WELDING

Welding is a process of joining two or more similar or dissimilar metals by heating them to a suitable temperature, with or without application of pressure and with or without the use of filler material.

TYPES OF WELDING :

Welding can be classified into two types based on principle employed.

① Pressure Welding or plastic Welding.

② Non-pressure Welding or Fusion Welding.

1] Pressure Welding :-

* It is a welding process in which parts to be jooned are heated upto the plastic state and then fused or joined together by applying the external pressure.

* It is also called as Solid phase Welding because Welding is accomplished without really melting the parts of the joining surfaces.

Ex: Forge Welding, Resistance Welding etc.

2] Non-pressure Welding or Fusion Welding :

* It is a welding process in which parts to be joined are heated upto molten state using a filler metal and allowed to solidify. It is also called as liquid phase welding.

* In this type, bonding is obtained by melting the materials around the joint. If necessary a molten filler material is also added.

Ex: Gas Welding, Arc Welding etc.

Applications of Welding :

1] Used in building of bus, truck and car bodies & parts.

2] Used in the manufacturing of furnaces & tanks.

3] Used in the manufacturing of railway equipment.

4] Used in the manufacturing of cranes and hoists.

5] Used in the manufacture of Steel furniture.

6] Aircraft building industry uses welding process to join its various constituent parts.

7] Welding process is extensively used in the construction of various types of structures like bridges, buildings and ships.

8] cylinders, boilers and vessels manufacturing.

9] used in machine tool industry.

General Welding Procedure:

Step 1: Cleaning: The surfaces of the parts to be welded need to be thoroughly cleaned for removal of dirt, oil, grease etc.

Step 2: Edge preparation: * The process of preparing a contour at the edges of the pieces to be joined is called as edge preparation.

* This involves beveling and/or grooving.

* The idea behind this is to get fusion or penetration through the entire thickness of the member.

* The edge preparation is necessary mainly for butt welds of thickness greater than 3mm.

* The various types of edge preparations required for different butt joints are shown in fig below:

