MEM 3501
Welding Technology
4

Arc Welding

Arc welding is a welding process, in which heat is generated by an electric arc struck between an electrode and the work piece.

Electric arc is luminous electrical discharge between two electrodes through ionized gas.

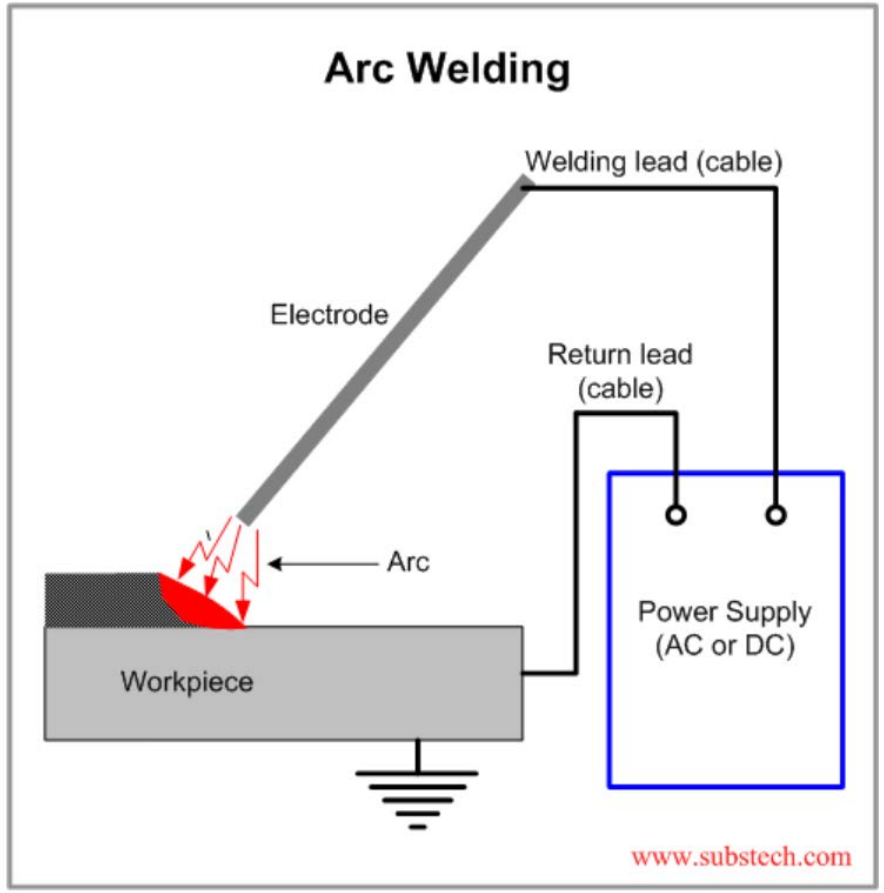
Any arc welding method is based on an electric circuit consisting of the following parts:

Power supply,

Welding electrode,

Workpiece,

Welding leads (electric cables) connecting the electrode and workpiece to the power supply.



