CLASS TEST

S.No. : 01SPME_ABCD_290224

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CASTING and WELDING

MECHANICAL ENGINEERING

Date of Test : 29/02/2024

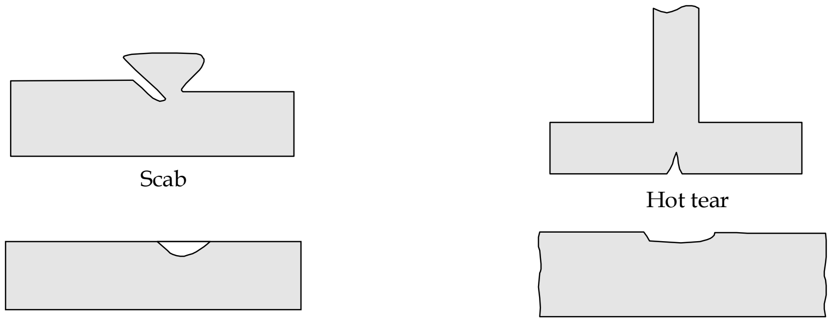
ANSWER KEY

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

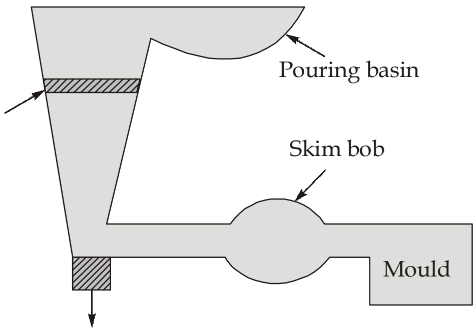
DETAILED EXPLANATIONS

1. (c)

Casting defects:



2. (b)



Pouring basin: Maintains constant pouring head and reduces eroding forces.
Strainer: Removes solid and foreing particles from molten metal.
Splash core: Reduces eroding force.

3. (c)

Given: $I_1 = 450A$, $D_1 = 60\%$, $I_2 = 1.1 \times 450 = 495\text{A}$

Since,
$$I^2D = \text{Constant}$$
$$I_1^2D_1 = I_2^2D_2$$
$$450^2 \times 60 = 495^2 \times D_2$$
$$D_2 = 49.59\%$$

4. (d)

Given: $d = 15$ cm, $h = 25$ cm, $A_g = 5$ cm^2, $h_t = 38$ cm,

$$\text{Volume of mould, } V = \frac{\pi}{4}d^2h = \frac{\pi}{4} \times 15^2 \times 25 = 4417.86 \text{ cm}^3$$

$$\text{Time of filling, } t_f = \frac{V}{A_g\sqrt{2gh_t}} = \frac{4417.86}{5 \times \sqrt{2 \times 981 \times 38}} = 3.24s$$

5. **(d)**

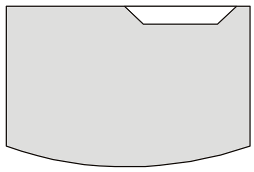
Factors affecting transverse shrinkage in butt weld are

1. Single V produces more shrinkage compared to double V.
2. More the total weight of the weld metal more the shrinkage.
3. Shrinkage increases with root opening.

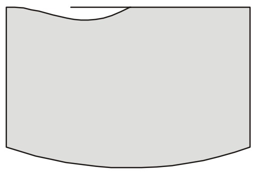
So, (d) configuration will have minimum shrinkage.

6. **(d)**

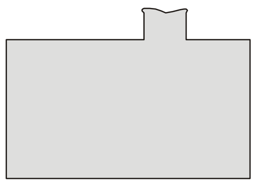
(a) Scar is usually found on flat casting surface.



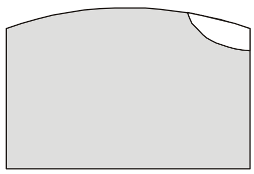
(b) Blister : It is scar covered by thin layer of metal.



