

Plasma Arc Welding

- Plasma is a gaseous mixture of positive ions, electrons and neutral gas molecules
- .
- Plasma Arc Welding is the welding process utilizing heat generated by a constricted arc struck between a tungsten non-consumable electrode and the work piece (transferred arc process)
- Transferred arc process produces plasma jet of high energy density and may be used for high speed welding and cutting of Ceramics, steels, Aluminum alloys, Copper alloys, Titanium alloys, Nickel alloys.

Plasma Arc Welding

Advantages of Plasma Arc Welding (PAW):

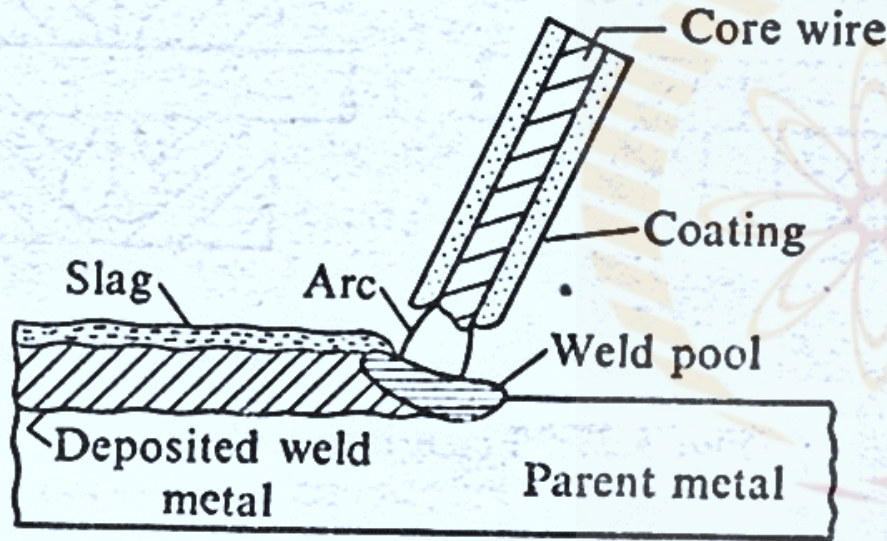
- Requires less operator skill due to good tolerance of arc to misalignments;
- High welding rate;
- High penetrating capability (keyhole effect);

Disadvantages of Plasma Arc Welding (PAW):

- Expensive equipment;
- High distortions and wide welds as a result of high heat input (in transferred arc process).

