is called dry sand. The dry sand moulds have greater strength, rigidity and thermal stability. These moulds used for large and heavy casting.

3: Loam Sand:-A mixture of 50 percent sand grains and 50 percent clay is called loam sand. It is used for loam moulds of large grey iron casting.

4: Facing Sand:-A sand which is used before pouring the molten metal, on the surface is called facing sand. It is specially prepared sand from silica sand and clay.

5: Backing or Floor Sand:-A sand used to back up the facing sand and not used next to the pattern is called backing sand. The sand which have been repeatedly used may be employed for this purpose. It is also known as black sand due to its color.

6: System Sand:-A sand employed in mechanical sand preparation and handling system is called system sand. This sand has high strength, permeability and refractoriness.

7: Parting Sand:-A sand employed on the faces of the pattern before the molding is called parting sand. The parting sand consists of dried silica sand, sea sand or burnt sand.

8: Core Sand:-The cores are defined as sand bodies used to form the hollow portions or cavities of desired shape and size in the casting. Thus the sand used for making these cores is called core sand. It is sometimes called oil sand. It is the silica sand mixed with linseed oil or any other oil as binder.

PROPERTIES OF MOULDING SAND

1: Porosity or permeability:-It is the property of sand which permits the steam and other gases to pass through the sand mould. The porosity of sand depends upon its grain size, grain shape, moisture and clay components are the molding sand. If the sand is too fine, the porosity will be low.

2: Plasticity:-It is that property of sand due to which it flows to all portions of the molding box or flask. The sand must have sufficient plasticity to produce a good mould.

3: Adhesiveness:-It is that properties of sand due to it adheres or cling to the sides of the molding box.

4: Cohesiveness:-It is the property of sand due to which the sand grains stick together during ramming. It is defined as the strength of the molding sand.

5: Refractoriness:-The property which enables it to resist high temperature of the molten metal without breaking down or fusing.

Pattern:-A pattern may be defined as a model of desired casting which when molded in sand forms an impression called mould. The mould when filled with the molten metal forms casting after solidification of the poured metal. The quality and accuracy of casting depends upon the pattern making. The pattern may be made of wood, metal(cast iron, brass, aluminum and alloy steel.), plaster, plastics and wax.

Pattern Allowances:-A pattern is always made larger than the required size of the casting considering the various allowances. These are the allowances which are usually provided in a pattern.

1: Shrinkage or contraction allowance:-The various metals used for casting contract after solidification in the mould. Since the contraction is different for different materials, therefore it will also differ with the form or type of metal.

2: Draft allowance:-It is a taper which is given to all the vertical walls of the pattern for easy and clean withdraw of the pattern from the sand without damaging the mould cavity. It may be expressed in millimeters on a side or in degrees. The amount of taper varies with the type of patterns. The wooden patterns require more taper than metal patterns because of the greater frictional resistance of the wooden surfaces.

3: Finish or machining allowance:-The allowance is provided on the pattern if the casting is to be machined. This allowance is given in addition to shrinkage allowance. The amount of this allowance varies from 1.6 to 12.5 mm which depends upon the type of the casting metal, size and the shape of the casting. The ferrous metals require more machining allowance than non ferrous metals.

4: Distortion or camber allowance:-This allowance is provided on patterns used for casting of such design in which the contraction is not uniform throughout.

5: Rapping or shaking allowance:-This allowance is provided in the pattern to compensate for the rapping of mould because the pattern is to be rapped before removing it from the mould.

Types of Patterns:

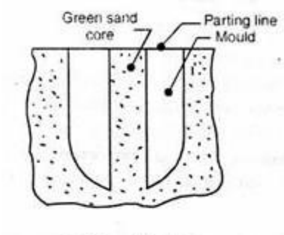
The common types of patterns are as follows:
1. Solid or single piece patterns
2. Split or two/multiple piece patterns
3. Match plate pattern
4. Cope and drag pattern
5. Loose piece pattern
6. Gated patterns
7. Sweep pattern
8. Skeleton pattern
9. Shell pattern
10. Segmental pattern
11. Follow board pattern
12. Lagged up pattern
13. Left and right hand pattern

CORE:- A core is a device used in casting and molding processes to produce internal cavities and reentrant angles (an interior angle that is greater than 180°). The core is normally a disposable item that is destroyed to get it out of the piece. For example, cores define multiple passages inside cast engine blocks.

A core is usually made of the best quality sand and is placed into desired position in the mould cavity. Core prints are added to both sides of the pattern to create impressions that allow the core to be supported and held at both ends. When the molten metal is poured, it flows around the core and fill the rest of the mould cavity. Cores are subjected to extremely severe conditions, and they must, therefore, possess very high resistance to erosion, exceptionally high strength, good permeability, good refractoriness, and adequate collapsibility. Special vent holes are provided on the core to allow gasses to escape easily. Sometimes, cores are reinforced with low carbon steel wires or even cast-iron grids (in case of large cores) to ensure stability and resistance to shrinkage.

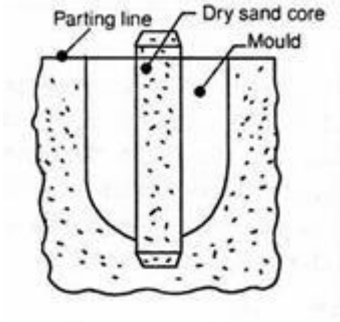
Types of Cores:- Generally, cores are of two types:

1. Green Sand Core::- A core formed by the pattern itself, in the same sand used for the mould is known as green sand core. The pattern is so designed that it provides the core of green sand. The hallow part in the pattern produces the green sand core.



(a) Green Sand Core.

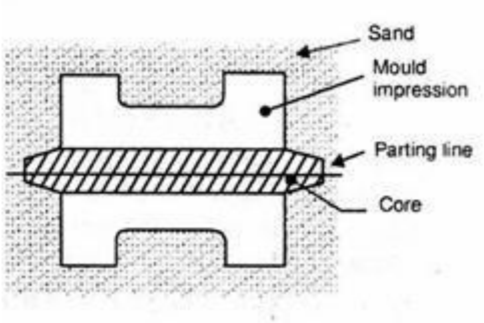
2. Dry Sand Core:-A core is prepared separately in core boxes and dried, is known as dry sand core. The dry sand cores are also known as process cores. They are available in different sizes, shapes and designs as per till requirement.



(b) Dry Sand Core.

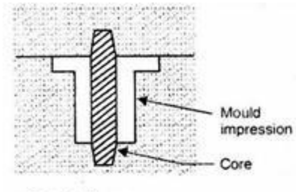
Some common types of dry-sand cores are:

(i) Horizontal Core:-The horizontal core is the most common type of core and is positioned horizontally at the parting surface of the mould. The ends of the core rest in the seats provided by the core prints on the pattern. This type of core can withstand the turbulence effect of the molten metal poured.



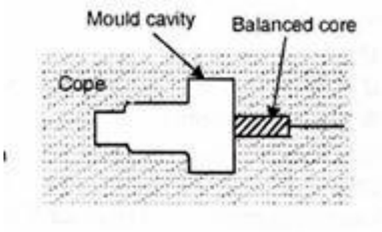
(c) Horizontal core.

(ii) Vertical Core:-The vertical core is placed vertically with some of their portion lies in the sand. Usually, top and bottom of the core is kept tapered but taper on the top id greater them at bottom.



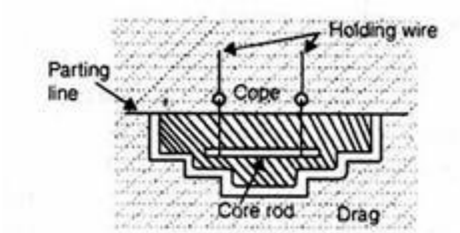
(d) Vertical core.

(iii) Balance Core:-The balance core extends only one side of the mould. Only one core print is available on the pattern for balance core. This is best suitable for the casting has only one side opening. This is used for producing blind holes or recesses in the casting.



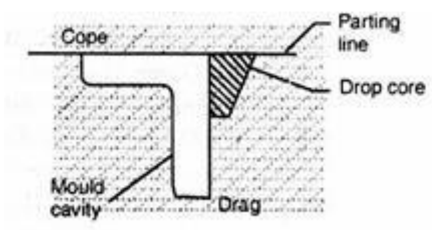
(e) Balanced core.

(iv) Hanging Core:-The hanging core is suspended vertically in the mould. This is achieved either by hanging wires or the core collar rests in the collar cavity created in the upper part of the mould. This type of core does not have bottom support.



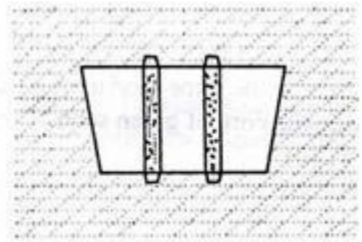
(h) Hanging core.

(v) Drop Core:-The drop core is used when the core has to be placed either above or below the parting line. This core is also known as wing core, tail core, chair core, etc.



(f) Drop core.

(vi) Kiss Core:-The kiss core is used when a number of holes of less dimensional accuracy is required. In this case, no core prints are provided and consequentially, no seat is available for the core. The core is held in position approximately between the cope and drag and hence referred as kiss core.



(g) Kiss core.

Core Materials:-The compositions of core material are the mixture of sand, binders and additives. Core sands are silica, zircon, Olivine etc. and core binders are core oils, resins, molasses, dextrin etc., are generally used for preparation of core materials. Sand contains more than 5% clay reduces not only permeability but also collapsibility and hence not suitable for core making.

Properties of Good Core Materials:-A good dry sand core must have the following properties in order to successfully use in casting process:

1. Strong:-It should be strong enough to withstand the turbulence force of molten metal. It should be erosion resistant.

2. Hardness:-It should be capable, of being baked to obtain good hardness strength.

3. Permeability:-It must be permeable to allow the easy escape of the gases formed.

4. Refractoriness:-It must be highly refractory in nature to withstand high temperature of the molten metal.

5. Dimensional Stability:-It should be stable in dimensional accuracy, shape and size during pouring and solidification.

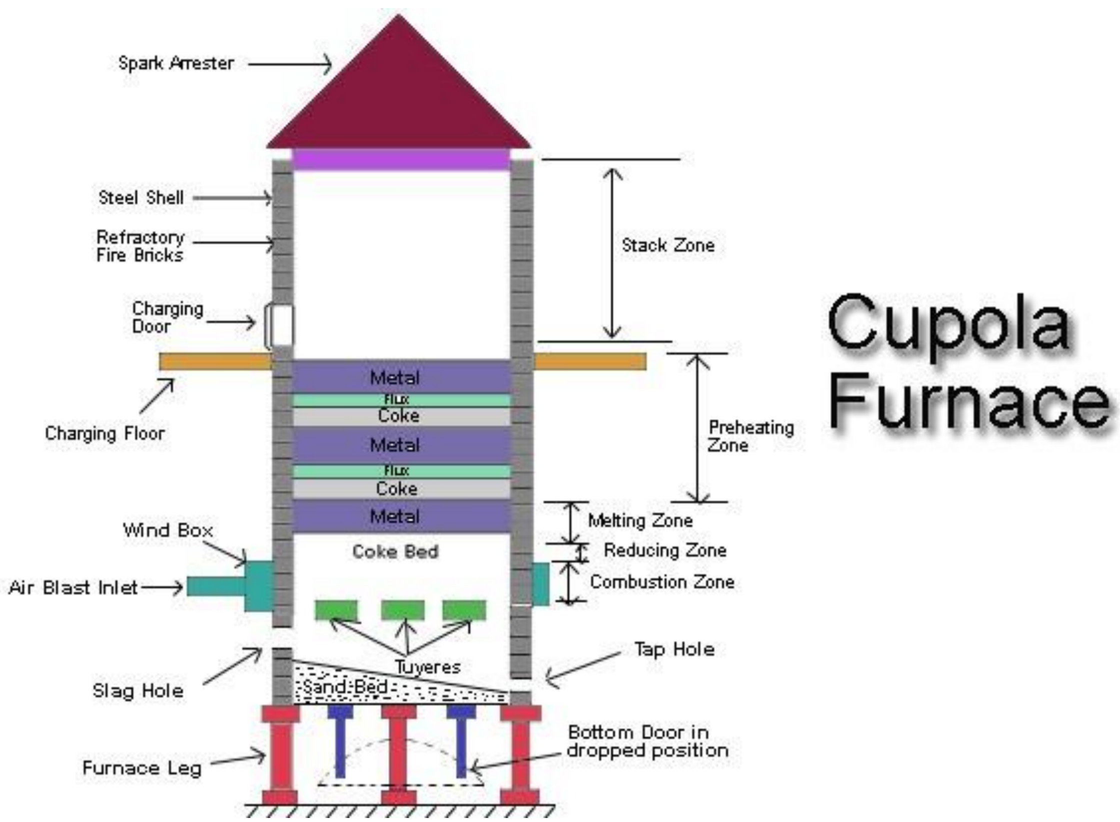
6. Minimum Gas-Formation:-Core material should generate minimum gases, while subjecting to molten metal in casting process.