(c) Drop : It is irregular projection on cope surface of casting.



(d) Blow : It is produced by gases and can be avoided by proper venting.



7. **(b)**

$$\left(\frac{V}{A_s}\right)_{\text{riser}} = \frac{\frac{\pi}{4}D^2H}{\pi DH + \frac{\pi}{4}D^2} = \frac{D}{5}$$

$$\left(\frac{V}{A_s}\right)_{\text{casting}} = \frac{25\times25\times5}{2[25\times25+25\times5+25\times5]} = 1.78$$

$$\text{Freezing ratio} = \frac{(V/A_s)_{\text{riser}}}{(V/A_s)_{\text{casting}}}$$

$$1.5 = \frac{D}{5\times1.78}$$

$$D = 13.35 \text{ cm}$$

$$r = D/2 = 6.68 \text{ cm}$$

8. (a)

Shape factor of casting, $SF = \frac{L+W}{T} = \frac{30+15}{6}$

$SF = 7.5$

So, $\frac{V_r}{V_c} = 0.6$

$$\frac{\pi}{4}D^2H = 0.6(30 \times 15 \times 6)$$

$$\frac{\pi}{4}D^3 = 1620$$

$$D = 12.73 \text{ cm}$$

9. (d)

Given: $I = 450$ A, $V = 20$ V, $v = 5$ mm/s, $E = 1170$ J/mm^3

Heat transfer efficiency, $\eta_{HT} = \frac{E \times v}{VI}$

$$\eta_{HT} = \frac{1170 \times 5}{20 \times 450} = 0.65$$

Percentage of heat transferred to surrounding is

$= 1 - 0.65 = 0.35 = 35\%$

10. (a)

In bottom gating system unfavourable temperature gradient is obtained.

11. (c)

$$V_p = 40 - \frac{I}{80}$$

$$V_a = 3l_a + 30$$

We know, $V_p = V_a$

$$40 - \frac{I}{80} = 3l_a + 30$$

$$I = (10 - 3l_a)80$$

Now, $\text{power} = V_a I = (3l_a + 30)[(80)(10 - 3l_a)]$

At $l_a = 2$ mm,

$$P_1 = (3(2) + 30)[80(10 - 3(2))]$$

$$P_1 = 11520 \text{ W}$$

and at $l_a = 3$ mm,

$$P_2 = (3(3) + 30)(80(10 - 3(3))$$

$$P_2 = 3120 \text{ W}$$

So, change in power

$$P_1 - P_2 = 11520 - 3120$$

$$P_1 - P_2 = 8400 \text{ W} = 8.4 \text{ kW}$$

12. (a)

For slush casting,

$$\text{thickness } (t) = C_1\sqrt{t_s} + C_2$$

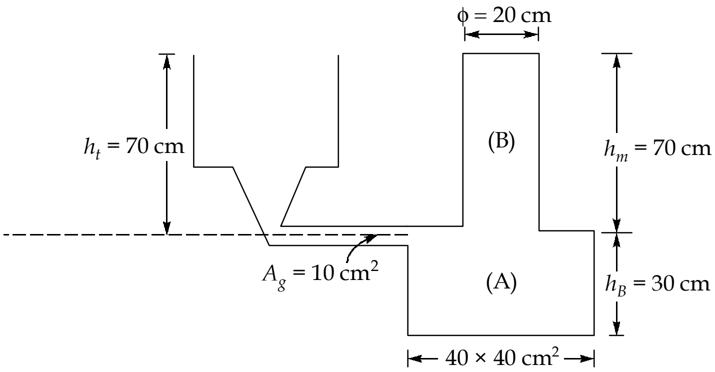
where t_s = solidification time

Now, $$t \propto \sqrt{t_s}$$

So, $$\frac{t_1}{t_2} = \sqrt{\frac{t_{s1}}{t_{s2}}}$$

$$\frac{16}{4} = \sqrt{\frac{10}{t_{s2}}} \Rightarrow t_{s2} = 0.625 \text{ min}$$

