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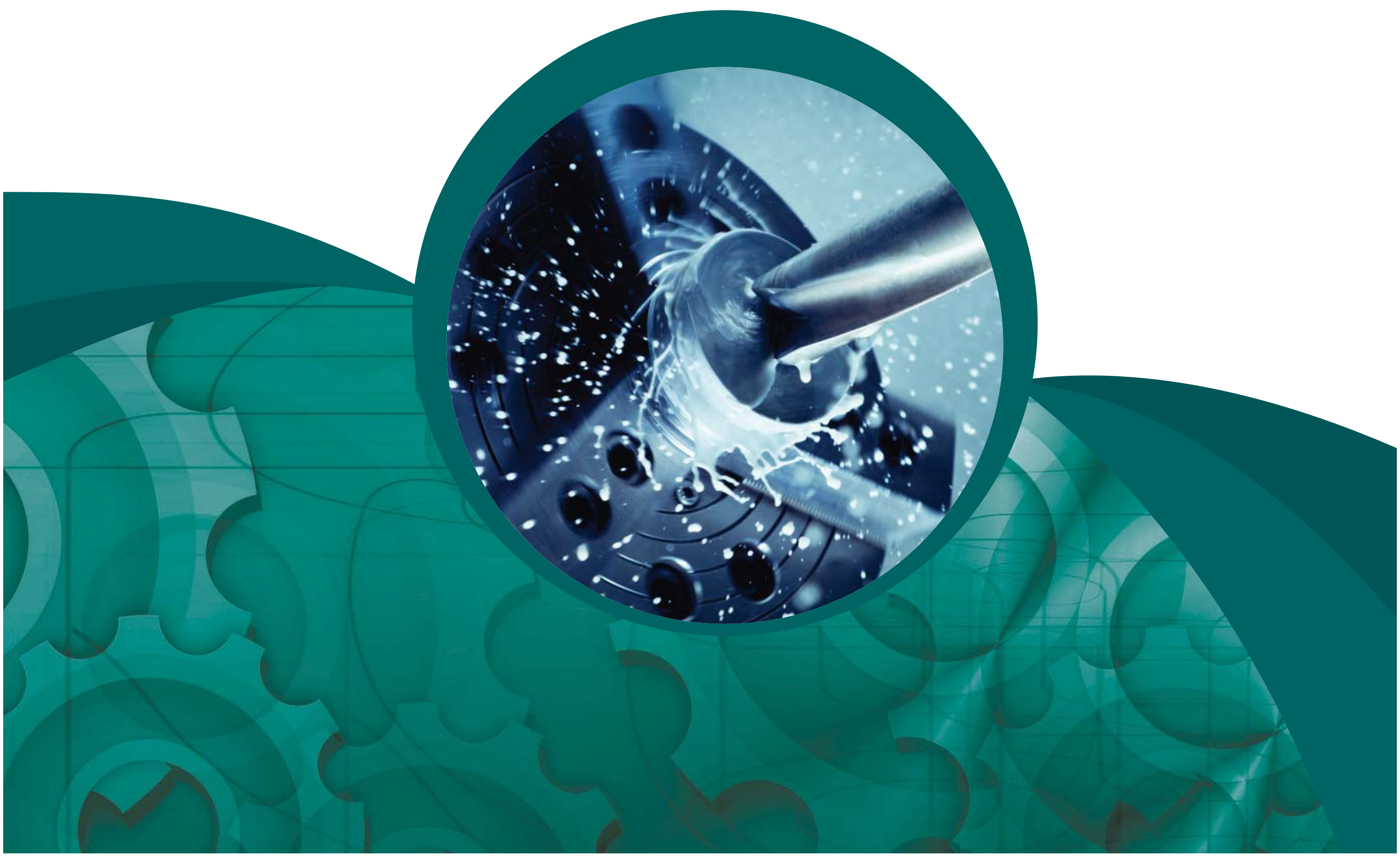
Volume - 1 : Study Material with Classroom Practice Questions



Production Technology

Solutions for Volume – I _ Classroom Practice Questions

Chapter- 1
Metal Casting

01. Ans: (d)

Sol: Permeability number $= \dfrac{VH}{PAT}$

For standard specimen H = D = 5.08 cm

P = 5 gm/cm^2, V=2000 cc, T= 2 min

$$PN = \frac{2000 \times 5.08}{5 \times \frac{\pi}{4} \times 5.08^2 \times 2} = 50.12$$

02. Ans: (c)

Sol: Net buoyancy force = Weight of core – weight of the liquid which is displaced by core

$= V.g\,(\rho - d)$

$= \dfrac{\pi}{4} \times d^2 h \times g \times (\rho - d)$

$= \dfrac{\pi}{4} \times (0.12)^2 \times 0.18 \times 9.81 \times (11300 - 1600)$

= 193.6N

03. Ans: (a)

Sol: Pouring time $= \dfrac{\text{Volume}}{A_C \times V_{max}}$

$$= \frac{2 \times 10^6}{200 \times \sqrt{2 \times 10000 \times 175}}$$

= 5.34 sec

04. Ans: (a)

Sol: $Q = 1.6 \times 10^{-3}$ m^3/sec

A = 800 mm^2

$Q = A \times V$

$1.6 \times 10^{-3} = (800 \times 10^{-6}) \times V$

V = 2 m/sec = $\sqrt{2gh}$

$$h = \left(\frac{2}{\sqrt{2 \times 9.81}}\right)^2 = 0.203\text{m}$$

= 203 mm

05. Ans: (c)

Sol: Vol. of casting $= \dfrac{\pi}{4} D^2 \times L$

$= \dfrac{\pi}{4} \times 150^2 \times 200$

$= 3534291$ mm^3

$h_t = 200 + 50 = 250$ mm

$A_C = A_{min}$ = sprue base area

$= \dfrac{400}{2} = 200$ mm^2

G.R.= 1:1.5:2

Pouring time $= \dfrac{\text{Volume of Casting}}{A_{C.} \times V_{max}}$

$$= \frac{3534291}{200 \times \sqrt{2 \times 9810 \times 250}}$$

$$= \frac{17671}{\sqrt{2 \times 9810 \times 250}} = 8\ Sec$$

06. Ans: (c)

Sol: The dimension of pouring basin will not affect the pouring time

Let V = maximum velocity of molten metal in the gating system,

$d = d_{min}$ = dia. Sprue bottom

$$\text{Pouring time} = \text{P. T} = \frac{\text{volume of casting}}{A_c \times V_{max}}$$

$$= \frac{35^3}{\frac{\pi}{4}d^2 \times V} = 25$$

$$V = \frac{35^3}{\frac{\pi}{4}d^2 \times 25} = 2183.6/d^2 \ldots\ldots (1)$$

To ensure the laminar flow in the gating system $R_e \le 2000$

For limiting condition $R_e = 2000$

$$R_e = 2000 = \frac{\rho V d}{\mu} = \frac{Vd}{\nu}$$

$$\Rightarrow 2000 = \frac{Vd}{\nu}$$

$$V = \frac{2000\nu}{d} = \frac{2000 \times 0.9}{d} = \frac{1800}{d} \ \ldots (2)$$

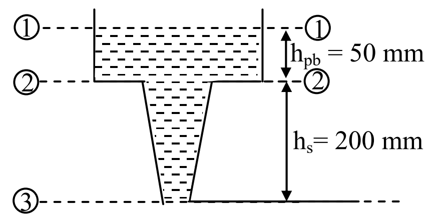
From (1) and (2)

$$\frac{2183.6}{d^2} = \frac{1800}{d}$$

$$d = \frac{2183.6}{1800} = 1.21\text{mm}$$

07. Ans: (c)

Sol:



h = height of sprue = 200 mm

$A_2 = 650\ mm^2$

Q = flow rate = $6.5 \times 10^5\ mm^3/s$

$g = 10^4\ mm/sec^2$

$$V_2 = \frac{6.5 \times 10^5}{650} = 1000\ mm^2/Sec$$

$$= \sqrt{2gh_{pb}} = \sqrt{2 \times 10^4 \times h_{pb}}$$

h_{pb} = 50 mm = height of molten metal in the pouring basin

h_t = total height of molten metal above the bottom of the sprue

= 200 + 50mm

$$Q = A_2V_2 = A_3V_3 = A_3\sqrt{2 \times 10^4 \times 250}$$

$$= 6.5 \times 10^5\ mm^3/s$$

$\Rightarrow A_3 = 290.7\ mm^2$

08. Ans: (d)

Sol: d_{top} = 225 mm

h_t = 250 + 100 = 350 mm

Volume flow rate Q = $40 \times 10^6\ mm^3/sec$

$$V_{bottom} = \sqrt{2 \times g \times h_t} = \sqrt{2 \times 9810 \times 350}$$

= 2620 mm/s

$$Q = A_{top} \times V_{top} = A_{bottom} \times V_{bottom}$$

$$A_{bottom} = \frac{40 \times 10^6}{2620} = 15267.17\ mm^2$$

$d_{bottom} = \sqrt{\dfrac{4\times 15267.17}{\pi}} = 139.42$ mm

09. Ans: (b)

Sol: $A_2V_2 = A_3V_3$

$$\frac{\pi}{4}\times 2252\times\sqrt{2\times 9810\times 100}$$

$$= \frac{\pi}{4}\times d_b^2\times\sqrt{2\times 9810\times 350}$$

$\Rightarrow \quad d_b = 164.5$mm

So aspiration will not occur.

Common Data for 10 & 11

10. Ans: (a)

11. Ans: (b)

Sol: 3 castings of spherical, cylindrical and cubical

$V_{sp} = V_{cube}$

$$\frac{4}{3}\pi R^3 = a^3$$

$$a = R\sqrt[3]{\frac{4}{3}\pi} = 1.61\text{ R}$$

$V_{cyl} = V_{Sp}$

$$\frac{\pi}{4}D^2H = \frac{4}{3}\pi R^3$$

$$\frac{\pi}{4}D^3 = \frac{4}{3}\pi R^3 \quad (\because D = H)$$

$$D = \sqrt[3]{\frac{16}{3}R^3} = \left(\frac{16}{3}\right)^{\frac{1}{3}}R = 1.75R$$

$$\frac{\tau_{SP}}{\tau_{Cub}} = \left(\frac{M_{SP}}{M_{Cub}}\right)^2 = \left(\frac{D/6}{a/6}\right)^2 = \left(\frac{D}{a}\right)^2$$

$$= \left(\frac{2R}{a}\right)^2 = \left(\frac{2R}{1.61R}\right)^2 = 1.54$$

$$\frac{\tau_{SP}}{\tau_{cyl}} = \left(\frac{M_{SP}}{M_{cyl}}\right)^2$$

$$= \left(\frac{D/6}{D/6}\right)^2 = \left(\frac{D_{Sp}}{D_{cyl}}\right)^2 = \left(\frac{2R}{1.75R}\right)^2 = 1.306$$

12. Ans: 1.205

Sol: Casting – 1 (circular)

Diameter = 20mm, length = 50mm

Casting -2 (elliptical)

Major/Minor = 2, length = 50mm,

C.S. area of the casting -1 = C.S area of the casting -2

$$\left[\frac{\text{solidification time of casting} - 1}{\text{solidification time of casting} - 2}\right]$$

$$= \left[\frac{M_{c1}}{M_{c2}}\right]^2 = \left[\frac{V_{c1}\times A_{c2}}{V_{c2}\times A_{c1}}\right]$$

$$V_{c1} = \frac{\pi}{4}\times d^2\times h = \left[\frac{\pi}{4}20^2\times 50\right]$$

$$= 15707.96\text{ mm}^3$$

$$A_{c1} = 2\times\frac{\pi}{4}\times d^2 + \pi dh$$

$$= \left[\frac{\pi}{4}20^2\times 2 + \pi\times 20\times 50\right]$$

$$= 3769\text{ mm}^2$$

C.S area of cylinder = C.S area of ellipse

$$\left[\frac{\pi}{4}\times 20^2\right] = \frac{\pi\times \text{maj.axis}\times \text{min.axis}}{4}$$

$$= \frac{\pi\times 2\times(\text{min.axis})^2}{4}$$

$$\Rightarrow \text{Minor axis} = \left[\frac{\pi}{4}\times 20^2\times\frac{4}{\pi\times 2}\right]^{\frac{1}{2}}$$

Minor axis = 14.14mm

Major axis = 2 × minor axis = 28.3mm

$$\text{Perimeter} = 2\pi\sqrt{\frac{a^2+b^2}{2}}$$

where a = major axis /2 $= \frac{28.3}{2}$ = 14.14 mm

b = minor axis /2 $= \frac{14.14}{2}$ = 7.07 mm

Perimeter = 70.24 mm

Surface area of ellipse

= perimeter × length + 2× C.S. area

= 70.24×50 + 314 × 2

= 4140 mm^2 = A_{C2}

Volume of the ellipse

= C.S area × length

= 314 × 50 = 15708 mm^3 = V_{c2}

$$\left[\frac{\text{solidification time of casting} - 1}{\text{solidification time of casting} - 2}\right]$$

$$= \left[\frac{M_{c1}}{M_{c2}}\right]^2$$

$$= \left[\frac{V_{c1}\times A_{c2}}{V_{c2}\times A_{c1}}\right]^2 = \left[\frac{15707.96\times 4140}{15708\times 3769.9}\right]^2$$

= 1.205

13. Ans: 50

Sol: m = 2 kg, Q = 10 kW

Time taken for removing latent heat

= 20 – 10 = 10 sec

$$\text{Time} = \frac{\text{Latent heat}}{Q}$$

Latent heat = time × Q

= 10 × 10 = 100 kJ

$$\text{Latent heat/kg} = \frac{100}{2} = 50 \text{ kJ/kg}$$

14. Ans: (a)

Sol: Circular disc casting Squared disc casting

$$\frac{C_1}{d = 20\text{cm}};\quad \frac{C_2}{a = 20\text{cm}}$$

$t = 10\text{cm}$; $t = 10\text{cm}$

$$\text{Freezing ratio (F.R)} = X_1 = \frac{\left(\frac{A_s}{V}\right)_{C1}}{\left(\frac{A_s}{V}\right)_R} = 1.4$$

$$\Rightarrow \left(\frac{A_s}{V}\right)_R = \frac{\left(\frac{A_s}{V}\right)_{C1}}{1.4}$$

$$X_1 = \frac{\left(\frac{A_s}{V}\right)_{C2}}{\left(\frac{A_s}{V}\right)_R} = \frac{\left(\frac{A_s}{V}\right)_{C2}}{\frac{\left(\frac{A_s}{V}\right)_{C1}}{1.4}} = 1.4$$

$$\left(\because \left(\frac{A_s}{V}\right)_{C2} = \left(\frac{A_s}{V}\right)_{C1} = 0.4\right)$$

$$\text{Volumetric ratio,(V.R)} = Y_1 = \frac{V_R}{V_C} = 0.8$$

$$\Rightarrow V_R = 0.8\ V_{C_1}$$

Now $Y_2 = \frac{V_R}{V_{C_2}} = \frac{0.8V_{C_1}}{V_{C_2}}$

$$= \frac{0.8\left(\frac{\pi}{4}\times 20^2\times 10\right)}{20\times 20\times 10} = 0.628$$

15. Ans: (b)

Sol: $V_C = 40 \times 30 \times 0.3 = 360$ cc

V_{Sc} = shrinkage volume

$$= \frac{3}{100}\times 360 = 10.8\ cc$$

Volume of riser $V_r = \frac{\pi}{4}d^2\times h$

$$= \frac{\pi}{4}\times 4^2\times 4 = 50.24\,\text{cc}$$

$V_r \geq 3\ V_{sc} \Rightarrow V_r \geq 3\times 10.8 = 32.4\text{cc}$

$V_r \geq 3\ V_{Sc} \rightarrow$ Satisfied

$\tau_r \geq \tau_C$

where

τ_r = time taken for riser material to solidify

τ_C = time taken for casting to solidify

$M_r \geq M_c$

$$\Rightarrow \left(\frac{V}{A_s}\right)_r > \left(\frac{V}{A_s}\right)_{casting}$$

$$\frac{V}{A_s} = \frac{360}{2(40\times 30 + 30\times 0.3 + 0.3\times 40)}$$

$$\Rightarrow \left(\frac{V}{A_s}\right)_r = \frac{d}{6} = \frac{4}{6} = 0.666$$

$$= \frac{360}{2442} = 0.147$$

$\therefore \quad \tau_r > \tau_C$

Hence diameter of riser = 4 cm

Common Data for Q.16 & Q. 17

16. Ans: (a) **17. Ans: (a)**

Sol: In centrifugal casting

Centrifugal force = $F_C = ma = m\,r\,\omega^2$

$a = r\omega^2$

$$75\text{ g} = \frac{D}{2}(2\pi N)^2$$

$$75\times 9810 = N^2 D\times\frac{4\pi^2}{2}$$

$$\text{Constant} = N^2 D = \frac{75\times 9810}{2\pi^2} = 37273$$

Constant = $N^2 D = 37273$

$$D = \frac{0.5+0.52}{2} = 0.51\text{ m} = 510\text{ mm}$$

$$N = \sqrt{\frac{37273}{D}} = \sqrt{\frac{37273}{510}} = 8.55\text{ RPS}$$

18. Ans: 51.84 mm

Sol: $\frac{\tau_R}{\tau_C} = \left(\frac{m_R}{m_C}\right)^2$

$$m_c = \frac{80\times 120\times 20}{2[(80\times 120)+(120\times 20)+(80\times 20)]}$$

$m_c = 7.05$

$m_R = \frac{d}{6}$ [$\because$ side riser given]

