Heat Flow Characteristics in Welding Processes

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Lesson Objectives

- Eight numericals related to welding

Problem 1: Two 1mm thick steel sheets are to be spot welded at a current of 5000A. Assuming effective resistance to be 200 micro-ohms and current flow time of 0.2 second, find out the heat generated during the process. [GATE2004]

Solution to Problem No.1

- $H = I^2 \times R \times t = (5 \times 10^3)^2 \times 200 \times 10^{-6} \times 0.2 = 25 \times 2 \times 10^6 \times 10^{-4} \times 2 \times 10^{-1} = 10^3$ J
- Ans. 10^3 J

2. Problem Spot welding of two 1mm thick sheets of steel (density=8000 kg/m^3) is carried out successfully by passing a certain amount of current for 0.1 second through the electrodes. The resultant weld nugget formed is 5mm in diameter and 1.5mm thick. If the latent heat of fusion of steel is 1400 kJ/kg and the effective resistance in the welding operation is 200 ohms, find out the current passing through the electrodes. [GATE2005]

Solution to Problem 2

$$\rho \times \text{Volume} \times L = 8000 \times \left\{ \frac{\pi (0.005)^2}{4} \times 0.0015 \right\} \times \left(1400 \times 10^3\right) J = 330\,J$$

$I^2Rt = 330$ J, $I = 4.06$ amp

Problem 3. In an arc welding process, the voltage and current are 25V and 300A respectively. The arc heat transfer efficiency is 0.85 and welding speed is 8 mm.$(s)^{-1}$. Find out the net heat input in J/mm. [GATE2006]

Solution to Problem 3

V=25v, I=330 A, efficiency=0.85
weld speed = 8 $mm.s^{-1}$
Power Generated at arc = V.I= 25 X 300 $J.s^{-1}$
Heat transferred = 0.85 X 7500 = 6375 $J.s^{-1}$
So net Heat Input = 6375 / 8 = 797 $J.(mm)^{-1}$

- **Ans. 796.8 J/mm**

Problem 4. Two metallic sheets, each of 2 mm thickness are welded in a lap joint configuration by a Resistance Spot welding current of 10 kA and welding time of 10 millisecond. A spherical fusion zone extending upto full thickness of each sheet is formed and properties of metallic sheets aregiven as Ambient temperature = 293K, Melting temperature = 1793K Density = 7000 kg/m latent heat of fusion = 300 kJ/kg,Specific heat = 800J/kgK Assume (i) contact resistance along sheet-interface is 500 micro-ohm and electrodesheet interface is zero;(ii)no conductive heat loss through the bulk sheet materials(iii) the complete weld fusion zone is at the melting temperature.Find the melting efficiency in the process. [GATE2007]

Solution to the problem No. 4

Heat Generated due to current $H_1 = I^2Rt$

$H_1=(10X10^3)^2\ X500X10^{-6}X10\ X\ 10^{-3} = 500J$

Heat required for melting $H_2=mL+mc\Delta t$

$H_2=r_oV(L+c\Delta t)$

volume=4/3 X pi X R^3 mm^2

$H_2=7000\ X\ 33.51X10^{-9}\{300X10^3+800X(1793-293)\}=351\ J$

Melting efficiency=H^2/H^1=70.2%

Solution to problem 4

- Ans. 70.38%

P r o b l e m 5 .

In arc welding of a butt joint, the welding speed is to be selected such that the highest cooling rate is achieved. Melting efficiency and heat transfer efficiency are 0.5 and 0.7 respectively. The area of the weld cross-section is $5mm^2$ and the unit energy required to melt the metal is $10J/mm^3$. If the welding power is 2kW, find the welding speed.
[G A T E 2 0 0 8]

Welding Power applied = Heating power needed

$= P \times \grave{\eta}_m \times \grave{\eta}_{H.T.} = E_U \times (A) \times f$

$= 2 \times 10^3 \times 0.5 \times 0.7 = 10 \times 5 \times f$

$f = 14\ mm.s^{-1}$

Solution to problem 5

- Ans. 14 mm/sec

Problem 6. Two pipes of inner diameter 100mm and outer diameter 110mm each are joined by flashbutt welding using 30 V power supply. At the interface, 1mm of material melts from eachpipe which has a resistance of 42.4 ohms. If the unit melt energy is 64.4 MJ/mm3, find the time required for welding in seconds. [GATE2010]

