Dynamic characteristics of welding power sources

This chapter presents the dynamic characteristics of welding power sources and classes of insulation used in windings and cables of power sources. The concept of duty cycle and its relationship with welding current has been elaborated. Further, need of high frequency unit in welding and different types of electrode wire feed drives have also been discussed.

Keywords: Dynamic characteristics, Duty cycle, class of insulation, HF unit, arc length, feed drives

10.1 Rising Characteristics

Power sources with rising characteristics show increase in arc voltage with increase of weld[illegible]tic welding processes where strictly constant v[illegible] with rising characteristics are used.

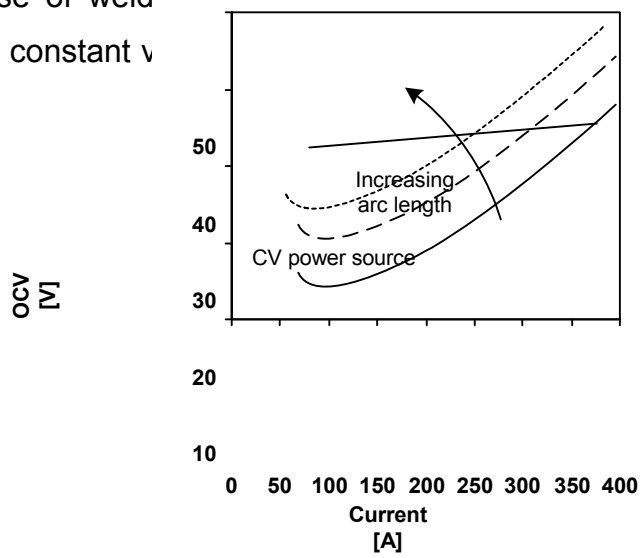
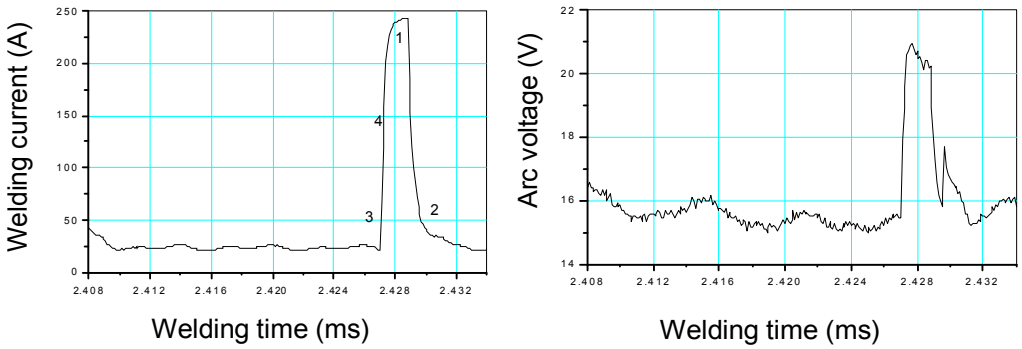


Fig. 10.1 Static characteristics of rising voltage welding power showing operating points with different arc length

10.2 Dynamic characteristic

Welding arc is subjected to severe and rapid fluctuations in arc voltage (due to continuous minor changes in arc length) and welding current (Fig. 10.2). Number from 1 to 4 in figure 5 indicates different stages of welding arc during welding, suggesting that welding arc is never in a steady state. It causes transients in starting, extinction and re-ignition after each half cycle in A.C. welding. To cope up with these conditions power source should have good dynamic characteristics

to obtain stable and smooth arc. Dynamic characteristic of the power source describes the instantaneous variation in arc voltage with change in welding current over an extremely short period of welding. A power source with good dynamic characteristic results in an immediate change in arc voltage and welding current corresponding to the changing welding conditions so as to give smooth and stable arc.



a) b)

Fig. **10.3** Dynamic characteristics of a power source showing a) current vs time and b) voltage vs time relationship.

10.3 Duty Cycle

Duty cycle is defined as ratio of arcing time to the weld cycle time multiplied by 100. Welding cycle time is either 5 minutes as per European standards or 10 minutes as per American standard and accordingly power sources are designed. If arcing time is continuous for 5 minutes then as per European standard it is considered as 100% duty cycle and that will be 50% duty cycle as per American standard. At 100% duty cycle, minimum current is drawn from the welding power source. Welding power source operating at low duty cycle allows high welding current for welding purpose safely. The welding current which can be drawn at a duty cycle can be evaluated from the following equation;

$D_R \times I_R^2 = I^2_{100} \times D_{100}$……..(equation 10.1)

Where I - Current at 100% duty cycle

D_{100} - 100% duty cycle

I_R - Current at required duty cycle

D_R - Required duty cycle

Example

Current rating for a welding power source is 400 A at 60% duty cycle. Determine the welding current for automatic continuous welding i.e. 100% duty cycle.