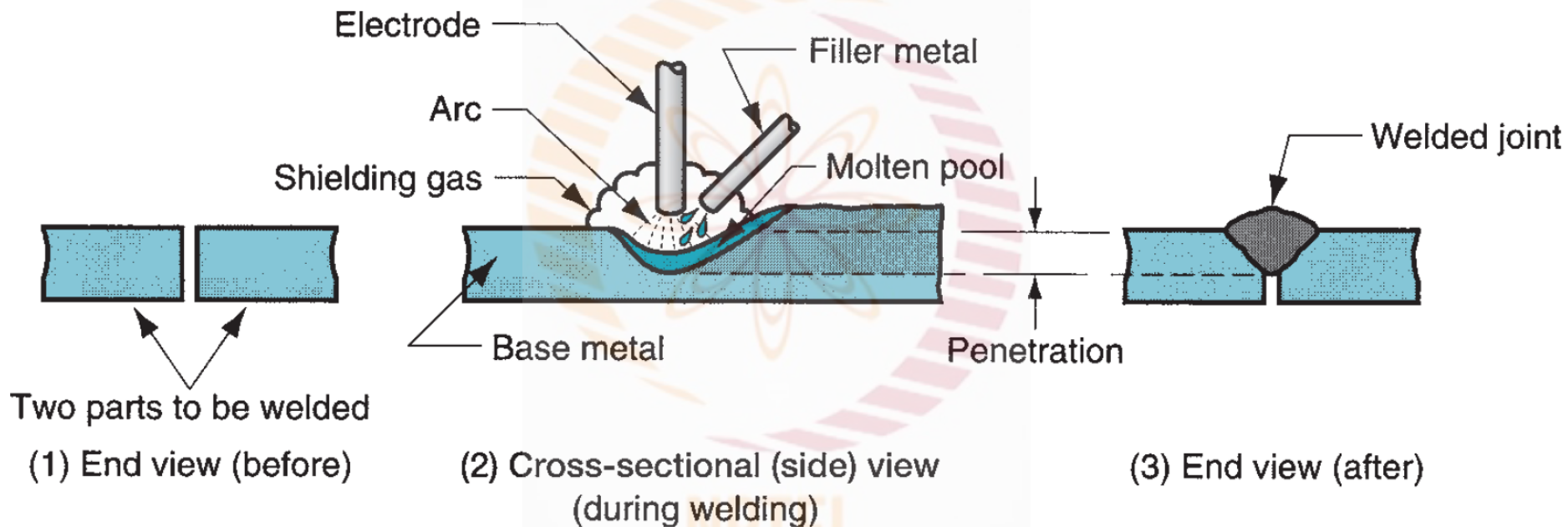
Liquid State (Fusion) Welding

1. Arc Welding



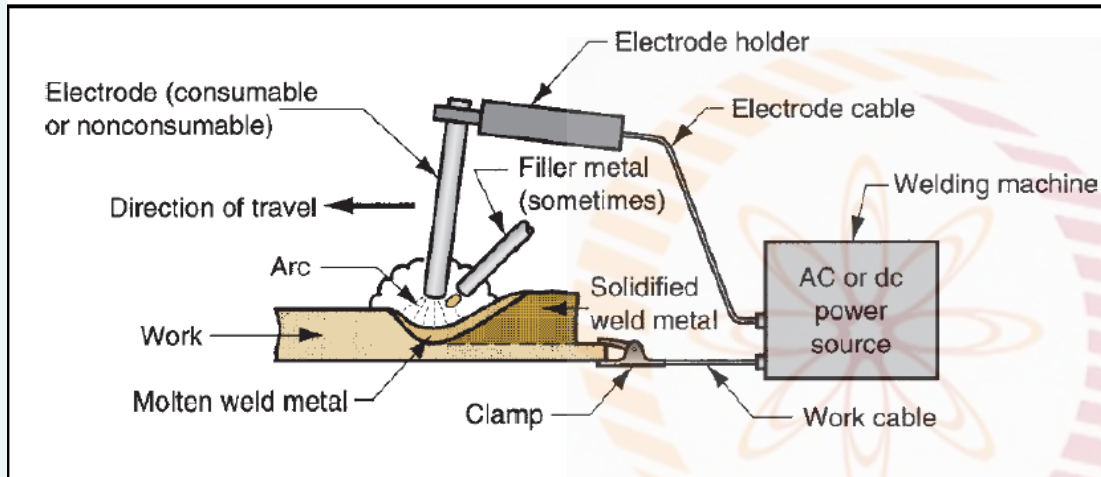
- Developed in mid-1800s
- Uses a consumable or non-consumable electrode (rod or wire)
- Arc is produced between the tip of the electrode and workpiece to be welded
- Arc is started by momentarily touching the electrode to the workpiece and then withdrawing it to a short distance (a few mm)

Basic Principles of Arc Welding



Arc Welding

Schematic Diagram



Electrodes consumable or non-consumable.

Consumable electrodes provide the source of the filler metal in arc welding.

Available in two principal forms: rods (also called sticks) and wire.

Arc Shielding: argon and helium, both of which are inert.

A **flux** is a substance used to prevent the formation of oxides and other unwanted contaminants, or to dissolve them and facilitate removal.

Arc welding with coated electrodes:

The coating serves following purposes:

- ❖ Shields the melt pool from the atmosphere contamination
- ❖ It acts as a carrier for alloying elements, deoxidants, etc.

Flux provides

- (1) A protective atmosphere for welding,
- (2) stabilize the arc, and
- (3) reduce spattering.

Power Source in Arc Welding Both direct current (DC) and alternating current (AC) are used

Arc temperature is about 30,000°C!

