POSTAL Book Package 2023

Mechanical Engineering

Conventional Practice Sets

Production and Maintenance Engineering

Contents

MADE EASY Publications

2 CHAPTER Welding

Practice Questions : Level-I

Q.1 In an arc welding process, the voltage and current are 25 V and 300 A respectively. The arc heat transfer efficiency is 0.85 and welding speed is 8 mm/s. Determine the net heat input (in J/mm)?

Solution:

Given,

Voltage: $V = 25$ volt

Current: $I = 300$ A

Efficiency: $\eta = 0.85$

Weld speed: $v = 8$ mm/s

Power generated due to arc = VI

$$\text{Power utilized as heat} = \eta VI$$
$$= 0.85 \times 25 \times 300 = 6375 \text{ J/s}$$
$$= \frac{6375}{v}\text{J/mm} = \frac{6375}{8}$$
$$= 796.8 \text{ J/mm} \approx 797 \text{ J/mm}$$

Q.2 A direct current welding machine with a linear power source characteristic provides open circuit voltage of 80 V and short circuit current of 800 A. During welding with the machine, the measured arc current is 500 A, corresponding to an arc length of 5.0 mm and the measured arc current is 460 A corresponding to an arc length of 7.0 mm. Establish the linear voltage (E) – arc length (L) characteristic of the welding arc (where E is in volt and L is in mm).

Solution:

The power source characteristic can be written analytically as

$$E = 80 - \frac{80}{800}I \quad \text{(a)}$$

The arc characteristic is given as

$$I = aL + b$$

where a and b are constant

Given,

when $I = 500$ A

then $L = 5.00$ mm

$\therefore$ $500 = 5a + b$ (i)

when $I = 460$ A

then $L = 7.00$ mm

$\therefore$ $460 = 7a + b$ (ii)

Solving Equations (i) and (ii), we get

$a = -20$

and $b = 600$

Then arc characteristic equation

$$I = -20\,L + 600 \quad \text{(b)}$$

From equations (a) and (b)

$$E = 80 - \frac{80}{800}(-20\,L + 600) = 80 - 0.1\,(-20\,L + 600)$$

$$= 80 + 2L - 60 = \mathbf{20 + 2L}$$

Q.3 Two metallic sheets, each of 2.0 mm thickness, are welded in a lap joint configuration by resistance spot welding at a welding current of 10 kA and welding time of 10 millisecond. A spherical fusion zone extending up to the full thickness of each sheet is formed and properties of the metallic sheets are given as:

Ambient temperature = 293 K
Melting temperature = 1793 K
Density = 7000 kg/m^3
Latent heat of fusion = 300 kJ/kg
Specific heat = 800 J/kgK

Assume:

(i) contact resistance along sheet-interface is 500 micro-ohm and along electrode-sheet interface is zero;
(ii) no conductive heat loss through the bulk sheet materials; and
(iii) the complete weld fusion zone is at the melting temperature.

Determine the melting efficiency (in %) of the process.

Solution:

Given data: Current, $I = 10^4$ A; Time, $t = 10^{-2}$ s; Density, $\rho = 7000$ kg/m^3
Resistance, $R = 500 \times 10^{-6}\,\Omega$; Ambient temperature, $T_\infty = 293$ K
Melting temperature, $T_m = 1793$ K; Latent heat of fusion, $L = 300$ kJ/kg
Specific heat, $c_p = 800$ J/kgK; Radius of sphere, $r = 2\times 10^{-3}$ m

Total heat supplied,

$$H_S = I^2Rt = (10^4)^2 \times 500 \times 10^{-6} \times 10 \times 10^{-3} = 500 \text{ J}$$

$$\text{Mass} = \frac{4}{3}\pi r^3 \times \rho = \frac{4}{3}\pi\,(2\times 10^{-3})^3 \times 7000 = 2.346 \times 10^{-4} \text{ kg}$$

Total heat for melting,

$$H_i = mL + m\,c_p\,(T_m - T_0) = 2.346 \times 10^{-4}\,[300 \times 1000 + 800(1793 - 293)]$$

$$H_i = 351.9 \text{ J}$$

$$\text{Efficiency} = \frac{H_i}{H_S} \times 100 = \frac{351.9}{500} \times 100 = \mathbf{70.38\%}$$

Practice Questions : Level-II

Q.4 In MIG welding, the power source characteristic is $V_P = 36 - \dfrac{I}{60}$ and arc characteristic $V_a = 2\,l_a + 27$, V_P & V_a voltage, I-current and l_a arc length in mm. Find the change in power of the arc if the arc length is changed from 2 mm to 4 mm. If the maximum current capacity of the power source is 360 amps, find minimum arc length sustainable?