$\Rightarrow \frac{m_R}{m_C} = \sqrt{1.5}$

$\Rightarrow \quad d = 51.84$ mm

20. Ans: 0.05 s

Sol: Momentum is considered as constant

Momentum of water = Momentum of liquid metal

$$\frac{\text{pressure} \times \text{time}}{\text{density}} = \frac{\text{pressure} \times \text{time}}{\text{density}}$$

$$\frac{200 \times 0.05}{1000} = \frac{400 \times \text{time}}{2000}$$

$$\Rightarrow \quad \text{time} = 0.05\,\text{s}$$

21. Ans: (b) **22. Ans: (d)**

23. Ans: (c) **24. Ans: (b)**

25. Ans: (c) **26. Ans: (a)**

27. Ans: (c) **28. Ans: (a)**

29. Ans: (d) **30. Ans: (b)**

31. Ans: (d) **32. Ans: (b)**

33. Ans: (c) **34. Ans: (a)**

35. Ans: (b) **36. Ans: (c)**

37. Ans: (b) **38. Ans: (a)**

39. Ans: (a) **40. Ans: (a)**

Chapter- 2 Welding

01. Ans: (a)

Sol: $V_0 = 80$ V, $I_S = 800$ A

Let for arc welding V = a+bL

For power source, $V_p = V_0 - \frac{V_0}{I_s} I$

For stable $V = V_p$

$$\Rightarrow a + bL = V_0 - \frac{V_0}{I_s} I$$

When L = 5, I = 500

$$\Rightarrow a + b \times 5 = 80 - \frac{80}{800} \times 500 = 30$$

$$a + 5b = 30$$

when L = 7, I = 460

$$a + b \times 7 = 80 - \frac{80}{800} \times 460 = 34$$

By solving, b = 2, a = 20

$\therefore$ V = a + bL = 20 + 2L

02. Ans: 4860 W, 1.5 mm

Sol: For power source,

$$V_p = 36 - \frac{I}{60}$$

$$V_a = 2L + 27$$

At equilibrium conditions

$$V_a = V_P$$

$$27 + 2L = 36 - \frac{I}{60}$$

$$\frac{I}{60} = 36 - 27 - 2L = 9 - 2L$$

I = 60 (9 – 2L)

If current is 360 Amps

360 = 60 (9 – 2L)

$$9 - 2L = \frac{360}{60} = 6$$

2L = 9 – 6 = 3

$$L = \frac{3}{2} = 1.5$$

If L = 1.5 mm,

V = 27 + 2 ×1.5 = 27+ 3 = 30 V

I = 60 (9 – 2 ×1.5) = 360 A

P = 30 ×360 = 10800 W

If L = 4 mm, V = 27 + 1.5 ×4 = 33 V

I = 60 (9 – 1.5 ×4) = 180 A

P = 33 × 180 = 5940 W

Change in power = 10800 – 5940

= 4860 W

If the maximum current capacity is 360A, the maximum arc length is 1.5mm

03. Ans: 425

Sol: V = 100 + 40 L ,

L = 1 to 2 mm , I = 200 to 250 A

L = 1, I = 250

$$V = 100 + 40\times1 = 140 = V_0 - \frac{V_0}{I_s}\times 250$$

L = 2, I = 200

$$V = 100 + 40 \times 2 = 180 = V_0 - \frac{V_0}{I_s}\times 200$$

$$\Rightarrow 40 = 50\times\frac{V_0}{I_s}$$

$$\frac{V_0}{I_s} = \frac{40}{50} = \frac{4}{5}$$

$$V_0 = 140 + \frac{4}{5}\times 250$$

= 140 + 200 = 340

$$\frac{V_0}{I_s} = \frac{4}{5} \Rightarrow I_s = \frac{V_0\times 5}{4} = \frac{340\times 5}{4} = 425\,A$$

04. Ans: 26.7 sec

Sol: Rated Power = $V_r\,I_r = 50\times10^3$

$$\Rightarrow I_r = \frac{50\times10^3}{25} = 2000\,A$$

D_r = 50% (rated duty cycle)

If I_d = 1500 A (desired current)

Desired duty cycle,

$$D_d = \frac{I_r^2\,D_r}{I_d^{\,2}} = \left(\frac{2000}{1500}\right)^2 \times 0.5 = 0.89$$

$$D_d = \frac{\text{Arc on time}}{\text{Total welding time}} = 0.89\times30$$

= 26.7 sec

05. Ans: 27.78 mm/sec

Sol: Power = P = $4 + 0.8L - 0.1L^2$

For optimum power

$$\frac{dP}{dL} = 0 \Rightarrow 0.8 - 0.2L = 0$$

$$L = \frac{0.8}{0.2} = 4\,mm$$

$P = 4 + 0.8L - 0.1\,L^2$

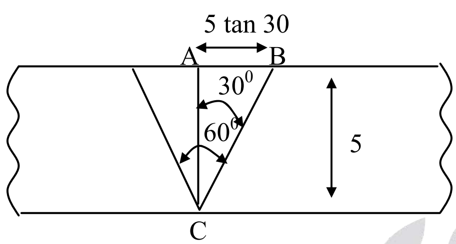
$= 4 + 0.8\times4 - 0.1\times4^2 = 5.6$ kW

Energy losses = 20% , η = 80%

Area of weld bead (WB)

$$= 2\times\frac{1}{2}\times AB\times AC$$

$$= 5\tan 30 \times 5 = 14.43$$



Volume of W.B = 14.43 × 1000

$= 14433\ mm^3$

Weight of W.B = $14433 \times 10^{-6} \times 8$

= 115.5 g

Heat required for melting of W.B

= 115.5 ×1400 = 161.66 kW

Time for welding = $\frac{161.66}{0.8\times5.6} = 36\,Sec$

Welding speed = $\frac{1000}{36}$

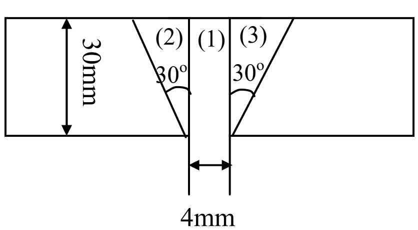
$= 27.78$ mm/sec

Common data for 06, 07 & 08.

06. Ans: (d) **07. Ans: (d)**

08. Ans: (c)

Sol:



l = 1 m =1000 mm;

t = 30 mm,

d = 4 mm,

L_t = 450 mm;

L_S = 50 mm,

$A_1 = 4 \times 30 = 120\ mm^2$

$A_2 = A_3 = \frac{1}{2}\times 30\tan 30\times 30 = 259.8\ mm^2$

Total volume of weld bead

= volume of weld bead + crowning

= 1.1 × volume of weld bead

$= 1.1 \times(A_1+2A_2)\times1000 = 703560\ mm^3$

Volume /Electrode = $\frac{\pi}{4}\times D^2\times L_e$

$= \frac{\pi}{4}\times 4^2\times(450-50) = 1600\pi$

No of electrodes required

$= \frac{\text{Total volume of weld bead}}{\text{volume / Electrode}}$

$= \frac{703560}{1600\pi} = 139.96 = 140$

x = 200mm (given)

No of electrodes/pass = $\frac{1000}{200} = 5$

No of passes = $\frac{140}{5} = 28$

Total Arc on time

$= \frac{1000}{100}\times 28 = 280$ minutes

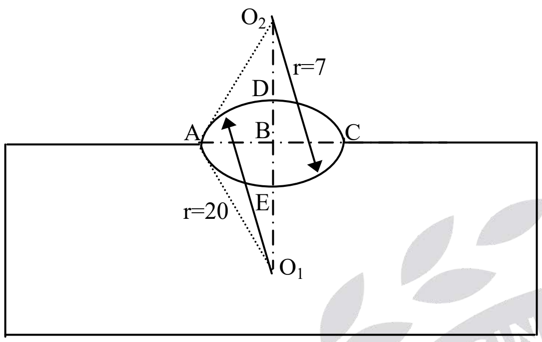
Total weld time = $\frac{280}{0.6}$ = 466.67 minutes

09. Ans: 0.64 mm & 2.1 mm

Sol: Given AC = 10 mm,

$O_1A = O_1C = 7$ mm,

$O_2A = O_2C = 20$ mm



Height of Bead $= BD = O_1D - O_1B$

$= O_1D - \sqrt{O_1A^2 - AB^2}$

$= 20 - \sqrt{20^2 - 5^2}$

$= 0.64$ mm

Depth of Penetration $= BE = O_1E - O_1B$

$= (O_1E) - \sqrt{(O_2A)^2 - (AB)^2}$

$= 7 - \sqrt{7^2 - 5^2} = 2.10$ mm

Common Data Q. No 10 and 11

10. Ans: (c)

Sol: I = 200, V = 25, speed = 18 cm /min

D = 1.2 mm, f = 4 m /min, η = 65%,

$$\text{Heat input} = \frac{V \times I \times \eta}{\text{speed}}$$

$$= \frac{25 \times 200 \times 0.65 \times 60}{18}$$

= 10.83 kJ / cm

11. Ans: (b)

Sol: Filling rate of weld bead = filled rate by electrode

$$\text{Area of W.B} \times \text{Speed} = \frac{\pi}{4} d^2 \times f$$

$$\text{Area of W.B} = \frac{\frac{\pi}{4} \times 1.2^2 \times 4000}{180} = 25.12 \text{ mm}^2$$

Common data for 12 & 13

12. Ans: 2000 J

Sol: H.G = $I^2 R \tau$

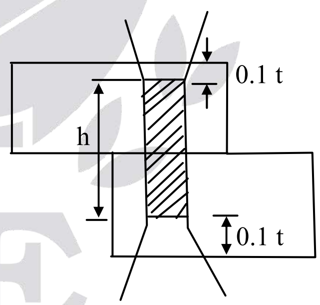
$$= (10000)^2 \times 200 \times 10^{-6} \times \frac{5}{50} = 2000 \text{ J}$$

13. Ans: 1264 J

Sol: h = 2t – 2 × 0.1 t = 1.8 t

= 1.8 × 1.5 = 2.7 mm

$D = 6\sqrt{t} = 6\sqrt{1.5} = 7.35$ mm



$$\text{Vol. of nugget} = \frac{\pi}{4} D^2 h$$

$$= \frac{\pi}{4}(7.35)^2 \times 2.7 = 114.5 \text{ mm}^2$$

Heat required = Volume ×ρ ×heat required /g

$= 114.5 \times 10^{-3} \times 8 \times 1380$

= 1264 J

14. Ans: 2.3 & 4.6 MJ

Sol: $R_C = 0.85\left(\frac{\rho}{n\pi r}\right)$

ρ = Resistivity of metal

$(\text{Heat generation})_1 = I^2R = \left(\frac{V}{R}\right)^2 \times R = \frac{V^2}{R}$

$R_{C_1} = \frac{0.85 \times 2 \times 10^{-5}}{25 \times \pi \times 0.02} = 1.082\times10^{-5}$

$R_{C_2} = \frac{0.85 \times 2 \times 10^{-5}}{50 \times \pi \times 0.02} = 5.41 \times 10^{-6}$

$(\text{H.g})_1 = \frac{5^2}{1.082 \times 10^{-5}} = 2310546.04$

$(\text{H.g})_2 = \frac{5^2}{5.41\times10^{-6}} = 4621072.08$

15. Ans: (c)

Sol: Heat generated = Heat utilized

$I^2R\tau$ = Vol. of nugget $\times \rho \times$ H. R/g

$I^2 \times 200\times10^{-6} \times 0.1$

$= \frac{\pi}{4}(0.005)^2 \times 1.5\times10^{-3} \times 8000\times1400\times10^3$

I = 4060 A

Common Data Q. 16 & Q. 17

16. Ans: (c)

Sol: I = 3000 A, τ = 0.2, R = 200 $\mu\Omega$

Volume of nugget = 20 mm^3

Heat generation = $I^2R\tau$

$= 3000^2 \times 200\times10^{-6} \times 0.2 = 360$ J

Heat required $= \rho V\left[c_p\left(T_m - T_r\right) + LH\right]$

$= 8000\times20\times10^{-9}\times500\times(1520-20)+1400\times10^3$

= 344 J

17. Ans: (b)

Sol: Heat dissipated = 360 – 344 = 16 J

18. (i) Ans: (a), (ii) Ans: (b)

Sol: P = 2 kW = 2 × 10^3 Watt,

V = 200 mm/min, L = 300 mm

Heat required (HR) = 40 Kcal

$= 40\times10^3\times4.2$ Joule

Welding time $= \frac{300}{200} = 1.5\,\text{min} = 1.5\times60$

= 90sec

Heat input = 2 × 10^3 × 90 Joule

$\eta_{HI} = \frac{HR}{HI} = \frac{40\times10^3\times4.2}{2\times10^3\times90} = 0.9333$

= 93.33%

19. Ans: (d)

Sol: Heat supplied = Heat utilized

0.5 J = m (S.H. + L.H) = ρV (SH+LH)

= $(a\times h)\,\rho\,(C_p\,(T_m-T_r)+LH)$

$= 0.05 \times 10^{-6} \times h \times 2700\,[896 \times (933 - 303) + 398 \times 10^3]$

$\Rightarrow$ h = 0.00385 m = 3.85 mm

20. Ans: (c)

Sol: Volume to be melted $= \frac{\pi}{4}(110^2 - 100^2)\times 2$

$= 3298.66\ mm^3$

Total heat required

$= 3298.66 \times 10^{-9} \times 64.4 \times10^6$

= 212.4 Joules

$P = VI = V\times\frac{V}{R} = \frac{V^2}{R} = \frac{30^2}{42} = 21.43$

Total heat required = heat to be generated

$$212.4 = P\times t$$

$$t = \frac{212.4}{21.43} = 10\,\text{sec}$$

21. Ans: (a)

Sol: Frictional force F = Pressure × Area ×μ

$$= 200\times\frac{\pi}{4}\times 10^2\times 0.5 = 7854$$

$$\text{Torque} = F\times\frac{3}{4}\times\text{Radius}$$

$$\text{Torque} = 7854\times\frac{3}{4}\times 5\times 10^{-3} = 29.45$$

$$\text{Power, } P = \frac{2\pi NT}{60000}$$

$$= \frac{2\pi\times 4000\times 29.45}{60000} = 12.33\text{ kW}$$

22. Ans: 0.065 sec

Sol: Given:

Volume = 80 mm^3,

Current (I) = 10000 A,

E = 10 J/mm^3,

Q_{lost} = Heat lost = 500 J,

R = 0.0002 ohms

Total energy supplied during process

= [(80 × 10) + 500] J

Q_{total} = 1300J = i^2Rt

1300 = $(10^4)^2$ × 0.0002 × t

⇒ t = 0.065 seconds

23. Ans: 61.53 %

Sol: $$\text{Thermal efficiency} = \frac{\text{Heat required}}{\text{Heat supplied}}\times 100$$

Heat required = 10 × 80 = 800 J

$$\eta_{thermal} = \frac{800}{1300}\times 100 = 61.53\ \%$$

24. Ans: 464.758 A

Sol: D_d = 100% = 1, I_r = 600A, D_r = 0.6

$$\frac{D_d}{D_r} = \frac{I_r^2}{I_d^2}$$

$$\frac{1}{0.6} = \frac{600^2}{I_d^2} \Rightarrow I_d^2 = 600^2\times 0.6$$

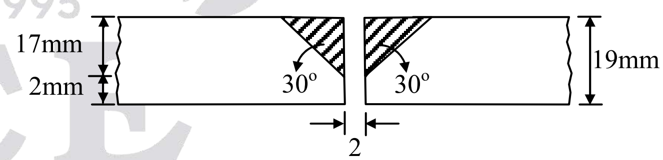
⇒ I_d = 464.758A

25. Ans: 17

Sol: Number of electrodes

$$= \frac{\text{Total volume of metal deposited}}{\text{Volume deposited from one electrode}}$$

$$= \frac{\text{Total Volume of metal deposited}}{\frac{\pi}{4}(3^2)\times(450-50)}$$



$$\tan 30^\circ = \frac{x}{17\text{mm}}$$

x = 9.814 mm

$$\text{Area} = \left(\frac{1}{2}\times 9.814\times 17\times 2 + (2\times 19)\right)\times 1.1\times 1.15$$

$$\text{Volume} = (204.85\text{mm}^2)\times 1.1\times 1.15\times 180$$

$$= 46645.30767\text{mm}^3$$

∴ Number of electrodes = 17

27. Ans: (c) **28. Ans: (c)**
29. Ans: (a) **30. Ans: (b)**
31. Ans: (c) **32. Ans: (b)**

33. Ans: (425A)

Sol: V = 100 + 40 L ,

L = 1 to 2 mm , I = 200 to 250 A

L = 1, I = 250

$$V = 100 + 40\times1 = 140 = V_0 - \frac{V_0}{I_s}\times 250$$

L = 2, I = 200

$$V = 100 + 40\times 2 = 180 = V_0 - \frac{V_0}{I_s}\times 200$$

$$\Rightarrow 40 = 50\times\frac{V_0}{I_s}$$

$$\frac{V_0}{I_s} = \frac{40}{50} = \frac{4}{5}$$

$$V_0 = 140 + \frac{4}{5}\times 250$$

$$= 140 + 200 = 340$$

$$\frac{V_0}{I_s} = \frac{4}{5} \Rightarrow I_s = \frac{V_0\times 5}{4} = \frac{340\times 5}{4} = 425\,A$$

34. Ans: (b) **35. Ans: (c)**
36. Ans: (d) **37. Ans: (a)**
38. Ans: (c) **39. Ans: (c)**
40. Ans: (c) **41. Ans: (b)**
42. Ans: (b)

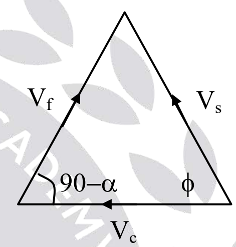
Chapter- 3
Metal Cutting

Common Data for Q. 01 & 02

01. Ans: (a)

02. Ans: (d)

Sol:



V_c = 40 m/min; V_f = 20 m/min

$\alpha = 10^o$; $r = \frac{V_f}{V_c} = 0.5$

$$\phi = \tan^{-1}\left(\frac{r\cos\alpha}{1 - r\sin\alpha}\right)$$

$$= \tan^{-1}\left(\frac{0.5\cos 10}{1-0.5\sin 10}\right) = 28.33^o$$

$$V_s = \frac{V_f}{\sin\phi}\times\cos\alpha$$

$$= \frac{20}{\sin 28.33}\times\cos 10 = 41.5 \text{ m/min}$$

03. Ans: 10°

Sol: f = 0.25 mm/rev,

t_1 = 0.25, i = 10°, α = ?

