CLASS TEST

S.No. : 01_PT_ME_ABC_200722

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CASTING & WELDING

MECHANICAL ENGINEERING

Date of Test : 20/07/2022

ANSWER KEY

1.	(a)	7.	(a)	13.	(b)	19.	(b)	25.	(b)
2.	(b)	8.	(a)	14.	(c)	20.	(c)	26.	(a)
3.	(d)	9.	(a)	15.	(c)	21.	(b)	27.	(b)
4.	(b)	10.	(d)	16.	(b)	22.	(c)	28.	(a)
5.	(d)	11.	(a)	17.	(c)	23.	(c)	29.	(b)
6.	(d)	12.	(c)	18.	(d)	24.	(d)	30.	(b)

DETAILED EXPLANATIONS

1. (a)

$$\text{Volume of weld} = \frac{\pi}{4}d^2 l = \frac{\pi}{4} \times 1.5^2 \times 3.2 \times 1000$$

$$= 5652 \text{ mm}^3/\text{min}$$

$$\text{Area of weld} = \frac{5652}{\text{Welding speed}} = \frac{5652}{150} = 37.68 \text{ mm}^2$$

2. (b)

Given: $P = 6 \text{ g/cm}^3$

$T = 1 \text{ min } 50 \text{ s} = 1.833 \text{ min}$

$$\text{Permeability number, } R = \frac{501.28}{P \times T} = \frac{501.28}{6 \times 1.833} = 45.579$$

4. (b)

Volume of casting, $V_c = 15 \times 15 \times 15 = 3375 \text{ cm}^3$

Minimum volume of the riser to be approximately three times of percentage of shrinkage volume of casting.

Volume of riser, $V_r = 3 \times 0.065 \times V_c$

$= 3 \times 0.065 \times 3375$

$= 658.125 \text{ cm}^3$

5. (d)

Given: $I = 7000 \text{ A}$

$t = 0.3 \text{ sec}$

$R = 250 \text{ micro-}\Omega = 0.25 \times 10^{-3}\ \Omega$

Heat generated, $Q = I^2 Rt = (7000)^2 \times 0.25 \times 10^{-3} \times 0.3 \text{ J}$

$= 3675 \text{ J}$

6. (d)

Given: $d = 0.13 \text{ m}$, $h = 0.2 \text{ m}$

$\rho_c = 1500 \text{ kg/m}^3$, $\rho_z = 12000 \text{ kg/m}^3$

$$\text{Net force} = g.V(\rho_z - \rho_c) = 9.81 \times \frac{\pi}{4} \times (0.13)^2 \times 0.2(10500) = 273.442 \text{ N}$$

8. (a)

$$\text{Volume of casting } V_c = \frac{\pi}{4} \times 120^2 \times 180 = 2035752$$

$h_t = 180 + 50 = 230 \text{ mm}$

$A_c = A_{min} = \text{Sprue base area} = 400 \text{ mm}^2$

$$\text{Pouring time, } t = \frac{V_c}{A_c \times V_{max}} = \frac{2035752}{400 \times \sqrt{2 \times 9810 \times 230}} = 2.395 \text{ sec.}$$

10. (d)

Surface area of cube = $6l^2$

Surface area of sphere = $4\pi r^2$

According to Chorinov's relation

$$\text{Solidification time} \propto \left(\frac{\text{volume}}{\text{surface area}}\right)^2$$

as volume of cube and sphere are equal

$$\frac{t_c}{t_s} = \left(\frac{A_s}{A_c}\right)^2 = \left(\frac{4\pi r^2}{6l^2}\right)^2$$

$$\frac{t_c}{t_s} = \left(\frac{4\pi}{6}\right)^2\left(\frac{r}{l}\right)^4$$

11. (a)

$$\text{Power, } P = VI$$

$$4V + I = 240$$

$$V = \frac{240 - I}{4}$$

$$P = \left(\frac{240 - I}{4}\right) \times I$$

$$\frac{dP}{dI} = \frac{d}{dI}\left(\frac{240\,I - I^2}{4}\right)$$

$$240 - 2I = 0$$

$$I = 120 \text{ Amp.}$$

∴ Voltage for maximum power,

$$4V + I = 240$$

$$4V = 240 - 120$$

$$V = 30 \text{ Volt}$$

12. (c)

