Welding, Soldering and Brazing

Introduction

Welding is a process of joining two pieces of metals by the application of heat, with or without the application of pressure and with or without the addition of filler metal. The joint formed by welding is a permanent joint. Welding is extensively used in fabrication work, construction work, repair work etc.

Welding processes can be broadly classified into two categories namely

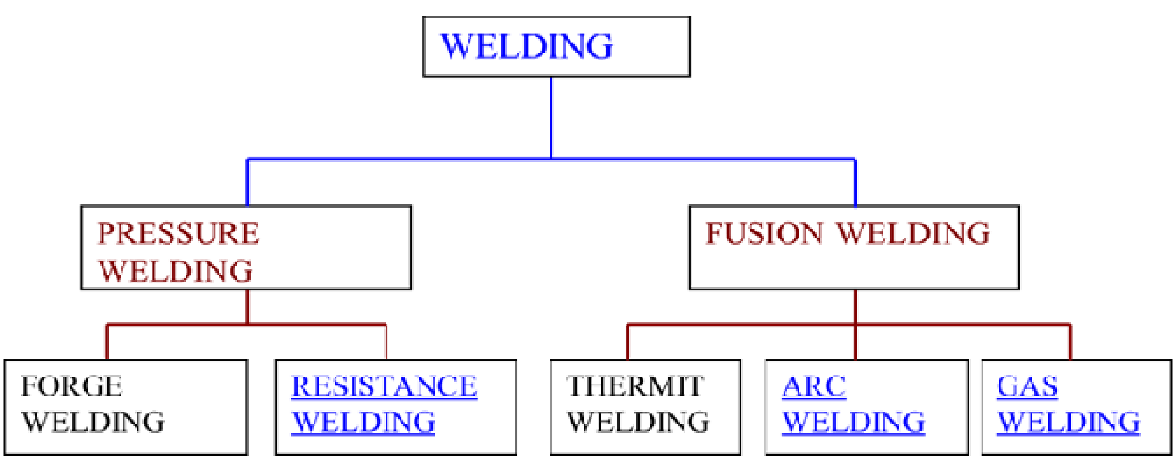
1. Pressure Welding or Plastic Welding
2. Non Pressure Welding or Fusion Welding

1. Pressure Welding

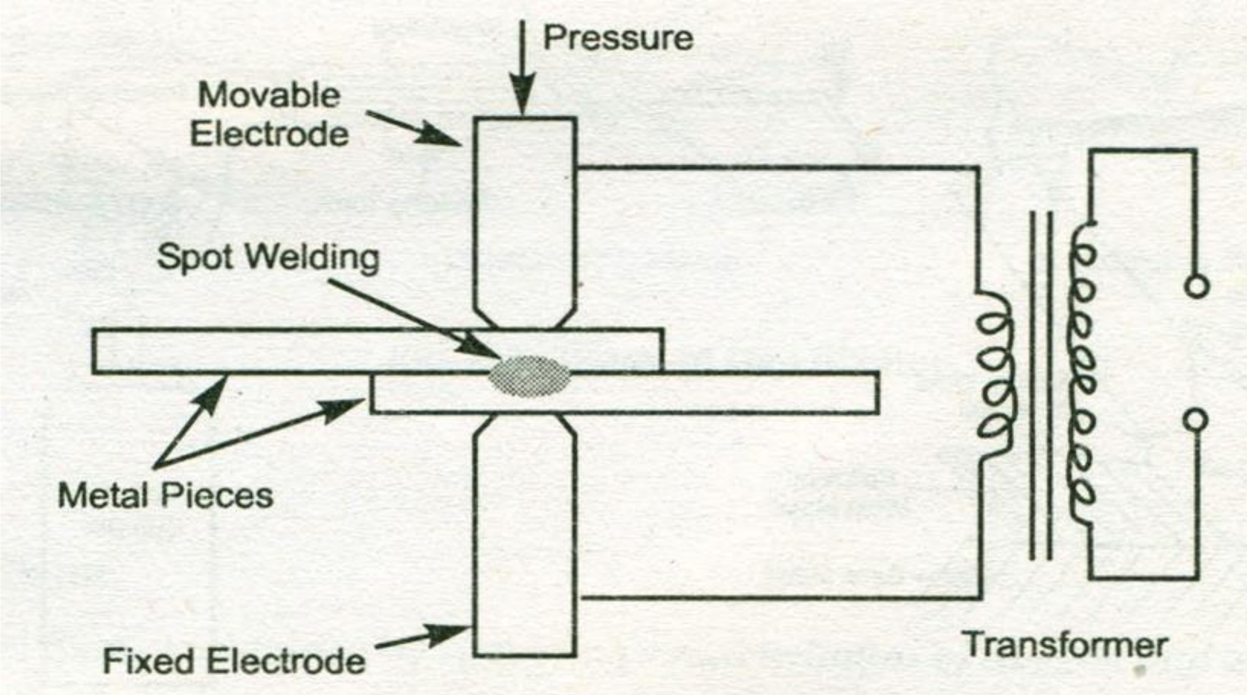
In pressure welding the metal parts to be joined are heated to the plastic state and then external pressure is applied to join them or to complete the weld. Fillar metal is not used in pressure welding. The different types of pressure welding are Forge welding and Resistance welding.

