LEACTURE NOTE

NAME: CHANDRASEKHAR DASH

DESIGNATION: PTGF MECHANICAL ENGINEERING DEPARRTMENT

SUBJECT: PRODUCTION TECHNOLOGY

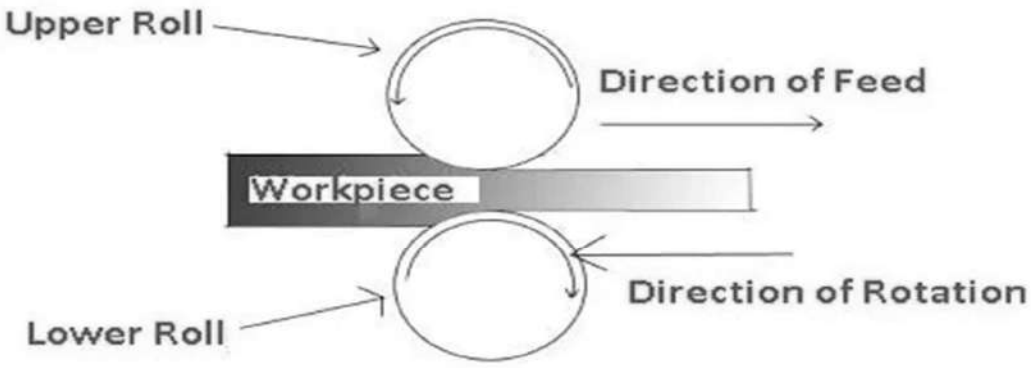
Types of Rolling Mills

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.

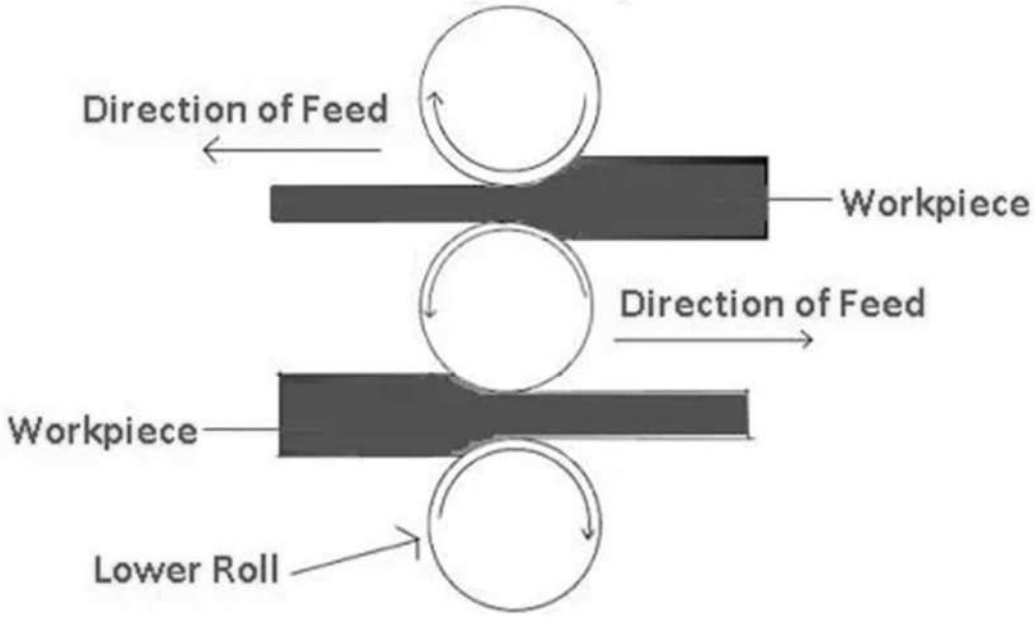


Two High Rolling Mills

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.



Three High Rolling Mills

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.