Initiating an Electric arc

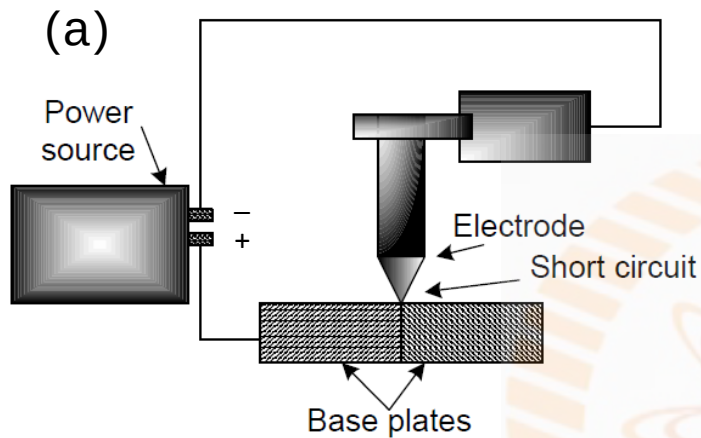
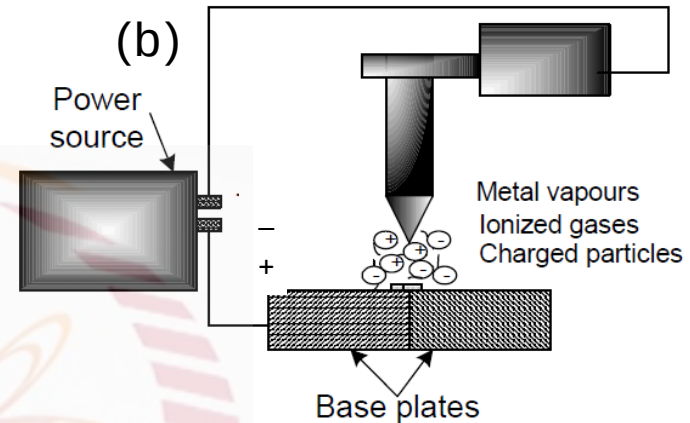
There are two common methods for initiating an electric arc:

In **touch start method**, the electrode is brought in contact with the workpiece and then pulled apart to create a very small gap. Due to direct contact, short circuiting happens resulting in a large current flow leading to heating, partial melting and slight evaporation of workpiece metal at the electrode tip. Heating of the electrode releases electrons due to thermal ionization. Vaporization of metal also produces ions and electrons. Upon withdrawal of the electrode, flow of current starts through these charged particles and arc is initiated.

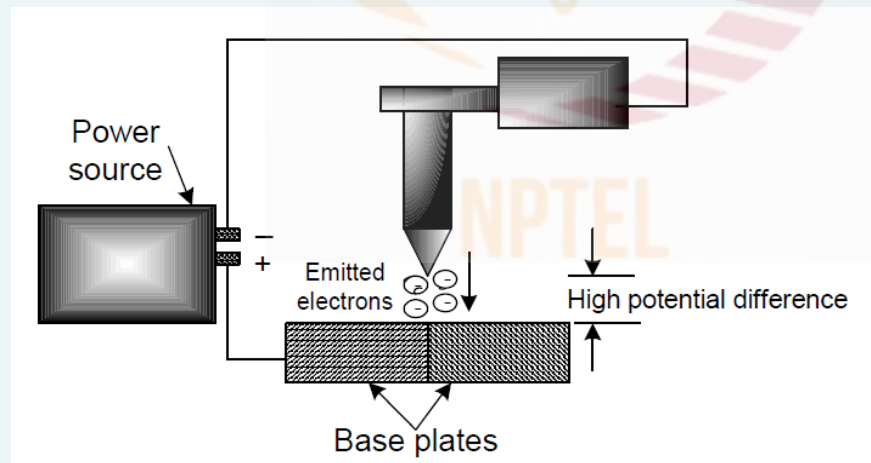
Initiating an Electric arc (Contn)

In **field start method**, a very high potential difference ($\sim 10^7$ V) is applied between the electrode (cathode) and workpiece (anode). Due to high potential difference, electrons are released from the cathode via field emission. Due to the movement of electrons under the high potential difference, an arc is set up. Once sufficient number of electrons are available in the arc gap, the potential difference is brought back to normal to ensure movement of electrons and maintenance of the arc. This process is primarily used for automated welding processes and also where direct contact between workpiece and electrode is not preferred.

