Casting Forming and Welding Lab (ME39007)
Experiment No. 1: Down hand Arc Welding (SMAW)

Objectives

- To study the arc phenomena in down hand arc welding. i.e.,
  - The mode of metal transfer and
  - The variation of arc voltage with arc gap
- To determine the nature of variation of arc gap with electrode feed rate and current setting of the machine

Equipments

- Welding power source
- Preset feed machine or any other device for automatically feeding electrode
- Voltage, current measurement devices
- Setup for projecting the magnified image of the arc in order to facilitate the arc length measurement.

About SMAW

- SMAW uses consumable electrode consisting of a filler metal rod coated with chemicals that provide flux and shielding
- Currents typically used in SMAW range between 30 and 300 A at voltages from 15 to 45 V.
- Usually performed manually
- Most common welding, 50 % of industrial welding uses SMAW

SMAW: Electrode-coating functions

- Produces gases to shield weld from air
- Adds alloying elements
- De-oxidation
- Produces slag to protect & support weld
- Controls cooling rates
- Stabilizes arc

Constituents of electrode coating in SMAW-

- Shielding gas generator: Shielding gas is generated by either the decomposition or dissociation of the coating. 3 types
  - Cellulosic→Generates H_2, CO, H_2O and CO_2
  - Limestone($CaCO_3$)→generates $CO_2$and CaO slag
  - Rutile (TiO_2)up to 40% →easy to ignite, gives slag detachability, fine bead appearance, generates O_2& H_2 by hydrolysis

- Slag formers (flux): SiO, MnO2, FeO.Al2O3
- Arc stabilizers: Na2O, CaO, MgO, TiO2
- Deoxidizer:Graphite, Al, Wood flour
- Binder:sodium silicate, K silicate
- Alloying elements: V, Co, Mo, Zr, Ni, Mn, W etc.

