DT - 20/09/2022

Production :- Production is a organise activity of transforming of resources into finish product in the from of good and service.

Types of production :-

1. Primary production
2. Secondary production
3. Tertiary production

① **Primary Production** :-

* Production is carried out by extracting industries like Agriculture, Mining, oil extraction
* These industries are engaged in such activity as extracting the resources from the earth surface and from the oceans.

② **Secondary Production** :-

* This includes production in manufacturing industry i.e. turning out semi-finished and finished good from materials and intermediate goods.
* They are generally described as manufacturing & construction industries, such as manufacturing of cars, clothing, building.

③ **Tertiary Production** :-

* Industries in the tertiary sector produce all those services which enables the finished goods to be put in the hands of consumers.
* Infact these services are supplied to the firms in all types of industry and directly to consumers.

Ex:- Banking, transport, Education etc.

Metal forming :-

* Metal forming can be defined as a process in which the desired size and shape are obtained through the deformation of metals plastically under the action of externally applied forces.
* Metal forming includes a large group of manufacturing process in which plastic deformation is used to change the shape of metal work pieces.
* Plastic deformation a permanent change of shape.
* Usually a die is needed to force deformed metal into a shape of the die, so that the product has the same cross area as the die.
* Metals used in the metal forming processes are stainless steel, galvanised steel, aluminium, brass and copper among other materials.

In industrial processes forming is characterised by :-

(i) High levels of loads and stresses ranging from 50 to 2500 Newton per sq. mm.

(ii) By heavy and expensive machinery, which can generate a high amount of stresses and loads.

(iii) Many parts that are produced in less time, which helps in maximizing the production economy.

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Extrusion :-

* 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 into desire shape.
* This process is extensively used in pipes and steel rods manufacturing.
* The force used to extrude the workpiece is compressive in nature.
* The most common material extruded are plastic and aluminium.

Working Principle :-

* Extrusion is a simple compressive metal froming process. In this process, piston or plunger is used to apply compressive force at work pieces.

Steps / Process :-

(i) First fillet or ingot is produced.
(ii) This fillet is heated in hot extrusion or remains at room temperature and placed into a extrusion press.
(iii) Now a compressive force is applied to this part by plunger fitted into the press which pushes to fillet towards die.
(iv) The die is small opening at required cross-section.
(v) This high compressive force allow the work metal to flow through die and convert into desire shape.
(vi) Now the extruded part remove form press and is heat treated for better mechanical properties.

Classification: (i) According to the direction of flow of metal.

1. Direct extrusion
2. Indirect extrusion
3. Impact extusion

(ii) According to the working temperature.

A. Hot extrusion
B. Cold extrusion

(i) Direct extrusion :-

* In this type of extrusion process metal is forced to flow in the direction of feed of punch. The punch moves towards die during extrusion.
* This process required higher force due to higher friction between fillet and container
* Direct extrusion also called forward extrusion.

② **Indirect Extrusion :-**

* In this process, metal is allow toward opposite direction of plunger movement.
* The die is fitted at opposite side of punch movement.
* In this process the metals is allowed to flow through annual space between punch and container.
* Also known as backward extrusion.

③ **Impact extrusion :-**

* A manufacturing process in which a small shot of solid material is placed in the die and is impacted by a ram, which causes cold flow in the material.
* It may be either direct or indirect extrussion and usually performed on a high speed mechanical press.

④ **Hot Extrusion :-**

* If the extrusion process take place above recrystalization temp. which is about 50-60% of its melting temp.

Advantages :-

(i) Low force required.
(ii) Easy to work in hot from.
(iii) The product is free from strain hardening.

Disadvantages :-

(i) Low surface finish.
(ii) Increase die wear.
(iii) High maintenance required.

⑤ **Cold Extrusion :-**

* If the extrusion take place below the recrystalization temp. or room temp. the process is known as cold extrusion

Advantages :-

(i) High mechanical properties.
(II) High surface finish.
(III) No oxidation of metal surface.

Disadvantages :-

(I) High force required.
(II) product is accomplished with strain hardening.

Application of extrusion :-

(i) Extrusion is widely used in production of tubes and hollow pipes.
(II) Alumin. extrusion is used in structure work in many industries.
(III) This process is used to produce frames, door, window etc in Automative industries.
(iv) Extrusion is widly used to produce plastic objects.

Advantages of extrusion :-

(i) High extrusion ratio
(II) It can easily create completely cross section.
(III) This working can be done with both brittle and ductile materials.
(iv) High mechanical properties can be achieved by cold extrusion.

Disadvantages :-

(I) High initial or set up cost
(II) High compressive force required.

Mechatronic is composed of mecha - mech
tronic = electronics.

01/11/22

Types of Rolling Mills

Following are the 6 different types of rolling mills used in many industries:

1. Two high rolling mills
2. Three high rolling mills
3. Four high rolling mills
4. Cluster rolling mills
5. Planetary rolling mills
6. Tandemdem or Continuous mills

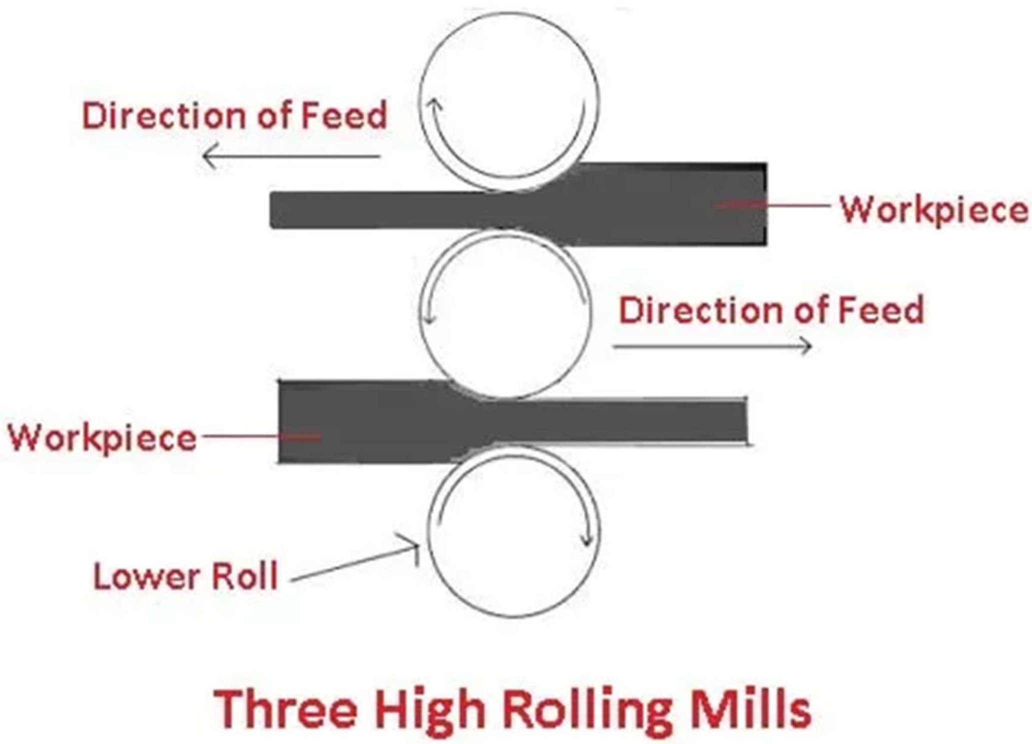
1. Two High Rolling Mills

It contains two heavy rolls fixed one over the other. The rolls are supported in bearing housed in sturdy upright frames (called stands) which are grouted to the rolling mill floor. The vertical gap between the roll is adjustable. The rolls rotate in opposite directions and are driven by electrical motors.

The direction of rotation of rolls cannot be changed, therefore the work has to be fed into rolls from one direction only. If rolling requires more than one 'pass' in the same set of rolls, the material will have to be brought back to the same side after the first pass.

2. Three High Rolling Mills

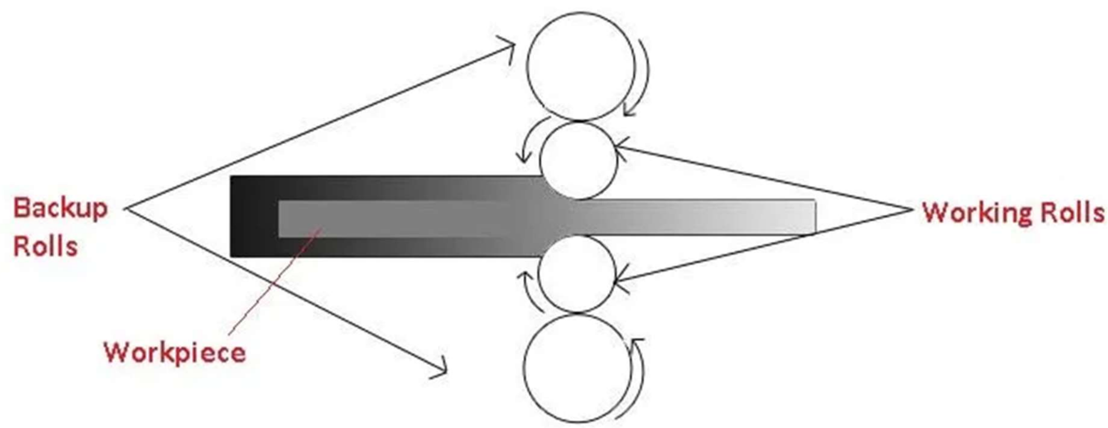
It consists of three rolls positioned directly over one another as shown in the figure below. The direction of rotation of the first and second rolls are opposite as in the case of two high mills. The direction of rotation (path) of the second and third rolls is always opposite to each other.



Always all three rolls rotate in their bearings in the same direction. The advantage of this will mill is that work material can be fed in one direction between the first and second rolls and the return pass can be provided between the second and third rolls. This results in the transport of material from one side of the rolls to the other.

3. Four High Rolling Mills

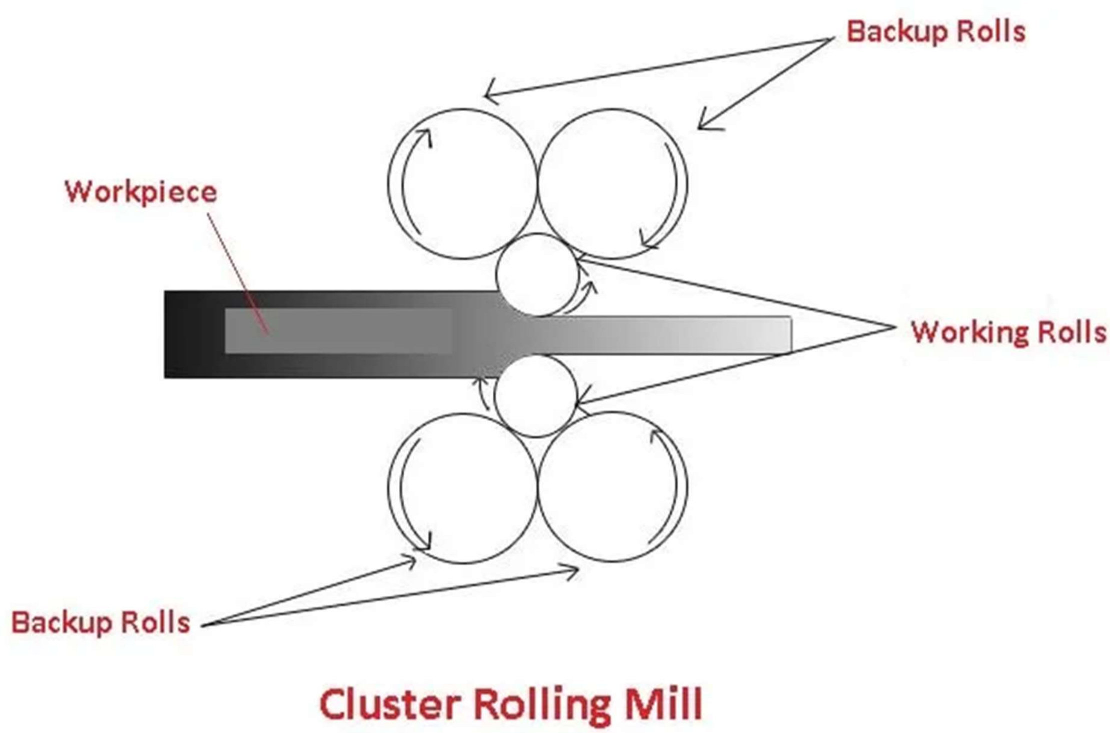
The mill has four horizontal rolls, two smaller diameters and two much larger. The larger rolls are called backup rolls. The smaller rolls are the working rolls, but they would be thicker in the center and thinner at either end.



Four High Rolling Mill

Backup rolls hold the working rolls and restrict deflection when the material is being rolled. The usual products of these mills are hot and cold plates and sheets.

4. Cluster Rolling Mill

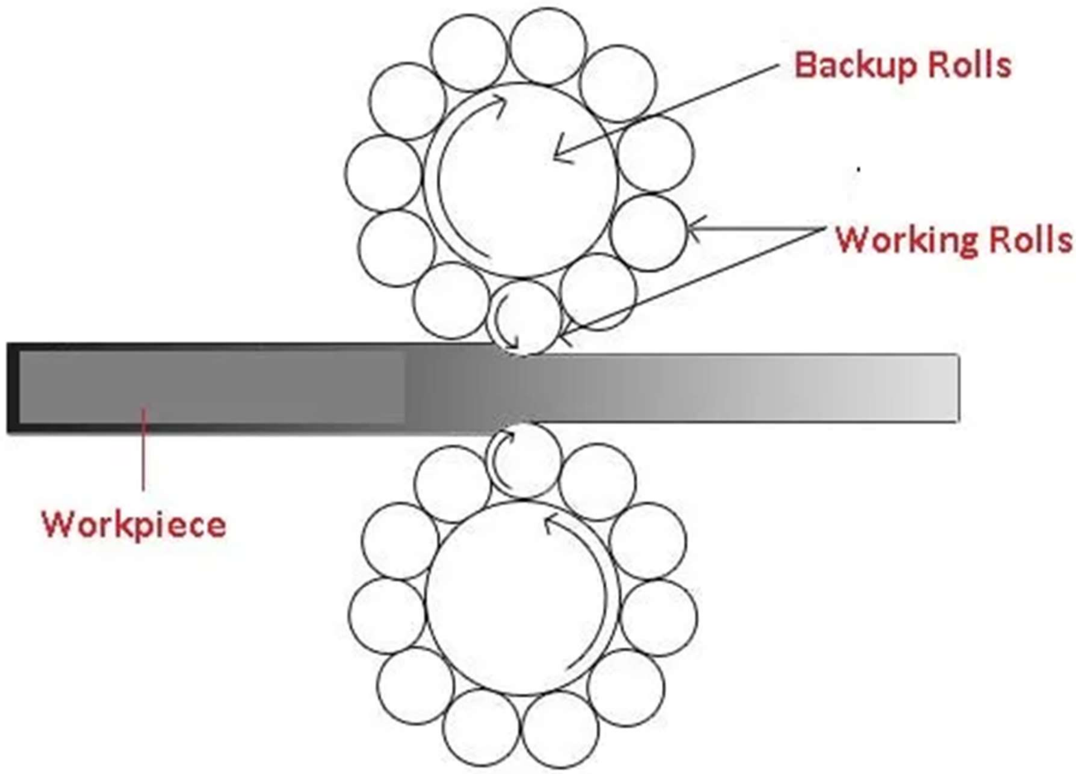


It consists of two small diameter working rolls and four or more backing rolls. The larger number of backup rolls provided becomes necessary as the backup rolls cannot exceed the diameter of working rolls by more than 2-3 times.

