21 ARC WELDING

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21.1 INTRODUCTION

Arc welding is widely used method of joining the metal parts. Here the source of heat is an electric arc. Arc welding is a group of welding processes wherein heating is produced with an electric arc or arcs, mostly without the application of pressure and with or without the use of filler metal, depending upon the base plate thickness.

Various arc welding processes are :

- Carbon-arc welding
- Flux shielded metal arc welding
- TIG (GTAW) welding
- MIG (GMAW) welding
- Submerged arc welding
- Electroslag welding
- Electrogas welding
- Plasma arc welding

Arc welding processes in syllabus.

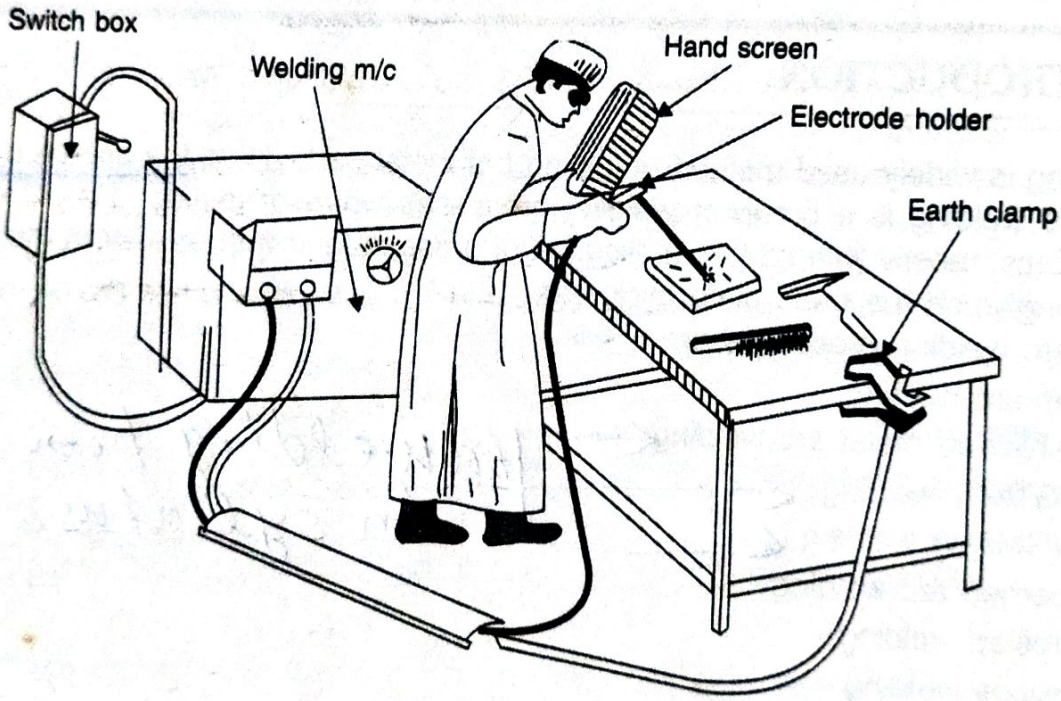
21.2 ARC WELDING PRINCIPLE

In arc welding, arc is generated between the positive pole of D.C. (direct current) called anode and negative pole of D.C. called cathode. When these two poles are brought together, and separated for a small distance (1.5 to 3 mm) such that the current continues to flow through a path of ionized particles, called plasma, an electric arc is formed. Since the resistance of this ionized gas column is high, so more ions will flow from anode to the cathode. Heat is generated as the ions strike the cathode.

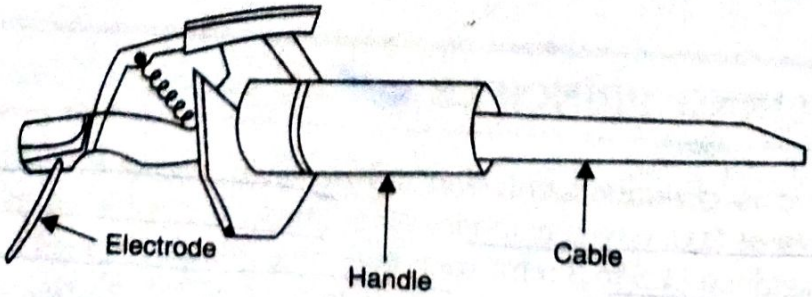
21.3 ARC WELDING EQUIPMENT

The most commonly used equipments for arc welding are :

- A.C. or D.C. power supply source
- Electrode holder
- Electrode
- Cable, cable connectors
- Cable lug
- Chipping hammer
- Earthing clamps
- Wire brush
- Helmet
- Safety goggles
- Hand gloves
- Aprons, sleeves etc.