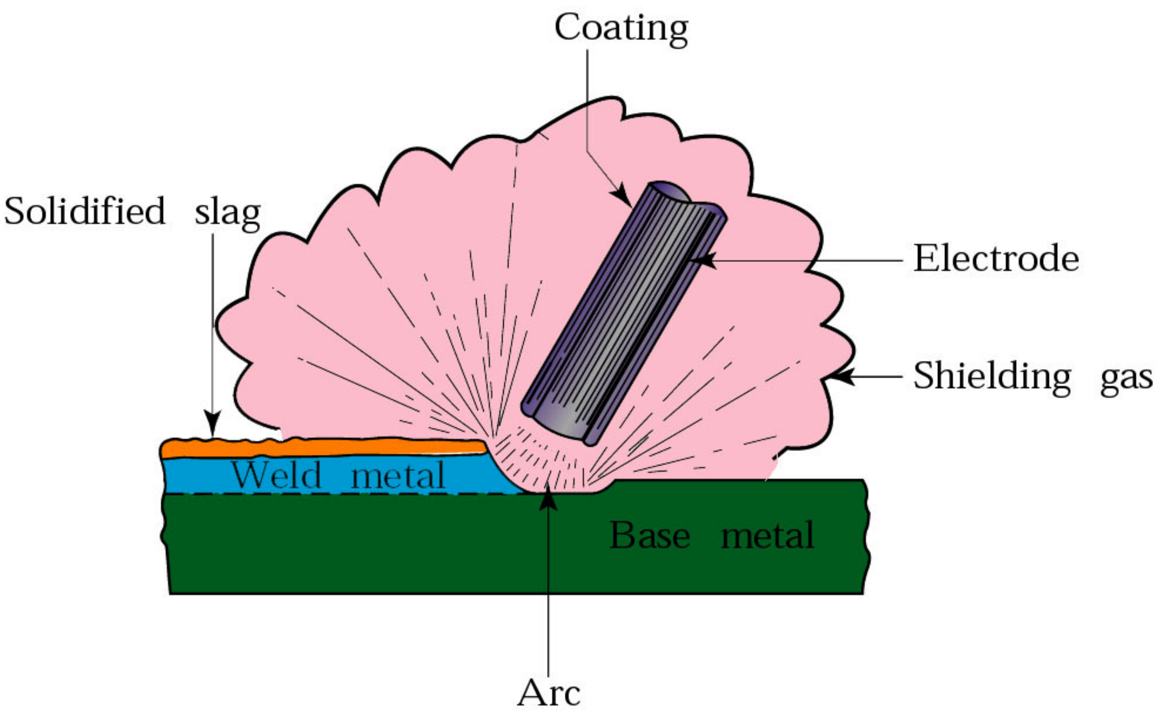

Figure 1. Shielded metal arc welding (SMAW)

Theory

In a welding arc, major portion of the heat generates at its two ends. i.e., at the electrode and the workpiece. The transfer of the metal takes place in the form of droplets and sometimes as spray. As the electrode melts, a droplet starts forming. The cycle thus keeps on repeating. This phenomenon of droplet growth leads to cyclic change in the actual gap. This consequently changes the arc voltage. The magnitude and nature of voltage fluctuation affect the arc stability, which in turn affects the quality of weld. The elements present in the electrode coating also affects these voltage fluctuations and a study of these phenomena is useful from the point of view of understanding electrode performance. A diagram for voltage fluctuation recorded for a typical arc is shown in Figure 2.

Another observation which can be made is regarding the apparent arc gap and actual arc gap. Apparent arc gap is the distance of the workpiece from the solid end of the electrode. This distance does not change during the cycle but its magnitude depends upon other welding parameters like electrode feed rate and the current setting of the machine. The apparent arc gap also affects the bead appearance and the quality of the weld produced. However, the actual arc gap is the effective arc length during the droplet transfer process.

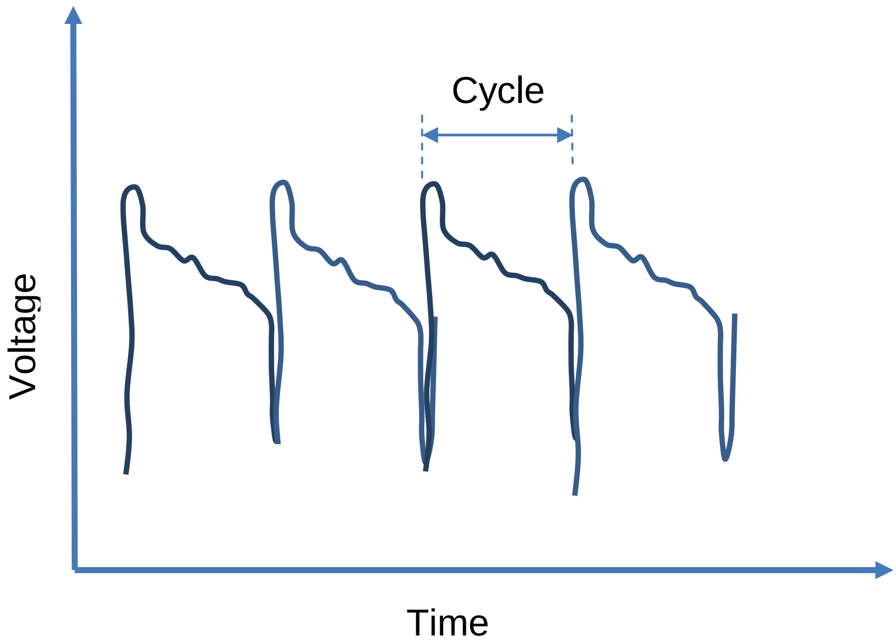

Figure 2. Variation of arc voltage with time using DC

Arc: V-A Characteristics

- Arc welding →low-voltage, high-current arcs between a nonconsumable or consumable electrode and a work piece
- Arc welding power source →static and dynamic characteristics
- Static volt-ampere characteristics,(1) constant-current and (2) constant-voltage
- Dynamic characteristics →determined by measuring very short-duration (~1 ms) transient variations in output voltage and current that appear in the arc itself
- The total potential of an arc first falls with increasing current, and then rises with further increases in current
- The initial decrease is attributed to a growthof thermally induced electron emission at the arc cathode and thermal ionization

