Arc welding

Introduction

- Arc welding is a welding process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals.

- It is a type of welding that uses a welding power supply to create an electric arc between a metal stick ("electrode") and the base material to melt the metals at the point of contact. Arc welders can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes.

- The welding area is usually protected by some type of shielding gas, vapor, or slag. Arc welding processes may be manual, semi-automatic, or fully automated.

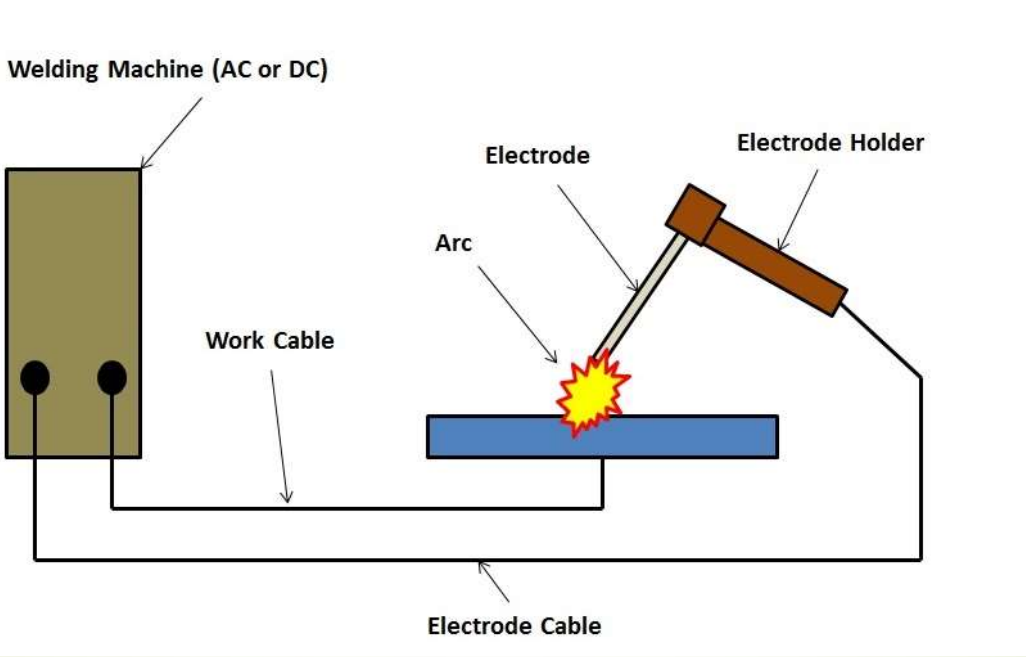

Fig. 1 Circuit diagram of simple arc welding

Types of arc welding

- Metal Arc Welding
- Gas Tungsten Arc Welding
- Gas Metal Arc Welding
- Submerged Arc Welding
- Plasma Arc Welding
- Carbon Arc Welding

Manual metal arc welding

- Manual metal arc welding was first invented in Russia in 1888. It involved a bare metal rod with no flux coating to give a protective gas shield. The development of coated electrodes did not occur until the early 1900s.

- When an arc is struck between the metal rod (electrode) and the workpiece, both the rod and workpiece surface melt to form a weld pool of molten metal. Simultaneous melting of the flux coating on the rod will form gas and slag which protects the weld pool from the surrounding atmosphere. The slag will solidify and cool and must be chipped off the weld bead once the weld run is complete.

- The process allows only short lengths of weld to be produced before a new electrode needs to be inserted in the welding electrode holder. Weld penetration is low and the quality of the finished weld deposit is highly dependent on the skill of the welder.

- Manual metal arc welding is also known as shielded metal arc welding because electrode is shielded with flux.

Polarity

- The term 'polarity' is used to describe the electrical connection of the electrode in relation to the terminal of a power source.
- Manual metal arc welding may be done by using two different types of polarity:-

Straight polarity

Reverse polarity

- Straight polarity :-

When electrode is connected with the negative terminal of the power source and base metals are connected with the positive terminal. It is also known as direct current electrode negative (**DCEN**).

- Reverse polarity :-

When electrode is connected with the positive terminal of the power source and base metals are connected with the negative terminal. It is also known as direct current electrode positive (**DCEP**).

- Straight or reverse polarity matters only when we use direct current for welding. When we use alternative current for welding then polarity changes every half cycle. SMAW generally uses AC or DCEP.

- In straight polarity $2/3^{rd}$ of the total arc heat is generated near base plate and rest is generated at electrode tip while in reverse polarity $2/3^{rd}$ of the total arc heat is generated at electrode tip and rest is generated near base plate.