Solution:

During operation $V_P = V_a$

$$\therefore \quad 36 - \frac{I}{60} = 2\,l_a + 27$$

$$\frac{I}{60} = 36 - 2\,l_a - 27$$

$$\frac{I}{60} = 9 - 2\,l_a$$

$$I = 540 - 120\,l_a$$

$$\text{Power, } P = V_a.I = (2\,l_a + 27) \times (540 - 120\,l_a) = 60\,(2\,l_a + 27)\,(9 - 2\,l_a)$$

$$= 60\,(18\,l_a - 4\,l_a^2 + 243 - 54\,l_a)$$

$$P = 60\,(243 - 36\,l_a - 4\,l_a^2) \quad \text{... (i)}$$

Power at $l_a = 2$ mm $\quad P_2 = 60\,(243 - 36 \times 2 - 4 \times 4) = 60\,(243 - 88) = 9300$ W

at $l = 4$ mm $\quad P_4 = 60\,(243 - 36 \times 4 - 4 \times 16) = 60\,(243 - 208) = 2100$ W

Change in power = 9300 – 2100 = 7200 W

At $I = 360$ amps $\quad 360 = 540 - 120\,l_a$

$$120\,l_a = 540 - 360$$

$$l_a = \frac{180}{120} = 1.5 \text{ mm}$$

Power at $I = 360$ amp $\quad P = 60\,(243 - 36 \times 1.5 - 4 \times 1.5^2) = 60 \times 180 = 10800$ W

Q.5 The voltage length characteristic of *a d.c.* arc is given by $V = (20 + 4l)$ volts, where l = length of arc in mm. During a welding operation, it is expected that the arc length will vary between 4 mm and 6 mm. It is desired that the welding current is limited to 450-550 amp. Assuming a linear power source characteristic, determine the open circuit voltage and short circuit current of power source.

Solution:

Voltage length characteristic, $\quad V = 20 + 4\,l \quad$ ... (i)

Power source characteristic is linear,

$$V = a + bI \quad \text{... (ii)}$$

where '*a*' and '*b*' are constant

∴ $\quad l \Rightarrow$ 4-6 mm and $I \Rightarrow$ 450 – 550 amps

∴ $\quad$ Voltage at $l = 4$ mm, $\quad V_1 = 20 + 4 \times 4 = 36$ volt

$\quad$ Voltage at $l = 6$ mm, $\quad V_2 = 20 + 4 \times 6 = 44$ Volt

We know that for stable point of operation as the length of arc increases or voltage increases the current decreases.

∴ $\quad I = 450$ amp at $V = 45$ Volt

and $\quad I = 550$ amp at $V = 36$ Volt

∴ $\quad$ from equation (i), $\quad 36 = a + 550\,b$

$$\underline{44} = \underline{a} + \underline{450}\,b$$

$$-8 = 100\,b$$

$$b = \frac{-8}{100}$$

$$a = 44 - \left(-\frac{8}{100}\right) \times 450 = 44 + 36 = 80$$

∴ Power source characteristic $V = 80 - 0.08\,I$

(i) Open circuit voltage,

$$I = 0$$
$$V_{OC} = 80 \text{ Volt}$$

(ii) Short circuit current,

$$V = 0$$
$$I = \frac{80.00}{0.08} = 1000 \text{ amp}$$

Q.6 Volt-amp characteristics of a power source is given by equation $I_t^2 = -600(V - 60)$.

1. If the arc characteristic is $I = 20(V - 16)$, determine the power of stable arc.
2. If arc length voltage are represented by $V_a = 30 + 5.5I$, determine optimum arc length for maximum power.

Solution:

1. Arc characteristic is given by

$$I_a = 20(V - 16)$$

Volt-amp characteristic of power source is given by

$$I_t^2 = -600(V - 60)$$

as current-voltage variation is parabolic, so the power source is doppler as constant current source. Hence for the stability of arc:

$$I_t = I_a \qquad \text{(i.e., current across transformer is equal to the current across arc)}$$
$$I_t^2 = I_a^2$$
$$-600(V - 60) = [20(V - 16)]^2$$
$$-600\text{ V} + 36000 = 400V^2 + 102400 - 12800\text{ V}$$
$$4V^2 - 122\,V + 664 = 0$$

By solving this equation we get, roots of this equation,

$$V = 23.4 \text{ volts}; \quad 7.09 \text{ volts}$$

But at $V = 7.09$ volts; $I_a = 20(V - 16) = 20(7.09 - 16) = -ve$

So, Neglect $V = 7.09$ volts

Hence, Voltage, $(V) = 23.4$ volts

Current of arc at this voltage $(I) = 20(V - 16)$

$$I = 20(23.4 - 16) = 148 \text{ Amp}$$

So, Power of arc $= V \times I = 23.4 \times 148 = 3463.2$ W

2. Arc length voltage is given by

$$V = 30 + 5.5I$$

Volt-amp characteristic of power source is given by

$$I_t^2 = -600(V - 60)$$

on putting value of V in the above equation, we get,

$$I_t^2 = -600(30 + 5.5I - 60)$$
$$I_t = [-600(5.5I - 30)]^{1/2}$$

As, power (P) is given by,

$$P = V \times I$$