welding

- Welding is a materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone, and with or without the use of filler material.

- Welding is used for making permanent joints.
- It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

TYPES

- **Plastic Welding or Pressure Welding**

  The piece of metal to be joined are heated to a plastic state and forced together by external pressure

  (Ex) Resistance welding

- **Fusion Welding or Non-Pressure Welding**

  The material at the joint is heated to a molten state and allowed to solidify

  (Ex) Gas welding, Arc welding

Classification of welding processes

(i). **Arc welding**
- Carbon arc
- Metal arc
- Metal inert gas
- Tungsten inert gas
- Plasma arc
- Submerged arc
- Electro-slag

(ii). **Gas Welding**
- Oxy-acetylene
- Air-acetylene
- Oxy-hydrogen

(iii). **Resistance Welding**
- Butt
- Spot
- Seam
- Projection
- Percussion

(iv)Thermit Welding

(v)Solid State Welding
- Friction
- Ultrasonic
- Diffusion
- Explosive

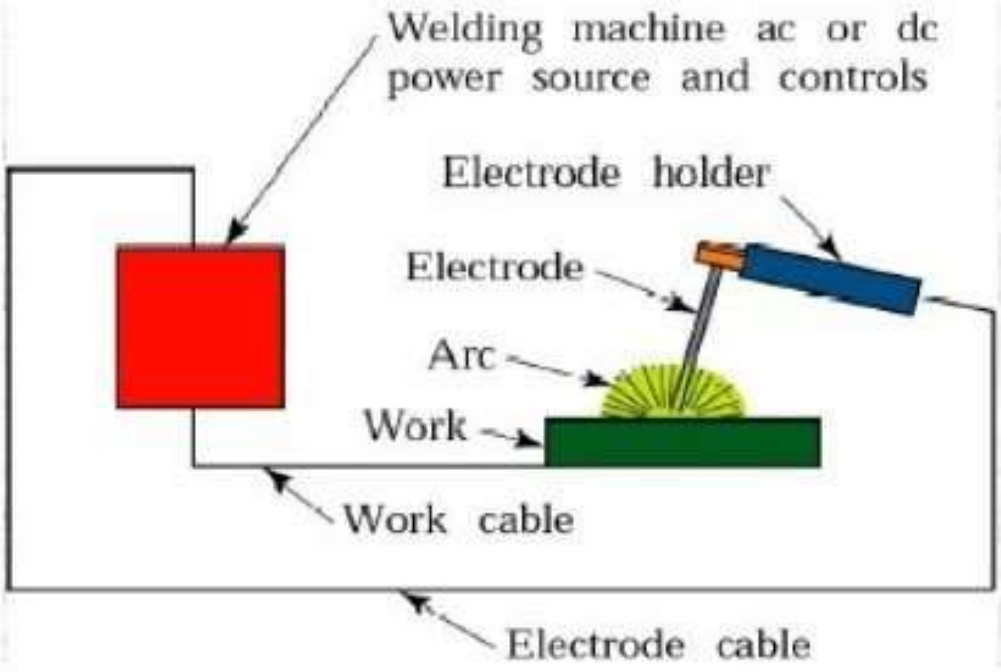
(vi)Newer Welding
- Electron-beam
- Laser

(vii)Related Process
- Oxy-acetylene cutting
- Arc cutting
- Hard facing
- Brazing
- Soldering

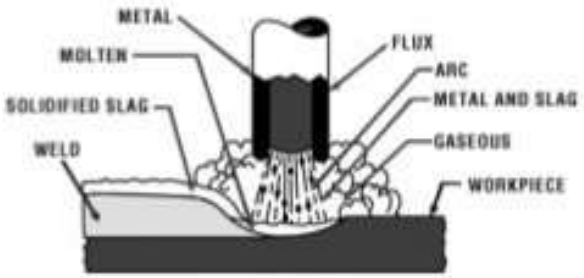
Arc welding

- **Equipments:**
- A welding generator (D.C.) or Transformer (A.C.)
- Two cables- one for work and one for electrode
- Electrode holder
- Electrode
- Protective shield
- Gloves
- Wire brush
- Chipping hammer
- Goggles