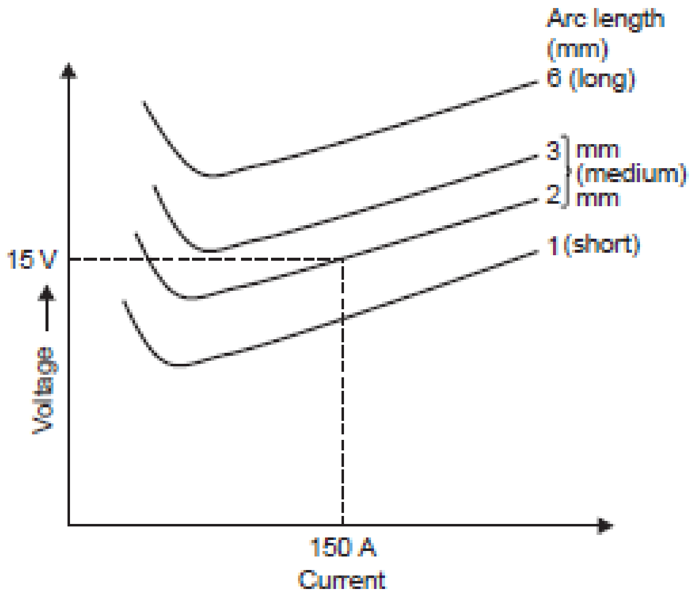

Figure 3. V-I characteristics

Influence of Arc length

- Potential barrier increases with the arc length (gap)
- Lengthening the arc →exposes more of the arc column to cool boundary →More losses →Higher demand for voltage

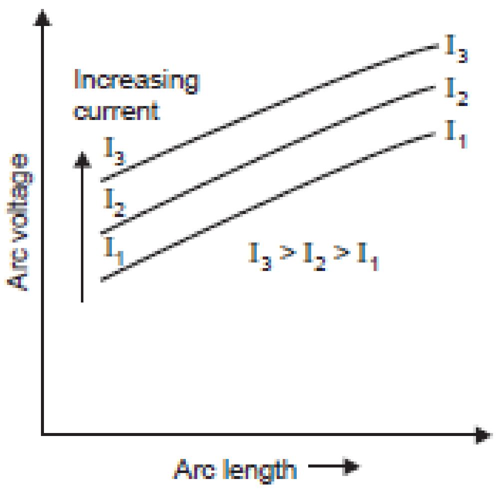

Figure 4. Influence of arc voltage on the arc length

Constant current power sources

- A change in arc length will cause corresponding change in arc voltage and small change in current.
- Electrode melting and metal deposition rate remain constant with slight changes in arc length

- Greater tolerance to arc length Variations
- Used for manual SMAWand GTAW
- Used primarily with coated electrodes
- Small change in amperage and arc power for a corresponding relatively large change in arc voltage or arclength
- The curve of a constant current machine drops down-ward sharply →often called a*"drooper"*
- In welding with coated electrodes, the amperage is set by the operator while the voltage is designed into the unit
- The operator can vary the arc voltage by increasing or decreasing the arc length

