CLASS TEST

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CASTING and WELDING

MECHANICAL ENGINEERING

Date of Test : 18/05/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (d)

Strainer : It is a ceramic coated screen with many holes in sprue which removes dross.
Splash core : It reduces eroding force of liquid metal thus preventing mould erosion.
Skim bob : It prevents heavier and lighter impurities from reaching mould cavity.

2. (c)

Power input × η_{melt} × $\eta_{transfer}$ = Energy required

$$3000\,\text{J/sec} \times 0.80 \times 0.4 = 26\,\text{J/mm}^3 \times 20 \times v$$

$$\text{Weld speed, } v = 1.846\text{ mm/s} \simeq 1.85\text{ mm/s}$$

3. (d)

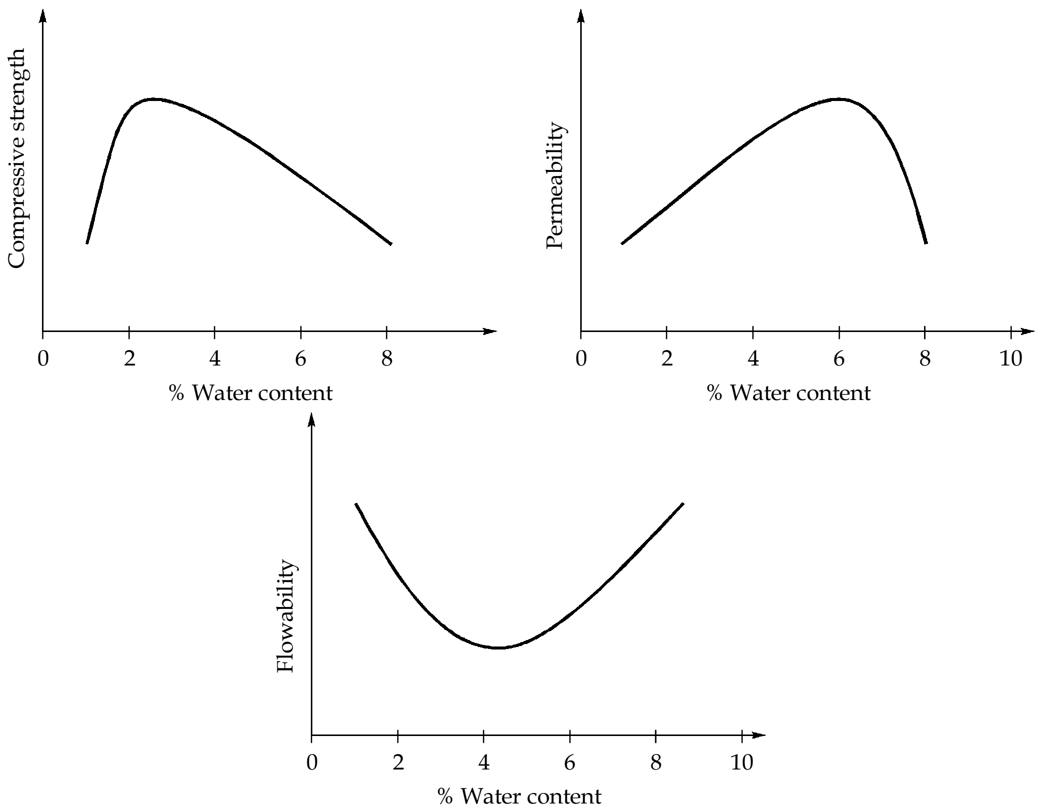
$$t_1 = \frac{V}{\left(A \times \sqrt{2gh}\right)}$$

Now, for t_2 we have $h_2 = 4h,\ A_2 = \dfrac{A}{2}$

$$t_2 = \frac{V}{\left[\left(\frac{A}{2}\right) \times \sqrt{2g \times 4h}\right]}$$

So, $$\frac{t_2}{t_1} = 1$$

4. (d)



