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CASTING+WELDING+FORMING

MECHANICAL ENGINEERING

Date of Test : 22/10/2026

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. (d)

As per given data,

$$\rho_f = 750 \text{ kg/m}^3, \rho_{\text{top}} = 320 \text{ kg/m}^3$$

 $\therefore$ Average density of liquid vapour mixture in the riser tube,

$$\rho_m = \frac{\rho_f + \rho_{\text{top}}}{2} = \frac{750 + 320}{2} = 535 \text{ kg/m}^3$$

$$\therefore \Delta P = gH(\rho_f - \rho_m)$$

$$\Delta P = 9.81 \times 20 \times (750 - 535)$$

$$\Delta P = 42.18 \text{ kPa}$$

2. (a)

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

3. (c)

The size of the round blank is given by

$$D = \sqrt{d^2 + 4dh} = \sqrt{(25)^2 + 4 \times 25 \times 15} = 46.09 \text{ mm}$$

4. (b)

Volume of weld = $5V \text{ mm}^3/\text{s}$; V = Velocity of weldingEnergy required = $10 \times 5V = 50V \text{ J/s}$ Now, $(2 \times 10^3) \times 0.5 \times 0.7 = 50V$

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

5. (b)

$$\text{Heat required, } H_r = 0.1 \times 40 \times \frac{100}{60} = 6.67 \text{ kJ/sec}$$

 $\therefore$ Efficiency of welding,

$$\eta_{\text{welding}} = \frac{H_r}{H_s} \times 100 = \frac{6.67}{14} \times 100 = 47.61\%$$

 $\therefore$ Based on the efficiency, the welding process used is arc welding process.

For arc welding efficiency varies as 45 to 55%.

6. (d)

$$I_r = 110 \text{ A}, D_r = 60\%, I_d = 150 \text{ A}$$

$$\text{Duty cycle, } I_r^2 \times D_r = I_d^2 \times D_d$$

$$\therefore D_d = I_r^2 \times \frac{D_r}{I_d^2} = 60 \left(\frac{110}{150} \right)^2 = 32.26\%$$

$$\therefore \text{Percentage reduction in the output cycle} = \frac{60 - 32.26}{60} \times 100 = 46.22\%$$

7. (b)

As bend radius, $R \geq 2t$; stretch factor, $k = 0.5$

So bend allowance, $L_b = \alpha(R + kt) = 1(98 + 0.5 \times 4) = 100 \text{ mm}$

8. (a)

$$A_1 v_1 = A_2 v_2$$

$$d_1^2 \sqrt{h_c} = d_2^2 \sqrt{30 + h_c}$$

$$\Rightarrow \left(\frac{d_1}{d_2} \right)^4 = \frac{30 + h_c}{h_c}$$

Given; $\frac{d_1 + d_2}{d_1 - d_2} = 3$

$$4d_2 = 2d_1$$

$$\Rightarrow \frac{d_1}{d_2} = 2$$

$$\Rightarrow (2)^4 = \frac{30 + h_c}{h_c}$$

$$h_c = 2 \text{ cm}$$

9. (c)

$$\begin{aligned} \text{Dimensions of casting} &= 200 \times 100 \times 50 \text{ mm}^3 \\ &= 0.2 \times 0.1 \times 0.05 \text{ m}^3 \end{aligned}$$

$$\text{Density of molten metal, } \rho = 7500 \text{ kg/m}^3$$

$\therefore$ Mass of a single unit of casting,

$$m = \rho \times 0.2 \times 0.1 \times 0.05$$

$$m = 7500 \times 0.2 \times 0.1 \times 0.05 = 7.5 \text{ kg}$$

$$\begin{aligned} \text{Casting yield} &= \frac{\text{Mass of casting (m)}}{\text{Mass of molten metal supplied}} \\ &= \frac{7.5}{12.5} = 0.6 \end{aligned}$$

10. (a)

Given: Initial thickness of sheet, $h_1 = 40 \text{ mm}$

Roller diameter, $D = 300$ ($\therefore R = 150 \text{ mm}$)

Coefficient of friction, $\mu = 0.25$

Maximum possible reduction,

$$\begin{aligned} \Delta H_{\max} &= \mu^2 R \\ h_1 - h_{2,\min} &= 0.25^2 \times 150 \\ h_{2,\min} &= 40 - 0.25^2 \times 150 \\ &= 30.625 \text{ mm} \simeq 30.6 \text{ mm} \end{aligned}$$