13. (c)



Filling time for cavity (A), as top gate,

$$t_{fA} = \frac{h_B A_m}{A_g V_g} = \frac{(30)(40\times 40)}{(10\sqrt{2g(h_t)})}$$

$$t_{fA} = \frac{30\times 40\times 40}{10\times\sqrt{2\times 981\times 70}}$$

$$t_{fA} = 12.95 \text{ s}$$

Filling time for cavity (B), as bottom gate,

$$t_{fB} = \frac{2A_m}{A_g}\frac{1}{\sqrt{2g}}\left(\sqrt{h_t} - \sqrt{h_t - h_m}\right)$$

$$t_{fB} = \frac{2A_m\sqrt{h_t}}{A_g\sqrt{2g}} \qquad (\text{Here } h_m = h_t)$$

$$t_{fB} = \frac{2\times\frac{\pi}{4}(20)^2\times\sqrt{70}}{10\times\sqrt{2\times 981}} = 11.87s$$

Total filling time, $t_f = t_{fA} + t_{fB}$

$= 12.95 + 11.87 = 24.82\text{s}$

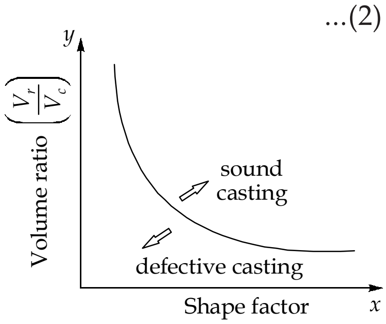
14. (a)

Plate dimensions: 25 × 12.5 × 5 cm^3

$$\text{Shape factor, } x = \frac{l+w}{t} = \frac{25+12.5}{5} = 7.5$$

$$x = 7.5 \quad \text{...(1)}$$

$$\text{Volume ratio } (y) = \frac{V_r}{V_c} \quad \text{...(2)}$$



for sound casting, $xy \geq 10$

for minimum volume of riser, $xy = 10$

Now, $xy = 10$

From equation (1) and (2), we get

$$(7.5)\left(\frac{V_r}{V_c}\right) = 10$$

$$7.5 \times \frac{V_r}{25 \times 12.5 \times 5} = 10$$

$$V_r = \frac{10 \times 25 \times 12.5 \times 5}{7.5} = 2083.33 \text{ cm}^3$$

Now, volume of cylindrical riser,

$$V_r = \frac{\pi}{4} d^2 h$$

$$2083.33 = \frac{\pi}{4}(h^3) \qquad (\because d = h)$$

$$h = 13.84 \text{ cm or } 0.1384 \text{ m}$$

15. (c)

Given: Current (I) = 15000 A

Resistance (R) = 200 μΩ

Time (t) = 0.1 s

Thickness (t_1) = 2 mm

So, heat supplied $(H_s) = I^2Rt = (15000)^2(200 \times 10^{-6})(0.1)$

= 4500 Joules

Now, diameter of nugget, $d_n = 6\sqrt{t_1} = 6\sqrt{2} = 8.485$ mm

height of nugget (h_n) = 2(thickness – indentation)

$$= 2\left(2 - \left(\frac{10}{100} \times 2\right)\right) = 3.6 \text{ mm}$$

So, volume of nugget $(V_n) = \frac{\pi}{4} d_n^2 \cdot h_n$

$$V_n = \frac{\pi}{4}(8.485)^2(3.6)$$

$$V_n = 203.561 \text{ mm}^3$$

$$V_n = 203.561 \times 10^{-3} \text{ cm}^3$$

Now, density of nugget = 10 gm/cm^3

So, mass of nugget = 10 × 203.561 × 10^{-3}

$$= 2.03561 \text{ gm}$$

and, total heat required for melting $= 1500 \times 2.03561$

$$= 3053.415 \text{ J}$$

then, efficiency $= \dfrac{\text{Heat required}}{\text{Heat supplied}}$

$$= \frac{3053.415}{4500} = 0.6785 = 67.85\%$$

16. (c)