5. (d)

Given : $I = 50\text{ A}, V = 10\text{ V}, v = 100\text{ mm/min}$

$$\text{Heat input} = \frac{VI}{v} = \frac{10\times50\times60}{100} = 300\text{ J/mm}$$

6. (d)

According to Chvorinov's rule,

$$t_s \propto \left(\frac{\text{Volume}}{\text{Surface area}}\right)^2$$

$$\Rightarrow \quad t_s \propto \left(\frac{V}{A}\right)^2$$

$$\therefore \quad \left(\frac{V}{A}\right)_{cube} = \left(\frac{a}{6}\right)$$

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

$$\therefore \quad \frac{(t_s)_{cube}}{(t_s)_{sphere}} = \frac{(a/6)^2}{(a/6)^2} = 1:1$$

7. (b)

Volume of weld = 5V mm^3/s; V = Velocity of welding

Energy required = 10 × 5V = 50V J/s

Now, $(2 \times 10^3) \times 0.5 \times 0.7 = 50V$

$\Rightarrow \quad V = 14\text{ mm/s}$

8. (c)

9. (a)

In investment casting, complex shape of the objects with high melting point materials are produced.

10. (c)

AC welding should be used in place of DC to nullify effect of magnetic field which ultimately reduces arc blow.

11. (b)

Energy required for the weld operation = Specific energy × Area of weld bead

$= 19\text{ J/mm}^3 \times 20\text{ mm}^2$

$= 380\text{ J/mm}$

Energy supplied $= VI$

$= 120 \times 30$

$= 3600\text{ J/s}$

$$\eta_{th} = \frac{\text{Energy required}}{\text{Energy supplied}}$$

$$0.70 = \frac{380 \times v}{3600}$$

$\Rightarrow$ Weld speed = 6.6315 mm/s

12. (c)

$$V_{arc} = 20 + 4l$$

for l = 5 mm, V_{arc} = 40 V

for l = 7 mm, V_{arc} = 48 V

$$V = V_O - \frac{V_O}{I_S} I$$

$$40 = V_O - \frac{V_O}{I_S} \times 500 \qquad \text{...(i)}$$

$$48 = V_O - \frac{V_O}{I_S} \times 400 \qquad \text{..(ii)}$$

From equation (i) and (ii),

$$-8 = \frac{V_O}{I_S}(400 - 500)$$

$$\frac{V_O}{I_S} = \frac{8}{100}$$

$$40 = V_O - \frac{8}{100} \times 500$$

$$V_O = 80 \text{ Volt}$$

13. (a)

$$Z = \frac{L + W}{t}$$

Z = Shape factor, L = Length, w = Width, t = Thickness

$$Z = \frac{35 + 20}{10} = 5.5$$

$$\frac{\text{Riser volume}}{\text{Casting volume}} = 0.35$$

$$\frac{\frac{\pi d^2}{4} \times h}{35 \times 20 \times 10} = 0.35$$

$$\frac{\pi d^3}{4} = 0.35 \times 35 \times 20 \times 10$$

$$d = 14.61 \text{ cm}$$

14. (c)

$$h = 20 \text{ cm}$$

$$A_{base} = 2.5 \text{ cm}^2$$

$$\text{Volume} = 1560 \text{ cm}^3$$

The velocity of the molten metal at the base,

$$v = \sqrt{2 \times 981 \times 20} = 198.1 \text{ cm/s}$$

Volumetric of flow rate, $Q = A_{\text{base}} \times v$

$= 2.5 \times 198.1 = 495.227 \text{ cm}^3/\text{s}$

Time required to fill the mold cavity,

$$t = \frac{\text{Volume}}{Q}$$

$$= \frac{1560}{495.227} = 3.15 \text{ sec}$$

15. (a)