Initiating an Electric arc (Contn)



Touch start method (a) shot circuiting (b) emission of ions and electrons on slightly withdrawing the electrode



Field start method

Arc Welding: Characteristics

- Process is applicable to all metals and alloys except pure copper, pure aluminum and some low-melting point metals.

Use of Electrode Coating:

- Shields weld pool from atmospheric contamination by creating a suitable gaseous atmosphere and slag. Slag also refines the molten metal.
- Acts as a carrier of alloying elements, deoxidants and other elements necessary to produce the desired arc and metal transfer characteristics.

Arc produces a temperature of $5000 - 30000^{\circ}\text{C}$

Current – 50 – 300 A (AC or DC); Power < 10 Kw

Polarity – Straight or Reverse; W/P thickness - 3-19 mm

Two Basic Types of AW Electrodes

- *Consumable* – consumed during welding process
 - Source of filler metal in arc welding
- *Nonconsumable* – not consumed during welding process
 - Any filler metal must be added separately



Consumable Electrodes

- Forms of Consumable Electrodes
 - Welding rods (also called sticks) are 9 to 18 inches and 3/8 inch or less in diameter and must be changed periodically
 - Weld wire can be continuously fed from spools with long lengths of wire, avoiding frequent interruptions
- In both rod and wire forms, electrode is consumed by arc and added to weld joint as filler metal

NPTEL

Nonconsumable Electrodes

- Made of tungsten which resists melting
- Gradually depleted during welding (vaporization is principal mechanism)
- Any filler metal must be supplied by a separate wire fed into weld pool

Power Source in Arc Welding

- Direct current (DC) vs. Alternating current (AC)
 - AC machines less expensive to purchase and operate, but generally restricted to ferrous metals
 - DC equipment can be used on all metals and is generally noted for better arc control

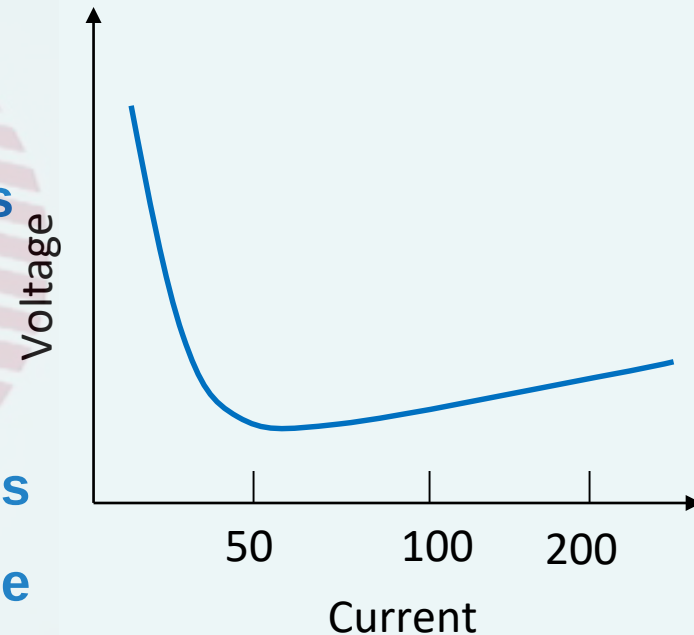
AW Processes that use Consumable Electrodes

- Shielded Metal Arc Welding
- Gas Metal Arc Welding
- Flux-Cored Arc Welding
- Electrode Gas Welding
- Submerged Arc Welding



