Engineering materials

1.1 Introduction

Materials is defined as that which consists of matter or occupies space. The common use of materials are food articles, medicines, house, cloths, communication, transportation and many more. Engineers and technologists need different materials for design and manufacturing of aircraft engines, shipbuilding, construction etc., Materials are essential part of engineering industry. An engineer needs materials to give shape for his concept and design.

Earth has in its crest enormous range of materials to serve the needs of human being in all aspects. All materials have their own usefulness or application. Materials which have applications in engineering and making an article of utility is called engineering materials. Components can be manufactured by using various processes depends in its applications. Fabrication is an important process which involves joining process like soldering, brazing and welding. These processes can be used depending on the permanency of the joint, thickness of material etc.,

1.2 Classification

Engineering Materials may be classified into four basic types based on their nature

1. Metals and alloys
2. Ceramics
3. Polymers
4. Composites

A **metal** is an elemental substance in pure form while an alloy is formed when two or more metals are mixed together to form homogenous mixture.

Example: iron and steel

Ceramics are compounds of metallic and nonmetallic elements which are very hard in nature

Example: Magnesium oxide and Silicon carbide

Polymers are direct derivatives of carbon which are having long chain molecules with 3D structures

Example: plastics and polyethylene

Composites are special materials where one or more reinforcement are added with base metal (Matrix) to form a homogeneous mixture. Here the properties of the base metal which are enhanced by adding small quantity of reinforcing materials.

Example: fiber reinforced plastic (FRP) and carbon reinforced rubber

2 Ferrous and nonferrous metals

Metals are broadly classified as ferrous and nonferrous metals. These are used for different purpose based on the application.

2.1 Ferrous metals and its alloys

Ferrous is a Latin word "ferrum" means iron. Metals which contains iron and there alloying element are called as ferrous metals. They have a wide range in applications which are not found in any other type of materials. They are broadly classified as follows

Ferrous metal is classified as

1. pig iron
2. cast iron
    a. grey cast iron
    b. white cast iron
    c. malleable cast iron
    d. nodular cast iron
3. Wrought iron
4. Steel
    a. Carbon Steel
        i. low Carbon Steel
        ii. medium Carbon Steel
        iii. high Carbon Steel
        iv. tool Carbon Steel
    b. alloy Steel
        i. stainless steel
        ii. magnetic Steel
        iii. heat resistant Steel
        iv. high speed Steel

2.2 Ferrous metals

2.2.1 Pig Iron

Composition: 93% Fe, 3-4% C, traces of Si, Mn, S

Application: Used to produce cast iron, steel and Wrought iron

2.2.2 Cast Iron

Composition: 90 – 92 % Fe, 2-4% C, 1-3% Si, traces of Mn, S, P

Applications: Manufacturing of machines frames, columns, flywheel. Automotive parts like gear box, Cylinder head etc.,

2.2.3 Grey cast iron

Composition: 3-3.5% C, 1-2.7% Si, 0.4-1% Mn, 0.15-1.5% P

Application: Base structure of Machinery, Rotor of disc, Clutch plates. Pump casing

2.2.4 White cast iron

Composition: 2-2.3% C, 0.85-1.2% Si, 0.1-0.4% Mn, 0.05-0.2% P, remaining iron.

Applications: Railway breaks blocks, Pump lining, Nozzles, Rollers of rolling mills

2.2.5 Malleable cast iron

Compositions: 3.2-3.6% C, 0.4-1.1% Si, 0.1-0.4%Mn, remaining iron.

Application: Pipes and pipe fittings, Automobile parts, Hardware items, frame equipment.

2.2.6 Nodular cast iron

Composition: 3.3% C, 0.6% Si, 0.4%Mn, 0.03% P, 0.075% Ni, remaining iron

Application: Gears, dies, Punches, Rolls, Crank shafts, connecting rod.

2.2.7 Wrought iron

Composition: 0.02% C, 0.12% Si, 0.018%S, 0.02%P, remaining Iron

Application: fences, gates, railings, balconies, porches, canopies, roof cresting, lamp, grilles, hardware, nails, iron cramps, structural members in tension

2.2.8 Low carbon steel

Composition: 0.05-0.3% C, 0.4% Mn, remaining Iron

Application: car parts, pipes, construction, boiler plates, food cans

2.2.9 Medium carbon steel

Composition: 0.3-0.6% C, 0.6-1.65% Mn, remaining Irion

Application: making shafts, axles, gears, crankshafts, couplings, and forgings

2.2.10 High carbon steel

Composition: 0.6-1.5% C, 0.5% Mn, remaining Iron.

Application: cutting tools like drills, taps, reamers, lathe tool shaper tools, milling tool, springs, great-strength wire, and dies

2.2.11 Tool steel

Composition: 0.7-0.8% C, 12-20% Tungsten, 3-5% Chromium, 1-2% Vanadium, 5-10% cobalt.

Application: make cutters, reamers, bits etc., used for machining metals, plastics, and wood

Applications of ferrous metal and its alloys

1. Structural: concrete reinforcement in building, fabrication of Gates and grills.

2. Automobile: Chassis, Gearbox, axels, body parts.

3. Marine: ship Hull, engines, turbines.

4. Defense: tanks, weapons, guns, shells, structures.

5. Consumable products: home applications, toys, tools.

6. Industrial applications: cutting tools, machine tools, Holdings, Jigs and Fixtures.

2.3 Non-ferrous metals.

As the name indicates these are metals without iron content in it. They have low strength, lower melting point and high shrinkage property then ferrous metals. But in recent days these are widely used Engineering Materials because of following reasons.

1. Good corrosion resistance
2. Ease of casting
3. Ease of cold working
4. Good electrical properties.

Example: aluminum, copper, Lead etc.,

They are broadly classified as follows

1. Metals
   a. Aluminum
   b. Copper
   c. Lead
   d. Tin
   e. Zinc
   f. Silver
   g. Gold
2. Alloys
   a. Bronze
   b. Brass
   c. Gunmetal
   d. Bell metal

2.3.1 Aluminum

Aluminum is an important metal that is used in a wide range of applications due to its low weight and ease of machining. Despite being a relatively expensive material, aluminum is also the base metal for many alloys.