Solution:

Rated current: 400 A

Rated duty cycle: 60%

Desired duty cycle: 100%

Desired current ?

Desired duty cycle= $\frac{(\text{rated current})^2 \text{ X rated duty cycle}}{(\text{desired current})^2}$

$$100 = \frac{(400)^2 \text{ X } 60}{(\text{desired current})^2}$$

Answer: Desired current: 310A

10.3.1 Importance of duty cycle

During the welding, heavy current is drawn from the power source. Flow of heavy current through the transformer coil and connecting cables causes electrical heating. Continuous heating during welding for long time may damage coils and cables. Therefore, welding operation should be stopped for some time depending upon the level of welding current being drawn from the power source. The total weld cycle is taken as sum of actual welding time and rest time. Duty cycle refers to the percentage of welding time of total welding cycle i.e. welding time divided by welding time plus and rest time. Total welding cycle of 5 minutes is normally taken in India as in European standard. For example, welding for 3 minutes and followed by rest of 2 minutes in total welding cycle of 5 minutes corresponds to 60% duty cycle.Duty cycle and associated welding current are important as it ensures that power source is safe and its windings are not damaged due to increase in temperature due to electrical resistance heating beyond specified

limit. Moreover, the maximum current which can be drawn from a power source at given a duty cycle depends upon size of winding wire, type of insulation and cooling system of the power source. In general, large diameter cable wire, high temperature resistant insulation and force cooling system allow high welding current drawn from the welding source at a given duty cycle.

10.4 Class of Insulation

The duty cycle of a power source for a given current setting is primarily governed by the maximum allowable temperature of various components (primary and secondary coils, cables, connectors etc.), which in turn depends on the quality and type of insulation and materials of coils used for manufacturing of power source. The insulation is classified as A, E, B, F& G in increase order of their maximum allowable temperature 60, 75, 80, 100 &125 ^{0}C respectively.

10.5 High Frequency Unit

Some power sources need high frequency unit to start the arc like in TIG and plasma arc welding. High frequency unit is introduced in the welding circuit. Filters are used between the control circuit and HF unit to avoid damage of control circuit. High frequency unit is a device which supplies pulses of high voltage (of the order of few kV) and low current at high frequency (of few kHz). The high voltage pulse supplied by HF unit ionizes the gaseous medium between electrode and workpiece/nozzle to produce starting pilot arc which ultimately leads to the ignitions of the main arc. Although high voltage can be fatal for operator but at high frequencies current passes through the skin and does not enter the body. This is called skin effect i.e. current passes through the skin without any damage to the operator.

10.6 Feed drives for constant arc length

Two types of feed systems are generally used for maintaining the arc length a) constant speed feed drive and b) variable speed feed drive. In constant speed feed drives, feed rollers rotating at fixed speed are used for pushing/pulling wire to feed into the weld so as to maintain the arc length during welding (Fig. 10.4 a). This type drive is normally used with constant voltage power sources in conjunction with small diameter electrodes where self regulating arc helps to

attain the constancy in arc length. In case of variable speed feed drives, feed rollers used for feeding electrode wire (in consumable arc welding processes like SAW and GMAW) are rotated at varying speed as per need to maintain the arc length during welding. Fluctuation in arc length due to any reason is compensated by increasing or decreasing the electrode feed rate. The electrode feed rate is controlled by regulating the speed of feed rollers powered by electric motor (Fig. 10.4 b). Input power to the variable speed motor is regulated with help of sensor which takes inputs from fluctuations in the arc gap. For example, an increase in arc gap sensed by sensor increases the input power to the variable speed motor to increase the feed rate of electrode so as to maintain arc gap.

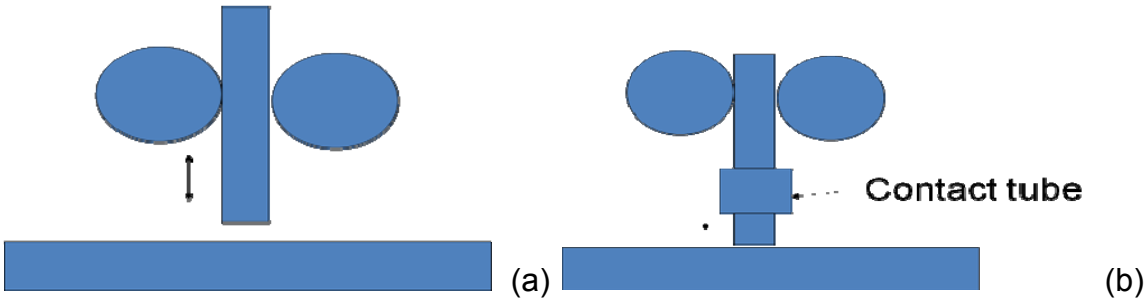


Fig. **10.4** Schematics diagrams show electrode feed drives for controlling arc length a) variable speed feed drive and b) constant speed feed drive

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