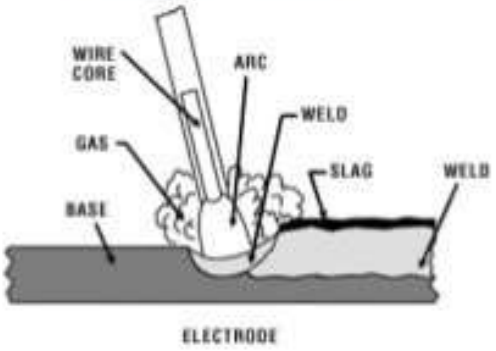
Arc Welding Equipments



Metal arc welding



STICK WELDING PROCESS



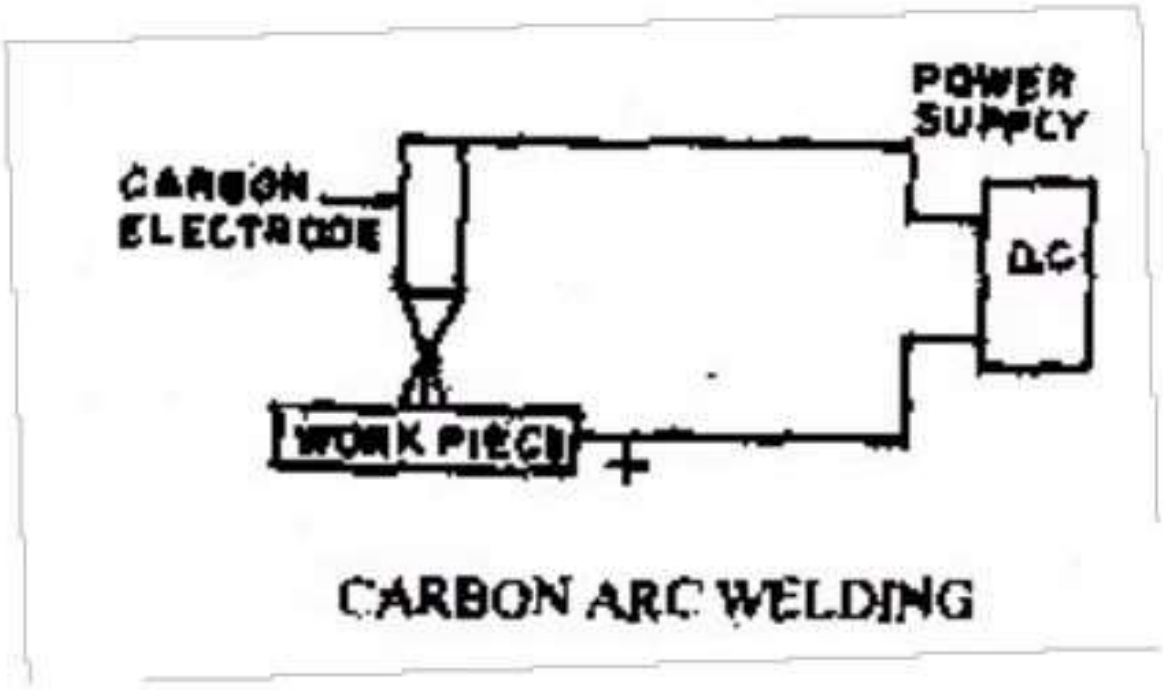
Arc Welding

Uses an electric arc to coalesce metals

Arc welding is the most commor method of welding metals

Electricity travels from electrode to base metal to ground

Carbon Arc Welding



Arc welding

Advantages

- Most efficient way to join metals
- Lowest-cost joining method
- Affords lighter weight through better utilization of materials
- Joins all commercial metals
- Provides design flexibility

Limitations

- Manually applied, therefore high labor cost.
- Need high energy causing danger
- Not convenient for disassembly.
- Defects are hard to detect at joints.

Comparison of A.C. and D.C. arc welding

Alternating Current (from Transformer)

More efficiency

Power consumption less

Cost of equipment is less

Higher voltage – hence not safe

Not suitable for welding non ferrous metals

Not preferred for welding thin sections

Any terminal can be connected to the work or electrode

Comparison of A.C. and D.C. arc welding

Direct Current (from Generator)

Less efficiency

Power consumption more

Cost of equipment is more

Low voltage – safer operation

suitable for both ferrous non ferrous metals

preferred for welding thin sections

Positive terminal connected to the work

Negative terminal connected to the electrode

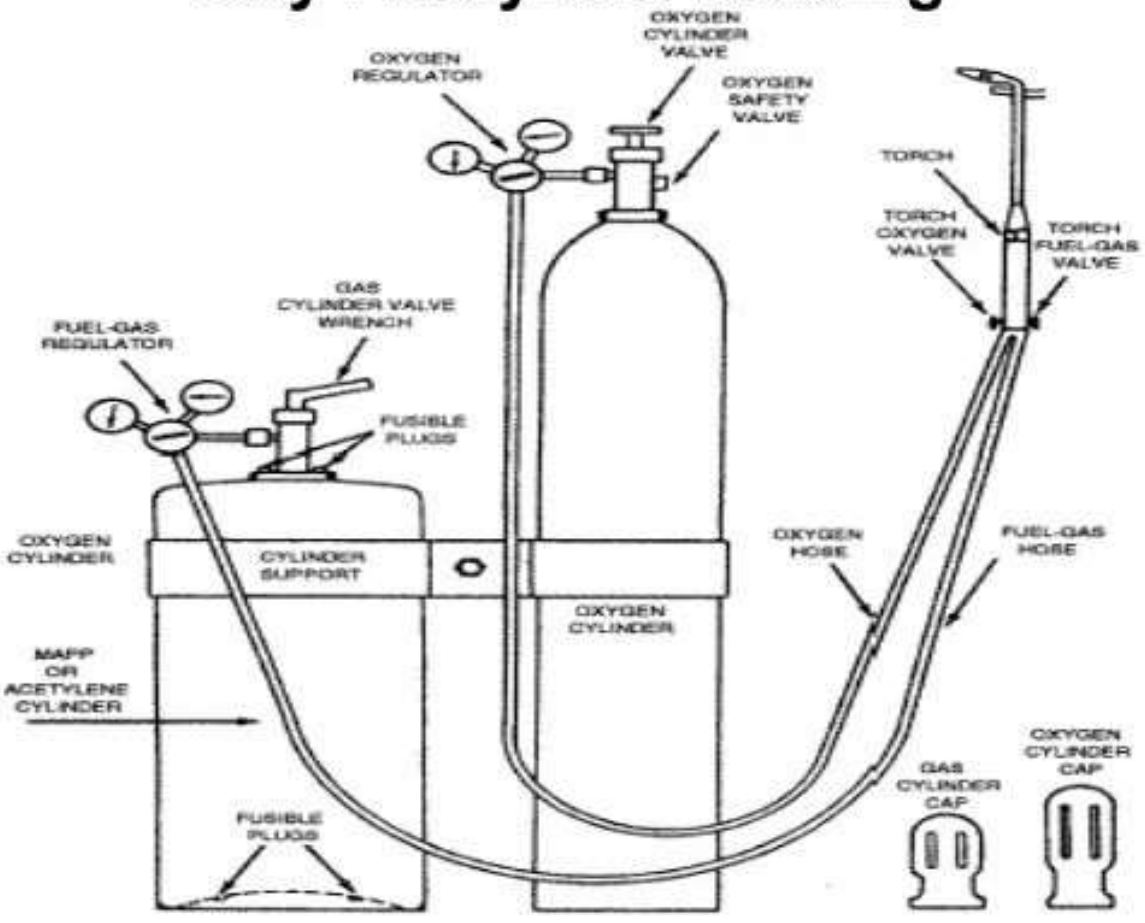
GAS WELDING

- Sound weld is obtained by selecting proper size of flame, filler material and method of moving torch
- The temperature generated during the process is 3300^{0}c
- When the metal is fused, oxygen from the atmosphere and the torch combines with molten metal and forms oxides, results defective weld
- Fluxes are added to the welded metal to remove oxides
- Common fluxes used are made of sodium, potassium. Lithium and borax.
- Flux can be applied as paste, powder,liquid.solid coating or gas.