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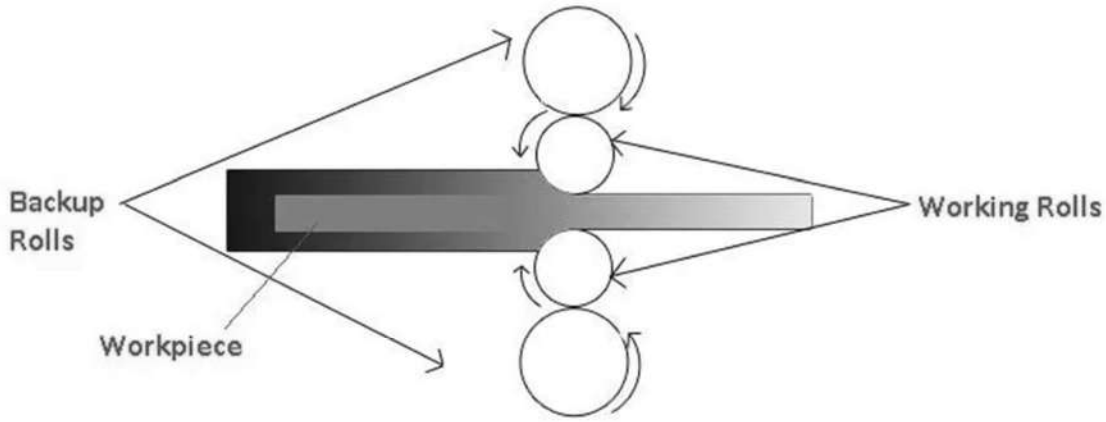
3. Four High Rolling Mills

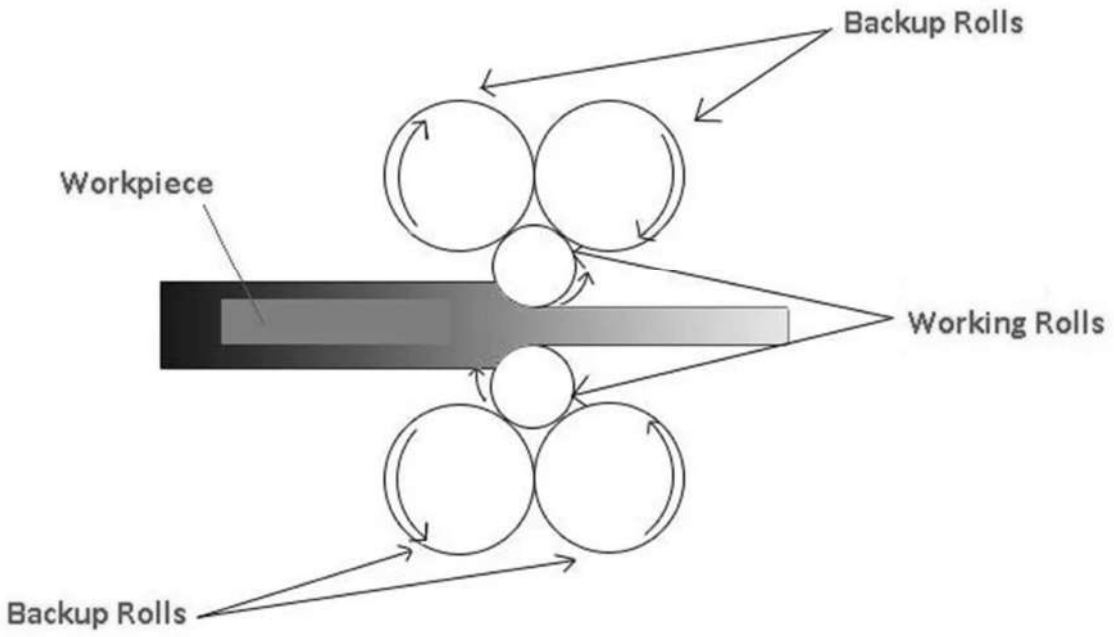
The mill has four horizontal rolls, two smaller diameters and two much larger. The larger rolls are called backup rolls. The smaller rolls are the working rolls, but they would be thicker in the center and thinner at either end.