11. (d)

Given : $I = 9950\text{ A}$; $R = 0.00015\ \Omega$; $u = 8\text{ J/m}^3$; $V = 72\text{ mm}^3$

Heat required for melting, $H_m = uV$

$$H_m = 8 \times 72 = 576\text{ Joule}$$

Total energy to be supplied by source,

$$H_s = 576 + 454 = 1030\text{ J}$$

$$\therefore \text{Thermal efficiency, } \eta = \frac{H_m}{H_s}$$

$$\eta = \frac{576}{1030} = 0.5592 \text{ or } 55.92\%$$

12. (a)

$$\text{Time taken for welding, } t = \frac{\text{Length of weld}}{\text{Welding speed}}$$

$$t = \frac{300}{150} = 2\text{ minutes} = 120\text{ seconds}$$

$$\therefore \text{Total energy supplied} = 120 \times 2 = 240\text{ kJ}$$

$$\begin{aligned} \text{Thus, percentage utilization} &= \frac{\text{Total energy utilized}}{\text{Total energy supplied}} \times 100 \\ &= \frac{60}{240} \times 100 = 25\% \end{aligned}$$

13. (c)

For punching operation,

$$\text{Punch size} = \text{Hole size} = d$$

The maximum crushing stress induced in the punching tool,

$$\sigma_{c, \max} = \frac{4F}{\pi d^2} \quad \dots(i)$$

The maximum allowable shearing stress,

$$\tau_{s, \max} = \frac{F}{\pi dt} \quad \dots(ii)$$

Since,

$$\sigma_{c, \max} = 4\tau_{s, \max}$$

$$\frac{4F}{\pi d^2} = 4\left(\frac{F}{\pi dt}\right)$$

$$\Rightarrow d = t$$

$\therefore$ The required ratio is 1.

14. (b)

For arc length, $L_1 = 4\text{ mm}$; $I_1 = 600\text{ A}$; $V_1 = 25 + 5 \times 4 = 45\text{ V}$

and for arc length, $L_2 = 6\text{ mm}$; $I_2 = 400\text{ A}$; $V_2 = 25 + 5 \times 6 = 55\text{ V}$

For linear power source,

$$V = V_0 \left(1 - \frac{I}{I_s}\right)$$

$$\therefore 45 = V_0 \left(1 - \frac{600}{I_s} \right) \quad \dots(i)$$

$$55 = V_0 \left(1 - \frac{400}{I_s} \right) \quad \dots(ii)$$

Solving (i) and (ii),

$$I_s = 1500 \text{ A}$$

15. (c)

16. (a)

Given : $d_0 = 150 \text{ mm}$; $h_0 = 100 \text{ mm}$; $h_f = 75 \text{ mm}$; $k = 1000 \text{ MPa}$; $n = 0.3$

$$\text{True strain, } \epsilon = \ln \left(\frac{h_0}{h_f} \right) = \ln \left(\frac{100}{75} \right) = 0.288$$

Flow curve equation for the material,

$$\begin{aligned} \sigma &= k\epsilon^n = 1000\epsilon^{0.3} \\ &= 1000(0.288)^{0.3} = 688.4 \text{ MPa} \end{aligned}$$

17. (c)

Given : $L = 100 \text{ mm}$; $d_i = 20 \text{ mm}$; $d_f = 16 \text{ mm}$; $\sigma_m = 40 \text{ MPa}$

$$\text{Extrusion ratio, } R = \frac{A_i}{A_f} = \left(\frac{d_i}{d_f} \right)^2 = \left(\frac{20}{16} \right)^2$$

$$R = 1.5625$$

$$\therefore \text{Extrusion pressure, } P = \sigma_m \ln R$$

$$P = 40 \times \ln 1.5625 = 17.85 \text{ MPa}$$

$$\therefore \text{Ideal plastic work, } W = P \times \frac{\pi}{4} d_i^2 L$$

$$= 17.85 \times \frac{\pi}{4} \times 20^2 \times 100$$

$$= 560805.7 \text{ N.mm} \simeq 560.8 \text{ Nm or J}$$

18. (d)