Being corrosion resistant and a good conductor of heat and electricity (albeit less so than copper), as well as having good ductility and malleability, aluminum can require annealing as it becomes hard following cold working.

Applications: The light weight of aluminum makes it perfect for aerospace and automotive applications as well as for marine use in yachts. Aluminum is also found in bicycle frames, saucepans and drink cans.

2.3.2 Copper

The properties of copper and its alloys include high thermal conductivity, high electrical conductivity, good corrosion resistance, and high ductility. Copper also oxidizes to a green color.

Applications: These properties have allowed copper and its alloys to be used for heat exchangers and heating vessels, as an electrical conductor in wiring or motors, as a roofing material, for plumbing fittings, as well as for saucepans and statues.

2.3.3 Lead

Lead has been used over the centuries for a range of applications, including for bullets, in fuels and even in paint. However, it was found to be unhealthy when released into the atmosphere, while other applications also caused harm to users.

Lead is the heaviest common metal and is resistant to corrosion. It also doesn't react with many chemicals and is soft and malleable.

Although many of its former uses are no longer allowed, lead is still widely used for batteries, power cables, and acid tanks.

Applications: Solder, Bearing material for axles and crankshafts, electrical fuses, boiler plugs, battery grids, Lead foils are used in radiation shielding

2.3.4 Tin

Tin is silverish-white metal obtained from oxide called tin stone by refining in a reverberatory furnace.

Application: cooking utensils, soft solder, lanterns, candle shields, mirror frames, roofing material

2.3.5 Zinc

Zinc has been used for centuries as an alloying element, particularly to alloy steel for a range of purposes as well as alloying copper to create brass.

Galvanizing materials with alloying elements offers them a greater resistance to rust. Zinc is also used as a sacrificial anode in cathodic protection (CP) and as an anode material for batteries. Zinc oxide is also used as a white pigment in paints and to disperse heat during rubber manufacture.

Applications: uses for chain-link fencing, guardrails, suspension bridges, lampposts, metal roofs, heat exchangers, and car bodies

2.3.6 Silver

Silver has been used as a precious metal for centuries. With the highest electrical conductivity, thermal conductivity and reflectivity of any metal, silver is also soft and malleable when heated and is highly resistant to corrosion.

Applications: Used for jeweler and currency, solar panels, tableware, mirrors dental alloys, printed circuit boards.

2.3.7 Gold

Another precious metal that has been used for jeweler and coinage, gold is the most malleable of metals as well as being ductile and resistant to corrosion and many other chemical reactions.

Its electrical conductivity has seen gold used in computer devices as well as for infrared shielding, for the production of colored glass, for gold leaf and also for tooth restoration.

Application: Bars for monetary exchange, ornaments and jewelry, electronic circuits, gold plating is done on contact switches, relays and connectors, medals, trophies. Gods and/or parts of temples are made from gold.

Applications of non-ferrous metals and its alloys.

1. Aerospace: structure, fuselage, Rudders.
2. Marine: boat Hull, shafts, rotor blades.
3. Power generation: turbine blades, casing.
4. Automobile: engine blocks, body parts, alloy wheels.
5. Structural: Windows, doors, pipe fittings, electrical wires, galvanized pipes.
6. Decorative items: show lamps, idols, Bells, jewelries.

3 Silica

Silica, also called silicon dioxide, compound of the two most abundant elements in Earth's crust, silicon and oxygen, SiO_2. The mass of Earth's crust is 59 percent silica, the main constituent of more than 95 percent of the known rocks. Silica has three main crystalline varieties: **quartz** (by far the most abundant), **tridymite**, and **cristobalite**. Other varieties include coesite, keatite, and lechatelierite.

Application: Silica sand is used in buildings and roads in the form of Portland cement, concrete, and mortar, as well as sandstone. Silica also is used in grinding and polishing glass and stone; in foundry molds; in the manufacture of glass, ceramics, silicon carbide, ferrosilicon, and silicones; as a refractory material; and as gemstones. Silica gel is often used as a desiccant to remove moisture.

4 Engineering ceramics

Engineering ceramics are inorganic solid material containing compounds of metals and non-metallic elements, most frequently oxides, nitrates, carbides. Example: aluminium oxide, tungsten carbide, boron carbide, silicon nitride, aluminium nitride etc., with reference to structure, ceramic materials maybe in crystalline state with atoms bonded together in a regular pattern or Amorphous State with atoms having non regular arrangement. A few properties and applications of engineering ceramics are listed below

1. High hardness
2. High melting point

3. Good Thermal insulator
4. Highly electricity resistance
5. Low mass density
6. Generally, chemically inert
7. Brittle in nature
8. Zero ductility
9. Low tensile strength

Application: They are used in space industry because of their low weight, They are used as cutting tools, as refractory materials, as thermal insulator, as electrical insulator

5 Glasses

Glass, an inorganic solid material that is usually transparent or translucent as well as hard, brittle, and impervious to the natural elements. Glass has been made into practical and decorative objects since ancient times, and it is still very important in applications as disparate as building construction, housewares, and telecommunications. It is made by cooling molten ingredients such as silica sand with sufficient rapidity to prevent the formation of visible crystals.

Glasses are amorphous or non-crystalline ceramic material, usually silicate containing other oxide like CaO, Na_2O, K_2O and Al_2O_3 in order to obtain favourable properties such as reflective index, Electrical conductivity, etc.,

Applications: glass find application in doors, windows, laboratory equipment's and incandescent bulbs, x-ray tubes, fiberglass installation, windscreen, backlights and similar such components for automotive and aerospace applications etc.,

6 Graphite

Graphite is formed by the metamorphosis of sediments containing carbonaceous material, by the reaction of carbon compounds with hydrothermal solutions or magmatic fluids, or possibly by the crystallization of magmatic carbon. It occurs as isolated scales, large masses, or veins in older crystalline rocks, gneiss, schist, quartzite, and marble and also in granites, pegmatites, and carbonaceous clay slates. Small isometric crystals of graphitic carbon (possibly pseudomorphs after diamond) found in meteoritic iron are called cliftonite.