(*a*) Set up of Metal Arc Welding (FMAW).



(*b*) Electrode holder for metal arc welding.

Fig. 21.1. *Arc Welding Equipment.*

A.C. or D.C. Machines

Depending upon the application, A.C. or D.C. machines are used in arc welding, but in some cases either of them can be used. D.C. supply is usually obtained from generators driven by electric motor or if no electricity is available then diesel engine can be used. D.C. welding is mostly used for heavy work and at sites where electricity is not available.

Where supply mains are available, an A.C. source transformers are used. The function of transformer is to step down the voltage from 440 volts to the normal open circuit welding voltage (80-100 volts). There is no fixed polarity at the terminals when using A.C. and they interchange in every cycle. Also the alternating current acquires zero value twice in each cycle with the result, at these particular moment the potential difference between the terminals is also zero and hence a higher voltage is required to maintain the arc at this moment. Polarity is very significant factor in all D.C. welding works.

Fig. 21.2 shows how the voltage current relationship exists for arc welding process. It would be noted that for a given spacing and the electrode material, voltage reduces upto current 50 A and starts increasing gradually and very slowly with further increase in current. This relationship determines the characteristics of the power source. The electric power supply usually has a drooping characteristic *i.e.* with increase in current, voltage drops. The drop may be either sharply drooping or nearly flat depending on type of power supply source.

Fig. 21.3 shows how potential difference across arc is distributed. Anode spot is the area on the anode surface where the electrons are absorbed. Anode space is the gaseous region adjacent to the anode surface where a sharp drop in voltage takes place. Arc column is the visible portion of the arc consisting of plasma where the voltage drop is not sharp. Cathode space is the gaseous region adjacent to the cathode. Sharp voltage drop in this region is necessary as the electrons have to be pulled up from this region. Relative voltage drops in various zones are dependent upon the spacing, current and electrode materials.

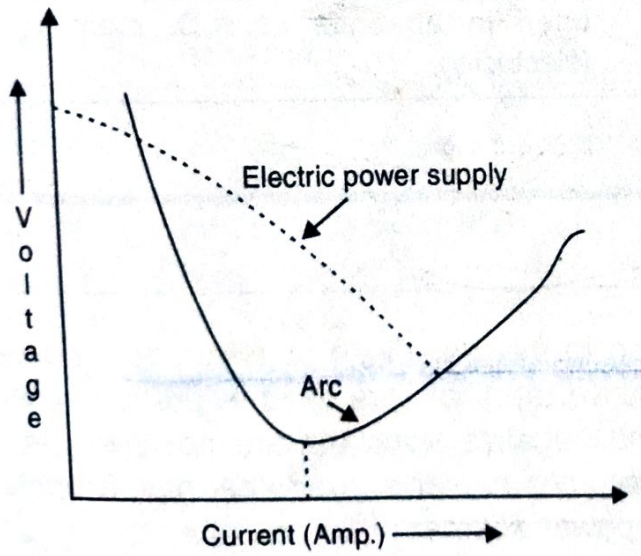


Fig. 21.2. *Voltage Current Relationship for Arc Welding.*

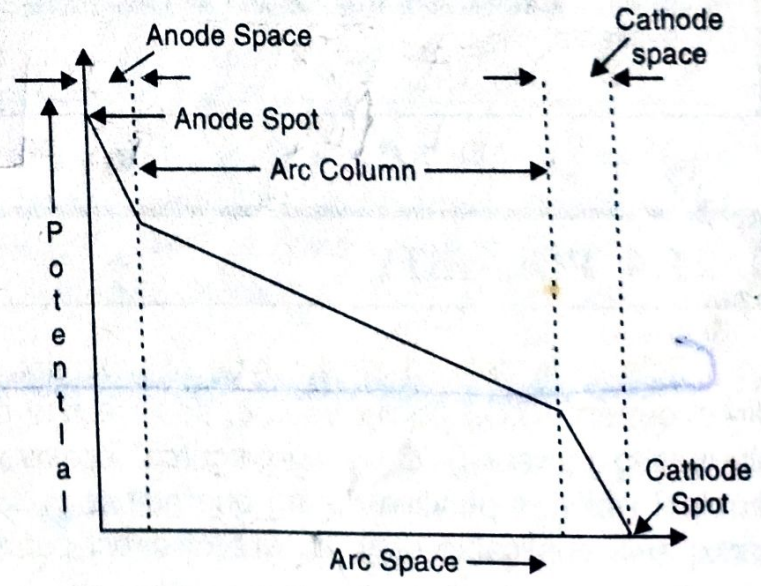


Fig. 21.3. *Potential Difference Across Arc.*

21.7 ELECTRODES

The electrodes are used for providing heat input in arc welding. Electrodes can be classified on the following basis :