5. Planetary Rolling Mill

In the planetary mill type of rolling machine, a large backup roller is surrounded by a number of planetary working rollers as shown in the figure.

Each planetary roll gives a continuous reduction. It is employed to reduce large thicknesses in a single pass of a steel strip. Its rolling capacity is higher than a cluster machine but less than a tandem rolling machine.

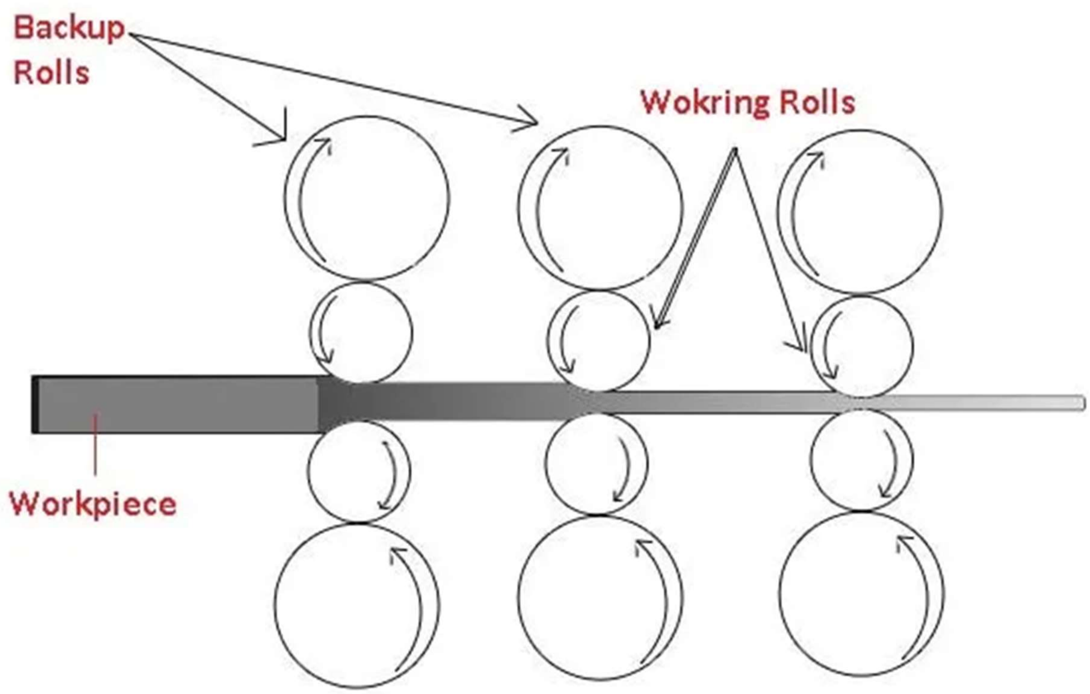


Planetary Rolling Mill

Tandem or Continuous Mill

In this tandem mill types of rolling mills, It includes a number of non-reversing two-high rolling mills provide one after other. So that the material can be passed through them all in order.

This is only suitable for mass production work, as lower volumes require a quicker change of set up and they will consume a lot of labor and work.



Tendem or Continuous Rolling Mill

2.1 Welding process

Welding is a process of joining two or more similar or dissimilar metals with or without the application of heat, with or without the application of pressure, and with or without the application of filler materials.

Filler Materials: Supply extra molten metal to the welding.

Advantages of welding:

- Strong and tight joining.
- Cost-effectiveness.
- Simplicity of welded structures design.
- Welding processes may be mechanized and automated.

Disadvantages of welding:

- Internal stresses, distortions, and changes of micro-structure in the weld region;
- Harmful effects: light, ultra-violate radiation, fumes, high temperature.

Applications of welding:

- Buildings and bridge structures.
- Automotive, ship, and aircraft constructions.
- Pipelines.
- Tanks and vessels.
- Railroads
- Machinery elements.

2.1 Classification of welding Process

1. Fusion Welding:

Fusion welding is a process that uses heat to join or fuse two or more materials by heating them to the melting point. The process may or may not require the use of filler material.

The joint is called a fusion welding operation by melting the parent materials.

The fusion welding process is divided into 3 types:

a. Gas Welding:

Gas welding uses heat generated from burning a fuel gas (like acetylene) to cut and/or join metals together.

Gas welding is a metal joining process in which fuel gases (gasoline) and oxygen are used to weld and cut metals.

It is also a metal joining process in which edge pieces of a metal that required joining are heated at their interface by producing coalescence with one or more gas flames such as oxygen and acetylene.

The welding process can weld with or without the application of filler material to the joint.

b. Arcs Welding:

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

c. Chemical welding:

In the chemical welding process, an exothermic chemical reaction is used to supply the essential heat energy. That reaction involves the burning of Thermit, which is a mixture of fine aluminum powder and iron oxide in a ratio of about 1:3 by weight.

An Exothermic reaction is a chemical reaction that involves the release of energy in the form of heat or light**.**

Types of Gas Welding:

a. oxy-Acetylene gas welding:

Oxyacetylene welding also known as Oxy-fuel Welding (OFW), includes any welding operation that uses combustion with oxygen as a heating medium.

With this family of processes, the base metal and a filler rod are melted using a flame produced at the tip of a welding torch.

Fuel gas and oxygen are combined in the proper proportions inside a mixing chamber in the torch.

Molten metal from the plate edges and filler metal, if used, intermix in a common molten pool and join when cooling.

Commonly used fuel gases include acetylene, propylene, propane, and natural gas.

b. Air Acetylene:

It is a type of welding process in which heat is produced by combining a mixture of acetylene and air. In this process, there is an increase in temperature of about 2700-degree C. There is the formation of weld points without the application of heat or without using filler metals.

c. Oxy-Hydrogen:

Oxyhydrogen is a mixture of hydrogen (H_2) and oxygen (O_2) gases. This gaseous mixture is used for torches to process refractory materials and was the firstgaseous mixture used for welding.

a ratio of 2:1 hydrogen: to oxygen is enough to achieve maximum efficiency.

d. Atomic Hydrogen:

It is an arc welding process that uses an electric arc between two tungsten electrodes in the presence of hydrogen. The shielding atmosphere in atomic hydrogen welding consists of hydrogen.

2.2 Explain fluxes used in welding:

Flux is a mixture of various minerals, chemicals, and alloying materials that primarily protect the molten weld metal from contamination by oxygen and nitrogen, and other contaminants in the atmosphere. The addition of certain chemicals and alloys also helps to control arc stability and mechanical properties.

Flux is used in the following arc welding processes Shielded Metal Arc Welding (SMAW), Flux Cored Arc Welding (FCAW), and Submerged Arc Welding (SAW).

During a welding process, the base metal and the filler undergo significant temperature changes in a very short amount of time. The heated metal may interact with the surrounding air and cause oxidation, which creates an oxide layer on the weld, reducing the weld strength.

The main condition for a flux to work is that it should be inert to the metals being joined. In other words, no reaction should occur between the flux and the metals.

Functions of the flux are:

- Creates a protective slag over the molten metal
- Removes impurities from the motel metal
- Reduces splatter
- Prevents hardening by slowing down cooling time etc.

Types of electrode flux:

- Rutile electrode
- Basic flux

- Cellulose electrode coating
- Iron oxide coating

a. Rutile electrode:

Rutile electrode coating is made from titanium oxide. They offer excellent arc control and slag control to the welder.

b. Basic Flux:

Basic flux is made from calcium carbonate, calcium fluoride, magnesium carbonate, and a few other shielding compounds. The benefit of using basic flux is that it results in better mechanical properties and low hydrogen diffusion levels.

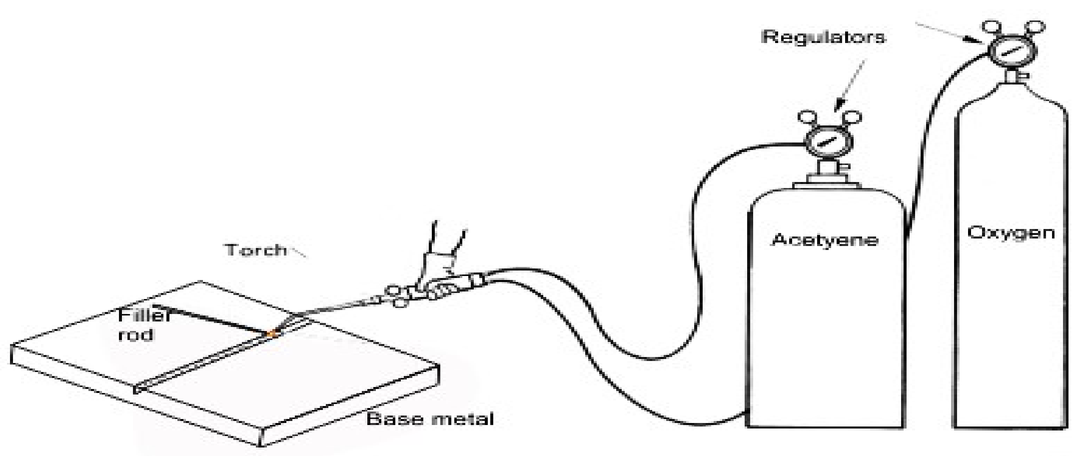
c. Cellulose electrode coating:

Cellulose electrode coating uses a mixture of cellulose and other organic compounds. When cellulose undergoes high temperatures in welding, it decomposes to produce carbon monoxide and hydrogen.

d. Iron oxide agent:

The iron oxide coating is a mixture of metallic oxides of iron, manganese, and silica. Once they are under heat, they produce a molten acidic slag.

2.3 oxy-acetylene welding process



Oxyacetylene welding also known as Oxy-fuel Welding (OFW), includes any welding operation that uses combustion with oxygen as a heating medium.

With this family of processes, the base metal and a filler rod are melted using a flame produced at the tip of a welding torch.

Fuel gas and oxygen are combined in the proper proportions inside a mixing chamber in the torch.

Molten metal from the plate edges and filler metal, if used, intermix in a common molten pool and join when cooling.

Commonly used fuel gases include acetylene, propylene, propane, and natural gas.

2.4 Flames and Types of Flame

Flames are used to heat metals or thermoplastics to melt and allow them to cool.

Most gas welding processes use oxy-fuel welding. It is one of the oldest welding processes 1st developed in1903.

The gas is combined with oxygen to raise the temp of the flame.

The torch consists of hoses that attach to the gas tank.

If we want to weld, open the valve and ignite the gas as it exits the flashlight.

We can adjust the valves to the flow of each gas, changing the gas ratio.

Each flamehas many areas called cones.

The inner cone is the hottest part of the flame. This is where acetylene and oxygen combine.

The outer cone is colder because it receives more oxygen from the surrounding air. It is also commonly called the outer envelope or sheath.

Flames play a major role in forming a weld joint, and the weld properties are highly dependent on them.

Types of flames

There are three basic flame types: neutral (balanced), excess acetylene (carburizing), and excess oxygen (oxidizing).

- **A neutral flame** is named neutral since in most cases will have no chemical effect on the metal being welded.
- **A carburizing flame** will produce iron carbide, causing a chemical change in steel and iron. For this reason, a carburizing flame is not used on metals that absorb carbon.
- **An oxidizing flame** is hotter than a neutral flame and is often used on copper and zinc.

The Neutral Flame

The neutral flame has a one-to-one ratio of acetylene and oxygen. It obtains additional oxygen from the air and provides complete combustion. It is generally preferred for welding.

The neutral flame has a clear, well-defined, or luminous cone indicating that combustion is complete.

Neutral welding flames are commonly used to weld:

- Mild steel
- Stainless steel
- Cast Iron
- Copper
- Aluminum

The welding flame should be adjusted to neutral before either the carburizing or oxidizing flame mixture is set.

There are two clearly defined zones in the neutral flame.

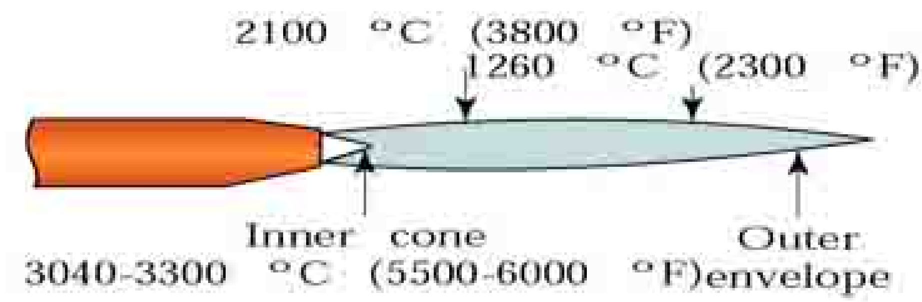
1. The inner zone consists of a luminous cone that is bluish-white.
2. Surrounding this is a light blue flame envelope or sheath.

This neutral flame is obtained by starting with an excess acetylene flame in which there is a “feather” extension of the inner cone. When the flow of acetylene is decreased, or the flow of oxygen is increased the feather will tend to disappear. The neutral flame begins when the feather disappears.

The neutral or balanced flame is obtained when the mixed torch gas consists of approximately one volume of oxygen and one volume of acetylene. It is obtained by gradually opening the oxygen valve to shorten the acetylene flame until a clearly defined inner cone is visible.

For a strictly neutral flame, no whitish streamers should be present at the end of the cone.

In the neutral flame, the temperature at the inner cone tip is approximately 5850ºF (3232ºC), while at the end of the outer sheath or envelope the temperature drops to approximately 2300ºF (1260ºC).



The Carburizing Flame

The carburizing flame has excess acetylene, the inner cone has a feathery edge extending beyond it.

This white feather is called the acetylene feather.

If the acetylene feather is twice as long as the inner cone it is known as a 2X flame, which is a way of expressing the amount of excess acetylene. The carburizing flame may add carbon to the weld metal.

Reducing or carburizing welding flames are obtained when slightly less than one volume of oxygen is mixed with one volume of acetylene.

This flame is obtained by first adjusting to neutral and then slowly opening the acetylene valve until an acetylene streamer or “feather” is at the end of the inner cone.

The length of this excess streamer indicates the degree of flame carburization. For most welding operations, this streamer should be no more than half the length of the inner cone.

The reducing or carburizing flame can always be recognized by the presence of three distinct flame zones. There is a clearly defined bluish-white inner cone, a white intermediate cone indicating the amount of excess acetylene, and a light blue outer flare envelope. This type of flare burns with a coarse rushing sound. It has a temperature of approximately 5700ºF (3149ºC) at the inner cone tips.

A carburizing flame is advantageous for welding high carbon steel and hard-facing such nonferrous alloys as nickel and Monel.

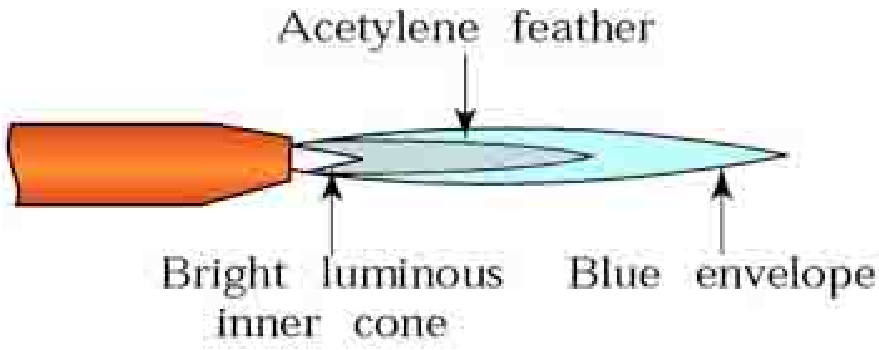


Figure 2: Carburizing Flame

The Oxidizing Flame

Oxidizing welding flames are produced when slightly more than one volume of oxygen is mixed with one volume of acetylene.