2. Fusion welding: In fusion welding the metal parts to be joined are heated at the joint surface along with the filler metal to the molten state to form a homogeneous mixture and then allowed to solidify to form the weld joint. External pressure is not applied in fusion welding.The different types of fusion welding are Arc welding and gas welding.

Classifications of Welding:



Resistance Spot Welding:



Electric Resistance Welding

In resistance spot welding the metal pieces to be welded are heated to the plastic state over a limited area because of their resistance to the flow of electric current and external pressure is applied to complete the weld.

Resistance spot welding is used for welding overlapping metal strips. The metal pieces to be welded are held between two copper electrodes. One end of the electric supply is connected to the upper electrode carried in a movable arm and the other end is connected to the lower electrode mounted in the fixed arm. When a heavy electric current is passed between the pieces the current encounters very high resistance at the joint, as a result which the temperature increases at the joint surface. When temperature reaches the plastic temperature of the parts external mechanical pressure is applied by forcing the upper electrode downwards using a pneumatic system to complete the spot weld.

Since in spot welding the maximum temperature should occur at the joint surface it is essential to keep the resistance between the electrodes and the workpieces as low as possible. This can be achieved by using electrodes materials having excellent thermal conductivity such as copper.

The electrodes are usually water cooled to protect them from softening or melting. Spot welding is used in building automobile bodies, sheet metal fabrication, ventilating ducts etc.