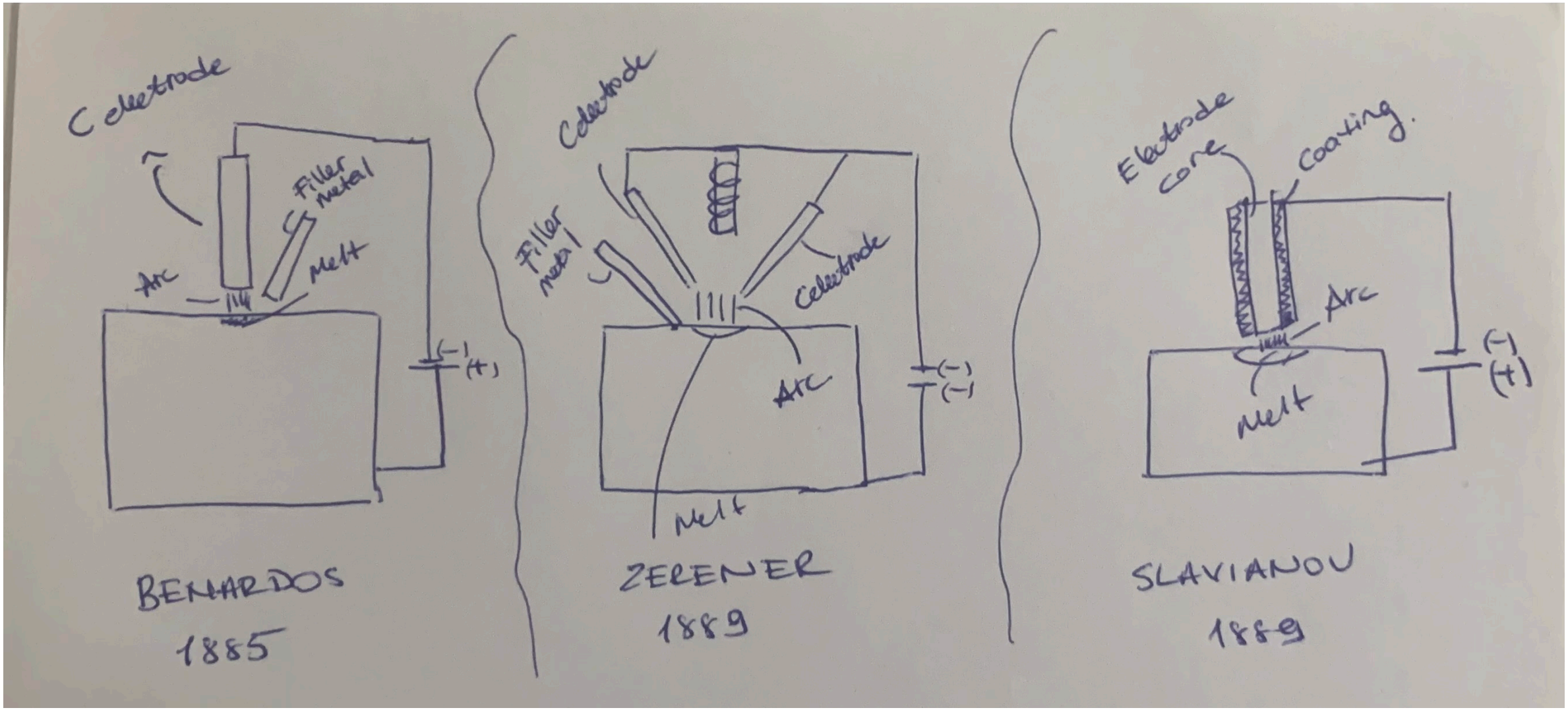
Arc Welding

Electric arc between the electrode and work piece closes the electric circuit. The arc temperature may reach 10000°F (5500°C), which is sufficient for fusion the work piece edges and joining them.

When a long join is required the arc is moved along the joint line. The front edge of the weld pool melts the welded surfaces when the rear edge of the weld pool solidifies forming the joint.

When a filler metal is required for better bonding, filling rod (wire) is used either as outside material fed to the arc region or as consumable welding electrode, which melts and fills the weld pool. Chemical compositions of filler metal is similar to that of work piece.

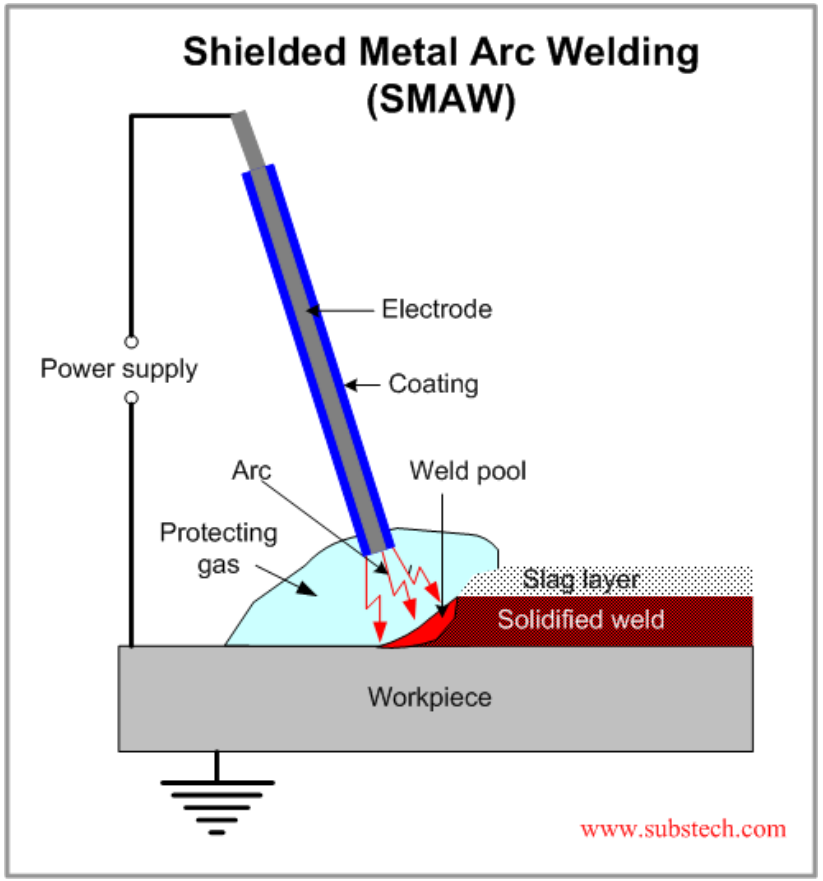
Molten metal in the weld pool is chemically active and it reacts with the surrounding atmosphere. As a result weld may be contaminated by oxide and nitride inclusions deteriorating its mechanical properties. Neutral shielding gases (argon, helium) and/or shielding fluxes are used for protection of the weld pool from atmospheric contamination. Shields are supplied to the weld zone in form of a flux coating of the electrode or in other forms.