7. Good Surface Finish:-Core surface should be smooth enough to provide good surface finish of the casting.

8. Sufficiently Collapsible:-Cores must be sufficiently collapsible i.e., easy removal of the core from the casting after solidification.

CUPOLA FURNACE CONSTRUCTION AND WORKING

Cupola Furnace is a melting device which used to melt cast iron, Bronze and other alloying elements are melted. It is mainly used to convert pig iron to cast iron. Cupola furnace is cylindrical in shape and the equipment of this furnace is vertically fitted inside this cylindrical shell with doors. For many years Cupola Furnace was used to melt iron in iron foundries because it produces good Cast iron from Pig Iron. The top of the cupola furnace is sometimes fitted with a cap to prevent the escape of harmful gases to the environment and this cap also protect it from rainwater. The cupola shell is made of steel and has a lining of refractory brick and plastic refractory patching material. The bottom of this shell is lined with clay and sand mixture and it is a temporary lining. Sometimes coal is mixed with clay lining so that when coal heats up it decomposes and the bond becomes friable. In some cupola lining cooling jackets are also fitted to keep the sides cool. Sometimes oxygen injection are also provided to make the coke fire burn hotter.



Parts of Cupola Furnace :-

1) Cylindrical Shell:-It is the outermost part of the Cupola Furnace. It is made up of steel sheet and other parts of this furnace are present inside this shell.

2) Legs:-At the bottom of the Cupola Furnace legs are provided to support this furnace.

3) Cast Iron Door:-This cast iron is present at the bottom of the furnace above the legs which is closed by the support of the legs.

4) Sand Bed:-Above the cast iron door sand bed is present. It is in taperred form so that the melted iron can flow out easily from its top.

5) Slag Hole:-It is present at the opposite side of the hole from which melted iron comes out.It is present near the elevated part of sand bed. This slag hole is used to remove slag formed on melted iron due to impurities.

6) Air Pipes and Tuyers:-The air pipe is provided to allow the air to reach inside the furnace. Inside the furnace wind belt is present. The air entering from the air pipes reaches each part of the wind belt and in the wind belt there are holes which are called tuyers. Air reaches the furnace through this tuyers and will help in combustion.

7) Spark Arrester Or Cap Of Furnace :-It is present at the top of the furnace. When gases are released out of the furnace, some burning particles are present in it which can harm the environment. So this cap or spark arrester is used to capture the burning particles and only allow the gas to pass to the environment.

8) Charging Door :-It is present near the top of the furnace. It is used to supply charge to the furnace. The charges in this furnace are Pig Iron, Coke and Lime Stone. Coke is used for combustion, pig iron is the material that is to be melt and lime stone is used as a flux. This flux mix with impurities to form slag and this slag comes out of the slag hole.

9) Well:-The part of the furnace from the send bed to lower part of tuyers is known as Well. It is named as well as in this part molten iron is stored and then the molten iron comes out of the tapping hole.

10) Tuyers Zone:-The part of the furnace in which the wind belt and tuyers are present is known as Tuyers Zone.

11) Combustion Zone:-In this zone combustion takes place. The air coming from the tuyers contains oxygen and this oxygen reacts with carbon to form carbon dioxide. It is also known as oxidixing zone as carbon oxidizes in this zone to form carbon dioxide and liberate heat. Apart from carbon other impurities like manganese, silicon also oxidizes in this zone to form their oxides and liberate heat.

12) Reducing Zone:-It is present above the combustion or oxidizing zone. It this zone carbon reacts with carbon dioxide to form carbon monoxide. In this zone temperature is reduced by a small amount, so this zone is known as reducing zone.

13) Melting Zone:-In this zone iron melts and this molten iron comes out of the tap hole. The temperature of this zone is very high nearly 1600 degree Celsius.

14) Preheating Zone:-In this zone the metal to be melted is preheated, in this zone metal is heated to about 1090 degree Celsius.

15) Stack Zone:-Gases formed in the furnace after burning passes to the environment through this zone. In this zone, spark arrester is present which prevent burning particles to reach the environment.

Construction Of Cupola Furnace :-

The outermost part of cupola furnace is cylindrical steel shell. The diameter of this shell ranges from 1.5 to 13 feet depending upon the size of the furnace. The inner side of the furnace is lined withrefractory brick and plastic refractory patching material.This furnace is supported on Cast iron legs mounted on concrete base. At the bottom of the furnace, two cast iron doors are hinged with the bed plate of the furnace. Near the bottom, it has send bed above which the melted iron flow. This sand bed is tapered. Near the elevated side of the tapered sand bed, slag hole is present through which slag formed from impurities comes out. Near the downside of the down bed, the tap hole is present through which molten iron comes out. Above the send bed, tuyers are present through which air reaches the furnace and helps in combustion.

At the top of the furnace spark arrester or cap is present that traps the burning particles and only allow the gases to release to the environment.

Near the top of the furnace, charging door is present through which metal, coke and lime stone are fed into the furnace.

Working of Cupola Furnace :-At first wood is ignited above the sand bed. When the wood starts burning properly, coke is dumped on the well from the top to a predetermined height of nearly 40 inches. This forms a 40 inch coke bed.

Then the combustion starts in the coke bed using the fire from the burning wood and using the air from the tuyers. At this time, the air blast is turned out at a lower blowing rate than normal to provoke the coke.
After nearly 3 hours of burning when the coke starts burning properly, alternate layers of limestone, pig iron and coke is charged until it reaches the level of charging door is reached. At this time the air blast is tuned on to normal blowing rate and the combustion occurs more rapidly in the coke bed.
All oxygen from the air blast is consumed by the combustion in the combustion zone. The chemical reaction which takes place is,
$C + O_2 \rightarrow CO_2$ + Heat
This is an exothermic reaction and in the combustion zone the temperature varies from 1150 to 1850 degree Celsius.
The portion of the coke bed above the combustion zone is reducing zone. This zone prevent the oxidation of metal charge above and while dropping through it.As the ho carbon dioxide moves up through this zone, some of it is reduced by the following reaction,
$CO_2 + C \rightarrow 2CO$
The layer of iron above reducing zone is melting zone where the solid iron is converted into molten iron. This melted iron trickles down through the coke bed and is collected in the well. Sufficient carbon content is picked up by the molten metal in this zone and is represented by the chemical reaction given as :-
$3 Fe + 2 CO \rightarrow Fe_3C + CO_2$
Above the melting zone, there is preheating zone where the charge is preheated by the outgoing gases and the temperature of this zone is about 1900 degree Celsius.
Apart from limestone, fluorspar and soda ash are also used as flux material. Main function of flux is to remove impurities from iron and protect iron from oxidation.
Within 5 to 10 minutes of starting of air blast to normal blowing rate , the first molten iron appears at the tap hole.
The charging door is closed till the metal melts. The contents of the charge move down as the melting proceeds. The rate of charging i.e the rate of adding layers of charge is equal to the rate of melting. The furnace is kept full throughout the process.
When the melting process is finished and no more molten irons is required then the feed of charge is stopped and the air blast is also stopped. The bottom plate swings to open when the prop is removed and the slag is removed.
Normally copula furnace is not used more than 4 hours but can be used for 10 hrs of continuous operation.

Advantages of Cupola Furnace :-

- Simple in Construction.
- Wide range of material can be melted.

- Less floor space is required.
- Very skilled operators are not required. Can be easily operated by low skill person.
- Low cost of operation.
- Low cost of maintenance.
- Low cost of construction.

Disadvantages of Cupola Furnace:-

- The main disadvantage is that sometimes it is very hard to control the temperature in this furnace.
- Metal elements are converted to their oxide which are not suitable for casting.

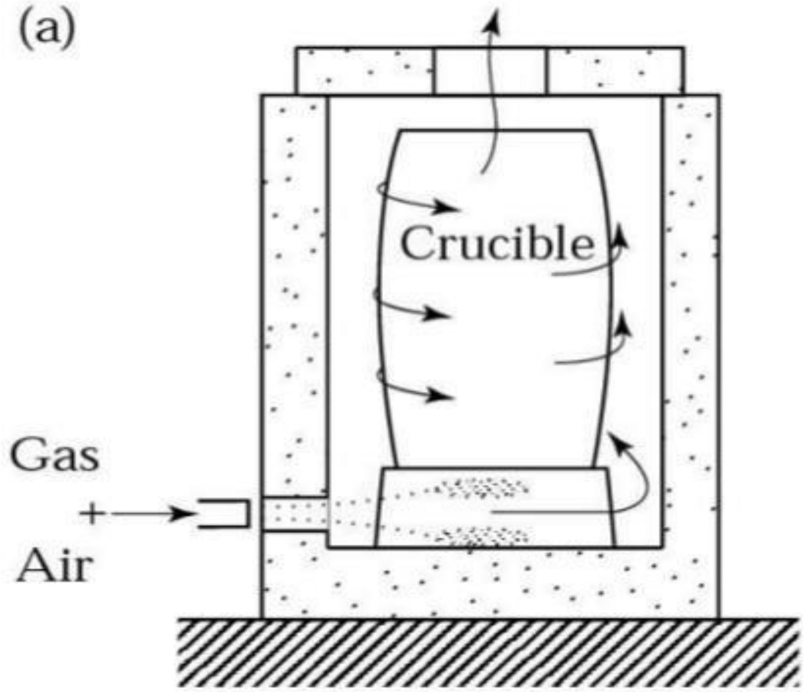
Application of Cupola Furnace:-

- It is mainly used to convert pig iron to molten iron.
- More types of cast iron are produced from this furnace like malleable and grey cast iron.
- The cooper base alloy is also manufactured by this device.

CRUCIBLE FURNACE:- Crucible furnace, metallurgical furnace consisting essentially of a pot of refractory material that can be sealed. Crucibles of graphite or of high-grade fire clay were formerly used in the steel industry, heated directly by fire; modern high-quality steel is produced by refining in air-evacuated crucibles heated by induction. Metals such as titanium, which must be protected from air while hot, are melted and annealed in hermetically sealed crucibles. Crucible furnaces are one of the oldest and simplest types of melting 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. Crucible melting is commonly used where small batches of low melting point alloy are required. The capital outlay of these furnaces makes them attractive to small non-ferrous foundries. Crucible furnaces are typically classified according to the method of removing the metal from the crucible:

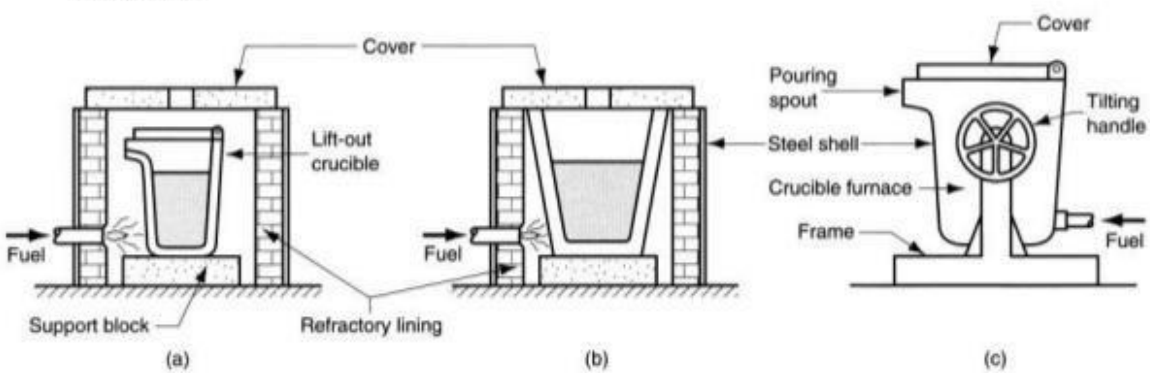
1. **Tilting furnace**:-in which the molten metal is transferred to the mould or ladle by mechanically tilting the crucible and furnace body.
2. **Lift-out furnace**:- in which the crucible and molten metal are removed from the furnace body for direct pouring into the mould.
3. **Bale-out furnace**:- in which the metal is ladled from the crucible to the mould.