Applications: Graphite is used in pencils, lubricants, crucibles, foundry facings, polishes, arc lamps, batteries, brushes for electric motors, and cores of nuclear reactors.

7 Diamond

Diamond, a mineral composed of pure carbon. It is the hardest naturally occurring substance known; it is also the most popular gemstone. Because of their extreme hardness, diamonds have a number of important industrial applications

Applications: Jewellery, in industry drill, grind or cut materials, Beauty Products such as facial and diamond exfoliator, diamond dust.

8 Polymer

Polymer, any of a class of natural or synthetic substances composed of very large molecules, called macromolecules, that are multiples of simpler chemical units called monomers. Polymers make up many of the materials in living organisms, including, for example, proteins, cellulose, and nucleic acids. Moreover, they constitute the basis of such minerals as diamond, quartz, and feldspar and such man-made materials as concrete, glass, paper, plastics, and rubbers.

Applications:

Agricultural field: Mulching films, green house films are the best examples for the polymer films. Biodegradable polymers are generally used for this purpose.

Medical field: Syringes, capsules, medicine packaging, urine bags etc are the examples.

Transport field: car bumpers, wheel covers etc are also made by the use of polymers.

Electrical field: wire coating, switches etc.

Household applications: Bowls, kitchen accessories are also made by the polymers

Speciality polymers like PEEK, PEK are used in aeroplanes.

9 Shape Memory Alloys (SMA)

The alloys which remember their original shape and that when deformed (subjected to strain) return to their original shape when heated are called SMAs. Hence, they display super elasticity. These are light weight, solid state, alternative to hydraulic, pneumatic and motor based systems.

A few examples for SMAs are alloys of Cu-Al-Ni, Ni-Ti, Au-Cd, Fe-Mn-Si etc. SMAs can also be created by alloying Zn, Cu, Au and Fe. Alloys like Ni - Mn - Ga and Ferromagnetic. Shape Memory Alloys (FSMA) possess shape memory effect using magnetic field. Such alloys are called Magnetic Shape Memory Alloys (MSMA). The magnetic response of FSMA is faster and efficient than temperature induced response. Apart from these. Shape Memory Polymers have been developed.

Applications: These are used in Robotics, automotive, aerospace, civil structures, oil and waterline piping, biomedical, medicine, dentistry, optometry, orthopedic surgery, smart phones etc.

Advantages of Smart Materials

- High reliability.
- Self-repair capability.
- Low power requirements.
- Counteract dangerous conditions.
- Provide new capabilities.

MODULE 4

RAKESH R
Assistant Proff

SOLDERING, BRAZING AND WELDING :-

Fabrication of metals involves joining of two or more metals together. There are various processes available which are based on the type of material, its thickness, degree of permanency in joint required, applications etc., It can be done through welding, brazing, soldering, riveting, fastening, using adhesive etc., of all these soldering, brazing & welding are important in day today fabrication process and is discussed below.

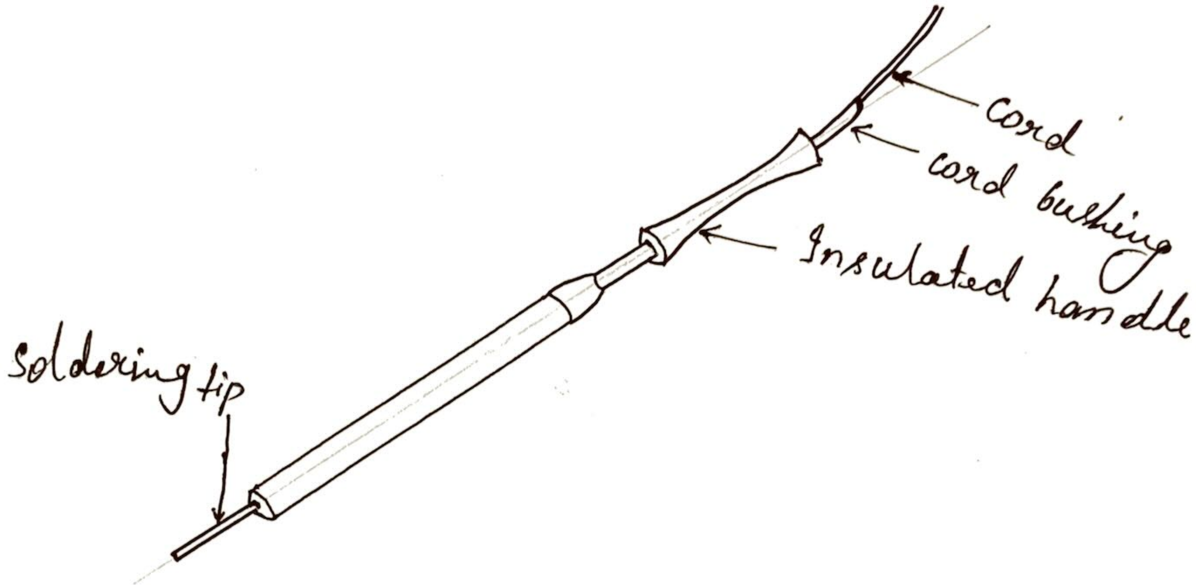
Soldering :-

Principle of Soldering :-

Soldering is a joining process in which two similar or dis-similar metals are joined by means of a filler metal called 'solder' which is an alloy of tin & lead in various proportions, whose melting temperature is below 450°C. The surface to be joined are first cleaned in order to remove the dirt, grease & other oxides. Then 'flux' is applied at the area of the parts to be joined. Zinc chloride, dilute hydrochloric acid and alcoholic resin are some of the fluxes commonly used in soldering.

The flux is used to wet the surface of the work piece & to allow the molten metal to flow easily into the area to be joined. The solder is heated & melted by a soldering iron & the molten solder is deposited at the joint.

Later the joint is allowed to cool for some time & then cleaned to remove any flux residues in order to avoid corrosion. A typical soldering gun is as shown in the figure



A typical Soldering Gun

- The important applications of soldering are commonly seen in electronic industry, in sheet metal work & in sealing of metal containers.