C electrode
Filler metal
Arc
Melt
(-)
(+)
BENARDOS
1885
C electrode
Filler metal
C electrode
Arc
Melt
(-)
(-)
ZERENER
1889
Electrode core
Coating
Arc
Melt
(-)
(+)
SLAVIANOV
1889

Manuel Metal Arc Welding

Manual Metal Arc (MMA) welding is the most flexible and one of the most widely used arc welding processes. It involves striking an arc between a covered metal electrode and a workpiece. The heat of the arc melts the parent metal and the electrode which mix together to form, on cooling, a continuous solid mass.

Generally, it has been known as '*Shielded Metal Arc Welding*', '*Flux Shielded Arc Welding*' or '*Stick Welding*'.



Manuel Metal Arc Welding Electrodes

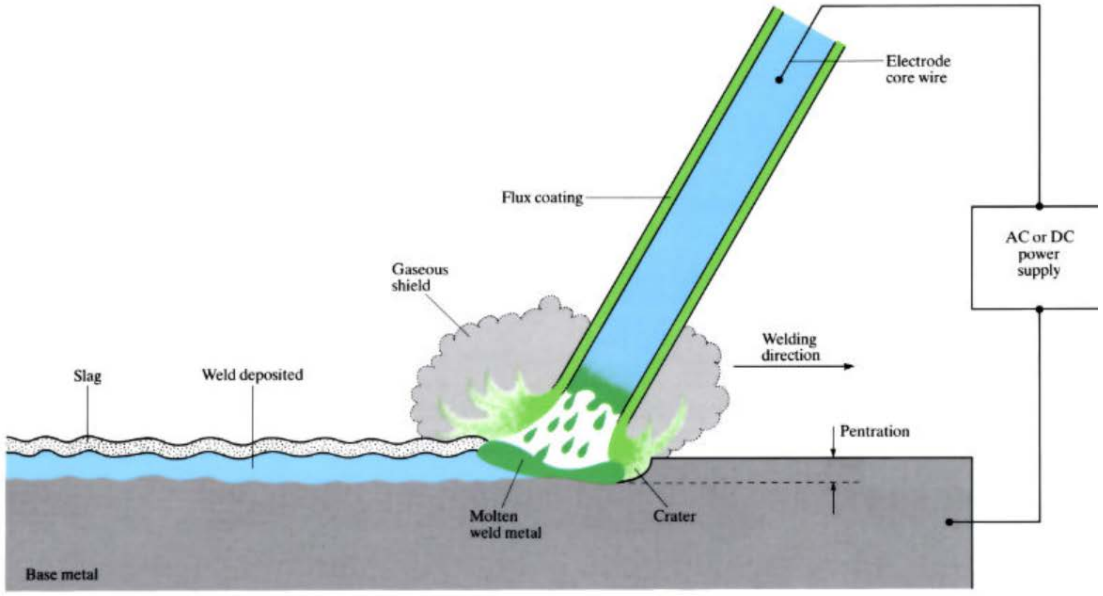
When a piece of metal is heated in the atmosphere it combines with oxygen and nitrogen to form oxides and nitrides which combine with the metal.