Advantages

- Little pollution
- Efficient energy use
- High production rates

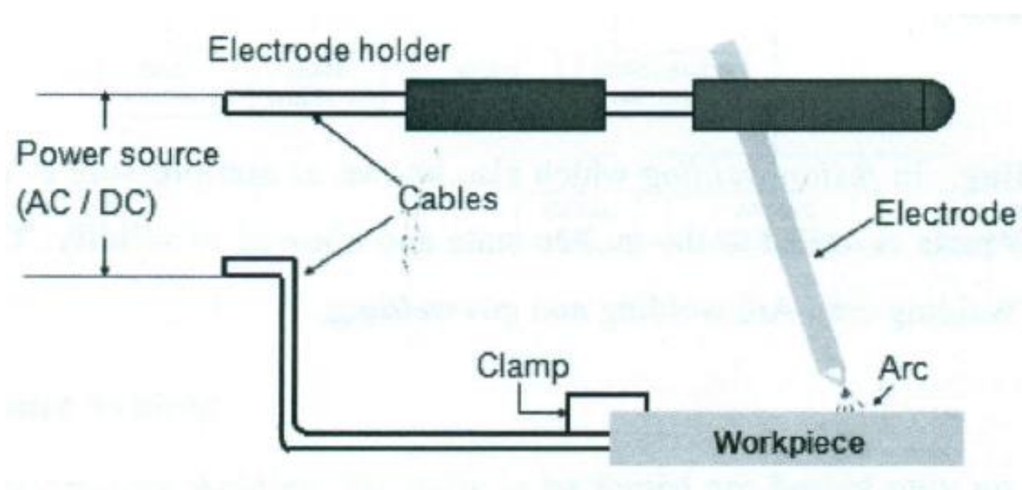
Disadvantages

- Used for joining relatively thin materials (sheet metal)
- Equipment is costly.

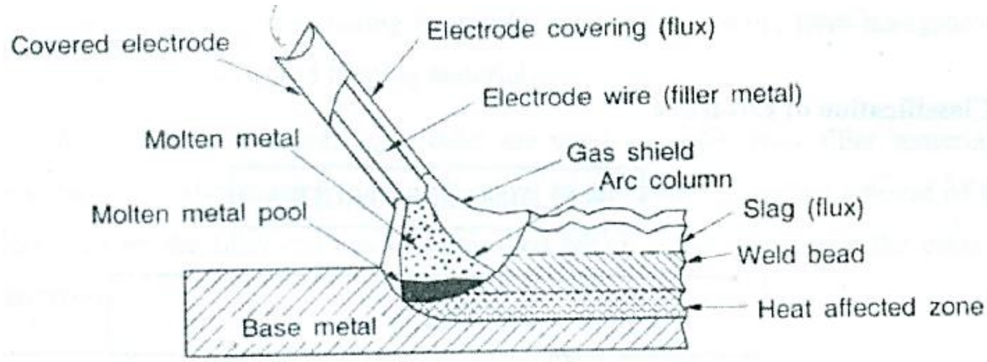
Arc Welding:

Arc welding is a fusion welding process in which welding is carried out by producing heat from an electric arc maintained between the work pieces and the electrode. External pressure is not applied in arc welding process. The electrode acts as the filler metal which is heated to its molten state and gets deposited on to the joint to complete the weld.

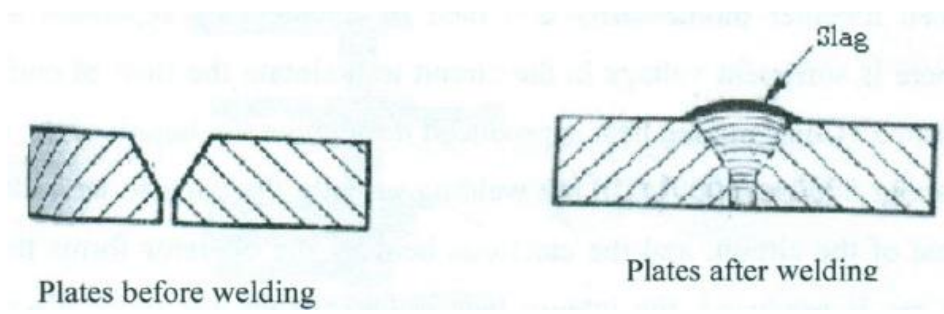
The principle of arc welding involves when two conductors of an electric circuit are touched together momentarily and then instantaneously separated slightly, assuming that there is sufficient voltage in the circuit to maintain the flow of current, an electric arc is formed. Concentrated heat is produced throughout the length of the arc at a temperature of about 5000 to 6000°c.