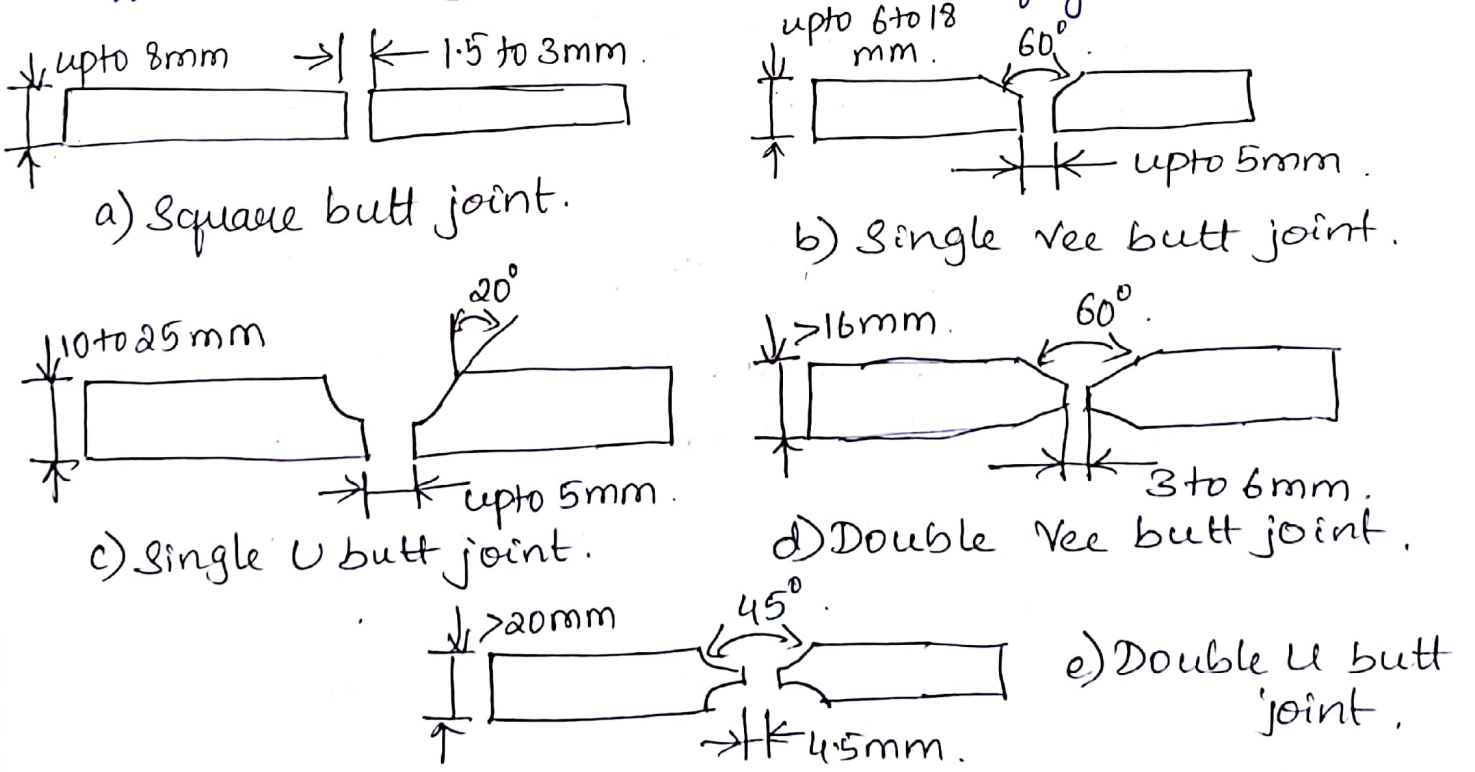

Fig: Edge preparation for butt joints.

Step 3: Clamping: Next, the parts to be welded are clamped suitably through jigs and fixtures so that there are no undesirable movements during welding.

Step 4: Check for Safety Equipment: Safety personal protective equipment like goggles and shields to protect the eyes, protective clothing to prevent the sparks and flying globules of molten metal, safety shoes, gloves, aprons and other safety equipment must be ensured.

Step 5: The initial weld: * Initial tack welds are done at the opposite corners of the joint to secure the pieces together.

* Any cracks at this stage must be chipped off as the presence of these cracks causes residual stresses.

* The length & spacing of the tack weld varies with the thickness of the metal and length of the joint.

Step 6: Intermediate and final welding:

* The weld joint is formed through various weaving movements (of various shapes called weld beads).

* During the process, filler metal and a suitable flux are used.

* After intermediate run of welding, final run is taken.

Step 7: Excess Material Removal: Extra material on the weld surface can be removed using tongs & chippers. The final weld is now allowed to cool and finally cleaned.

ELECTRIC ARC WELDING:

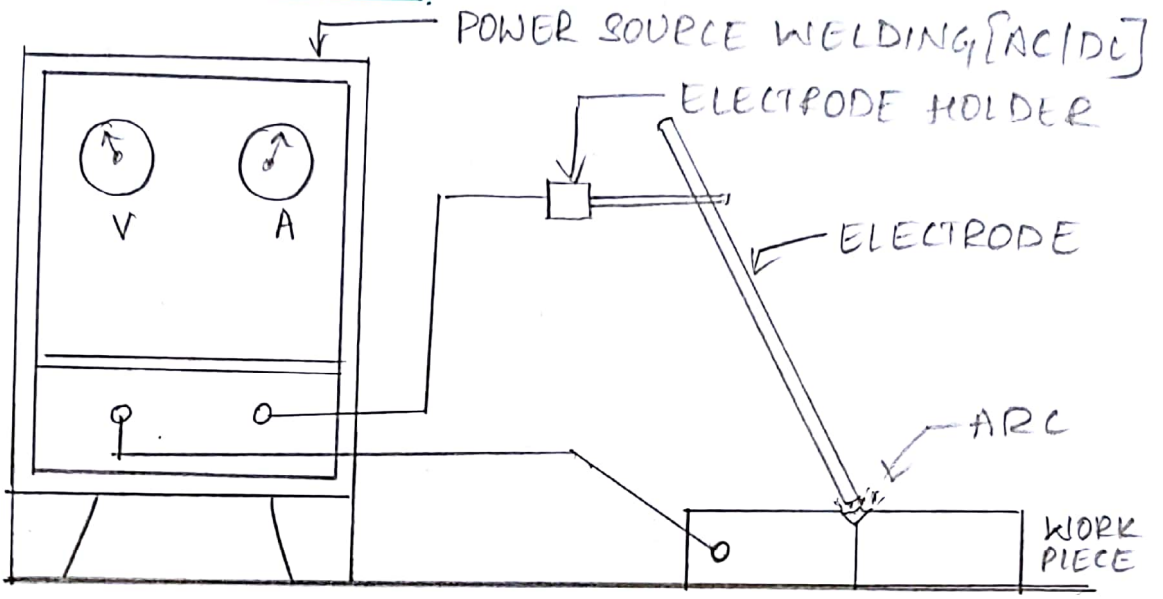

fig: a) Arc Welding circuit

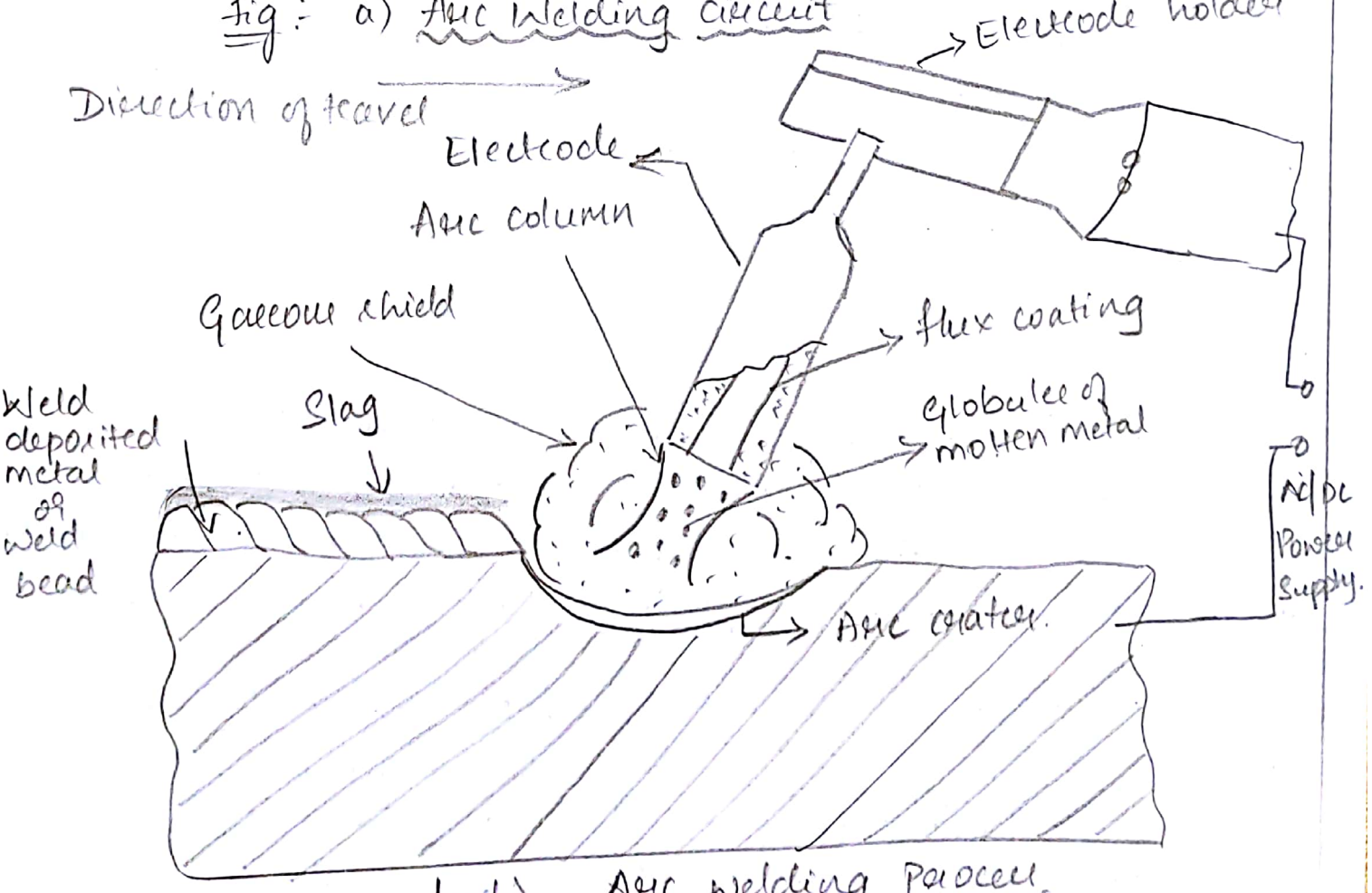

fig b) Arc welding Process

Arc welding process is a fusion method of welding that utilizes the high intensity of the arc generated by the flow of current to melt the workpieces. A solid continuous joint is formed upon cooling.