$t_1 = f \cos C_S$

$0.25 = 0.25 \cos C_S$

$\cos C_S = 1 \Rightarrow C_s = 0$

$\lambda = 90 - C_S = 90°$

$$\begin{bmatrix}\tan\alpha_b\\ \tan\alpha_s\end{bmatrix} = \begin{bmatrix}\sin\lambda & \cos\lambda\\ -\cos\lambda & \sin\lambda\end{bmatrix}\begin{bmatrix}\tan i\\ \tan\alpha\end{bmatrix}$$

$\tan\alpha_b = \sin\lambda \tan i + \cos\lambda \tan\alpha$

$\tan\alpha_b = \sin 90 \tan i + 0$

$\Rightarrow \alpha_b = i = 10°$

Common Data for Q.04, 05 & 06

04. Ans: (c) **05. Ans: (b)**

06. Ans: (d)

Sol: $d = t_1 = 2$ mm, $w = b = 15$ mm

$V_C = 0.5 \text{m/s}, \quad \alpha = 0$

$F_C = 1200, \quad F_T = 800, \quad \phi = 30^0$

$$\beta = \alpha + \tan^{-1}\frac{800}{1200} = 33.69^0$$

$\mu = \tan\beta = \tan 33.69 = 0.67$

$$\text{Power} = P = F_C \times V_C = 1200 \times \frac{60}{60}$$

$= 1200$ W

Length of shear plane $= L_S$

$$= \frac{t_1}{\sin\phi} = \frac{2}{\sin 30} = 4\text{mm}$$

07. Ans: (a)

Sol: For theoretically minimum possible shear strain to occur

$2\phi - \alpha = 90$

$$\phi = \frac{90+\alpha}{2} = \frac{90+6}{2} = 48°$$

Common Data for Q. 08 & 09

08. Ans: (c)

09. Ans: (c)

Sol: $\alpha = 6°$, $V_C = 1 \text{m/s}$

$b = w = 3$, $d = t_1 = 1$ mm

$t_2 = 1.5$ mm; use $2\phi + \beta - \alpha = 90°$

$$r = \frac{t_1}{t_2} = \frac{1}{1.5} = \frac{2}{3} = 0.67$$

$$\phi = \tan^{-1}\left(\frac{0.67\cos 6}{1 - 0.67\sin 6}\right) = 35.62^0$$

For minimum energy condition use

$2\phi + \beta - \alpha = 90°$

$\beta = 90 + \alpha - 2\phi = 90 + 6 - 2 \times 35.62$

$= 24.76°$

$\mu = \tan\beta = \tan 24.76 = 0.461$

$V_f = r v_c = 0.67 \times 1 \times 60$

$= 40.2 \text{m/min}$

Area of shear plane $= A_s = L_s \times b$

$$= \frac{t_1 \times b}{\sin\phi} = \frac{1\times 3}{\sin 35.62} = 5.2 \text{mm}^2$$

Common Data for Q. 10 & 11

10. Ans: (d)

11. Ans: (d)

Sol: $D_0 = 32$ mm, $\alpha = 35°$, $K_1 = 0.1$ mm,

$F_C = 200$ N, $V_C = 10$ m/min,

$L_2 = 60$ mm, $F_T = 80$ N

$$r=\frac{t_1}{t_2}=\frac{L_2}{L_1}=\frac{60}{\pi D_0}=\frac{60}{\pi\times 32}=0.59$$

$$r=\frac{t_1}{t_2}\Rightarrow t_2=\frac{t_1}{r}=\frac{0.1}{0.59}=0.169$$

$$\phi=\tan^{-1}\left(\frac{0.59\cos 35}{1-0.59\sin 35}\right)=36.15^0$$

$$\tan(\beta-\alpha)=\frac{F_T}{F_C}=\frac{80}{200}$$

$$\beta=\alpha+\tan^{-1}\left(\frac{80}{200}\right)$$

$$=35+21.8=56.8^\circ$$

$$\mu=\tan\beta=\tan 56.8=1.52$$

(In general $\mu < 1$)

Hence by applying classical friction theorem

$$\mu=\frac{ln\left(\frac{1}{r}\right)}{\frac{\pi}{2}-\alpha}=\frac{ln\left(\frac{1}{0.59}\right)}{\frac{\pi}{2}-35\times\frac{\pi}{180}}$$

$$=\frac{0.5276}{1.04}=0.55$$

$$\frac{V_f}{V_C}=r\Rightarrow V_f=rV_c=0.59\times 10=5.9\text{ m/min}$$

$$V_s=\frac{V_f}{\sin\phi}\cos\alpha=\frac{5.9}{\sin 36.15}\times\cos 35$$

$$=8.42\text{ m/min}$$

12. Ans: 56.23°

Sol: $\alpha = 10$, $t_1 = 0.125$,

$F_c = 517$ N; $F_T = 217$ N

$t_2 = 0.43$; $C_m = 2\phi + \beta - \alpha$

$$r=\frac{t_1}{t_2}=\frac{0.125}{0.43}=0.29$$

$$\phi=\tan^{-1}\left(\frac{r\cos\alpha}{1-r\sin\alpha}\right)$$

$$=\tan^{-1}\left(\frac{0.29\cos 10}{1-0.29\sin 10}\right)=16.73^\circ$$

$$\beta=\alpha+\tan^{-1}\left(\frac{F_T}{F_C}\right)$$

$$=10^\circ+\tan^{-1}\left(\frac{217}{517}\right)=32.77^\circ$$

$C_m = 2 \times 16.73 + 32.77 - 10 = 56.23°$

13. Ans: 272 N & 436 W

Sol: $S_0 = 0.12$ mm $= t_1$,

$t = 2.0$ mm, $a_2 = t_2 = 0.22$

Major cutting for, $b = p_z = F_c$

$$= S_0.t.\tau_S(\xi\sec\gamma-\tan\gamma+1)$$

$S_0 = 0.12$, $\tau_S = 400$

$t = 2 – 0$,

$$\xi=\frac{t_2}{t_1}=\frac{a_2}{S_0}=\frac{0.22}{0.12}=1.83$$

$\gamma = 0$

$P_z = 0.12\times2.0\times400(1.83\sec0–\text{Tan}0+1)$

$= 272$ N

$$\text{Power} = p = F_C\times V_C = p_Z\times\frac{V_f}{r}$$

$$=p_Z\times V_f\times\xi=271\times\frac{52.6}{60}\times 1.83$$

$= 436$ W

14. Ans: (d)

Sol: $\phi = 30^o$, $F_T = 800$ N, $F_c = 1200$ N

$$F_s = \frac{F_C}{\cos(\beta-\alpha)}\cos(\phi+\beta-\alpha)$$

$$\tan(\beta-\alpha) = \frac{F_T}{F_C}$$

$$\beta-\alpha = \tan^{-1}\left(\frac{800}{1200}\right) = 33.69^o$$

$$F_s = \frac{1200}{\cos 33.69}\times\cos(30+33.69) = 639.23\text{N}$$

Common Data for Q. 15 & 16

15. Ans: (a)

16. Ans: (b)

Sol: D = 100 mm, f = 0.25 mm/sec,

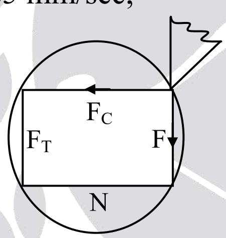
d = 4 mm

V = 90 m/min

$F_C = 1500$ N

$F_C = N = 1500$

$F_T = F$



Common Data for Q. 17 & 18

17. Ans: (b) & 18. Ans: (b)

Sol: $VT^a\, f^b\, d^c = K$

a = 0, 3   b = 0, 3,   c = 0, 15

$$f_2 = \frac{f_1}{2}, \qquad d_2 = 2d$$

$$T_1 = T_2 = 60$$

$$V_1T_1^a\, f_1^b\, d_1^c = V_2T_2^a\, f_2^b\, d_2^c$$

$$\frac{V_2}{V_1} = \left(\frac{f_1}{f_2}\right)^b\left(\frac{d_1}{d_2}\right)^c$$

$$= 2^{0.3}\left(\frac{1}{2}\right)^{0.15} = 1.11$$

$$V_2 = 1.11\,V_1$$

$$\%\text{ change in speed} = \frac{V_2-V_1}{V_1} = 11\%$$

Productivity is proportional to MRR

% change in productivity

$$= \frac{\text{MRR}_2 - \text{MRR}_1}{\text{MRR}_1}$$

$$= \frac{f_2d_2V_2 - f_1d_1V_1}{f_1d_1V_1} = 11\ \%$$

19. Ans: 49.2 %

Sol: T_0, V_0 = original tool life and velocity

If $V_1 = 1.2V_0$ $\quad T_1 = 0.5T_0$

$V_2 = 0.9V_0$, $\quad T_2 = ?$

$$V_1T_1^n = V_0T_0^n$$

$$\left(\frac{T_1}{T_0}\right)^n = \frac{V_0}{V_1}$$

$$n = \frac{ln\left(\frac{V_0}{V_1}\right)}{ln\left(\frac{T_1}{T_0}\right)} = \frac{ln\left(\frac{1}{1.2}\right)}{ln(0.5)} = 0.263$$

$$V_0T_0^n = V_2T_2^n$$

$$T_2 = T_0\left(\frac{V_0}{V_2}\right)^{1/n} = T_0\left(\frac{V_0}{0.9V_0}\right)^{\frac{1}{0.263}} = 1.4927T_0$$

% change in tool life

$$= \frac{T_2 - T_0}{T_0} = \frac{1.4927T_0 - T_0}{T_0} = 0.4927$$

20. Ans: (b)

Sol: Let Q = no. of parts produced

T.C on E.L = T. C on T.L

$$\frac{30}{60}\times Q\times 80 = 500+\frac{60}{60}\times Q\times 160$$

$$40Q = 500+16Q$$

$$40Q-16Q = 24Q = 500$$

$$\Rightarrow\ Q = \frac{500}{24} = 20.83 = 21$$

21. Ans: (a)

Sol: n = 0.12, C = 130

$C^1 = 1.1 \times 130 = 143$,

$V = V^1 = 90$ m/min

$$VT^n = C \Rightarrow T = \left(\frac{130}{90}\right)^{\frac{1}{0.12}} = 21.4\,\text{min}$$

$$V^1T^{1^n} = C^1 \Rightarrow T^1 = \left(\frac{143}{90}\right)^{1/0.12} = 47.4\,\text{min}$$

Increased tool life = 47.4 min

Increase in tool life = 47.4 – 21.4 = 26 min

22. Ans: (a)

Sol: Tool life = $T_1 = \frac{500}{10} = 50$,

$$T_2 = \frac{122}{10} = 12.2,$$

$V_1 = 50\text{rpm}$, $V_2 = 80\,\text{rpm}$

The feed and depth of are same in both cases

$$V_1T_1^n = V_2T_2^n$$

$$n = \frac{\ln\frac{V_2}{V_1}}{\ln\frac{T_1}{T_2}} = \frac{\ln\frac{80}{50}}{\ln\frac{50}{12.2}} = \frac{0.47}{1.41} = 0.333$$

$$V_1T_1^n = V_3T_3^n$$

$$\Rightarrow T_3 = T_1\left(\frac{V_1}{V_3}\right)^{1/n} = 50\left(\frac{50}{60}\right)^{\frac{1}{0.333}} = 29$$

23. Ans: 30.8 m/min

Sol: T_C = 3min, T_g = 3 min,

L_m = Rs. 0.5/min

Depreciation of tool regrind = Rs 0.5

C = 60, n = 0.2

$C_g = (3+3) \times 0.5 + 0.5 = 3.5$

$$V_{Opt} = C\left[\frac{n}{1-n}.\frac{L_m}{C_g}\right]^n$$

$$= 60\left[\frac{0.2}{1-0.2}.\frac{0.5}{3.5}\right]^{0.2} = 30.8\ \text{m/min}$$

24. Ans: 57.91

Sol: $C_m = \frac{18C}{V}$, $C_t = \frac{270C}{TV}$, $VT^{0.5} = 150$

$TC = k + C_m + C_t$

$$= k+\frac{18C}{V}+\frac{270C}{TV}$$

$$= k+\frac{18C}{V}+\frac{270C}{V\times\left(\frac{C}{V}\right)^{\frac{1}{n}}}$$

$$= k+\frac{18C}{V}+\frac{270C\,V^{\left(\frac{1}{n}-1\right)}}{C^{\frac{1}{n}}}$$

For min TC, $\frac{d(TC)}{dV} = 0$

$$\frac{-18C}{V^2} + \frac{270C\, V^{\left(\frac{1}{n}-2\right)} \times \left(\frac{1}{n}-1\right)}{C^{\frac{1}{n}}} = 0$$

$$\frac{270C\, V^{\left(\frac{1}{0.25}-2\right)} \times \left(\frac{1}{0.25}-1\right)}{C^{\frac{1}{n}}} = \frac{18C}{V^2}$$

$$\frac{270\times 3}{150^4} \times V^2 = \frac{18}{V^2}$$

$$V^4 = \frac{18\times 150^4}{270\times 3}$$

$\therefore$ V = 57.91 m/min

25. Ans: 2.5 & 23°

Sol: $\alpha = 10^o$

$t_1 = f.\sin\lambda = 0.15 \sin 75 = 0.144$

$t_2 = 0.36$, $r = \frac{t_1}{t_2} = 0.402$

chip reduction coefficient = t_2/t_1

$$\Rightarrow \frac{1}{r} = K = 2.5$$

$$\phi = \tan^{-1}\left(\frac{r\cos\alpha}{1 - r\sin\alpha}\right)$$

$$= \tan^{-1}\left(\frac{0.402\cos 10}{1 - 0.402\,\sin 10}\right) = 23.18^o$$

27. Ans: 0.944

Sol: T = 60 min

$$V_A = \frac{67}{(60)^{0.11}} = 42.70\,\text{m/min}$$

$$V_B = \frac{77}{(60)^{0.13}} = 45.22\,\text{m/min}$$

Under similar conditions with same tool life cutting velocity on material B is greater than the material A. Hence the machinability of material 'B' is higher than the material 'A'.

$$\frac{V_A}{V_B} = \frac{42.7}{45.22} = 0.944$$

28. Ans: 12°

Sol: Given, $t_1 = 0.2$ mm,

w = 2.5 mm,

$F_c = 1177$ N,

$F_t = 560$ N

As the cutting is approximated to be orthogonal.

$\tan i = \cos\psi \tan\alpha_b - \sin\psi \tan\alpha_s$

$\tan 0° = \cos\psi \tan\alpha_b - \sin\psi \tan\alpha_s$

$= \cos 30° \tan 7° - \sin 30° \tan\alpha_s$

$\Rightarrow \alpha_s = 12°$

29. Ans: 298

Sol: The given problem is the oblique machining problem.

Hence, $t_1.b = f.d = 0.25 \times 4 = 1\text{mm}^2$

Specific cutting energy

$$=\frac{F_c \times V_c}{t_1 \times b \times V_c \times 1000}=1.49$$

$F_c = 1.49 \times t_1 \times b \times 1000 = 1490N$

Because the power consumption is taking place only in the cutting stroke,

Velocity of tool in the cutting stroke

= length of work or stroke length × RPM of the crank

= 200 × 60 = 12m/min

Power required = F_c × cutting velocity

$$=\frac{(1490\times 12)}{60} = 298\text{Watts}$$

30. Ans: (a) **31. Ans: (a)**

32. Ans: (b) **33. Ans: (d)**

34. Ans: (c) **35. Ans: (c)**

36. Ans: (a) **37. Ans: (d)**

38. Ans: (a)

Chapter- 4
Machining

01. Ans: (i) 20 min, (ii) 50 min

Sol: Time / cut = $\frac{L}{fN} = \frac{576}{0.2\times 144} = 20$ min

$$V=\frac{\pi DN}{1000}=\frac{\pi\times 100\times 144}{1000}=45.2 \text{ m/min}$$

$$VT^{0.75} = 75 \Rightarrow T=\left(\frac{75}{V}\right)^{\frac{1}{0.75}}$$

$$=\left(\frac{75}{45.2}\right)^{1.333}=1.96 \text{ min}$$

No. of tool changes = $\frac{20}{1.96}-1 = 9.2 \approx 10$

(Because 1 tool is already mounted on W.P)

Total change time / piece = 20 + 10 × 3

= 50 min

02. Ans: (a)

Sol: For producing RH threads the direction of rotation of job and lead screw must be in the same direction, for this if the designed gear train is simple gear train use 1, 3, 5 odd number idle gear to get same direction of rotation, if the designed gear train is compound gear train use 0, 2, 4,.. even number of idle gears to get same direction. In the given problem the designed gear train is a compound gear train, to change the hand of the thread it requires to change the direction of rotation of job and lead screw for this use 1, 3, 5… odd number of idle gears.

03. Ans: (b)

Sol: Train value = Gear ratio = $\frac{N_{follower}}{N_{Driver}}$

$$= \frac{\text{pitch of job threads}}{\text{pitch of lead screw threads}}$$

$$= \frac{3.175\times 40}{6\times 40} = \frac{127}{240} \rightarrow \text{not possible}$$

$$= \frac{127}{40}\times\frac{1\times 20}{6\times 20}$$

$$= \frac{127}{40}\times\frac{20}{120} \rightarrow \text{possible}$$

04. Ans: (c)

Sol: 1. Plane turning 2. Taper turning 3. under cutting 4. Thread cutting

05. Ans: (d)

Sol: Gear Ratio = Train value = $\frac{N_{follower}}{N_{driver}}$

$$= \frac{T_{driver}}{T_{follower}} = \frac{P_{driver}}{P_{follower}}$$

$$G.R = \frac{P_{job}}{P_{L.S}} = \frac{P_{spindle}}{P_{Ls.S}} = \frac{N_{L.S}}{N_{Spindle}}$$

P = pitch

$$\frac{N_{Spindle}}{N_{L.S}} = \frac{P_{L.S}}{P_{Spindle/job}} = \frac{6}{2\times 2} = \frac{3}{2}$$

06. Ans: (d)

Sol: With this any change in U_V will also changes the speed of lead screw, the pitch of the threads produced depends on the speed of work and speed of lead screw. U_s will not affect the speed of the work

07. Ans: (b)

Sol: No. of D.S/min = 10

B = 300 min, f = 0.3 mm /stroke

$$\text{Time/cut} = \frac{B}{f}\times\frac{1}{\text{No. of D.S}}$$

$$= \frac{300}{0.3} = \times\frac{1}{10} = 100\,\text{min}$$

08. Ans: (b)

Sol: L = 2m

= 50 + 900 + 50 + 50 + 900 + 50

B = 300 + 5 + 5 = 310

f = 1 mm/stroke, V_C = 1 m /sec,

$M = \frac{1}{2}$

$$\text{Time per two pieces} = \frac{B}{f}\times\frac{1}{V}(1+M)$$

$$= \frac{310}{1}\times\frac{2000}{1000}(1+0.5) = 930 \text{ sec}$$

$$\text{Time/piece} = \frac{930}{2} = 465\,\text{sec}$$

09. Ans: (d)

Sol: Shaping operation

M = 0.6 , L = 500 mm

Double stroke / time = 15

N = time / D.S = 1/15

$$\text{Average speed, } V = \frac{L}{V}(1+M)$$

$$= \frac{500}{\left(\frac{1}{15}\right)}(1+0.6) = 12000 \text{ mm / min}$$

= 12 m / min

10. Ans: (c)

Sol: Total depth to be removed = 30 – 27

= 3 mm

Given, $m = \frac{2}{3} = 0.67$

feed = 0.5,

depth = 2

V = 60 m/min

$\left.\begin{array}{l}\text{Approach} = 50\text{ m}\\ \text{Over time} = 50\text{ min}\end{array}\right\}$ length wise

$\left.\begin{array}{l}\text{Approach} = 5\text{ m}\\ \text{Over time} = 5\text{ m}\end{array}\right\}$ width wise

$\text{Time/cut} = \frac{L}{V}(1+M)\times\frac{B}{f}$

$l = 800$,

L = 800 + 50 + 50 = 900

B = 400 + 5 + 5 = 410

$\text{Time / cut} = \frac{900}{60000}\left(1+\frac{2}{3}\right)\times\frac{410}{0.5}$

= 20.5 min

$\text{No. of cuts} = \frac{3}{2} = 1.5 \approx 2\text{cuts}$

Total time = 20.5×2 = 41 mins

11. Ans: (b)

Sol: Time per hole = L/f.N

= 25/(0.25× 300)

= 1/3 min = 20sec.