$$Q_{req.} = \frac{\pi}{4}d^2h \times 12 = \frac{\pi}{4} \times 4^2 \times 1.8 \times 12$$

$$= 271.434 \text{ J}$$

$$Q_{Supplied} = I^2Rt = (10000)^2 \times 120 \times 10^{-6} \times 0.2$$

$$= 2400 \text{ J}$$

$$Q_{lost} = Q_{Supplied} - Q_{Required}$$

$$= 2400 - 271.434 = 2128.56 \text{ J}$$

13. (b)

$$\text{Solidification time, } t_c = K\left(\frac{V}{A}\right)^2$$

Where V = Volume of casting

A = Surface area of casting

$$K = \text{Constant}$$

Given: For sphere and cube of given case, surface areas are same

i.e. $A_s = A_c$

or $4\pi R^2 = 6a^2$

$$\Rightarrow \quad \frac{R^2}{a^2} = \frac{6}{4\pi}$$

$$\text{Volume of sphere, } V_s = \frac{4}{3}\pi R^3$$

Where, R = Radius of sphere

Volume of cube, $V_c = a^3$

Where, a = Side of cube

$$\therefore \frac{\text{Solidification time of sphere}}{\text{Solidification time of cube}} = \frac{K.(V_s/A_s)^2}{K.(V_c/A_c)} \quad [\text{Where } A_s = A_c]$$

$$\frac{t_s}{t_c} = \left(\frac{V_s}{V_c}\right)^2 = \left(\frac{\frac{4}{3}\pi R^3}{a^3}\right)^2$$

$$= \left(\frac{4\pi}{3}\right)^2 \times \left(\frac{R^2}{a^2}\right)^3 = \left(\frac{4\pi}{3}\right)^2 \times \left(\frac{6}{4\pi}\right)^3 = \frac{6}{\pi}$$

14. (c)

$$\frac{V_t}{V_s} + \frac{I_t}{I_o} = 1$$

$$\frac{V_t}{60} + \frac{I_t}{600} = 1$$

$$V_t = 60\left(1 - \frac{I_t}{600}\right)$$

$$P = V_t I_t = 60 I_t \left(1 - \frac{I_t}{600}\right)$$

$$\frac{dP}{dI_t} = 60\left(1 - \frac{2I_t}{600}\right) = 0$$

$$I_t = \frac{600}{2} = 300A$$

$$V_t = 60 \times \frac{1}{2} = 30V$$

$$H_{\text{supplied}} = \frac{VI}{Av} \times \eta_h = \frac{300 \times 30}{20 \times v} \times 0.80 = \frac{360}{v}$$

$$H_{\text{supplied}} = 10$$

$$\eta_{\text{melting}} = \frac{H_{\text{required}}}{H_{\text{supplied}}} = \frac{10v}{360}$$

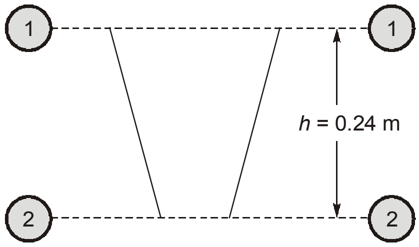
$$\Rightarrow \quad 0.25 = \frac{10v}{360}$$

$$\Rightarrow \quad v = 9 \text{ mm/s}$$

15. (c)

Given:

$$h = 0.24 \text{ m}$$
$$A_1 = 2.2 \text{ m}^2$$
$$Q = 3 \text{ m}^3/\text{s}$$
$$A_2 = ?$$



$$V_2 = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.24}$$
$$= 2.169 \text{ m/s}$$
$$Q = A_2 V_2$$
$$A_2 = \frac{3}{2.169} = 1.38 \text{ m}^2$$

16. (b)

For a linear power source,

$$V = V_{oc} - \left(\frac{V_{oc}}{I_{sc}}\right) \times I = 40 - \frac{40}{400} I$$

$$\text{Power, } P = VI = (40 - 0.1I)I$$

$$\text{For maximum power, } \frac{dP}{dI} = 0$$

$\Rightarrow$ $40 - 0.2I = 0$

$\Rightarrow$ $I = 200 \text{ A}$

$\Rightarrow$ $V = 20 \text{ V}$

Now, $P_{max.} = VI = 200 \times 20 = 4000 \text{W} = 4 \text{ kW}$

17. (c)