Crucible furnace



Crucible Furnaces

Figure 11.19 Three types of crucible furnaces: (a) lift-out crucible, (b) stationary pot, from which molten metal must be ladled, and (c) tilting-pot furnace.



WORKING OF CRUCIBLE FURNACE:-

After the regenerators have brought the furnace up to a high heat, the charged crucibles are lowered one by one into the melting holes. The chimney draft prevents flame from coming out of the melting-hole openings while the crucibles are being lowered in, but these openings should not be left open longer than absolutely necessary.

The path of the gases through the regenerators is changed about every 20 minutes to keep the crucibles from eating away on the hot side. In about an hour the melter looks into the pots to see if the melting has begun, using a pair of blue glasses framed in a small board to protect his eyes. His experience enables him to make such other inspections as will keep him in thorough touch with the progress of melting. In from 3 to 6 hours the charge is thoroughly melted. It is slightly stirred with an iron rod to lift any lumps of muck bar possibly at the bottom, and to mix the charge thoroughly. The seal of the lid on the crucible is broken by such inspections, but a new joint is soon made by the heat of the furnace.

After becoming molten, the temperature of the metal will increase, and soon the occluded gases begin to boil out. This step lasts about 20 minutes and is called "killing" or "melting to a dead heat." It requires skill to determine when this has gone far enough. At the proper time, the crucible is lifted from the furnace and is set into a holder shown in Fig. 31 to be poured directly into a small mould, or into a hot ladle in which the contents of several crucibles are assembled if a large mould is to be poured.

If a crucible is taken from the furnace before the metal is "dead" it will pour "fiery," throwing off sparks and showing some agitation due to the escape of gasses, but if kept too long in the furnace, the metal will pour quietly, and the moulded ingots will be solid, but will be brittle and weak. The cause of this is uncertain, but is possibly to the absorption of an excess of silicon from the crucible walls at a very high heat.

In pouring from the crucible into the mould, which is washed inside with lime-wash to prevent the steel from sticking, great care must be exercised to keep the metal from striking the side of the mould as this would chill a film of it and cause a lamination in the ingot.

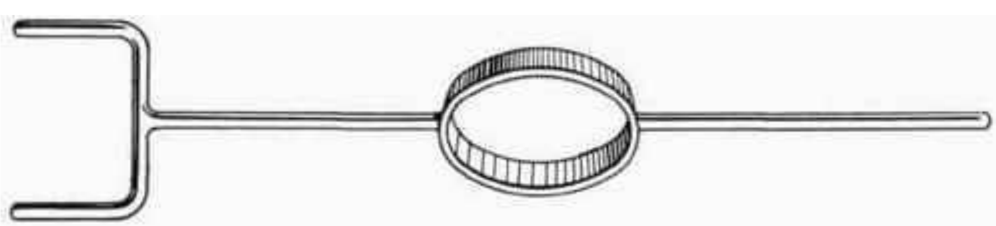


Fig. 31. - Ladle Shanks.

It requires a large crucible plant, expert skill and quick handling to assemble enough crucible steel to make successfully a large casting. The Krupp works in Germany make crucible-steel ingots large enough for high-powered guns and armor plate.

DIE CASTING METHOD:- Die casting is a metal casting process in which molten metal is forced into a steel mold under high pressure into a mold cavity. The steel molds, known as dies, are fabricated to produce castings with intricate shapes in a manner that insures both accuracy and repeatability.
The die casting process consists of 5 basic steps

1) Clamping :-The first step in die casting is clamping. The dies are cleaned and lubricated to aid in step two, injection. Once the dies have been properly cleaned and lubricated, the die halves are closed and clamped together with high pressure.

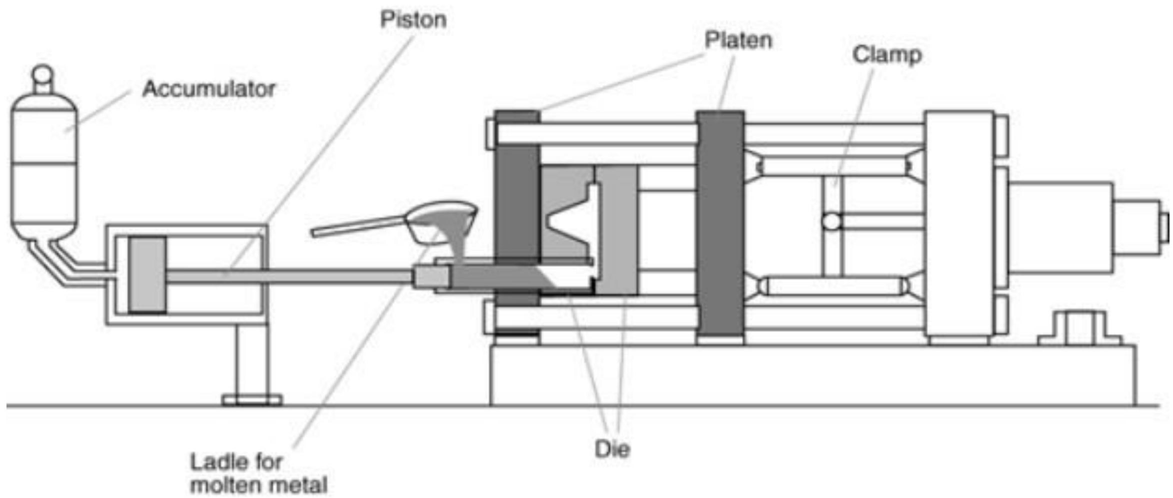
2) Injection :-The molten metal is transferred from a furnace into a ladle. The ladle then pours the molten metal into shot chamber where it is ready to be injected into the clamped die. The molten metal is then forced into the die using extremely high pressure. The high pressure then holds the metal in the die until it has time to solidify.

3) Cooling :-The third step in the process is cooling. After the molten metal is injected into the die, it must have time to solidify and cool. During this time the die cannot be unclamped. Once the metal has completely cooled it takes on its final shape of the casting.

4) Ejection:- Once the cooling process has finished, the die halves can be unclamped and an ejection mechanism pushes the solidified casting out of the die.

5) Trimming :-The final step in the die casting process is trimming. While the metal is cooling, the excess metal in the spur and runner must be removed along with any flash that has transpired. This extra material is then trimmed away from the final casting. The trimmed spur, runners, and flash can then be recycled and reused in the die casting process.

Die Casting Machine

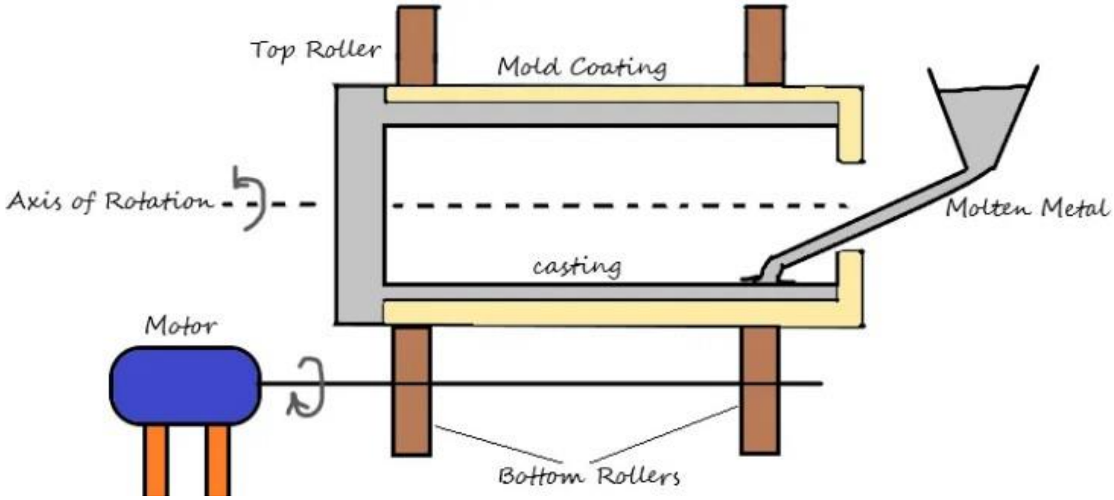


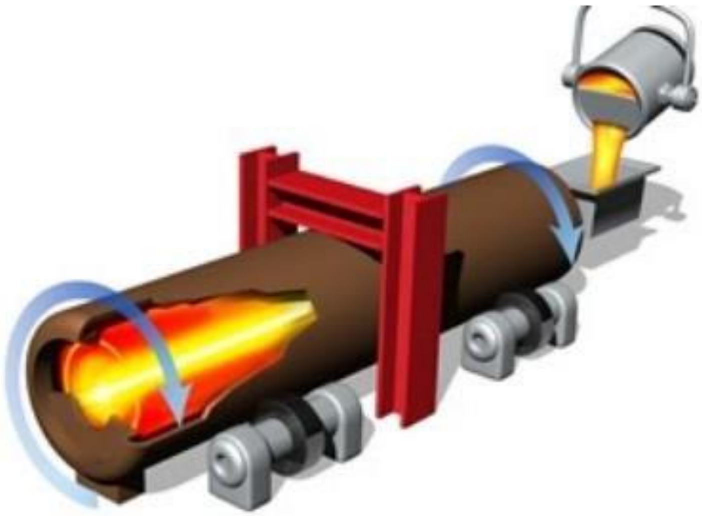
CENTRIFUGAL CASTING:- Centrifugal casting is used where we require strength, reliability, and material soundness in the end product. Unlike high cost and variable strength with forging; modern centrifugal casting provides high-quality end products with strength, high density, good performance, and even granular structure at a much lower cost.

In centrifugal casting molten metal is introduced into the mold which is continuously rotated during the whole casting process. The mold can itself be rotated horizontally or vertically depending upon the design requirements.

WORKING PRINCIPLE OF CENTRIFUGAL CASTING:- In this process molten metal is poured into the spinning mold preheated to a certain temperature. The mold is placed vertically or horizontally based on the required shape of product. Once poured it is then continued to rotate about its central axis.

Due to the rotational motion of the mold; a centrifugal force is acted upon the molten metal just poured into the spinning mold. This force displaces the molten metals towards the periphery forcing them to deposit on the walls. The molten metal is spread uniformly on to the walls of the die; thanks to the centrifugal force 100 times greater than of gravity. As the process continues with more and more metal poured into the mold; the relatively denser element tends to deposit on towards the wall while lighter elements and slug deposit at the center. The mold is then left to rotate till the whole mold solidify and then other light elements like slag are separated from the center. The whole process itself leads to a reduction in defects due to slag's , irregular grain structure, and trapped air. The final product have closed grain structure with improved elongation, tensile strength, and yield strength.





<u>Types</u>:-

1) <u>True Centrifugal Casting:-</u>

True centrifugal casting is sometime known as centrifugal casting is a process of making symmetrical round hollow sections. This process uses no cores and the symmetrical hollow section is created by pure centrifugal action. In this process, the mould rotates about horizontal or vertical axis. Mostly the mould is rotated about horizontal axis and the molten metal introduce from an external source. The centrifugal force acts on the molten metal which forces it at the outer wall of mould. The mould rotates until the whole casting solidifies. The slag particles are lighter than metal thus separated at the central part of the casting and removed by machining or other suitable process. This process used to make hollow pipes, tubes, hollow bushes etc. which are axi-symmetrical with a concentric hole.

