DATE 28/10/16

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.

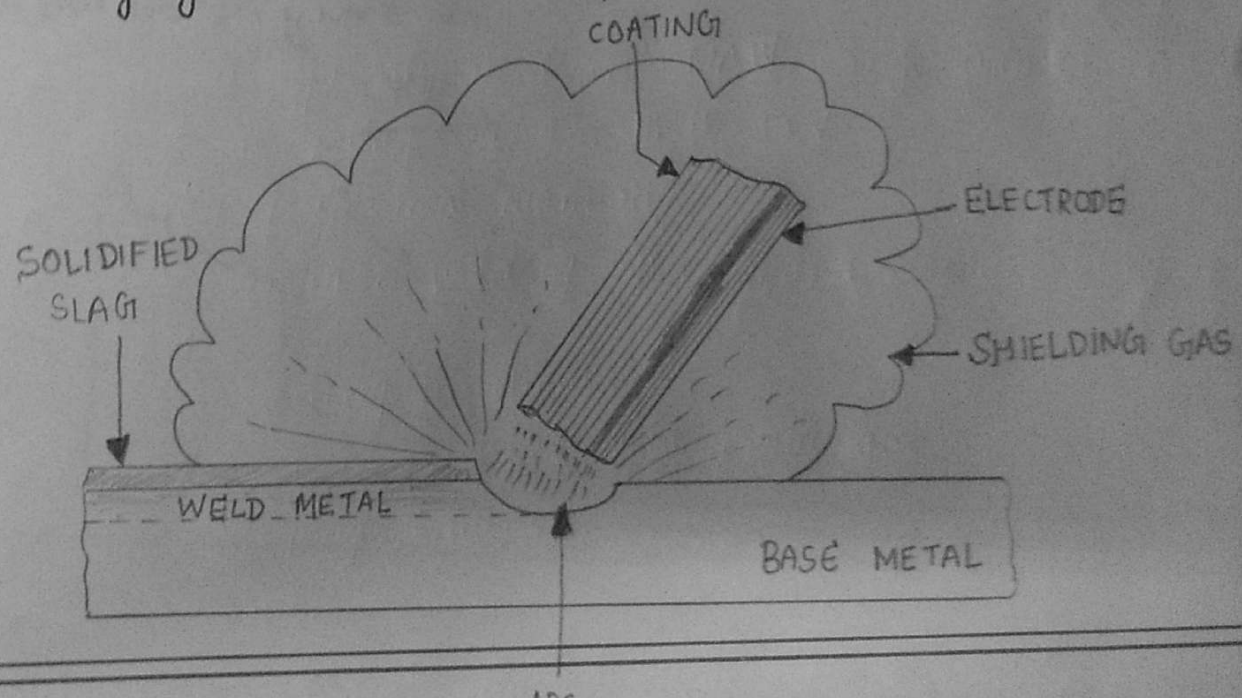
Equipments:
- Welding power source
- Preset feed machine or any other device for automatically feeding electrode
- Voltage, current measurement devices.
- Setup for projecting the magnified image of the arc in order to facilitate the arc length measurement.

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 and support weld.

- controls cooling rates
- stabilizes arc.