To obtain this type of flame, the torch should first be adjusted to a neutral flame. The flow of oxygen is then increased until the inner cone is shortened to about one-tenth of its original length. When the flame is properly adjusted, the inner cone is pointed and slightly purple.

An oxidizing flame can also be recognized by its distinct hissing sound. The temperature of this flame is approximately 6300ºF (3482ºC) at the inner cone tip.

Oxidizing welding flames are commonly used to weld these metals:

- zinc
- copper
- manganese steel
- cast iron

When applied to steel, an oxidizing flame causes the molten metal to foam and give off sparks. This indicates that the excess oxygen is combined with the steel and burning it.

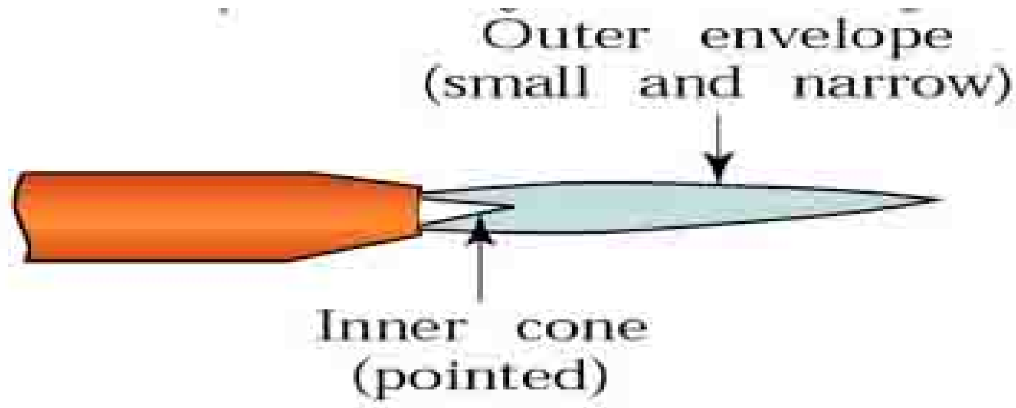


Figure3: Oxidizing Flame

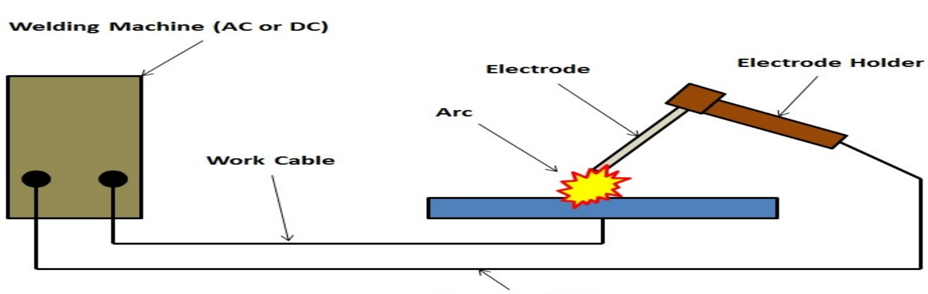
An oxidizing flame should not be used for welding steel because the deposited metal will be porous, oxidized, and brittle. This flame will ruin most metals and should be avoided**.**

2.5 Arc Welding Process

Arc welding is one of many fusion welding processes used to join metals. It uses an electric arc to create intense heat to melt and join metals. A power source generates an electric arc between a consumable or non-consumable electrode and base metal. Arc welders can use either direct current (DC) or alternating current (AC).

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

The arc is formed between the workpiece and the electrode, which is moved along the line of the joint either mechanically or manually. The electrode can



Basic Arc Welding Circuit Diagram

either be a rod that carried the current between the tip and the workpiece, or it can be a rod or wire that conducts current as well as melts and supplies filler metal to the joint.

Metal tends to react chemically to elements in the air such as oxygen and nitrogen when heated to extreme temperatures by the arc. This creates oxides and nitrides, which ruin the strength of the weld. Therefore, a protective shielding gas, slag, or vapor needs to be used to lessen the contact of the molten metal with the air. After the piece has cooled, the molten metal can solidify to create a metallurgical bond.

TYPES OF ARC WELDING

CONSUMABLE ELECTRODE METHODS

METAL INERT GAS WELDING (MIG) AND METAL ACTIVE GAS WELDING (MAG)

This form of arc welding is also known as Gas Metal Arc Welding (GMAW). MIG uses a shielding gas such as argon, carbon dioxide, or helium to protect the base metals from being destroyed by contamination.

SHIELDED METAL ARC WELDING (SMAW)

This form of welding is also known as stick welding or manual metal arc welding. In this process, the arc is placed between the metal rod that is electrode flux coated and the work segment to melt it and form a weld pool. The electrode flux coating on the metal rod is melted to form a gas, which shields the weld pool from the air. This process does not use pressure and the filler metal is formed by the electrode. This process works best for ferrous metals because they can be welded in all positions. Ferrous metals are alloys that are made up mostly of iron and contain carbon.

FLUX-CORED ARC WELDING (FCAW)

This form of welding can be used as a substitute for SMAW. FCAW uses the gas formed by the flux to shield the workpiece from contamination. This enables the operator to weld outdoors even if it is windy. It works by using a constantly fed consumable flux-cored electrode and a continual voltage power supply togenerate a constant arc length. This form of welding is great for general repairs and shipbuilding because it works well with thicker joints.

SUBMERGED ARC WELDING (SAW)

SAW involves the formation of an arc between a constantly fed consumable electrode or wire, and the workpiece. This process creates a cover of fusible flux, which generates a protective gas to shield the work area. The process becomes conductive when molted and generates a current path between the electrode and the workpiece. The flux is great because it prevents spatter and sparks while simultaneously quelling fumes and ultraviolet radiation.

ELECTRO-SLAG WELDING (ESW)

ESW is a welding process that uses heat that is generated by an electric current moving between the consumable electrode and the workpiece. This creates a molten slag, which covers the weld surface. The molten slag's resistance to the passage of the electric current creates heat for melting the wire and plate edges. The metal solidifies as it is hit with water. This is a vertical process that is used to weld thick plates that are above 25 mm in a single pass.

ARC STUD WELDING (SW)

Stud welding joins a metal stud such as a nut or fastener, to a metal workpiece by heating both parts with an arc of electricity.

NON-CONSUMABLE ELECTRODE METHODS

TUNGSTEN INERT GAS WELDING (TIG)

This process is also referred to as Gas Tungsten Arc Welding (GTAW). TIG uses a non-consumable tungsten electrode to generate an electric arc. The arc also works as a shield of gas to protect the weld from the air, which can cause oxidation. This is a favored method for welding aluminum.

PLASMA ARC WELDING (PAW)

This method uses an electric arc between a non-consumable electrode and a base metal. The electrode is placed in a torch and the plasma forming gas is separated from the shielding gas, which produces narrow and deep welds.

Advantages

Arc welding provides a plethora of advantages compared to other types of welding. These advantages include:

- Low cost. This is an affordable technique because the cost of equipment is low. It also requires less equipment due to the lack of gas.
- Portability. The materials in this technique are easy to transport.
- Used on unclean metals. Arc welding can be performed on dirty metals.
- Work in any environment. A lot of arc processes use shielding gas so work can only be done in one place. With arc welding, there is no need for shielding gas so work can happen regardless of weather conditions.

Disadvantages

While there are many great benefits to arc welding, there are also some shortcomings. These disadvantages include:

- Cost. While cost is considered an advantage, it is also a disadvantage because it produces more metal waste than other methods, resulting in higher project costs.
- Requires a high level of skill and training. Not all operators have a high level of training and skills.
- Thin metal. Arc welding does not work well on certain thin metals.

Application

- Arc welding is commonly used to join materials and is used across a lot of different industries.
- The aerospace industry uses arc welding to manufacture and repair aircraft, join sheeting, and do precision work. The automotive industry uses arc welding to bond exhaust systems and hydraulic lines. Arc welding can deliver extremely strong bonds even between thin metals.
- The construction industry uses arc welding to guarantee strong, sustainable connections within buildings, bridges, and other infrastructures. Other industries that use arc welding are the oil and gas industry and the power industry.

2.6 Specify arc welding electrodes

A metal wire coated with a similar composition to the metal being joined is defined as a welding electrode.

The **welding electrode** selection largely depends upon weld strength, easy to clean up. better bead quality, and minimal spatter.

Welding electrodes need to be stored in moisture-free surroundings and removed carefully from the package to avoid any damage following directions carefully.

Welding Electrodes Cover

Once the molten metal is exposed to the environment, it absorbs oxygen and nitrogen which affect it adversely and become brittle. A slag blanket would have to cover molten/ solidifying weld metal to shield from the atmosphere and electrode coating provides us with this shield.

The coating is there to protect from damage and arc stabilization and improves the welding in the following ways.

- Minimum spatter in the welding vicinity zone
- A smooth surface of weld metal and edges even
- A stable and smooth welding arc
- A tough and strong coating
- Easy slag removal
- Better deposition rate
- Penetration control in welding.

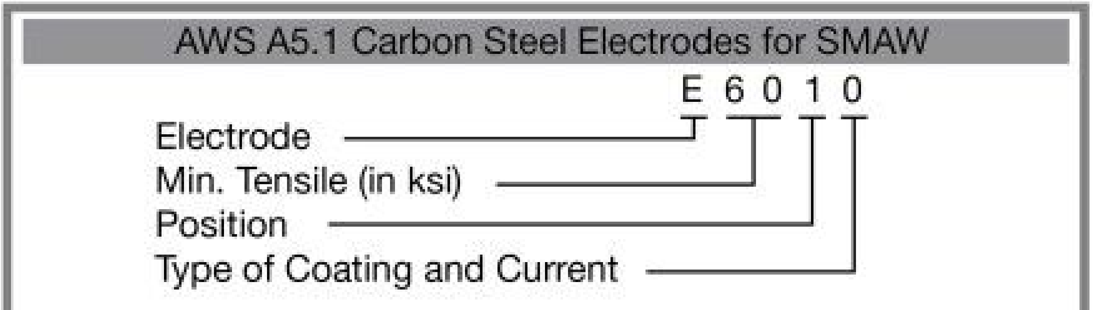
The electrode covering's composition determines the utility of the electrode, and the specification deposited material decides the electrode. The category of electrode used largely depends upon the special properties within the weld deposit required.

These properties include corrosion resistance, high enduringness, ductility, base metal type to be welded, the position of the weld as horizontal, vertical, overhead, and kind of current and polarity.

Classification of Welding Electrodes

The welding industry has adopted the welding rod classification number series decided by the American Welding Society (AWS).
The identification system of the electrode for steel arc welding is adopted as follows.

- E- This E indicates electrode for arc welding
- The 1st two or three digits – It indicates the tensile strength in thousands of pounds /square inch of deposited material once tried to pull apart.
- The 3rd or 4th digit – Indicates the position of the weld. If 0 it shows no classification used, 1 is for every position, 2 for flat and horizontal, and 3 is for flat position only.
- The 4th digit – Indicates the type of coating and the type of electric power supply, AC/DC, straight or reverse polarity.
- The number E6010 – Now indicates an arc welding rod with a stress tensile strength of 60,000psi, can be used in all positions, and direct current with terse polarity.



Key to Type of SMAW Coating and Current		
Digit	Type of Coating	Current
0	High Cellulose Sodium	DC+
1	High Cellulose Potassium	AC, DC±
2	High Titania Sodium	AC, DC-
3	High Titania Potassium	AC, DC±
4	Iron Power, Titania	AC, DC±
5	Low Hydrogen Sodium	DC+
6	Low Hydrogen Potassium	AC, DC+
7	High Iron Oxide, Iron Powder	AC, DC±
8	Low Hydrogen Potassium, Iron Powder	AC, DC±

The Stainless-Steel Arc Welding Electrode

Its classification goes as follows:

- E – This letter indicates the electrode for arc welding.
- The first 3 digits indicate the American iron and steel type of stainless steel.
- The last 2 digits indicate the position and current used in welding.
- The example of number E-308-16 suggests stainless steel type 308, for every position, with AC or reverse polarity direct current.

Storage

It is mandatory to keep electrodes dry as moisture may destroy the characteristics of their coatings and may lead to excessive spatters. It may cause porosity and cracks development in the welded zone. Once electrodes are exposed to the damp environment for more than 2-3 hours, they should be advised to heat dry in a suitable oven for a minimum of 2 hours at 500 degrees F.

Once out of the oven, they should be stored in a damp-proof container. Never bend the electrode as it may damage the coatings and expose the core wire. We should not use the electrode with exposed wire for welding. The electrodes supplied with the suffix R have a higher moisture resistance.

Types of Electrodes

Bare Electrodes

These bare electrodes are composed of wire compositions for those specific applications. There are no coatings extra except those required in the wire drawing. The wire drawing coatings have a little stabilizing effect on the arc but no specific consequences. These bare electrodes are used to weld manganese steel and other indications where the coated electrode is not desired.

Light Coated Electrodes

There is always a definite composition of the light-coated welding electrodes.

They applied a light coating on the surface by dipping, washing, brushing, spraying, wiping, and tumbling. These coatings were meant: to improve the arc stream. The E45 is the electrode identification system listed in the series.

These coatings have the following functions:

- It reduces/ dissolves the oxide, phosphorus, and oxide as impurities.
- It alters the surface tension of the molten metal. It makes the globules of the electrode smaller sizes and more frequent. It makes the movement of the molten metal smooth and uniform.
- It improves arc stability by readily ionized materials introduced into the arc cascade.

- The light coatings generate a slag that is thin unlike shielded arc electrode type slag

Shielded Arc/Heavy Coated Electrodes

These electrodes have a definitive composition and have a coating, applied by extrusion and dipping, and are manufactured in 3 general types.

- With cellulose coatings
- With mineral coatings
- With a combination of minerals and cellulose

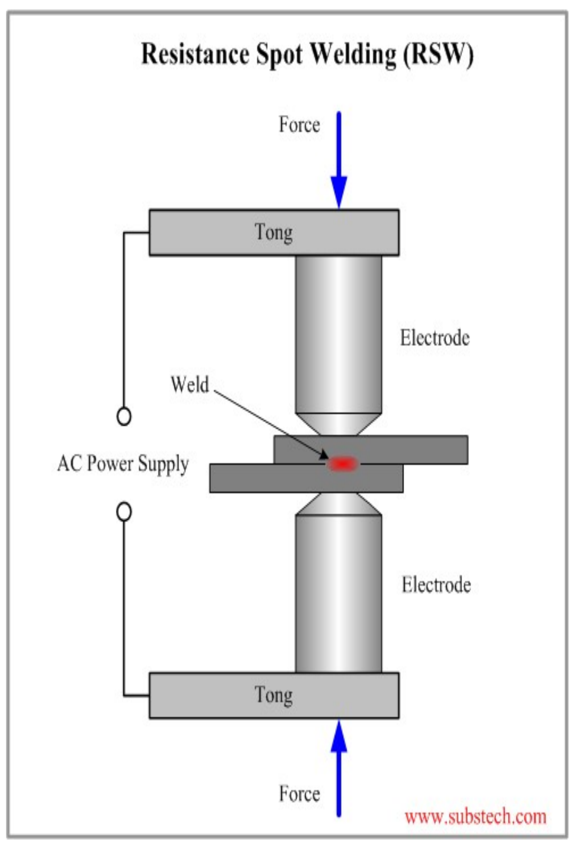
The cellulose coatings consisted of soluble cotton/ any other form of cellulose with a little amount of sodium, potassium, titanium, and some other added minerals. The cellulose coatings protect the molten metal with a gaseous section around the arc and the welding zone.

The mineral coatings include sodium silicate, metal oxide clay, and other inorganic substances and combinations. These electrodes generate a slag deposit.