Types of Solder :- A solder is a special alloy which has low melting temperature & used as a filler metal in soldering operation. There are two types of solder

Soft Solder	Hard Solder
1) These are alloys of tin & lead (tin 64% & lead 36%)	1) These are alloys of silver, copper & Zinc [Silver 50%, copper 35%, Zinc 15%]
2) Melting range is between 160-200°C	2) Melting range is between 350°-950°C
3) Used where the joints are not subjected heavy loads & high temp	3) Used to make strong joint & can be used for ferrous & non ferrous alloys

Various methods in soldering:-

Soldering are broadly classified based on the mode of heat applied they are.

(i) Soldering iron method
(ii) Torch soldering method
(iii) Induction soldering method
(iv) Furnace soldering method
(v) Resistance soldering method
(vi) Ultrasonic soldering method.

Important

(i) Soldering iron method :-

It is the most common & widely used method of soldering. In this method the tool used is called as soldering iron. These are available in the market with various ratings ranging from 15W to over 100W. Higher the wattage, faster is the soldering process. The heat generated here is by using electric power.

(ii) Torch soldering method:-

In this method oxy-acetylene flame is used for heating the surface to be joined. The filler metal is used which will spread between the joint by capillary action during the process

(iii) Induction soldering method:-

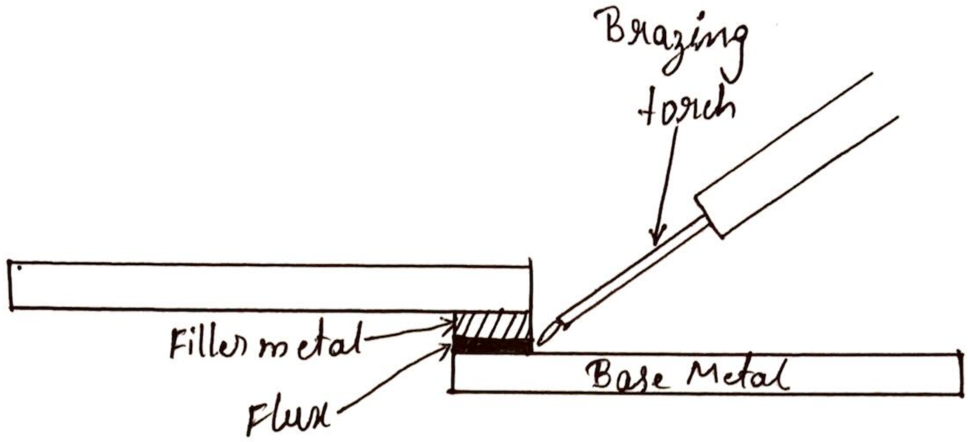
Here the bonding is produced by the heat obtained from the resistance to the flow of induced current offered by the joint by work piece & the filler metal is distributed in the joint by capillary action.

Brazing :-

Principle of Brazing :-

Brazing is a joining process in which two similar or dissimilar metals joined by a special filler metal whose melting temperature is above 450°C but below the melting point of the base metal. The filler metal used in thais process is called 'Spelter' which is a non--ferrous alloy or metal. The most commonly used filler metals in brazing are copper & copper alloys, silver alloys & aluminium alloys depending on the application.

The surface to be joined is first cleaned in order to remove dirt, grease & other oxides. Later, flux is applied at the joint. Borax, boric acid, fluorides or chlorides are the commonly used flux materials. The base metal is heated by an oxy-acetylene welding torch & the filler metal is placed at the joint. These is heated with the flame as shown in figure. The filler metal melts & flows throughout the joint by capillary action. The work piece is then allowed to cool. The joint is then cleaned to remove any flux residues in order to avoid corrosion.



Brazing

Methods of brazing :-

Brazing methods are classified based on the mode of heat applied. Various brazing method are-

(i) Torch brazing method
(ii) Induction brazing method
(iii) Furnace brazing method
(iv) Resistance brazing method
(v) Infrared brazing method
(vi) Vaccum brazing method.

(i) Torch brazing method:-

In this method of brazing, oxy-acetylene flame is used for heating the surface to be joined & the filler metal is distributed in the joint by capillary action.

(ii) Induction brazing method:-

Here the bonding is produced by the heat obtained from the resistance of the work to the flow of induced current & the filler metal is distributed in the joint by capillary action

(iii) Furnace brazing method:-

In this method of brazing, bonding is produced by the furnace heat & the filler metal is distributed in the joint by capillary action

Comparison between Soldering & Brazing

Soldering	Brazing
1) Filler metal is called solder	1) Filler metal is called spelter
2) Melting point of filler metal is below 450°C	2) Melting point of filler metal is above 450°C but below melting point of work piece metal
3) Strength is comparatively low	3) Stronger joint can be obtained.

4) Soldered joint corrode to some extent	4) Brazed joint resist corrosion
5) Soldering is a cheaper process	5) Brazing is a costlier process

Welding:-

Welding is a commonly used metallurgical process in which the parts to be joined are heated to molten state & then fused together either with or without the application of pressure. An additional material called filler metal is used when there is a gap. Welding can also be carried out without the use of filler material.

"Welding can be defined as the metallurgical process of joining two or more similar or dissimilar materials with the application of heat, with or without the application of filler metal to produce a homogeneous joint."

So, during welding, application of heat is must but application of pressure or filler metal is optional i.e., either one will be used

Classification of welding:-

Welding process can be classified into two types

a) Plastic or pressure welding

b) Fusion or non-pressure welding

(i) Plastic or pressure welding is a process in which the metal parts to be joined are heated to the plastic state (or above) and then fused together by applying external pressure. No filler metal is used in this process. Eg: Force welding, Resistance welding

(ii) Fusion or non-pressure welding is a process where the parts to be joined are heated above their melting temperature & then allowed to solidify by cooling here filler metal is used to fill the gap.
Eg: Arc welding & gas welding.