Given: $L = 25$ cm, $B = 10$ cm, $H = 10$ cm, $k = 0.9 \times 10^6$ s/m², $d = h = 12$ cm

Solidification time of casting,

$$t_c = k\left(\frac{V}{A_s}\right)^2 = 0.9 \times \frac{10^6}{10^4}\left[\frac{25 \times 10 \times 10}{2(25 \times 10 \times 2 + 10 \times 10)}\right]^2$$

$$= 390.63 \text{ seconds}$$

Solidification time of riser,

$$t_r = k\left(\frac{V}{A_s}\right)^2 = 0.9 \times \frac{10^6}{10^4}\left[\frac{\frac{\pi}{4} \times d^2 \times h}{\frac{\pi}{4}d^2 + \pi dh}\right]^2$$

$$= 0.9 \times 100 \times \left(\frac{12}{5}\right)^2 = 518.4 \text{ seconds}$$

$$t_r - t_c = 518.4 - 390.63$$

$$= 127.77\text{s}$$

17. (d)

Given: $b = 1$ m, $V = 30$ V, $I = 550$ A, $n = 20$, $d = 4$ mm, $l = 32$ cm, $\eta_m = 40\%$, $\eta_{HT} = 70\%$, $E = 25$ J/mm³

Total volume of electrode used

$$= n \times \frac{\pi}{4} \times d^2 \times l$$

$$= 20 \times \frac{\pi}{4} \times 4^2 \times 320 = 80424.77 \text{ mm}^3$$

Area of weld, $A = \dfrac{80424.77}{1000} = 80.42 \text{ mm}^2$

Energy supplied = Energy consumed

$$\eta_{HT} \times \eta_M \times V \times I = E \times A \times v$$

$$0.7 \times 0.4 \times 30 \times 550 = 25 \times 80.42 \times v$$

$$v = 2.3 \text{ mm/s}$$

18. (b)

Given: $m = 35$ kg, Gating ratio = 1 : 2 : 2, $t_p = 13$ sec, $h = 220$ mm, $\rho = 7960$ kg/m³, $C_d = 0.85$

As it is a case of unpressurised gating system. So choke area will be at sprue base.

Choke area, A = Area of sprue base $= \dfrac{m}{\rho t_p C_d \sqrt{2gh}}$

$$A_s = \frac{35 \times 100^2}{7960 \times 13 \times 0.85\sqrt{2 \times 9.81 \times 0.22}} = 1.915 \text{ cm}^2$$

$$\text{Area of ingate} = 2 \times A_s$$

$$A_G = 3.83 \text{ cm}^2 = \frac{\pi}{4} d_G^2$$

$$d_G = 2.21 \text{ cm}$$

19. (a)

$$\text{Volume of casting} = 250 \times 125 \times 125$$
$$= 3906250 \text{ mm}^3$$
$$\text{Surface area of casting} = 2[250 \times 125 \times 2 + 125 \times 125]$$
$$= 156250 \text{ mm}^3$$

$$t_s = k\left(\frac{V}{A}\right)^2 = 1.8\left(\frac{3906250}{156250}\right)^2 = 1125s$$

20. (c)

Given : $V = 23 + 5l$, OCV = 96 V, SSC = 720 A

Voltage-ampere characteristic is given by,

$$V = OCV - \left(\frac{OCV}{SSC}\right)I$$

$$V = 96 - \left(\frac{96}{720}\right)I$$

For stable arc,

$$23 + 5l = 96 - \left(\frac{96}{720}\right)I$$

$$I = (73 - 5l)7.5$$
$$P = VI$$
$$P = (23 + 5l)(73 - 5l)7.5 = 7.5\,(1679 + 250l - 25l^2)$$