Because dia of drill bit was not given, hence AP_1 is zero.

12.

Sol: D = 15 mm, V_c = 20 m/min,

$$N = \frac{1000\,V}{\pi\times D} = \frac{1000\times 20}{\pi\times 15} = 425\text{ rpm}$$

N = 425rpm

f = 0.2 mm /rev

T = 100 min, $l = 45\ mm$

Time for idle time = 20s

Tool change time = 300 s

$$\text{Time/hole} = \frac{L}{fN} = \frac{\ell+0.5D}{fN}$$

$$= \frac{45+\frac{15}{2}}{0.2\times 425} = 0.617\text{ min}$$

= T_m = machining time

i) No. of holes produced / drill

$$= \frac{100}{0.617} = 162$$

ii) Total time/hole

= T_m + idle time + Tool change time

$$= 0.617+\frac{20}{60}+\frac{300}{162\times 60}$$

= 0.9812 min = 58.87 = 59 sec

13. Ans: (b)

14. Ans: (b)

Sol: Given n = 6, D_{max} = 25 mm

D_{min} = 6.25 mm

V = 18 m/min

$$r = \sqrt[n-1]{\frac{N_{max}}{N_{min}}}$$

$$N_{max} = \frac{1000V}{\pi D_{min}} = \frac{1000 \times 18}{\pi \times 6.25}$$

$$N_{min} = \frac{1000V}{\pi D_{max}} = \frac{1000 \times 18}{\pi \times 25}$$

$$r = \sqrt[6-1]{\frac{N_{max}}{N_{min}}} = \sqrt[5]{\frac{25}{6.25}}$$

$= 1.3195 = 1.32$

15. Ans: (d)

Sol: Hobbing process

No. of teeth = 30 (Not required)

Module = 3 mm

Pressure angle = 20^0 (Not required)

Radial depth= Addendum+1m+1.25m

= 2.25 module = 2.25 × 3

Radial depth = 6.75 mm

16.

Sol: Part size = 200 × 80 × 60 mm

D = 100 mm, Z = 12,

V = 50 m/min,

$$N = \frac{1000\,V}{\pi D} = \frac{1000 \times 50}{\pi \times 100} = 159 \text{ rpm}$$

$f_t = 0.1$ mm, AP = OR = 5 mm

i) With symmetrical milling

$$AP_1 = \frac{1}{2}\left(D - \sqrt{D^2 - w^2}\right)$$

$$= \frac{1}{2}\left(100 - \sqrt{100^2 - 80^2}\right) = 20\,\text{mm}$$

$$L = l + AP_1 + AP + OR$$

$= 200 + 20 + 5 + 5 = 230$

$$\text{Time/cut} = \frac{L}{f_t N Z}$$

$$= \frac{230}{0.1 \times 159 \times 12} = 1.2 \text{ min}$$

ii) If offset = 5mm with asymmetrical milling

$$AP_1 = \frac{1}{2}\left(D - \sqrt{D^2 - w_i^2}\right)$$

Where, $w_i = w + 2(O_f)$

$= 80 + 2 \times 5 = 90$

$$AP_1 = \frac{1}{2}\left(100 - \sqrt{100^2 - 90^2}\right)$$

= 28.2 mm

L = 200 + 28.2 + 5 + 5 = 238.2

$$\text{Time/cut} = \frac{L}{f_t N z}$$

$$= \frac{238.2}{0.1 \times 12 \times 159} = 1.25 \text{ min}$$

17. Ans: (b)

Sol: $\text{Crank rotation} = \frac{40}{\text{No. of teeths}}$

$$= \frac{40}{28}$$

$$= 1\left(\frac{12}{28}\right) = 1\frac{3}{7}$$

$$= 1\left(\frac{9}{21}\right)$$

1 complete revolution and 9 holes in 21 hole circle.

18. Ans: (d)

Sol: d = 70 mm , Z = 12 teeth

V = 22 m/min

f_t = 0.05 mm/tooth

$f_m = f_t Z N,\ N = \dfrac{1000\,V}{\pi\,d}$

$f_m = 0.05 \times 12 \times \dfrac{1000 \times 22}{3.14 \times 70} = 60$ mm/min

19. Ans: (b)

Sol: Crank rotation $= 1\dfrac{10}{30} = 1\dfrac{1}{3} = \dfrac{4}{3} \times 360$

$= 480°$

Job rotation $= \dfrac{CR}{40} = \dfrac{480}{40} = 12°$

20. Ans: (b)

Sol: Given,

D_{tool} = 15 cm = 150 mm

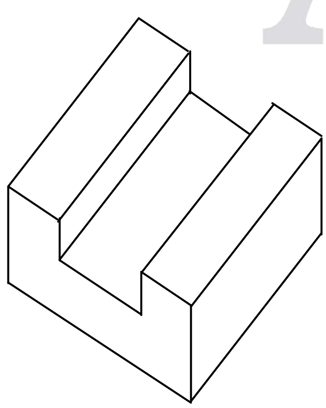
Feed = 0.08 mm/rev

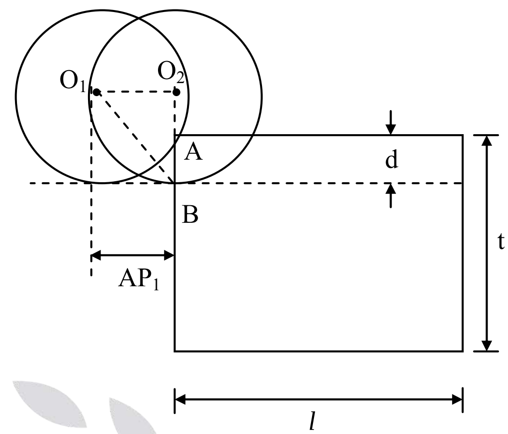
$Depth_{max}$ = 0.5 mm = d

Length of workpiece, l = 200 mm

Cutting Velocity, V = 120 m/min

Total depth to be cut = 2 mm





$N = \dfrac{1000V}{\pi D} = \dfrac{1000 \times 120}{\pi \times 150} = 254.64$ rpm

Approach $= AP_1 + O_1O_2 = \sqrt{d(D-d)}$

$= \sqrt{0.5(150-0.5)} = 8.645$ mm

Total time/machining

= No. of cuts×Time/cut

No. cuts $= \dfrac{\text{Total depth}}{\text{depth per cut}} = \dfrac{2}{0.5} = 4$

Time/cut $= \dfrac{L}{fN} = \dfrac{\ell + AP}{fN}$

$= \dfrac{200 + 8.645}{0.08 \times 255} = 10.227$ min

Total time = 10.227 × 4 = 40.91

= 41 min

21. Ans: 8.05 min

Sol: Broaching machine

P = 1.5 kW

d_1 = 20 mm enlarged to d_f = 26 mm

t = 25 mm

p = 10 mm/tooth

h = 0.075 mm/tooth

V = 0.5 m/min

Equation for time for broaching operation

$$= \frac{\text{Length of tool travel}}{\text{Linear velocity of tool}}$$

Length of tool travel = L

$= t + L_e + AP + OR$

As (AP + OR) is not given so take it zero

L_e = effective length or cutting length

Depth of cut $d = \frac{26-20}{2} = 3$

n = no. of teeth = d/h = 3 / 0.075 = 40

$L_e = n \times p = 40 \times 10 = 400$mm

$L_e = 400$ mm

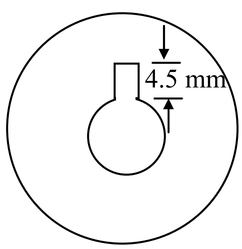
Time for broaching $= \frac{t + L_e}{V}$

$$= \frac{25+400}{0.5\times100} = 8.05 \text{ min}$$

Time for broaching = 8.05 min

22. Ans: (c)

Sol:



$d_{total} = 4.5\,\text{mm}$

$d_f = 0$

$d_S = n_s \times h_s = 0.0125 \times 8 = 0.1$

$d_r = d_{total} - (d_f + d_s)$

$= 4.5 - 0.1 = 4.4$

$n_r = \frac{d_r}{h_r} = \frac{4.4}{0.1} = 44$ teeth

Cutting length = effective length = L_e

$= L_r + L_S + L_f$

$= 44 \times 22 + 8 \times 20 + 4 \times 20$

= 1208mm

23. Ans: (b)

Sol: Out of all conventional method grinding is one which required largest specific cutting energy.

1) Because of random orientation of abrasive particles, rubbing energy losses will be very high
2) Lower penetration of abrasive particle
3) Size effect of the larger contact areas between wheel and work.

24. Ans: (a)

Sol: Common alignment test for shaper and lathe are (1) Straightness (2) Flatness.

Runout is used in lathe.

Parallelism used in shaper.

25. Ans: (a)

Sol: The curvature given is the concave curvature hence it increases the stress concentration factor therefore it is used for supply of lubricating oil to bearing mounting

26. Ans: 18

Sol: The output per annum = 800 × 52

= 41600 units.

The rejection rate is 20%.

∴ The quantity to be produced (including rejection) = $\frac{\text{Required output}}{(1-\text{rejection rate})}$

$= \frac{41600}{(1-0.2)}$ = 52,000 units

Total time required for turning

= 52,000 × 40/60

= 34666.6 hours

Production time required with 80 per cent efficiency = 34666.6 /0.8 = 43333.3 hours

Time available per lathe per annum

= 48 × 52 = 2496 hrs

∴ Number of lathes required

$= \frac{\text{Time required (hrs)}}{\text{Time available (hrs)}}$

$= \frac{43333.33}{2496}$ = 17.36 = 18

∴ No. of lathes required = 18

29. Ans: (c) **30. Ans: (a)**

31. Ans: (c) **32. Ans: (c)**

33. Ans: (b) **34. Ans: (b)**

35. Ans: (b) **36. Ans: (b)**

37. Ans: (d) **38. Ans: (a)**

39. Ans: (d) **40. Ans: (c)**

Chapter- 5
Metal Forming Process

01. Ans: (a)

Sol: $\sigma_y = 1400 \in^{0.33}$

At maximum load, true strain $= \frac{1}{3}$

$$\sigma_y = 1400\left(\frac{1}{3}\right)^{0.33} = 971 \text{ MPa}$$

02. Ans: (b)

Sol: A_{0p} = C.S area of P originally

A_{1p} = C.S area of P after 1st reduction

= 0.7 A_{0p}

$A_{2p} = 0.8 \times 0.7 \times A_{0p} = 0.56\, A_{0p}$

$\in_p = \textit{True strain in "P"} = \ln\left(\frac{A_{op}}{A_{2p}}\right)$

$= \ln\left(\frac{A_{op}}{0.56\, A_{op}}\right) = 0.58$

A_{0Q} = C.S area of Q originally

A_{1Q} = C.S area of Q after 1st reduction

= 0.5 A_{0Q}

$\in_Q = \ln\left(\frac{A_{0Q}}{A_{1Q}}\right) = \ln\left(\frac{1}{0.5}\right) = 0.693$

03. Ans: (a)

Sol: d_o = 25, d_i = 5mm

$\sigma_y = 315 \in^{0.54}$

$$\in = \ell n \frac{A_o}{A_1} = \ell n \left(\frac{d_o}{d_i}\right)^2$$

$$= \ell n \left(\frac{25}{5}\right)^2 = 3.22$$

$$\sigma_y = 315\,(3.22)^{0.54} = 592 \text{ MPa.}$$

04. Ans: 1.98 MN

Sol: Given: $H_0 = 4.5$ mm

$H_1 = 2.5$ mm

$\Delta H = 2$

$D_{roll} = 350$, $R_{roller} = 175$ mm

Strip wide = 450 mm = b

Average coefficient of friction = 0.1

$\sigma_y = 180$ MPa

RSF = P_{avg} × projected area

$$= \frac{2}{\sqrt{3}} \times \sigma_y \left(1 + \frac{\mu L}{4H}\right) \times b \times L$$

$$L = \sqrt{R\Delta H} = \sqrt{175 \times 2} = 18.7$$

$$4 = \frac{H_0 + H_1}{2} = \frac{4.5 + 2.5}{2} = 3.5$$

$$= \frac{2}{\sqrt{3}} \times 180 \left(1 + \frac{0.1 \times 18.7}{4 \times 3.5}\right) \times 450 \times 18.7$$

RSF = 1982.64 kN = 1.98 MN

05. Ans: (a)

Sol: $H_o = 4$, $H_1 = 3$mm, $R = 150$mm,

N = 100 rpm.

Velocity of strip at neutral point

= Surface Velocity of rollers

$$= \frac{\pi DN}{1000 \times 60} = \frac{\pi \times 300 \times 100}{1000 \times 60}$$

= 1.57 m/sec

06. Ans: (a)

Sol: $H_o = 20$ mm,

b = 100 mm

H_1=18 mm,

R = 250 mm,

$N = 10$ rpm, $\sigma_y = 300$ MPa

$$\Delta H = 20 - 18 = 2\text{mm}$$

$$\mu = \sqrt{\frac{\Delta H}{R}} = 0.089$$

$$L = \text{length of deformation zone} = \sqrt{R\Delta H}$$

$$= \sqrt{250 \times 2} = 22.36 \text{ mm}$$

$$H = \frac{20 + 18}{2} = 19$$

$$F_{avg} = R.S.F = \frac{2}{\sqrt{3}} \sigma_y b \times L \left[1 + \frac{\mu L}{4H}\right]$$

$$= \frac{2}{\sqrt{3}} \times 300 \times 100 \times 22.36 \left[1 + \frac{0.089 \times 22.36}{4 \times 19}\right]$$

= 795 kN.

$T = F_{avg} \times a$,

Where

a = moment arm = λ L

= 0.3L to 0.4 × L

$$T = F_{avg} \times 0.4L = 795 \times 10^3 \times 0.4 \times 22.36$$

= 7110 kN-mm

= 7.11 kN-m

$$P_{av\delta} = \frac{2\pi\, NT}{60} = \frac{2\pi \times 10 \times 7.110}{60}$$

= 7.44 kW / roller

Total Power = 7.44 × 2 = 14.88 kW

07. Ans: (d)

Sol: $H_o = 16$ mm,

$H_1 = 10$ mm,

$R = 200$ mm

$$\text{Angle of Bite} = \alpha = \tan^{-1}\sqrt{\frac{\Delta H}{R}}$$

$$= \tan^{-1}\sqrt{\frac{16-10}{200}} = 9.9$$

08. Ans: (a)

Sol: Given rolling process

Initial thickness $H_0 = 30$ mm

Final thickness = $H_1 = 14$ mm

$D_{roller} = 680 = R = 340$ mm

$\sigma_y = 200$ MPa

Thickness at neutral $H_n = 17.2$

$$\text{Forward slip} = \frac{V_1}{V_n} - 1 = \frac{H_n}{H_1} - 1$$

$$= \frac{17.2}{14} - 1 = 0.2285 = 23\%$$

$$\text{Backward slip} = 1 - \frac{V_0}{V_n} = 1 - \frac{H_n}{H_0}$$

$$= 1 - \frac{17.2}{30} = 42.6\% \approx 43\%$$

09. Ans: (b)

Sol: Roll separation distance

$= 2 \times R + H_1 = 2 \times 300 + 25$

$= 625$ mm

10. Ans: (b)

Sol: $d_o = 15$ mm,

$d_f = 0.1$ mm

$$\%\text{Reduction} = \frac{\text{dia reduced in the draw}}{\text{dia before draw}}$$

$$= \frac{d_0 - d_1}{d_o} \rightarrow \text{Ist draw}$$

$$= \frac{d_1 - d_2}{d_1} \rightarrow \text{2nd draw}$$

a) 3 stages with 80% reduction at each stage

$$0.8 = \frac{d_o - d_1}{d_o}$$

$d_1 = 0.2\, d_o = 3$mm

$d_2 = 0.2.\, d_1 = 0.6$mm

$d_3 = 0.2\, .d_2 = 0.12$mm (Error is 20%)

b) 4 stages with 80% reduction in 1st 3 stages followed by 20% in 4th stage

$d_1 = 0.2.\, d_0 = 3$

$d_2 = 0.2.\, d_1 = 0.6$

$d_3 = 0.2.\, d_2 = 0.12$

$d_4 = 0.8.\, d_3 = 0.096$ (Error is 4%)

c) 5 stages, with 80, 80, 40, 40, 20 etc

$d_1 = 0.2.\, d_0 = 3$

$d_2 = 0.2.\, d_1 = 0.6$

$d_3 = 0.6.\, d_2 = 0.36$

$d_4 = 0.6.\, d_3 = 0.0216$

$d_5 = 0.8.\, d_4 = 0.1728$ (Error is 72%)

From the given multiple choice B, the final diameter of wire close to 0.1 mm.