Principle:

This is a type of non-pressure or fusion welding which works on the principle that an electric arc is produced when two electric conductors (flux coated metallic electrode and base material) in electric circuit comes in contact for a moment and then simultaneously separated by a small gap.

Assuming that there is sufficient voltage in the circuit to maintain the flow of current. This electrical energy is converted into heat energy. This heat energy at the tip of the electrode is sufficient to melt the workpiece. The tip of the electrode melts and combines with the molten metal of the workpiece thereby forms a homogeneous joint.

Working:

In this process, the flux coated metallic electrode and electrode holders together form the negative pole of electric circuit whereas the base material i.e., part to be welded forms the positive pole of the circuit.

When an arc [orders of 2700°C to 6000°C] is struck, electrical energy is converted into heat energy. This heat energy is sufficient to melt both electrode & the workpiece and forms the homogeneous mixture.

This mixture when cooled solidifies and forms strong joint. The electrode is normally inclined at 60° to 70° to the workpiece to get deep penetration.

The arc temperature can be varied by employing high or low currents. A high current - arc with a small length produces very intense heat. The flux coated on electrode decomposes due to high temperature generated by arc and produces a gaseous shield to protect the molten metal pool from atmospheric oxidation.

WELDING DEFECTS:

1] Cracking: It occurs due to incorrect electrodes or wrong working procedures. Cracked welds must be cut out and re-welded.

2] Incorrect Edge preparation:

* Too narrow an angle of the edges of the workpieces result in poor fusion, slag inclusion & weak weld.
* Too wide an angle b/w the inclined edges result in heavy welding, resulting in overheating & locked up stresses.

3] Craters:

These are concave depressions in the external surface of the welded joints which reduces the volume of the weld and thus the strength of the joint.

④ Undercutting : It is the excess melting of the parent metal which reduces its strength.

⑤ Unequal legs : In fillet welding, the unequal length of the legs of the weld reduces the strength of the joint.

⑥ Porous Weld : Insufficient gap between the electrode & the workpiece results in poor penetration which may cause slag inclusion & porous welds.

⑦ Over welding : When welding is carried over an already welded layer, it may overheat the earlier layers of weld and there may not be proper fusion b/w the two layers.

ii) Arc Welding electrodes:

The 2 types of electrodes used in arc welding are

a) Consumable electrodes

b) Non-consumable electrodes.

a) consumable electrodes:

* consumable electrodes also melt along with the workpiece and fill the joint. They are made of various metals depending upon their purpose and the chemical composition of the workpiece. The consumable electrodes either will be bare or coated.

* When the bare electrodes are used, the globules of the molten metal while passing from the electrodes absorb oxygen and nitrogen from the atmospheric air to form non-metallic constituents which gets trapped in the

Solidifying weld metal and thereby decreasing the strength of the joint.

* The coated electrodes facilitate.
  - ✓ The protection of molten metal from oxygen & nitrogen of the air by providing a gas shield around the arc and the molten pool of metal.
  - ✓ To establish and maintain the arc throughout welding
  - ✓ The formation of slag over the joint thus protects from rapid cooling.
  - ✓ The addition of alloying element.

* The electrodes are made of either soft steel wire or alloy steel. The coating is usually composed of chalk, ferro manganese, starch, kaolin, alloying & binding materials.

b) Non-consumable electrodes:

* When non consumable electrodes are used, an additional filler material is also required.

* The advantages of using this type of electrode is that the amount of the metal deposited by the filler rod can be controlled which is not possible in the other types of electrodes.