- Welding
  - Pressure welding
    - Forge welding
    - Resistance welding
  - Fusion welding
    - Thermit welding
    - ARC welding
    - Gas welding

Application of welding:-

welding has been employed in industry as a tool for

1) Manufacturing of automobile, aircrafts, refrigerators pressure vessels, furnaces, building constructions etc.,

2) Repair and maintenance work like joining broken parts, rebuilding work out components etc.,

Electric Arc Welding :-

Electric arc welding is a fusion welding method. This method uses the high intensity of the arc that is generated during the process to melt the work piece

Principle of arc welding :-

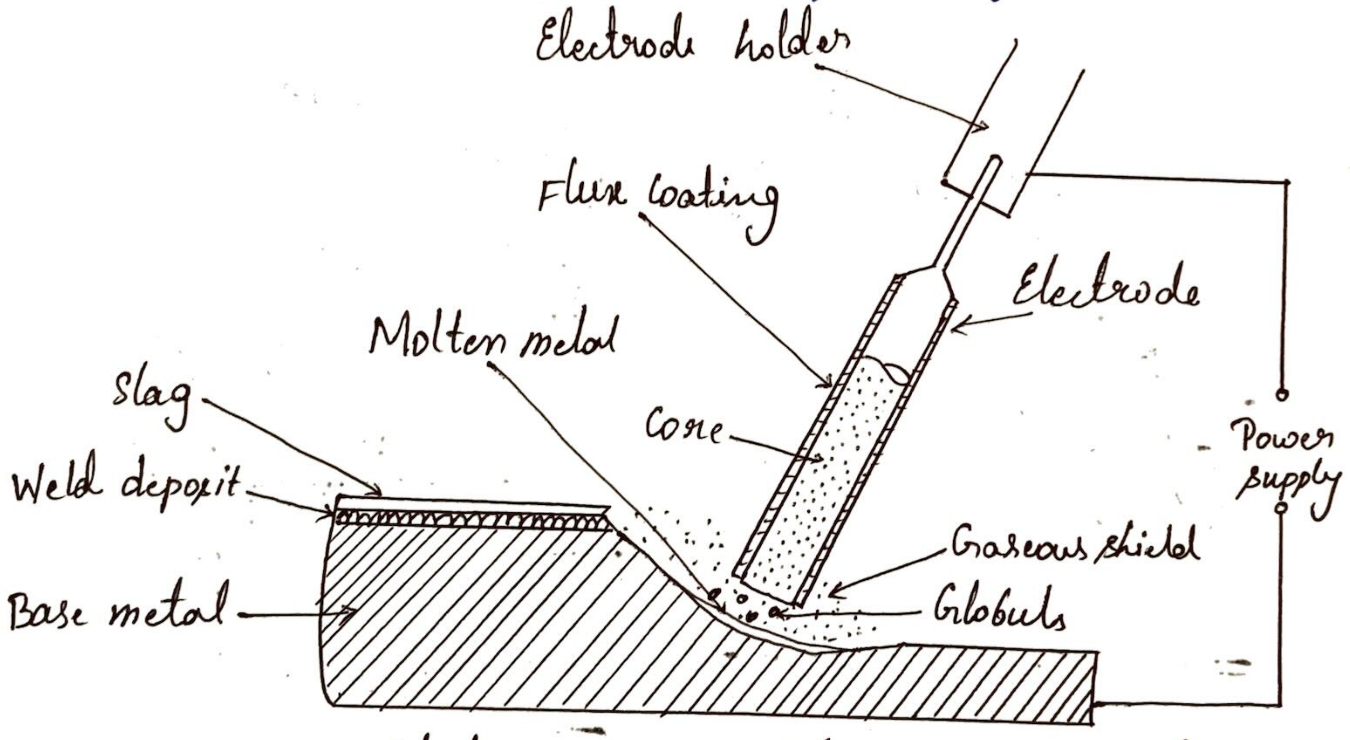
In this process the heat is produced by an electric arc. The arc is produced by striking the electrode on the work piece & momentarely seperated by a small gap of 2-4 mm. This will assist in maintai-ning the arc between the work piece & the electrode. thus the electric energy is converted into heat energy. The high temperature at the tip of the electrode is sufficient to melt the work piece. Also the electrode melts & combines with the molten metal of the work piece thereby forming a homogeneous joint.

Working :-

The schematic representation of the arc welding process is shown in figure. Here the electrode holder, holding the electrode forms one pole of the circuit & the parts to be welded forms the other pole. The electrode acts as both filler metal as well as arc generator.

The arc which is struck between the electrode & the work piece produces temperature ranging from 5000-6000°c. Thus the heat of the arc melts the work piece metal forming a small molten metal pool. At the same time, the electrode tip also melts & is transfered into the molten metal of the work piece in the form of globules (droplets) of molten metal.

The molten metal fills the joint & bonds the joint to form a single piece of homogeneous metal.



Electric Arc welding

Applications:-

Arc welding process finds wide application from simple fabrication work to aircraft industries. They include repair & maintenance work, joining of large pipes, construction of building & bridges, ship building & automotive industries