11. Ans: (a)

Sol: Given wire drawing process

$d_0 = 6$ m, $d_1 = 5.2$ mm

Die angle = 18^0, diameter land = 4 mm

Coefficient of friction = 0.15

Yield dress = 260 MPa

$A_0 = \frac{\pi}{4}6^2 = \frac{\pi}{4}136 = 21.237$

$A_1 = \frac{\pi}{4}5.2^2 = \frac{\pi}{4} = 21.237$

Drawing stress = σ_2

$$= \sigma_y\left(\frac{1+B}{B}\right)\left(1-\left(\frac{A_1}{A_0}\right)^B\right)$$

$B = \mu\cot\alpha$

$\alpha = \frac{1}{2}$ Die angle $= \frac{1}{2}\times 18 = 9^0$

$\alpha = 9$

$B = 0.15 \times \cot 9^0 = 0.947$

$\sigma_2 = 126.958$MPa

$$= (260)\left(\frac{1+0.947}{0.947}\right)\left(1-\left(\frac{21.27^0}{28.270}\right)^{0.947}\right)$$

$= 260(2.056)(0.2375)$

Total drawing stress $\sigma_2 = \sigma_y + (\sigma_2 - \sigma_y)\,e^{\frac{-2\mu L}{R_1}}$

(By considering friction)

$= 260 + (130-260)\,e^{\frac{-2\times 0.15\times 4}{2.6}}$

$\sigma_{total} = 260 - 81.94 = 178.05$ MPa

Total drawing load = $\sigma_t \times A_1$

$= 178.05 \times 21.237$

$= 3.781$ kN

Common data for Q 12, 13 & 14

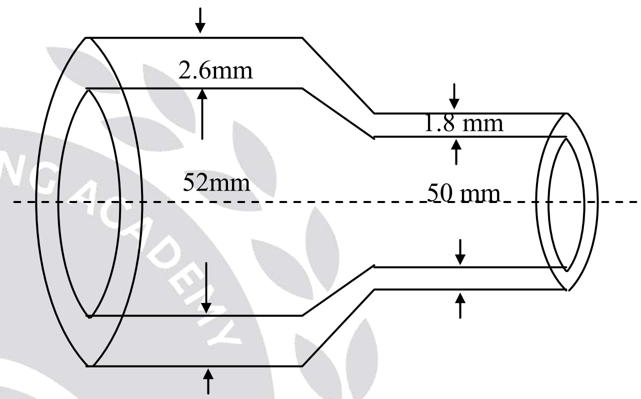
12. Ans: (b) , 13. Ans: (c), 14. Ans: (a)

Sol: Initial inside diameter of tube

$d_0 = 52$ mm, $H_0 = 2.6$

$H_1 = 1.8$, $D_1 = 50$ mm

$2d = 24° \Rightarrow \alpha = 12°$, $\mu = 0.12$



For stationary mandrel $B = \frac{\mu_1 + \mu_2}{\tan\alpha}$

$$B = \frac{0.12+0.12}{\tan(12°)} = 1.29$$

$$\sigma_2 = \sigma_y\left[\frac{1+B}{B}\right]\left[1-\left(\frac{H_1}{H_0}\right)^B\right]$$

$$\sigma_2/\sigma_y = \left[\frac{1+1.29}{1.129}\right]\left[1-\left(\frac{1.8}{2.6}\right)^{1.19}\right]$$

$\sigma_2/\sigma_y = 0.64$

13. Movable mandrel

$B = \mu\cot\alpha = (0.12)\cot(12°) = 0.564$

$$\sigma_2/\sigma_y = \left[\frac{1+0.564}{0.564}\right]\left[1-\left(\frac{1.8}{2.6}\right)^{0.564}\right] = 0.519$$

14. Floating mandrel

B = 0

$$\frac{\sigma_2}{\sigma_y} = \ell n\left(\frac{h_0}{h_1}\right)$$

$$= \ell n\left(\frac{2.6}{1.8}\right) = 0.367$$

Common data for Q 15. & 16.

15. Ans: 6 & 16. Ans: 3.4

Sol: $d_0 = 6$ mm, $d_f = 1.34$ mm

Given ideal condition

$\mu = 0.2$ $\alpha = 6^0$

$\sigma_f = 60$ MPa

Maximum reduction condition

$$\frac{\sigma_2}{\sigma_y} = 1 \Rightarrow 1 = \left(\frac{1+B}{B}\right)\left(1-\left(\frac{d_1}{d_0}\right)^{2B}\right)$$

$B = \mu\cot\alpha$; $B = 1.9$

$$\frac{B}{1+B} = 1-\left(\frac{d_1}{d_0}\right)^{2B}$$

$$\left(\frac{d_1}{d_0}\right)^{2B} = 1-\frac{B}{1+B}$$

$$= \frac{1}{1+B}$$

$$\frac{d_1}{d_0} = \sqrt[2B]{\frac{1}{1+B}}$$

$$d_1 = d_0\left(\sqrt[2B]{\frac{1}{1+B}}\right) = 6\left(\frac{1}{1+1.9}\right)^{\frac{1}{2\times1.9}}$$

$d_1 = 4.53$ ……… (1) stage

$$d_2 = d_1\sqrt[2B]{\frac{1}{1+B}}$$

$$C = \left(\frac{1}{1+B}\right)^{\frac{1}{2B}} = 0.756$$

Dia of wire in 2nd stage = 3.424 mm

$d_1 = d_0 \times c$

$d_2 = d_1 \times c = 4.53\times0.756$

$= 3.424 > 1.34$

$d_3 = d_2 \times c$

$= 3.424 \times 0.756$

$= 2.589 > 1.34$

$d_4 = d_3\times c = 1.957 > 1.34$

$d_5 = d_4 \times c = 1.4797 > d_f$

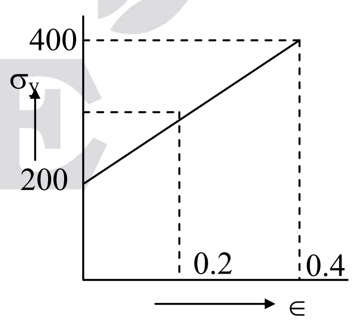
$d_6 = d_5\times c = 1.1186 < d_f$

$\therefore$ Hence No. of stages = 6

Common data for Q 17, 18

17. Ans: (c) & 18. Ans: (b)

Sol:



$d_o = 12.214$, $L_o = 100$m

$d_f = 10$mm, $L_f = ?$

σ_y before = 200 MPa ,

σ_y after = 400 MPa

$A_o L_o = A_f L_f$

$$L_f = L_o \times \frac{A_o}{A_f} = L_o\left(\frac{d_o}{d_f}\right)^2$$

$$= 100 \times \left(\frac{12.214}{10}\right)^2 = 150\text{m}$$

True strain in the drawing process

$$= \in = \ell n\frac{A_o}{A_1} = \ell n\left(\frac{d_o}{d_1}\right)^2 = 0.4$$

From the graph σ_y at $\in = 0.2$,

$$\sigma_y = 300 \text{ MPa}$$

19. Ans: (b)

20. Ans: (c)

Sol: $(\text{Extrusion force})_{min} = \sigma_y \times A_0$

$$= 10 \times \frac{\pi}{4} \times 10^2 = 78539.8\text{N}$$

$$\text{Extrusion force} = \frac{(E.F)_{min}}{\eta_{ext}} = \frac{78539.8}{0.4}$$

= 196346.5 N

= 196 Tons

21. Ans: (b)

Sol: Extrusion constant = K = 250

$d_o = 100$ mm, $d_f = 50$ mm

$$\text{Extrusion Force} = A_o\ K\ \ln\frac{A_o}{A_f}$$

$$= \frac{\pi}{4}100^2 \times 250\ \ln\left(\frac{100}{50}\right)^2 = 2.72 \text{ MN.}$$

22. Ans: 1

Sol: Let, $d_1 = d_2 = d$

h_1 = height of first cylinder

h_2 = height of second cylinder

Assume $h_1 < h_2$

Let % reduction in height = 10%

I[st] cylinder

$$\frac{h_0 - h_f}{h_0} = 0.1$$

$h_0 - h_f = 0.1\ h_0$

$h_f = h_0 - 0.1\ h_0 = 0.9\ h_0$

$A_0 h_0 = A_f h_f$

$d_0^2 h_0 = d_f^2 h_f$

$$d_f = d_0\sqrt{\frac{h_0}{h_f}} = d_0\sqrt{\frac{h_0}{0.9h_0}}$$

$= 1.054\ d_0 = 1.054\ (d_0)_1$

II[nd] cylinder

$A_0 h_0 = A_f h_f$

$d_0^2 h_0 = d_f^2 h_f$

$$d_f = d_0\sqrt{\frac{h_0}{h_f}}$$

$$= d_0\sqrt{\frac{h_0}{0.9h_0}} = 1.054\ (d_0)_2$$

$$\text{Ratio} = \frac{(d_0)_1}{(d_0)_2} = \frac{1.054(d_0)_1}{1.054(d_0)_2} = 1$$

Common data for Q 23 & 24

23. Ans: 7068 J & 24. Ans: 0.354 m

Sol: $d_o = 100$ mm, $h_o = 50$ mm,

$h_f = 40\,\text{mm}$, $\sigma_y = 80$ MPa

$$d_f = d_o\sqrt{\frac{h_o}{h_f}} = 100\sqrt{\frac{50}{40}} = 111.8\text{mm}$$

$$F_{i\,min} = A_0 \times \sigma_y$$

$$= \frac{\pi}{4} \times 100^2 \times 80 = 628.318 \text{ kN}$$

$$F_{f\,min} = A_f \times \sigma_y = \frac{\pi}{4}(111.8)^2 \times 80$$

$$= 785.350 \text{ kN}$$

$$F_{min} = \frac{F_{i\,min} + F_{f\,min}}{2} = 706.834 \text{ kN}$$

$$W.D = F_{min} \times (h_o - h_f) = 7068\text{J}$$

$$= 2 \times W \times H$$

$$H = \frac{7068}{2 \times 10 \times 10^3} = 0.354 \text{ m}$$

25. Ans: (b)

26. Ans: 58%

Sol: Area after 1st pass = $A_1 = (1 - 0.4)A_0$

$= 0.6\ A_0$

Area after 2nd pass = $A_2 = (1 - 0.3)A_1$

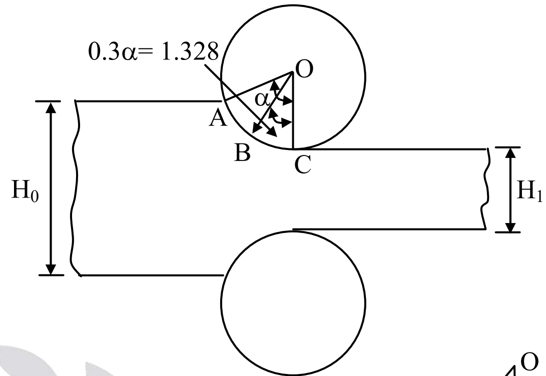
$= 0.7 \times 0.6 \times A_0 = 0.42\ A_0$

Overall % reduction = $(1 - 0.42) \times 100$

$= 58$ %

27. Ans: 7.26

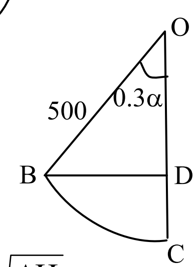
Sol:



$H_o = 10$ mm,

$H_1 = 7$ mm,

$$R = \frac{1000}{2} = 500 \text{ mm}$$



$$\text{Angle of bite } (\alpha) = \tan^{-1}\sqrt{\frac{\Delta H}{R}}$$

$$= \tan^{-1}\sqrt{\frac{10-7}{500}} = 4.429$$

$$1.328 = \frac{OD}{OB}$$

OD = 500×cos1.328 = 499.865

DC = 500 – OD = 0.1343 mm

Thickness of neutral point = At point B

$= 7 + 2 \times 0.1343 = 7.2686$ mm

29. Ans: 7.687 MPa, 19.7 %

Sol: $d_0 = 6.25$ mm; $d_1 = 5.60$ mm;

$\mu = 0$; $\tau_y = 35\ \text{N/mm}^2$

$B = \mu\cot\alpha = 0$

$$\tau_2 = \tau_y\left(\frac{1+B}{B}\right)\left(1 - \left(\frac{A_1}{A_0}\right)^B\right) = \frac{0}{0}$$

By applying L – Hospital rule

$$\sigma_2 = \sigma_y \ell n\left(\frac{A_0}{A_1}\right)$$

$$= \sigma_y \times 2\ell n\left(\frac{d_0}{d_1}\right)$$

= 7.687 MPa

% reduction in area = $\frac{A_0 - A_1}{A_0} = \frac{d_0^2 - d_1^2}{d_0^2}$

= 19.71%

30. Ans: 29.85 tons

Sol: Initial size = 25×25×150mm

Final size = 6.25×100×150mm

$\mu = 0.25$;

$\sigma_y = 0.7 \text{kg/mm}^2$

As given piece is pressed; height is reduced

$h_0 = 25$;

$h_f = 6.25$

$A_0 = 25\times150$;

$A_f = 100\times150$

Forging force = $\sigma_y A_f\left[1 + \frac{2\mu h r_f}{3h_f}\right]$

$(A_c)_{circular} = (A_c)_{non-circular}$

$\pi r_f^2 = 100\times150$

$r_f = 69.098$mm

Forging force

$$= 0.7\times15\times10^3\left[1+\frac{2\times0.25\times69.098}{3\times6.25}\right]$$

= 29847.44kg = 292.80kN

31. Ans: 20.52 kW

Sol: $d_0 = 10$ mm;

$$0.3 = \frac{A_0 - A_1}{A_0} = 1 - \frac{A_1}{A_0}$$

$$0.3 = 1 - \frac{d_1^2}{d_0^2}$$

$d_1 = 8.36$ mm

$B = \mu\cot\alpha = 0.1\cot(6^o) = .951$

$$\sigma_2 = \sigma_y\left(\frac{1+B}{B}\right)\left(1-\left(\frac{A_1}{A_0}\right)^B\right)$$

$$= 240\left(\frac{1+0.951}{0.951}\right)\left(1-(0.7)^{0.951}\right)$$

= 141.687 MPa

Drawing load = $\sigma_2 \times A_1 = 141\times\frac{\pi}{4}\left(d_1^2\right)$

$$F_d = 141.687\frac{\pi}{4}d_1^2$$

$$= 141\times\frac{\pi}{4}\left(8.36^2\right) = 7777.364 = 7.8 \text{ kN}$$

P (motor) = $\frac{F_d \times v}{\eta_{motor}}$

$$P = \frac{7.8\times2.5}{0.95}$$

$\Rightarrow$ P = 20.52 kW

32. Ans: (b)
33. Ans: (d)
34. Ans: (c)
35. Ans: (d)
36. Ans: (d)
37. Ans: (d)
38. Ans: (c)
39. Ans: (c)
40. Ans: (a)
41. Ans: (a)
42. Ans: (d)
43. Ans: (d)
44. Ans: (b)
45. Ans: (a)

Chapter- 6
Sheet Metal Operation

Common data for Q. 1 to 5

01. Ans: (b)

Sol: For punching operation

Punch size = Hole size = 12.7

Die size = punch size + clearance

= 12.7 + 2 × 0.04 = 12.78

02. Ans: (a)

Sol: Die size = Blank size = 25.4mm

Punch size = Die size – 2(radial clearance)

= 25.4 – 2(0.04)

Punch size = 25.32 mm

03. Ans: (b)

Sol: $F_{max} = F_{p\ max} + F_{b\ max}$

$= \pi \times 12.7 \times 1.25 \times 800 + \pi \times 25.4 \times 1.25 \times 800$

= 40 +80 = 120 kN

04. Ans: (c)

Sol: Force required is Max [F_{punch}, F_{blank}]

⇒ force required is Max [40, 80]

⇒ force required = 80 kN

05. Ans: (b)

Sol: $F_p = \dfrac{F_{p\max}.Kt}{Kt + I}$

$= \dfrac{40 \times 0.6 \times 1.25}{0.6 \times 1.25 + 1} = 17.14\ \text{kN}$

$F_b = \dfrac{F_{b\max} kt}{kt + I}$

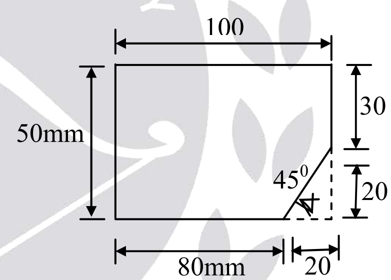
$= \dfrac{80 \times 0.6 \times 1.25}{0.6 \times 1.25} = 34.28\ \text{kN}$

$F = F_p + F_b = 51.42\ \text{kN}$

Common data for Q. 06, 07 & 08

06. Ans: 83.6 N

Sol:



$P = 100 + 30 + 20\sqrt{2} + 80 + 50 = 288.28$

$F_{max} = Pt\tau_u = 288.28 \times 2 \times 145 = 83.6\text{kN}$

07. Ans: 66.88 J

Sol: Work done in blanking open

$= F_{max}.K.t$

$= 83.6 \times 10^3 \times 0.4 \times 2 \times 10^3$

= 66.88 J

08. Ans: 1.98 mm

Sol: I = ?

F = 24 kN

F_{max} = 83.6 kN

$F(Kt + I) = F_{max} \times Kt$

$$I = \frac{F_{max} \times Kt}{F} - Kt$$

$$= \left(\frac{83.6 \times 0.4 \times 2}{24} - 0.4 \times 2\right) = 1.98 \text{ mm}$$

09. Ans: (a)

Sol: $F_{max} = 5 = \pi dt\,\tau_u \Rightarrow dt\tau_u = \frac{5}{\pi}$

$$F_{max} = \pi \times 1.5d \times 0.4t \times \tau_u$$

$$= \pi \times 1.5 \times 0.4 \times dt\tau_u$$

$$= \pi \times 1.5 \times 0.4 \times \frac{2}{\pi} = 3\,KN$$

Common Solution for Q. 10 & 11

10. Ans: (a)

11. Ans: (b)

Sol: t = 5 mm, L = 200 mm, τ_u = 100 MPa,

K = 0.2

W.D = F_{max} Kt = L × t × τ_u × K.t

= 200 × 5 × 100 ×0.2 × 5

$$= \frac{100 \times 10^3}{1000} = 100 \text{ N} - \text{m (or) J only}$$

Shear provided over a length of

$$200\ mm \rightarrow \frac{20}{400} \times 200 = 10 \text{ mm}$$

F_{max} Kt = F (Kt + I)

$$F = \frac{100 \times 10^3 \times 0.2 \times 5}{0.2 \times 5 + 10} = 9.09 = 10 \text{ kN}$$

12. Ans: (d)

Sol: d = 25 mm, t = 2.5 mm → piercing

τ_u = 350 MPa

Diameter clearance = C

$$= 0.0064\,K\sqrt{t}$$

$$= 0.0064 \times 2.5\sqrt{350} = 0.3 \text{ mm}$$

In piercing

P.S = H.S = 25 mm.

D.S = P.S + C = 25 + 0.3 = 25.3

$$F_{max} = \pi dt\,\tau_u = \pi \times 25 \times 2.5 \times 350$$

= 68.72 kN.