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

$$\text{For cube, } V = L^3,\ A = 6L^2$$

$$t_{\text{cube}} = k\left(\frac{L}{6}\right)^2$$

$$\text{For cylinder, } V = \frac{\pi}{4}D^3$$

$$A = 2\times\frac{\pi}{4}D^2 + \pi D^2 = \frac{3\pi D^2}{2}$$

$$t_{\text{cylinder}} = k\left(\frac{D}{6}\right)^2$$

$$\text{Ratio of solidification time, } \frac{t_{cube}}{t_{cylinder}} = \left(\frac{L}{D}\right)^2$$

16. (d)

Given, $t_{\text{casting}} = 50\% \text{ of } t_{\text{riser}}$

Using Chvorinov's rule,

$$k\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{2}k\left(\frac{V_r}{A_r}\right)^2$$

$$\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{2}\left(\frac{\frac{4}{3}\pi r^3}{4\pi r^2}\right)^2 = \frac{1}{2}\left(\frac{r}{3}\right)^2$$

$$\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{2}\left(\frac{d}{6}\right)^2 = \frac{1}{2}\left(\frac{2}{6}\right)^2$$

$$\left(\frac{V_c}{A_c}\right)^2 = \frac{1}{18} \quad \text{...(i)}$$

For casting L = 2W = 4H

$$\Rightarrow \quad W = \frac{L}{2} \text{ and } H = \frac{L}{4}$$

Thus,
$$\frac{V_c}{A_c} = \frac{(L)\left(\frac{L}{2}\right)\left(\frac{L}{4}\right)}{2\left((L)\left(\frac{L}{2}\right)+\left(\frac{L}{2}\right)\left(\frac{L}{4}\right)+\left(\frac{L}{4}\right)(L)\right)}$$

$$\frac{V_c}{A_c} = \frac{\frac{L^3}{8}}{2\left(\frac{L^2}{2}+\frac{L^2}{8}+\frac{L^2}{4}\right)} = \frac{\frac{L^3}{8}}{\frac{7L^2}{4}} = \frac{L}{7(2)} = \frac{L}{14}$$

From equation (i), $\left(\frac{L}{14}\right)^2 = \frac{1}{18}$

$$L^2 = \frac{14^2}{18}$$

$\Rightarrow$ $$L = \frac{14}{\sqrt{18}} = 3.3 \text{ cm}$$

17. (b)

For gray cast iron, the shrinkage allowance is positive like all other metals. It expands only during solidification and not in solid state.

Thus, pattern dimensions after considering shrinkage allowance are:

$$l = 250+\left(\frac{10}{1000}\times 250\right) = 252.5 \text{ mm}$$

$$W = 100+\left(\frac{10}{1000}\times 100\right) = 101 \text{ mm}$$

$$t = 50+\left(\frac{10}{1000}\times 50\right) = 50.5 \text{ mm}$$

Now, shake allowance is a negative allowance and is given only on the dimensions parallel to the parting line.

Therefore, dimensions after shake allowance,

$\therefore$ $l = 252.5 - 2 = 250.5$ mm

$W = 101 - 2 = 99$ mm

$t = 50.5$ mm

Thus, volume of pattern $= l \times w \times t$

$= 250.5 \times 99 \times 50.5$

$= 1252374.75 \text{ mm}^3$

$= 12.52 \times 10^{-4} \text{ m}^3$

18. (b)

Area to be welded, $A = \frac{1}{2}bh = \frac{1}{2}\times 10\times 10 = 50 \text{ mm}^2$

Now, thermal efficiency,

$$\eta_{th} = \frac{\text{Energy required for melting}}{\text{Energy supplied by power source}}$$

$$= \frac{u \times A \times v}{VI}$$

where, u = specific energy, v = welding speed

$$\therefore \quad I = \frac{u \times A \times v}{V \times \eta_{th}} = \frac{10.5 \times 50 \times 10}{30 \times 0.8} = 218.75\,A$$

19. (c)