GAS WELDING EQUIPMENT...

1. Gas Cylinders
   Pressure
      Oxygen – 125 kg/cm2
      Acetylene – 16 kg/cm2
2. Regulators
      Working pressure of oxygen 1 kg/cm2
      Working pressure of acetylene 0.15 kg/cm2
      Working pressure varies depends upon the thickness of the work pieces welded.
3. Pressure Gauges
4. Hoses
5. Welding torch
6. Check valve
7. Non return valve

Oxy-Acetylene welding

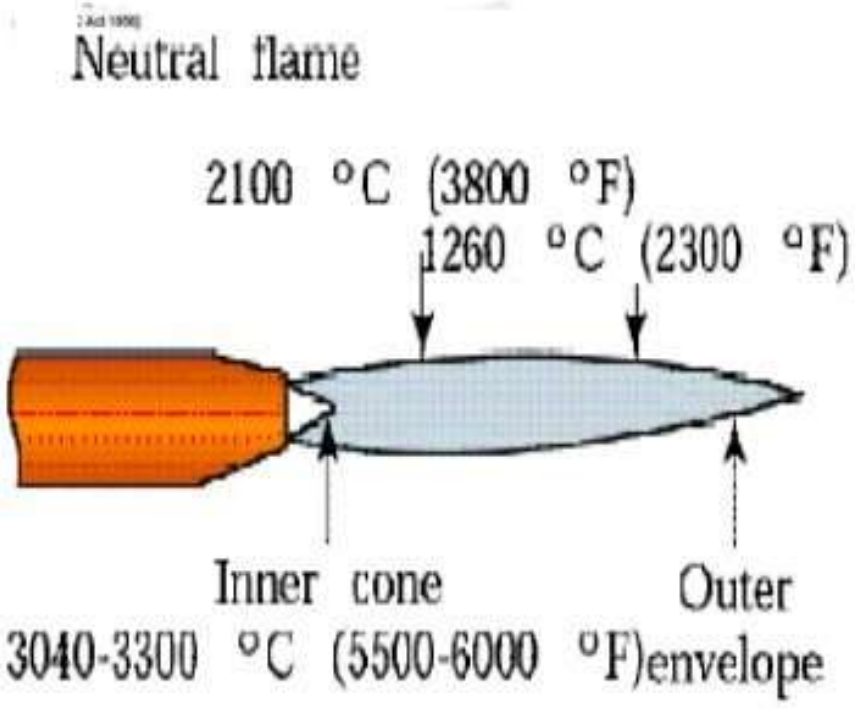


TYPES OF FLAMES...

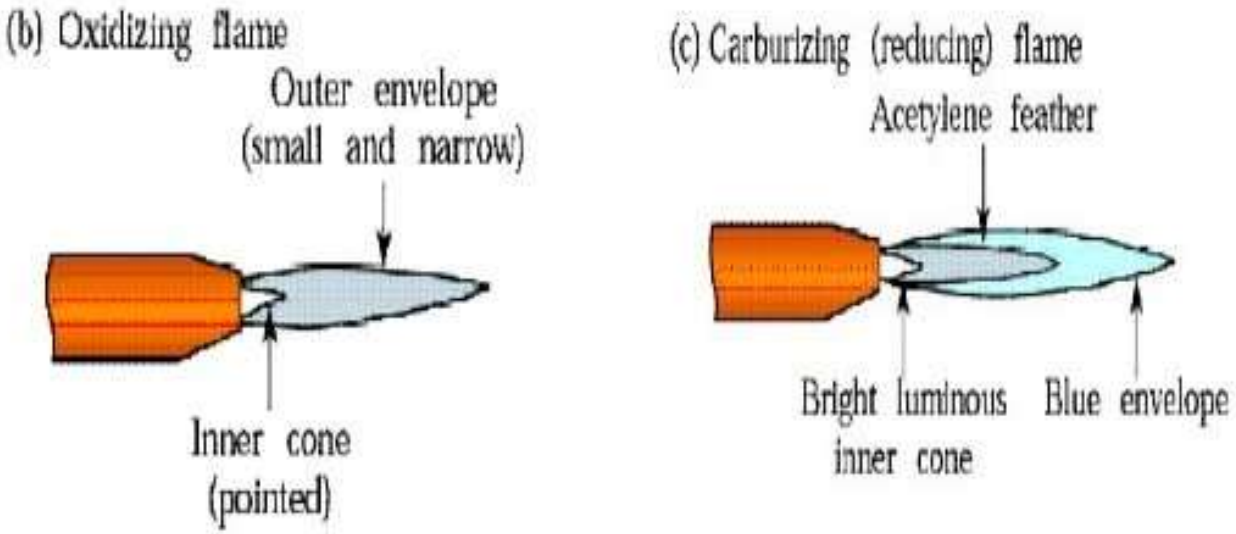
- Oxygen is turned on, flame immediately changes into a long white inner area (Feather) surrounded by a transparent blue envelope is called **Carburizing flame** (3000^{0}c)

- Addition of little more oxygen give a bright whitish cone surrounded by the transparent blue envelope is called **Neutral flame** (It has a balance of fuel gas and oxygen) (3200^{0}c)
- Used for welding steels, aluminium, copper and cast iron

- If more oxygen is added, the cone becomes darker and more pointed, while the envelope becomes shorter and more fierce is called **Oxidizing flame**
- Has the highest temperature about 3400^{0}c
- Used for welding brass and brazing operation



Three basic types of oxyacetylene flames used in oxyfuel-gas welding and cutting operations: (a) neutral flame; (b) oxidizing flame; (c) carburizing, or reducing flame.