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



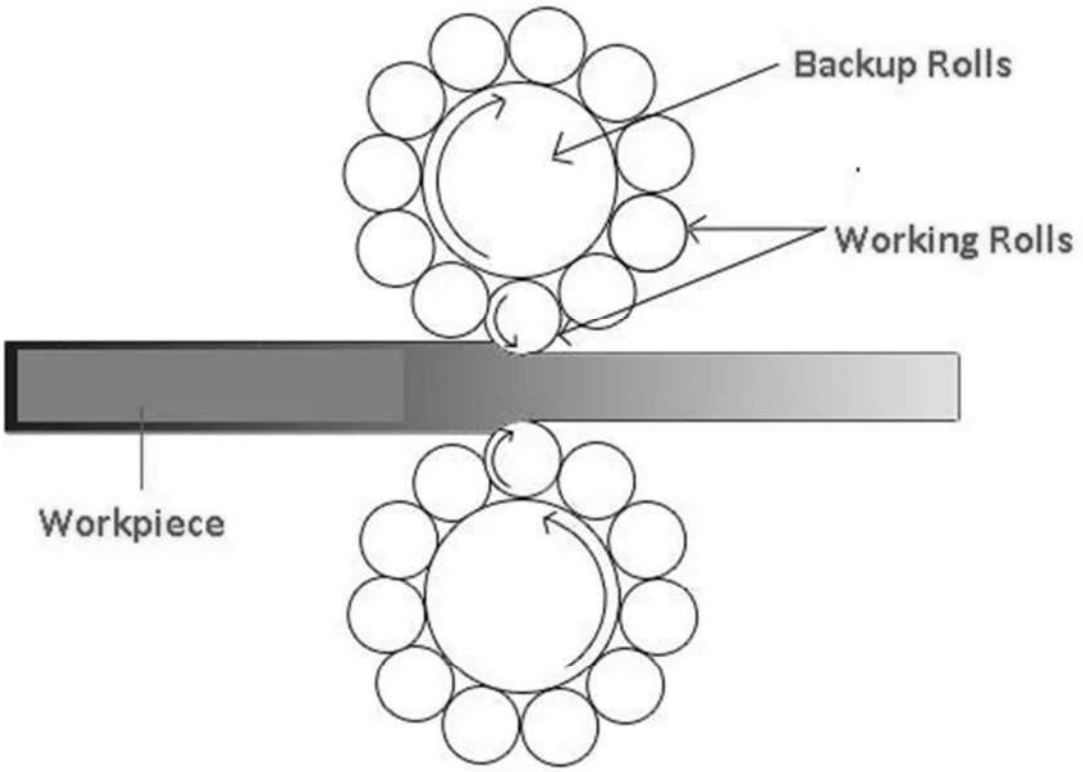
Cluster Rolling Mill

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.

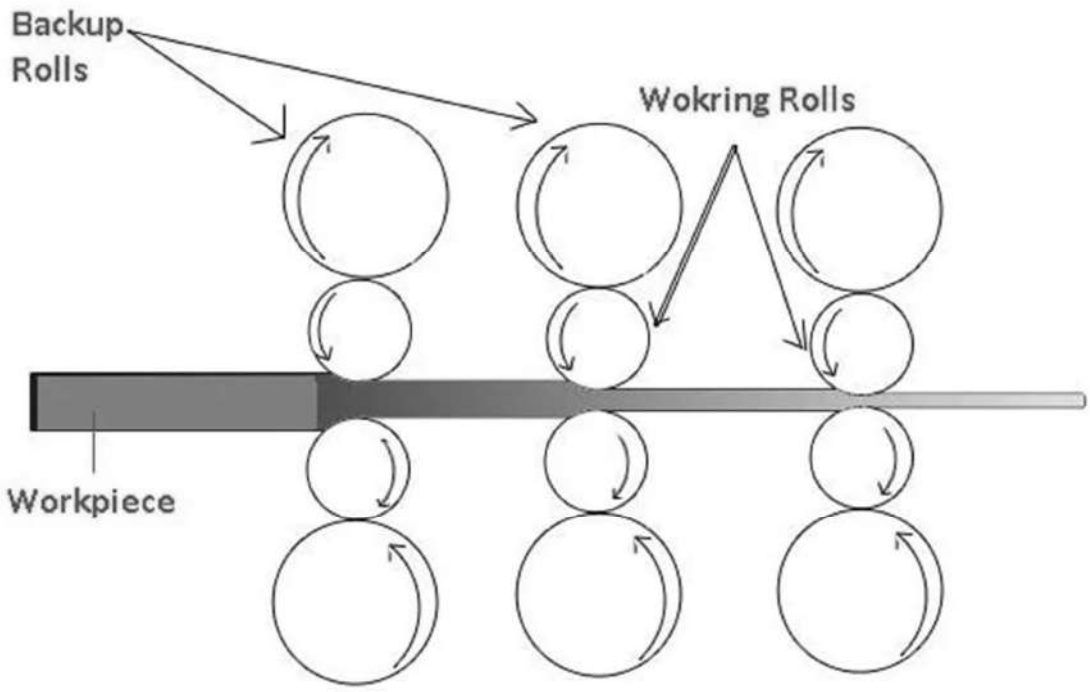


Planetary Rolling Mill

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

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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.