Given : $d_1 = 12 \text{ mm}$; $v = 0.4 \text{ m/s}$; $d_2 = 9.6 \text{ mm}$; $\sigma_{yt} = 800 \text{ MPa}$

Drawing stress under ideal condition is given as;

$$\begin{aligned} \sigma_d &= \sigma_{yt} \ln \left(\frac{A_1}{A_2} \right) \\ &= \sigma_{yt} \ln \left(\frac{d_1^2}{d_2^2} \right) = 800 \times \ln \left(\frac{12^2}{9.6^2} \right) = 357.03 \text{ MPa} \end{aligned}$$

$$\text{Drawing force, } F_d = \sigma_d A_2 = (357.03) \times \frac{\pi}{4} \times (9.6)^2 = 25842.65 \text{ N}$$

$$\text{Drawing power, } P = F_d \cdot v$$

$$= 25842.65 \times 0.4$$

$$= 10337.06 \text{ W} = 10.33706 \text{ kW}$$

$$\simeq 10.34 \text{ kW}$$

19. (b)

Given : $D = 320 \text{ mm}$; $b = 220 \text{ mm}$; $h_1 = 25 \text{ mm}$; $h_2 = 22 \text{ mm}$; $N = 45 \text{ rpm}$; $k = 310 \text{ MPa}$;
 $n = 0.2$; $m = 0.1$

$$\text{True strain, } \epsilon_T = \ln\left(\frac{h_2}{h_1}\right) = \ln\left(\frac{22}{25}\right) = -0.1278$$

$$\Rightarrow |\epsilon_T| = 0.1278$$

$$\text{Average flow stress, } \sigma_0 = \frac{k|\epsilon_T|^n}{n+1} = \frac{310 \times (0.1278)^{0.2}}{0.2+1} = 171.19 \text{ MPa}$$

$$\text{Roll strip contact length, } L_p = \sqrt{R \Delta h} = \sqrt{160 \times (25 - 22)} = 21.91 \text{ mm}$$

$$\text{Projected area, } A_p = L_p \cdot b = 21.91 \times 220 = 4820.2 \text{ mm}^2$$

$$\begin{aligned} \text{Required roll force, } F &= \sigma_0 \cdot A_p \\ &= 171.19 \times 4820.2 \\ &= 825170.038 \text{ N} \simeq 825 \text{ kN} \end{aligned}$$

20. (c)

Given : $L_1 = 120 \text{ mm}$; $d_1 = 60 \text{ mm}$; $d_2 = 40 \text{ mm}$; $\sigma_0 = 310 \text{ MPa}$

$$\text{Extrusion ratio, } R = \frac{A_1}{A_2} = \frac{\left(\frac{\pi}{4} d_1^2\right)}{\left(\frac{\pi}{4} d_2^2\right)} = \frac{d_1^2}{d_2^2} = \frac{(60)^2}{(40)^2} = 2.25$$

$$\begin{aligned} \text{Extrusion stress, } \sigma_e &= \sigma_0 \cdot \ln(R) \\ &= 310 \times \ln(2.25) \\ &= 251.388 \text{ MPa} \end{aligned}$$

$$\begin{aligned} \text{Extrusion force, } F_e &= \sigma_e \cdot A_1 \\ &= 251.388 \times \frac{\pi}{4} \times (60)^2 \\ &= 710782.8 \text{ N} = 710.7828 \text{ kN} \simeq 711 \text{ kN} \end{aligned}$$

21. (a)

Given : $D = 1200 \text{ mm}$; $H = 50 \text{ mm}$; $c = 2.2 \text{ s/mm}^2$; $n = 2$

Using Chvorinov's law, the solidification time is given as

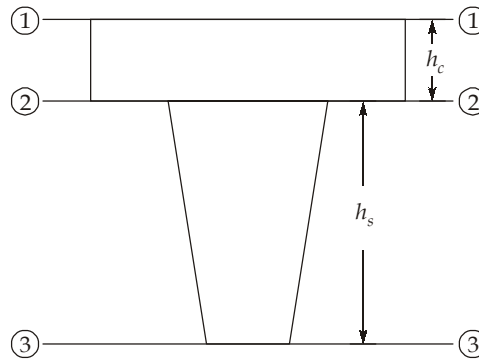
$$\begin{aligned} t_s &= c \left(\frac{V}{A} \right)^n = c \left(\frac{\frac{\pi}{4} D^2 H}{\pi D H + \frac{\pi}{4} D^2 \times 2} \right)^n \\ &= 2.2 \times \left(\frac{\frac{\pi}{4} \times (1200)^2 \times 50}{\pi \times 1200 \times 50 + \frac{\pi}{4} \times (1200)^2 \times 2} \right)^2 \end{aligned}$$

$$= 1171.597s = \frac{1171.597}{60}s = 19.5266 \text{ min}$$

$$\simeq 19.53 \text{ min}$$

22. (a)