- Proper fusion of the base metal can be achieved easily in DCEN, So it eliminates the lack of fusion and lack of penetration defects. While in DCEP due to less heat generation near base plate, incomplete fusion of the base plate may occur.

- In case of consumable electrodes, filler metal deposition rate is quite low in DCEN. While filler metal deposition rate is quite high as greater portion of heat is generated at electrode tip in DCEP.

Electrode

- Electrodes are divided into three types:-

  Cellulosic

  Rutile

  Basic

- Cellulosic electrodes contain a high proportion of cellulose in the coating and are characterised by a deeply penetrating arc and a rapid burn-off rate giving high welding speeds. Weld deposit can be coarse and with fluid slag, deslagging can be difficult. These electrodes are easy to use in any position.

- Rutile electrodes contain a high proportion of titanium oxide (rutile) in the coating. Titanium oxide promotes easy arc ignition, smooth arc operation and low spatter. These electrodes are general purpose electrodes with good welding properties. They can be used with AC and DC power sources and in all positions. The electrodes are especially suitable for welding fillet joints in the horizontal/vertical (H/V) position.

- Basic electrodes contain a high proportion of calcium carbonate (limestone) and calcium fluoride (fluorspar) in the coating. This makes their slag coating more fluid than rutile coatings - this is also fast-freezing which assists welding in the vertical and overhead position. These electrodes are used for welding medium and heavy section fabrications where higher weld quality, good mechanical properties and resistance to cracking (due to high restraint) are required.

History of arc welding in rolling stock

- Earlier, most of the fabrication in rolling stocks such as coaches, wagons and locomotives used to be of riveted design.
- Welding, prior to the fifties, was only used as a method of repairs on Indian Railways. Due to various constraints – both economically and technologically. Manual metal arc welding was the predominant method of welding on Indian Railways. You will be surprised to note that the same rutile type of electrodes was used for different varieties of steels.
- Consequently, improvements in welding technology has aimed at higher productivity and lowering the fabrication cost and also with the setting up of Chittaranjan Locomotive Works (CLW), welding was accepted as a tool for fabrication on the railways for the manufacture of welded boilers for steam locomotives followed by Integral Coach Factory (ICF) for manufacturing of coaches and Diesel Locomotive Workshop (DLW) for the manufacturing of diesel locomotives. During the introduction of welding of the boilers for the steam locomotives, Industrial Radiography was introduced in 1956 at Chittaranjan for the first time.
- Indian Railways used this Radiography technology to maintain the quality of the welded joints, which were most important for the safety and economy. After the steam locomotives phased out, CLW switched over to diesel- electric / electric locomotives, which were also of welded design. Gradually, the railways set up two more production units viz. Diesel Loco Modernisation Workshop at Patiala and Railway Coach Factory at Kapurthala where welding is carried out on a large scare in the manufacturing of diesel loco components and coaches respectively.

- The Shielded Metal Arc Welding (SMAW) process continues to be the predominant method for repair and maintenance of railway components. This process is also used extensively in the fabrication of permanent installations like platform structures, overhead traction structures, foot-over bridges and similar applications where static and / or dynamic loading is involved.
- Subsequently, welding was also extensively used for the fabrication of several components of higher capacity BOX, BCX, BOI, BOY type wagons.

Gas tungsten arc welding

- The gas tungsten arc welding (GTAW) is also called as Tungsten inert gas welding (TIGW). In this type of welding process, a tungsten electrode which is non-consumable can be employed for welding the material. The electrode which is used in this welding can be enclosed with gases such as argon, helium, etc. These gases will guard the weld region against the oxidization. This kind of welding can be used for welding thin sheets.