Three basic types of oxyacetylene flames used in oxyfuel-gas welding and cutting operations:
(a) neutral flame; (b) oxidizing flame; (c) carburizing, or reducing flame.

GAS CUTTING

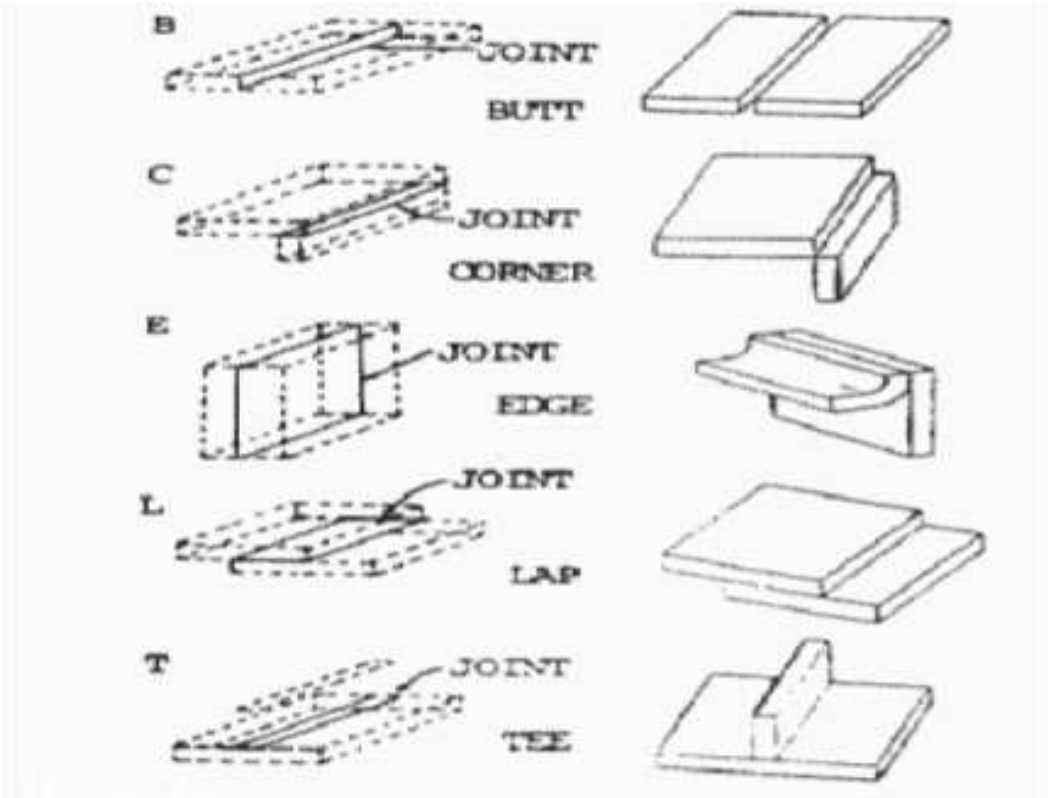
- Ferrous metal is heated in to red hot condition and a jet of pure oxygen is projected onto the surface, which rapidly oxidizes
- Oxides having lower melting point than the metal, melt and are blown away by the force of the jet, to make a cut
- Fast and efficient method of cutting steel to a high degree of accuracy
- Torch is different from welding
- Cutting torch has preheat orifice and one central orifice for oxygen jet
- **PIERCING** and **GOUGING** are two important operations
- **Piercing**, used to cut a hole at the centre of the plate or away from the edge of the plate
- **Gouging**, to cut a groove into the steel surface

GAS CUTTING…

Automatic Gas Cutting

Manual Gas Cutting

Weld joints



The five basic types of joints

Brazing and Soldering

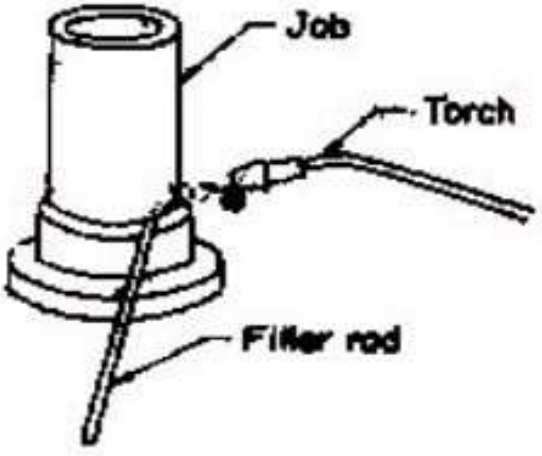
- **Brazing**

It is a low temperature joining process. It is performed at temperatures above 840° F and it generally affords strengths comparable to those of the metal which it joins. It is low temperature in that it is done below the melting point of the base metal. It is achieved by diffusion without fusion (melting) of the base

Brazing can be classified as

Torch brazing
Dip brazing
Furnace brazing
Induction brazing

Brazing



BRAZING

Advantages & Disadvantages

Advantages

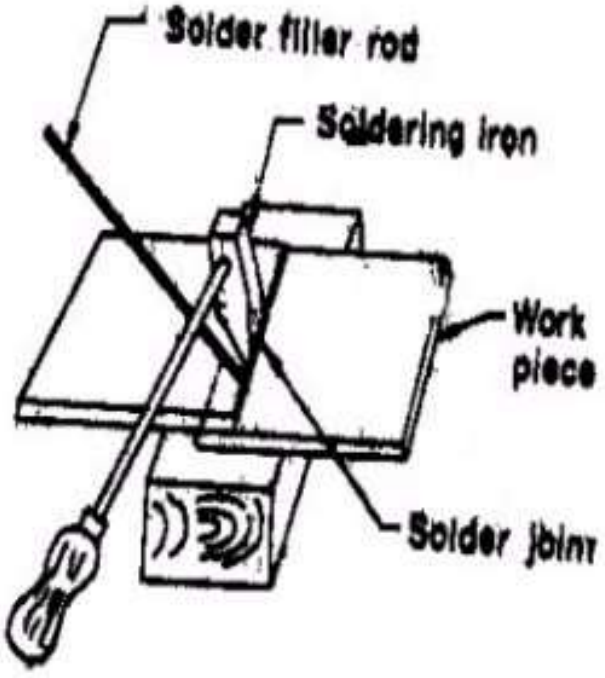
- Dissimilar metals which canot be welded can be joined by brazing
- Very thin metals can be joined
- Metals with different thickness can be joined easily
- In brazing thermal stresses are not produced in the work piece. Hence there is no distortion
- Using this process, carbides tips are brazed on the steel tool holders