1. Consumable or Non-consumable.
2. Bare or coated electrodes.

1. (*a*) Consumable Electrodes. When the arc is obtained with a consumable electrodes, the weld metal and the tip of the electrode also gets melted under the arc. The molten metal from the electrode and the base metal gets mixed under the arc and provides the necessary joint. So in this process, once the arc is initiated, the electrode is continuously consumed. Thus the electrode is serving the purpose of filler rod as well as the heat input to the joint. Consumable electrodes are made of various materials depending on the purpose and chemical composition of the metals to be welded.

(*b*) Non-Consumable electrode. Non-consumable electrodes are those electrodes, which are not consumed during welding. Separate filler rods if necessary can be used to fill the gap along the joints. Non-consumable electrodes are made of carbon, graphite or tungsten. The carbon and graphite electrodes are used only in D.C. welding, whereas tungsten electrodes are used for both D.C. and A.C. welding. So in this, we can have better control over the heat input and filler metal because the sources are separate. Non-consumable electrodes are used in carbon arc welding or tungsten inert gas arc welding (TIG).

2. (*a*) Bare Electrode. If the electrode is not coated with flux, it is called the bare electrode. In that case flux (Refer 21.8) will be added separately if necessary. Bare electrodes are used in carbon arc welding and tungsten arc welding. The striking of arc is difficult with this type of electrode especially with A.C. supply.

(*b*) Coated Electrode. If the electrode is coated with flux, it is called the coated electrode. The coating on the electrodes serves many purposes (Refer 21.8, purposes of flux). The coated electrode also called "stick" electrodes is available in the length 350 or 450-mm.

One of the major concerns with the coated elecrodes, is the moisture pick up by the coating. This moisture, dissociate into oxygen and hydrogen with the hydrogen being absorbed by the liquid metal and subsequently released during solidification, causing porosity. So, there should be kept in a dry place.

21.8 FLUX

During welding if the metal is heated/melted in air, oxygen from the air combines with the metal to form oxides which results in poor quality, low strength welds and in some cases, may even make welding impossible. Sometimes the flux will be added separately. Covering of the coated electrode is also called flux. Sometimes the purpose of flux is also solved by inert or active gas (TIG, MIG, and MAG). The materials used for flux coating are termed as components. These components may be sub-divided into the following categories :

Gas Forming : The gas forming components are organic matters such as starch, wood pulp etc. which form gas layer, thus isolating the welding zone from the ambient air.

Slag Forming : The slag forming components are chinaclay, felspar, manganese and titanium ores etc. These components enhance slag formation.

This slag covering the molten metal prevents it from coming into contact with the ambient air.

The merging of weld metal with base metal in this case is considerably smooth.

Reducing

The reducing components such as ferro-silicon, ferro-titanium, ferro-manganese reduces the oxides, which are likely to be formed in the liquid bath of molten metal.

Alloys

The alloying components such as ferro-silicon, ferro-manganese, ferro-chromium, chromium oxide are used for rendering this metal heat proof.

Stabilizing

The stabilizing components also form slag. In the presence of arc, these components, ionize the zone between the electrode and the parts to be welded and thus ensuring the stable burning of the arc.

Binding

The binding components will be added so that covering should have proper binding with the bare electrode.

21.11 FLUX SHIELDED METAL ARC WELDING

In this arc welding process, welding heat is produced from an electric arc set up between a flux coated electrode and the workpiece. The electrode is consumable so supplies the necessary filler metal. The covering on the electrode serves the purpose of flux.

During the welding process, the metal electrode is melted by the heat of the arc and fuses with the workpiece. The temperature produced by the heat is about 2400°C to 2700°C. The arc temperature and thus the arc heat can be increased or decreased by employing higher or lower arc currents. A high current arc with a smaller arc length produces a very intense heat. Both D.C. and A.C. may be used. For current over 750 amperes, A.C. equipment is preferred as it has high efficiency, negligible loss at peak load and minimum maintenance. The basic setup is shown in Fig. 21.7.