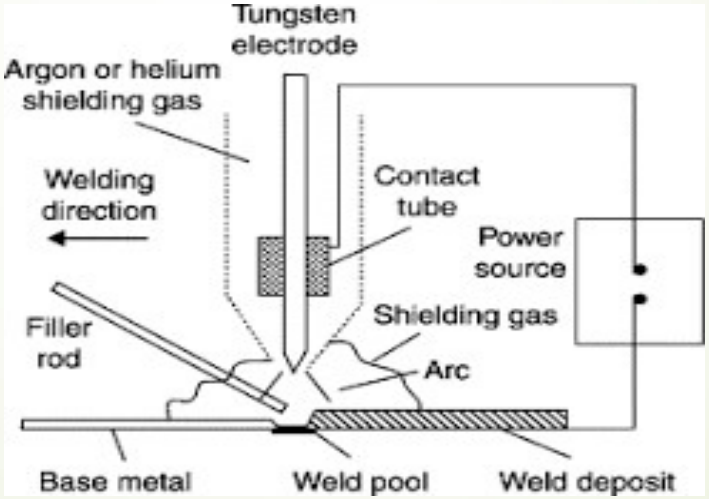

Fig. 2 Working of TIG welding

Gas metal arc welding

- The Gas metal arc welding (GMAW) is also called as Metal inert gas welding (MIGW). It uses a fresh metal electrode which is protected by the gas like helium, argon, etc. These gases will protect the join area from oxidation and generates multiple welding material layers. In this type of arc welding process, a filler wire can be fed constantly using a non-consumable metal electrode for welding the metal.

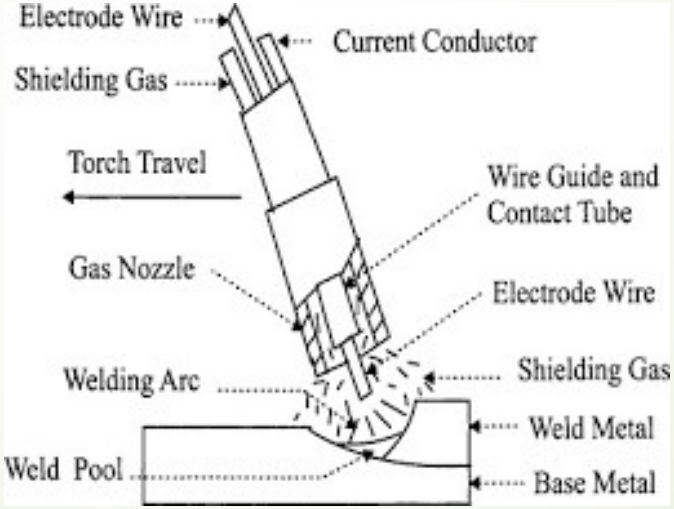

Fig. 3 Working of MIG welding

Submerged arc welding

- The Submerged arc welding (SAW) can be extensively utilized within an automatic welding method. In this kind of welding process, an electrode is completely submerged by the granular coating of flux, and this flux can be an electric conductor which will not oppose the electric supply. The solid coating of flux stops the melted metal to ultra-violate radiation and atmosphere.

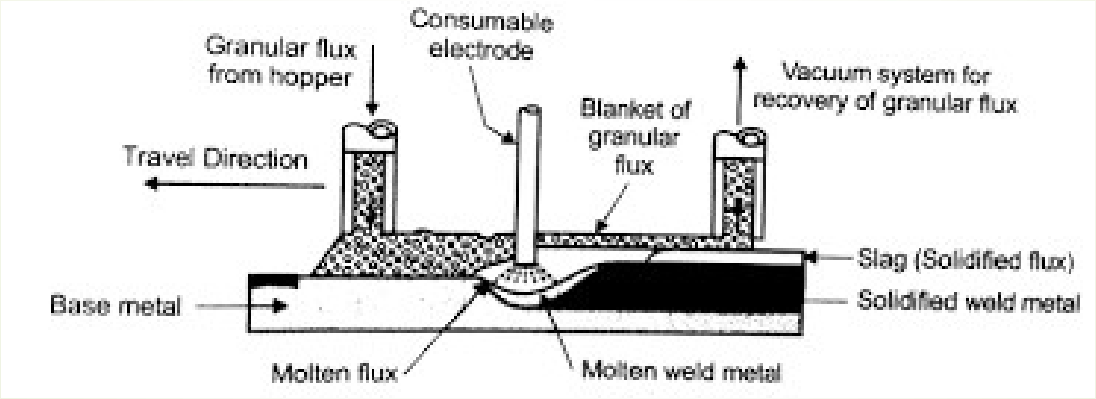

Fig. 4 Working of submerged arc welding

Plasma arc welding

- The Plasma arc welding (PAW) is similar to GTAW or gas tungsten welding. In this kind of welding process, the arc will generate among work part as well as the tungsten electrode. The major dissimilarity among plasma arc welding and gas tungsten welding is that the electrode is located within the torch of Plasma arc welding. It can be heated the gas at the temperature of 30000oF & changes it into the plasma to attack the welding region.

Carbon arc welding

- The Carbon arc welding (CAW) process mainly uses a carbon rod like an electrode for welding the metal joint. This kind of arc welding is the oldest arc welding process and requires high current, low voltage for generating the arc. In some cases, an arc can be generated among two carbon electrodes which are named as twin carbon arc welding.

THANK YOU