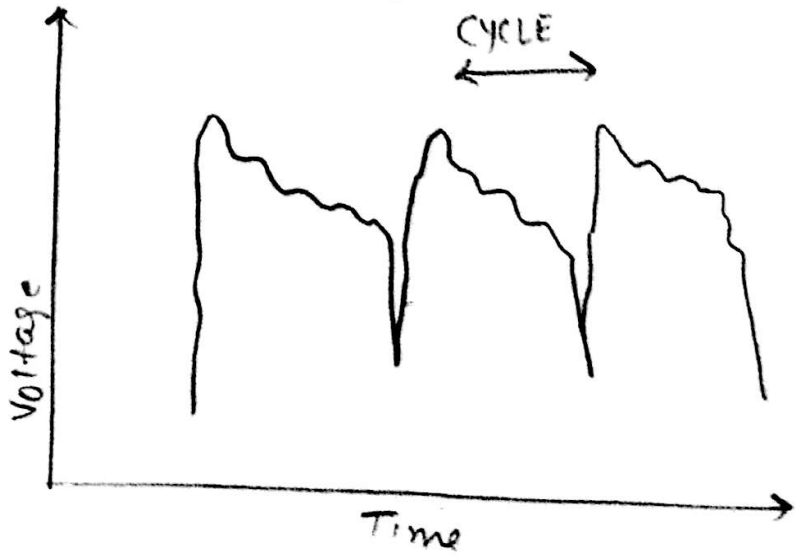
- **constituents of electrode coating in SMAW:**
  - Shielding gas generator: shielding gas is generated by either the decomposition or dissociation of the coating. 3 types
    - → Cellulosic: Generates H_2, CO, H_2O, CO_2
    - → Limestone ($CaCO_3$): Generates CO_2 and CaO slag.
    - → Rutile (TiO_2) up to 40%: easy to ignite, gives slag detachability, fine bead appearance, generates O_2 and H_2 by hydrolysis.
    - → Slag formers (flux): SiO, MnO_2, FeO, Al_2O_3
    - → Arc stabilizers: Na_2O, CaO, MgO, TiO_2
    - → Deoxidizer: graphite, Al, Wood flour
    - → Binder: sodium silicate, K silicate
    - → Alloying elements: V, Co, Mo, Zr, Ni, Mn, W, etc.



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 cycles thus keeps on reducing. 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 effect the arc stability, which in turn affects the quality of weld. The elements present in the electrode coating also affects these voltages 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 show in Figure 2.

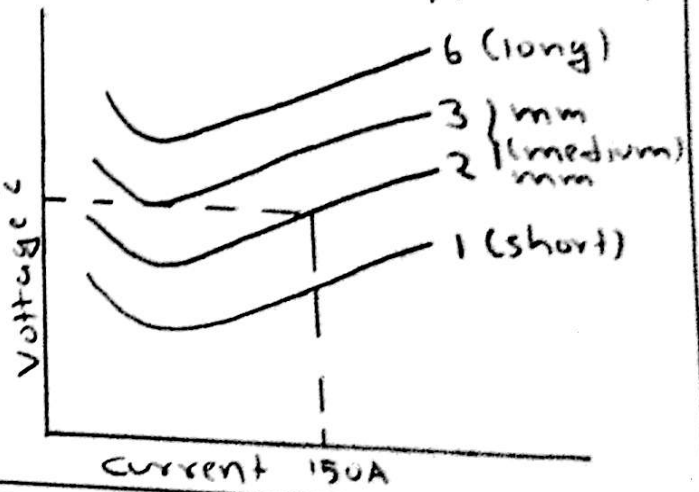


Variation of arc voltage with time using DC

Another observation which can be made is regarding the apparent arc gap and actual arc gap. Apparent arc gap is the distance of the work-piece 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.

Arc: V-A Characteristics

- Arc welding → low voltage, high current arcs between a non consumable 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 characterics → 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 growth of thermally induced electron emission at the arc cathode and thermal ionization.



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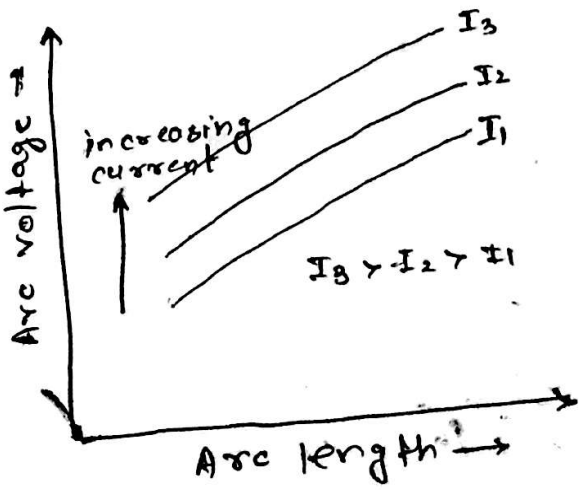
Influence of Arc length :-

- Potential barrier increases with the arc length (gap)
- Lengthening the arc causes more of the arc column to cool boundary. It leads to more loss of energy. As a result, there is more demand for voltage.