Disadvantages

- Brazed joints have lesser strength compared to welding
- Joint preparation cost is more
- Can be used for thin sheet metal sections

Soldering

- It is a low temperature joining process. It is performed at temperatures below 840°F for joining.
- Soldering is used for,
    - Sealing, as in automotive radiators or tin cans
    - Electrical Connections
    - Joining thermally sensitive components
    - Joining dissimilar metals



24.40. ARC WELDING ELECTRODES

Electrodes commonly used are generally of two types :

1. Bare electrodes
2. Coated electrodes.

Bare electrodes are cheaper but the welds produced through these are of poor quality and their use calls for a very high degree of skill on the part of welder if satisfactory results are to be expected. They are, therefore, very rarely used in modern welding practice. However, in coil form they are used with inert gases in a special welding process called *Inert gas metal arc welding (MIG).*

More popularly used in *metal arc welding* are the *coated electrodes* which carry a *core* of bare metallic wire provided with a coating or covering on the outside surface. *Mild steel* is the most commonly used material for core wire, but electrodes with core of other metals and alloys are also manufactured to suit welding of different metals and alloys under varying welding conditions and requirements. Some of the other metals and alloys used as core wire materials are low alloy steel, nickel steel, chromium-molybdenum steel, manganese-molybdenum steel, nickel-manganese-molybdenum-steel, nickel-molybdenum vanadium steel, aluminium, Albronze, lead-bronze, phosphor bronze, etc. Practically all the mild steel coated electrodes are almost similar in composition but differ in the type of covering and flux used on them. The coverings are provided by either dipping the wire cores in a bath or during extrusion. About 20 to 25 mm length at one end is left bare where the electrode is held in the electrode holder.

Electode Coverings. It has been discussed in the earlier articles that the *flux coating* provided on the electrodes perform, many functions, such as providing a reducing atmosphere to prevent oxidation, forming slag with metal impurities, stabilising arc, providing necessary alloying elements to the weld metal and so on. to meet these requirements many different materials are used for making electrode coverings. The common ingredients of a flux which help in slag formation

and metal refining are asbestos, mica, silica, flourspar, stealite, titanium dioxide, iron oxide, magnesium carbonate, calcium carbonate and different aluminas. Ingreadients used for producing the reducing atmosphere include cellulose, calcium carbonate, dolomite, wood floor, starch, dextrin, etc. *Iron powder* provides a higher deposition rate. Ferromanganese and manganese oxide provide alloying elements. The latter also helps in slag formation. Potassium silicate and potassium titanate are the principal arc stabilizers. Arc stability is also helped by titanium dioxide, feltspar and mica.

Normal thicknesses of these coverings on all commonly used *light* and *medium coated* electrodes vary from 10 percent to 55 percent of the total diameter of the coated electrode. However, in some *heavy coated* electrodes it may be as high as 100 percent and above.

Electrode size. Electrodes are commonly manufactured in standard lengths of 250 mm, 300 mm, 350 mm, and 450 mm. Similarly, the standard sizes of the electrodes being commonly manufactured in this country are 1.6 mm, 2 mm, 2.5 mm, 3.2 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm and 9 mm.

24.41. ELECTRODE CLASSIFICATION AND CODING

According to ISI coding system an electrode is specified by six digits with a prefix letter *M*, which indicates its suitability for metal-arc welding. These six digits stand for the following :

1. **First digit.** Numbering from 1 to 8. Each number stands for a particular type of covering provided on the electrode.

2. **Second digit.** It also carries numbers from 1 to 6 and each number represents a particular position or positions of welding in which the electrode can be used.

3. **Third digit.** May carry any number from 0 to 7. Each number represents a particular current condition suitable for that particular electrode.

4. **Fourth digit.** It indicates the minimum tensile strength of the weld metal. It may carry any number from 1 to 8 and each number represents a particular tensile strength in kg/cm^2.

5. **Fifth digit.** It indicates the percentage elongation of deposited weld metal in tensile testing. Different percentages are represented by numbers from 1 to 5.

6. **Sixth digit.** It indicates the minimum impact value of the weld metal. Different values are represented by humbers from 1 to 5.

For detailed study of the above specfications and coding system readers are advised to refer to IS : 815-1956 and IS : 814-1963.

24.42. SELECTION OF ELECTRODES

It is evident from foregoing discussions that welding has to be performed in various different conditions and selection of a proper electrode to suit those

conditions is a vital factor for successful welding. The factors which influence the selection of particular electrode for metal are welding can be summarised as follows :

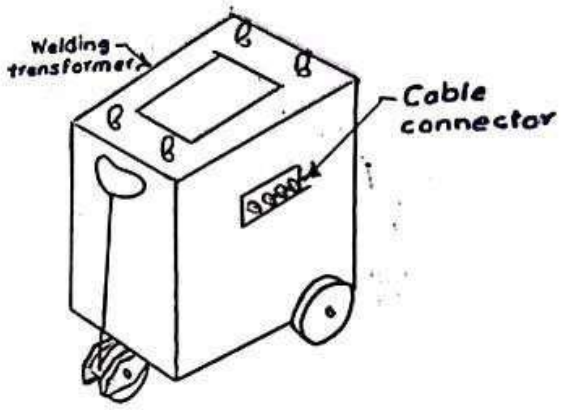
1. Availability of current—A.C. or D.C.
2. Composition of the base metal.
3. Thickness of the base metal.
4. Welding position—flat, horizontal, vertical or overhead.
5. Fit-up of the components to be welded.
6. Expected pbysical properties of welded joints—*i.e.*, strength, ductility, soundness, appearance, etc.
7. Amount of penetration required in welding.
8. Skill of the welders in using particular types of electrodes under specific conditions.
9. Economic considerations—welding costs are largely effected by deposition rate and also by electrode costs.