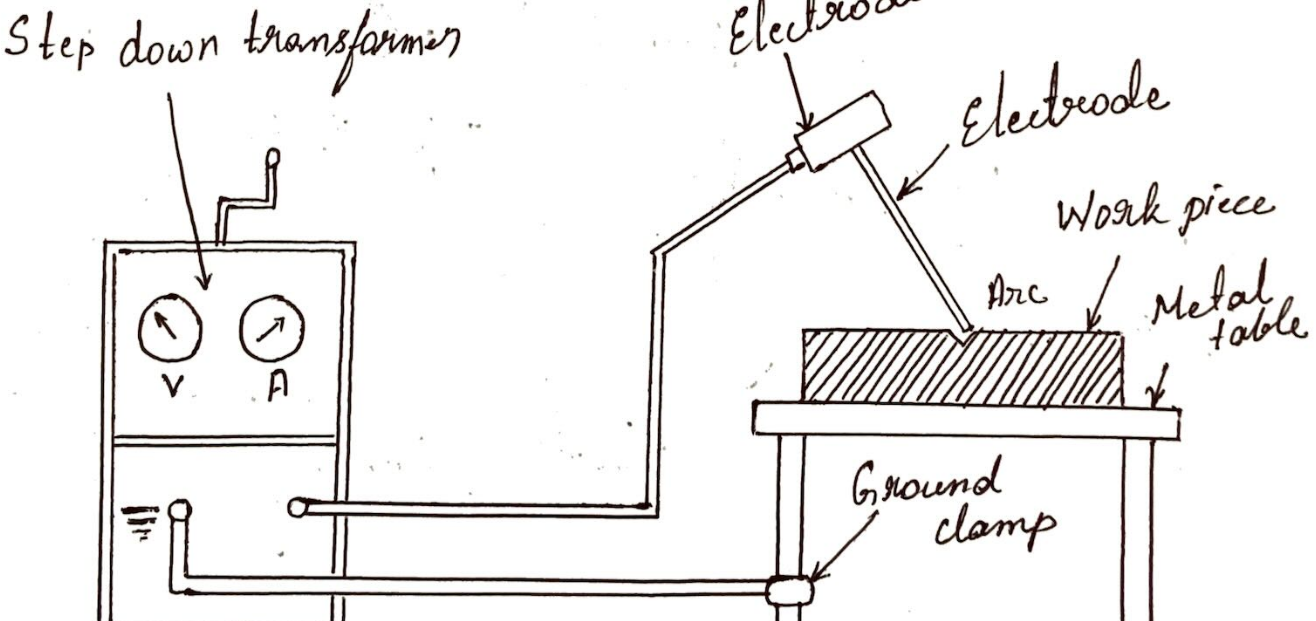
Arc welding Machines:-

Arc welding process uses electric power as its source of energy. To supply the current, two types of power sources are available viz Alternating current (AC) & Direct current [DC]

The two types are discussed below.

The schematic representation of an AC welding circuit is shown in figure

a) Arc welding using AC current:-



Arc welding Machine using AC current

This is the common welding machine which we see in the workshops. The main parts of this machine are

i) Step down transformer:- To reduce the usual supply voltage (220-440V) to that required for welding (15-90V)

2) <u>Cables</u>:- One cable to connect the electrode holder holding the electrode & the other to connect the ground clamp.

3) <u>Electrode holder</u>:- To hold the electrode

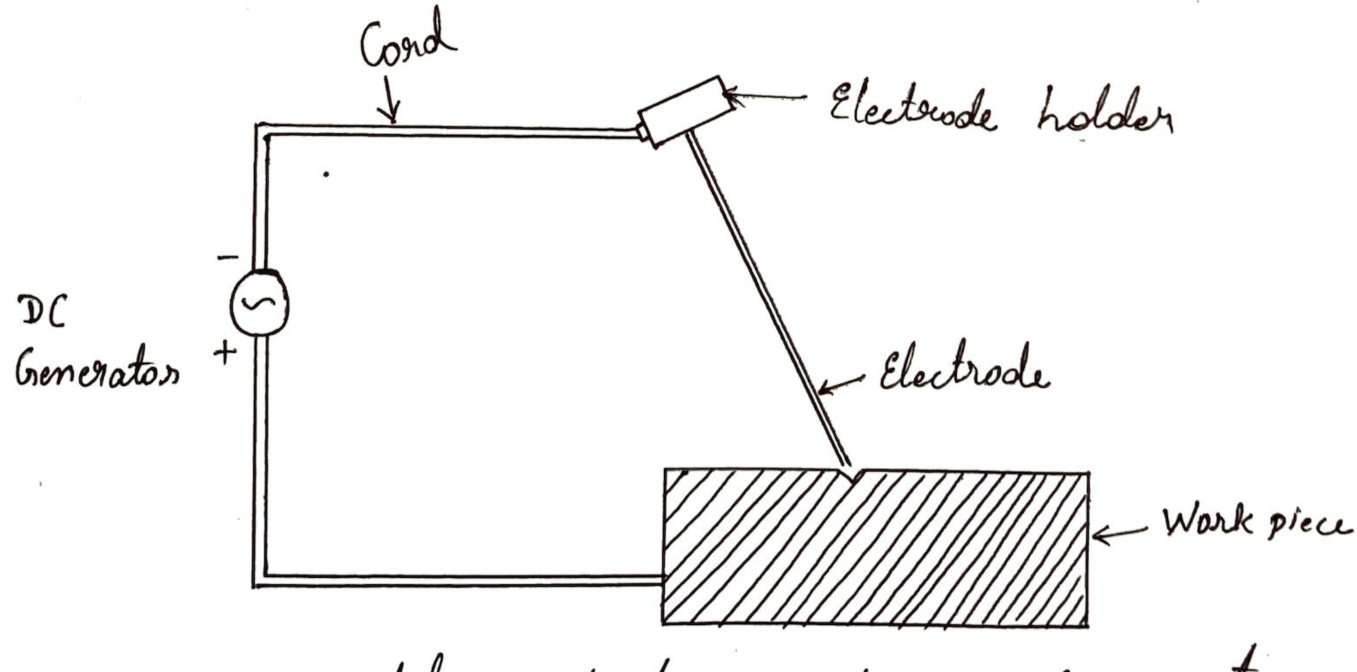
4) <u>Ground clamp</u>:- To connect the workpiece or the table carrying the workpiece & the grounding cable.

5) <u>Electrode</u>: The filler metal

The other commonly used equipments for arc welding are

(i) Chipping hammer
(ii) Wire brush
(iii) Safety goggles/shield
(iv) Hand gloves.
(v) Apron
(vi) Helmets.

b) Welding using the DC Current:-

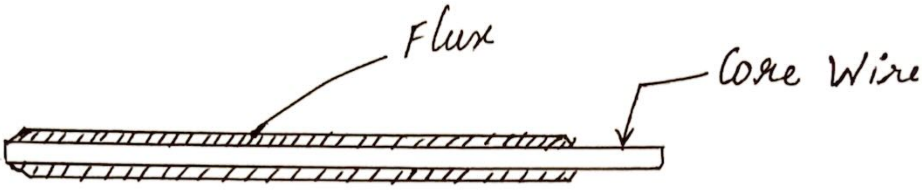


<u>Arc welding Machine using DC Generator</u>

DC welding consists of a DC Generator ~~or~~ connected to an electrode which acts as one terminal & the workpiece as the other terminal. In this process, greater heat is generated at the positive pole. If the workpiece is connected to the positive pole of the D.C generator & the electrode to the negative pole, greater amount of the work piece material is melted. This kind of setup is called 'Straight polarity'. If the workpiece is connected to negative & electrode to positive then, more heat is generated at the electrode. This is called 'reverse polarity'. But in AC welding we dont have this option.