13. Ans: (a)

Sol: Die size = Blank size = 25 – 0.05

= 24.95

Punch size = Die size – clearance

= 24.95 – 2 × 0.06 = 24.83

Common data for Q. 14 & 15

14. Ans: (b)

Sol: $$\text{Draw Ratio} = \frac{\text{Dia.before}}{\text{Dia.after}}$$

$$\Rightarrow d_1 = \frac{13.22}{1.8} = 7.34 > 5\text{cm}$$

$$\Rightarrow d_2 = \frac{7.34}{1.8} = 4.08 < 5 \text{ cm}$$

n = 2

15. Ans: (a)

Sol: $D = \sqrt{d_1^2 + 4d_1h_1}$

$4d_1h_1 = D^2 - d_1^2$

$h_1 = \frac{D^2 - d_1^2}{4\times d_1} = \frac{13.22^2 - 7.34^2}{4\times 7.34} = 4.11$ mm

$P_1 = \pi D t \sigma_y$

$= \pi\times 132.22\times 1.5\times 315$

$= 196238$ N = 196.238 kN

E = P_1h_1 = $196.238\times 4.11\times 10^{-3}$ = 806.6 kJ

16. Ans: (b)

Sol: $DRR_1 = 0.4 = \frac{D - d_1}{D}$

$d_1 = D(1-0.4) = 30.2\times 0.6 = 18.12$

$d_2 = d_1(1-0.25) = 18.12(0.75) = 13.59$

$d_3 = d_2(1-0.25) = 13.59(0.75) = 10.19$

$d_3 < 12 \Rightarrow n = 3$

17. Ans: (b)

Sol: $P_1 = \pi D t \sigma_y = \pi\times 30.2\times 2\times 35 = 6641.3$

$$\sigma_{21} = \frac{P_1}{\frac{\pi}{4}\left(d_1^2 - (d_1 - 2t)^2\right)}$$

$$= \frac{6{,}641.3}{\frac{\pi}{4}\left(18.12^2 - (18.12 - 2\times 2)^2\right)}$$

= 65.5 MPa

Common data for 18 & 19

18. Ans: 6

Sol: $D = \sqrt{d^2 + 4dh} = \sqrt{30^2 + 4\times 30\times 150}$

$= 137.47$

$d_1 = D\times 0.6 = 137.47\times 0.6 = 82.48 > 30$

$d_2 = 82.48\times 0.8 = 65.984 > 30$

$d_3 = 65.984\times 0.8 = 52.7 > 30$

$d_4 = 52.7\times 0.8 = 42.2 > 30$

$d_5 = 42.2\times 0.8 = 33.7 > 30$

$d_6 = 33.7\times 0.8 = 27 < 30$

n = 6

19. Ans: 52.7 mm

Sol: d_3 = 52.7 mm

20. Ans: 144.42

Sol: $\frac{d}{r} = \frac{100}{6} = 16.66 \approx 15 \text{ to } 20$

$$D = \sqrt{d^2 + 4dh} - \frac{r}{2}$$

$$= \sqrt{100^2 + 4\times 100\times 25} - \frac{6}{2}$$

= 138.42 +2×3

$D_{total} = D + 2\times 3 = 144.42$ mm

21. Ans: (d)

22. Ans: (c)

Sol: Number of earing defects produced $=2^n$

Where n is an integer

So possible option is 64.

23. Ans: 467 mm

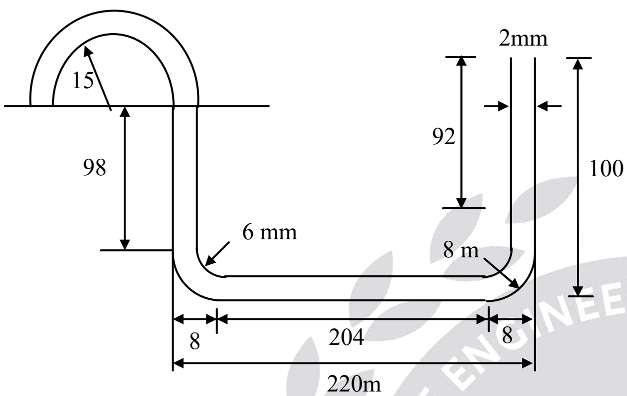
Sol: $B_1 = (15 + 0.5\times 2)\times 180\times \frac{\pi}{180}$

= 50.265 mm

$$B_2 = (6 + 0.5 \times 2) \times 90 \times \frac{\pi}{180} = 10.99 \text{ mm}$$

$$L_0 = 98 + 204 + 92 + B_1 + 2B_2$$

$$= 466.245 \text{ mm}$$



24. Ans: (b)

25. Ans: 3

Sol: $D = \sqrt{d^2 + 4dh}$

$$= \sqrt{50^2 + 4 \times 50 \times 100} = 150\text{mm}$$

$$0.4 = \frac{D - d_1}{D}$$

$0.4 \times 150 = 150 - d_1$

$d_1 = 90\text{mm} > 50$

$d_2 = d_1(1 - 0.4) = 54 > 50$

$d_3 = 32.4 < 50$

$\therefore$ **n = 3**

26. Ans: 7.536 kN

Sol: Punching a 10 mm circular hole from 1 mm thickness sheet:

Punch size = Blank size = 10 mm

Die size = Punch size + 2 C

C = Clearance = $0.0032t\sqrt{\tau}$

t = thickness = 1 mm

where, $\tau = 240 \text{ N/mm}^2$

$C = 0.0032 \times 1 \times \sqrt{240}$

$= 0.0495$ mm $= 0.05$ mm

Die size = 10 + 2 × 0.05 = 10.1 mm

Force required = $\tau_s \times \pi d \times t$

$= 240 \times \pi \times 10 \times 1$

$= 7.536$ kN

Chapter- 7
Metrology

7.1 Limits, Fits & tolerances

01. Ans: (a)

Sol: For Clearance fit

L- hole > H- shaft

02. Ans: (c)

Sol: Hole = $40^{0.050}_{0.000}$ mm ,

Min. clearance = 0.01 mm,

Tolerance on shaft = 0.04 mm ,

Max. clearance of shaft = ?

0.01 = L.hole – H.shaft

0.01 = 40.000 – H.shaft

$\Rightarrow$ H.shaft = 40.000 – 0.01 = 39.99mm

H.shaft – L.shaft = 0.04

L.shaft = 39.99 – 0.04 = 39.95

Max. clearance = H.hole – L.shaft

= 40.05 – 39.95 = 0.10 mm

03. Ans: (d)

Sol: X_{max} = 50.02 – (37.985 + 9.99) = 2.045

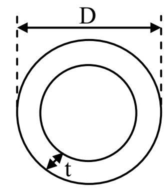
X_{min} = 49.98 – (38.015 + 10.01) = 1.955

$X = X_{max} - X_{min}$ = 0.09

Dimension X = 2 ± **0.045**

04. Ans: (c)

Sol:



t = 0.01 to 0.015mm

When, t = 0.01 mm

D = 30.01 + 2×0.01 = 30.03 mm

= 30.05 + 2× 0.01 = 30.07 mm

When, t = 0.015 mm

D = 30.01 + 2×0.015 = 30.04 mm

= 30.05 + 2× 0.015 = 30.08 mm

$D = 30^{+0.08}_{+0.03}$ mm

05. Ans: (d)

Sol: A = $25.2^{+0.01}_{-0.02}$

B = 30.4 ± 0.01

C = 32.7 ± 0.02

$T_{max} = L_{max} - A_{min} - B_{min} - C_{min}$

= (118 + 0.08) – (25.2 – 0.02) – (30.4 – 0.01) – (32.7 – 0.02)

= 29.83 = $30^{-0.17}$

$T_{min} = L_{min} - A_{max} - B_{max} - C_{max}$

= (118 – 0.09) – (25.2 + 0.01) – (30.4 + 0.01) –(32.7+ 0.02)

= 29.57

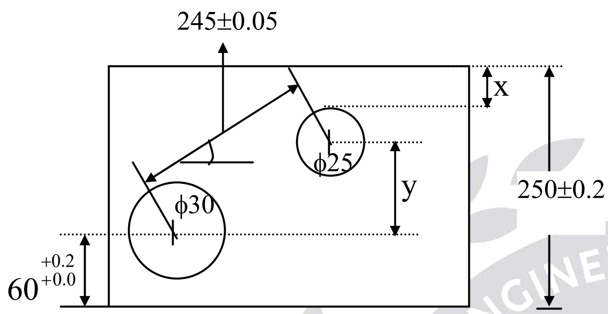
$T_{min} = 30^{-0.43}$

$\therefore$ $T = 30^{-0.17}_{-0.43}$

06. Anc: (c)

07. (i) Ans: (d)

Sol: Let the vertical distance between the holes is 'y'



$\sin 30 = \frac{y}{245} \Rightarrow y = 245\sin 30$

$y_{max} = 245_{max} \times \sin 30_{max}$

$= (245 + 0.05)\sin(30 + 15/60) = 123.45$

$y_{min} = (245 - 0.05)\sin(30^0 - 15/60) = 121.55$

(ii) **Ans: (c)**

$x_{max} = 250_{max} - (60_{min} + (30/2)_{min} + y_{min} + (25/2)_{min})$

$= (250 + 0.2) - (60 + 15 + 121.55 + 12.5)$

$= 41.15\text{mm}$

$x_{min} = 250_{min} - (60_{max} + (30/2)_{max} + y_{max} + (25/2)_{max})$

$= (250 - 0.2) - (60.2 + 30.025/2 + 123.45 + 25.025/2)$

$= 38.625$ mm

Tolerance on X = $X_{max} - X_{min}$ = 2.525 mm

08.

Sol: L Hole = BS = 65mm

H Hole = BS + Tolerance = 65.05mm

(i) **Ans: (c)**

Allowance = $(L.L)_{hole} - (H.L)_{Shaft}$

$\Rightarrow 0.09 = 65 - (H.L)_{shaft}$

$\Rightarrow (H.L)_{shaft} = 65 - 0.09 = 64.91$ mm

Tolerance = $(HL)_{shaft} - (LL)_{shaft}$

$\Rightarrow 0.05 = 64.91 - (LL)_{shaft}$

$\Rightarrow (LL)_{shaft} = 64.86$ mm

Shaft = piston = $65^{-0.09}_{-0.14}$

(ii) **Ans: (a)**

$(L.L)_{hole} = 65$ mm

$(Tolerance)_{hole} = (HL)_{hole} - (LL)_{hole}$

$\Rightarrow 0.05 = (HL)_{hole} - 65$

$\Rightarrow (HL)_{hole} = 65.05$ mm

Hole = Bore = $65^{+0.05}_{0.00}$

(iii) **Ans: (b)**

Max Clearance = 65.05 – 64.86

= 0.19 mm

09.

Sol: $A_{max} = 15_{max} + 30_{max}$

$= 15.06 + 30.1 = 45.16$

$A_{min} = 15_{min} + 30_{min} = 44.84$

$A = 45 \pm 0.16. = A \pm \Delta A$

$B_{max} = A_{max} - 20_{min}$

$= 45.16 - 19.93 = 25.23$ mm

$B_{min} = A_{min} - 20_{max}$

$= 44.84 - 20.07 = 24.77$ mm

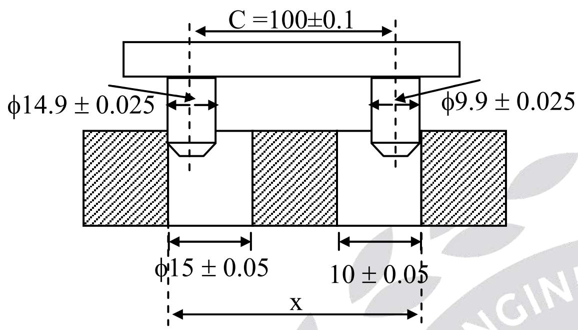
$\Rightarrow B \pm \Delta B = 25 \pm 0.23.$

10.

Sol: Let

C = center distance between holes

C_{max} = max. Outer distance of pins – sum of min rod holes.



$$X_{max} = 100_{max} + \left(\frac{9.9}{2}\right)_{max} + \left(\frac{14.9}{2}\right)_{max}$$

$$= 100.1 + \frac{9.925}{2} + \frac{14.925}{2}$$

= 112.525 mm

$$X_{min} = 100_{min} + \left(\frac{9.9}{2}\right)_{min} + \left(\frac{14.9}{2}\right)_{min}$$

$$= 99.9 + \frac{9.875}{2} + \frac{14.875}{2}$$

= 112.275 mm

$$C_{max} = X_{max} - \left[\left(\frac{15}{2}\right)_{min} + \left(\frac{10}{2}\right)_{min}\right]$$

$$= 112.525 - \left(\frac{14.95}{2} + \frac{9.95}{2}\right)$$

= 100.075 mm

$$C_{min} = X_{min} - \left[\left(\frac{15}{2}\right)_{max} + \left(\frac{10}{2}\right)_{max}\right]$$

$$= 112.525 - \left(\frac{15.05}{2} + \frac{10.05}{2}\right)$$

= 99.725 mm

$$\therefore C = 100^{+0.075}_{-0.275}$$

11.

Sol: For the given conditions

$$X = 100.1 + \frac{14.875}{2} + \frac{9.875}{2}$$

= 112.475 mm

$$C = X - \left(\frac{15.05}{2} + \frac{10.05}{2}\right)$$

C = 99.925 mm

Because C is lying in between the limits, the assembly is possible.

12. Ans: (b)

Sol: Fundamental deviation of hole 'h' is zero.

13.

Sol: Hole = $20^{+0.03}_{-0.00}$

Min. interference = 0.03mm,

Max. interference = 0.08 mm

0.03 = L.shaft – H.hole

L.shaft = 0.03 + 20.03 = 20.06 mm

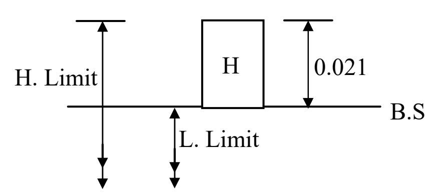
0.08 = H.shaft – L.hole

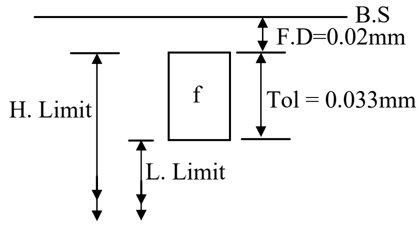
H.shaft = 0.08 + 20.00 = 20.08mm

shaft = $20^{+0.08}_{+0.06}$

14.

Sol:





$D = \sqrt{18 \times 30} = 23.24\text{mm}$

$i = 0.45\sqrt[3]{D} + 0.0010 = 1.3\mu m$

FD of hole H = 0

FD Shaft $= -5.5(23.24)^{0.41} = -20\mu m$

Hole tolerance, IT7 $=16i = 20.8\mu m$

$= 21\mu m = 0.021$ mm

Shaft tolerance, IT 8 = 25i

$= 32.5\mu m = 33\mu m$

$= 0.033$mm

L - hole = basic size =25 mm

H - hole = 25 + 0.021 = 25.021 mm

H - shaft = 25 – 0.02 = 24.98 mm

L - shaft = 24.98 – .033 = 24.947 mm

(i) **Ans: (a)**

L- hole > H- shaft → Clearance fit

(ii) **Ans: (b)**

Allowance = difference between max. material limits = L.hole – H.shaft

= 25.00 – 24.98 = 0.02 mm

(iii) **Ans: (b)**

Shaft $= 25^{-0.02}_{-0.053}$, Hole $= 25^{+0.021}_{+0.00}$

Max clearance = different between minimum material limits

= H.hole – L.shaft

= (25.021) – (24.947)

= 0.074 mm

(iv) **Ans: (a)**

Size of the GO plug gauge = max. material limit of hole = L.hole = 25 mm

(v) **Ans: (b)**

Size of the NOGO plug gauge = min. material limit of hole = H.hole = 25.021 mm

(vi) **Ans: (c)**

Size of the GO ring gauge = max. material limit of shaft = H.shaft = 24.98 mm

(vii) **Ans: (d)**

Size of the NOGO ring gauge = min. material limit of shaft = L.shaft = 24.947 mm

(viii) **Ans: (a)**

15. Ans: (c)

Sol: $D = \sqrt{18 \times 30} = 23.2$

$i = 0.45\ 3\sqrt{D} + 0.001\ D = 1.3$

IT8 = 26i = 26 × 1.3 = 33.8

$= 34\ \mu m = 0.034$ mm

Hole size $= 25H_8 = 25^{+0.034}_{+0.000}$

16. Ans: (a)

Sol: $D = \sqrt{50 \times 80} = 63.24$ mm

i = 1.86 microns = 1.9 microns

IT8 = 25i = 47.5 microns

Tolerance = 0.0475 mm

F.D = $-5.5\, D^{0.41} = -5.5 \times 63.24^{0.41}$

= 30 Microns = 0.03 mm

H. shaft = 60 – F.D = 60 – 0.03 = **59.97 mm**

L. shaft = H. shaft – Tolerance

= 59.97 – 0.047 = **59.923 mm.**

17. Ans: (d)

Sol: Case (i) $25H_7$

L.L = 25.00

U.L = 25.021

Case (2) 25 H_8

UL = 25.033

Case (3) $25H_6$, UL - ?

$(UL)_{H8} - (UL)_{H7} = (UL)_{H7} - (UL)_{H6}$

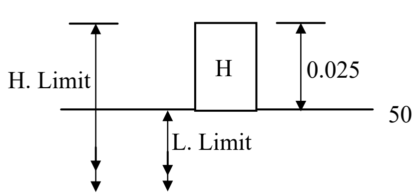
25.033–25.021 = 25.021 – (25 + x)

x = 0.009

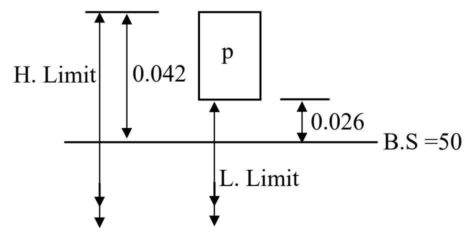
$\therefore$ $(UL)_{H6} = 25.009$

18. (i) Ans: (a) , (ii) Ans: (a), (iii) Ans: (a), (iv) Ans: (c)

Sol:



$\text{Hole} = 50^{+0.025}_{+0.000}$



$\text{Shaft} = 50^{+0.042}_{+0.026}$

L.hole = B.S = 50

H.hole – L.hole = Tolerance = 0.025 mm

H.hole = L.hole + Tolerance = 50.025 mm

Max. interference = difference between max. material limits = H.shaft – L.hole

= 50.042 – 50.00 = 0.042 mm

Min. interference = difference between min. material limits = L.shaft - H.hole

= 50.026 – 50.025 = 0.001 mm

19. Ans: (c)

20. Ans: (b)

Sol: To calculate exactly the data was not given in the problem. But for shaft "h",

H – Shaft = 25.000

L – Shaft = less than 25.