Low hydrogen electrodes. Hydrogen adversely effects alloy-steels, causing intergranular underbead cracks. It is known as hydrogen embrittlement and leads to low strength and reduced fatigue resistance of welded joints. To avoid this low hydrogen electrodes are used in welding of such alloys. The coverings of these electrodes are made from such materials which will provide minimum or no hydrogen deposit in the weldment, such as cellulose, asbestos, iron powder, clays, lime, titania, etc. These electrodes should not be allowed to remain exposed to atmosphere for a long period otherwise they may abosrb moisture. Also, as a precaution they should be stored in closed boxes and redried at a temperature of 120°C before using.

Carbon electrodes. These electrodes are used in carbon-arc welding and cutting. They are available in two varieties—*carbon electrodes* and *graphite electrodes.* The latter type is a better conductor and has more uniform structure. Bare carbon and graphite electrodes become hot during welding due to the resistance offered by the material to the current flow. Their hot surface starts oxidising by coming in contact with atmospheric air, and this leads to a reduction in electrode size. To prevent this oxidation these electrodes are sometimes coated with copper.

EQUIPMENTS AND TOOLS

TRANSFORMERS: The transformer type of welding machine produces A.C current and is considered to be the least expensive. It takes power directly from a power supply line and transforms it to the voltage required for welding. Transformers are available in single phase and three phase in the market.

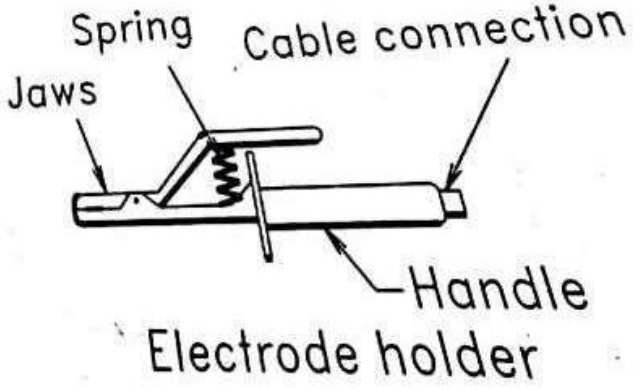


MOTOR GENERATORS: These are D.C generator «ets, in which electric motor and alternator are mounted on the same shaft to produce D.C power as per the requirement for welding. These are designed to produce D.C current in either straight or reversed polarity. The polarity selected for welding depends upon the kind of electrode used and the material to be welded.

WELDING CABLES: Two welding cables are required, one from the machine to the electrode holder and the other, from the machine to the ground clamp. Flexible cables are usually preferred because of the ease of using and coiling the cables. Cables are specified by their current carrying, capacity, say 300 A, 400 A, etc.

ELECTRODES: Filler rods used in arc welding are called electrodes. These are made of metallic wire called core wire, having approximately the same composition as the metal to be welded. These are coated uniformly with a protective coating called flux. Flux acts as an insulator of electricity. The size of an electrode is measured and designated by the diameter of the core wire in SWG and length, apart from the brand and code names; indicating the purpose for which they are most suitable

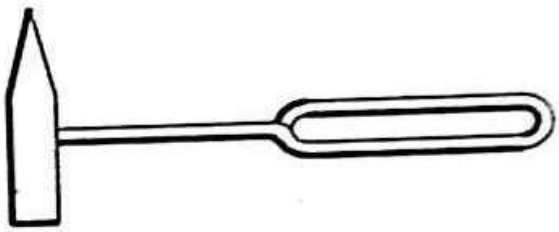
ELECTRODE HOLDER: The electrode holder is connected to the end of the welding cable and holds the electrode. It should be light, strong and easy to handle and should not become hot while in operation. The jaws of the holder are insulated, offering protection from electric shock.



Electrode holder

GROUND CLAMP: It is connected to the end of the ground cable and is clamped to the work or welding table to complete the electric circuit . It should be strong and durable and give a low resistance connection.

WIRE BRUSH AND CHIPPING HAMMER: A wire brush is used for cleaning and preparing the work for welding. A chipping hammer is used for removing slag formation on welds.


Chipping hammer

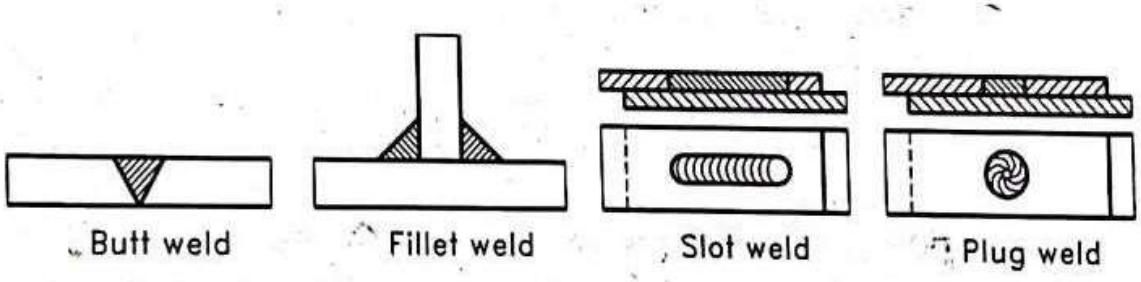
FACE SHIELD: A face shield is used to protect the eyes and face from the rays of the arc and from spatter or flying particles of hot metal. It is available either in hand or helmet type. The hand type is convenient to use wherever the work can be done with one hand. The helmet type is more comfortable to wear and both hands free for the work.

Face shield

HAND GLOVES: These are used to protect the hands from electrical shock and hot spatters.