If these were allowed to form in the weld it would result in a poor quality, weak and brittle weld. It is therefore necessary to protect the weld area from the air. This can be done either by surrounding the weld area by an inert gas or by the use of suitable fluxes.

It is usual, with manual metal arc welding, to use coated electrodes. These electrodes consist of a metal core surrounded by a layer of suitable flux coating.

Manuel Metal Arc Welding

An electric arc is produced between a metal electrode, carrying a high current, and the workpiece to be joined. Under the intense heat of the arc temperature (2700–5500°C), a small area of the base metal is brought to the melting point. At the same time, the end of the electrode is melted and droplets of molten metal pass through the arc to the base metal. A flux coating on the electrode provides a gaseous shielding against oxidation.



Welding process

Either alternating (a.c.) or direct (d.c.) current is used for MMA welding. When a.c. is used, the arc must re-ignite at each half-cycle, as the polarity is reversed. This causes some instability of the arc, which can be alleviated by the use of arc-stabilising agents in the flux coating. When d.c. is used, there is a choice of polarity – the positive pole of the arc is the hottest.

Arc voltages are maintained between 14 and 45 V, with open-circuit voltages of 50–100 V. Power sources range from 30 to 500 Amps a.c. or d.c.

Coated electrodes contain slag-forming ingredients (that produce a fluid coating over the weld as it cools) and gas-forming ingredients (that generate atmospheres of CO2, CO or H2 around the arc). Principal materials used in electrode coatings include:

Carbonaceous material of the cellulose type $(C_6H_{10}O_5)_n$ – produces a shielding gas (CO).

Silica (SiO_2) – combines with metallic oxides to form slag.

Titanium oxide (TiO_2) – to stabilise the arc.

Calcium carbonate ($CaCO_3$) – decomposes to form CaO, and hence a basic slag.

Calcium fluoride (CaF_2)– increases slag fluidity.

Sodium oxide (Na_2O) – acts as a coating binder and promotes slag fluidity.

Ferro-silicon – acts as deoxidant.

Iron powder – increases the rate of deposition.

Sizes of welding machines are designated according to their output rating, which may range from 150 to 1000 Amps.

Deposition rates in range 2–5 kg h-1.

Materials

Most engineering metals and alloys can be welded by the MMA welding process (very versatile process).

In welding carbon and low alloy steels, the coated electrodes are usually of low carbon steel. For alloy steels prone to formation of hard and brittle martensite on cooling, low alloy steel electrodes are used.

Also, these steels are prone to hydrogen embrittlement, and coatings must be free from hydrogen-forming cellulose. Instead, TiO_2 and $CaCO_3$ are added to the coating. Austenitic compositions (up to 25% chromium and 20% nickel) are also useful to prevent martensite formation.

Cast irons are welded with nickel-rich or monel electrodes (Ni-Cu).

Most non-ferrous metals and alloys are welded with electrodes of a composition similar to the metal being welded. Aluminium alloy electrodes are coated with fluxes consisting of mixtures of fluorides and chlorides to dissolve the aluminium oxide Al_2O_3 surface layer.

The precipitation hardening Al-Mg-Si alloys are now welded by the TIG and MIG processes. Copper, copper-tin (bronzes) and copper-zinc (brasses) alloys have large coefficients of thermal conductivity, so require greater amounts of heat and need pre-heating before MMA welding (up to 250–450°C). Nickel alloys can be welded with pre-heated electrodes.

Equipment in Manuel Metal Arc Welding

Welding power source,

Cables,

Electrode holder,

Clamp.