Electrode used in arc welding :-

Arc welding process makes use of a 'filler metal' to supply additional material to fill the gap between the work piece. The filler metal used in the welding process is called 'Electrode'. It is made of a metallic wire called 'core' which is of the same material i.e, the same chemical composition as that the work piece metal. This core is uniformly coated with a material called as 'flux'



Welding Electrode [Coated]

Two types of electrode are used in arc welding
1) Consumable electrode.
2) Non-Consumable electrode.

Consumable electrode are further classified into
a) Coated electrode
b) Plain or bare electrode

a) Coated electrodes :-

These electrodes are the metallic core wire which are coated with 'flux'. During welding, both work piece & electrode melt & may absorb oxygen & nitrogen from the atmospheric air there by decreasing the strength of joint. In order to avoid this, a 'flux' is coated on the metallic wire. Various constituents like titanium oxide, cellulose, mica, manganese oxides, calcium carbonates, iron oxides etc., are used as flux materials for coating.

Following are the functions of flux coated on electrode performs.

(i) Prevents oxidation of molten metal by forming an inert gas shield covering the welding zone.

(ii) Chemically reacts with the oxides & foreign particles to form 'slag'. The slag floats & covers the top portions of the molten metal there by preventing it from rapid cooling

(iii) To stabilize the arc to get a weld bead

b) Plain/bare-electrode:-

It is plain or no-coated metallic wire. These electrode donot prevent oxidation nor slow cooling of the weld bead there by obtaining a weak joint.

2) Non-consumable electrode

Non-consumable electrode are those electrode which donot get consumed during welding process. However an additional filler metal has to be used

Eg: Carbon, graphite or tungsten electrode

Gas Welding Process :-

Principle:-

Gas welding is a fusion type of welding process. This makes use of a strong flame, generated by the combustion of various gases to melt the workpiece. These gases are mixed in proportion to get different flames.

The various combination of gases used in this process are

1) Oxygen & acetylene.
2) Oxygen & hydrogen.
3) Oxygen & LPG.

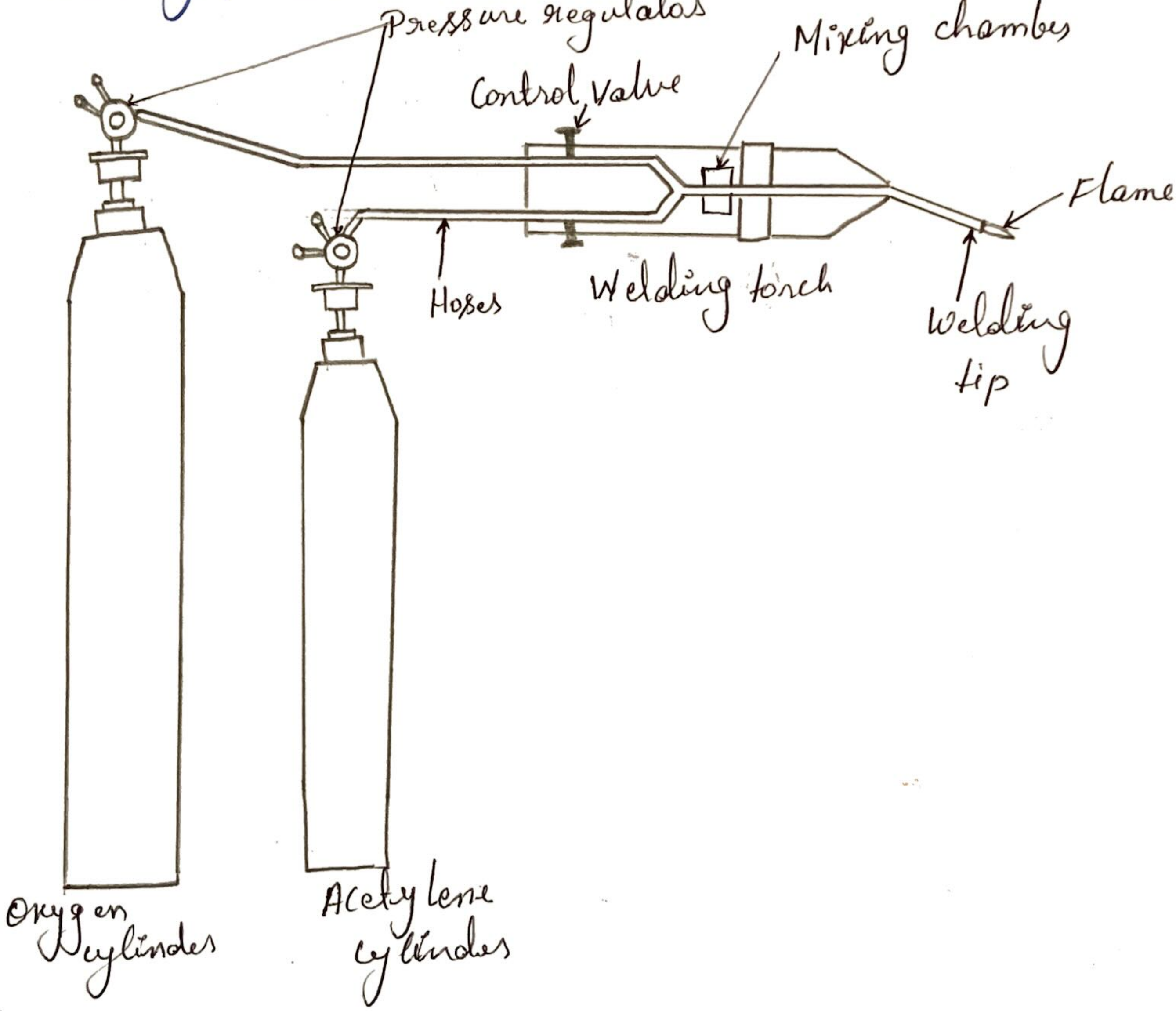
But, Oxygen & acetylene mixture is most commonly used in gas welding & the flame is called as oxy-acetylene flame.