And $h_7 \rightarrow$ 7 indicates IT 7 not 7 microns.

21. Ans: (a)

Sol: GO size = max. material limit of hole

= 20.01 mm

NOGO size = min. material limit of hole

= 20.05 mm

22. Ans: (d)

Sol: To produce an interference fit, L-shaft must be greater than H-hole. For this with multiple choice D it is possible because

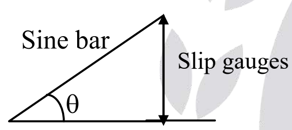
For D: L-shaft = 20 – 0.02 = 19.98 mm,
H-shaft = 20 + 0.02 = 20.02 mm
L-hole = 20 – 0.035 = 19.965mm,
H-hole = 20 – 0.03 = 19.97mm,

Hence, **L-shaft (19.98) > H-hole (19.97)**

7.2 Angular Measurements

01. Ans: (a)

Sol:



Given sine bar length = 200 = l

Angle $\theta = 32°5'6'' = 32.085°$

Slip gauge height = h say

$$\sin\theta = \frac{h}{\ell}$$

$$\sin(32.085^0) = \frac{h}{200}$$

$\Rightarrow$ h = 106.235

02. Ans: i-(b), ii-(a)

Sol: $l = 50$, L = 500

$50 \rightarrow 0.08$

$$200 \rightarrow 200\times\frac{0.08}{50} = 0.32$$

$h' = h + 0.32 = 28.87 + 0.32 = 29.19$

$$\text{Sin}\,\theta = \frac{h'}{L} = \frac{29.19}{200} = 8'23'32''$$

03. Ans: (d)

04. (i) Ans: (c)

Sol: $\sin\theta = \dfrac{h}{L}$

$h = \sin 30^o \times 125 = 62.5$ mm

(ii)

(A) Ans: (a)

$$d\theta = \tan 30°\left[\frac{0}{62.5} - \frac{0.005}{125}\right] = 4.76''$$

(B) Ans: (a)

$$dh = r_2 - r_1 = \frac{d_2 - d_1}{2} = \frac{0.002}{2} = 0.001$$

$$d\theta = \tan 30°\left[\frac{0.001}{62.5} - \frac{0}{125}\right] = 2''$$

(C) Ans: (b)

dh = 0.002

$$d\theta = \tan 30°\left(\frac{0.002}{62.5} - \frac{0}{125}\right) = 4''$$

(D) Ans: (d)

dh = ± 0.005

$$d\theta = \tan 30°\left(\frac{\pm 0.005}{62.5} - \frac{0}{125}\right) = \pm 10''$$

05. Ans: 0.048 mm/m

Sol: Gradient of spirit level

= Sensitivity specified in mm/m

$$= \frac{10}{3600}\times\frac{\pi}{180}\times 1000 = 0.04845 \text{ mm/m.}$$

06. Ans: (d)

07.

Sol: (i) Ans: (b)

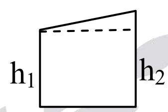
$$\sin\theta = \frac{h_2 - h_1}{w}$$

$$h_2 - h_1 = 100\sin 30 = 50$$

$$h_2 = h_1 + 50 = 75$$

(ii) Ans: (d)

$$\sin(30) = \frac{h - 25}{100.005}$$



$\Rightarrow$ $h = 75.0025$ mm

$\Rightarrow$ $h_2 = 75.0025 + 0.005 = 75.0075$ mm

08. Ans: (a)

Sol: L = 250 mm, d = 20 mm

h = 100 – (d/2) = 100 – 10 = 90 mm

$$\sin\theta = \frac{90}{250}$$

$\Rightarrow \theta = 21.2$ deg

09. Ans: 11.556 mm

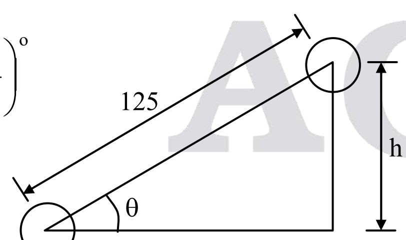
Sol: $\theta = 27°32'$

$$= 27° + \left(\frac{32}{60}\right)^{o}$$

$$= 27.533°$$

$$\sin\theta = \frac{h}{25}$$

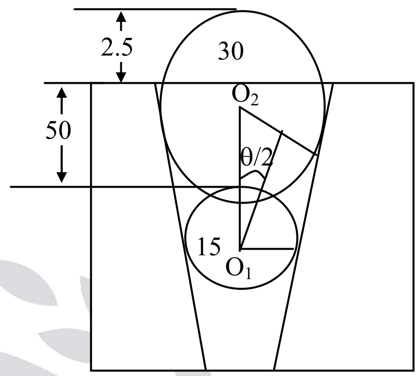
h = 11.556 mm



7.3 Taper Measurement

01. Ans: 19.2°

Sol:



$$\sin(\theta/2) = \frac{d_2 - d_1}{2(h_1 - h_2) - (d_2 - d_1)}$$

$$\sin(\theta/2) = \frac{30 - 15}{2(52.5) - (30 - 15)}$$

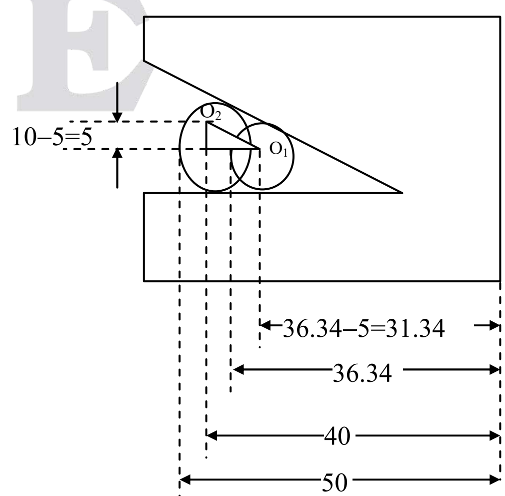
$$= \frac{15}{105 - 15} = 1/6$$

$\therefore$ $\theta = 19.2°$

02. Ans: 60

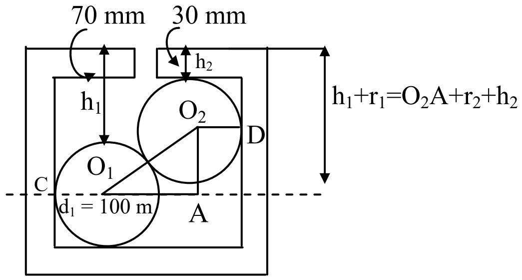
Sol: $\tan(\theta/2) = \dfrac{5}{8.66}$

$\Rightarrow$ $\theta = 60°$



03. Ans: 112.41 mm

Sol:



Diameter = $O_1C+O_1A+O_2D$

$$= \frac{d_1}{2} + \sqrt{(O_1O_2)^2 - (O_2A)^2} + \frac{d_2}{2}$$

$O_1O_2 = r_1 + r_2 = 75$

$O_2A = h_1 + r_1 - r_2 - h_2$

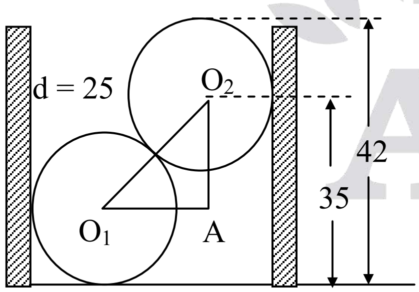
$= 70 + 50 - 30 - 25 = 65$

$D = 50 + \sqrt{75^2 - 65^2} + 25$

$= 112.4165$ mm

04. Ans: 43.33 mm

Sol:



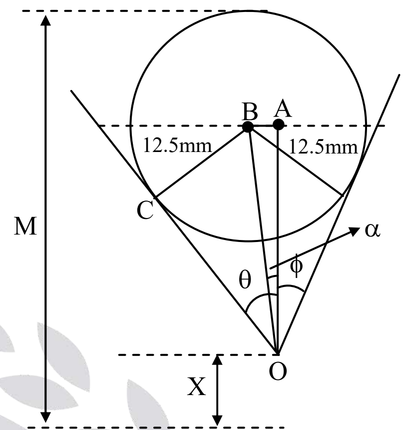
$O_1A = \sqrt{25^2 - 17^2} = 18.33$

$D = r + O_1A + r$

$= 25 + 18.33 = 43.33$ mm

05. Ans: 78.074 mm

Sol:



$\theta + \phi = 45°50' + 29°10' = 75°$

$\frac{\theta+\phi}{2} = 37.5°$

$\alpha = \frac{75}{2} - \phi = 37.5 - \phi = 37.5° - 29°10'$

$= 8°20'$

Δle OBC

$\sin 37.5 = \frac{BC}{OB}$

$\Rightarrow OB = \frac{BC}{\sin 37.5} = \frac{12.5}{\sin 37.5} = 20.533$

Δle OAB

$\cos 8°20' = \frac{OA}{OB}$

$\Rightarrow OA = OB \cos 8°20' = 20.316$ mm

$X = M - (OA + R)$

$= 110.89 - (20.316 + 12.5)$

$= 78.074$ mm

06. Ans: 1.1

Sol: $d_2 - d_1 = 10$; $h_2 - h_1 = 12.138$

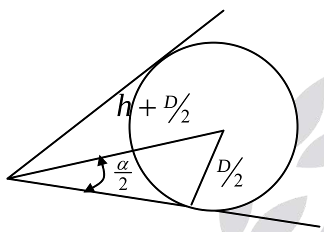
$$\sin\left[\frac{\theta}{2}\right] = \frac{d_2 - d_1}{2\times(h_2 - h_1) - (d_2 - d_1)}$$

$$\theta = 88.9$$

Error = 90 – 88.9 = 1.1

07. Ans: 38.94

Sol:



$$\text{Sin}\left[\frac{\alpha}{2}\right] = \frac{D/2}{h + D/2} = \frac{D}{2h + D}$$

$$\text{Sin}\frac{\alpha}{2} = \frac{D}{2h + D}$$

If D = 0, h = 0

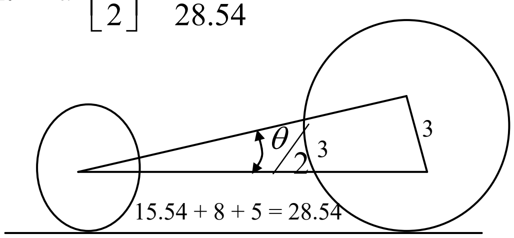
D = 1, h = 1

$$\text{Sin}\left[\frac{\alpha}{2}\right] = \frac{1}{2\times1+1} = \frac{1}{3}$$

$$\left[\frac{\alpha}{2}\right] = 19.47 \Rightarrow \alpha = 38.94$$

08. Ans: (d)

Sol: $\text{Tan}\left[\frac{\theta}{2}\right] = \frac{3}{28.54}$



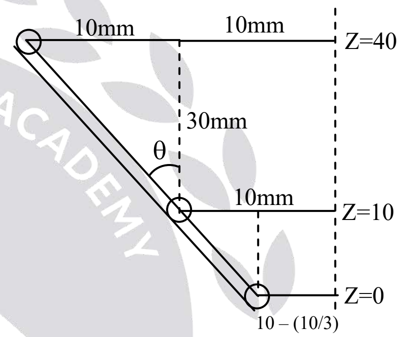
$$\frac{\theta}{2} = Tan^{-1}\left(\frac{3}{28.54}\right) = 6$$

Taper angle $\left(\frac{\theta}{2}\right) = 6^0$

Included angle = 12^0

09. Ans: (c)

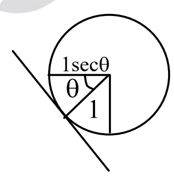
Sol: $\tan\theta = \frac{10}{30} \Rightarrow \theta = \tan^{-1}(1/3) \Rightarrow \theta = 18.434°$



Distance at Z = 0,

$$D_0 = 2(10 - 10\tan 30) = 2\left(10 - \frac{10}{3}\right)$$

$$= 6.67 \times 2 = 13.33 \text{ mm}$$



With probe diameter compensation

$$D_{actual} = 13.334 + 2\times r\ \sec\theta$$

$$= 13.334 + 2 \times (1 \sec \times 18.435)$$

$$= 15.442 \text{ mm.}$$

10. Ans: (d)

7.4 Screw Thread Measurements

01. Ans: (d)

Sol: Major diameter = s + (R_2 –R_1)

= 35.5 + (11.8708 –9.3768)

= 37.994 mm

02. Ans: (a)

Sol: Minor diameter

= 30.5 + (15.3768 – 13.5218)

= 32.355 mm

Correct answer is (a)

03. Ans: (a)

Sol: best wire diameter, $d = \left(\frac{p}{2}\right)\sec\left(\frac{\theta}{2}\right)$

$= \left(\frac{3.5}{2}\right)\sec\left(\frac{60}{2}\right) = 2$

M = 30.5 + (12.2428 – 13.3768)

= 29.366 mm

$D_e = M - \left(d + \frac{p}{2}\tan\frac{\theta}{2}\right)$

$= M - \left(2 + \frac{3.5}{2}\times\tan 30\right)$

= 29.366 – 3.010366 = 26.355 mm

04. Ans: (a)

Sol: VED = D_e ± VC

$$VC = \delta P\cos\frac{\theta}{2} + 0.0131P(\delta\theta_1 + \delta\theta_2)$$

δP = pitch error

$\delta\theta_1$, $\delta\theta_2$ – flank angle errors in deg

$\delta\theta_1 = 7^1 = 0.11667 - 2.04\times10^{-3}$

$\delta\theta_2 = 9^1 = 0.15 - 2.618\times10^3$

δP = 0.004

D_e = 30.6651

θ = 60° (metric thread)

Virtual correction

VC = (0.004 × cos30) + (0.0131 × 3.5(0.11667 + 0.15))

VC = 0.01569

VED = D_e + VC

= 30.6651 + 0.01569 = 30.6807

05. Ans: (a)

06. Ans: (d)

Sol: $\text{Sin}\left[\frac{\theta}{2}\right] = \frac{R_2 - R_1}{M_2 - M_1 - (R_2 - R_1)}$

$= \frac{1.4434 - 0.8660}{22.06 - 20.32 - (1.4434 - 0.8660)}$

θ = 59.5566 = 59°33′23″

07. Ans: 16.433 mm

Sol: $D_e = M - \left(d + \frac{p}{2}\tan\frac{\theta}{2}\right)$

$M = 14.701 + (1.155 + \frac{2}{2}\tan 30) = 16.433$

08. Ans: (d)

Sol: Lead = pitch × no of starts

$\text{Pitch} = \frac{\text{lead}}{\text{no of starts}} = \frac{3}{2} = 1.5$

09. Ans: (d)

Sol: Rollers will not used to measure pitch diameter.

Best size diameter $d = \left(\frac{p}{2}\right)\sec\left(\frac{\theta}{2}\right)$

$= \left(\frac{2}{2}\right)\sec\left(\frac{60}{2}\right)$

$= 1.1547 = 1.155$

10. Ans: (d)

Sol: $V.C = \delta P.\cos\left(\frac{\theta}{2}\right) + 0.0131P(\delta\theta_1 + \delta\theta_2)$

$= 0.2 \cos 30 = 0.346$

Common data Q 11 & 12

11. Ans: (a)

Sol: Best size diameter, $d = \left(\frac{p}{2}\right)\sec\left(\frac{\theta}{2}\right)$

$= \left(\frac{2}{2}\right)\sec\left(\frac{60}{2}\right) = 1.155$ mm

12. Ans: (a)

Sol: $D_{eff} = M - \left(d + \frac{p}{2}\tan\frac{\theta}{2}\right)$

$= 16.455 - 1.155.\tan 30 = 14.7226$ mm

13. Ans: 1.732 mm

Sol: The best wire size = $(p/2)\sec(\alpha/2)$

$= (3/2)\sec(60/2)$

$= 1.732$ mm

7.5 Surface Finish Measurement

01.

(i) Ans: (c)

Sol: R_t = max. peak – min.valley

$= 42 - 18 = 24$

(ii) Ans: (c)

Sol: $CLA(R_a) = (h_1+h_2+h_3+\ldots\ldots+h_{10})/n$

$= \frac{300}{10} = 30$

(iii) Ans: (b)

Sol: Peaks 35 40 35 42 35

Valley 25 22 18 25 23

$R_z = \frac{\Sigma peaks - \Sigma valleys}{no\ of\ peaks}$

$= \frac{(35+40+35+42+35)-(25+22+18+25+23)}{5} = 15$

(iv) Ans: (b)

Sol: $RMS = \sqrt{\frac{h_1^2 + h_2^2 + h_3^2 + \ldots\ldots + h_n^2}{n}} = 33$

(or) $RMS = 1.1 \times R_a = 1.1 \times 30 = 33$

(v) Ans: (c)

Sol: If R_a value from 18.75 to 37.5 international grade of roughness is given by N11.

02. Ans: (c)

Sol: $R_a = \frac{\sum A}{w} \times \frac{1}{HM} \times \frac{1000}{VM}$

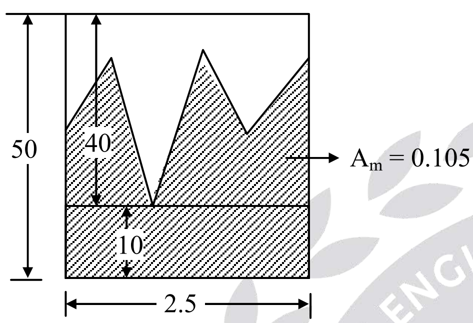
$= \frac{480+480}{0.8} \times \frac{1}{100} \times \frac{1000}{15000} = 0.8$

03. Ans: (d)

Sol: $R_t = \frac{0.05}{\tan 45} = 50\ \mu m$

04. Ans: (c)

Sol:



$A_{m\,act} = 0.105 - 0.01 \times 2.5 = 0.08$

$$K = \frac{A_{m\,act}}{(10^{-3} \times 2.5) \times 0.04}$$

$$= \frac{0.08^2}{(2.5 \times 10^{-3} \times 0.04)} \times \frac{1}{1000} = 0.8$$

05. Ans: (c)

06. Ans: (c)

07. Ans: (a)

08. Ans: 2

Sol: $R_a = \frac{\Sigma h}{n} = \frac{16 \times 4 + 16 \times 0}{32} = \frac{64}{32} = 2\mu m$

Chapter- 8
Advanced Machining Methods Numerical Control (NC)

01. Ans: (a)

Sol: Pitch of lead screw = 5mm

1 rev = 5mm

1mm = 1/5 rev

200mm = 1/5 × 200 = 40rev

= 40 ×360 = 14400 deg.