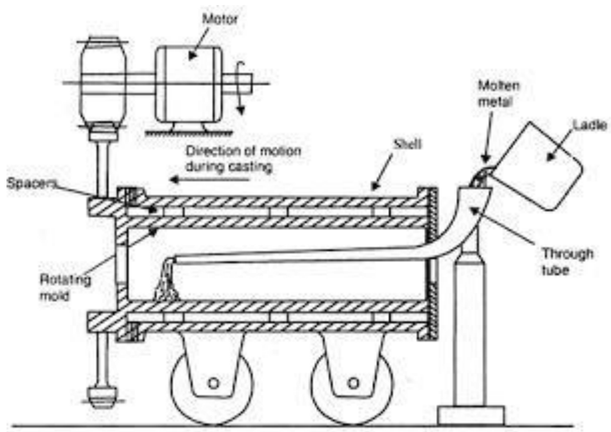


Fig. 4.15. A true centrifugal casting machine.

2) <u>Semi Centrifugal Casting</u>:-

This process is used to cast large size axi symmetrical object. In this process mould is placed horizontally and rotated along the vertical axis. A core is inserted at the center which is used to cast hollow section. When the mould rotates, the outer portion of the mould fill by purely centrifugal action and as the liquid metal approaches toward the center, the centrifugal component decreases and gravity component increase. Thus a core is inserted at center to make hollow cavity at the center without centrifugal force. In this process centrifugal force is used for uniform filling of axi symmetrical parts. Gear blanks, flywheel etc. are made by this process.

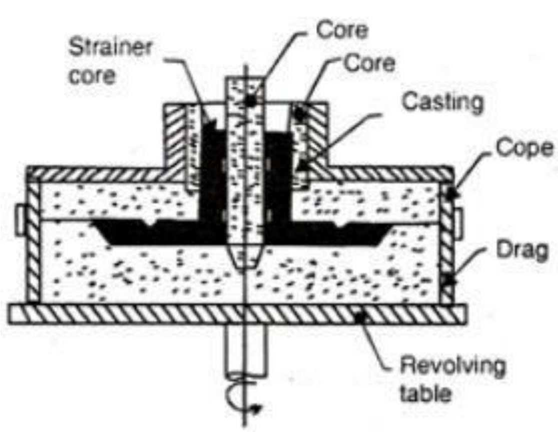


Fig. 4.16. Semi-centrifugal Casting.

3) **Centrifuging:-**In this process there are several mould cavities connected with a central sprue with radial gates. This process uses higher metal pressure during solidification. It is used to cast shapes which are not axi symmetrical. This is only suitable for small objects.

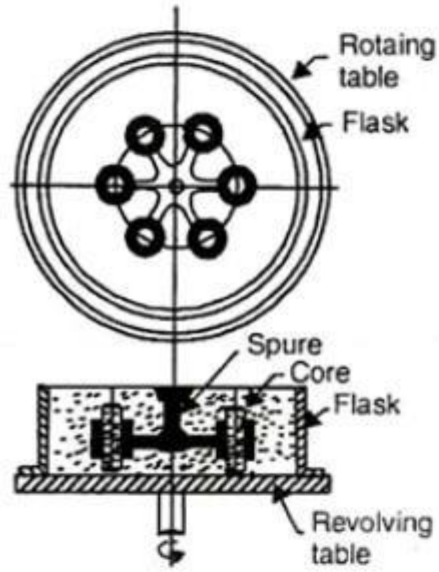


Fig. 4.17. Centrifuging casting.

Application:-

- It is widely used in aircraft industries to cast rings, flanges and compressor casting.
- It is used for cast Steam turbine bearing shell.
- Roller for steel rolling mill is another example of centrifugal casting.
- It is used in automobile industries to cast gear blank, cylindrical liners, piston rings etc.
- It is used to cast bearings.
- This process used to cast switch gear components used in electronic industries.

Advantages:-

- It provides dense metal and high mechanical properties.
- Unidirectional solidification can obtain up to a certain thickness.
- It can use for mass production.
- No cores are required for cast hollow shapes like tubes etc.
- Gating system and runner are totally eliminated.
- All the impurity like oxide or other slag particles, segregated at center from where it can easily remove.

- It required lower pouring temperature thus save energy.
- Lower casting defects due to uniform solidification.

Disadvantages:

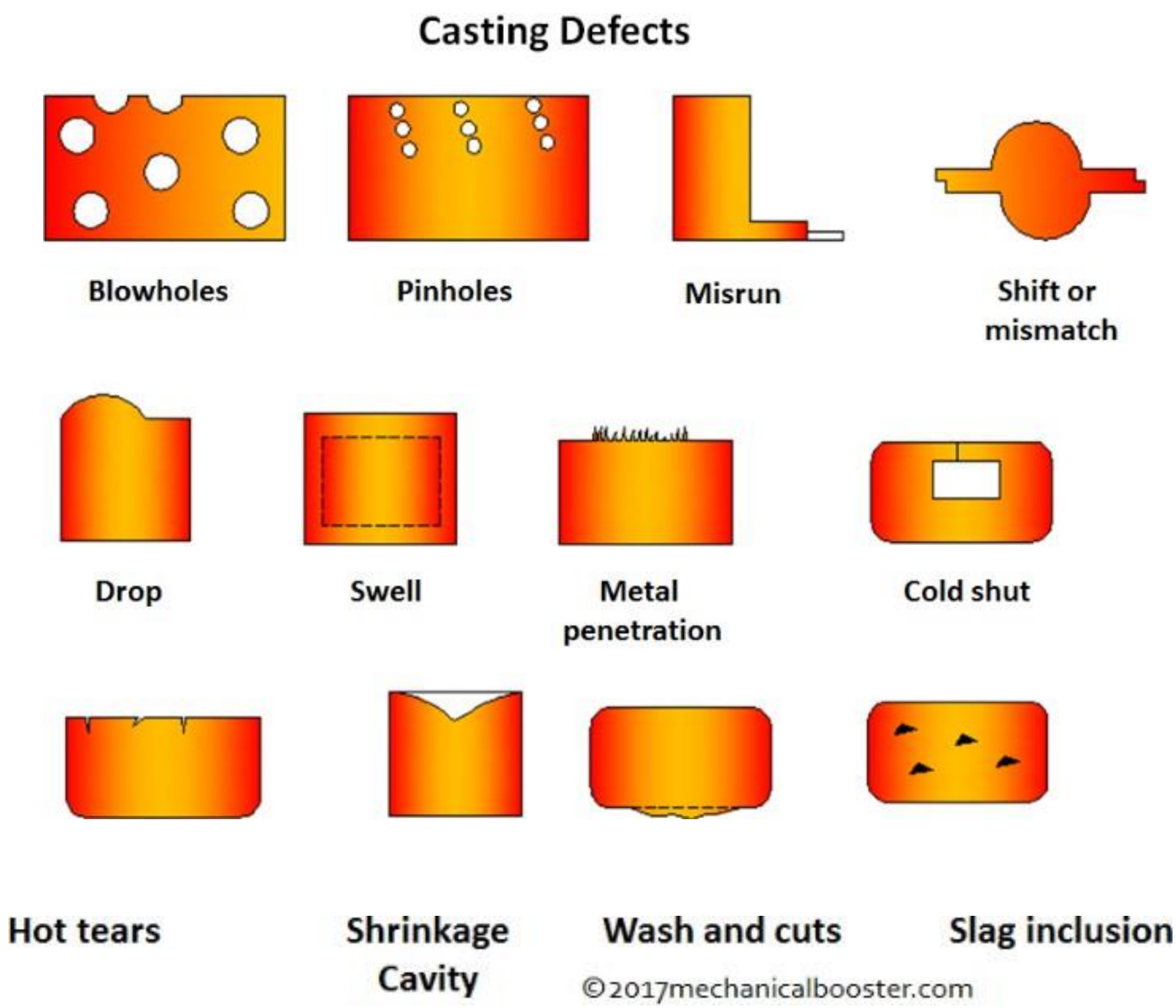
- Limited design can be cast. It can cast only symmetrical shapes.
- High equipment or setup cost.
- It is not suitable for every metal.
- Higher maintenance required.
- High skill operator required.
- In this casting process, solidification time and temperature distribution is difficult to determine.

CASTING DEFECTS:- It is an unwanted irregularities that appear in the casting during metal casting process. There is various reason or sources which is responsible for the defects in the cast metal. Different types of casting defects are unwanted occurrence on a casting during the casting process. It may lead to bad shape, weak casting, and poor functionality. Casting defects are broken down into five main categories: gas porosity, shrinkage, mold material, pouring metal, and metallurgical Casting defects. Some casting defects can be repaired while some are tolerated. Avoiding any of this types of casting defects, one needs to have clear understanding on its types and their remedies. This defects are less when technical level of each operation is perfectly done. That could be achieved by skills of the operator, management quality, and good and maintained equipment.

Types

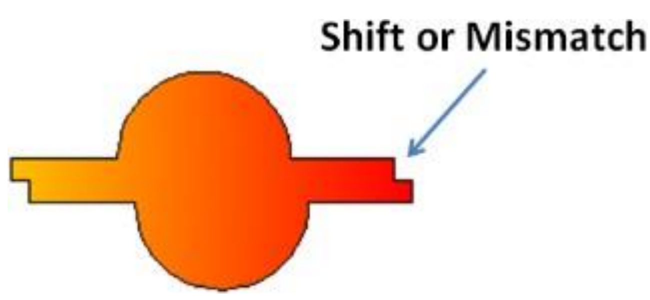
Casting defects can be categorized into 5 types

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



The various casting defects that appear in the casting process are

<u>1. Shift or Mismatch</u>:-The defect caused due to misalignment of upper and lower part of the casting and misplacement of the core at parting line.



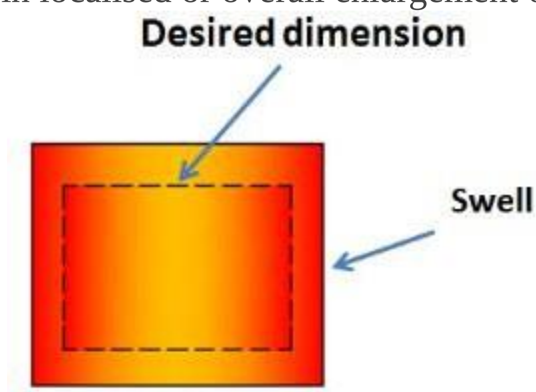
Cause:-

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

Remedies:-

1) Proper alignment of the pattern or die part, molding boxes.
2) Correct mountings of pattern on pattern plates.
3) Check the alignment of flask.

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



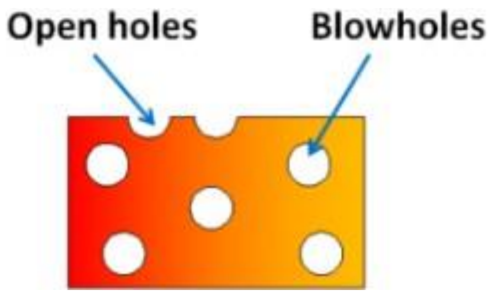
Causes

(i) Defective or improper ramming of the mold.

Remedies

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

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



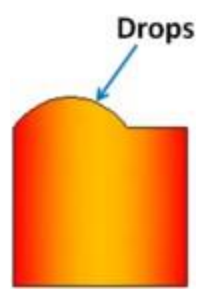
Causes

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

Remedies

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

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



Causes:-

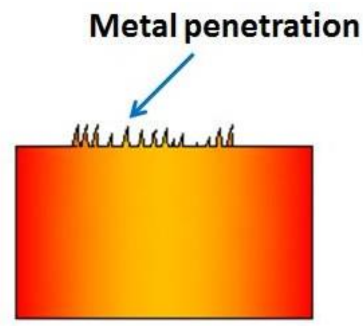
(i) Soft ramming and low strength of sand.
(ii) Insufficient fluxing of molten metal. Fluxing means addition of a substance in molten metal to remove impurities. After fluxing the impurities from the molten

metal can be easily removed.
(iii) Insufficient reinforcement of sand projections in the cope.