The heavy-coated or shielded arc electrodes are employed to weld cast iron, steel, and hard surfaces.

2.7 Resistance Welding

Resistance welding, sometimes called electric resistance welding (ERW), is a process by which metals can be joined together by applying pressure and conducting a strong electric current through the metal combination to heat the welding joint and melt the metals, forging them together.



Resistance welding is generally used to join two plain metal work pieces together. An electric current is delivered to the metal sheets (or any workpieces being joined) through weld electrodes which apply force to the sheets. This force is then converted to heat. The heat is generated so that it melts the metal at the point where they join – the point of 'resistance' between the faying surfaces. The electrode then extracts heat from the molten weld area which forms a weld nugget at the point where it solidifies. A force is applied before, during, and after a current is applied, which confines the contact area.

Types of Resistance Welding

There are many resistance welding processes with different uses, such as spot welding, seam welding, and butt welding. Each one has a different specific welding application that makes it optimal for a particular situation.

1. Resistance Spot Welding

Resistance spot welding has been used extensively in the automotive industry for the joining of steel and in the aerospace industry for airframe components made from aluminum alloys. It is one of the oldest and simplest forms of resistance welding, in which a weld nugget is produced by passing an electric current between the two metal components whilst they are held together between electrodes, typically made from copper-based alloys due to their superior conductive properties.

2. Resistance Seam Welding

Resistance seam welding is a variation of the standard spot welding form, however, instead of spot one nugget, a series of overlapping nuggets is produced. This is usually done by replacing the conventional spot welding electrodes with wheels, which turn as the parts are fed between them. The process thus produces a continuously welded seam rather than a single spot. Seam welding is often used in the production of thin sheets, and leak-tight containers such as fuel tanks, and is generally unsuitable for welding aluminum.

3. Resistance Projection Welding

Resistance projection welding is a form of resistance welding where the electricity, force, and weld time are concentrated on raised 'projections' across the surface. Projection welding is generally used for welds using thicker materials than the thinner metal pieces that spot welding is usually required for, and often not metals. It is used primarily in the electrical, automotive, and construction industries.

4. Resistance Butt Welding

Resistance butt welding is a process in which the two components of similar cross sections can be joined together in one operation that takes place simultaneously across the entirety of the affected object, rather than just in small spots. The welding application of butt welding is often in wires and rods with small diameter measurements, generally up to about 16mm in diameter.

5. Flash Butt Welding

Flash butt welding is similar, but in this case, the energy transfer is primarily provided by the resistance heat arising from the parts themselves. This is a faster type of resistance welding where the welder joins the parts by applying some pressure, then by passing a heavy current through the joint which burns away surface irregularities. After the weld has generated enough heat, the parts are connected by applying heat and pressure simultaneously. This produces a forge butt weld with no melted metal remaining in the joint.

Advantages

- Similar and dissimilar metals are capable of being welded
- Highly automated
- Efficient with a high production rate and high welding rate
- Cost-effective
- Environment-friendly, produces little waste or pollution
- No need for filler metal or extraneous materials such as rods, fluxes, inert gasses, oxygen, or acetylene are required

Disadvantages

- Complex and often high-cost machinery – a resistance welding machine generally requires a high level of technically trained personnel to use
- The thickness of the workpiece is often limited
- It is less efficient for high conductive materials
- High electric power required.

2.8 Various Resistance Welding Processes

Flash Welding

Flash welding, *also called flash butt welding*, is a resistance welding process, in which the ends of the workpieces are pressed together and a heavy electric current is passed through the joint during the welding process.

In flash welding, the electrical current is applied to the workpieces before they are brought together so that when they meet arcing (or *flashing*) takes place.

Parts of Flash Welding

The main parts of the flash welding process are described below −

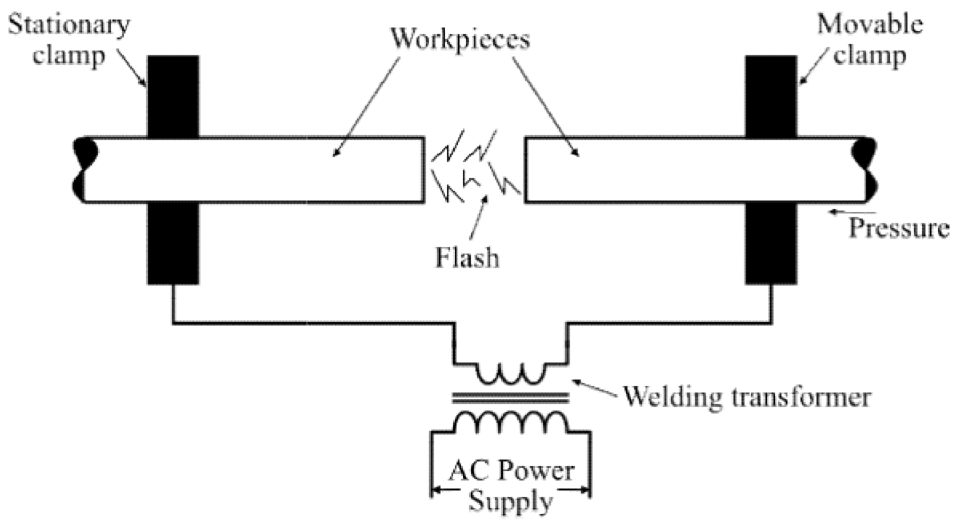
- Power Supply – An AC power supply is used to provide power for the flash welding or flash butt welding.
- Welding Transformer – A welding transformer is used for changing the current and voltage for the welding process.
- Clamps – In the flash welding process, two clamps are used viz. *stationary clamp* and *movable clamp*. The stationary clamp remains in a fixed position while the movable clamp moves about its axis. The metal workpieces are held by these clamps.

In the flash welding process, the two workpieces to be welded are clamped strongly in a flash welding machine.

The two workpieces are brought together, and the flash created and the resistance to the current flow heats the contacting surfaces.

As soon as the workpieces have been brought to their melting temperature, the supply of current is cut off and the workpieces are rapidly brought together under high mechanical pressure which forces the fused metal and slag out of the joint and makes a good solid weld.

When the ends of the workpieces collide, the squeezed molten metal flashes out in the outward direction, and this outward direction of the metal causes a flashing effect. Due to this flashing effect, this welding process is called flash welding.



Flash (Butt) Welding

Advantages of Flash Welding

- In flash welding, the power consumed is less as the arc also produces some heat required for the welding process.
- Flash welding is very cheap.
- Flash welding can be used for welding metals having different melting temperatures.
- Flash welding produces neat, clean, and strong welds.

Disadvantages of Flash Welding

- The welding machine used for flash welding is bulky.
- Chance of fire hazards is high.
- In flash welding, metal is lost during flashing.

Applications of Flash Welding

- Flash welding is used extensively in production work, particularly in welding rods and pipes together.
- Flash welding is widely used in automobile construction on the body, axis, wheels, frames, and other parts.
- Flash welding is also used in welding motor frames, transformer tanks, and many other types of steel containers.

Butt Welding

Butt welding is one of the simplest and most versatile resistance welding processes. In the butt-welding process, heat is produced by the contact resistance between two metal workpieces. The faces of the workpieces should be machined, or edge prepared.

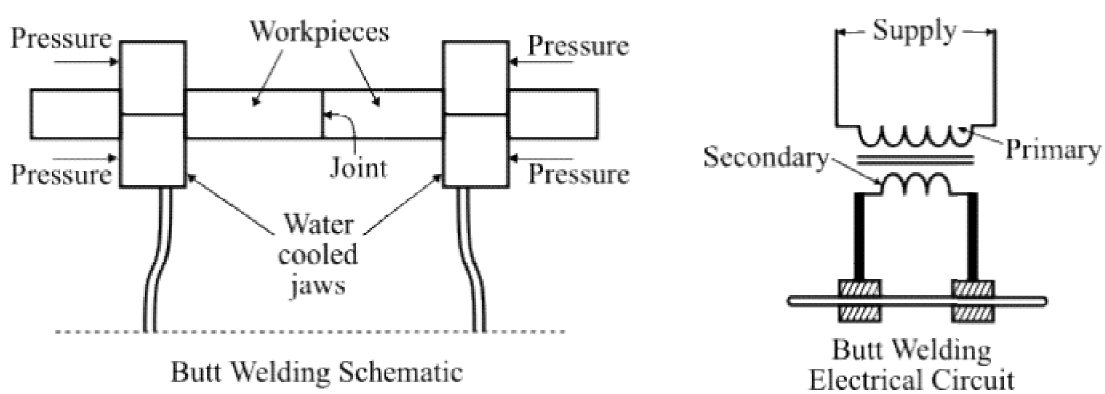


Figure - Butt Welding

In butt welding, the two workpieces are brought together, and mechanical pressure is applied along the axial direction by a spring.

A welding transformer is used that is having a larger number of turns in the primary winding and a smaller number of turns in the secondary winding.

A heavy current is passed from the welding transformer, which creates the required heat at the joint due to the comparatively high resistance of the contact area.

This heat melts the metal at the joint and the two workpieces fuse producing a weld joint.

Advantages of Butt Welding

- Butt welding process is easy to machine.
- It provides distortion control
- It produces welds of high strength with complete fusion.

Disadvantages of Butt Welding

- For butt welding, the welding geometry can limit its applications.
- Welds made by butt welding are sensitive to faying surface conditions.
- Butt welding process may require fixturing or backing.

Applications of Butt Welding

- Butt welding is used, where the metal pieces are joined end to end or edge to edge.
- Butt welding is used for welding such articles whose cross-sectional area is as much as 6.25 cm^2 such as steel rails.
- Butt welding is also used for welding pipes, wires, and rods, etc.

Spot Welding

The welding process which is used for welding two or more metal sheets together by applying pressure and heat from an electric current to the weld area is known as spot welding.

Spot welding is a type of resistance welding process, which is why it is also known as resistance spot welding.

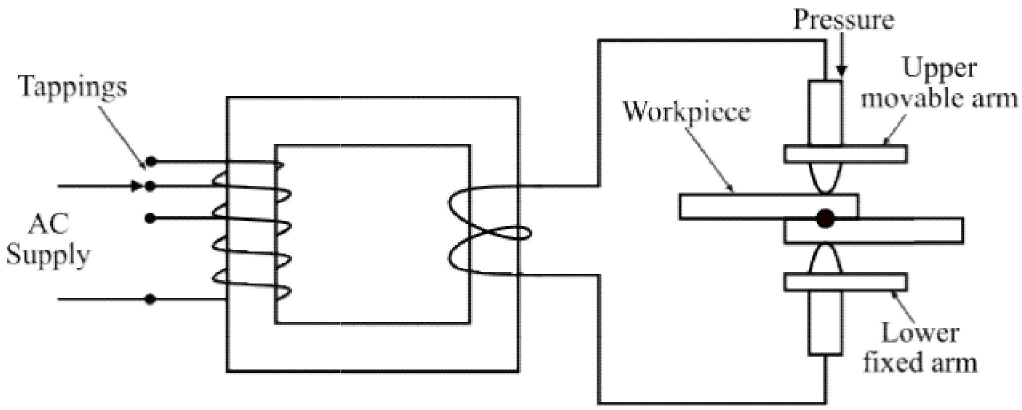


Figure - Spot Welding

Spot welding is the simplest and most universally adopted method of making lap joints in thin sheets up to a maximum thickness of 12.7 mm.

A typical spot-welding machine consists of a transformer to produce high current at low voltage and the electrodes are connected to the ends of the secondary winding for leading the current to the work.

There is also an arrangement to bring the electrodes in contact with the work and to apply the necessary mechanical pressure.

Advantages of Spot Welding

- Spot welding has high compatibility with efficiency and uniformity.
- Spot welding is economical, i.e., it is relatively cheap to operate.
- Spot welding provides a much more efficient way of utilizing electrical energy for the welding process.
- Spot welding is a fast-welding process.

Disadvantages of Spot Welding

- Spot welding requires a large working area.
- The welding gun used in spot welding is heavy and requires great strength when using it. Therefore, spot welding may be very dangerous to aged welders.

- Spot welding is not suitable for thicker materials.

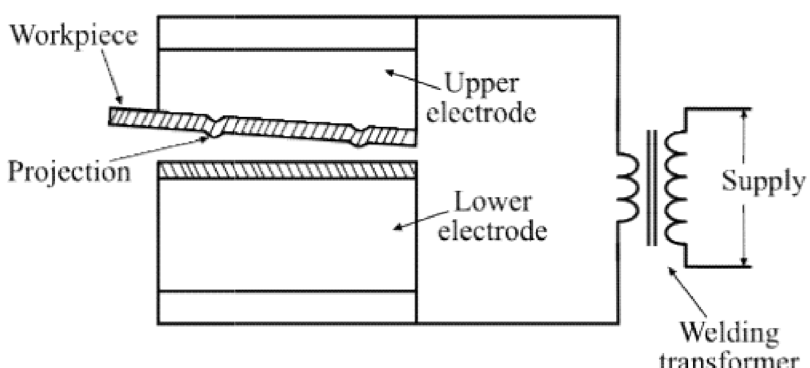
Applications of Spot Welding

- Spot welding is used in various industries such as automotive, aerospace, metal furniture, electronics, building construction, etc.
- Spot welding is used in high-volume production applications.
- It is applied for the welding of thin sheets.
- Spot welding is also used for fabricating all types of sheet metal structures where high mechanical strength is required.
- Spot welding can also be applied to all types of boxes, cores and enclosing cases, etc.

Projection welding

It is the resistance welding process that joins the metal pieces together by using the heat generated by an electric current. In this welding process, different projections are formed on the workpieces for effective welding, which is why the name "projection welding."

Projection welding does not use electrodes for the concentration of heat, instead, the projection on the workpiece is used for this purpose. Projection welding is a modified version of spot welding. It consists of forming slight projections on one metal.



Projection Welding

The setup used for projection welding consists of two copper electrodes.

The metal pieces to be welded are kept between these two electrodes as shown in the above figure.

After that, the projections are accurately formed in precise locations on the metal workpieces by using a special set of dies.

Once the projections are formed, the raised portions on one workpiece are pressed into contact with another workpiece.

At the same time, a high electric current is passed through the workpieces.

When the raised portions touch the second workpiece of metal, the electric current flows through the contact points, which heats and fuses the two metal workpieces.

Advantages

- There is no limitation on the metal thickness, i.e., the metal of any thickness can be welded with the projection welding.
- With projection welding, more than one weldis done at a time. Hence, more output is obtained.
- In projection welding, less current is passed through the electrodes and low pressure is applied. Thus, the electrode life is increased.
- Projection welding gives good heat balance while the welding process.
- The weld with a well-furnished appearance is obtained in the projection welding.

Disadvantages

- The process of projection formation is complicated and time-consuming.
- It requires highly skilled welders.
- Projection welding cannot be applied to all types of workpieces.
- Equipment used for projection welding is expensive

Applications of Projection Welding

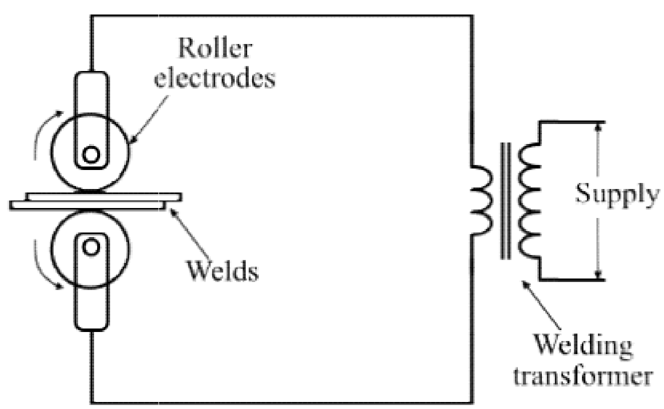
- Projection welding is used for welding studs, nuts to plates, etc.
- Projection welding is also used in automobile industries, shipbuilding works, sheet metal works, etc.
- It is also used for welding the parts of refrigerators, grills, condensers, etc.