Arc Welding Setup



Arc Welding

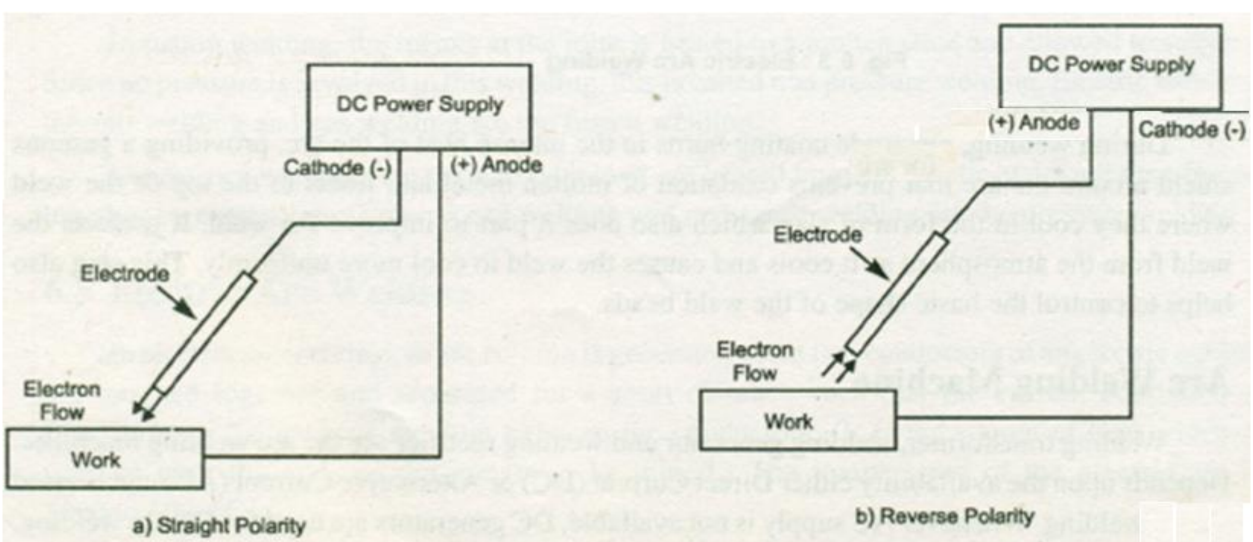


Welded Joint

In arc welding first the workpieces to be welded are brought together to form either a butt joint or a lap joint. The workpieces to be welded are connected to one pole of the electric circuit and the electrode held by the operator is connected to the other pole. When the electrodes and workpieces are touched together and are separated by a small distance so that the current continues to flow through the path an electric arc is formed. When the arc is produced, the intense heat of the arc melts the work piece metal which is directly under it forming a small pool of molten metal. At the same time the tip of the electrode at the arc also melts and this molten metal of the electrode is carried over by the arc to the molten metal pool of the work piece. The molten metal in the pool is agitated by the action of the arc thoroughly mixing the base and the filler metal. This serves to fill the joint and a solid joint will be formed when the molten metal cools and solidifies. Once started the arc should be advanced at a uniform speed along the desired line of welding. The flux coating over the electrode produces an inert gaseous shield surrounding the arc and protects the molten metal from getting oxidized by coming in contact with the atmospheric air.

Both alternating current (A.C) and direct current (D.C) can be used in arc welding. Whenever A.C. supply is not available D.C generators are used for arc welding. For AC arc welding a step down transformer is used. The transformer receives the A.C supply between 200 and 440 volts and steps down the same to the required low voltage in the range of 80 to 100 volts. A high current of 100A to 400A will be suitable for general arc welding work.

In D.C welding the polarity can be chosen to suit the joint to be welded. When the workpiece is connected to the positive pole of a D.C generator and the electrode to the negative pole in order to melt greater mass of metal in the base material, it is said to be Straight Polarity. When workpiece is connected to the negative terminal and the electrode to the positive terminal it is said to be Reverse Polarity. The polarity can be chosen to suit the joints to be welded. Nearly 2/3rd or 67% of the heat is released at the positive end and 1/3rd or 33% at the negative end. Thicker jobs require more heat than the electrodes which are comparatively thin, hence straight polarity is used in such cases. For thin and lighter workpieces reverse polarity is used.