Given : $h_s = 220 \text{ mm}$; $A_2 = 115 \text{ mm}^2$; $Q = 28900 \text{ mm}^3/\text{s}$; $g = 9.81 \text{ m/s}^2$



Velocity at the top portion of sprue,

$$V_2 = \sqrt{2gh_c} = \sqrt{2 \times 9.81 \times h_c} \text{ mm/s}$$

$$\text{Discharge, } Q = A_2 \times V_2$$

$$28900 = 115 \times \sqrt{2 \times 9.81 \times h_c}$$

$$\Rightarrow h_c = 3.22 \text{ mm}$$

Now, total height at the bottom of sprue,

$$h_t = h_c + h_s = 3.22 + 220 = 223.22 \text{ mm}$$

So, area of sprue at base,

$$A_3 = \frac{Q}{\sqrt{2gh_t}} = \frac{28900}{\sqrt{2 \times 9.81 \times 223.22}} \\ = 13.809 \text{ mm}^2 \simeq 13.809 \text{ mm}^2$$

23. (b)

Using Chvorinov's rule, the solidification time is given as

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

For cylindrical bloom;

$$2 \times 60 = k \left(\frac{\frac{\pi}{4} \times (800)^2 \times 1400}{2 \times \frac{\pi}{4} \times (800)^2 + \pi \times 800 \times 1400} \right)^2$$

$$\Rightarrow 120 = k \times \left(\frac{1400}{9} \right)^2 \quad \dots(i)$$

For rectangular block;

$$t_s = k \times \left(\frac{400 \times 500 \times 600}{2 \times (400 \times 500 + 500 \times 600 + 600 \times 400)} \right)^2$$

$$\Rightarrow t_s = k \times \left(\frac{3000}{37} \right)^2 \quad \dots(ii)$$

Using equation (i) and (ii),

$$\begin{aligned} t_s &= \frac{120}{\left(\frac{1400}{9} \right)^2} \times \left(\frac{3000}{37} \right)^2 \\ &= 32.6023 \text{ seconds} \simeq 32.6 \text{ seconds} \end{aligned}$$

24. (a)

Given: $r = 4.0 \text{ min/cm}^2$ and $n = 1.6$

Chvorinov's rule is $T = r \left(\frac{V}{A} \right)^n$,

$$\text{Volume, } V = 30 \times 10 \times 2 = 600 \text{ cm}^3$$

$$\text{Area} = 2 \times (30 \times 10 + 30 \times 2 + 10 \times 2) = 760 \text{ cm}^2$$

$$\begin{aligned} T &= 4.0 \left(\frac{600}{760} \right)^{1.6} = 2.74 \frac{\text{min}}{\text{cm}^2} \times \text{cm}^2 \\ &\approx 2.74 \text{ minutes} \end{aligned}$$

25. (a)

Given: $D = 220 \text{ mm}$, $h_f = 60 \text{ cm}$, $\mu = 0.2$.

$$\frac{\Delta h}{h_i} \times 100 = 20\%$$

$$\Rightarrow \frac{h_i - h_f}{h_i} \times 100 = 20$$

$$\Rightarrow \frac{h_f}{h_i} = 0.80$$

$$\Rightarrow h_i = \frac{h_f}{0.80} = \frac{60}{0.80} = 75 \text{ cm}$$

$$\text{Also, } \Delta h = D(1 - \cos\theta)$$

$$\Rightarrow h_i - h_f = D(1 - \cos\theta)$$

$$\Rightarrow 75 - 60 = 22(1 - \cos\theta)$$

$$\Rightarrow \cos\theta = 0.31818$$

$$\Rightarrow \theta = 71.45^\circ$$

$$\Rightarrow \theta = 1.247 \text{ radians}$$

$$\Rightarrow \theta \simeq 1.25 \text{ radians}$$