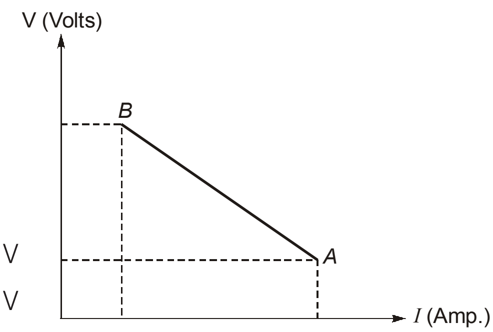
Power source characteristics is linear, as given,

$$V = 20 + 6L$$
$$L_1 = 4 \text{ mm}$$
$$L_2 = 6 \text{ mm}$$
$$I_1 = 450 \text{ amp}$$
$$I_2 = 350 \text{ amp}$$

Open circuit voltage, $V_{oc} = ?$

$\because$ $V_1 = 20 + 6L = 20 + 6 \times 4 = 44 \text{ V}$

$V_2 = 20 + 6L = 20 + 6 \times 6 = 56 \text{ V}$



From the formula, $V = V_{oc} - \left(\frac{V_{oc}}{I_{sc}}\right) I$

At (V_1, I_1), $44 = V_{oc} - \left(\frac{V_{oc}}{I_{sc}}\right) 450$ ... (i)

At (V_2, I_2), $56 = V_{oc} - \left(\frac{V_{oc}}{I_{sc}}\right) 350$ ... (ii)

After solving equations (i) and (ii), we get

$$V_{oc} = 98 \text{ V}$$

18. (d)

$$\text{Freezing ratio, } X = \frac{SA_{casting} / V_{casting}}{SA_{riser} / V_{riser}}$$

$$SA_{casting} = 2 \times 25 \times 25 + 4 \times 25 \times 5 = 1750 \text{ cm}^2$$
$$V_{casting} = 25 \times 25 \times 5 = 3125 \text{ cm}^3$$
$$V_{riser} = \frac{\pi D^3}{4} = 0.785 \times 12^3 = 1357.168 \text{ cm}^3$$
$$SA_{riser} = 2 \times \frac{\pi D^2}{4} + \pi D^2 = 1.5\,\pi D^2 = 1.5 \times 3.14 \times 144 = 678.58 \text{ cm}^2$$
$$X = \frac{(1750/3125)}{(678.58/1357.168)} = 1.12$$

19. (b)

Given:
$$K = 2 \text{ s/mm}^2 = 2 \times 10^6 \text{ s/m}^2$$
$$h = 1000 \text{ mm} = 1 \text{ m}$$
$$d = 720 \text{ mm} = 0.72 \text{ m}$$

$$\text{Solidification time, } t = K\left(\frac{\text{Volume}}{\text{Surface area}}\right)^2 = 2\left(\frac{\frac{\pi}{4}d^2h}{2\left(\frac{\pi}{4}d^2\right) + \pi dh}\right)^2$$
$$= 2\left(\frac{\frac{\pi}{4} \times 0.72^2 \times 1}{2\left(\frac{\pi}{4} \times 0.72^2\right) + \pi \times 0.72 \times 1}\right)^2 = 2\left(\frac{0.4072}{0.8143 + 2.2619}\right)^2$$
$$= 35044.22 \text{ sec} = 584.07 \text{ min}$$

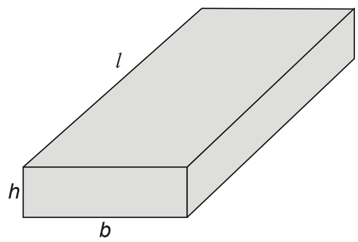
20. (c)

Given:
$$V = 30 \text{ V}$$
$$I = 250 \text{ A}$$
$$Q = 700 \text{ J/mm}$$
$$\eta = 0.8$$
$$\text{Speed, } C = ?$$
$$C = \frac{(\eta \cdot VI)}{Q} = \frac{0.8 \times 250 \times 30}{700}$$
$$= 8.57 \text{ mm/sec}$$
$$= 514.285 \text{ mm/min}$$