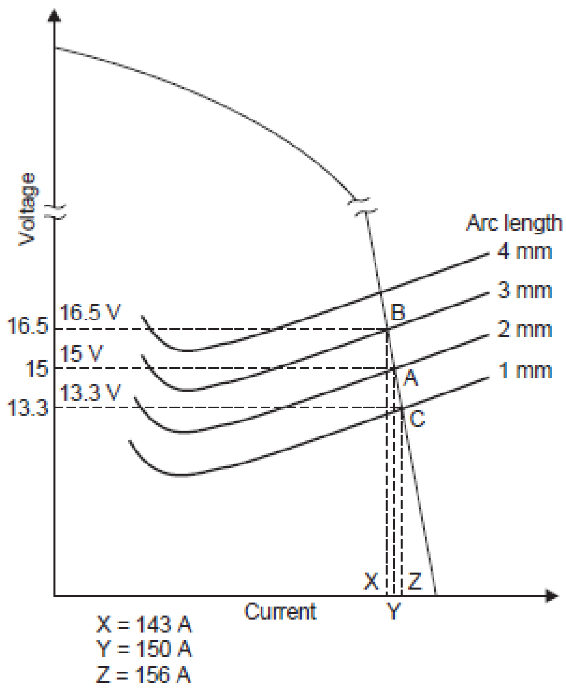

Figure 5. V-I characteristics of a constant current power source

Metal transfer in Arc welding

- The manner in which molten filler metal is transferred to the weld pool →profound effects on the performance of a consumable electrode arc welding process
- These effects include
    - Ease of welding in various positions
    - Extent of weld penetration;
    - Rate of filler deposition and
    - Heat input
    - Stability of the weld pool
    - Amount of spatter loss

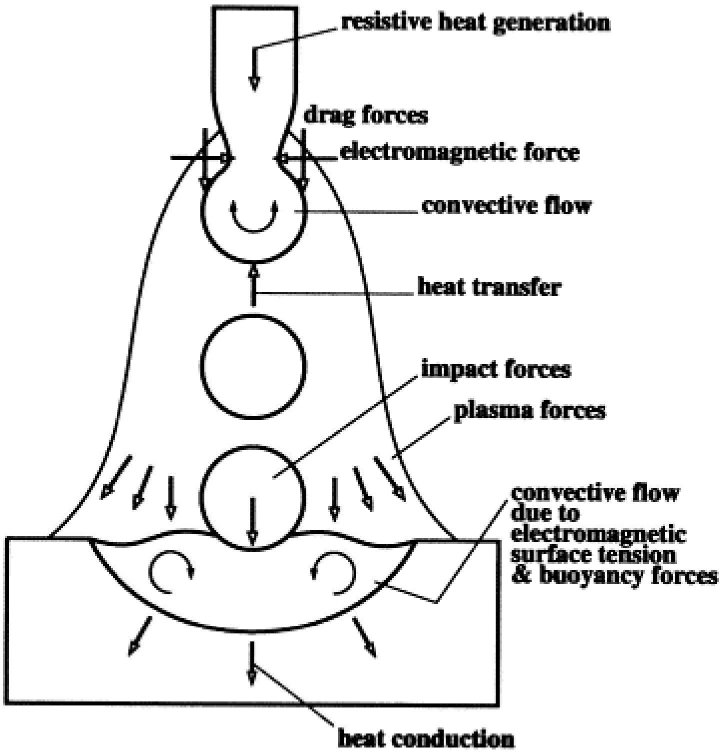

Figure 6. Mechanism of molten metal transfer in arc welding

Mode of Metal transfer-Influencing parameters

- Pressure generated by the evolution of gas at the electrode tip (for flux-coated or flux-cored electrode processes)
- Electrostatic attraction between the consumable electrode and the workpiece
- Gravity
- “Pinch effect” caused near the tip of the consumable electrode by electromagnetic field forces →spray
- Explosive evaporation of a necked region formed between the molten drop and solid portions of the electrode due to very high conducting current density
- Electromagnetic action produced by divergence of current in the arc plasma around a drop.
- Friction effects of the plasma jet (plasma friction)
- Surface tension effects once the molten drop (or electrode tip) contacts the molten weld pool

Experimental Procedure

- Set the workpiece on the preset feed machine
- Initiate the arc by shorting the gap
- Observe the phenomena of droplet formation and arc length variations on the projected (magnified) image of the arc
- Run the machine at two different electrode feed rate (178 & 218 mm/min)

- At every feed rate, run the machine at three different current settings (140, 150 & 160 amperes) as admissible.
- For every setting measure the average arc voltage and the apparent arc length over the image

Observations & Calculations

Horizontal speed of the electrode with respect to workpiece = mm/min

a) Electrode feed rate = mm/min

Sl No.	Current (A)	Projected arc length	Actual arc length	Open circuit voltage	Closed circuit voltage

b) Electrode feed rate = mm/min

Sl No.	Current (A)	Projected arc length	Actual arc length	Open circuit voltage	Closed circuit voltage

- Plot the following graphs
  - Arc length Vs Arc voltage
  - Current setting Vs Arc length (for constant electrode feed rate).