For maximum power,

$$\frac{dP}{dl} = 0$$

$$\frac{dP}{dl} = 250 - 5l = 0$$

$$l = \frac{250}{50} = 5 \text{ mm}$$

$$\text{Power at optimum length} = (23 + 5 \times 5)\,(73 - 5 \times 5) \times 7.5$$
$$= 17280 \text{ W}$$

21. (a)

Given : $I = 10000\text{A}$, $t = 10 \times 10^{-3}$ s, $h = 4$ mm, $d = 3$ mm, $h_{fg} = 1400$ kJ/kgK,
$\rho = 7500$ kg/m^3, c = 600 J/kgK, $T_m = 1795$ K, $T_s = 298$ K, $\eta_m = 60\%$

Heat required to form weld nugget,

$$Q = \rho \times \frac{\pi}{4} d^2 \times h \times \left[c \times (T_m - T_s) + h_{fg}\right]$$

$$= 7500 \times \frac{\pi}{4} \times (0.003)^2 \times 0.004 \times \left[600 \times (1795 - 298) + 1400 \times 10^3\right]$$

$$= 487.35 \text{ J}$$

$$\text{Melting efficiency, } \eta_m = \frac{Q}{I^2 Rt}$$

$$0.6 = \frac{487.35}{10000^2 \times R \times 10 \times 10^{-3}}$$

$$R = 8.1225 \times 10^{-4}\ \Omega$$

$$R = 812.25\ \mu\Omega$$

22. (d)

$$\text{Volume shrinkage} = 0.03 \times 26 \times 13.5 \times 6$$

$$= 63.18\ \text{cm}^3$$

$$\text{Volume of riser} = 4 \times 63.18$$

$$= 252.72\ \text{cm}^3$$

$$\frac{\pi}{4} d^2 \times h = \frac{\pi}{4} d^3 = 252.72$$

$$d = 6.85\ \text{cm}$$

But, for sound casting riser should solidify after casting so

$$\left(\frac{V}{A_s}\right)_{riser} \geq \left(\frac{V}{A_s}\right)_{casting}$$

$$\left(\frac{d'}{6}\right) > \left(\frac{26 \times 13.5 \times 6}{2(26 \times 13.5 + 13.5 \times 6 + 26 \times 6)}\right)$$

$$d' > 10.74\ \text{cm}$$

As $d < d'$

So, minimum diameter of riser should be 10.74 cm.

23. (b)

$$\text{Cross-section area of weld} = \frac{1}{2} \times (13 + 9) \times 10 = 110\ \text{mm}^2$$

$$\eta \times VI = E \times A_{weld} \times v$$

$$0.9 \times 40 \times 420 = 9.4 \times 110 \times v$$

$$v = 14.62\ \text{mm/s} \simeq 14.7\ \text{mm/s}$$

24. (b)

Given: h = 2 mm, I = 7200 A, t = 0.3s, d = 5 mm, H_D = 2500 J, R = 220 μΩ.

$$\text{Heat generated} = I^2Rt = 7200^2 \times 220 \times 10^{-6} \times 0.3$$

$$= 3421.44\ \text{J}$$

$$\text{Volume of nugget} = \frac{\pi}{4} d^2 h = \frac{\pi}{4} \times 5^2 \times 4 = 78.54\ \text{mm}^3$$

Energy required (E) = Heat generated – Head dissipated

$$E = 3421.44 - 2500 = 921.44\ \text{J}$$

For 1 mm^3,

$$\frac{E}{V} = \frac{921.44}{78.54} = 11.73\ \text{J/mm}^3$$

25. **(c)**

Under cutting : It is generally due to excessive welding speed, big electrodes.

Porosity : It is caused by entrapment of gas bubbles by freezing dendrite during cooling of weld pool.

Spatter : It occurs due to arc blow, long arc length.

Lack of fusion : It is usually caused by insufficient heat or too fast travel of torch.

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