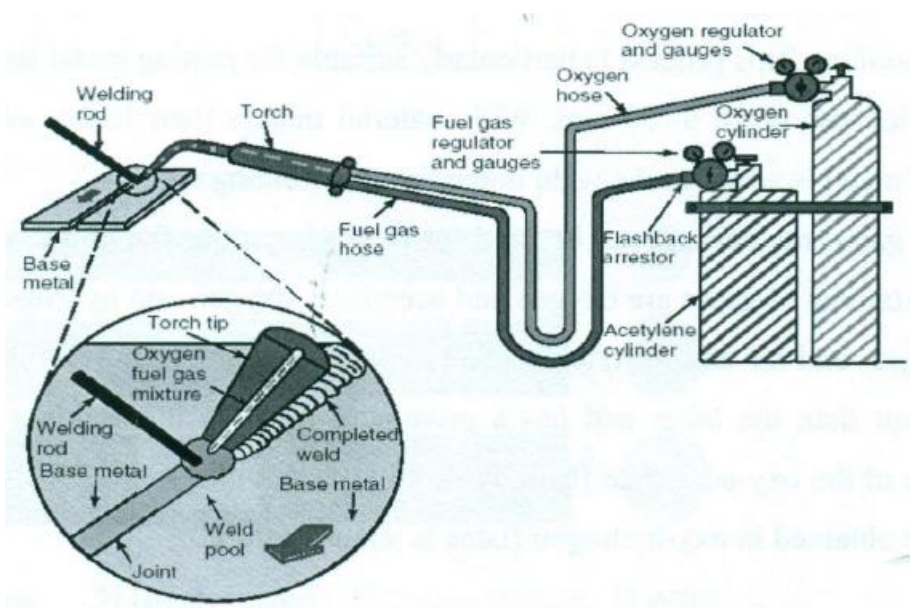
Arc Welding Circuit for DC Power Source

In AC arc welding, there is no choice of polarity since they change in every cycle, the heat liberated is 50% at each end of the arc. In A.C., the voltage reduces to zero twice in each cycle, hence the arc will naturally get extinguished at those instants. In order to overcome this difficulty the current is made lagging by a very large angle so that the current flows at the time when the voltage is zero. And the increase of voltage later on will be enough to send the current through the gap before the arc would be extinguished. For this purpose the circuit is made lagging or inductive by including a choke.

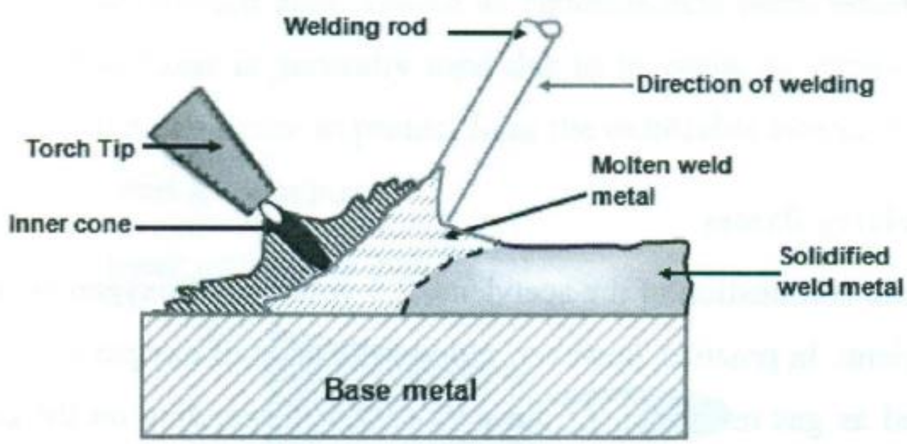
Oxy-Acetylene Gas welding:

Gas welding is a fusion method of welding in which a strong gas flame is used to raise the temperatures of the workpieces to be welded, so as to melt them at the joint surface and a filler metal is generally used to fill the joint. Various gas combinations can be used for producing the hot flame for welding the metals. Common mixtures of gases are oxygen and acetylene and oxygen and hydrogen. The oxygen-acetylene mixture is most commonly used in gas welding.