Remedies:-
(i) Sand of high strength should be used with proper ramming (neither too hard nor soft).
(ii) There should be proper fluxing of molten metal, so the impurities present in molten metal is removed easily before pouring it into the mold.
(iii) Sufficient reinforcement of the sand projections in the cope.

5. Metal Penetration:-

These casting defects appear as an uneven and rough surface of the casting. When the size of sand grains is larges, the molten fuses into the sand and solidifies giving us metal penetration defect.

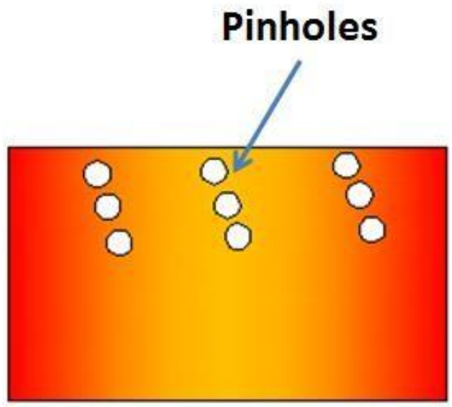


Causes:-
(i) It is caused due to low strength, large grain size, high permeability and soft ramming of sand. Because of this the molten metal penetrates in the molding sand and we get rough or uneven casting surface.

Remedies:-
(i) This defect can be eliminated by using high strength, small grain size, low permeability and soft ramming of sand.

6. Pinholes:-

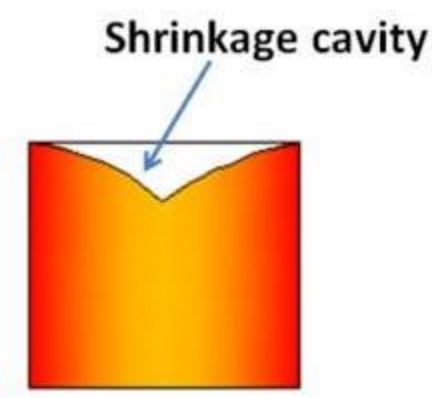
They are very small holes of about 2 mm in size which appears on the surface of the casting. This defect happens because of the dissolution of the hydrogen gases in the molten metal. When the molten metal is poured in the mold cavity and as it starts to solidify, the solubility of the hydrogen gas decreases and it starts escaping out the molten metal leaves behind small number of holes called as pinholes.



Causes:-
(i) Use of high moisture content sand.
(ii) Absorption of hydrogen or carbon monoxide gas by molten metal.
(iii) Pouring of steel from wet ladles or not sufficiently gasified.

Remedies:-
(i) By reducing the moisture content of the molding sand.
(ii) Good fluxing and melting practices should be used.
(iii) Increasing permeability of the sand.
(iv) By doing rapid rate of solidification.

7. Shrinkage Cavity:-
The formation of cavity in the casting due to volumetric contraction is called as shrinkage cavity.

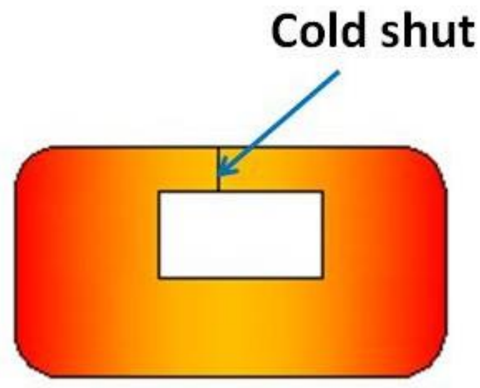


Causes:-
(i) Uneven or uncontrolled solidification of molten metal.
(ii) Pouring temperature is too high.

Remedies:-
(i) This defect can be removed by applying principle of directional solidification in mold design.
(ii) Wise use of chills (a chill is an object which is used to promote solidification in a specific portion of a metal casting) and padding.

8. Cold Shut:-

It is a type of surface defects and a line on the surface can be seen. When the molten metal enters into the mold from two gates and when these two streams of molten metal meet at a junction with low temperatures than they do not fuse with each other and solidifies creating a cold shut (appear as line on the casting). It looks like a crack with round edge.

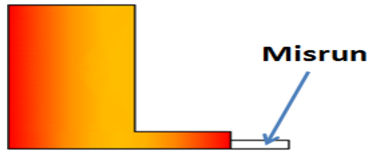


Causes:-
(i) Poor gating system
(ii) Low melting temperature
(iii) Lack of fluidity

Remedies:-
(i) Improved gating system.
(ii) Proper pouring temperature.

9. Misrun:-

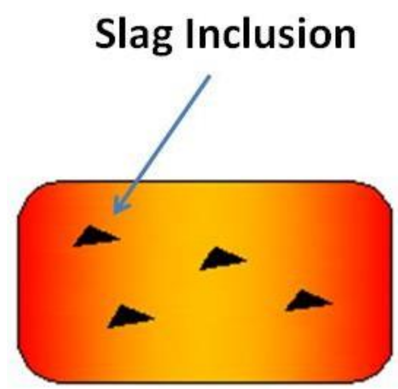
When the molten metal solidifies before completely filling the mold cavity and leaves a space in the mold called as misrun.



Causes:-
(i) Low fluidity of the molten metal.
(ii) Low temperature of the molten metal which decreases its fluidity.
(iii) Too thin section and improper gating system.

Remedies:-
(i) Increasing the pouring temperature of the molten metal increases the fluidity.
(ii) Proper gating system
(iii) Too thin section is avoided.

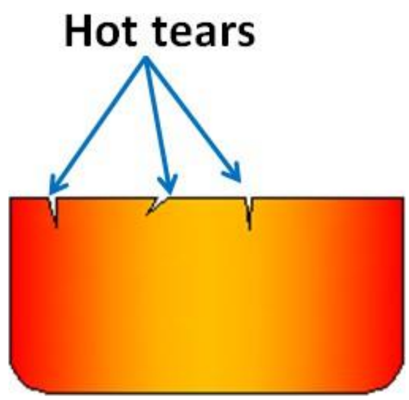
10. Slag Inclusion:-
This defect is caused when the molten metal containing slag particles is poured in the mold cavity and it gets solidifies.



Causes
(i) The presence of slag in the molten metal

Remedies
(i) Remove slag particles form the molten metal before pouring it into the mold cavity.

11. Hot Tears or Hot Cracks:-when the metal is hot it is weak and the residual stress (tensile) in the material cause the casting fails as the molten metal cools down. The failure of casting in this case is looks like cracks and called as hot tears or hot cracking.



Causes
(i) Improper mold design.

Remedies
(i) Proper mold design can easily eliminate these types of casting defects.
(ii) Elimination of residual stress from the material of the casting.

12. Hot Spot or Hard Spot:-
Hot spot defects occur when an area on the casting cools more rapidly than the surrounding materials. Hot spot are areas on the casting which is harder than the surrounding area. It is also called as hard spot.

Causes
(i) The rapid cooling an area of the casting than the surrounding materials causes this defect.

Remedies
(i) This defect can be avoided by using proper cooling practice.
(ii) By changing the chemical composition of the metal.

13. Sand Holes:-
It is the holes created on the external surface or inside the casting. It occurs when loose sand washes into the mold cavity and fuses into the interior of the casting or rapid pouring of the molten metal.

Causes:-
(i) Loose ramming of the sand.
(ii) Rapid pouring of the molten metal into the mold results in wash away of sand from the mold and a hole is created.
(iii) Improper cleaning of the mold cavity.

Remedies

(i) Proper ramming of the sand.
(ii) Molten metal should be poured carefully in the mold.
(iii) Proper cleaning of the molten cavity eliminates sand holes.

14. Dirt

The embedding of particles of dust and sand in the casting surface, results in dirt defect.

Causes:

(i) Cursing of mold due to improper handling and Sand wash (A sloping surface of sand that spread out by stream of molten metal).
(ii) Presence of slag particles in the molten metal.

Remedies:

(i) Proper handling of the mold to avoid crushing.
(ii) Sufficient fluxing should be done to remove slag impurities from molten metal.

15. Honeycombing or Sponginess

It is an external defect in which there is a number of small cavities in close proximity present in the metal casting.

Causes:

(i) It is caused due to dirt and scurf held mechanically in the suspension of the molten metal.
(ii) Due to imperfect skimming in the ladle.

Remedies

(i) Prevent the entry of dirt and scurf in the molten metal.
(ii) Prevent sand wash.
(iii) Remove slag materials from the molten metal by proper skimming in the ladle.

16. Warpage:

It is an accidental and unwanted deformation in the casting that happens during or after solidification. Due to this defect, the dimension of the final product changes.

Causes:

(i) Due to different rates of solidification of different sections. This induces stresses in adjoining walls and result in warpage.
(ii) Large and flat sections or intersecting section such as ribs are more prone to these casting defects.

Remedies

(i) It can be prevented by producing large areas with wavy, corrugated construction, or add sufficient rib-like shape, to provide equal cooling rates in all areas.

(ii) Proper casting designs can reduce these defects more efficiently.

17. Fins

A thin projection of metal, not considered as a part of casting is called as fins or fin. It is usually occurs at the parting of the mold or core section.

Causes:

(i) Incorrect assembling of mold and cores.

(ii) Insufficient weight of the mold or improper clamping of the flask may produce the fins.

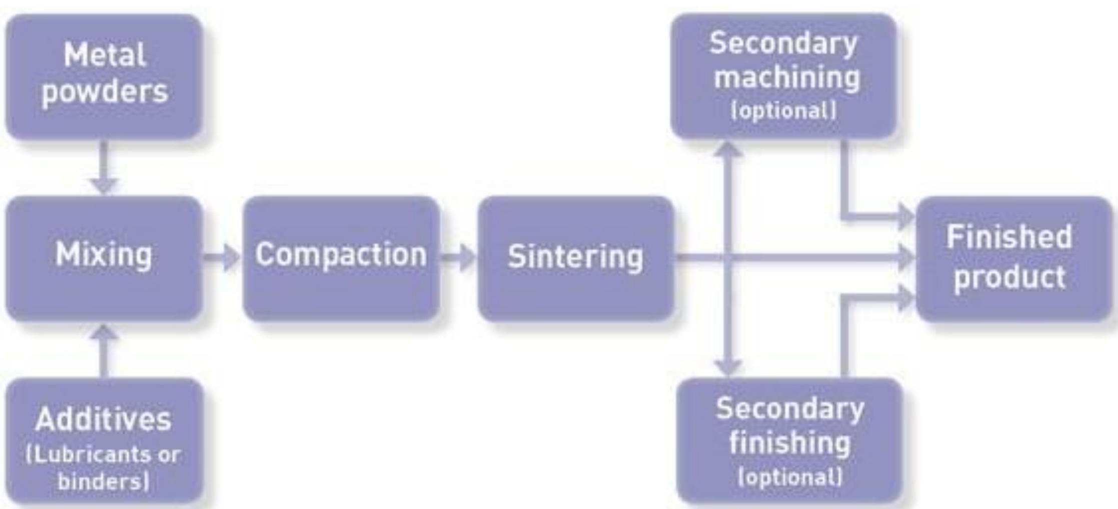
Remedies

(i) Correct assembly of the mold and cores.

(ii) There should be sufficient weight on the top part of the mold so that the two parts fit together tightly.

4.0 POWDER METALLURGY

Powder Metallurgy Process:-



Powder Metallurgy comprises a family of production technologies, which process a feedstock in powder form to manufacture components of various types. These production technologies generally involve all or most of the following process steps:

1) Powder production:-Virtually all iron powders for PM structural part production are manufactured using either the sponge iron process or water atomization. Non ferrous metal powders used for other PM applications can be produced via a number of methods.

2) Mixing of powders:-This can often involve the introduction of alloying additions in elemental powder form or the incorporation of a pressing lubricant.