21. (b)

According to chronikov's rule,

$$t = k\left(\frac{V}{A}\right)^2$$



Now let l, b, h be the dimensions of cuboid,

$$V_i = lbh$$
$$A_i = 2[lb + bh + hl]$$

According to question, $V_f = (3l)(3b)(3h) = 3^3 V_i$

$$A_f = 2 \times 3^2\,[lb + bh + hl]$$

$$= 3^2 A_i$$

$$t_i = k\left(\frac{V_i}{A_i}\right)^2 \qquad t_f = k\left(\frac{3^2 V_i}{3^2 A_i}\right)^2$$

$$\frac{t_f}{t_i} = 9$$

$$\frac{t_f}{t_i} - 1 = 9 - 1$$

$$\left(\frac{t_f - t_i}{t_i}\right) \times 100 = 800\%$$

22. (c)

Given: $\dfrac{d_1 + d_2}{d_1 - d_2} = 3$

$$d_1 + d_2 = 3d_1 - 3d_2$$

$$2d_1 = 4d_2$$

$$d_1 = 2d_2$$

$$A_1 v_1 = A_2 v_2$$

For no, aspiration, $\dfrac{A_2}{A_1} = \sqrt{\dfrac{h_c}{0.2 + h_c}}$

$$\frac{d_2^2}{d_1^2} = \sqrt{\frac{h_c}{0.2 + h_c}}$$

$$\frac{d_2^2}{4d_2^2} = \frac{h_c}{0.2 + h_c} \qquad (d_1 = 2d_2)$$

$$0.2 + h_c = 16h_c$$

$$h_c = \frac{0.2}{15} = 0.01333 \text{ m} = 1.33 \text{ cm}$$

23. (c)

Pouring time, $t = 2.3\sqrt{w}$ sec

$$t = 2.3\sqrt{25} = 11.5 \text{ sec}$$

choke area = area of sprue base (1 : 2 : 2 - unpressurised casting)

$$A = \frac{w}{c\rho t\sqrt{2gh}} = \frac{25}{0.89 \times 8.0 \times 10^{-3} \times 11.5 \times \sqrt{2 \times 9.81 \times 20} \times 100}$$

where c is the flow efficiency factor

$$= 1.54 \text{ cm}^2$$

Sprue area at the top = $2\,A = 2 \times 1.54 = 3.08 \text{ cm}^2$

diameter of sprue at the top = $\sqrt{3.08 \times \dfrac{4}{\pi}} = 1.98$ cm

24. (d)

Let welding current $= I$

So, Heat generated $= VI = 40I$ J/s

Heat required for welding, $= \frac{\pi d^2}{4} \times R \times \rho \times (L + c_p \times \Delta T)$

$= \frac{\pi}{4} \times 1.5^2 \times 10^{-6} \times \frac{14}{60} \times 8000(265.6 \times 10^3 + 600 \times (1580 - 30)) = 3943.89$ J/s

Now, heat available for melting $= \eta_{electic} \times$ Heat generated

$= 0.65 \times 40 \times I = 26I$ J/s

Heat required for welding $= \eta_{melting} \times$ Heat available for melting

$3943.89 = 0.4 \times 26I$

$$I = \frac{3943.89}{10.4} = 379.22 \text{ Amp.} = 380 \text{ Amp.}$$

25. (b)

Power in this arc welding operation, $P = V.I.$

$P = 300 \times 20 = 6000$ W

The rate of heat used for welding is

= (melting factor × heat transfer factor × P)

$= 0.5 \times 0.7 \times 6000 = 2100$ Watt

The volume rate of metal welded

$$= \frac{2100 \text{ Joule/sec}}{10 \text{ Joule/mm}^3} = 210 \text{ mm}^3\text{/sec}$$

26. (a)

Given V_C = Volume of casting $= 20 \times 20 \times 5$ cm^3

$= 2000$ cm^3

for side riser $h = d$

$$\left(\frac{A}{V}\right)_r = \frac{6}{d}$$

Step-1:

V_r = Volume of riser = 3 × times the percentage shrinkage volume × V_C

linear shrinkage = 1%

= final dimension $= (1 - 0.01) \times a$

⇒ %volume shrinkage $= (1 - 0.99^3) \times 100\% = 2.97\%$

⇒ Volume shrinkage $= 2000 \times \frac{2.97}{100} = 59.402$ cm^3

⇒ $V_r = 3 \times 59.402 = 178.206 \text{ cm}^3 = \frac{\pi}{4} d^3$

⇒ $d = 6.1$ cm

⇒ $\left(\frac{A}{V}\right)_r = \frac{6}{d} = 0.983 \text{ cm}^{-1}$, but for casting, $\left(\frac{A}{V}\right)_c = \frac{(20 \times 20 + 2 \times 20 \times 5) \times 2}{2000}$

$= 0.6 \text{ cm}^{-1}$

⇒ $\left(\frac{A}{V}\right)_r \le \left(\frac{A}{V}\right)_c$ at critical condition

$$\Rightarrow \quad \left(\frac{A}{V}\right)_r = \left(\frac{A}{V}\right)_c$$

$$\Rightarrow \quad \frac{6}{d} = 0.6$$

$$\Rightarrow \quad d = 10 \text{ cm}$$

27. (b)

for steel rectangular plate

$$\text{volume, } V_1 = 7.5 \times 12.5 \times 2.0 = 187.5 \text{ cm}^3$$

$$\text{surface area, } A_1 = 2(7.5 \times 12.5 + 12.5 \times 2.0 + 2.0 \times 7.5)$$

$$= 267.5 \text{ cm}^2$$

$$t_{s1} = 1.6 \text{ min}$$

as we know

$$\text{chvorinov's rate, } t_{s1} = K\left(\frac{V}{A}\right)_1^2$$

$$\text{mould constant, } K = \frac{1.6}{\left(\frac{187.5}{267.5}\right)^2}$$

$$\text{mould constant, } K = 3.26 \text{ min/cm}^2$$

for cylindrical riser design

$$\text{Since} \quad \frac{D}{H} = 1.0 \text{ it is the condition for side riser}$$

$$V_2 = \frac{\pi D^3}{4}$$

$$A_2 = \pi D^2 + 2\pi D^2/4 = 1.5\pi D^2$$

$$\left(\frac{V}{A}\right)_2 = \left(\frac{D}{6}\right)$$

from chvorinov's equation

$$t_{s2} = K\left(\frac{V}{A}\right)_2^2$$

$$3.0 = 3.26\left(\frac{D}{6}\right)^2$$

$$D = 5.755 \text{ cm}$$

$$\frac{D}{H} = 1$$

$$\text{So,} \quad H = 5.755 \text{ cm}$$

28. (a)

$$\text{Energy input per unit length} = \frac{VI}{v} \times \eta_{HT} = \frac{500 \times 25}{5} \times 0.75 = 1875 \text{ J/mm}$$

29. (b)

$$t_s = \left(\frac{V}{A}\right)^2$$

$$\left(\frac{V}{A}\right)_{cube} = \frac{a^3}{6a^2} = \frac{a}{6}$$

For cube,
$$V = a^3 = 27$$
$$a = 3 \text{ cm}$$
$$\left(\frac{V}{A}\right)_{cube} = \frac{3}{6} = 0.5$$

For cylinder,
$$\frac{V}{A} = \frac{\pi R^2 h}{2\pi R^2 + 2\pi Rh} = \frac{Rh}{2R + 2h} = \frac{1 \times 6}{2 + 12} = \frac{6}{14}$$

$$\frac{(t)_{cylinder}}{(t)_{cube}} = \left(\frac{6}{14 \times 0.5}\right)^2 = 0.7347$$

$$(t)_{cylinder} = 0.7347 \times 180$$
$$= 132.246 \text{ sec} = 2.2 \text{ min}$$

30. (b)

Solidification time, $t_s = k\left(\frac{V}{A}\right)^2$

$$t_s \propto (\text{Thickness})^2$$

$$\frac{4}{2} = \left(\frac{t_2}{3}\right)^2$$

$$t_2 = 4.24 \text{ mm} \approx 4.2 \text{ mm}$$

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