The oxy-acetylene gas equipment consists of two large steel cylinders one containing oxygen at high pressure and the other dissolved acetylene also at high pressure, rubber tubes, pressure regulators and a welding torch. The oxygen and the acetylene are supplied to the welding torch separately where both of them get mixed in required proportions and comes out through the nozzle of the torch.



Gas Welding Set-up



Gas Welding

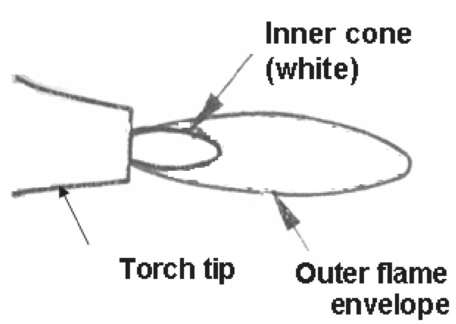
First the metal pieces to be welded are properly cleaned and placed near each other. The acetylene supply is then turned on in the welding torch and is ignited using a gas lighter. Next oxygen is supplied on to the flame. The supply of two gases is regulated so as to get the desired flame. The metal pieces are then heated to the melting temperature at the joint surface using the gas flame. A filler rod is brought very near to the joint and the flame. Finally the filler rod and the torch tip are slowly advanced along the desired length of the joint to complete the weld.

Types of Gas Welding Flames:

By suitably regulating the flow of oxygen and acetylene gases the following three flames can be used in gas welding. They are

1. Neutral Flame
2. Carburizing Flame
3. Oxidizing Flame

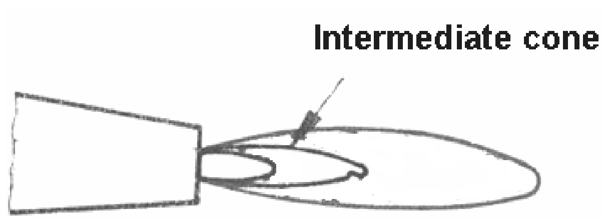
1. Neutral Flame:



Neutral Flame

Neutral flame is produced by mixing equal volumes of oxygen and acetylene gases. The temperature of the neutral flame is around 3200ºC. It has an sharp inner cone which is white in colour and extending a short distance from the tip of the torch. This is surrounded by an outer envelope which is bluish in colour. The inner cone provides the heat and the outer envelope protects the molten metal from oxidation.The neutral flame is widely used for welding steel, alloy steels and cast iron. A neutral flame is termed so because it does not cause any chemical change in the molten metal.

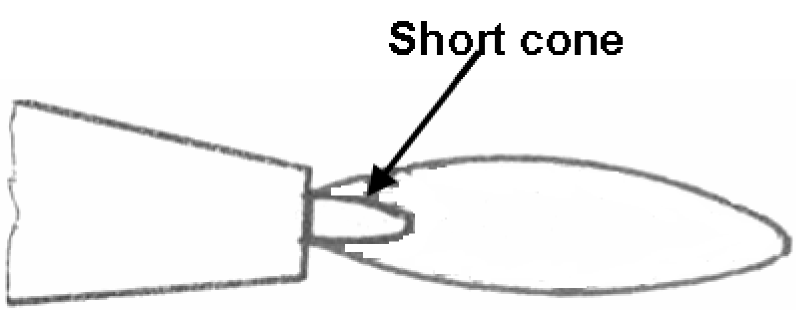
2. Carburizing Flame:



Carburizing Flame

This type of flame is obtained by supplying excess volumes of acetylene gas. It is recognized by an intermediate cone known as "intermediate flame feather" between the inner cone and the outer bluish envelope. Its length is an indication of the amount of excess acetylene. The temperature at the inner white cone is around 2900ºC. The outer bluish flame envelope is longer than that of the neutral flame and is usually much bright in colour.This flame is used for welding non ferrous metals and high carbon steels.