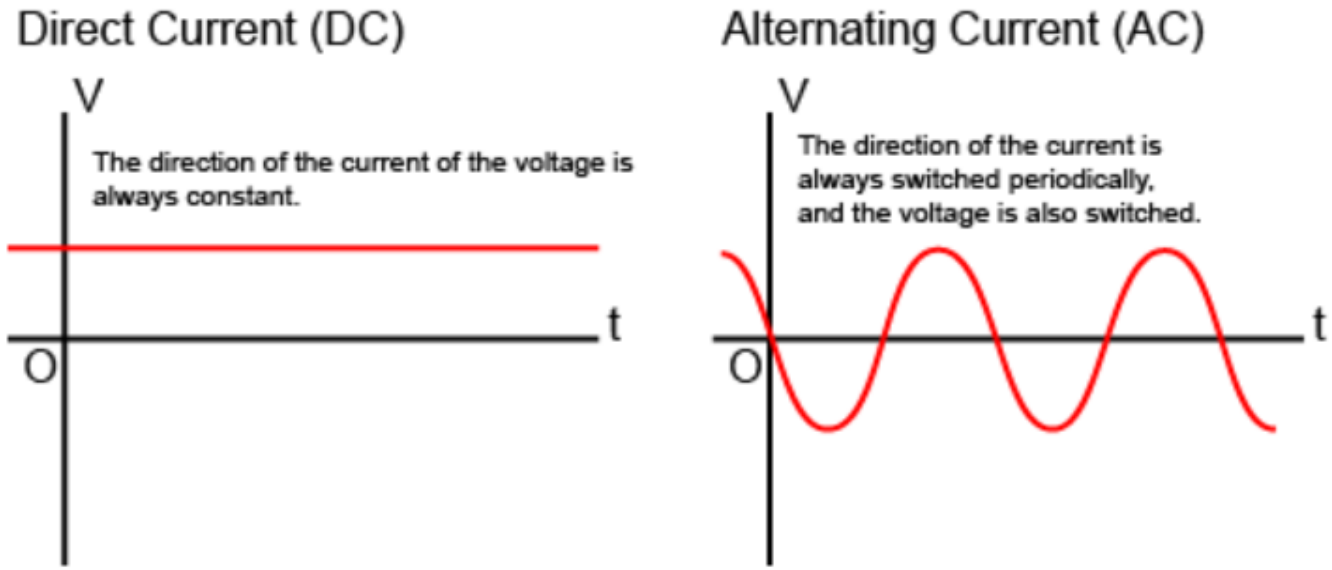
Manual metal arc power source and welding leads

Welding Power Supplies

There are two types of welding power sources used to supply current for metal arc welding.

Alternating Current (AC) type.

Direct Current (DC) type.



The AC and DC Power Sources

The AC power source

This power source takes its power directly from the main electricity supply. It uses a transformer to supply the correct voltage to suit the welding conditions.

The DC power source

There are two types of DC welding plants in use: DC generator and Transformer-rectifier.

The DC generator uses a motor (electric, petrol or diesel powered) to generate electricity. The generator provides DC current for the arc.

A Transformer-rectifier is basically a transformer with an electrical device for changing the alternating current into a direct current output. This device is known as a rectifier. The transformer-rectifier has the advantage that it can be made to supply AC or DC.

Characteristics of DC power supply

Advantages	Disadvantages
No advance or delay in the circuit,	Current interruption is difficult,
No reactive power is generated,	Difficult to convert voltage,
Can store electricity.	Strong electrolytic effect.

Characteristics of AC power supply

Advantages

Less power loss due to high voltage transmission,

Easy to transform,

Easy to shut down while power is flowing,

No need to worry about positive and negative voltage

Disadvantages

Requires a higher voltage than the target voltage

Affected by coils and capacitors

Not suitable for ultra-long distance transmission

Advantages of Manuel Metal Arc Welding

Manual Metal Arc Welding is the simplest of all the arc welding processes.

The equipment can be portable and the cost is fairly low.

This process finds innumerable applications, because of the availability of a wide variety of electrodes.

A wide range of metals and their alloys can be welded.

Advantages of Manuel Metal Arc Welding

Welding can be carried out in any position with highest weld quality.

The process can be very well employed for hard-facing and metal deposition to reclaim parts or to develop other characteristics like wear resistance etc.

Joints (e.g. between nozzles and shell in a pressure vessel) which because of their position are difficult to be welded by automatic welding machines are easily accomplished by flux shielded metal arc welding.