3) Forming of the mixed powder into a compact:-The dominant consolidation process involves pressing in a rigid toolset, comprising a die, punches and, possibly, mandrels or core rods. However, there are several other consolidation processes that are used in niche applications.

4) Sintering of the compact to enhance integrity and strength:-This process step involves heating of the material, usually in a protective atmosphere, to a temperature that is below the melting point of the major constituent. In some cases, a minor constituent can form a liquid phase at sintering temperature; such cases are described as liquid phase sintering. The mechanisms involved in solid phase and liquid phase sintering are discussed briefly in a later section.

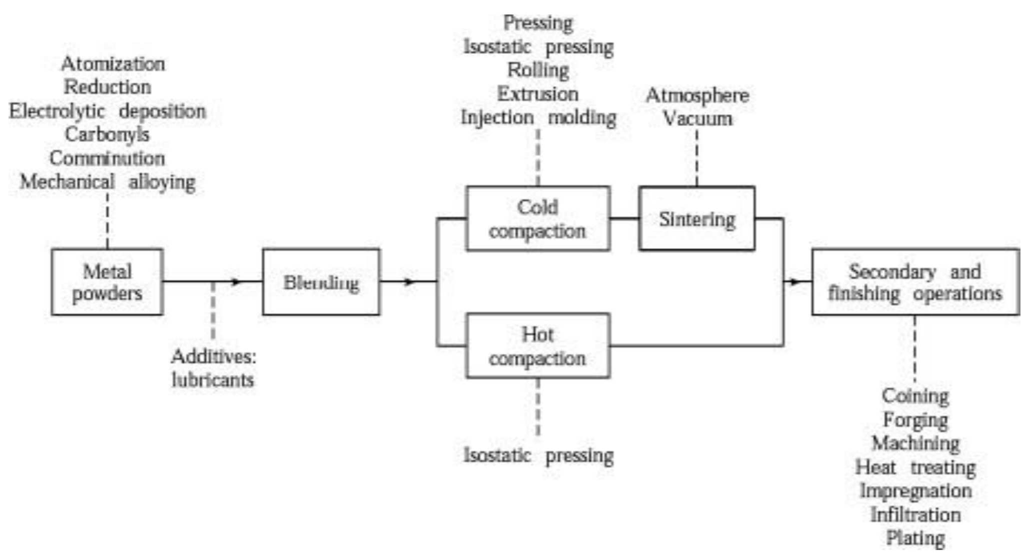
5) Secondary operations:-The application of finishing processes to the sintered part. In the Powder Metallurgy industry, such processes are often referred to as “secondary operations”.

Advantages of powder metallurgy:-

- Products made by P/M generally do not require further finishing
- There is no wastage of raw material
- Reasonably complex shapes can be made
- Different combinations of materials can be used in P/M products, which are otherwise impossible to make. For example, mixing ceramics with metals
- Automation of P/M process is easy as compared to other manufacturing processes
- It provides properties like porosity and self-lubrication to the manufactured parts

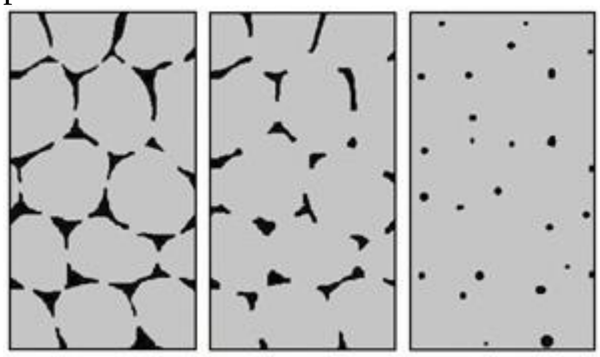
METHODS OF PRODUCING COMPONENTS BY POWDER METALLURGY TECHNIQUE

1. Preparation of powders: very fine powders are obtained using various techniques.
2. Blending of powders: The fine powders are mixed along with a lubricant. The lubricant helps in imparting good fluidity to the powders.
3. Compacting: The blended powder is compacted in a mold or die.
4. Sintering: The compacted mass is sintered at a high temperature in a furnace in a controlled atmosphere.
5. Sizing: The sintered component is passed in a mold or dies to trim the component and achieve high dimensional accuracy.
6. Machining: If required final machining is done on some specific locations including drilling very small holes.
7. Treatment: Parts are subjected to deburring and tumbling to remove any small projections and other treatments like oil impregnation tec., are given.
8.Inspection: Finally parts are inspected to check the quality .



SINTERING:- Sintering is a heat treatment applied to a powder compact in order to impart strength and integrity. The temperature used for sintering is below the melting point of the major constituent of the Powder Metallurgy material.

After compaction, neighbouring powder particles are held together by cold welds, which give the compact sufficient “green strength” to be handled. At sintering temperature, diffusion processes cause necks to form and grow at these contact points.

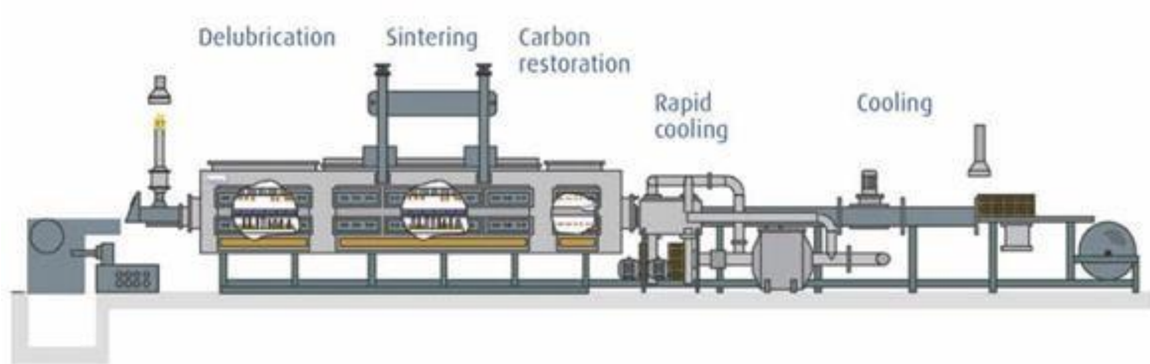


The three stages of solid state sintering: left: initial stage, centre: intermediate stage, right: final stage (Courtesy EPMA)

There are two necessary precursors before this "solid state sintering" mechanism can take place:-

- Removal of the pressing lubricant by evaporation and burning of the vapours
- Reduction of the surface oxides from the powder particles in the compact.

These steps and the sintering process itself are generally achieved in a single, continuous furnace by judicious choice and zoning of the furnace atmosphere and by using an appropriate temperature profile throughout the furnace.



Economic considerations for powder metallurgy structural parts

The vast majority of Powder Metallurgy structural part applications are based on the winning of a cost competition against other routes for forming the same component shape.

In turn, Powder Metallurgy's cost competitiveness against other technologies is based on two major issues – lower energy consumption in the process and superior utilization of the starting raw material.

There are a number of considerations that determine whether a component application might be a viable target for Powder Metallurgy:

- **Product size and weight**

Although material utilization is high in Powder Metallurgy, the powders used are a relatively expensive feedstock material compared with the steel bar or billet used in many competing processes. Powder Metallurgy therefore generally competes best in relatively small and light parts, where material costs can be contained to a relatively small percentage (perhaps around 20%) of total manufacturing costs. Also, the larger the part is in plan view, the larger is the compaction tonnage required and the tonnage capacity of Powder Metallurgy compaction presses is limited to no more than around 1,000 tones.

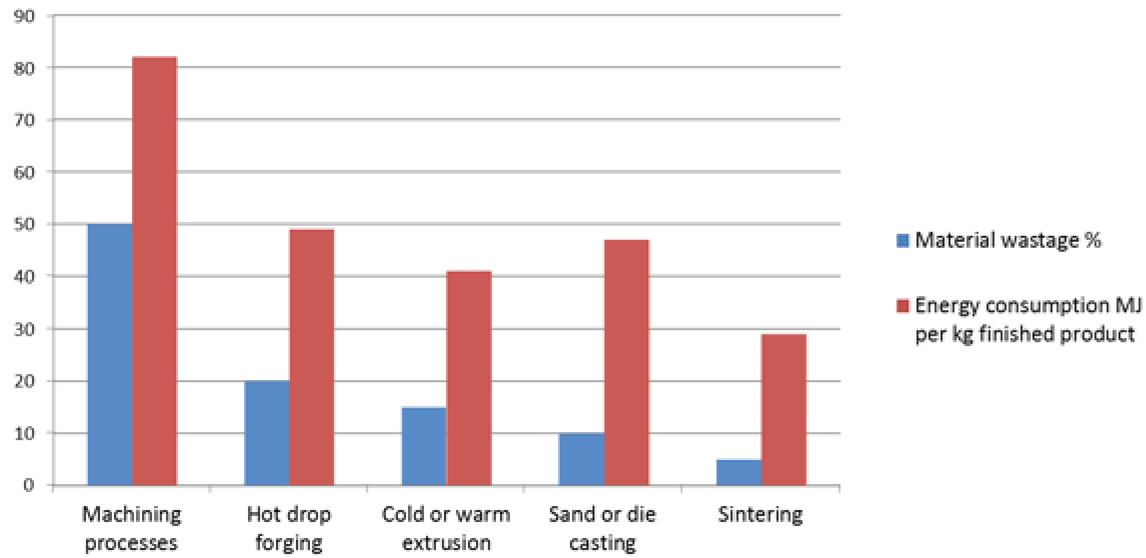
- **Product geometry**

Powder Metallurgy works best in making “prismatic” shapes with virtually unlimited shape complexity in two dimensions (the radial or plan view in the die), but much more limited complexity in the third dimension, the axial or through-thickness direction.

- **Production quantity requirements**

Powder Metallurgy requires large production runs in order to be viable. Firstly, the required forming tooling is generally complex and relatively expensive and the tooling cost needs to be amortized over a large number of products. Similarly, the capital costs of PM processing equipment (presses, furnaces) are high and need to be amortized over a large number of products. An issue associated with the equipment capital costs is that downtime between production jobs needs to be minimized and hence batch runs need to be relatively long in order that tool changeover/setting periods are not too frequent.

The competitive position of Powder Metallurgy against other technologies, in terms of both material utilization factors and energy consumption rates, is demonstrated in Fig.1. As shown in this figure, the typical Powder Metallurgy material utilization of 95% of the original raw material is superior to any of the competing processes.



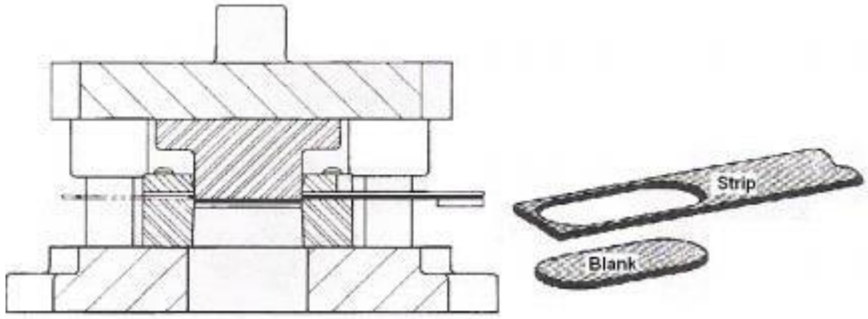
5.0 PRESS WORK

PRESS WORK:- Press working may be defined as, a manufacturing process by which various components are made from sheet metal. This process is also termed as cold stamping. The machine used for press working is called a press.