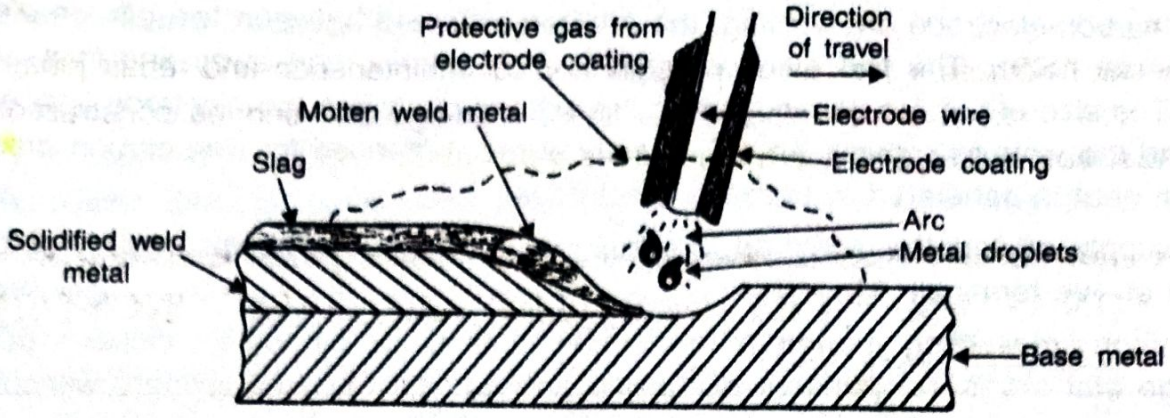


Fig. 21.7(*a*). *Principle of Flux Shielded Metal Arc Welding.*

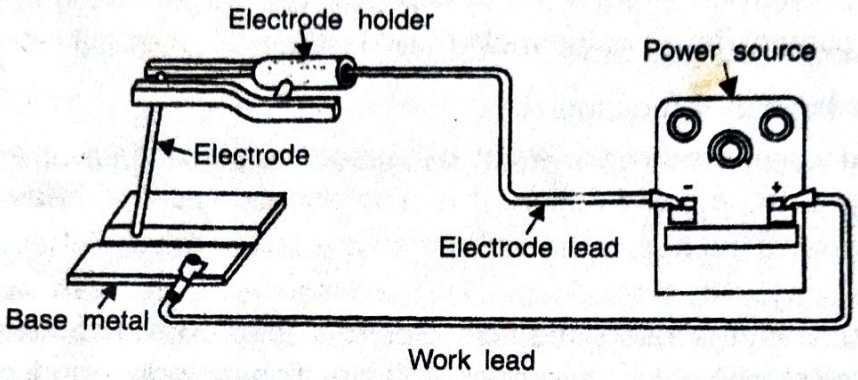


Fig. 21.7(*b*). *Setup of Flux Shielded Metal Arc Welding.*

Striking the Arc

Arc between the electrode and workpiece is generally struck either by momentarily touching the electrode with the workpiece or by using high frequency unit and when the arc starts. the electrode is taken away at a predetermined distance (arc length) for doing welding.

Welding the Joint

Once the arc has been established and the arc length adjusted, the electrode is inclined to an angle of approx. 20 degrees with the vertical. Arc gap should be maintained constant. The bead width can be increased by employing higher arc current, lower arc travel speeds and by suitably weaving the electrode. Before using the fresh electrode (new) the bead should be properly cleaned. After completing the weld, the slag is chipped off and weld bead is cleaned with a wire brush.

Advantages

- The welding equipment is simple, less costly, and portable.
- Welding can be carried out in any position with highest weld qualities.
- Wide varieties of electrodes are available.
- Total welding cost is less.

Disadvantages

- The length of each electrode is limited and when new electrode is used, proper cleaning has to be done which decreases the welding speed.
- Welding control is difficult as compared to MIG welding.
- If the covering absorbs moisture, this moisture causes the porosity defect.
- Because of flux coating, chances of slag entrapment are more.

Applications

- It is used both as a fabrication process and for maintenance and repair jobs.
- It is also used in shipbuildings, pipe lines, buildings and bridges construction, tanks, boilers, automotive and aircraft industries etc.