Points for discussion

- Why does a sharp rise in the voltage occur at the onset of a droplet formation cycle?
- What would be arc voltage pattern for AC? In what ways do the phenomena in AC different from DC?
- Why is a constant current source used?

Appendix

Constant-Voltage Power Sources

- A slight change in arc length causes a large change in current, so melting rate changes rapidly in response.
- This has the effect of self-regulation, increasing the melting rate as arc length is inadvertently shortened, (and vice versa)
- Attractive for constantly fed continuous electrode processes such as GMAW, FCAW, or SMAW, to maintain near-constant arc length.

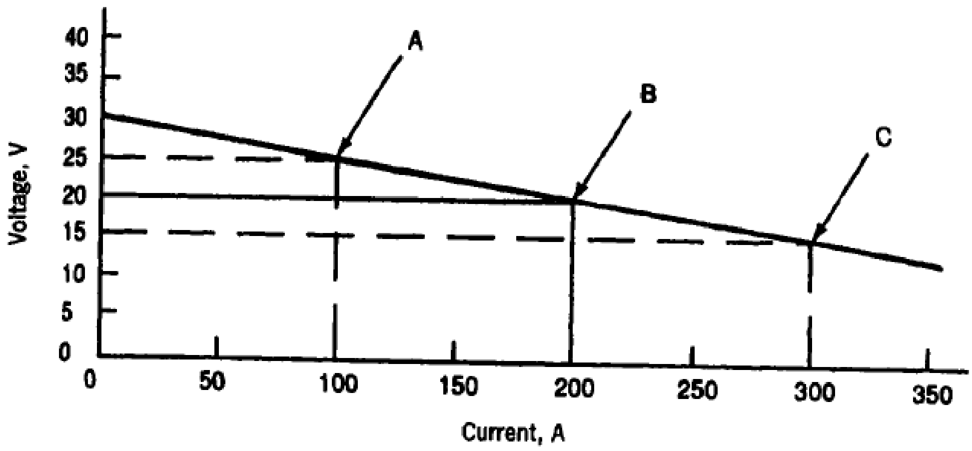

Figure 7. V-I characteristics of a constant voltage power source

Combined Characteristic Sources

- Single power supply that can provide either constant-voltage or constant-current
- Higher-voltage portion →Constant current
- Below a certain threshold voltage, the curve switches to a constant voltage type
- Utility for a variety of processes, and are actually a combination of the straight CV or CC types
- Useful for SMAW to assist in starting; avoids electrode sticking in the weld pool (in those cases where the welder is required to use shorter arc length)

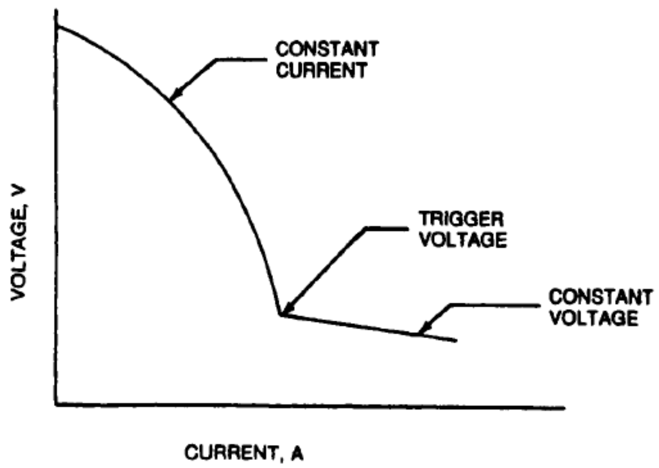

Figure 8. V-I characteristics of a combined power source