Oxy-Acetylene Welding:

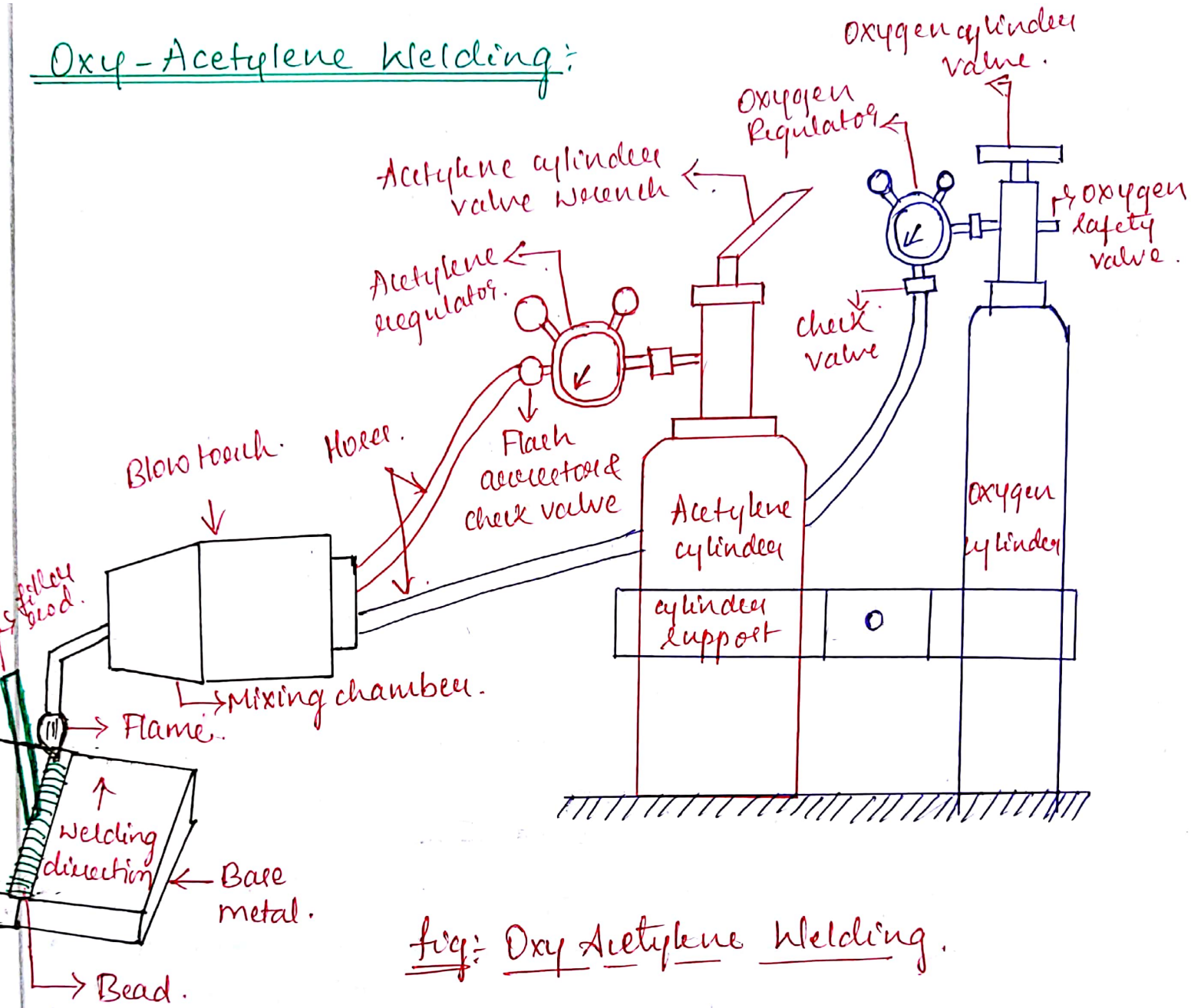

fig: Oxy Acetylene Welding.

* When right proportions of oxygen and acetylene are mixed in the welding torch and then ignited, the flame produced at the nozzle tip is called as the oxy-acetylene flame. This flame when used in welding is known as oxy-acetylene welding.

* The temperature attained by the oxy-acetylene flame is around 3200°C & therefore has the ability to melt all commercial metals. Thus, there is a complete bonding of the

joining metals that can be achieved during welding.