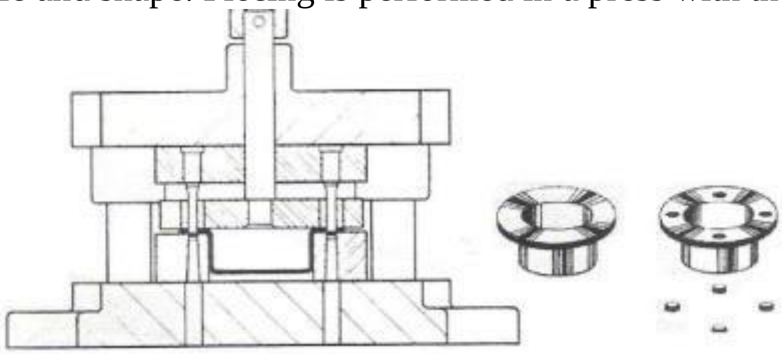
The main features of a press are:-

- A frame which support a ram or a slide and a bed, a source of mechanism for operating the ram in line with and normal to the bed.
- The ram is equipped with suitable punch/punches and a die block is attached to the bed.
- A stamping is produced by the downward stroke of the ram when the punch moves towards and into the die block.
- The punch and die block assembly is generally termed as a "die set" or simple as the "die"

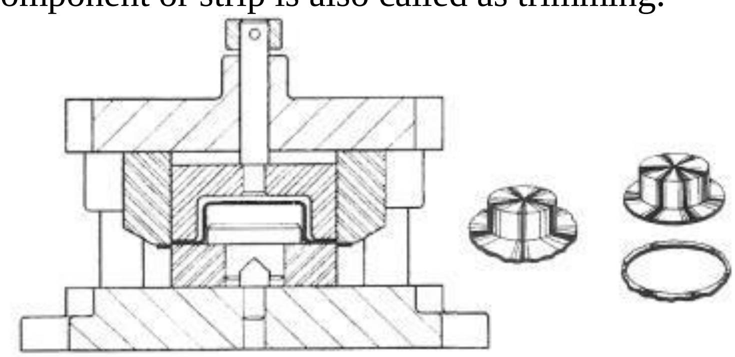
BLANKING:- When a component is produced with one single punch and die with entire periphery is cut is called Blanking. Stampings having an irregular contour must be blanked from the strip. Piercing, embossing, and various other operations may be performed on the strip prior to the blanking station.



PIERCING:- Piercing involves cutting of clean holes with resulting scrape slug. The operation is often called piercing, although piercing is properly used to identify the operation for the producing by tearing action, which is not typical of cutting operation. In general the term piercing is used to describe die cut holes regardless of size and shape. Piecing is performed in a press with the die.



TRIMMING:- When cups and shells are drawn from flat sheet metal the edge is left wavy and irregular, due to uneven flow of metal. This irregular edge is trimmed in a trimming die. Shown is flanged shell, as well as the trimmed ring removed from around the edge. While a small amount of Material is removed from the side of a component or strip is also called as trimming.



<u>Dies and its Types</u>

<u>Die:</u>-The die may be defined as the female part of a complete tool for producing work in a press. It is also referred to a complete tool consists of a pair of mating members for producing work in a press.

<u>Types of dies</u>:
The dies may be classified according to the type of press operation and according to the method of operation.

<u>(A): According to type of press operation</u>:-
According to this criterion , the dies may be classified as cutting dies and forming dies.

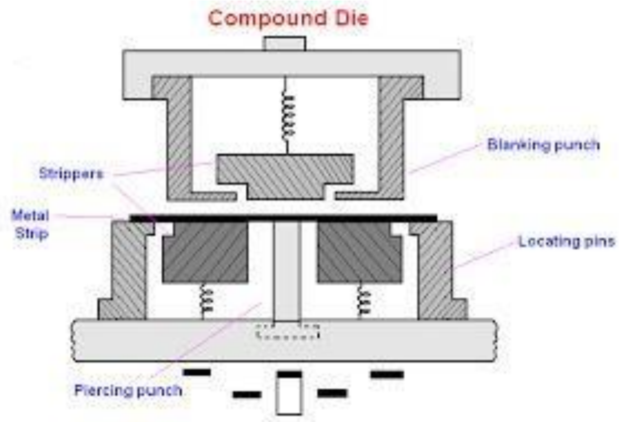
<u>1: Cutting Dies:</u>
These dies are used to cut the metal. They utilize the cutting or shearing action. The common cutting dies are : blanking dies , perforating dies , notching dies , trimming , shaving and nibbling dies.

<u>2: Forming Dies</u>:
These dies change the appearance of the blank without removing any stock. Theses dies include bending, drawing and squeezing dies etc.

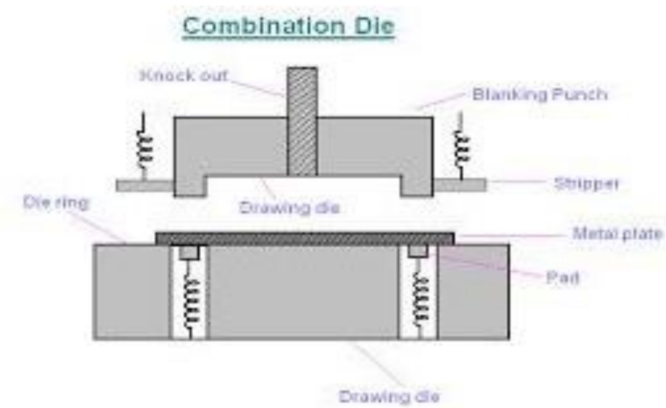
<u>(B) According to the method of operation</u>:
According to this criterion, the dies may be classified as : single operation or simple dies , compound dies , combination dies , progressive dies , transfer dies and multiple dies.

<u>1: Simple Dies</u>:-
Simple dies or single action dies perform single operation for each stroke of the press slide. The operation may be one of the operation listed under cutting or forming dies.

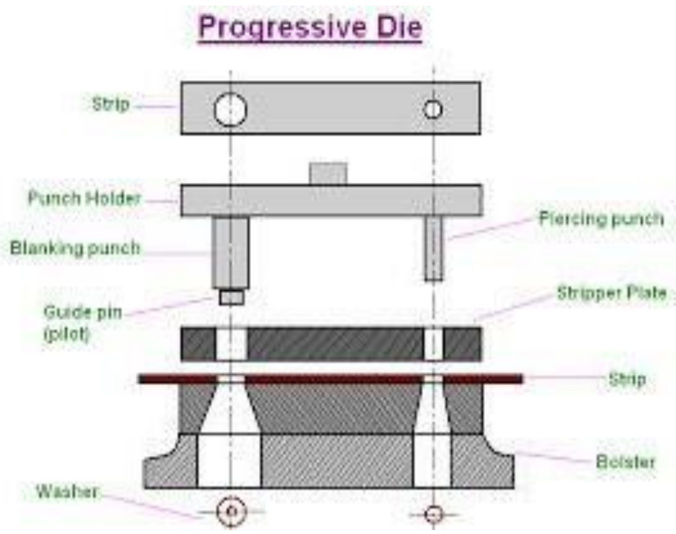
<u>2: Compound Dies</u>:-
In these dies, two or more operations may be performed at one station. Such dies are considered as cutting tools since, only cutting operations are carried out. Figure shows a simple compound die in which a washer is made by one stroke of the press. The washer is produced by simulation blanking and piercing operations. Compound dies are more accurate and economical in production as compared to single operation dies.



<u>3: Combination Dies</u>:-
In this die also , more than one operation may be performed at one station. It is difficult from compound die in that in this die, a cutting operation is combined with a bending or drawing operation, due to that it is called combination die.



<u>4: Progressive Dies</u>:-
A progressive or follow on die has a series of operations. At each station , an operation is performed on a work piece during a stroke of the press. Between stroke the piece in the metal strip is transferred to the next station. A finished work piece is made at each stroke of the press. While the piercing punch cuts a hole in the stroke , the blanking punch blanks out a portion of the metal in which a hole had been pierced at a previous station. Thus after the first stroke , when only a hole will be punched , each stroke of the press produces a finished washer.



6: Transfer Dies:-
Unlike the progressive dies where the stroke is fed progressively from one station to another. In transfer dies the already cut blanks are fed mechanically from one station to other station.

7: Multiple Dies:-
Multiple or gang dies produce two or more work piece at each stroke of the press. A gang or number of simple dies and punches are ganged together to produced two or more parts at each stoke of the press.

PUNCH:- Punches are fabricating tools used to perforate material and create cuts or holes in the shape of the punch edge. They include a variety of tools, dies and machine stamping devices that are used to produce components with specific shapes. Hand-held punches come in sets of different-sized dies with handles. They are struck with a hammer or mallet to cut the material on impact.

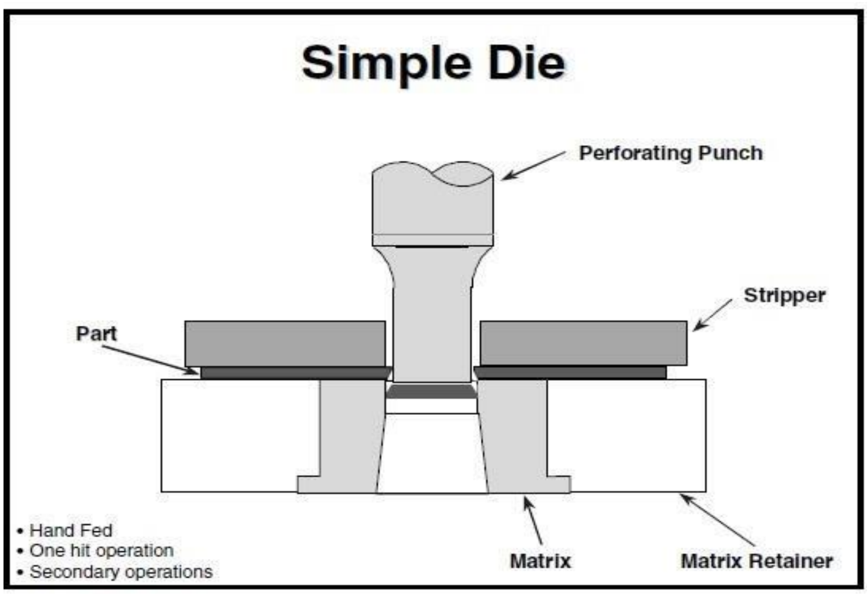
TYPES OF PUNCH:-

- **Center punches** are used to mark an indentation for guiding drill bits and identifying a location on a surface.
- **Drift punches** or drift pins are used to align bolt or rivet holes so that a fastener can be inserted.
- **Ejector punches** are designed to knock-out material or eject parts after a pressing or stamping operation.
- **Marking punches** are used to emboss or create a specific texture on the surface of a material or workpiece.

- **Pilot punches** have an inner pin that is used for aligning the punch to an existing hole, and allowing the outer point to cut out a larger hole.
- **Pin punches** are used to drive a pin into a mating bore.
- **Prick punches** are similar to center punches, but have a narrower point and are used for marking a design or layout.
- **Solid or regular punches** have a solid flat point with no voids or internal bores
- **Straight punches** are used to cut through sheet metal or other sheet materials such as leather or plastic.
- **Transfer punches** have a set shank diameter and are designed to transfer the geometry of several tapped holes by fitting the bore with close tolerances and marking the hole's center on another surface.

Each of these punches has a point with a specific shape and features. For example, some tools have D-shaped or hexagonal point that is flat or hollow.

SIMPLE DIE IT'S ADVANTAGES AND DISADVANTAGES



Advantages:

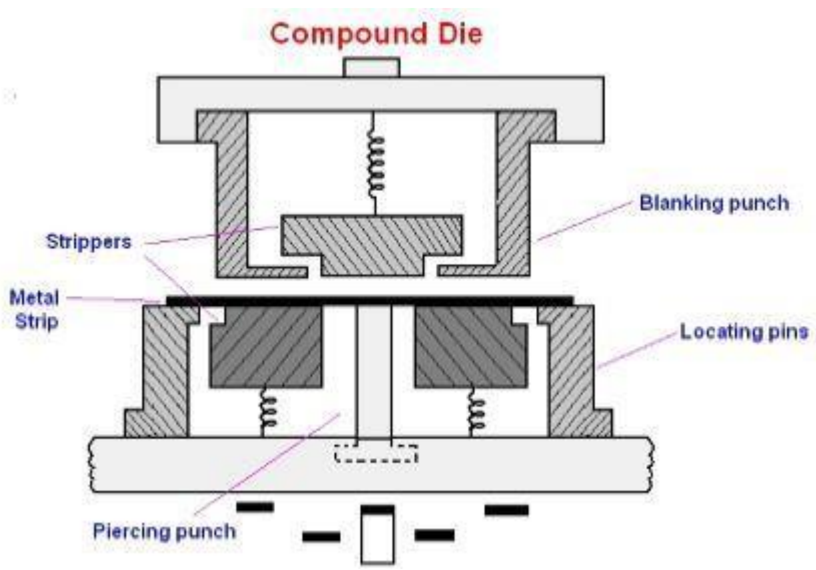
a. They often cost less than more complicated dies.
b. They can be timed to run together in a common press.

c. The operation's simplicity allows the part to be turned over or rotated in any axis by the operator or robot if necessary. This often allows for more complex geometries to be created.
d. Smaller individual tools are lighter and can be handled with lower-cost die handling equipment.
e. Maintaining a single station does not require removing all the dies.