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

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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**.**

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Types of Gas Welding:

oxy-Acetylene gas welding:

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a. 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 temperatureof about 2700-degree C. There is the formation of weld points without theapplication 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 first gaseous 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.

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2.1 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

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- 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.

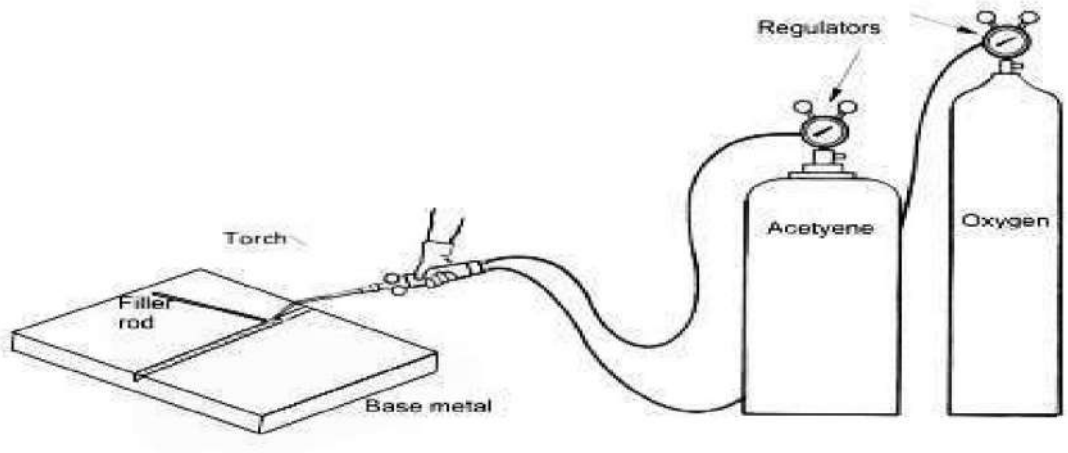
c. Cellulose electrode coating:

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.

2.2 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 naturalgas.

2.1 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

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- 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.

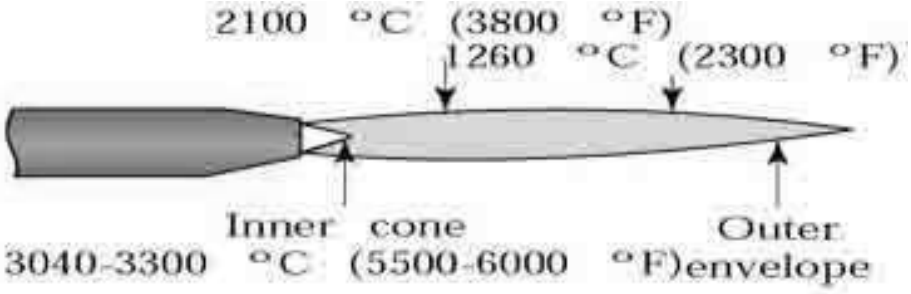
1. The inner zone consists of a luminous cone that is bluish-white.
2. Surrounding this is a light blue flame envelope or sheath.

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 tendto 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 5850°F (3232°C), while at the end of the outer sheath or envelope the temperature drops to approximately 2300°F (1260°C).



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

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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.