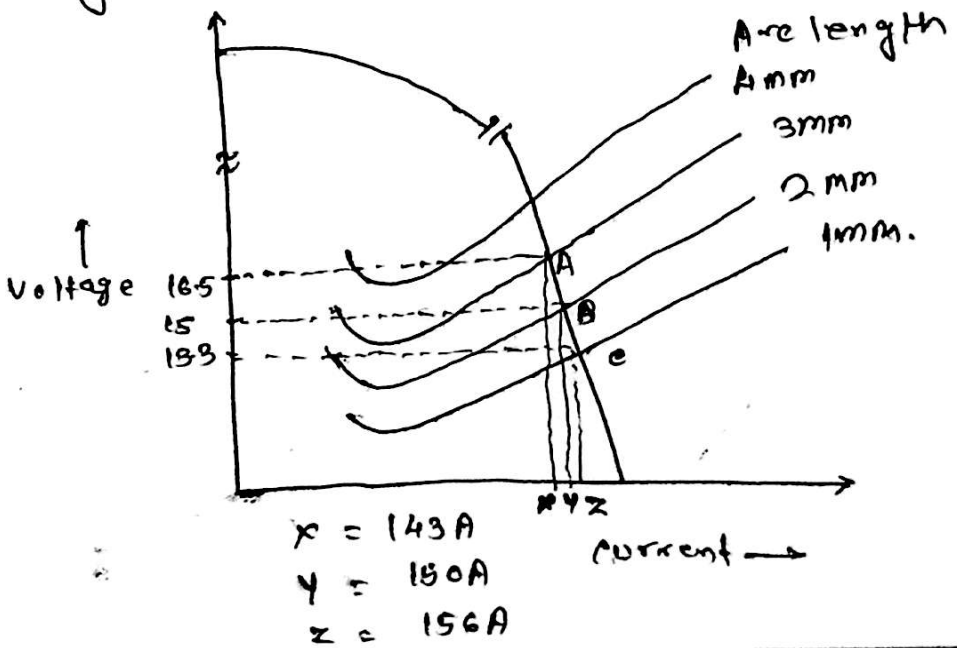


Influence of arc voltage on arc length

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 tolerence to arc length variations
- Used for manual SMAW and GTAW.
- Used primarily with coated electrodes.
- Small change in amperage & arc power for a corresponding relatively large change in arc voltage. or arc length.
- The curve of a constant current machine drops downward sharply. It is often called as '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.



Metal transfer in arc welding :-

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

Mode of Metal transfer - influencing parameter :-

- 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 work piece
- Gravity.
- 'Pinch Effect' caused near the tip of the consumable electrode by electro magnetic field forces → spray.

- Explosive evaporation of the necked region formed between the molten drop and solid portions of the electrode due to the very high conducting current density.
- Electromagnetic action produced by divergence of current in the arc plasma around the drop.
- Friction effects of the plasma jet. (Plasma friction)
- Surface tension effects once the molten drop (or electrode tip) contacts the molten weld pool.