Seam Welding

The welding process in which two similar or dissimilar materials are joined at the seam by the application of heat generated from electrical resistance is known as seam welding. Seam welding is a type of resistance welding, in which weld is produced by roller electrodes instead of tipped electrodes.

Most seam welding processes produce a continuous or intermittent seam weld near the edge of two overlapped metals by using two machine-driven roller electrodes. As in the seam welding process, the roller electrodes move over the metal workpieces, the workpieces are under pressure and the current passing through them heats the two workpieces of metal to the melting point. Thus, this process, is sometimes, also called seam spot welding.

Resistance seam welding is one of the most common welding processes used to join metal sheets with a continuous weld. In the seam welding process,when two similar or dissimilar materials are pressed together, there will be a small gap between them because of irregularities in the metal surface. This gap causes an electrical resistance between the two materials and results in them heating up at the seam.



Resistance Seam Welding

Types of Seam Welding

Resistance seam welding is broadly classified into two types, viz. −

- Intermittent Seam Welding – In the case of intermittent welding, the weld occurs at specific spots rather than as a continuous line. This type of seam welding is useful for welding thick metals where a continuous weld is not possible.
- Continuous Seam Welding – In continuous seam welding, an uninterrupted current flows through the electrodes and the metals to be joined are passed through the electrodes at a constant speed. As the workpieces remain under constant pressure, thus, it produces a uniform overlapping weld.

Advantages

- The welds produced by the seam welding are air-tight and water-tight.
- Seam welding is a fast-weldingprocess and it can be automated using robotic machines.
- It does not require any flux and filler materials.

Disadvantages

- As it has roller electrodes, thus, only straight line or uniformly curved line welds can be made with resistance seam welding.
- It is not suitable for metal sheets of thickness more than 3 mm per sheet.

Applications

- It is used for making lap joints.
- It is used in the manufacturing process of various types of pressure-tight or leak-proof tanks such as fuel tanks, oil switches, transformer tanks, aircraft tanks, etc.
- Used for welding parts of vessels that need to be air-tight and water-tight.
- For welding of pipes and tubes.

Tungsten Inert Gas Welding

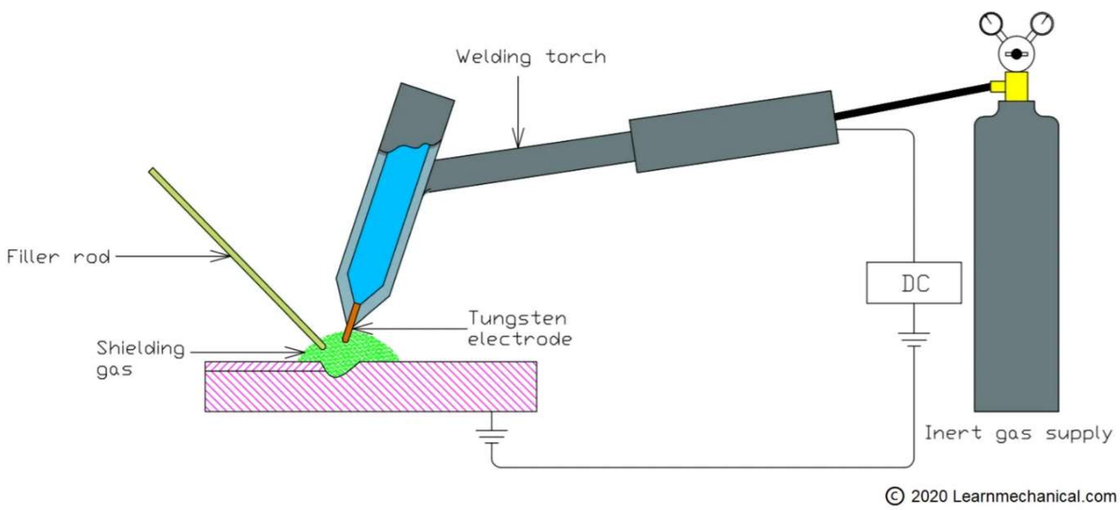
Tungsten inert gas (TIG) welding is one type of arc welding method where we use a non-consumable tungsten electrode, to weld the two metallic bodies.

The weld spot is protected from contamination by helium, argon, and other inert shielding gases.

Construction of Tungsten Inert Gas Welding Machine:

A Tungsten Inert Gas Welding Machine consists of the following equipment:

- Power Supply
- Inert Gas Supply
- Welding Torch/Holder
- Tungsten Electrode
- Shielding Gas
- Filler Rod



Power Supply:

In TIG welding we need a constant power supply because if there was a fluctuation of current then it is hard for the welder to weld the joints properly.

The power supply can be of two types:

1. DC Power Supply 2. AC Power Supply

In the DC power supply, we can weld steel, nickel, titanium, etc. And in the AC power supply, we can weld magnesium, aluminum, etc.

Inert Gas Supply:

In TIG Welding, we need an inert gas supply to provide the shielding to the weld area from the atmospheric gas (For example, Oxygen, Nitrogen, and Hydrogen).

In general, Argon is used as an Inert gas supply in TIG Welding.

Welding Torch:

In TIG Welding the welding torch is designed to do either automatic or manual operations.

However, in terms of construction, both are the same, in the manual torch, they are provided with a handle to hold, and in the case of the automatic, they are designed to mount on an automatic machine.

Torches are provided with a cooling system either by water or air.

When the Ampere of the current is less than 200A generally we use air-cooling, but if it exceeds 200A then we use water cooling to decrease the temperature of the welding torch.

The inside portion of the welding torch is generally made of copper to increase the conductivity of heat.

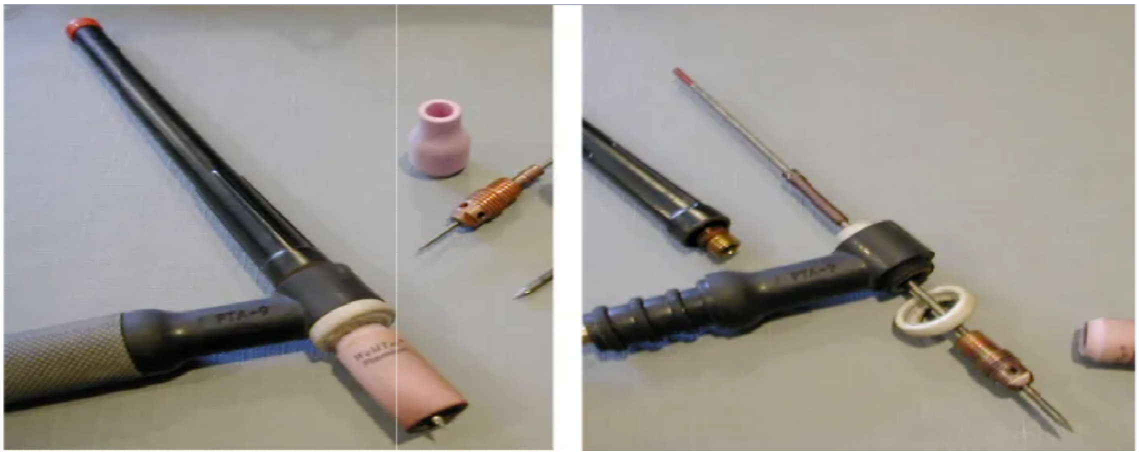
And the torches are provided with a holding arrangement (Port) to hold the Tungsten electrode firmly.

Tungsten Electrode:

In TIG Welding we use a non-consumable electrode made of Tungsten or Tungsten Alloy.

Due to the High-temperature resisting capacity (the Melting Temp of Tungsten is 3,422 °C) of tungsten rather than any other metal, that's why we use the tungsten electrode.

The diameter of the electrode generally varies from 0.5 mm to 0.65 mm, and the length varies between 75 mm to 610 mm.



Shielding Gas:

Shielding gases are used to protect the welding pool from atmospheric gases like nitrogen, and oxygen otherwise these gases can damage the welding surface by creating porosity, blowhole, etc.

However, generally, we use Argon as a shielding gas in TIG Welding. Sometimes Argon-helium mixtures are also used in this type of welding.

Working Principle of Tungsten Inert Gas Welding:

When we switch on the machine the high-frequency generator provides an electric spark.

The electric spark is struck between the Workpiece and the Electrode either by touching the electrode with scrap material or by using a high-frequency unit.

We need to do this operation at least 2-3 times to warm up the electrode before the actual operation started. Due to this, we can save the breaking of the electrode tip.

In actual operation, the heat generated by the electric spark fuses the metal from the joint area and produces a molten weld pool. The size of the pool depends on the size of the electrode and the amount of current supplied by the generator.

The arc area is surrounded by an inert or reducing gas shield to protect the weld pool and the non-consumable electrode.

The process may be operated autogenously, which that means without filler material or filler material may be added by feeding a consumable wire or rod into the established weld pool.

Tungsten Inert Gas Welding produces very high-quality welds across a wide range of materials with thicknesses up to about 8 or 10mm.

Advantages of TIG Welding:

The advantages of Tungsten Inert Gas Welding are the following:

- Tungsten welding offers a solution for welding critical joints, and for situations where small or exceptionally precise welds are required.
- It can be performed with a wide variety of metals
- And, when done correctly, it produces a high-quality and high-purity weld compared with other joining processes, which is crucial in many applications.
- It can be done both automatically and manually.
- Overall, it is one of the most efficient ways to join two metals.
- No slag is produced.
- TIG Welding can be done in any position.

Disadvantages of TIG Welding:

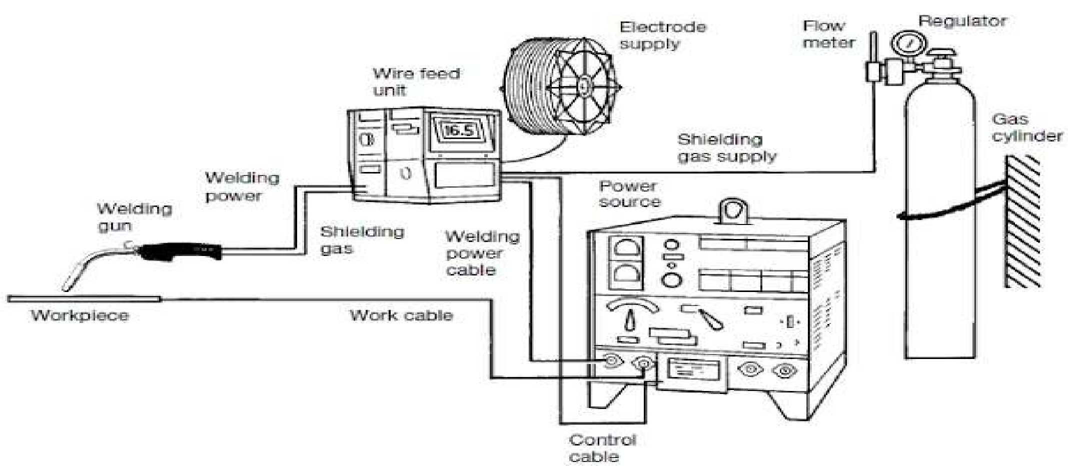
- Tungsten welding cannot be used for thicker sheets of metals.
- More complicated-High Skilled and professional workers are needed.
- The safety issue, welders are exposed to the high intensity of lights which can cause eye damage.
- The price of TIG welding services is high.
- It is a slow process of welding.

MIG WELDING

Mig works on the same principle as TIG or arc welding. It works on the basic principle of heat generation due to an electric arc.

This heat is further used to melt consumable electrode and base plates metal which solidifies together and makes a strong joint.

The shielded gases are also supplied through the nozzle which protects the weld zone from other reactive gases. This gives a good surface finish and a stronger joint.



Equipment:

Power Source:

In this type of welding process, a DC power supply is used with reverse polarity.

Reverse polarity means the electrode or in the case of the MIG welding electrode,the wire is connected positive terminal and the workpiece to the negative terminal.

Wire Feeder System:

MIG welding needs a continuous consumable electrode supply for welding two plates. This consumable electrode is used in form of wire.

This wire is continuously supplied by a wire feed mechanism or system.

It controls the speed of the wire and also pushes the wire fromthe welding torch to the welding area.

These are available in different shapes and sizes. It consists of a wire pool holder, a driving motor, a set of driving rollers, and wire feed controls.

Welding Torch:

In this torch, there is a mechanism thatholds the wire and supplies it continuously with the help of a wire feed.

The front end of the torch is fitted with a nozzle. The nozzle is used to supply inert gases.

Working:

- First, a high-voltage current is changed into a DC supply with a high current at low voltage. This current passesthroughthe welding electrode.
- A consumable wire is used as an electrode. The electrode is connected to the negative terminal and the workpiece from the positive terminal.
- A fine intense arc will generate between the electrode and workpiece due to the power supply. This arc is used to produce heat which melts the electrode and the base metal. Most electrode is made of base metal for making uniform joint.
- This arc is well shielded by shielding gases. These gases protect the weld from other reactive gases which can damage the strength of the welding joint.
- This electrode travels continuously on the welding area for making proper weld joints. The angle of the direction of travel should be kept between 10-15 degrees. For fillet joints, the angle should be 45 degrees.

Applications:

- MIG is best suited for the fabrication of sheet metal.
- Generally, all available metals can be welded through this process.
- It can be used for deep groove welding.

Advantages:

- It providesa higher deposition rate.

- It is faster compared to arc welding because it supplies filler material continuously.
- It produces clean welds with better quality.
- There is no slag formation.
- Minimize weld defects.
- This welding produces very little slag.
- It can be used to make deep groove welds.
- It can be easily automated.

Disadvantages:

- It cannot be used for welding in difficult-to-reach portions
- Higher initial or setup cost.
- It cannot be used for outdoor work because wind can cause damage tothe gas shield.
- It required highly skilled labor.

Welding Defects can be defined as the irregularities formed in the given weld metal due to the wrong welding process or incorrect welding patterns, etc.
The defect may differ from the desired weld bead shape, size, and intended quality. Welding defects may occur either outside or inside the weld metal.
Some of the defects may be allowed if the defects are under permissible limits but other defects such as cracks are never accepted.
Types

1) External Welding Defects:

1. Weld Crack
2. Undercut
3. Spatter
4. Porosity
5. Overlap
6. Crater

1) Internal Welding Defects:

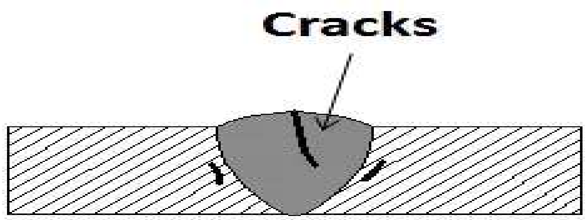
1. Slag Inclusion
2. Incomplete Fusion
3. Necklace cracking
4. Incompletely filled groove or Incomplete penetration

External Welding Defects

The various types of external defects with their causes and remedies are listed below:

1. Weld Crack

This is the most unwanted defect of all the other welding defects. Welding cracks can be present at the surface, inside of the weld material, or at the heat-affected zones.



Crack can also appear at different temperatures:

Hot Crack –

It is more prominent during crystallization of weld joints where the temperature can rise more than 10,000-degree Celsius.

Cold Crack –

This type of crack occurs at the end of the welding process where the temperature is quite low. Sometimes cold crack is visible several hours after welding or even after few days.