Oxy-Acetylene gas welding process:-

The oxy-acetylene welding process is shown in figure. The equipment consists of two large cylinders, one cylinder contains oxygen & others contains acetylene gas. Pressure regulators are provided to control the pressure of the gas as per requirements. The device used to mix both oxygen & acetylene gases in the proper proportion &

to burn the mixture at the tip which is called as welding torch. The two cylinders are connected to the welding torch by flexible cables.

Working process :-



Suitable proportions of oxygen & acetylene gases are let into the welding torch & burnt in atmosphere. The temperature of the flame at the tip of the torch is in the range of 3200°C & this heat is sufficient enough to melt the workpiece metal. Since a slight gap usually exist between the workpiece & ~~metal~~, a filler metal can be used to supply additional material so as to fill the gap. The deposited metal fills the joint & bonds the joint to form a single piece of metal

Types of flames produced in gas welding:-

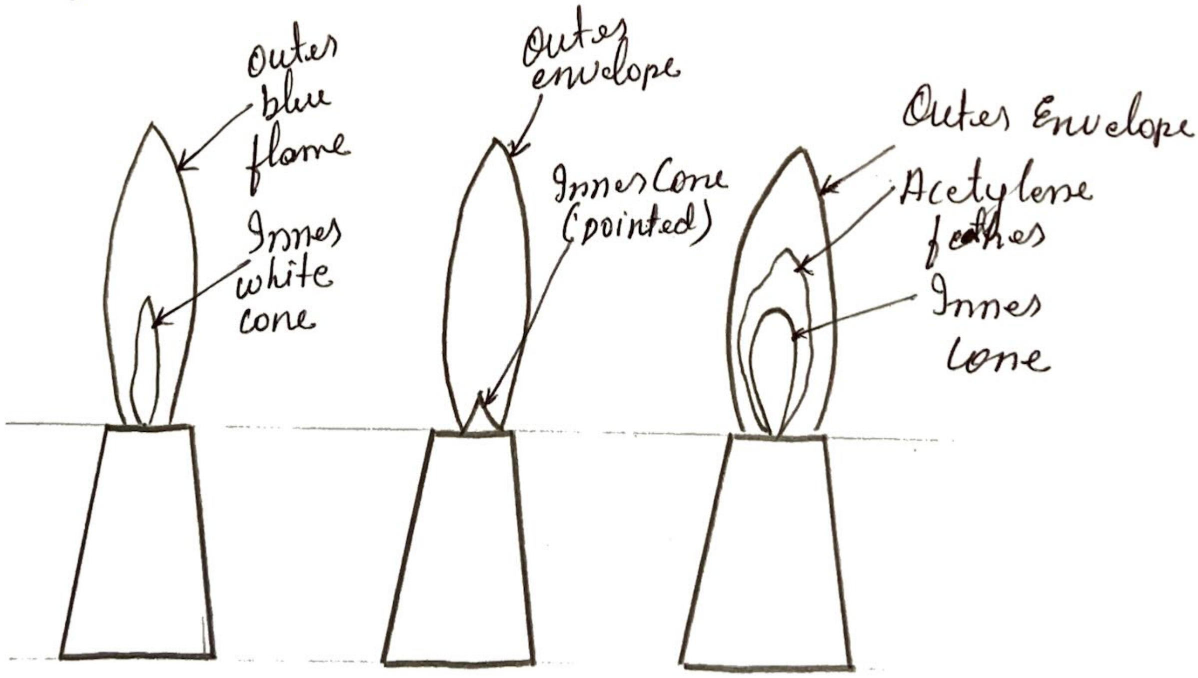
Figure shows the different types of flames produced by regulating the ratio of oxygen & acetylene

The three flames are

i) Neutral flame: Oxygen & acetylene are mixed in equal proportions.

ii) Oxidizing flame: Excess of oxygen [1.15 to 1.5]

iii) Carburizing or reducing flame: Excess of acetylene [0.85 to 1.0]



1) Neutral flame:- A neutral flame is produced when approximately equal volumes of oxygen & acetylene are burnt at the torch tip. The flame has a nicely defined inner whitish cone surrounded by a ~~commonly~~ sharp blue flame ~~for welding~~ as shown in figure(a). This flame is commonly used for welding mildsteel, aluminium, copper etc., & can also be used for metal cutting.

2) Oxidizing flame:- Excess of oxygen in neutral flame results in oxidizing flame which is as shown in figure(b) The ~~oxy~~ oxidizing flame appears similar to the neutral flame but with short inner white cone & the outer envelope being narrow & brightish in colour. Oxidizing flame is used for welding copper-base metals, zinc-base metals etc.,

3) Reducing flame:- When the volume of oxygen supply to the neutral flame which is shown in the figure is reduced the resulting flame will be a carburizing or reducing flame ie rich in acetylene. Refer fig(c). A reducing flame can be recognized by acetylene feathers that exists between the inner core & the outer envelope. The outer flame envelope is longer than that of neutral flame & usually much brighter in colour. Reducing flame is used for welding non-ferrous metals.

Difference between, Soldering brazing & welding :-

Soldering	Brazing	Welding
1) Soldering are weakest joint out of 3. Not ment to bear the load. Used to make electrical contacts generally	Brazing joints are weaker that welding joints but stronger than soldering joints. This can be used to bear the load up to some extent.	welding joints are strongest joints used to bear load. Strength of the welded portion of joint is usually more than the strength of base metal
2) Temperature requirement is up to 450°C in soldering joints	Temperature may go to 600°C in brazing joints	Temperature required is 3800°C in welding joint
3) Heating of the work piece is not required	work piece are heated but below their melting point	To join, work pieces need to be heated till their melting point
4) No change in mechanical properties after joining	May change in mechanical properties after joining but it is almost negligible	Mechanical properties of base metal may change at the joint due to heating & cooling
5) Cost involved & skill requirement ~~are~~ are very low	Cost required & skill required are in between other two	High cost is involved & high skill level is required
6) No heat treatment is required	No heat treatment is required after brazing	Heat treatment is generally required after welding
7) ~~No~~ pre heating of workpiece before soldering is good for making good quality joint	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature	No preheating of workpiece is required before welding as it is carried out at high temperature