Equipment:

- 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 blow torch.
- The oxygen and the acetylene are supplied to the blow torch separately, where both of them get mixed and come out through the nozzle of the blow torch.

Working:

* After the initial equipment preparation, the to be welded component setup and safety checks are completed, the Pressure regulators fitted to the Oxygen & acetylene cylinders are adjusted to draw the oxygen and acetylene gas in the required proportions from the cylinders respectively.

* The pressure regulator in each of the cylinders is fitted with two gauges. One gauge indicates the gas pressure inside the cylinder and the other gauge indicates the reduced pressure at which the gas goes out.

* The respective gases from cylinders are carried from the pressure regulator to the welding torch using the rubber hose pipes.

* Upon reaching the welding torch, these gases are allowed to mix in a mixing chamber and then are led out of the torch through the orifice of the blowpipe. The resultant flame at 3200 degree celcius is used to melt the workpieces.

* To fill up the gap between workpiece and to add strength to the joint, filler rods are added to the molten metal pool.

* A flux such as borax is used to dissolve and remove metal oxides formed during welding.

* The molten metal pool that contains molten metal of the filler rod and the workpiece solidifies to form a welded joint.

Types of Oxy-acetylene flames:

1) Neutral flame:

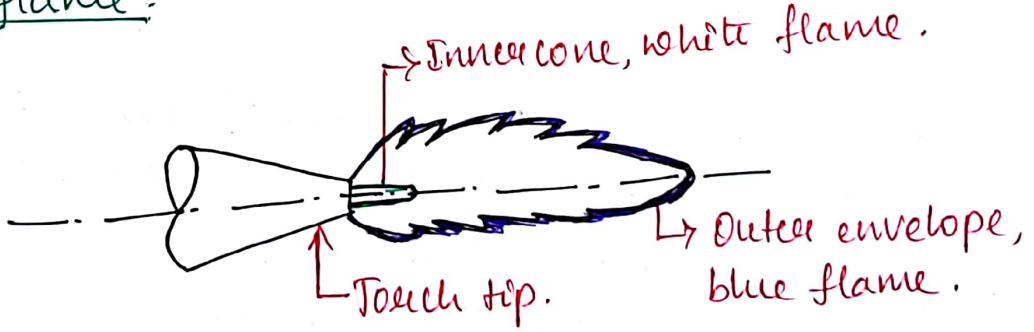

fig: Neutral flame.

* It may be obtained by mixing oxygen and acetylene in equal proportions (1:1). As a result, two distinct zones appear in the flame and produce a hissing sound.

* The flame zones are named as inner cone and outer envelope.

* A short but sharp brilliant white coloured symmetrical cone is formed from the tip of the torch. It has a maximum temperature of 3300°C.

* A faintly luminous bluish coloured flame surrounds the inner cone.

* The inner cone develops heat, while the outer one protects the molten metal from oxidation. As neutral flame has least chemical effect on the weldments, it is used to weld steel, stainless steel, cast iron, copper and aluminium and also for cutting metal.

2) Oxidizing flame.

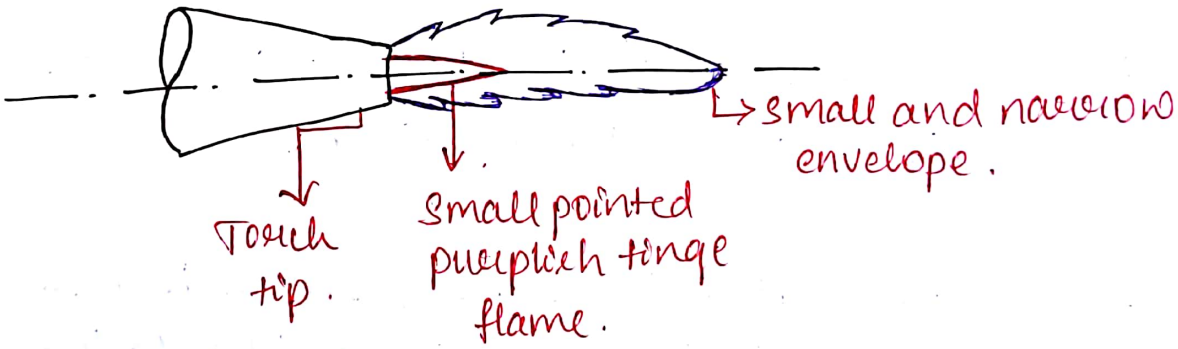

fig: Oxidizing flame.