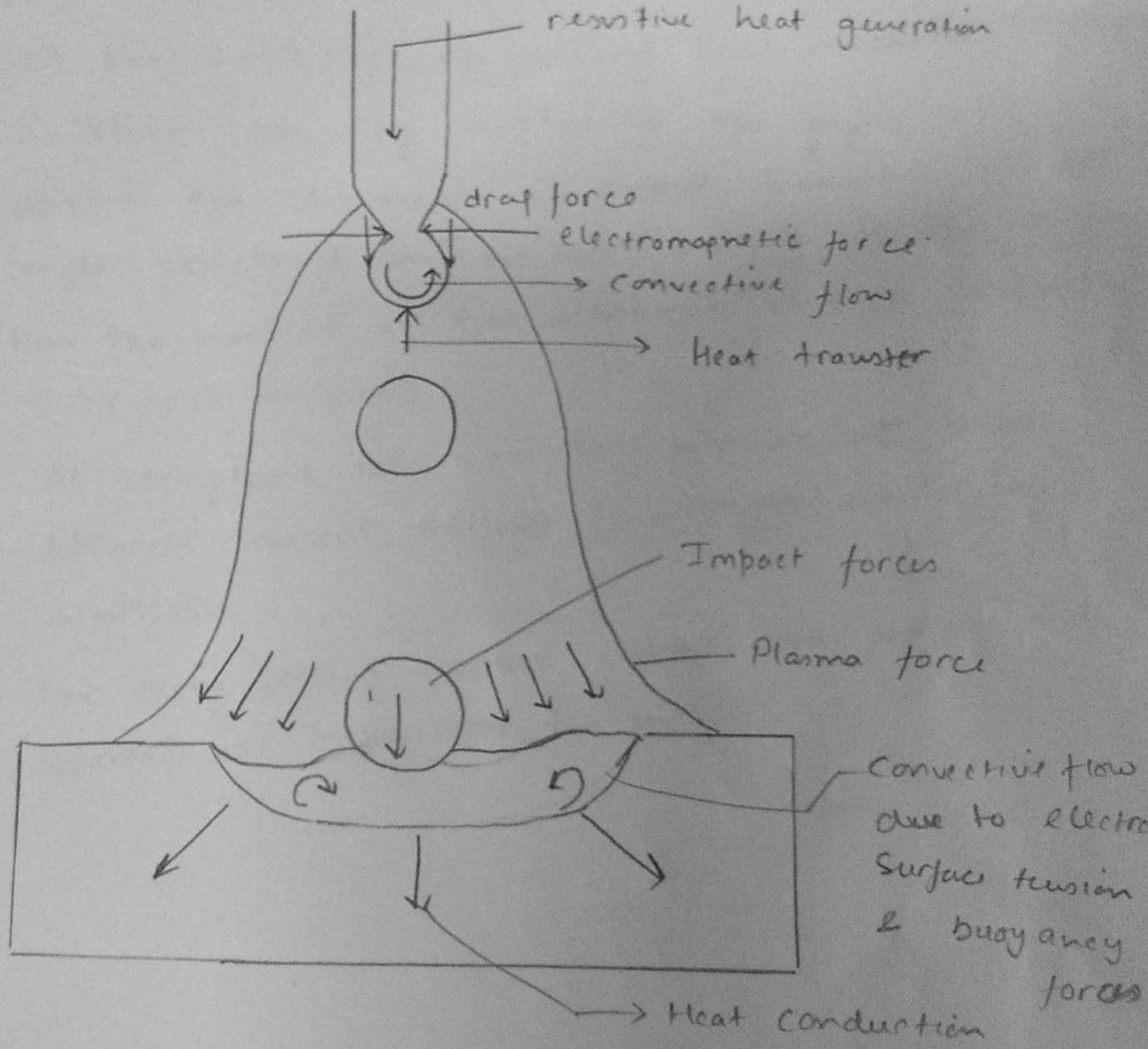


Fig.6 : Mechanism of molten metal transfer in arc welding

Experimental Procedure:

- Set the work piece on present feed machine
- Initiate arc by shortening the gap
- Observe the phenomena of droplet formation and arc length variations on projected images of the arc.
- Run the machine at two different electrode feed rates. (178 / 218 mm/min)
- At every feed rate, run the machine at three different current settings (140, 150, 160) amperes or admissable
- For every setting measure average arc voltage and apparent arc length over the image.

OBSERVATION TABLE

a) Electrode feed rate = 178 mm/min

Current (A)	OPEN CIRCUIT VOLTAGE	CLOSED CIRCUIT VOLTAGE	PROJECTED ARC LENGTH (cm)	ACTUAL ARC LENGTH (cm)
140	55	27.5	8.5	1.54
150	60	32	10	1.81
160	65	35	11.5	2.09

b) Electrode feed rate : 218 mm/min

CURRENT (A)	OPEN CIRCUIT VOLTAGE	CLOSED CIRCUIT VOLTAGE	PROJECTED ARC LENGTH (cm)	ACTUAL ARC LENGTH (cm)
140	55	25	8.5	1.54
150	60	27	10	1.81
160	65	30	11	2

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Discussions:-

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(1) Why does a sharp rise in the voltage occur at the onset of droplet formation?

Ans→ Just at the onset of droplet formation cycle the actual arc length is maximum and it decreases as the droplet starts forming. Maximum arc length at the onset of droplet formation means that resistance will be highest and since we are operating under constant current condition $V = IR$ is maximum. Now at an instant before this the arc length and thus voltage was minimum (fully formed droplet). Hence a sudden jump from the minimum to maximum voltage.