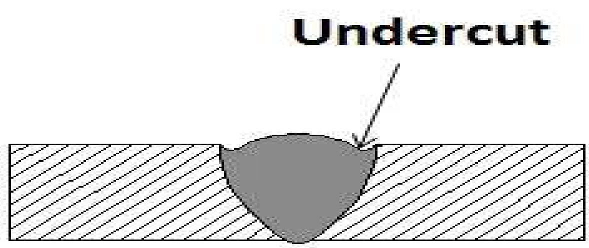
Causes Of Weld Crack:

1. Poor ductility of the given base metal.
2. The presence of residual stress can cause a crack on the weld metal.
3. The rigidity of the joint which makes it difficult to expand or contract the metals.
4. If there is high content on sulfur and carbon then also the cracks may appear.
5. Using hydrogen as a shielding gas while welding ferrous materials.

Remedies for Weld crack:

1. Using appropriate materials may decrease the chances of crack.
2. Preheating the weld and reducing the cooling speed joint helps in reducing crack.
3. Reduce the gap between the weld joints by using reasonable weld joints.
4. While welding releases the clamping force slowly which increases fill to capacity of welding material.

2. Undercut



When the base of metal melts away from the weld zone, then a groove is formed in the shape of a notch, then this type of defect is known as Undercut. It reduces the fatigue strength of the joint.

Causes

1. If the arc voltage is very high then this defect may occur.
2. If we use the wrong electrode or if the angle of the electrode is wrong, then also a defect may form.
3. Using a large electrode is also not advisable.
4. High electrode speed is also one of the reasons for this defect.

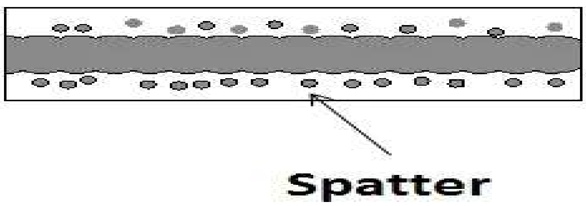
Remedies

1. Reduce the arc length or lower the arc voltage.
2. Keep the electrode angle from 30 to 45 degrees with the standing leg.

3. The diameter of the electrode should be small.

4. Reduce the travel speed of the electrode.

3. Spatter



When some metal drops are expelled from the weld and remain stuck to the surface, then this defect is known as Spatter.

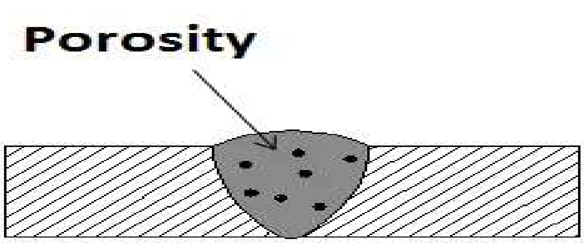
Causes

1. High Welding current can cause this defect.
2. The longer the arc the more chances of getting this defect.
3. Incorrect polarity.
4. Improper gas shielded may also cause this defect.

Remedies

1. Reducing the arc length and welding current
2. Using the right polarity and according to the conditions of the welding.
3. Increasing the plate angle and using proper gas shielding.

4. Porosity



Porosity in the condition in which the gas or small bubbles gets trapped in the welded zone.

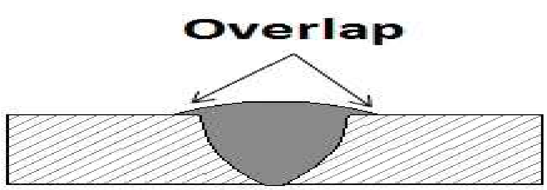
Causes

1. It occurs when the electrode is not coated properly.
2. Using a longer arc may also increase its chances.
3. Increased welding currents.
4. Rust or oil on the welding surface

Remedies

1. Proper selection of the electrode.
2. Decreasing the welding current.
3. Using smaller arc and slowing the process to allow the gases to escape.
4. Remove rust or oil from the surface and use a proper technique

5. Overlap



When the weld face extends beyond the weld toe, then this defect occurs. In this condition the weld metal rolls and forms an angle less than 90 degrees.

Causes

1. Improper welding technique.
2. By using large electrodes this defect may occur.
3. High welding current

Remedies

1. Using a proper technique for welding.
2. Use small electrode.
3. Less welding current.

6. Crater

It occurs when the crater is not filled before the arc is broken, which causes the outer edges to cool faster than the crater. This causes a stress and then crack is formed.

Causes

1. Incorrect torch angle.
2. Use of large electrode:
3. Improper welding technique

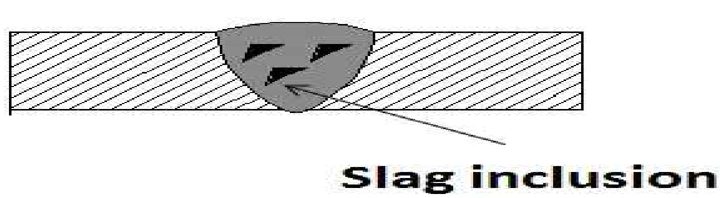
Remedies

1. Using a proper torch angle may reduce the stress on the metal
2. Using a small electrode may also decrease the crater.
3. Use a proper technique.

Internal Welding Defects

The various types of internal welding defects with their causes and remedies are listed below:

1. Slag Inclusion

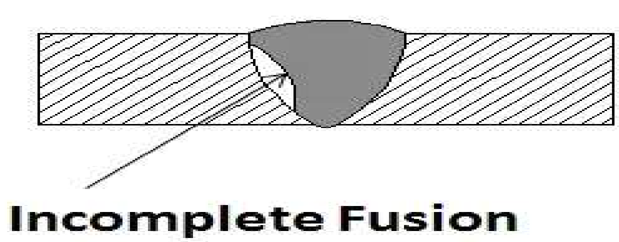


If there is any slag in the weld, then it affects the toughness and metal weldability of the given material. This decreases the structural performance of the weld material. Slag is formed on the surface of the weld or between the welding turns.

Causes

1. Slag is formed if the welding current density is very small, as it does not provide the required amount of heat for melting the metal surface.
2. If the welding speed is too fast then also slag may occur.
3. If the edge of the weld surface is not cleaned properly then also slag may form.
4. Improper welding angle and travel rate of welding rod.

2. Incomplete Fusion



Incomplete fusion occurs when the welder does not accurately weld the material and the metal pre solidifies which leads to a gap which is not filled with the molten metal.

Causes

1. It occurs because of the low heat input.
2. When the weld pool is very large and runs ahead of the arc.
3. When the angle of the joint is too low.

4. Incorrect electrode and torch angle may also lead to incomplete fusion.
5. Unproper bead position.

Remedies

1. Increasing the welding current and decreasing the travel speed helps in removing the chances of incomplete fusion.
2. Reducing the deposition rate.
3. Increasing the joint angle.
4. Try to position the electrode and torch angle properly so that the edges of the plate melt away.
5. Positioning the bead properly so that the sharp edges with other beads can be avoided.

3. Necklace Cracking

It occurs in the use of electron beam welding where the weld does not penetrate properly. Therefore, the molten metal does not flow into the cavity and results in a cracking known as "Necklace Cracking".

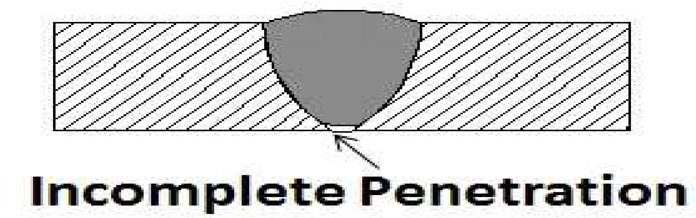
Causes

1. Improper welding technique.
2. It occurs in materials such as nickel base alloys, stainless steel, carbon steels and Tin alloys.
3. Using high speed of electron beam welding

Remedies

1. Using a proper welding technique reduce the chances of necklace cracking.
2. Using proper materials for welding.
3. Using a constant speed during the welding process.
3. Improper welding technique

4. Incompletely Filled Groove or Incomplete Penetration



These defects occur only in the butt welds where the groove of the metal is not filled completely. It is also called as incomplete penetration defect.

Causes

1. Less deposition of the weld metal
2. Use of improper size of the electrode
3. Improper welding technique

Remedies

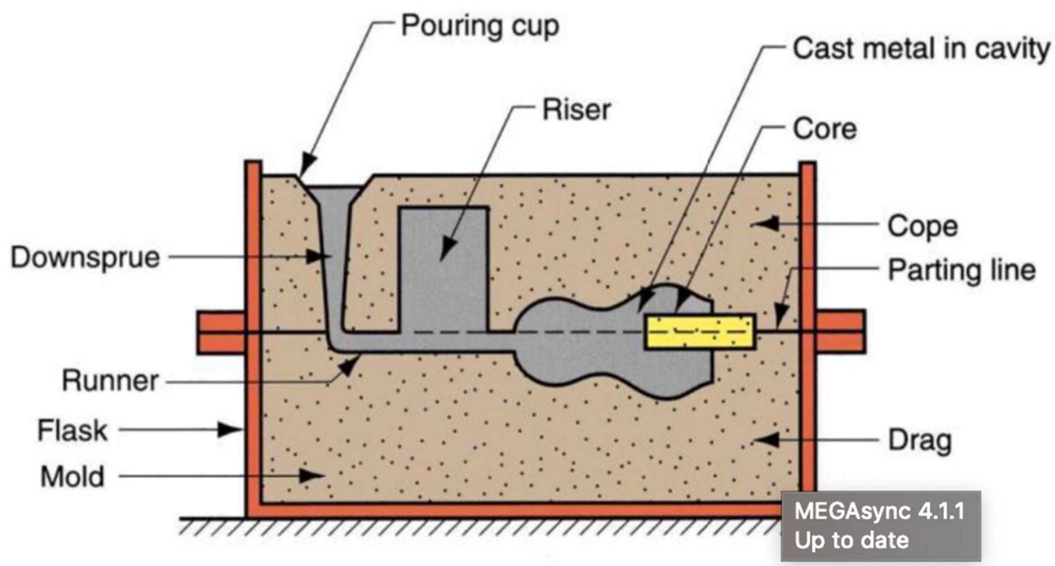
1. More deposition of the weld metal.
2. Use the proper size of the electrode.
3. By using a proper welding technique.

3.0 CASTING

3.1 Define Casting and Classify the various Casting processes:

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

Basic Terminologies of the Casting Process:



- **Flask**: A metal or wood frame in which mold is formed.
- **Cope:** The upper half of the flask is called the cope.
- **Drag**: The lower half of the flask is called drag.
- **Core**: Core is used to create an internal hollow cavity in the final product.
- **Vents:** These are the places created in the mold to carry off-gases produced when the molten metal comes in contact with the sand.

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

Steps Involved in Casting Process:

1. Pattern Forming
2. Core Forming
3. Mold Making
4. Pouring Process and
5. Solidification Process

Pattern Forming:

The First step of this process is to select the shape that we have to cast. Then we have to make the dummy material of the equipment that we have selected to cast. The dummy material is also called the pattern. The dummy material can be made of wax, wood, metal, plastic, etc.

Core Forming:

After making the pattern then comes the core making. The core is made when the casting requires some internal features like a hole. The core is made from sand of higher purity

Mold Making:

To make the mold we take a wooden box, and then place the pattern in the wooden box. After that, we will put the drag above the wooden box and fill the drag with sand. We will fill the sand tightly in the drag.

Pouring Process:

The first step of this method is to select the type of metal to be used for the casting purpose. Then the selected metal is melted to remove all the impurities and gases. And then this molten metal is poured into the mold so that the release of gases produced due to contact of the sand mold with the molten metal is the least. As well as the gases present in the mold get enough time to exit from the vents

Solidification Process:

Casting should be designed in such a way so, that directional solidification (from one end to another end) takes place to avoid defects.

The molten metal solidifies it is ejected from the casting mold either by breaking the mold or by using tools for ejection.

Classification of Casting

1. Shell Casting Process:

Shell molding is the casting process that uses a mold-like shell made up of materials like fine-grain silica, thermosetting resin, and alcohol.

In this method, the pattern is heated up to 250-degree Celsius.

This mold has high strength and is light-weighted. The mold is suitable for automatic casting.

This method can be used for both ferrous and non-ferrous metals.

2. Investment Casting Process:

This is the type of casting process in which casting is formed around a pattern made of wax or similar material.

In this casting, the pattern is used and is made up of wax and the casting is formed around the pattern by dipping it into the slurry made of silica flour, ethyl silicate & water.

3. Sand Casting Process:

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

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

4. Centrifugal Casting Process:

Centrifugal or roto casting works on the principle of centrifugal force to produce hollow cylindrical parts or products.

During this casting operation, a cylindrical mold revolves at a high velocity around its central axis as melted metal pours into it.

This rotation of the cylindrical mold creates centrifugal force, which pushes the molten metal to the circumference of the mold.

Resulting in forming of hollow cylindrical parts & products.

5. Gravity Die Casting Process:

Gravity dies casting is a type of permanent casting in which the molten metal is poured into the die with the ladle.

While filling the mold with the melted metal no force will act other than gravity force. The material that has high fluidity is made by gravity die casting.

Advantages of the Casting Process:

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

- It is the cheapest way to produce shapes and sizes with different mechanical properties.

Disadvantages of the Casting Process:

- High chances of defects.
- The dimensional accuracy of casting is not so good.
- In some cases, it is not possible to overcome defects.

3.2 Explain the Procedure of Sand Mould Casting

1. **Pattern-making** step in which a replica of the object to be cast is made of suitable material. The pattern usually is oversized to allow for metal shrinkage during the cooling phase
2. **In the mold-making step**, a sand mold is formed by packing sand into the mold around the pattern. The sand mold is divided into two halves, the top half is called the "Cope", and the bottom part is called the "Drag". When the pattern is removed from the cavity, it forms remains for pouring the molten metal. Mould will have other features such as Sprue, runners, gate, pouring cup, riser, etc, which is discussed in detail later.
3. **The clamping step** involves the two mold halves Cope and Drag securely clamped together, ready for pouring metal.
4. **Pouring molten metal** is maintained at a set temperature. Molten metal is poured in quickly to avoid early solidification and
5. Poured molten metal will begin to cool and solidify once it is inside the cavity. Most of the possible sand-casting defects are introduced at this solidification stage
6. Once the cooling period elapses the mold can be shaken out/broken off and casting
7. **Trimming** involves cleaning and removing the section that is connected to the main part such as the runner, Sprue, etc

3.3 Explain Different Types of Molding Sands with Their Composition and Properties:

1. Green Sand

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

Green sand is slightly wet when squeezed by hand. It could maintain the shape and impression given to it under the pressure. The green sand can is easily available, and it has a low cost. The mold that is prepared in this sand is called green sand mold. It is commonly used to produce ferrous and non-ferrous castings.

2. Dry Sand

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

3. Loam Sand

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

4. Facing Sand

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

5. Backing Sand

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

6. Parting Sand

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

7. Core Sand

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

Properties of Moulding Sand:

- **Refractoriness**– It should be able to withstand high temperatures.
- **Permeability**– Ability to allow gases, water vapor, and air to pass through it.
- **Greensand strength**– When the mold is formed of moist sand, it must have sufficient strength, otherwise, the mold will break.
- **Good flowability**– When it is arranged around a pattern in a molding box, it must be able to fill all nooks and corners, otherwise the impression of the pattern in the mold would not be sharp and clear.
- **Good collapsibility–** It should collapse easily after the casting has cooled down and has been extracted after breaking the mold. It is particularly important in the case of care making.
- **Cohesiveness–** Ability of sand grains to stick together. Without cohesiveness, the mold will lack strength.
- **Adhesiveness–** Ability of the sand to stick to other bodies. if the molding sand does not stick to the wall of the molding box, the whole mold will slip through the box.