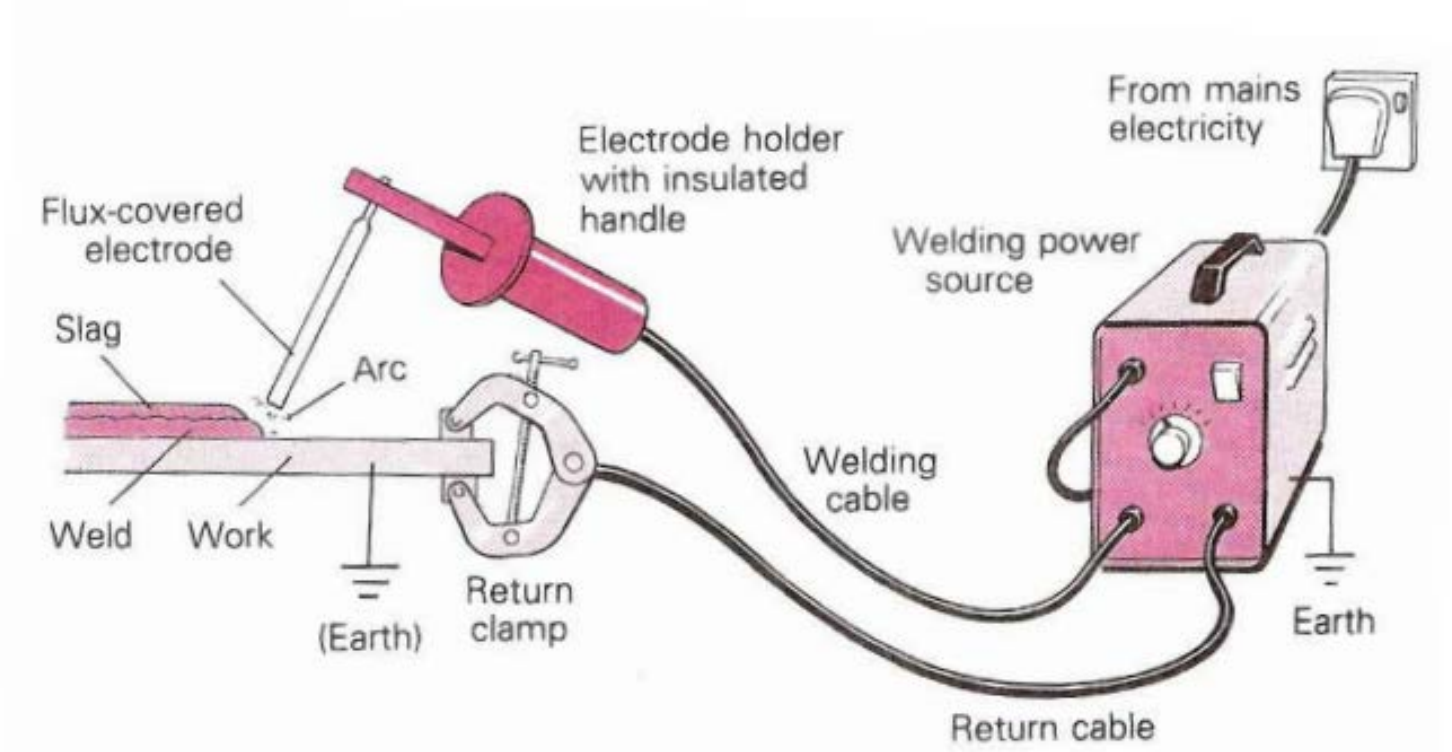
Disadvantages of Manuel Metal Arc Welding

Because of the limited length of each electrode and brittle flux coating, it is difficult to automate the process.

In welding long joints (e.g., in pressure vessels), as one electrode finishes, the weld is to be progressed with the next electrode. Unless properly cared, a defect (like slag inclusion or insufficient penetration) may occur at the place where welding is restarted with the new electrode.

The process uses stick electrodes and thus it is slower as compared to MIG welding.

Set-up for Manuel Metal Arc Welding



Functions of the Electrode Coating

The six main functions of the electrode coating are as follows:

1. To act as a flux and remove the impurities from the surfaces being welded.

2. To form a protection layer (slag) over the weld, which prevents contact with the air as it starts to cool down. This stops the weld forming brittleness and provides a smoother surface by preventing ripples caused during the welding process.

3. It forms a neutral gas atmosphere, which helps to protect the molten weld pool from oxygen and nitrogen in the surrounding air.

Functions of the Electrode Coating

4. It helps to stabilize the arc, allowing Alternating Current (A.C) to be used.

5. It can add certain constituents to the weld by replacing any lost during the welding process.

6. It can speed up the welding process by increasing the speed of melting of the metal and the electrode.

Functions of the Electrode Coating