Solution to problem 6

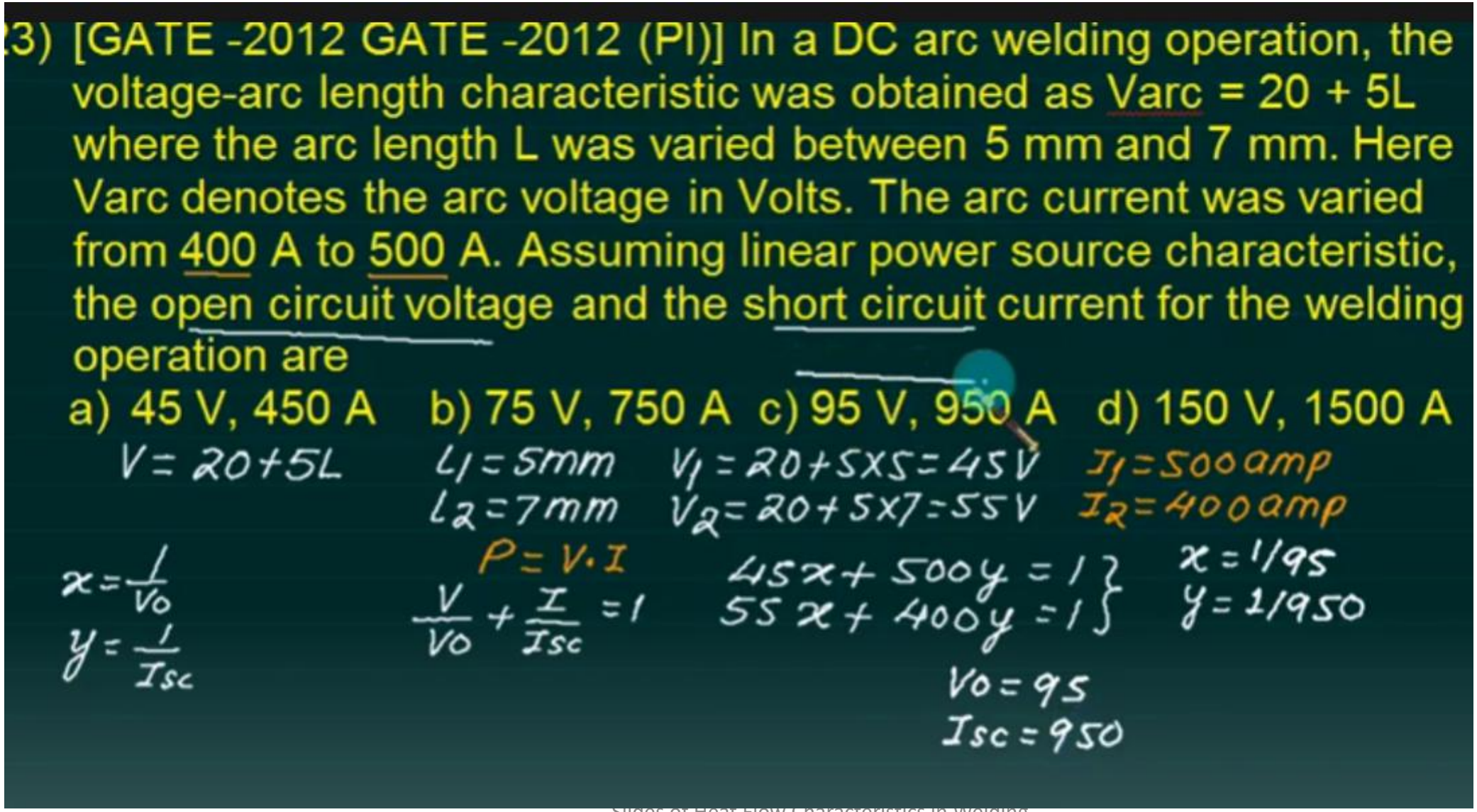
- Ans. 10 s

Problem 7. In a DC arc welding operation, the voltage –arc length characteristic was obtained as Varc= 20 + 5 L where arc length L is varied between 5mm and 7mm. Here Varc denotes the arc voltage in volts. The arc current was varied from 400A to 500A. Assuming linear power source characteristic, find the open circuit voltage and short circuit current for the welding operation. [G A T E 2 0 1 2]

Solution to problem 7

- $V/v_{(\text{open circuit voltage})} + I/i_{(\text{Short circuit current})}=1$
- $V=v \text{ X } (1 / I/i)$
- $V_1= 20+5xL_1=45$ v, $I_1=500$ A
- $V_2= 20+7 \text{ X } L_2=55$v, $I_2=400$A
- $500/v+45/i=1$ ---(1)
- $400/v+55/i=1$ ---(2)
- Solving (1) and (2) one can get
- v= 95 v, i=950 A(ans)

Solution to problem 7



Solution to problem 7

- Ans. 95 Volts, 950 Amp

Problem 8. A DC welding machine with a linear power source characteristic provides open circuit voltage of 80V and short circuit current of 800A. During welding with the machine, the measured arc current is 500 A corresponding to an arc length of 5mm and measured arc current is 460 A corresponding to an arc length of 7 mm. Find the linear voltage (V) –arc length (mm) characteristic of the welding arc. [GATE2007]

Solution to problem 8

- I/800+V/80 =1
- V= 80 X(1-I/800)=80-I/10
- For I= 500 amp V=80-50=30 volt
- For I= 460 amp V= 80-46=34 volt
- 30 = A +5 X B --- (1)
- 34 = A + 7 X B --- (2)
- B=2, A=20 (solving (1) & (2))
- Ans : E=20+2L