* It may be obtained by allowing more oxygen than acetylene (1.5:1) in the torch. As a result, with a loud roar, a small purplish tinge of flame appears at the tip and a small, narrow envelope surrounds the inner core. Since the oxidizing flame forms a thin layer of slag over the molten metal, it is used only to weld brass.

3) Carburizing flame or reducing flame:

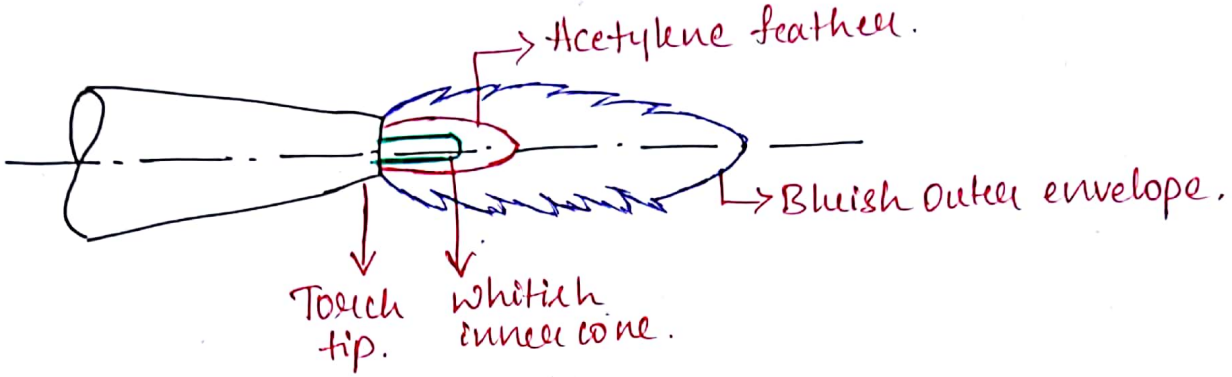

fig: Carburizing flame.

* It may be obtained by allowing less oxygen and excess acetylene (1:1.5) in the torch. As a result 3 distinct zones appear in the flame as shown in above fig.
  i) A sharply defined inner cone.
  ii) An intermediate whitish coloured cone (Acetylene feather).
  iii) A bluish coloured outer envelope.

* The temperature of this reducing flame is considerably reduced, which is very essential to weld various non-ferrous hard surfacing materials, Monel metal and nickel. It is also suitable for soldering, brazing and flame hardening.

Advantages of Welding:

1. Metals and alloys, whether similar or dissimilar can be joined together.
2. The joint is permanent and as strong as the base metal.
3. Welding machines are portable.
4. Welding is a cheap and economical process.

Disadvantages of Welding:

1. Harmful radiations, fumes and spatter.
2. Induction of thermal stress in the weldments.
3. Skilled operator is required to produce a good joint.
4. Jigs and fixtures are required to hold the weldments.

Note:

* Spatter means small hot particles (globules) of the weldments and fillers that are expelled during welding and adhering to the surface of the parent metal.

Differences between Soldering and Welding.

Soldering	Welding.
① Strength of the joint obtained is not stronger.	① Strength of the joint obtained is much stronger than the parent metal.
② Only thin similar metals can be joined.	② Any similar or dissimilar metals and alloys can be joined.
③ Heat source : Soldering iron or gun or small blow torch.	③ Heat source : Gas or electricity.
④ Melting point temperature below 450°C.	④ Melting point temperature ranges between 5000°C to 6000°C.
⑤ Different filler material can be used.	⑤ The filler material used is made of same material as that of the base metal.
⑥ Problems associated with heat affected zones are almost nil.	⑥ Due to higher temperature, problems associated with heat affected zones are more.
⑦ Surface finish obtained is good. Finishing and filing operation are not required.	⑦ certain finishing & filing operation are required on the weld surface.
⑧ Used for joining sheet metals, pipes, wires etc.	⑧ Used for fabrication and structural applications.