02. Ans: (b)

Sol: Pitch of lead screw = 5mm,

BLU = 0.005mm

⇒ Distance travelled /pulse

Length of travel = 9mm

No.of pulses = L/BLU = 9 / 0.005

= 1800 pulse.

03. Ans: (b)

Sol: For 1 rev of motor ⇒360° are required

⇒ 360 pulses are required

When motor is rotated by 1 rev

⇒ lead screw will rotate by 1 rev

When Lead screw is rotated by 1 rev ⇒3.6 mm distance is travelled by axis

In total

For 360 pulses ⇒ 360 deg of motor

⇒ 1 rev of motor

⇒1 rev of lead screw

⇒ 3.6 mm of linear movement of axis

360 pulses = 3.6mm

1 pulse = 3.6/360 = 0.01mm

= 10 microns

04. Ans: (b)

Sol: 10V = 100 rpm

= 100 × 5 = 500 mm/min

That is for 500mm/min = 10V

1mm /min = 10/500

3000mm/min = 10 × 3000 / 500=60 V

Common Data 05 & 06

05. Ans: (b) & 06. Ans: (a)

Sol: A, Stepper motor ⇒ 200 steps / rev

⇒ 200 pulses /rev

Pitch = 4 mm, no. of starts = 1,

Gear ratio = N_0/N_i = 1/4 = U

F = 10000 pulses per min

200 pulses ⇒ 1 rev of motor

⇒ 1/4 rev of lead screw

= 1/4 × 4 × 1 mm linear distance.

= 1mm linear distance

1 pulse = 1/200 = 0.005mm

= 5 microns = 1 BLU

Feed = BLU × pulse /min

= 0.005 × 10000 = 50mm/min

For changing BLU = 10 microns

= 0.01mm

⇒ Gear ratio has to be reduced to 1/2

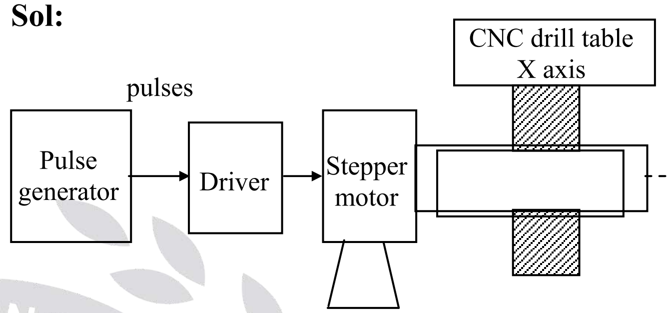
Feed = BLU × pulse /min

⇒ Pulses per min = feed / BLU

= 50/0.01 = 5000

07. Ans: (a)

Sol:



BLU = the distance traveled by the table for one pulse of electrical energy input to the motor.

Hence 200 pulse = 1 revolution of motor

= 1 revolution of lead screw = 4mm

That is 1 pulse = 4/200 = 1/50 = 0.02mm, hence BLU does not depends on the frequency of pulse generator. But if the speed of the table means it will get doubled.

08. Ans: 20

Sol: p = 5 mm

1000 pulses → 1 rev of motor

→ 1 rev of lead screw

Velocity of table = 6 m/min

= 6000 mm/min

= 100 mm/sec

1000 pulses → 1 rev of lead screw → 5 mm

$$1\text{pulse} \rightarrow \frac{5}{1000} = 0.005\,\text{mm}$$

BLU = 0.005 mm

Table speed = BLU × Rate of Pulses

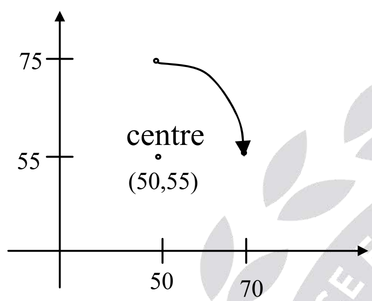
$$\text{Rate of pulses} = \frac{100}{0.005}$$

$$= 20000 \text{ pulses/sec}$$

$$= 20000 \text{ Hz} = 20 \text{ kHz}$$

09. Ans: (c)

Sol:



10. Ans: (b)

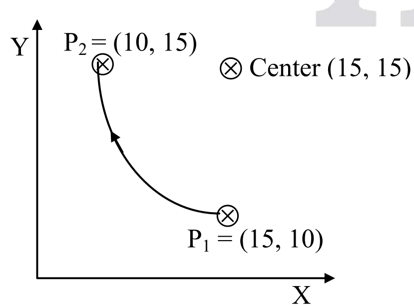
11. Ans: (a)

Sol: G02 – circular interpolation clockwise

G03 – circular interpolation counter clockwise

12. Ans: (c)

Sol: Because the tool has to travel from P_1 to P_2 in clock wise.



13. Ans: (d)

Sol: Appropriate answer but the correct answer is

N05 X5 Y5

N10 G02 X10 Y10 R5

Because in CNC part program we are not suppose to indicate information about one axis more than once in one block.

14. Ans: 60

Sol: In the combined movement, the tool is moving for 50mm with a speed of 100mm/min. whereas in the same time tool is traveling x-axis by only 30mm.

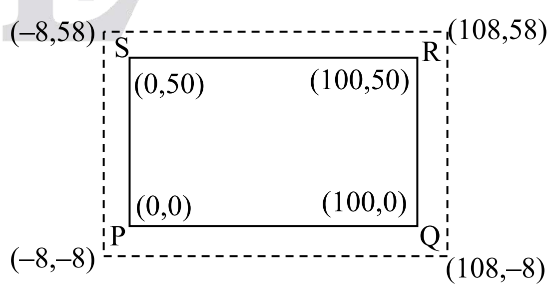
Hence,

For 50mm ⇒100mm/min

$$\text{For 30mm} \Rightarrow \frac{100}{50} \times 30 = 60\text{mm/min}$$

15. Ans: (a)

Sol: Because diameter of milling cutter is 16mm, the radius is 8mm. the dotted line indicates cutter center position, which is shifted by 8 mm all around the rectangular slot

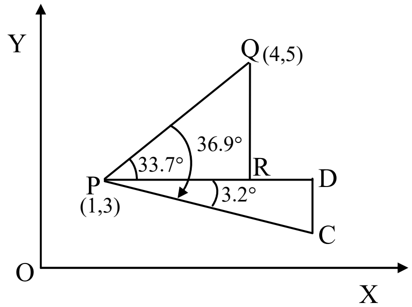


If the given shape is rectangular hole, then the answer is

(8,8), (92,8), (92,42), (8,42), (8,8)

16. Ans: (a)

Sol:



$PQ = \sqrt{2^2 + 3^2} = 3.6055 = PC$

$PD = PC \times \cos 3.2 = 3.6$

x co-ordinate of point C = 1 + 3.6 = 4.6

DC = 3.6 sin 3.2 = 0.2

y co-ordinate of point C = 3.0 – 0.2 = 2.8

17. Ans: (a)

Sol: "P" after translation = (1+2, 3+3, –5 –4)

= (3, 6, –9)

Rotation about z- axis means

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 3 \\ 6 \\ -9 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0-6+0+0 \\ 3+0+0+0 \\ 0+0-9+0 \\ 0+0+0+1 \end{bmatrix} = \begin{bmatrix} -6 \\ 3 \\ -9 \\ 1 \end{bmatrix}$$

Final point = [–6, 3, –9]

18. Ans: (b)

19. Ans: (a)

Sol: Given coordinates (0,0) to (100, 100)

Mean, L = 100, depth, d = 2 m

Diameter, D = 10

$AP_C = \sqrt{d(D-d)}$

$= \sqrt{2(10-2)} = 4$

$\text{Time/slot} = \dfrac{104}{f_N} = \dfrac{104}{50}$

= 2.08 min

= 124.8 sec ≈ 120

20. Ans: 54.166 mm/sec, 10 micron

Sol: f = 500 pulse/rev

p = 5 mm, N = 650 rpm

(i) $v = Np = \dfrac{650 \times 5}{60}$

v = 54.166 mm/sec

Now, 1 min = 650 rev

$1 \text{ sec} = \dfrac{650}{60} \text{rev}$

$\therefore f = 500 \times \dfrac{650}{60}$

f = 5416.66 pulse/sec

And, v = B.L.U.× f

$= 54.166 = BLU \times 5416.66$

B.L.U. = 0.01 mm

B.L.U. = 10 microns

21. Ans: 287

Sol: $\alpha = 0.9°$

$0.9° = 1$ pulse

$$360° = \frac{360}{0.9}\text{pulse} = 400\,\text{pulses}$$

$\therefore$ 1 revolution = 4 mm pitch = 400 pulses

$\Rightarrow\ \therefore$ 2.87 mm = 287 pulses

22. Ans: 100 pulse, 60 mm/min

Sol: Pulse rate = N × pulse/rev

$$= 15 \times \frac{400}{60} = 100\,\text{pulse/sec}$$

Feed rate = 15 rpm × 4 mm/rev

= 60 mm/min

23. Ans: (b) **24. Ans: (d)**

25. Ans: (c) **26. Ans: (d)**

27. Ans: (d) **28. Ans: (b)**

29. Ans: (d) **30. Ans: (c)**

31. Ans: (a) **32. Ans: (a)**

33. Ans: (a) **34. Ans: (a)**

35. Ans: (b) **36. Ans: (c)**

37. Ans: (b) **38. Ans: (a)**

Chapter- 9
NTM, Jigs and Fixtures

01. Ans (c) **02. Ans: (d)**

03. Ans: (c)

Sol: In EDM the mechanism of MR is due to melting and vaporization associated with cavitation and also erosion & cavitation or spark erosion and cavitation

04. Ans: (d)

Sol: The high thermal conductivity of the tool material will have high electrical conductivity hence the heat generated with in the tool is low and what ever heat generated it will be distributed easily therefore tool melting rate reduces and tool wear reduces. Where as due to specific heat of work material, the rise in temp of W.P is faster and more amount of MR is possible.

05. Ans: (b)

Sol: Given w = 1 + (2×0.5) = 2

t =5, f = 20 mm/rev

MRR = wtf = 2.5.20 = 200 mm/min

06. Ans: (a)

Sol: As the thermal conductivity of tool material is high the heat dissipation from the tool is taking place and if the specific heat is high, it needs large amount of heat for raising the temps of tool material up to MP.

07. (i) Ans: (a) , (ii) Ans: (c)

Sol: D = 12mm, t = 50mm, R = 40 Ω,

C = 20 μF, V_s = 220V, V_d = 110V

$$\text{Cycle time} = R.C \ln\left[\frac{V_s}{V_s - V_d}\right] = t_c$$

$$= 40 \times 20 \times 10^{-6} \times \ln\left[\frac{220}{110}\right]$$

$$= 554 \times 10^{-6} \text{ sec} = 0.55\, milli \text{ sec}$$

Average power input = W

$$= \left[\frac{E}{t_c}\right] = \left[\frac{0.5 \times CV_d^{\ 2}}{t_c}\right]$$

= 218 W = 0.218 kW

08. Ans: (b)

Sol: For Rough machining i.e. stock removal the electrolyte should have high electrical conductivity, called passivity electrolyte, where as for finish machining the electrolyte should have low electrical conductivity called non–passivity electrolyte will be used.

09. Ans: (b)

Sol: In ECM

MRR ∝ gram atomic weight of material

MRR ∝ Current density

$$MRR \propto \frac{1}{\text{distance between tool and work}}$$

MRR ∝ Thermal conduction of electrolyte.

10. Ans: (a)

Sol: In ECM

MRR ∝ gram atomic weight of material

∝ Current density

$$\propto \frac{1}{\text{distance between tool and work}}$$

∝ Thermal conduction of electrolyte.

11. Ans: (b)

Sol: I = 5000 A

A = 63, Z = 1, F = 96500

$$MRR = \frac{AI}{ZF} = \frac{5000 \times 63}{1 \times 96500}$$

$$= 3.264 \text{ g/sec}.$$

12. Ans: (a)

Sol: A = 55.85, Z = 2, F = 96540

Specific resistance = 2Ω-cm

Voltage = 12V

Inter electrode gap = 0.2 mm

Resistance

$$R = \frac{\text{Sp. Resistance} \times \text{Inter electrode gap}}{\text{Suface area}}$$

$$= \frac{2 \times 10 \times 0.2}{20 \times 20} = 0.01$$

$$I = \frac{V}{R} = \frac{12}{0.01} = 1200\text{A}$$

$$MRR = \frac{AI}{ZF} = \frac{55.85 \times 1200}{2 \times 96540}$$

$$= 0.3471 \text{ g/sec}$$

13. Ans: 51.542

Sol: $R = \frac{\rho L}{Area} = \frac{\frac{1}{0.02}\times 0.009}{Area} = \frac{50\times 0.009}{Area}$

$I = \frac{V}{R} = \frac{(12-1.5)\times Area}{50\times 0.009} = 23.333\times Area$

L = 3 + 6 = 9 μm = 0.009

$MRR = \frac{AI}{\rho ZF} = \frac{55.85\times 23.333\times Area}{7860\times 10^{-6}\times 2\times 96500}$

= 0.98189 × Area

$\frac{MRR}{Area} = 0.8590\,mm/sec$

$= 0.8590\times 60\,mm/min$

= 51.542 mm/min

14. Ans: 680

15. Ans: (c)

Sol: EDM, ECM and AJM are used for producing straight holes only but in LBM by maneuvering or bending laser gun slightly it is possible perform the Zig – Zag hole.

16. Ans: (b) (Both are Correct)

Sol: In EBM Vacuum is provided to avoid the dispersion of electrons after the magnetic lense, but this vacuum is giving an addition function of providing efficient shield to the weld bead.

17. Ans: (d)

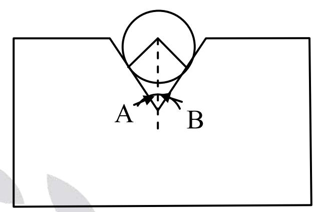
Sol: Out of all the NTM's ECM will give large MRR and EBM will give very small MRR.

18. Ans: (d)

Sol: Relative motion between tool and work piece is not necessary.

19. Ans: (c)

Sol:



If D = D_{min} = 59.9

X_1 = distance between center of shaft and corner of V – block $= \frac{\frac{59.9}{2}}{\sin 60} = 34.583$

$X_2 = \frac{\frac{60.1}{2}}{\sin 60} = 34.698$

Error in depth = $2(X_2 - X_1)$ = 0.223 mm

20.

Sol: Resolving the force "F" into Horizontal

$F\sin\alpha = 100$ .... (1)

$F\cos\alpha = 100+100 = 200$ ...... (2)

$\frac{(1)}{(2)} = \tan\alpha = \frac{100}{200}$

$\alpha = \tan^{-1}\left(\frac{1}{2}\right) = 26.565$

$F = \frac{100}{\sin\alpha} = 223.6\ kg$

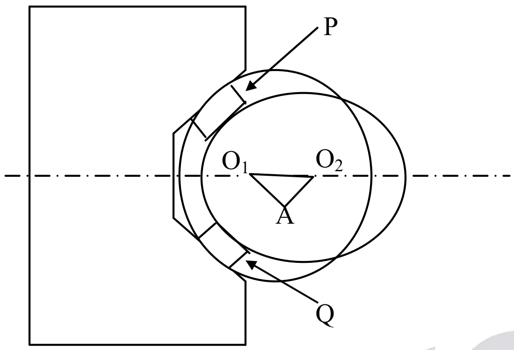
Taking the moments about vertical axis

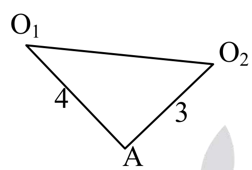
$xF\cos\alpha + 100\times 30 = 100\times 30 + 100\times 20$

⇒ x = 10 mm

21. (i) Ans: (d), (ii) Ans: 10.6 mm

Sol:





$O_1O_2 = \sqrt{4^2+3^2} = 5$

$O_1O_2 = 5 = \sqrt{x^2+x^2}$

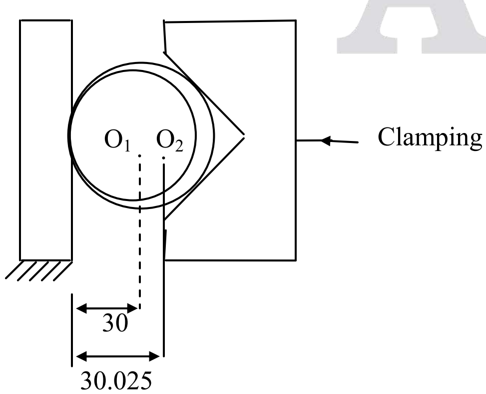
$x = 3.5$

Block of uniform thickness is preferable because of balanced condition.

22.

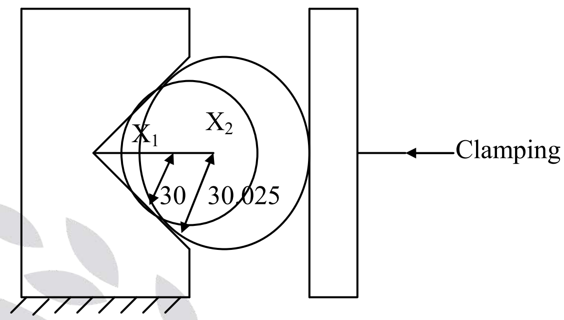
Sol:

(a) Fixed rectangular block and movable V – clamp.



Positional error = 30.025 – 30 = 0.025 mm

(b) Fixed V – block and movable rectangular block



$$x_1 = \frac{30}{\text{Sin } 60} = 34.64$$

$$x_2 = \frac{30.025}{\text{Sin } 60} = 34.66$$

(c) Positional error = $x_2 - x_1$ = 0.0298 mm

The positional error is mainly depends on the fixed element. So when fixed V – block and marble V – block is used, the positional error is remains same as (b).

Out of the 3 cases, case (a) is giving lower positional error, hence preferable.

23. Ans: (b) **24. Ans: (c)**

25. Ans: (b) **26. Ans: (c)**

27. Ans: (b) **28. Ans: (c)**

29. Ans: (b) **30. Ans: (b)**

31. Ans: (c) **32. Ans: (d)**

33. Ans: (c) **34. Ans: (b)**