WELDED JOINTS

Some common types of welded joints. Wherever possible, it is better to weld, by placing the parts in the flat position. In this, welding is done on top, so that gravity helps pull the molten metal into the joint.



Butt weld Fillet weld Slot weld Plug weld

WELDING POSITIONS

There are five recognized positions for welding:

1. Flat or down hand position.
2. Inclined position.
3. Horizontal position.
4. Vertical Position.
5. Over Head Position.

ADVANTAGES OF ARC WELDING

1. Welding process is simple.
2. Equipment is portable and the cost is fairly low.
3. All the engineering metals can be welded because of the availability of a wide variety of electrodes.

DISADVANTAGES OF ARC WELDING

1. Number of electrodes may have to be used while welding long joints. Unless proper care is taken; a defect (slag inclusion or insufficient penetration) may occur at the place where welding is restarted with a fresh electrode.

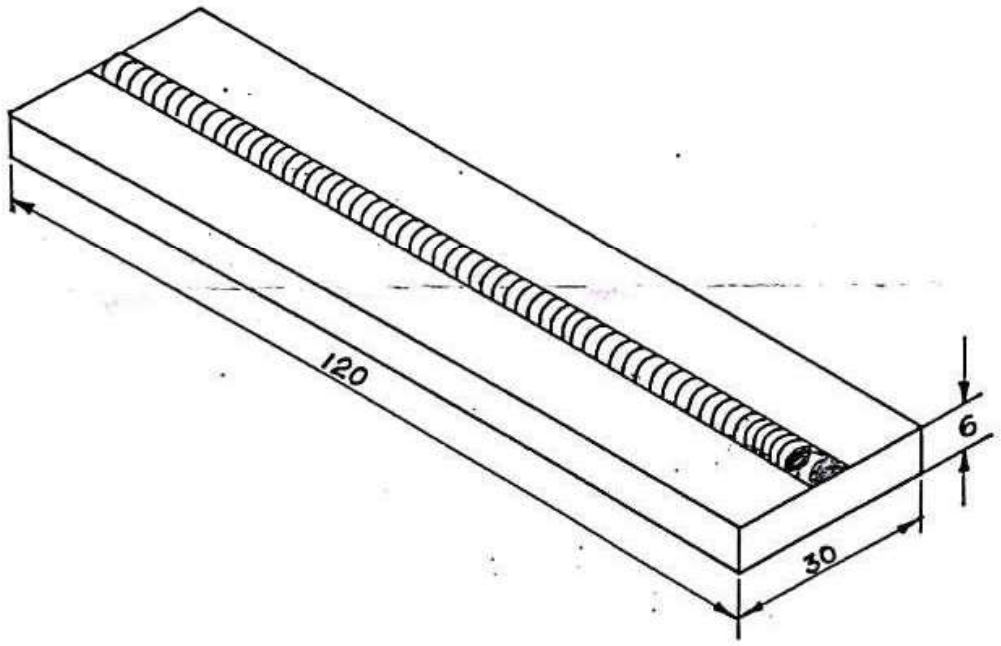
GAS WELDING: Oxy-acetylene flame is commonly used for gas welding. It consists of the supply of oxygen and acetylene under pressure in cylinders, pressure regulators, a torch, hoses and accessories like goggles and a lighter. The oxygen and acetylene cylinders are connected to the torch through pressure regulators and hoses . The regulator consists of two pressure gauges, one for indicating the pressure within the cylinder and the other shows the pressure of the gas fed into the torch, which may be regulated. The torch mixes the two gases and the flame may be controlled by adjusting the oxygen and acetylene supply.

TYPES OF FLAMES: The correct adjustment of the flame is important for efficient welding. When oxygen and acetylene are supplied to the torch in nearly equal volumes, a neutral flame is produced having a maximum temperature of 3200°C. The neutral flame is widely used for welding steel, stainless steel, cast iron, copper, aluminum, etc. Carburising flame produced with an excess of acetylene, is needed for welding lead. Oxidizing flame with excess of oxygen is used for welding brass and bronze.

Depending upon the thickness of the job, different torch nozzle sizes are used. The pressure of the gases and the flame size vary depending upon the size of the nozzle tip.