3. Oxidizing Flame:



Oxidizing Flame

This type of flame is obtained by supplying excess oxygen. It is similar to the neutral flame except that the inner white cone is shorter in length. It is not suitable for welding since the weld metal gets oxidized. It is used in oxy acetylene gas cutting. The temperature of the flame is around 3300ºC.

Soldering:

Soldering is a process of joining thin pieces of metal using a fusible alloy called the solder and by the application of heat. Soldering is extensively used in sheet metal work and in joining electrical and electronic circuits. The solder used is an alloy of lead and tin. Higher the percentage of tin lower will be the melting temperature of the solder. Electricians solder contains more tin, either 30% lead & 70% tin or 40% lead & 60% tin and melts at lower temperature. Plumbers solder contains 70% lead and 30% tin and melts at higher temperature.

In soldering heat is supplied using a soldering iron which has a copper bit at its end. The parts to be soldered are first thoroughly cleaned to make them free from dust, oil, scales etc. and are placed in position. Then the joining surfaces are coated with a flux usually zinc chloride, rosin or borax. This cleans the surfaces chemically and helps the solder in making a bond. The soldering iron is then heated to the desired temperature electrically. After heating the soldering iron to the desired temperature it is dipped in a mass of flux and is then rubbed on the solder. The solder melts and spreads over the hot surface of the bit and forms a coating over it. This operation is called tinning. This enables the bit to pick up the molten solder and deposit it as required on the joint surface. The joint is then allowed to cool so that the molten solder solidifies.

Soldering is classified into soft soldering and hard soldering

Soft soldering is used extensively in sheen metal work for joining parts that are not exposed to the action of high temperatures and are not subjected to excessive loads or vibrations. Soft soldering is also employed for joining wires and small parts. The solder is mostly composed of lead and tin and has a melting range of 150 to 350ºC. In soft soldering zinc chloride is generally used as the flux.

Hard soldering employs solder which melts at higher temperatures (600 - 900°C) and is stronger than that used in soft soldering. Hard solder is an alloy of copper, tin and silver.

Brazing:

The method of joining two similar or dissimilar metals using a special fusible alloy called spelter having a melting point of greater than 450ºC but lower than the melting point of the parts to be joined is called Brazing. It produces joints stronger than soldering. During brazing the base metal of the two pieces to be joined are not melted. The filler metal must have the ability to wet the surfaces of the base metal to which it is applied. Some diffusion or alloying of the filler metal with the base metal takes place even though the base metal does not reach its melting temperature. The materials used in brazing are copper base and silver base alloys. In brazing the filler metal when applied to the heated joint flows throughout the joint by capillary attraction.

The parts to be joined are first cleaned to remove dirt, oxides, grease and other impurities. Flux is then applied along the line of the joint. Usually Borax or Boric acid is used as the flux in brazing. Flux prevents the formation of oxides during heating, promotes free flowing of filler metal into the joint and dissolves any oxides that may be present on the surface prior to heating. After the flux is applied the joint is then heated to the required brazing temperature which is above the melting temperature of the filler metal using an oxy-acetylene welding torch. The solid filler metal then placed on the joint melts and flows by capillary action into the joint space and sticks to the surface by adhesion which on cooling produces a strong joint.

Brazing is used in many applications such as pipe fittings, carbide tips of tools, radiators, heat exchangers etc. Dissimilar metals such as stainless steel to cast iron can be joined by brazing. Silver brazing makes use of a silver based filler metal. Silver brazing is used to give high strength joints. Though originally used for jewelry applications, silver brazing is now extensively used in industrial applications.

Difference between Brazing and Soldering

Sl.No	Brazing	Soldering
1	Melting point of the filler material is above 450°C.	Melting point of the filler material is below 450°C.
2	Dissimilar metals can be joined easily.	Only similar metals can be joined.
3	Good surface finish.	Does not yield a good surface finish
4	Stronger joints	Less stronger joints

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