3.4 Classify Different Patterns and State Various Pattern Allowances:

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

Types of patterns:

Single Piece Pattern

Single piece pattern, also called solid pattern is the lowest cost casting pattern. It is very suitable for a simple process, and small-scale production and large casting manufacturers prefer it because this kind of casting pattern makes the casting process just need simple shapes and flat surfaces like simple rectangular blocks. One flat surface is used to separate planes.

Two-Piece Pattern

A two-piece pattern also called a split-piece pattern is a common casting pattern for intricate casting. This kind of pattern has parting planes which may have a flat or irregular surface, and the exact position of the plane was decided by the shape of the casting. There are two pieces of the split-piece pattern. One of the parts is molded in drag and another is molded in cope. And the cope part always has dowel pins. With the dowel pins, the two halves of split piece pattern can be aligned

Multi Piece Pattern

Multi-piece pattern is a good solution for complex designs which is hard to make. This kind of pattern includes 3 or more patterns that help you achieve mold-making.

Take the three-piece pattern as an example. The pattern is made of the top, bottom, and middle parts. The top part is cope, the bottom part drag, and the middle parts are called a checkbox.

Match Plate Pattern

The match plate pattern has a metallic plate to divide the cope and drag areas into the opposite face of the plate. This kind of pattern nearly has no hard work and can provide high output. It is widely used in the manufacturing industry, and usually has an expensive cost, precise casting, and high yield. And this kind of casting pattern is widely used in metal casting like aluminum

Gate Pattern

Gate patterns can consist of one or more patterns in a pattern molding pattern. It is designed for the mold which makes multiple components in one casting process. The gates are used to combine the different patterns, and runners to create a flow way for the molten materials. When the gates and runners have already attached, the patterns are lost. This kind of pattern is expensive, and it is usually used for small castings.

Cope and Drag Pattern

Just like its name, the cope and drag pattern has consisted of two separate plates, and it has two parts that can be separately molded on the pattern molding box, and these parts create the cavity. This kind of pattern has a bit similar to the two-piece pattern and is usually used in large casting.

Types of Pattern Allowance

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

- Shrinkage Allowance
- Draft Allowance
- Machining Allowance

- Deformation or Camber Allowance
- Shake or Rapping Allowance

1. Shrinkage allowance:

After solidification of the metal from further cooling (room temp.) dimensions of the patterns increases. So pattern size is bigger than that of the finished cast products. This is known as shrinkage allowance.

2. Draft or taper allowance:

Pattern draft is the taper placed on the pattern surfaces that are parallel to the direction in which the pattern is withdrawn from the mold (that is perpendicular to the parting plane), to allow removal of the pattern without damaging the mold cavity.

3. Distortion allowance:

This allowance is taken into consideration when casting products of irregular shapes. When these are cooled, they are distorted due to metal shrinkage

4. Finishing or machining allowance:

Machining allowance or finish allowance indicates how much larger the rough casting should be over the finished casting to allow sufficient material to insure that machining will "clean up" the surfaces.

This machining allowance is added to all surfaces that are to be machined.

The machining allowance is larger for hand molding as compared to machine molding.

5. Shaking or rapping allowance:

To take the pattern out of the mold cavity it is slightly rapped to detach it from the mold cavity. So, the cavity is increased a little.

3.5 Classify Core:

Cores are the compact mass of core sand prepared separately that when placed in the mold cavity at a required location with proper alignment do not allow the molten metal to occupy space for solidification in that portion and hence help to produce hollowness in the casting.

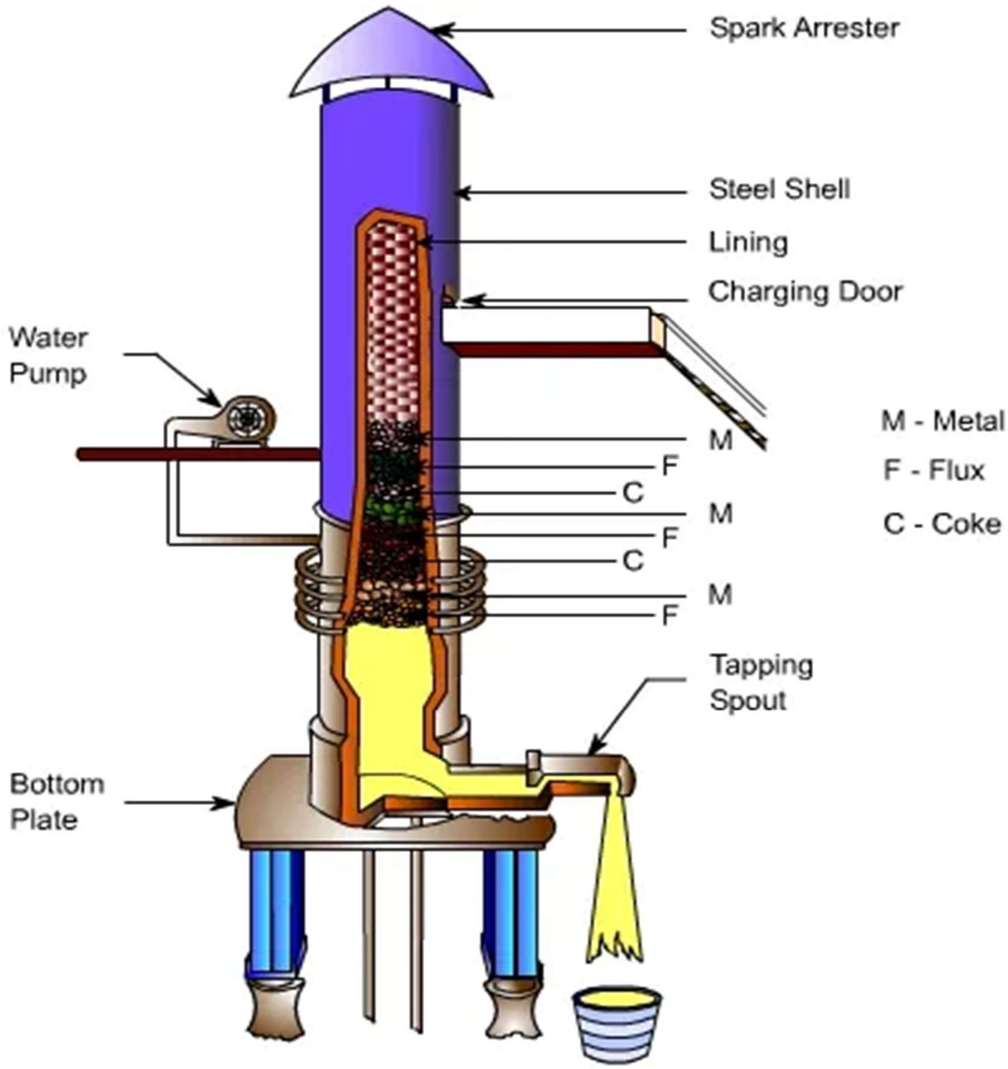
The core must withstand the severe action of hot metal which surrounds it. They may be of the type of green sand core and dry sand core. Therefore, the core must meet the following functions or objectives which are given as follows:

- Core produces hollowness in castings in form of internal cavities.
- It must be sufficiently permeable to allow the easy escape of gases during pouring and solidification.
- It may form a part of a green sand mold
- It may be deployed to improve mold surface.
- It may provide external undercut features in casting.
- It may be inserted to achieve deep recesses in the casting.
- It may be used to strengthen the mold.
- It may be used to form a gating system of large-size mold.

3.6 Describe the Construction and working of the Cupola and Crucible furnace:

Cupola Furnace Construction:

A cupola furnace is constructed in the form of a hollow cylindrical vertical steel shell, and it is lined from the inside with a refractory material. This furnace is generally supported on four cast iron legs mounted on a concrete base.



Working:
After building the cupola make sure it is dried completely before getting it to fire. Any slag around the tuyeres from previous runs needs to be cleaned properly. Over the Brunt area, a layer of refractory material is applied to about thickness 6 inches or more and is rammed on the bottom sloping toward the tap hole to ensure better flow of molten metal.

A hole opening of about 30 mm diameter and a tap hole of about 25 mm diameter is being provided there.
a fire of wood is ignited. When the wood burns well coke is dumped on the bed well from the top. Make sure that the coke gets burned too. A bed of coke about 40 inches is placed next to the sand.

Firstly, the air blast is turned on At a lower blowing rate than as normal for provoking the coke. A measuring rod is also used which indicates the height of the coke bed. For about 3 hours firing is done before the molten metal is required.

These constituents form alternate layers. Besides limestone, fluorspar and soda ash are also used as flux materials. The main function of flux is to remove the impurities in the iron and protect the iron from oxidation

At the end of the soaking period, the air blast is opened. The topmost opening is kept closed till the metal melts. Enough metal is collected. The contents of the charge move downwards as the melting proceeds.

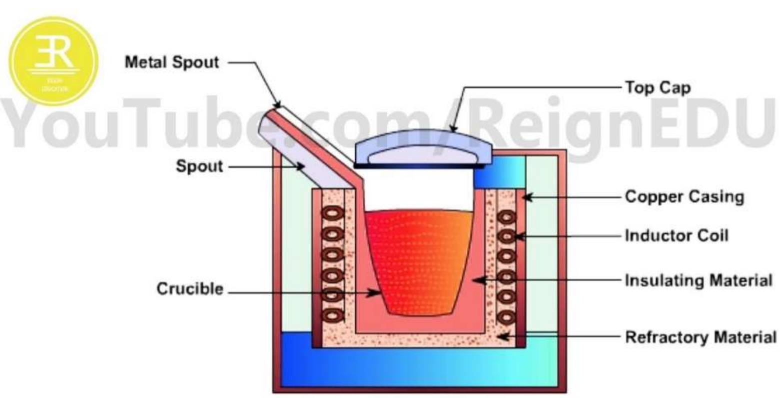
Closing feeding of charge and air blast is stopped when no more melting is required. The bottom plate swings to open when the prop is removed. The deposited slag is being removed. The cupola runs continuously and The melting period does not exceed 4 hours most of the time. But can be operated for more than 10 hours.

Crucible Furnaces

Crucible furnaces are one of the oldest and simplest types of melting units used in the foundry.

The furnaces use a refractory crucible which contains the metal charge. The charge is heated via the 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.



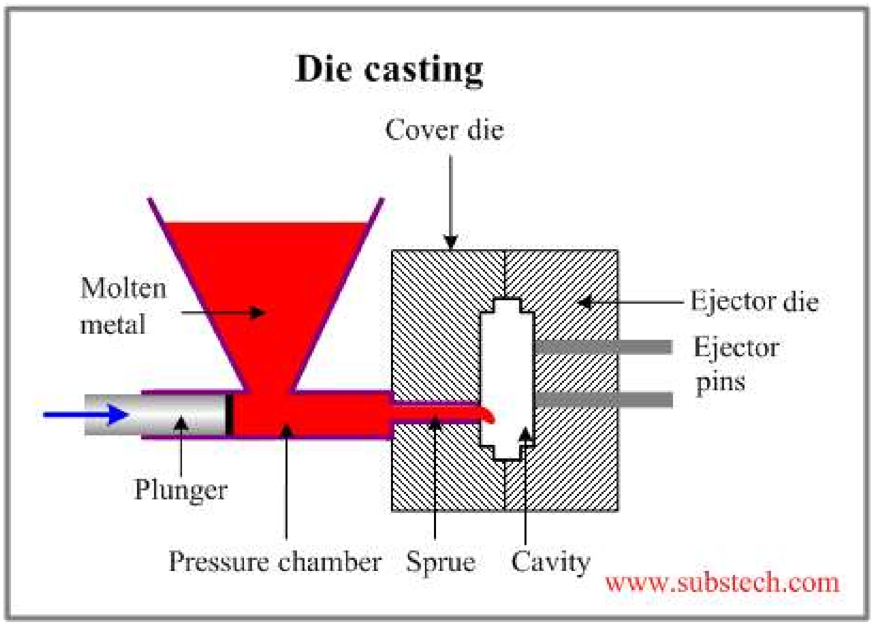
3.7 Explain Die Casting Method:

Die casting is a manufacturing process that can produce geometrically complex metal parts using reusable molds, called dies.

The die casting process involves the use of a furnace, metal, die casting machine, and die.

The metal, typically a non-ferrous alloy such as aluminum or zinc, is melted in the furnace and then injected into the dies in the die-casting machine.

There are two main types of die-casting machines - hot chamber machines (used for alloys with low melting temperatures, such as zinc) and cold chamber machines (used for alloys with high melting temperatures, such as aluminum).



Types of Die Casting Processes

The two die-casting processes used industrially are

1. hot chamber dies casting
2. cold chamber dies casting.

Hot Chamber Die Casting

The hot chamber die-casting process is the perfect method for working with low melting point materials such as zinc, tin, lead, and magnesium alloys.

It is not suitable for alloys with a higher melting point as it would damage the pump as the pump would directly contact the metal.

It involves melting the metal and injecting it into the die using pressure from a hydraulic system.

Cold Chamber Die Casting

The cold chamber dies casting is the perfect method for working with high melting point materials such as aluminum.

This process is ideal for such metals as the high temperature needed to melt the material can damage the pumping system.

The process involves ladling the melted material into a cold chamber before injection into the die.

The hydraulic system used in a cold chamber process is like that of the hot chamber process. However, it might require a larger pressure ranging from 2000 to 20000 psi.

3.8 Centrifugal casting:

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

High-quality products can be manufactured by the centrifugal casting process. It is mainly used to produce rotationally symmetric products.

The material we use to cast by centrifugal casting is cast iron, stainless steel, steel and aluminum, alloys of nickel, and copper.

After obtaining the product from this manufacturing the product requires some machining for good finishing and material luster.

Centrifugal Casting Parts:

The following parts of centrifugal casting are:

- Ladle
- Pouring Basin
- Core
- Rollers
- Motor

- Metal Mold

Ladle:

The ladle is a component that is used to put the molten metal into the pouring basin. It is made up of steel, or stainless steel.

Pouring Basin:

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

Core:

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

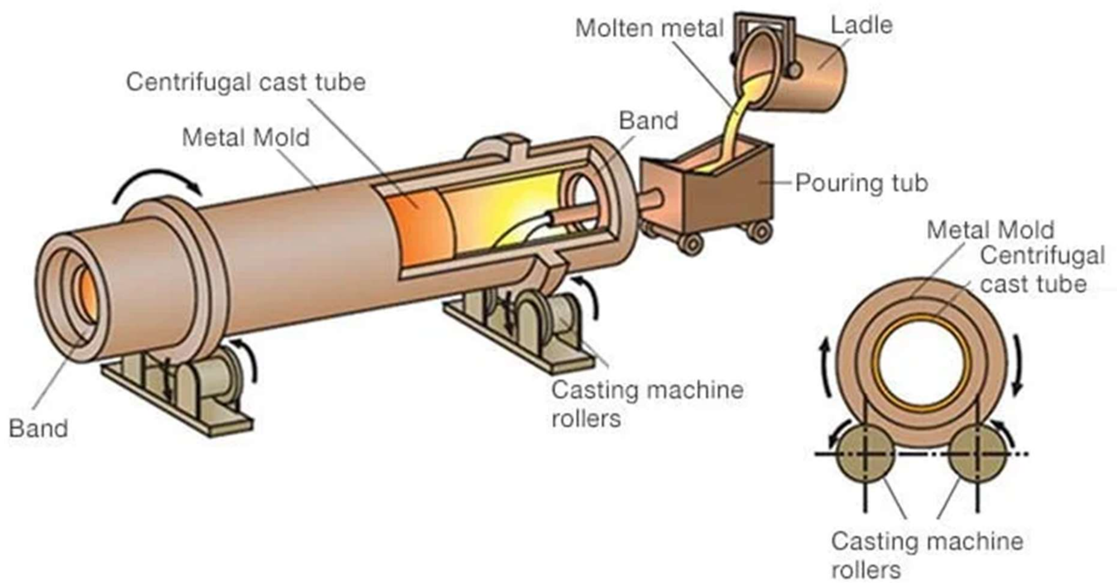
Rollers:

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

Motor:

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

Centrifugal Casting Working Process:



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

The motor starts get to rotate. The molten metal is put into the pouring basin with the help of a ladle.