Disadvantages:

1. They often cannot compete with production speeds achievable with other methods, such as progressive dies.
2. They require expensive robots or human labor.
3. They often require several presses to manufacture a single part.

COMPOUND DIE AND IT'S ADVANTAGES AND DISADVANTAGES



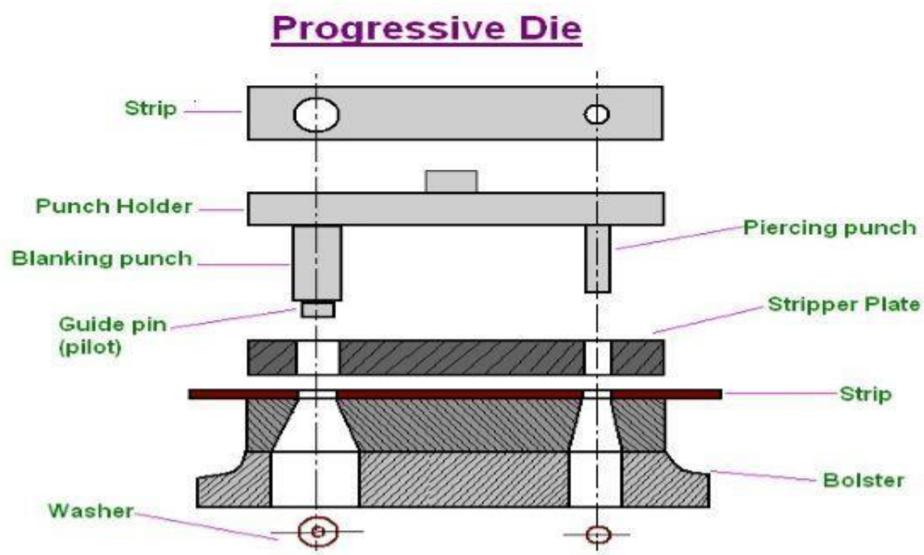
Advantages:-

1. Requires minimal space in the press.
2. Leaves all burrs in one direction.
3. Superior accuracy between holes and trim edges.
4. More economical to build than a progressive die.

Disadvantages:-

1) Compound die is the limited space which ends to leave die components thin and weak. This concentrates the load and shock on punches and matrixes resulting in tooling failures.
2) They often are quite costly

PROGRESSIVE DIE ADVANTAGES AND DISADVANTAGES:-



Advantages:

1. They can produce a great volume of parts very quickly.
2. They often can run unattended.
3. They require only one press.

Disadvantages:

1. They usually cost more than line or transfer dies.
2. They often require precision alignment and setup procedures.
3. They require a coil feeder system.
4. They require an open-ended press to allow for the metal to feed into the die.
5. Damage to a single station requires removing the entire die set.
6. They often are much heavier than single-station line dies.

6.0 JIGS AND FIXTURES

JIGS:- A jig is a work-holding device that holds, supports, and locates the work piece and guides the one or more tools to perform a specific operation.
In other words, this can also be defined as, used for holding the tools and also guiding the cutting tools.
The main purpose of a jig is to provide repeatability, accuracy, and interchangeability in the manufacturing of products.

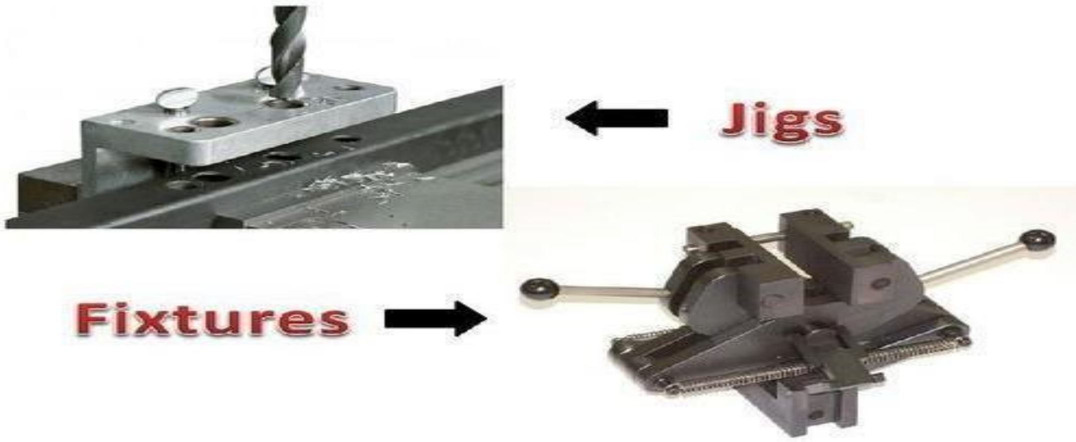
Some important points to remember about Jigs:-

- It is used in uni-dimensional machining processes like drilling, tapping, and reaming, etc.
- This system is found to be light and has a complex shape.
- Gauge blocks are not necessary and the cost of jigs is higher.
- Jigs are not fixed to the machine table until a large operation has to be performed.

FIXTURES:-
Fixtures are the work holding device, which holds, supports and locates the work piece but not guides the cutting tool to perform a specific operation.
In other words, the fixtures are only the work holding device that holds, supports and locates the work piece in the desired position to perform any operation.
The main purpose of the fixtures is to hold and locate the work piece during any machining operation and to provide repeatability, accuracy, and interchangeability in the manufacturing of products.

Some important points about fixtures:-

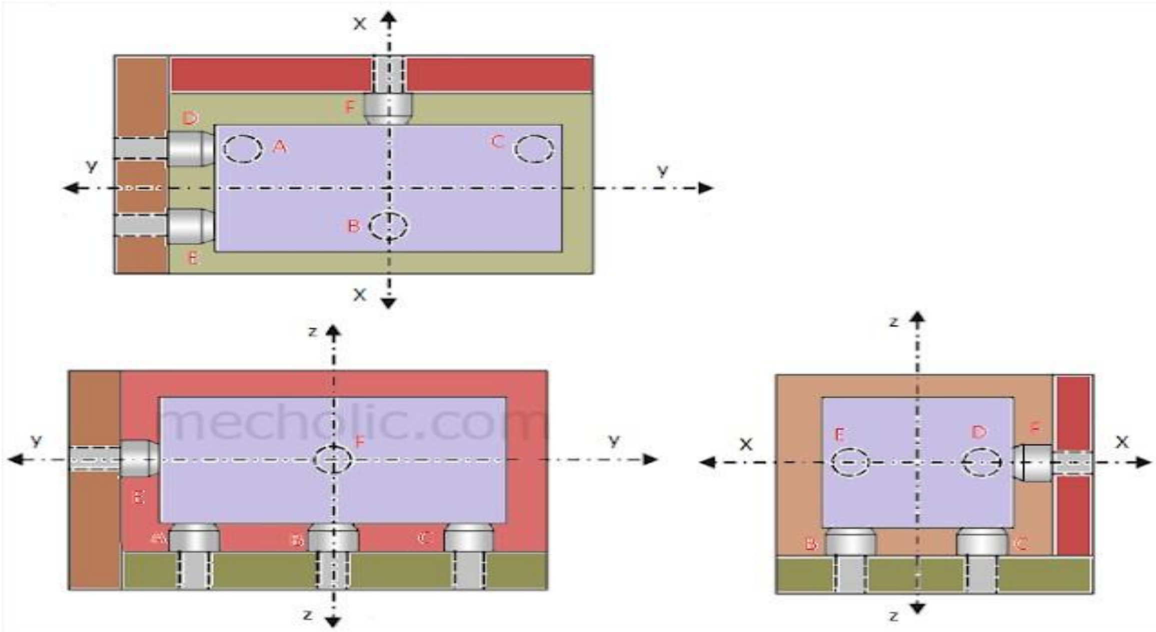
- Fixtures are used in multi-dimensional machining like milling, grinding, turning, etc.
- This system found to be heavy in weight, have simple designing.
- Gauge blocks provided for effective handling and the cost is average.
- Fixtures are having specific tools that use particularly in the milling machine, shapers and slotting machines.
- Fixtures are fixed to the machine table.



ADVANTAGES OF USING JIGS AND FIXTURES:-

S.no	Jigs	Fixtures
1.	It is a work holding device that holds, supports and locates the workpiece and guides the cutting tool for a specific operation.	It is a work holding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool
2.	jigs are used in unidimensional machining i.e. drilling,reaming, tapping, etc	fixtures are used in multidimensional machining i.e. milling,turning,grinding,etc .
3.	Jigs are light in weight.	Fixtures are rigid and bulky.
4.	Gauge blocks are not necessary.	Gauge blocks may be provided for effective handling.
5.	The jigs are special tools particularly used in drilling, reaming, tapping and boring operation.	Fixtures are specific tools used particularly in milling machine, shapers and slotting machine
6.	Usually it is not fixed to the machine table.	It is fixed to the machine table.
7.	Its cost is more.	Its cost is less as compared with the jig.
8.	Their designing is complex.	Their designing is less complex.

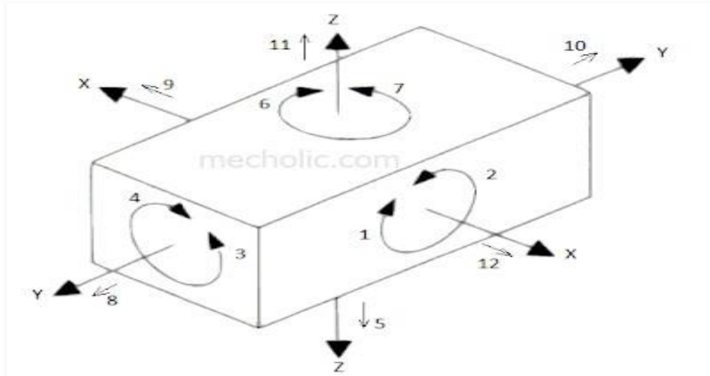
3-2-1 Principle of Location(Six point principle)Degree of freedom controlled by 3-2-1 location principle:-



3-2-1 Principle of Location

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

Degree of freedom controlled by 3-2-1 location principle



In this method, 9 degrees of freedom is controlled.

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

Pins D, E is in plane parallel to the plane containing X and Z axes. It prevents the rotation of component about Z axis (6, 7 degree of freedom) and the movement of the body in along Y axis towards one direction (8 degree of freedom).

- Basic Rules For Location
- Choosing Locating Surfaces

The last pin F is in a plane parallel to plane contains Y and Z axes. It restricts the movement component along X axis in one direction.

Three remaining degree of freedom 10, 11, 12 is unrestricted. It facilitates the loading of the component in the fixture. This three degree of freedom may restrict after loading of component by using clamping devices.

Types of Jigs:

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

Types of Fixtures:-

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

DIFFERENCE BETWEEN JIGS AND FIXTURES

DIFFERENCES

	JIG	FIXTURE
Definition	Locates and Holds the work and guides the cutting tool in true position of the work	Only Holds & Positions the work, but doesn't guide the work
Elements	Work Locating elements, Tool Guiding elements & Work Clamping elements	Work Locating elements, Tool setting elements & Work Clamping elements
Construction	Light	Heavy
Applications	Drilling, reaming , Tapping, Counterboring, Countersinking	Milling, Turning, Grinding, Broaching etc.,
Special features	Drill bushes used for tool guiding	Feeler gauges, setting blocks to adjust position of tool in relation to work