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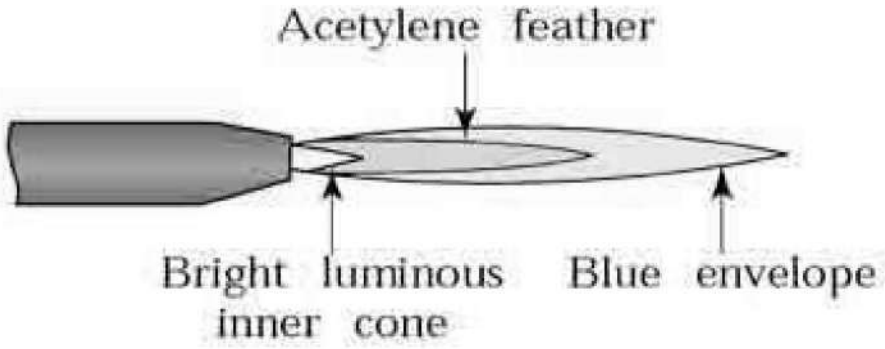


Figure 2: Carburizing Flame

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 conetip.

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.

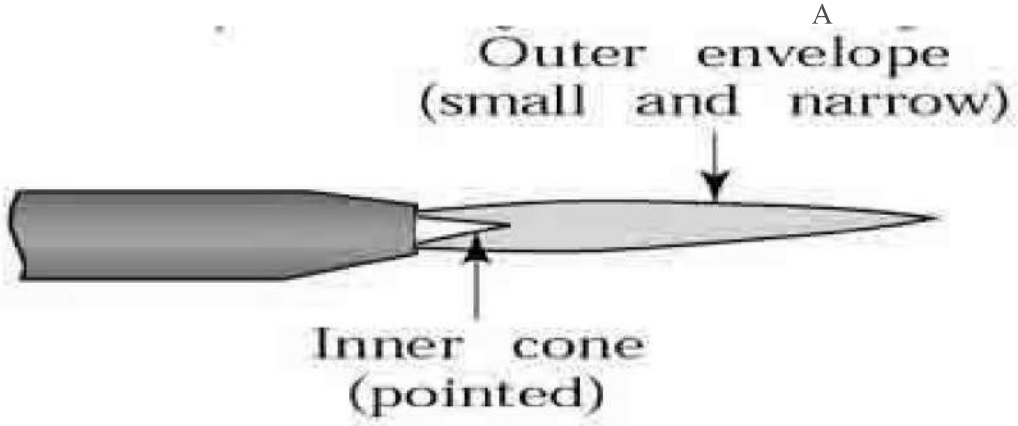


Figure3: Oxidizing Flame

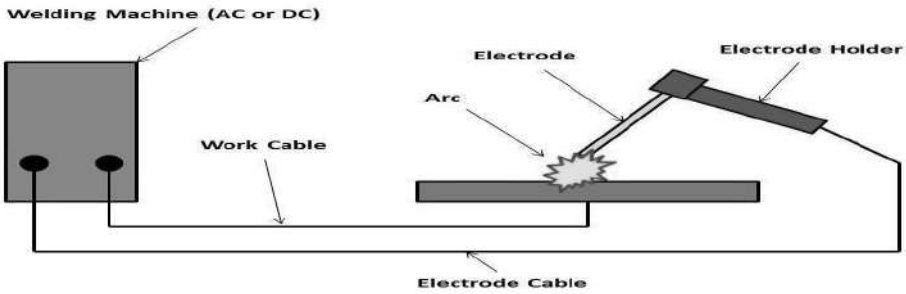
An oxidizing flame should not be used for welding steel because the deposited metal will be porous, oxidized, and brittle. This flame will ruin most metals and should be avoided.

2.2Arc 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

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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 oxidesand 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 weldpool from the air. This process does not use pressure and the filler metal is formed by the

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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)

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Stud welding joins a metal stud by heating both parts with an arc

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While there are many great benefits to arc welding, the e 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 industryuses 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.

2.3 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.

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

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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.

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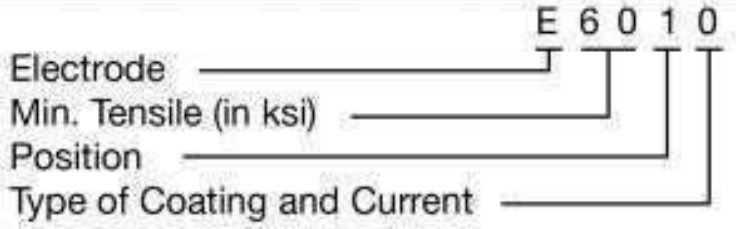
AWS A5.1 Carbon Steel Electrodes for SMAW



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±

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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 degreesF.