Given: L = 1000 mm, d = 750 mm, k = 2 s/mm^2,

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

$$\left(\frac{V}{A}\right)_{cylinder} = \frac{\frac{\pi}{4}D^2L}{2 \times \frac{\pi}{4}D^2 + \pi DL} = \frac{D^2L}{2D^2 + 4DL}$$

$$= \frac{(750)^2 \times 1000}{2(750)^2 + 4 \times 750 \times 1000} = 136.36 \text{ mm}$$

Now the solidification time,

$$t = k\left(\frac{V}{A}\right)^2 = 2 \times (136.36)^2$$

$$= 37188.1 \text{ s} = 619.8 \text{ min} \simeq 620 \text{ minutes}$$

20. (c)

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

$$5V + I = 250$$

$$V = \frac{1}{5}(250 - I)$$

$$P = \frac{1}{5}(250I - I^2)$$

For maximum arc power,

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

$$250 - 2I = 0$$

$$\therefore \quad I = 125\text{A}$$

21. (a)

$$V = OCV - \frac{OCV}{SSC}I$$

$$V = 62 - \frac{62}{130}I$$

$$V = 20 + 1.5\text{ L} = 20 + 1.5 \times 4 = 26 \text{ V}$$

For L = 4 mm,

$$26 = 62 - \frac{62}{130}I$$

$$\Rightarrow \qquad I = 75.5 \text{ A}$$

$$\text{Power consumed} = V \times I$$

$$P = 75.5 \times 26 = 1963 \text{ W}$$

$$\text{Heat input into work-piece} = 0.85 \times 1963 = 1668.25 \text{ W} \simeq 1668 \text{ W}$$

22. **(b)**

$$\text{Solidification time for riser when uninsulated} = k\left(\frac{V}{A}\right)^2 = k\left[\frac{\pi}{4}\frac{d^2h}{\pi dh}\right]^2 = \frac{kd^2}{16}$$

Solidification time doubles when insulation is used,

$$(t_s) = 2(t_s)_{\text{riser without insulation}}$$

$$= 2\frac{kd^2}{16} = \frac{kd^2}{8}$$

To prevent macroporosity or solidification shrinkage

$$(t_s)_{\text{riser}} = (t_s)_{\text{casting}}$$

$$\Rightarrow \qquad \frac{kd^2}{8} > k\left(\frac{a^3}{6a^2}\right)^2$$

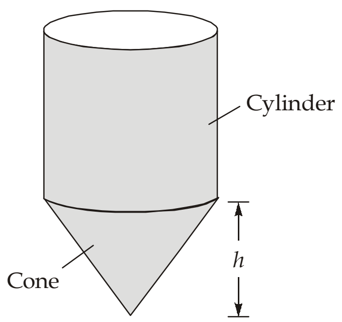
$$\Rightarrow \qquad \frac{d^2}{8} > \frac{a^2}{36}$$

$$\Rightarrow \qquad d^2 > \frac{8a^2}{36} = \frac{8\times 10^2}{36}$$

$$d > 4.714$$

$$d_{\min} \approx 4.8 \text{ cm}$$

23. **(a)**



$$\text{Size of casting} = \text{Volume of cone} + \text{volume of cylinder}$$

$$= \frac{\pi r^2 h}{3} + \pi r^2 (15 - h)$$

$$= \frac{\pi \times 7^2 \times 5}{3} + \pi \times 7^2 \times 10 = 1795.944 \text{ cm}^3 \simeq 1796 \text{ cm}^3$$

24. (a)

Using modulus method,

$$m_r = 1.2\, m_c$$

and for cylindrical top riser, $m_r = \dfrac{V}{A} = \dfrac{\frac{\pi}{4}D^2}{\pi D^2 + \frac{\pi}{4}D^2} = \dfrac{D}{5}$

$$\therefore \quad D = 6\, M_c$$

$$= 6\left(\frac{V}{A}\right)_C = 6\times\left(\frac{30\times30\times10}{2(30\times30+30\times10+10\times30)}\right) = 18 \text{ cm}$$