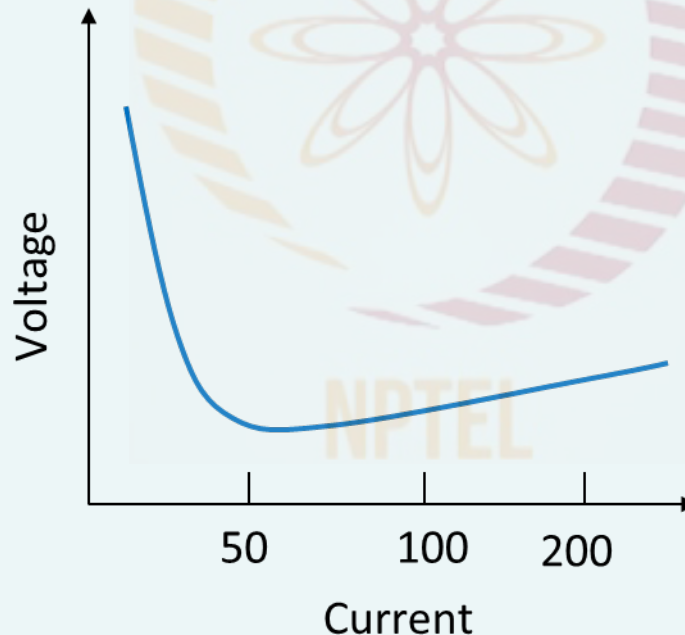
Current voltage characteristic of an arc

- For a given electrode material, voltage reduces with increasing current up to 50 Amp and increases thereafter.
- Until 50 Amps, shape of the arc is almost cylindrical. Surface/volume ratio decreases with increasing radius.
- Until 50 Amp, the arc radius increases and shape remains cylindrical $\rightarrow$ dissipates less heat $\rightarrow$ conductivity increases $\rightarrow$ resistance R decreases $\rightarrow$ voltage V decreases



Current voltage characteristic of an arc

- Beyond 50 Amps, the arc bulges out → the current path becomes more than the arc gap → resistance to current flow increased → voltage increases



Electrode polarity

Typically, direct current is used, and two different polarity is considered:

DCEN (Straight polarity): Direct Current Electrode Negative. Electrode is -ve and workpiece is +ve.

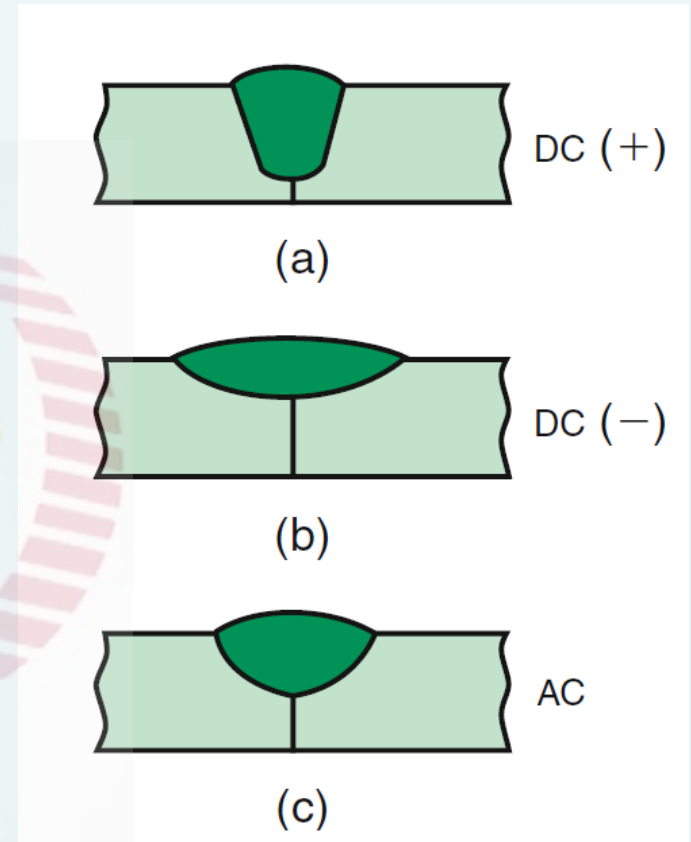
This method produces deep and narrow weld.

DCEP (Reverse polarity): Direct Current Electrode Positive. Electrode is +ve and workpiece is -ve.

This method produces wider and shallower weld.

Weld penetration is less – used for welding sheet metals

Using an **AC current supply**, the current pulsates rapidly. This method is suitable for welding thick sections and for using large diameter electrodes at maximum currents.



The effect of polarity and current type on weld beads (a) DCEN (b) DCEP (c) AC current