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.

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- Th light coatings generat

type slag

Shielded Arc/Heavy Coated El

These electrodes have a definiti

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Resistanc welding is generally u
An electric current is delivered
joined) through weld electrodes
then converted to heat. The heat i

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.

2.5 Various Resistance Welding Processes

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Flash Welding

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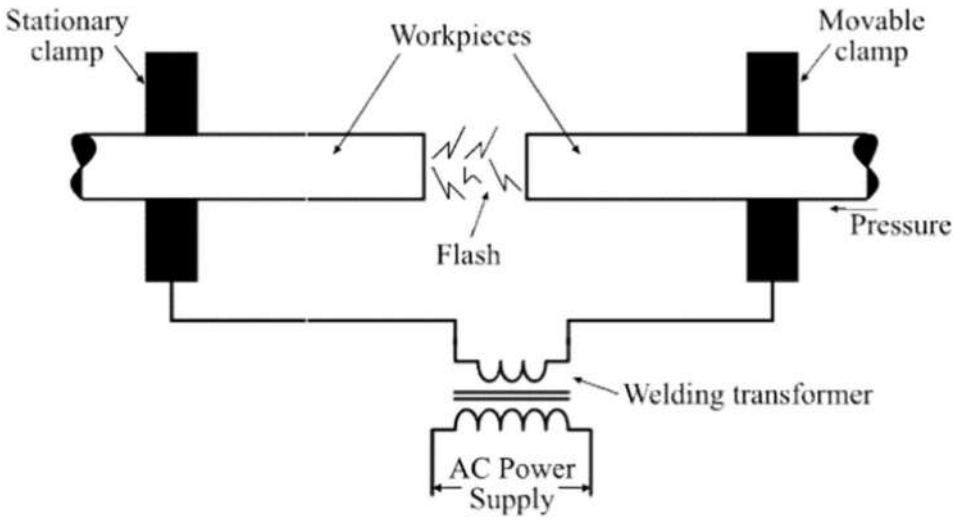
Flash welding, *also called flash* which the ends of the workpieces is passed through the joint during

In flash welding, the electrical cu



Flash (Butt) Welding

Advantages of Flash Welding

- In flash welding, the power consumed is less as the arc al o 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.

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Applications of Flash Welding

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- 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.

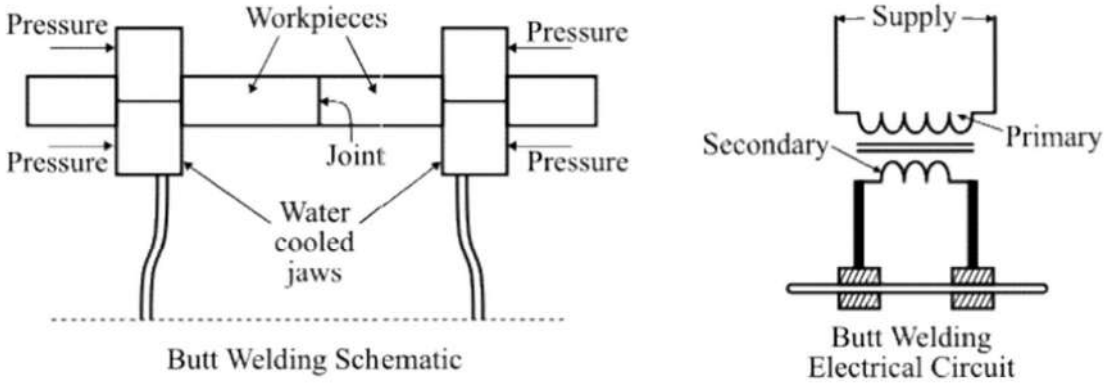

Figure - Butt Welding

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 sheetstogether by applying pressure and heat from an electric current to the weld areais known as spot welding.