25. (d)

Heat required to melt, $Q_R = \dfrac{\pi}{4}\times d^2\times h\times\rho\times u$

$$Q_R = \frac{\pi}{4}\times 4^2\times 1.5\times 0.0078\times 1795$$

$$= 263.912 \text{ J}$$

Heat supplied to weld, $Q_S = I^2Rt$

$$Q_S = (15000)^2 \times (100 \times 10^{-6}) \times 0.5$$

$$= 11250 \text{ J}$$

Heat lost to the surrounding, $Q_{\text{lost}} = Q_S - Q_R$

$$Q_{\text{lost}} = 11250 - 263.912$$

$$= 10986.08 \text{ J} = 10.986 \text{ kJ}$$

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Questions For Next Test

Q.29 The casting defect in which rough spots of excess metal appears because of erosion of moulding sand is known as

(a) Drop (b) Swell

(c) Metal penetration (d) Cuts

29. **(d)**

Cuts and washes : If velocity of molten metal is high or strength of mould is less then it results in erosion of moulding sand and results in appearance of rough spots.

Q.31 With an increase in the carbon content of steel alloys, its weldability

(a) increases (b) is not affected

(c) decreases (d) none of these

31. **(c)**

We know that carbon equivalent is

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

More the carbon equivalent, lesser is the weldabiltity of steel.

Q.32 The grain structure in the heat affected zone (HAZ) near the weld interface

(a) becomes coarser (b) becomes finer

(c) becomes columnar (d) remains unaffected

32. **(a)**

The metal in this zone has experienced temperatures that are below its melting point, yet high enough to cause microstructural changes in the solid metal. As a result the grains tend to grow in size, leading this area a coarser grain structure.

Q33 Which of the following metal transfer methods in GMAW has the highest deposition rate?

(a) short circuit transfer (b) globular transfer

(c) spray transfer (d) rotating spray transfer

33. **(d)**

Q.34 A sand core having volume 2500 cm^3 is used in the casting of a cast iron machine part. The density of core sand and cast iron is 1500 kg/m^3 and 6000 kg/m^3, respectively. The net force acting on the core during pouring is __________ N. (Take acceleration due to gravity, g = 10 m/s^2)

(a) (b)

(c) (d)

34. **112.5 (112 to 113)**

$$\text{Buoyancy force} = V_{core}(\rho_m - \rho_c)g$$
$$= 2500 \times 10^{-6}(6000 - 1500) \times 10 = 112.5 \text{ N}$$

Q.35 A direct current welding machine has the characteristics $5V + I = 250$, where V is the voltage and I is the current in ampere. At the maximum arc power, the current through the electrode is

(a) 25 ampere (b) 75 ampere

(c) 125 ampere (d) 250 ampere

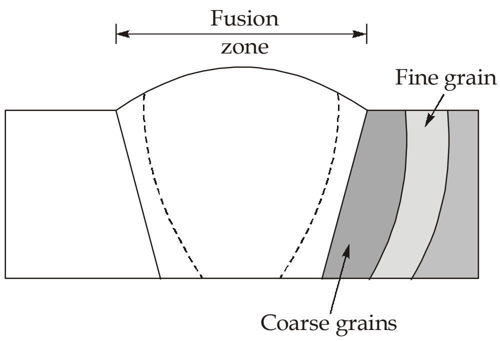
35. **(c)**

$$\text{Power, } P = VI$$
$$5V + I = 250$$
$$V = \frac{1}{5}(250 - I)$$
$$P = \frac{1}{5}(250I - I^2)$$