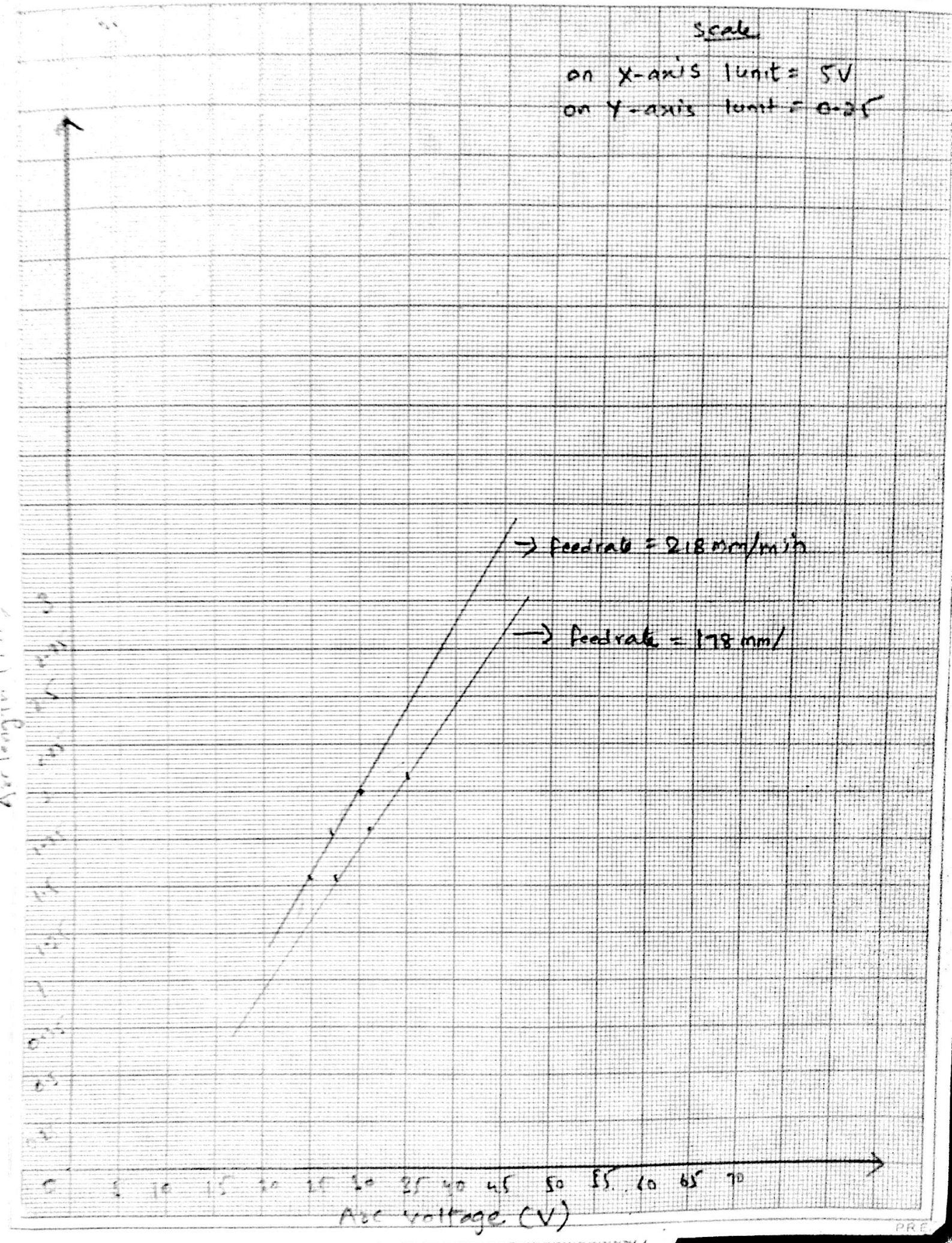
(2) What would be voltage pattern for AC? In what ways do phenomenon in AC is different from DC?

Ans→ The arc voltage pattern for AC will be sinosoidal. In case of AC, the direction of force on droplet keeps on changing which reduces the blow of the weld.

(3) Why is a constant current source used?

Ans→ A constant current sources ensures a continuous flow of ions between the ~~work piece~~ work piece and electrodes thus keeping the electrode melting and metal deposition rate constant with small changes in arc length. This ensures that constant current sources have a greater tolerance to arc length variation.

Plot of Arc length (V.S) Arc Voltage



Plot of Current Setting Vs. Arc Length