And from the pouring basin, it is further put into the metal mold which is attached to the motor and it is rotating therefore the centrifugal force comes into play.

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

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

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

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

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

True centrifugal casting:

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

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

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

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

Casting cools and solidifies from the outside therefore it results in good directional solidification.

It is used to make hollow pipes, tubes, bushes, and so on which are axisymmetric with a concentric hole.

Centrifugal Casting Applications:

- Centrifugal casting is used to cast hollow cylindrical metal pipes
- this casting process is used in the automobile industry for various product manufacturing like pistons, cylinder liners, and so on.
- It is also used to manufacture carriage wheels of railway and bearings
- It is also used to create any parts whose shapes are symmetrical about an axis.

Centrifugal Casting Advantages:

- The centrifugal casting process has lower casting defects because of uniform solidification.
- The energy can be saved as it requires a lower pouring temperature
- By centrifugal casting, a thin wall cylinder can be easily manufactured\

- For casting hollow shapes like tubes and other components we do not require cores.
- Inclusions and impurities of the casting process are lighter.

Centrifugal Casting Disadvantages:

- In centrifugal casting, the temperature distribution and solidification time is difficult to determine.
- It is good for manufacturing only cylindrical structures.
- The size of components we manufacture here is limited.
- The centrifugal casting cast only symmetrical shapes
- More maintenance and skilled operator are required

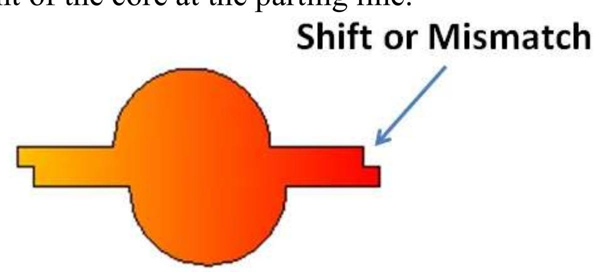
3.9 Casting Defects with their remedies:

Casting defects can be categorized into following types

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

1. Shift or Mismatch

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



Cause:

- Improper alignment of upper- and lower-part during mold preparation.
- Misalignment of flask

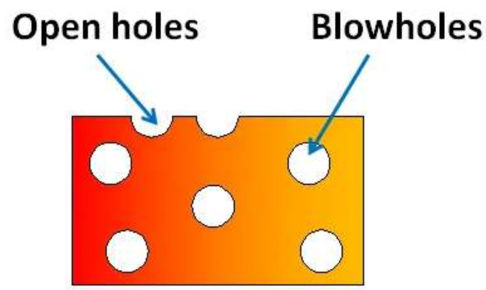
Remedies

- Proper alignment of the pattern or die part, molding boxes.
- Correct mountings of pattern-on-pattern plates.

- Check the alignment of flask.

2. 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

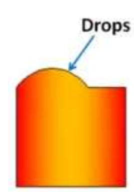
- Excessive moisture in the sand.
- Low Permeability of the sand.
- Sand grains are too fine.
- Too hard rammed sand.
- Insufficient venting is provided.

Remedies

- The moisture content in the sand must be controlled and kept at desired level.
- High permeability sand should be used.
- Sand of appropriate grain size should be used.
- Sufficient ramming should be done.
- Adequate venting facility should be provided.

3. Drop

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



Causes

- Soft ramming and low strength of sand.
- 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.
- Insufficient reinforcement of sand projections in the cope.

Remedies

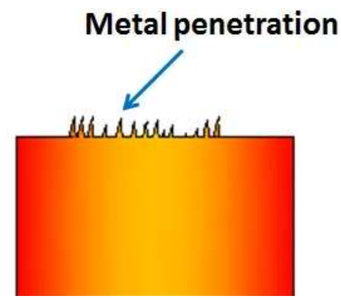
- Sand of high strength should be used with proper ramming.
- There should be proper fluxing of molten metal, so the impurities present in molten metal is removed easily before pouring it into the mold.
- Sufficient reinforcement of the sand projections in the cope.

4. 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

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

This defect can be eliminated by using high strength, small grain size, low permeability and soft ramming of sand.

5. Misrun

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

Causes

- Low fluidity of the molten metal.
- Low temperature of the molten metal which decreases its fluidity.
- Too thin section and improper gating system.

Remedies

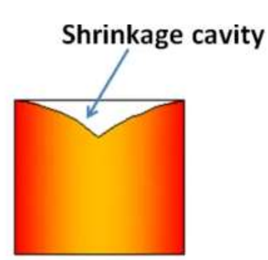
- Increasing the pouring temperature of the molten metal increases the fluidity.
- Proper gating system.
- Too thin section is avoided.

6. Shrinkage Cavity

The formation of cavity in the casting due to volumetric contraction is called as shrinkage cavity.

Causes

- Uneven or uncontrolled solidification of molten metal.
- Pouring temperature is too high.



Remedies:

- This defect can be removed by applying principle of directional solidification in mold design.

- 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.

4.1 Powder Metallurgy

Powder metallurgy is the name given to a process in which metallic powders are heated below their melting temperatures to achieve the bonding.

The powder metallurgy (P/M) process involves compacting of metal or alloy powders into the desired shape after blending and then heated in a controlled atmosphere at a temperature below the melting point to achieve the bonding of the particles to get the desired properties.

Powder metallurgy is a form of manufacturing that uses metal powder, and sometimes small amounts of non-metal powders, as raw materials to manufacture materials or products through mixing, forming, pressing, and sintering processes.

It is a mass-production method with little or no cutting, which can produce structural parts with complex shapes and high structural strength at a low cost.

It is presently the main method used for the mass production of bearings and self-lubricating parts.

Powder metallurgy can ensure uniformity of production at a low cost, with little need for subsequent mechanical processing.

Some refractory metals and their compounds, oxide dispersion-strengthened alloys, porous materials, ceramic materials, and cemented carbides can only be manufactured by powder metallurgy methods.

Raw material is not wasted during the processing while unusual materials or mixtures can be utilized.

Most of the powder metallurgy parts are in the size range of less than 2 kg, though parts as large as 20 kg were made. Large parts require very expensive tooling and as such are not widely made by powder metallurgy.

4.2 Advantages of the Powder Metallurgy Process

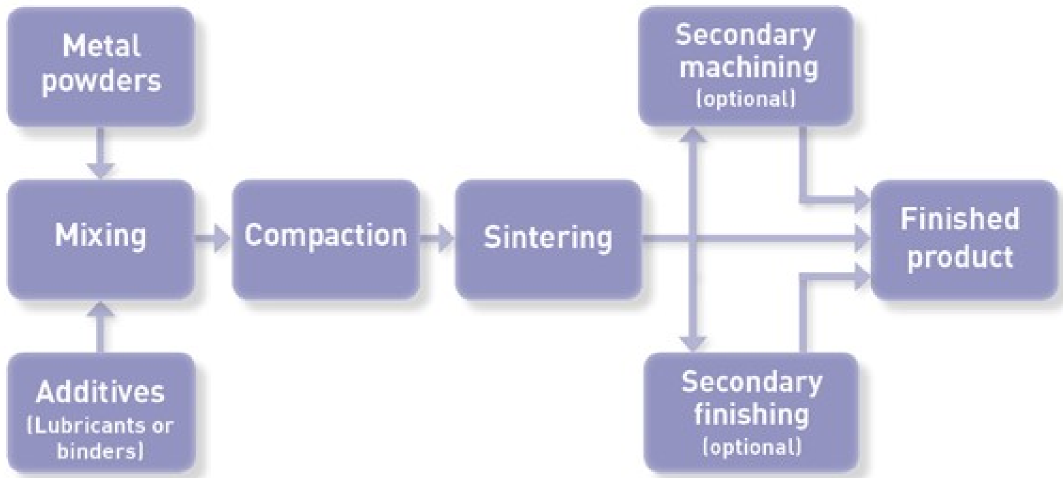
- Products made by Powder metallurgy generally do not require further finishing
- There is no wastage of raw material
- Reasonably complex shapes can be made
- Different combinations of materials can be used in powder metallurgy products, which are otherwise impossible to make. For example, mixing ceramics with metals.
- Automation of the powder metallurgy process is easy as compared to other manufacturing processes.

- It provides properties like porosity and self-lubrication to the manufactured parts.

4.3 The method of producing components by powder metallurgy technique:

1. Powder Preparation:

This is the first and basic step for producing any object by powder metallurgy process. Any material can convert into powder. There are various processes for producing powder such as atomization, grinding, chemical reaction, electrolysis process, etc.
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 several methods.



2. Mixing and Blending:
This step involves the mixing of two or more material powders to produce a high-strength alloy material according to the product requirement.

This process ensures the even distribution of powder with additives, binders, etc. Sometimes lubricants are also added in the blending process to improve the flow characteristic of powder.

3. Compacting:

Compacting means compressing the prepared powder mixture into pre-defined dies. This step ensures the reduction of voids and increases the density of the product.

The powder is compacted into the mold by the application of pressure to form a product which is called green compact (the product gets by compacting).

It involves a pressure range from 80 to 1600 MPa. This pressure depends on the properties of metal powder and binders.

For soft powder compacting pressure is about 100 – 350 MPa.

For steel, iron, etc. the pressure is between 400 – 700 MPa.

4. Sintering:

The green compact, produced by compressing, is not very strong and can't be used as the final product. This step involves heating green compact at an elevated temperature which ensures a permanent strong bond between adjacent particles. This process provides strength to green compact and converts it into the final product. The sintering temperature is generally about 70 to 90 percent of the melting temperature of metal powder.

5. Secondary Operation

The sintered object is more porous compared to fully dense material.
The density of the product depends upon press capacity, sintering temperature, compressing pressure, etc. Sometimes, the product does not require high density, and the sintered product is directly used as the final product.

But sometimes, a highly dense product is required (for example manufacturing bearing, etc.) where the sintered product cannot be used as a finished product. That's why a secondary operation is required to obtain high density and high dimensional accuracy.

The most common secondary operation used is sizing, hot forging, coining, infiltration, impregnation, etc.

4.4 Sintering

Sintering is a heat treatment process in which a large quantity of loose aggregate material is subjected to a sufficiently high temperature and pressure to cause the loose material to become a compact solid piece.

The amount of heat and pressure administered during the sintering process is slightly less than the material's melting point.

The purpose of sintering is to impart strength and integrity to the material.

Sintering Temperature and Time for Various Metals

Material	Temperature (°C)	Time (min)
Copper, brass, and bronze	760–900	10–45
Iron and iron–graphite	1000–1150	8–45
Nickel	1000–1150	30–45
Stainless steels	1100–1290	30–60
Alnico alloys (for permanent magnets)	1200–1300	120–150
Ferrites	1200–1500	10–600
Tungsten carbide	1430–1500	20–30
Molybdenum	2050	120
Tungsten	2350	480
Tantalum	2400	480

During the sintering process, the temperature must be kept below the melting point of the constituent materials.

The porous spaces between the material's particles are minimized during the sintering process as the material is squeezed together under high temperature and pressure. This increases some of the material's properties, including:

- Thermal and electrical conductivity
- Material strength
- Translucency

4.5Economics of Powder Metallurgy:

- Powder metallurgy can produce parts at the net near-net shape
- Eliminate many secondary manufacturing and assembly operations
- The high initial cost of punches, dies, and equipment
- Economical for quantities over 10,000 pieces and labor costs would not be high
- Reduces scrap

5.0 Press Works

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 supports 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"

Press working operations:
The sheet metal operations done a press may be grouped into two categories.

- Cutting operations
- Forming operations

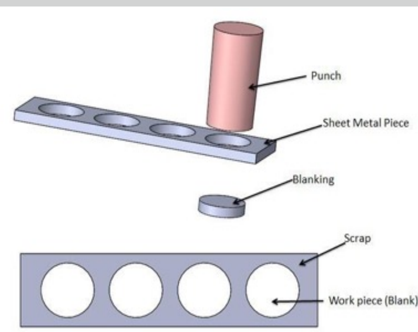
In cutting operations, the work piece is stressed by its ultimate strength. The stresses caused in the metal the applied forces will be shear stresses. The cutting operations include:

- Blanking
- Trimming
- Piercing

In forming operations,the stresses are below the ultimate strength of the metal, in this operation, there is no cutting of the metal but only the contour of the work piece is changed to get the desired product.
The forming operations include:

- Bending
- Drawing
- Squeezing

BLANKING



Blanking is a steel manufacturing process in which a flat, geometric shape is created by feeding a coil of sheet metal into a press and die.

In this process the blank is punched out from large metal sheet.

Press Blanking machinery can typically process material up to 72 inches (1828mm) wide and .250 inches (6.35mm) thick from coils up to 80,000 lbs.

Typically multiple sheets are blanked in a single operation and the blanked parts will require secondary finishing to smooth out burrs along the bottom edge.

PIERCING

Piercing is a shearing process in which raw metal is pierced with a machining tool, resulting in the creation of a circular or other shaped hole. As the raw metal is pierced, the metal from the newly created hole is considered scrap.

The amount of clearance between a punch and die for piercing is governed by the thickness and strength of the work-piece material being pierced.

The punch-die clearance determines the load or pressure experienced at the cutting edge of the tool, commonly known as point pressure

TRIMMING

The trimming process is the shearing of excess material from the headed configuration of complex shapes so as to obtain the final design and specifications.

5.2 Various types of die and punch

1. Simple Dies:

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

2. Compound Dies:

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

3.Combination dies:

Combination dies are used for operations involving more than one operation on a work station. The major difference between compound dies and combination dies is that in these dies a cutting operation is combined with with a bending or drawing operation, and hence the name “combination dies

4.Progressive Dies:

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

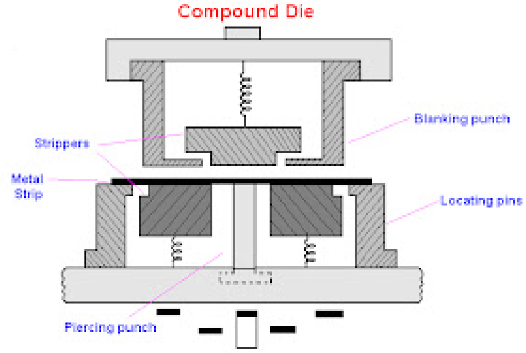
5. Multiple Dies:

Multiple dies also known as gang dies ate those dies which produce tow or more piees at each stroke of press. In these dies a number of simple dies are ganged together to produce tow or more parts via each stroke of the press.

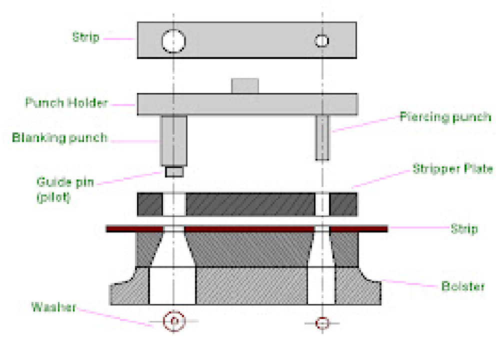
5.3 Explain simple, compound & progressive dies:

Simple Dies:
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.
Compound Dies:
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.

Compound Die



Progressive Die



Progressive Dies:
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.