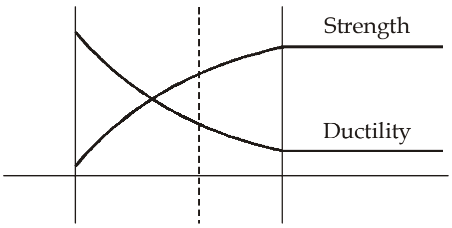
For maximum arc power,

$$\frac{dP}{dI} = 0$$
$$250 - 2I = 0$$
$$\therefore \quad I = 125\text{ A}$$

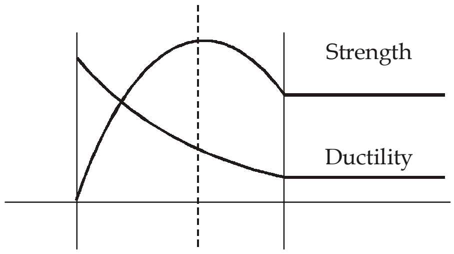
Q.36 Which of the following graph is correct representation between the ductility and strength in heat affected zone.



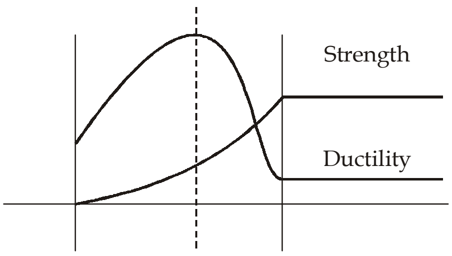
(a)



(b)



(c)



(d) None of these

36. **(c)**

Q.20 The voltage arc length characteristics of a DC current are is given by $V = (20 + 40L)$ Volt where L is the arc length in cm. The power source are approximate by a straight line with an open circuit voltage 80 V and short circuit current 1000 A. The relation between arc length (L) and corresponding power (P) is given by

(a) $P = 2000\ (1 + 2L)\ (3 - 2L)$ (b) $P = 5000\ (1 - 2L)\ (3 + 2L)$

(c) $P = 5000\,(1 + 2L)\,(3 - 2L)$ (d) $P = 2000\,(1 - 2L)\,(3 + 2L)$

20. **(c)**

Given: $V = 20 + 40L$

Power source characteristic equation can be written as,

$$\frac{V}{V_o} + \frac{I}{I_s} = 1$$

$$\Rightarrow \quad \frac{V}{80} + \frac{I}{1000} = 1$$

$$I = 1000\left(1 - \frac{V}{80}\right) = 1000 - 12.5V$$

$$= 1000 - 12.5(20 + 40L)$$

$$= 1000 - 250 - 500L$$

$$= 750 - 500L$$

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

$$= (20 + 40L)\,(750 - 500L)$$

$$= 20(1 + 2L) \times 250\,(3 - 2L)$$

$$P = 5000\,(1 + 2L)\,(3 - 2L) \text{ W}$$

Q.24 An electric-arc welding has the following VI characteristic.

$V = 9 + 7l$

where l is the length of arc in cm. The power source characteristic is approximated by a straight line with an open circuit voltage 36 V and a short circuit current 600 A. The optimum arc length is ________ mm.

(a) (b)

(c) (d)

24. **(12.86) (12.50 to 13.30)**

$$V_{OC} = 36 \text{ V} \qquad I_{SC} = 600 \text{ A}$$

Power characteristics is, $V = V_0\left(1 - \frac{I}{I_s}\right) = 36\left(1 - \frac{I}{600}\right)$ ... (i)

Arc characteristics, $V = 9 + 7l$ ... (ii)

Put V in to equation (i)

$$9 + 7l = 36\left(1 - \frac{I}{600}\right) = 36 - 36 \times \frac{I}{600}$$

$$36 \times \frac{I}{600} = 36 - 9 - 7l$$

$$I = \frac{600}{36}(27 - 7l)$$

$$P = VI = (9 + 7l)\frac{600}{36}(27 - 7l)$$

$$P = \frac{600}{36}(243 - 63l + 189l - 49l^2)$$

$$\text{for maximum power, } \frac{dp}{dl} = 0$$

$$-63 + 189 - 49 \times 2l = 0$$

$$l = 1.2857 \text{ cm}$$

$$l = 12.857 \text{ mm}$$

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