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

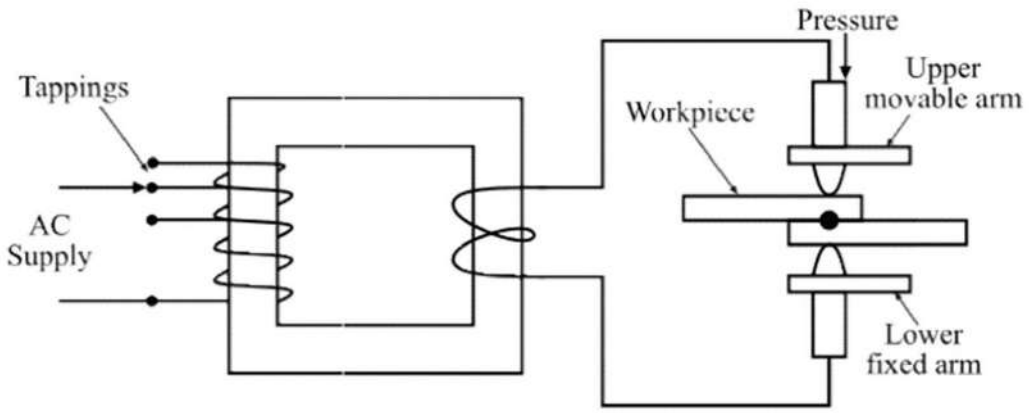

Figure - Spot Welding

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

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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.

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

Most seam welding processes p

near the edge of two overlappe

electrodes. As in the seam weldi

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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.

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Tungsten Inert Gas Welding

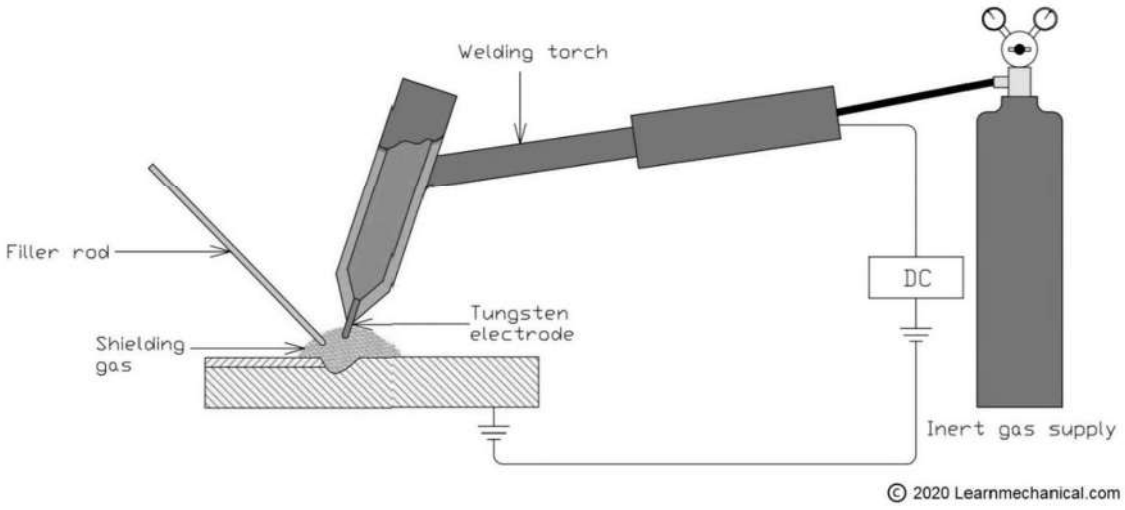
Tungsten inert gas (TIG) welding is one type of arc welding method where we use a non-consumable tungsten electrode, to weld the two metallic bodies.

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.

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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.

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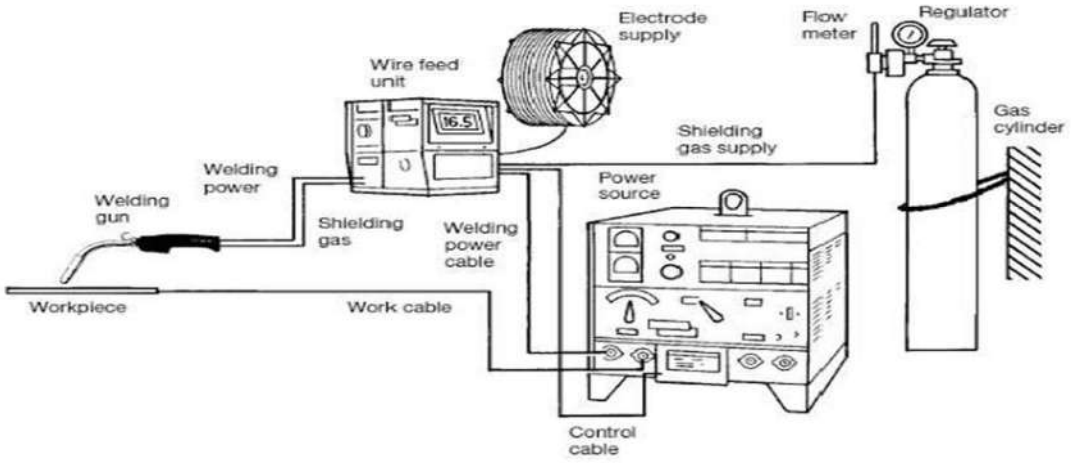
MIG WELDING