MODEL NO:1

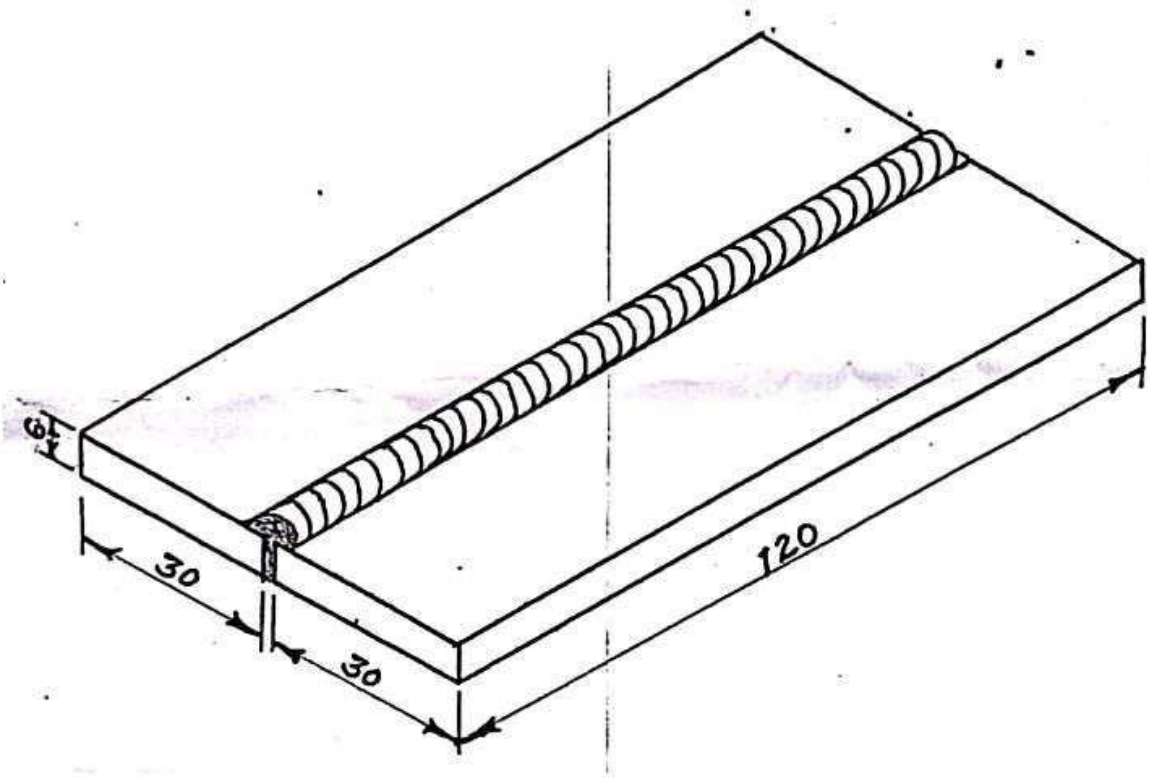
STRAIGHT BEADS



Scale 1:1
All dimensions are in mm

MODEL NO: 2

BUTT JOINT



Scale 1:1
All dimensions are in mm

MODEL NO: 3

FILLET (TEE) JOINT

AIM: - To make a butt joint on the given mild steel flat pieces in down hand position by arc welding.

MATERIALS REQUIRED:-

Work piece:-Mild steel flat of size 123 x 30 x 6mm – 2 nos.

Electrode: - Mild steel electrode 10SWG (3.2mm) - 1no.

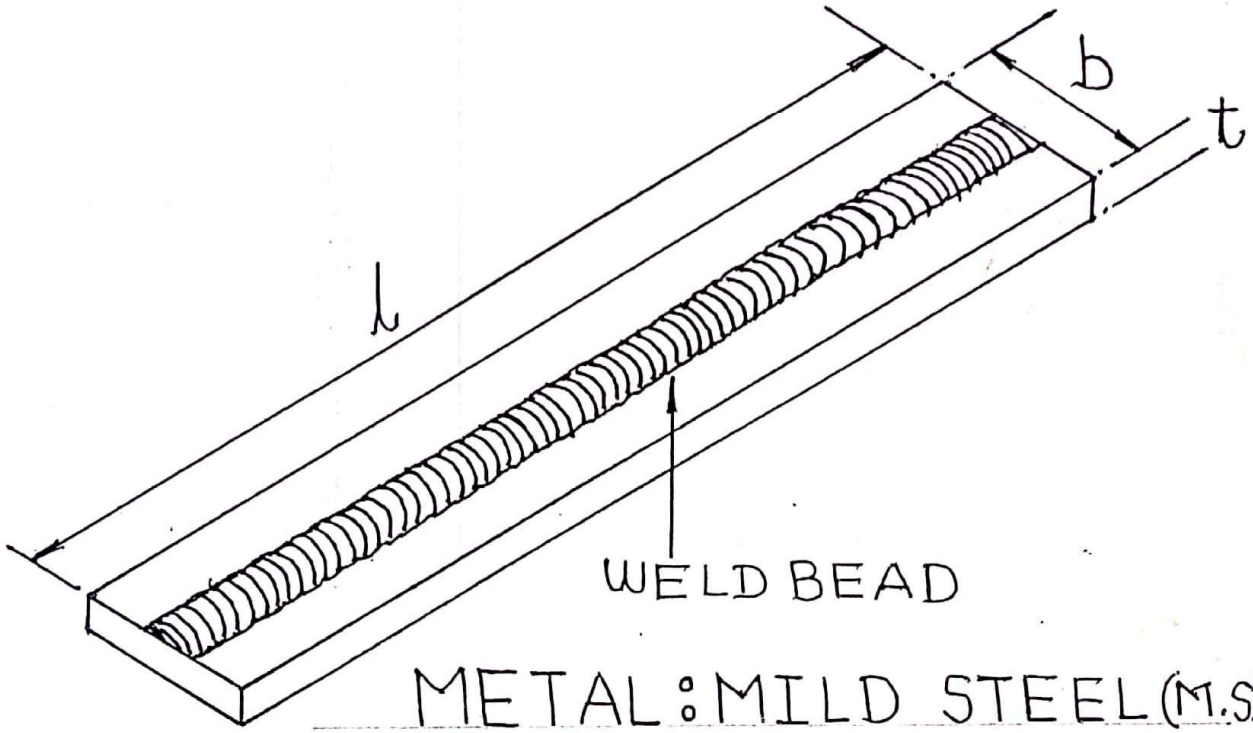
TOOLS REQUIRED:-Steel rule, Try square ,Scriber, Hacksaw ,Bench vice ,Flat file ,face shield ,Tongs, Wire-brush, Chipping hammer, Welding machine and all other arc welding accessories.

LIST OF OPERATIONS:-Measuring, Marking, Fixing, Cutting, Filing, Welding, Deslagging, Cleaning and Inspecting.

PROCEDURE

1. Copy the given drawing in the work record.
2. Cut the work piece as per the drawing.
3. File the work piece to the dimensional accuracy.
4. Kept the work piece on the welding table in the down hand position.
5. Set the ampere of the machine and use protective cloth, select suitable electrode and proper shield.
6. Tack welds the two ends of the work piece and checks the alignment.
7. Remove the slag and spatters using the chipping hammer and wire brush.
8. After completion of weld, the weld bead should be inspected.

WELDING
(I)ST YEAR
WS-51 ASSIGNMENT & DEMONSTRATION



METAL: MILD STEEL (M.S.)

ASSIGNMENT	DEMONSTRATION
METHOD: SMAW	METHOD: OXY-ACETYLENE GAS WELDING
l :- 140 mm.	l :- 140 mm
b :- 25 mm.	b :- 40 mm
t :- 5 mm	t :- 1·6 mm
POWER : AC	Acetylene pressure : 5 psi
VOLTAGE : 80	Oxygen pressure : 12 psi
AMPERE : 74	