Mig works on the same principle inciple of heat generation due to an electri c

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



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:

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:

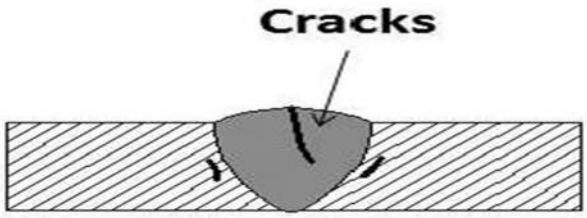
1. Slag Inclusion
2. Incomplete Fusion
3. Necklace cracking
4. Incompletely filled groove or Incomplete penetration

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. W lding 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.

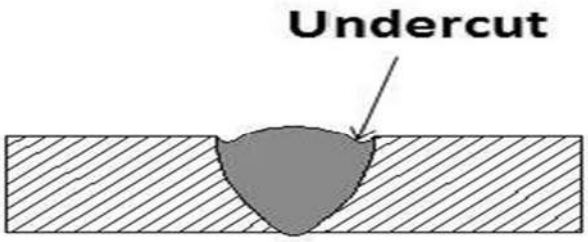
Causes Of Weld Crack:

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.

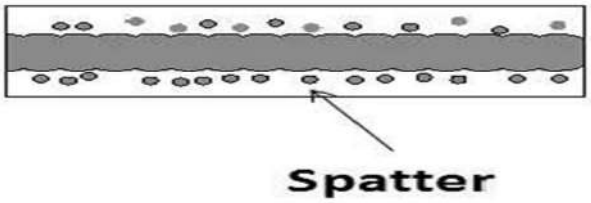
Remedies

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.

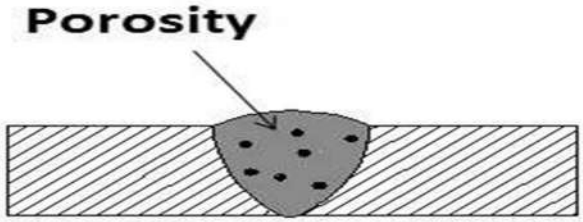
Causes

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



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 weldin ɛ surface

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

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 degre s.

Causes

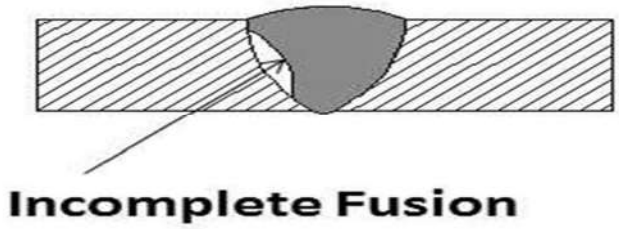
1. Improper welding techni c ue.
2. By using large electrodes this defect may occur.
3. High welding current

Remedies

Causes

1. Slag is formed if the wel ding 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 sl ag may form.
4. Improper welding angle and travel rate of welding rod.

1. 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.

2. 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

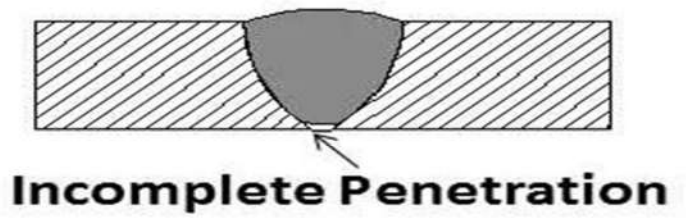
Causes

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

Remedies

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

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: