total marks 246

NAME -

ROLL NO —

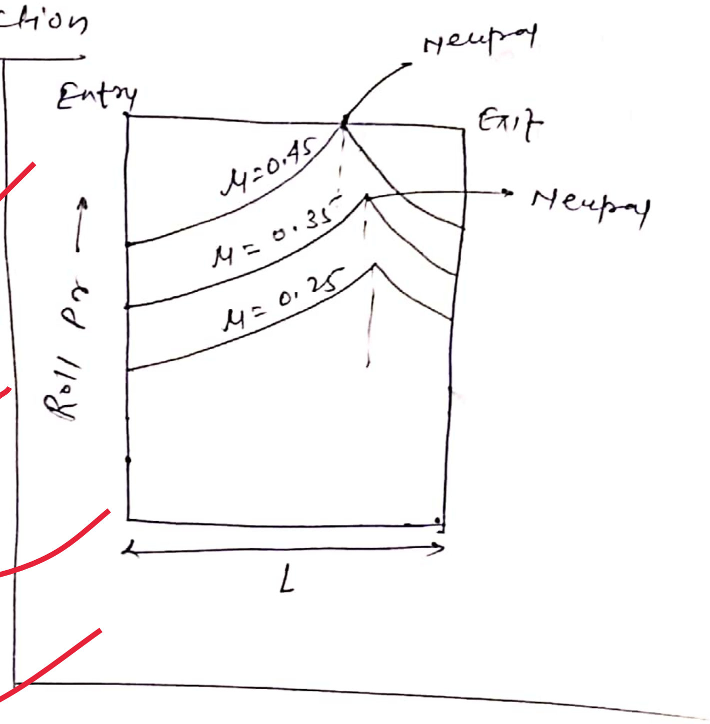
TEST NO. - 05

Q-1'a'

(i) Coefficient of friction

→ Roll pressure is max^m at neutral point

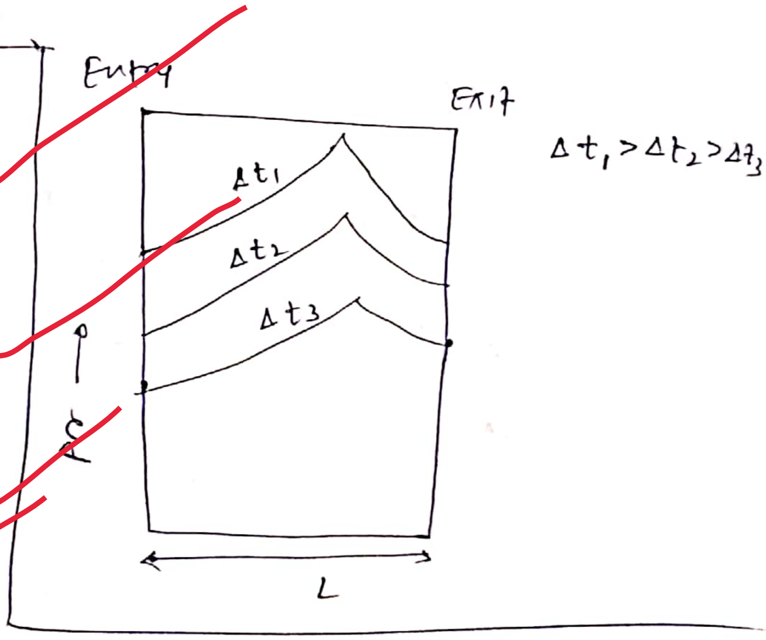
→ From Graph, It is clear that upon increasing coefficient of friction, Neutral point shifts towards entry.



(ii) Reduction in thickness

→ When Reduction in thickness increases. Roll pressure increases

and neutral point shifts towards entry when ~~thickness~~ Reduction in thickness increases



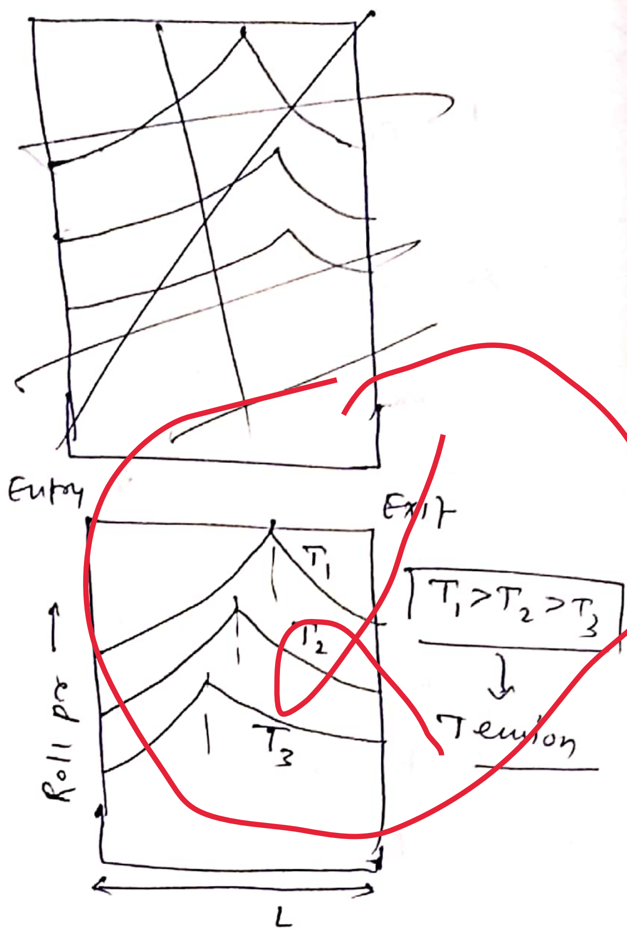
(iii) Front tension & Back tension

→ When Front tension ~~or b~~ and back tension increases, then less amount of Roll pressure is required for the same Reduction in thickness.

→ If Back tension or Front tension increases Neutral point shifts towards exit

refer solution

07



$\boxed{Q - 1'b'}$

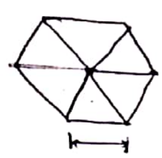
HCP → $\frac{c}{a} = 1.58$.

radius = 0.1445 nm = r

∴ for HCP, $a = 2r = (2 \times 0.1445)$ nm

∴ $\boxed{\text{unit cell volume} = \text{Area of Hexagon} \times \text{height}}$

Area of Hexagon = $6 \times \frac{\sqrt{3}}{4} \times a^2$



$\Rightarrow A = \frac{6 \times \sqrt{3}}{4} \times (2 \times 0.1445)^2$

$\Rightarrow \boxed{A = 0.216994 \text{ nm}^2}$

and height, $\boxed{c = 1.58 \times a}$

∴ Volume of unit cell, $V = A \times c$

$\Rightarrow V = 0.216994 \times 1.58 \times 2 \times 0.1445$

$\Rightarrow \boxed{V = 0.0990838\ nm^3} = \boxed{0.0990838 \times 10^{-21}\ cm^3}$

for a HCP, No. of atoms, $n = 6$

$\therefore$ Density $= \dfrac{n \times \text{Atomic wt.}}{\text{Avagadro No.} \times \text{Volume}}$

$\Rightarrow$ Density $= \dfrac{6 \times 47.87}{6.023 \times 10^{23} \times 0.0990838 \times 10^{-21}}$

$\Rightarrow \boxed{\underset{(\rho_a)}{\text{Density}} = 4.8128\ g/cm^3}$.

and Given literature value, $\rho_{lit} = 4.51\ g/cm^3$

$\therefore \boxed{\dfrac{\rho_a}{\rho_{lit}} = \dfrac{4.8128}{4.51} = 1.0671}$

i'e Actual Density is 1.0671 times greater than literature value.

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Q - 1'c'

Given, Ni = 70%, Cr = 20%, Fe = 5%, Ti = 5%

$\therefore$ ρ = Density of superalloy

$$\therefore \frac{1}{\rho} = \frac{0.7}{\rho_{Ni}} + \frac{0.2}{\rho_{Cr}} + \frac{0.05}{\rho_{Fe}} + \frac{0.05}{\rho_{Ti}}$$

$$\Rightarrow \frac{1}{\rho} = \frac{0.7}{8.9} + \frac{0.2}{7.19} + \frac{0.05}{7.86} + \frac{0.05}{4.51}$$

$$\Rightarrow \boxed{\rho = 8.07\ gm/cm^3}$$

And for superalloy

$$\frac{1}{e} = \frac{0.7 \times Z_{Ni}}{A_{Ni}} + \frac{0.2 \times Z_{Cr}}{A_{Cr}} + \frac{0.05 \times Z_{Fe}}{A_{Fe}} + \frac{0.05 \times Z_{Ti}}{A_{Ti}}$$

$$\Rightarrow \frac{1}{e} = \frac{0.7 \times 2}{58.71} + \frac{0.2 \times 2}{51.99} + \frac{0.05 \times 2}{55.85} + \frac{0.05 \times 3}{47.9}$$

$$\Rightarrow \boxed{e = 27.426\ gm/mol}$$

Now

$$m = ZIt$$

$$\Rightarrow \frac{m}{t} = ZI$$

$$\Rightarrow \frac{m}{\rho \times t} = \frac{ZI}{\rho} = \frac{eI}{F \times \rho}$$

$$\Rightarrow \frac{m}{\rho t} = \frac{27.426 \times 1500}{96500 \times 8.07} = 0.052827\ cm^3/sec$$

i.e. $MRR = 0.052827\ cm^3/sec = \left(\cancel{\frac{0.052827 \times 1000}{60}}\right)$

$$\Rightarrow MRR = (0.052827 \times 1000 \times 60)\ mm^3/min$$

$$\therefore \text{Rate of dissolution} = \frac{MRR}{Area} = \left(\frac{0.052827 \times 1000 \times 60}{1600}\right) mm/min$$

$$\boxed{\text{Rate of dissolution} = 1.981\ mm/min}$$

12

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Q - 1'd'

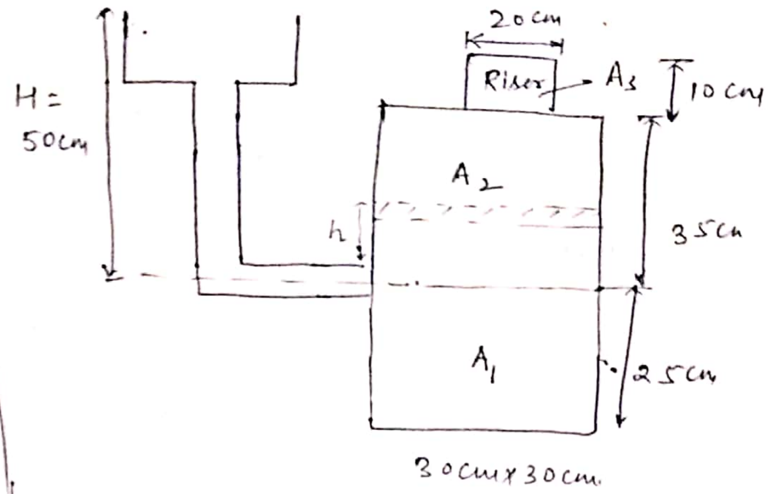
Given

Area of gate,

$A_g = 5\,cm^2$

for area $A_1 \Rightarrow$ Top Gate

for area A_2 & $A_3 \Rightarrow$ Bottom Gate



Filling of part 1

$$t_1 = \frac{A_1 \times h_1}{A_g \times \sqrt{2gH}} = \frac{30 \times 30 \times 25}{5 \times \sqrt{2 \times 9.81 \times 100 \times 50}}$$

$$\Rightarrow \boxed{t_1 = 14.367\ sec}$$

for part 2:-

$$A_2 dh = dt \times A_g \times \sqrt{2g(H-h)}$$

$$\Rightarrow dt = \frac{A_2}{A_g} \times \frac{1}{\sqrt{2g}} \times \frac{dh}{\sqrt{(H-h)}}$$

$$\Rightarrow \int_0^{t_2} dt = \frac{A_2}{A_g} \times \frac{1}{\sqrt{2g}} \int_0^{35} \frac{dh}{\sqrt{(H-h)}}$$

$$\Rightarrow t_2 = \frac{A_2}{A_g} \times \frac{1}{\sqrt{2g}} \left[\frac{(H-h)^{-\frac{1}{2}+1}}{(-\frac{1}{2}+1) \times (-1)} \right]_0^{35}$$

$$\Rightarrow t_2 = \frac{A_2}{A_g} \times \frac{1}{\sqrt{2g}} \times \left(\frac{2}{-1}\right) \times \left[\sqrt{(50-35)} - \sqrt{(50-0)}\right]$$

$$\Rightarrow t_2 = \frac{30 \times 30}{5} \times \frac{1}{\sqrt{2 \times 9.81 \times 100}} \times 2 \times \left[\sqrt{50} - \sqrt{15}\right]$$

$$\Rightarrow \boxed{t_2 = 25.992\ sec}$$

for part 3:-

$$A_3 dh = dt \times A_g \times \sqrt{2g\,(H-h)}$$

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$$\Rightarrow \int_0^{t_3} dt = \frac{A_3}{A_g} \times \frac{1}{\sqrt{2g}} \int_{35}^{45} \frac{dh}{\sqrt{(H-h)}}$$

$$\Rightarrow t_3 = \frac{A_3}{A_g} \times \frac{1}{\sqrt{2g}} \times 2 \times \left[\sqrt{(50-35)} - \sqrt{(50-45)}\right]$$

$$\Rightarrow t_3 = \frac{\frac{\pi}{4} \times 20^2}{5} \times \frac{1}{\sqrt{2 \times 9.81 \times 100}} \times 2 \times \left[\sqrt{15} - \sqrt{5}\right]$$

$$\Rightarrow \boxed{t_3 = 4.644 \text{ sec}}$$

$\therefore$ Total time, $t = t_1 + t_2 + t_3 = 14.367 + 25.992 + 4.644$

$$\Rightarrow \boxed{t = 45.003 \text{ sec} \simeq 45 \text{ sec}}$$

12

Q - 1(e)

Given. Rubidium — BCC

$\theta = 27°$.

First-order Reflection ie $\boxed{n = 1}$

Wavelength, $\lambda = 0.0711$ nm.

(1) Let d = Interplaner spacing.

$\therefore$ By Bragg's diffraction Law

$$\sin\theta = \frac{n\lambda}{2d}$$

$$\Rightarrow d = \frac{n\lambda}{2 \times \sin\theta}$$

$$\Rightarrow d = \frac{1 \times 0.0711}{2 \times \sin(27)}$$

$$\Rightarrow \boxed{d = 0.0783 \text{ nm}}$$

(11)

$$\therefore \quad d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

Given $h = 3, \quad K = 2, \quad l = 1$

$$\therefore \quad a = \sqrt{3^2 + 2^2 + 1^2} \times 0.0783$$

$$\Rightarrow \boxed{a = 0.29297 \text{ nm}}$$

for BCC → simple cubic.

$$a = \frac{4}{\sqrt{3}} r \quad , \quad \text{where, } r = \text{atomic Radius}$$

$$\therefore \quad r = \frac{\sqrt{3}}{4} \times a = \frac{\sqrt{3}}{4} \times 0.29297$$

$$\Rightarrow \boxed{r = 0.12686 \text{ nm}}$$

05

procedure is correct
refer solution

Q-3'a'

Given

Major cutting edge angle, $\lambda = 60°$

$\therefore$ Side cutting edge angle, $C_s = 90 - \lambda$

$\Rightarrow \boxed{C_s = 90 - 60 = 30°}$

and End cutting edge angle, $C_e = 10°$

and Feed, $f = 0.4$ mm/rev.

$\therefore$ Roughness Height, $H_{max} = \dfrac{f}{\tan(C_s) + \cot(C_e)}$

$\Rightarrow H_{max} = \dfrac{0.4}{\tan(30°) + \cot(10°)}$

$\Rightarrow \boxed{H_{max} = 0.06401 \text{ mm}}$

and $R_a = \frac{H_{max}}{4} = \frac{0.06401}{4} \simeq 0.016$ mm

$\therefore \boxed{R_a = 0.016 \text{ mm}}$

Now

If tool is ground to nose Radius, $R = 2$ mm

$\therefore$ Roughness height, $H_{max} = \frac{f^2}{8R}$

$\Rightarrow \boxed{H_{max} = \frac{(0.4)^2}{8 \times 2} = 0.01 \text{ mm}}$

$\therefore$ Reduction in Roughness height

$= 0.06401 - 0.01$

$\boxed{\Delta H = 0.05401 \text{ mm}}$

and R_a value for practical case ie when Nose Radius has some value

$\therefore R_a = \frac{f}{18\sqrt{3} \times R}$

$\Rightarrow \boxed{R_a = \frac{0.4}{18 \times \sqrt{3} \times 2} = 6.415 \times 10^{-3} \text{ mm}}$

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Q-3'b'

① Acrylonitrile - Butadine - Styrene (ABS) :-

* Characteristics
  - → Resistance to heat distortion
  - → Good electrical properties (Insulator)
  - → outstanding strength & toughness

* Applications
  - → As insulator in devices for living purpose
  - → Highway safety devices
  - → Lawn & Garden equipments

(ii) Acrylics (poly - methyl - methacrylate)

* Characteristics
  - → Resistance to weathering
  - → outstanding light transmission

* Applications
  - → Lenses, → Air craft Glases. (Transparent)

(iii) Polyamids (nylons)

* Characteristics
  - → Good mechanical strength
  - → Abrasion resistance, High toughness
  - → Water absorbing capacity

* Applications
  - → Bearings → Gears, → Jacketing for wire and cables.

(iv) Epoxies

* Characteristics
  - → Dimensionally stable.
  - → Good electrical properties.
  - → Good Mechanical properties & Corrosion resistance.

* Applications
  - Protective covers → Adhesives,
  - Electrical Insulators

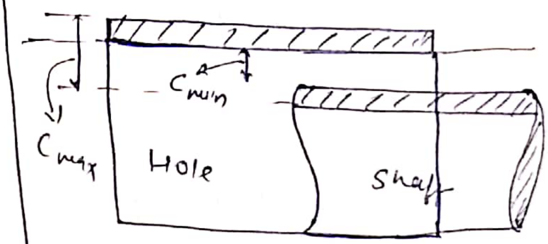
(v) Polyester (PET OR PETE)

* Characteristics
  - Excellent fatigue & tear strength
  - Resistance to humidity, acids.
  - Excellent toughness

* Applications
  - Automotic tyre Cords
  - Where, Repetitive loads applied
  - Beverage Containers

Q - 3'C'

① Hole Basis System



Lower limit of ~~shaft~~ Hole

$= $ Nominal size $= 60\,mm$

$$\boxed{(LL)_{Hole} = 60\,mm} \quad \text{(I)}$$

Maxm clearance, $C_{max} = (\text{Upper Limit})_{Hole} - (\text{Lower Limit})_{shaft}$

$$\Rightarrow \boxed{0.12 = (U.L)_{Hole} - (LL)_{Shaft}} \quad \text{(II)}$$

and

Minm Clearance, $C_{min} = 0.04\,mm$

$$\Rightarrow (LL)_{Hole} - (UL)_{Shaft} = 0.04$$

$$\Rightarrow 60 - (UL)_{shaft} = 0.04$$

$$\Rightarrow \boxed{(UL)_{shaft} = 59.96\,mm}$$

∴ Q: Also

Hole tolerance = 2 × Shaft tolerance

$\Rightarrow (UL)_{Hole} - (LL)_{Hole} = 2\times[(UL)_{shaft} - (LL)_{shaft}]$

$\Rightarrow (UL)_{Hole} - 60 = 2\times 59.96 - 2\times(LL)_{shaft}$

$\Rightarrow \boxed{(UL)_{Hole} = 179.92 - 2\times(LL)_{shaft}}$ (iii)

$\therefore 0.12 = 179.92 - 2\times(LL)_{shaft} - (LL)_{shaft}$

$\Rightarrow \boxed{(LL)_{shaft} = \frac{179.92 - 0.12}{3} = 59.933 \text{ mm}}$

and $\boxed{(UL)_{Hole} = 179.92 - 2\times 59.933 = 60.054 \text{ mm}}$

∴ Shaft
- UL = 59.96 mm
- LL = 59.933 mm

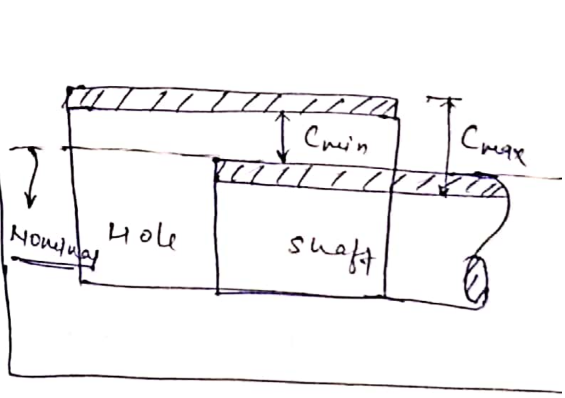
Hole
- UL = 60.054 mm
- LL = 60 mm

(ii) Shaft Basis System

~~$(UL)_{Hole}$~~

Upper limit of shaft = Nominal size = 60 mm

$\boxed{(UL)_{shaft} = 60 \text{ mm}}$



Also Min^m clearance, $C_{min} = 0.04$ mm

$\Rightarrow (LL)_{Hole} - (UL)_{shaft} = 0.04$

$\Rightarrow \boxed{(LL)_{Hole} = 0.04 + 60 = 60.04 \text{ mm}}$

Hole tolerance = 2 × shaft tolerance

$\Rightarrow (UL)_{Hole} - (LL)_{Hole} = 2\times(UL)_{shaft} - 2\times(LL)_{shaft}$

$\Rightarrow (UL)_{Hole} - 60.04 = 2\times 60 - 2\times(LL)_{shaft}$

$\Rightarrow \boxed{(UL)_{Hole} = 180.04 - 2\times(LL)_{shaft}}$

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Max^m clearance, $C_{max} = (UL)_{Hole} - (LL)_{shaft} = 0.12$

$\Rightarrow 180.04 - 3\times(LL)_{shaft} = 0.12$

$\Rightarrow \boxed{(LL)_{shaft} = 59.973 \text{ mm}}$

and $\boxed{(UL)_{Hole} = 180.04 - 2\times 59.973 = 60.094 \text{ mm}}$

Q- 3'd'

(i)

For Ni

$Ni \longrightarrow Ni^{2+} + 2e^- + (-0.250)$

For Cd

$Cd^{2+} + 2e^- \longrightarrow Cd + (0.4030)$

overall

$$\boxed{Ni + Cd^{2+} \longrightarrow Ni^{2+} + Cd} + 0.4030 - 0.250$$

Half cell potential for cadmium. $= -0.403$ V

Half cell potential for Ni $= -0.250$ V

$\therefore \Delta V = 0.403 - 0.250$

$\therefore \boxed{\Delta V = 0.153 \text{ volt}}$

(ii)

$$\Delta V = (V_2^\circ - V_1^\circ) - \frac{0.0592}{n} \log_{10}\left[\frac{M_1^{n+}}{M_2^{n+}}\right]$$

Ni Electrode 1

Cd Electrode 2

$\therefore V_2^\circ = -0.403$ V,

$V_1^\circ = -0.250$ V

$n = 2$

$M_1^{n+} = 10^{-3}$, $M_2^{n+} = 0.5$

$$\therefore \Delta V = [-0.403 - (-0.250)] - \frac{0.0592}{2} \log_{10}\left(\frac{10^{-3}}{0.5}\right)$$

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$\Rightarrow \Delta V = -0.0731$ V

$\therefore$ $\boxed{\text{Cell potential } \Delta V = 0.0731 \text{ volt}}$

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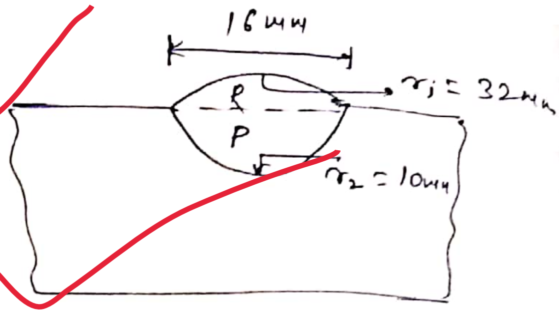
Q - 4'a1

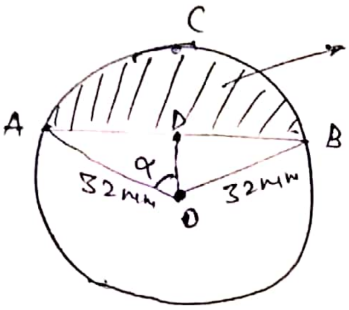
~~For~~

R → Reinforcement

P → Penetration



for Reinforcement



A_R = Area of Reinforcement

$AB = 16$ mm.

$OB = AO = 32$ mm

$\therefore AD = DB = 8$ mm

$\therefore OD = \sqrt{AO^2 - AD^2}$ [from Right triangle AOD]

$\Rightarrow OD = \sqrt{32^2 - 8^2}$

$\Rightarrow \boxed{OD = (8 \times \sqrt{15})\ \text{mm}}$

$\therefore \sin\alpha = \frac{AD}{AO} \Rightarrow \alpha = \sin^{-1}\left(\frac{8}{32}\right)$

$\Rightarrow \boxed{\alpha = 14.48^\circ}$

$\therefore$ Total angle of Arc $\overline{ACBOA}$ subtended at centre

$\boxed{2\alpha = 2 \times 14.48 = 28.96^\circ}$

$\therefore A_R$ = Area of Reinforcement ie shaded area

$\Rightarrow \boxed{A_R = \text{Area of } \cancel{\text{Arc}} \text{ sector}(ACBOA) - \text{Area of } \Delta AOB}$

$\therefore$ Area of sector (ACBOA) $= \frac{\pi \times r_1^2}{360^\circ} \times (28.96^\circ)$

$\boxed{\text{Area of sector (ACBOA)} = 258.789\ \text{mm}^2}$

and Area of $\Delta ADB = 2 \times \frac{1}{2} \times AD \times OD$

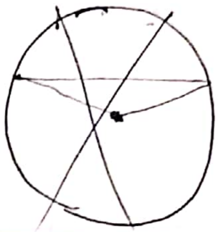
$\Rightarrow \boxed{A_{(\Delta AOB)} = 8 \times 8 \times \sqrt{15} = 64 \times \sqrt{15}\ \text{mm}^2}$

$\therefore A_R = 258.789 - 64 \times \sqrt{15}$

$\Rightarrow \boxed{A_R = 10.918\ mm^2}$ (I)

Now for penetration

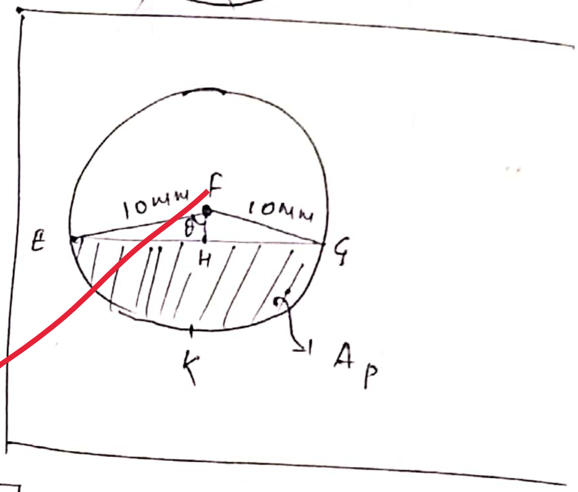
A_p = Area of penetration



$EF = 10mm$, $EH = HG = \frac{EG}{2} = \frac{16}{2} = 8mm$

$\therefore FH = \sqrt{(EF)^2 - (EH)^2}$

$\Rightarrow \boxed{FH = \sqrt{10^2 - 8^2} = 6\ mm}$



$\therefore$ Area of $\Delta EFG = 2 \times \frac{1}{2} \times EH \times FH$

$\Rightarrow \boxed{\text{Area of } (\Delta EFG) = 8 \times 6 = 48\ mm^2}$

Also

$\boxed{\theta = \sin^{-1}\left(\frac{8}{10}\right) = 53.13°}$

$\therefore$ Area of sector $(EKGFE) = \frac{\pi \times r_2^2}{360°} \times (2\theta)$

$\Rightarrow$ Area of sector $(EKGFE) = \frac{\pi \times 10^2 \times 2 \times 53.13}{360°}$

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$\Rightarrow \boxed{\text{Area of sector } (EKGFE) = 92.729\ mm^2}$

$\therefore$ Area of Penetration, $\boxed{A_p = \text{Area of sector } (EKGFE) - \text{Area of } (\Delta EFG)}$

$\therefore \boxed{A_p = 92.729 - 48 = 44.729\ mm^2}$ (II)

$\therefore$ % Dilution $= \left(\frac{A_p}{A_p + A_R} \times 100\right) = \frac{44.729}{44.729 + 10.918} \times 100$

$\therefore \boxed{\%\ \text{Dilution} = 80.38\%}$

Q-4 'b'

Given

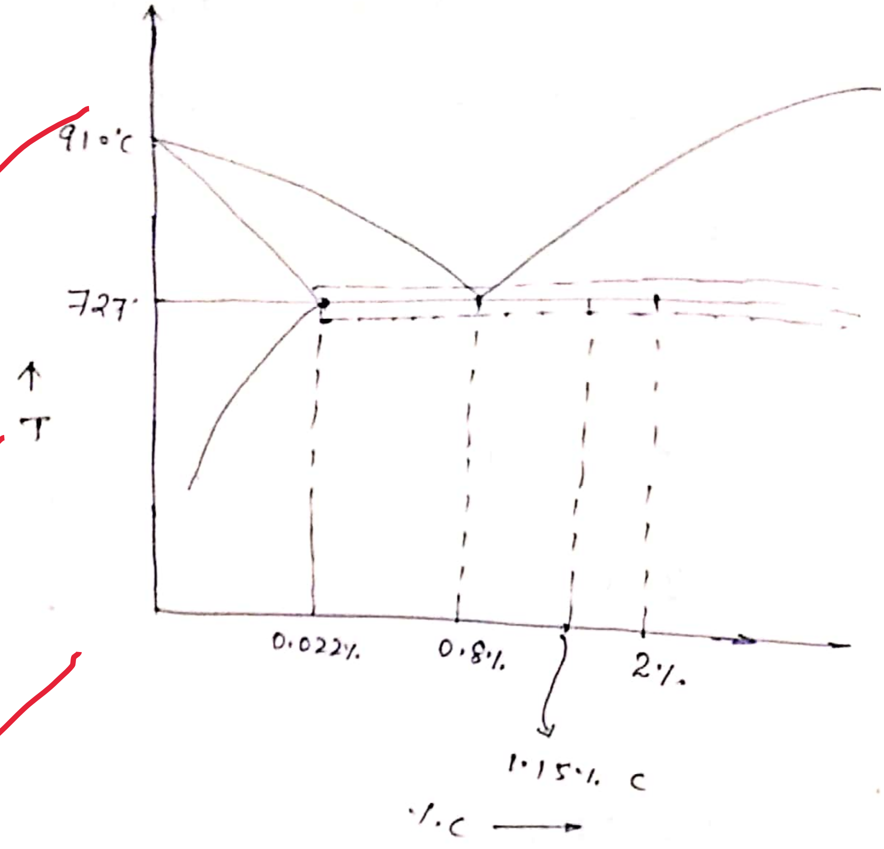
% C = 1.15 wt%

(I) for 1.15 wt % Carbon

pro-eutectoid phase

Pearlite & Cementite.

ie pro-Cementite is formed



(II)

fraction of Total Ferrite.

$$F_{\alpha} = \left(\frac{6.67 - 1.15}{6.67 - 0.022} \right) = 0.8303$$

$\therefore$ $\boxed{\text{Kg of total Ferrite} = 1 \times 0.8303 = 0.8303 \text{ Kg}}$

fraction of Total cementite $= \dfrac{1.15 - 0.022}{6.67 - 0.022} = 0.1697$

$\therefore$ $\boxed{\text{Kg of total Cementite} = 1 \times 0.1697 = 0.1697 \text{ Kg}}$

(III) fraction of pearlite & pro-eutectoid cementite

$$F_{\text{pro-cementite}} = \frac{1.15 - 0.8}{2 - 0.8} = 0.292$$

ie. $\boxed{\text{Kg of Pro-Cementite} = 0.292 \text{ Kg}}$

$\therefore$ fraction of Pearlite $= 1 - F_{\text{pro}-Fe_3C}$

$= 1 - 0.292 = 0.708$

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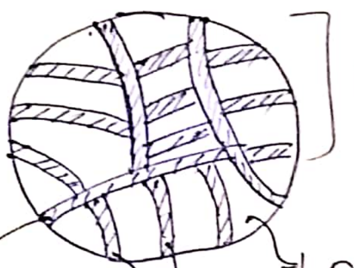
∴ $\boxed{\text{Kg of pearlite} = 0.708\ \text{Kg}}$

(iv)

pro-eutectoid Fe_3C is formed



⟸ This is microstructure if slightly below 727°c

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Q - 4 'C'

(1)

From triangle (Right angled)

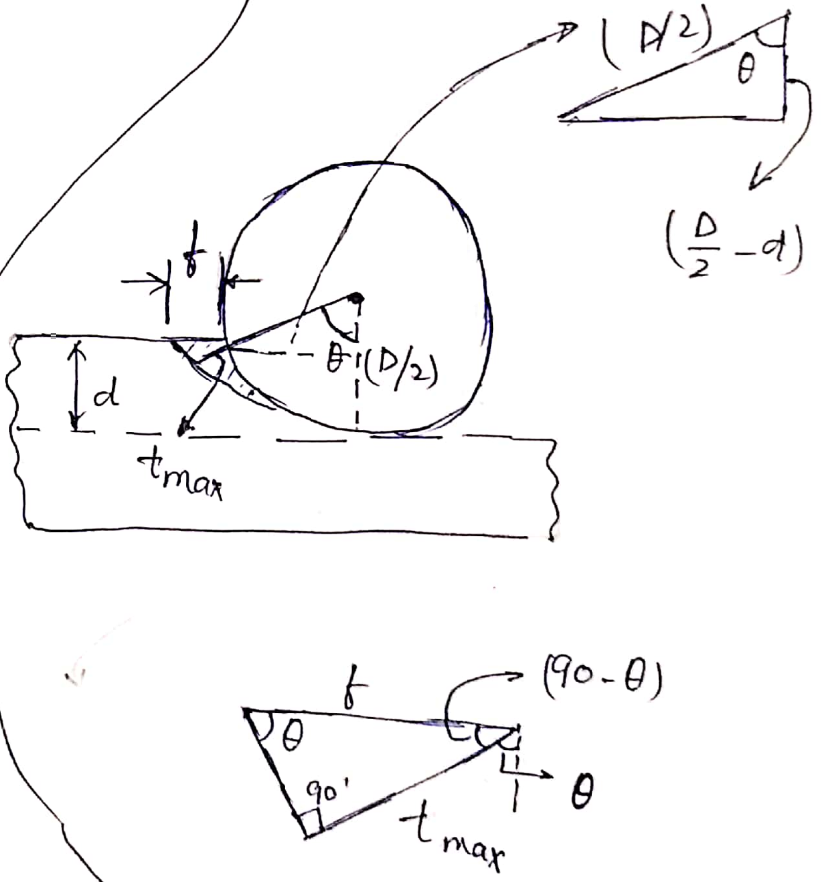
$$\sin\theta = \frac{t_{max}}{f}$$

Where

θ = Angle turned by cutter per teeth

f = feed per tooth

$$\therefore \boxed{t_{max} = f \sin\theta}$$



Also

$$\cos\theta = \frac{\left(\frac{D}{2} - d\right)}{\left(\frac{D}{2}\right)}$$

$$\Rightarrow \cos\theta = \left(1 - \frac{2d}{D}\right)$$

$\therefore \quad \sin\theta = \sqrt{1-\cos^2\theta} = \sqrt{1-\left(1-\frac{2d}{D}\right)^2}$

$\Rightarrow \sin\theta = \sqrt{1-1-\frac{4d^2}{D^2}+2\times\frac{2d}{D}}$

$\Rightarrow \sin\theta = \sqrt{\frac{4d}{D}-\frac{4d^2}{D^2}}$

$\Rightarrow \boxed{\sin\theta = 2\sqrt{\frac{d}{D}\left(1-\frac{d}{D}\right)}}$

$\therefore$ Max^m chip thickness, $t_{max} = f\sin\theta$

$\Rightarrow \boxed{t_{max} = 2f\sqrt{\frac{d}{D}\left(1-\frac{d}{D}\right)}}$

(11)

Slab Milling

No. of cutter, $Z = 15$,

Rake angle, $\alpha = 10°$, $N = 200$ rpm.

D = Dia of cutter 80 mm, f_m = table feed = 75 mm/min.

d = Depth of cut = 5 mm

w = width of Job = 50 mm, μ = coefficient of friction = 0.7

$\tau_{ultimate} = 420\ N/mm^2$

Now

$\cos\theta = \left(1-\frac{2d}{D}\right)$

$\Rightarrow \boxed{\theta = \cos^{-1}\left(1-\frac{2\times5}{80}\right) = 28.955°}$

and Angle between one teeth travel

$\boxed{\theta_t = \frac{360°}{Z} = \frac{360}{15} = 24°}$

Here $\boxed{\theta_t < \theta}$ $\Rightarrow$ Always 1 teeth is in contact.

Now Max^m uncut chip thickness, $t_{max} = 2f\sqrt{\frac{d}{D}\left(1-\frac{d}{D}\right)}$

f = feed per tooth = $\frac{f_m}{N\times Z}$

$$\therefore (t_1)_{max} = \frac{2 \times 75}{200 \times 15} \sqrt{\frac{S}{80}\left(1 - \frac{S}{80}\right)}$$

$$\Rightarrow \boxed{(t_1)_{max} = 0.0121 \text{ mm}}$$

Now

Shear force $(F_s)_{max}$

$$= \frac{\tau \times w \times (t_1)_{max}}{\sin\phi}$$

Where ϕ = shear angle

By Lee-Shaffer

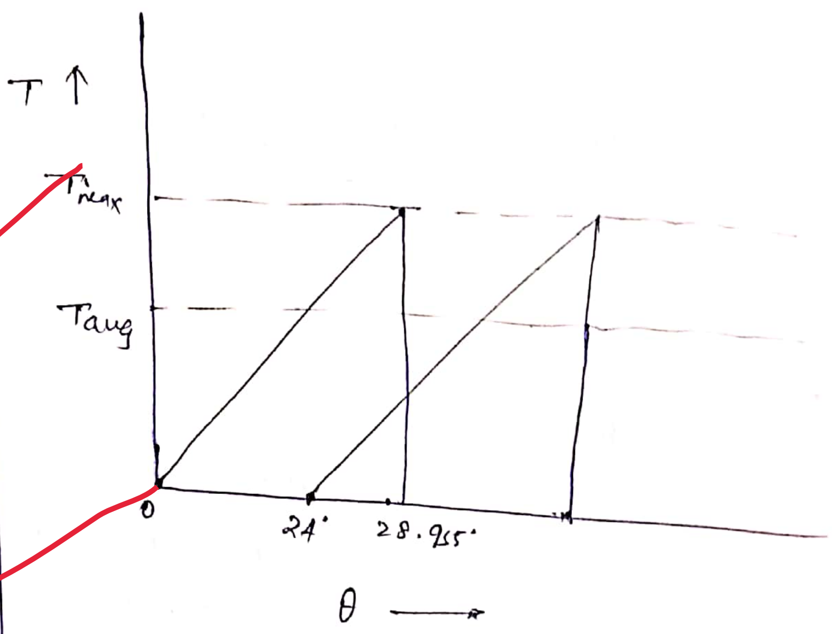
$$\boxed{\phi = 45° + \alpha - \beta}$$

Where, β = friction angle

$\beta = (\tan^{-1}\mu)$

$\Rightarrow \beta = \tan^{-1}(0.7)$

$\Rightarrow \boxed{\beta = 34.992°} \simeq 35°$



$$\therefore \boxed{\phi = 45 + 10 - \cancel{34.992}\ 35 = 20°}$$

$$\therefore (F_s)_{max} = \frac{\tau \times w \times (t_1)_{max}}{\sin\phi} = \frac{420 \times 50 \times 0.0121}{\sin 20°}$$

$$\Rightarrow \boxed{(F_s)_{max} = 742.94 \text{ N}}$$

20

$\therefore$ Maxm cutting force, $(F_c)_{max} = (F_s)_{max} \times \frac{\cos(\beta - \alpha)}{\cos(\beta - \alpha + \phi)}$

$$\Rightarrow \boxed{(F_c)_{max} = \frac{742.94 \times \cos(35-10)}{\cos(35-10+20)} = 952.236 \text{ N}}$$

$$\therefore T_{max} = (F_c)_{max} \times \frac{D}{2} = \left(952.236 \times \frac{80}{2 \times 1000}\right) \text{ N-m}$$

$$\boxed{T_{max} = 38.089 \text{ N-m}}$$

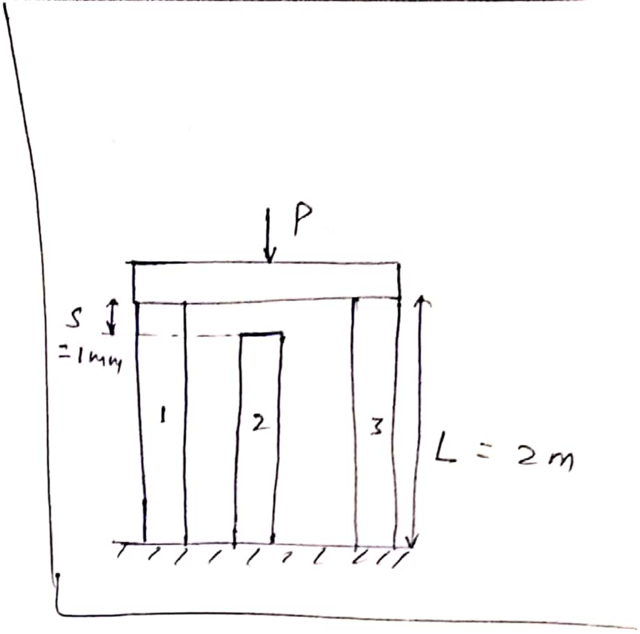
$$\therefore \frac{1}{2} \times T_{max} \times 28.955° = T_{avg} \times 24$$

$$\Rightarrow \boxed{T_{avg} = \frac{38.089 \times 28.955}{2 \times 24} = 22.98 \text{ N-m}}$$

$$\therefore \boxed{P_{avg} = T_{avg} \times \omega = 22.98 \times \frac{2 \times \pi \times 200}{60} = 481.292 \text{ W}}$$

Q-5'a'

Let, P_1, P_2, & P_3 are Load distribution by three posts



$$\therefore \boxed{P_1 + P_2 + P_3 = P} \quad \text{(I)}$$

When load applied

$$\delta_1 = \frac{P_1 \times L}{A_1 E_c} = \frac{P_1 \times 2000}{200 \times 200 \times 30 \times 1000}$$

$$\Rightarrow \boxed{\delta_1 = \frac{P_1}{600000} \text{ mm}} \quad \text{(II)}$$

for Post (3),
$$\delta_3 = \frac{P_3 \times L}{A_3 \times E_c} = \frac{P_3 \times 2000}{200 \times 200 \times 30 \times 1000}$$

$$\Rightarrow \boxed{\delta_3 = \frac{P_3}{60000} \text{ mm}} \quad \text{(III)}$$

from (II) & (III)

$$\boxed{P_1 = P_3}$$

$$\therefore \boxed{2P_1 + P_2 = P} \quad \text{(IV)} \quad [\text{from eq. (I)}]$$

But

Post 2

$$\delta_2 = \frac{P_2 \times L_2}{A_2 \times E_c} = \frac{P_2 \times 2000}{200 \times 200 \times 30 \times 1000} = \frac{P_2}{60000} \text{ mm}$$

But $\delta_2 = \delta_1 - s = \dfrac{P_1}{60000} - 1$

$$\Rightarrow \frac{P_2}{60000} = \frac{P_1}{60000} - 1$$

$$\Rightarrow \boxed{P_2 = (P_1 - 60000)} \quad \text{(V)}$$

$\therefore$ From (IV) & (V)

$$2 \times P_1 + (P_1 - 60000) = P.$$

$$\Rightarrow \boxed{3P_1 - 60000 = P} \quad \text{(VI)}$$

Given Allowable stress in compression

$$\sigma_{allow} = 18 \text{ MPa}$$

$\therefore \; P_1 = \sigma_{allow} \times A_1 = (18 \times 200 \times 200)\,N$

$\therefore \; P = 3 \times P_1 - 60000$

$\Rightarrow P = 3 \times 18 \times 200 \times 200 - 60000$

$\Rightarrow P = 2100000\ N$

$\Rightarrow \boxed{P = 2.1\ MN}$

check calculation

04

Q-5'b1

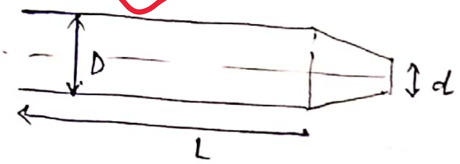
H = Head Supplied at entrance of pipe

h_f = head loss due to friction.

So

Net head available at Entrance of nozzle

$$\boxed{H_{net} = (H - h_f)}$$



* Assuming
  - No minor losses
  - No. loss of Energy in nozzle

∴ Due to this net head, power available at nozzle is

$$\boxed{P = \rho Q g H_{net}} \quad \text{—①}$$

Where,
a = Area of nozzle
ρ = Density of water
V_n = velocity through nozzle

$$\therefore \boxed{P = \rho \times a \times V_n \times g \times (H - h_f)}$$

But
$$h_f = \frac{f \times L \times V_p^2}{2 \times D \times g}$$

h_f = Friction head loss, L = Length of pipe
V_p = Velocity in pipe, f = Friction factor.

$$\therefore \boxed{P = \rho \times a \times V_n \times g \times \left(H - \frac{f \times L \times V_p^2}{2Dg}\right)}$$

Also
$$V_n = \frac{Q}{a} \quad \& \quad V_p = \frac{Q}{A}, \quad (A = \text{Area of pipe})$$

$$\therefore P = \rho \times a \times \frac{Q}{a} \times g \times \left[H - \frac{f \times L \times \frac{Q^2}{A^2}}{2Dg}\right]$$

$$\Rightarrow P = \rho Q g \left[H - \frac{f \times L \times Q^2}{\left(\frac{\pi}{4} \times D^2\right)^2 \times 2 \times Dg}\right]$$

$$P = \rho Q g H_{net} = \rho Q g (H - h_f)$$

For Max^m power, $\boxed{H = 3h_f}$

$$\therefore \boxed{P_{max} = \rho Q g (3h_f - h_f) = 2 \rho Q g h_f}$$

This Energy is Converted to Kinetic energy in nozzle.

$$\therefore 2 \rho Q g h_f = \frac{1}{2} \times \dot{m} \times (V_n)^2$$

($V_n \Rightarrow$ velocity of outlet of nozzle)

$$\Rightarrow 4 \times \dot{m} \times g \times h_f = \dot{m} \times (V_n)^2$$

$$\Rightarrow 4 \times g \times \frac{f \times L \times V_p^2}{2 \times D \times g} = V_n^2,$$

[Where, $h_f = \frac{f L V_p^2}{2Dg}$
V_p = velocity in pipe
D = Dia of pipe.]

$$\Rightarrow \frac{4 \times f \times L \times V_p^2}{2 \times D} = V_n^2$$

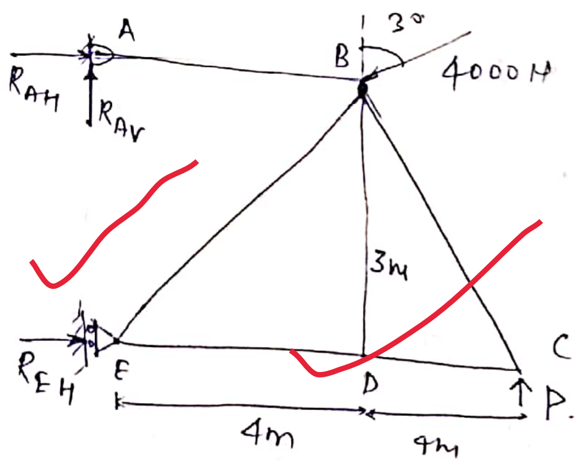
$$\Rightarrow \sqrt{\frac{2fL}{D}} \times V_p = V_n$$

$$\Rightarrow \sqrt{\frac{2fL}{D}} \times \frac{Q}{A} = \frac{Q}{a}$$

$$\Rightarrow \boxed{\frac{A}{a} = \sqrt{\frac{2fL}{D}}}$$

12

Q- 5'C'



R_{AH} = Horizontal Reaction at A

R_{AV} = vertical Reaction at A

R_{EH} = Horizontal Reaction at E

No vertical Reaction at 'E' as motion allowed in vertical Direction

For overall System

$$\sum F_v = 0 \Rightarrow R_{AV} + P = 4000 \cos 30°$$

$$\Rightarrow R_{AV} = 4000 \times \cos 30° - 500$$

$$\boxed{R_{AV} = 2964.1\ N} \quad -(i)$$

and $\sum F_H = 0 \Rightarrow R_{AH} + R_{EH} = 4000 \times \sin 30^\circ$

$$\Rightarrow \boxed{(R_{AH} + R_{EH}) = \frac{4000}{2} = 2000\ N}$$

Now take moment about ~~A~~ E

$\sum M_E = 0$

$\Rightarrow R_{AH} \times 3 - P \times 8 + 4000 \times \cos 30^\circ \times 4 - 4000 \times \sin 30^\circ \times 3 = 0$

$$\Rightarrow R_{AH} = \frac{500 \times 8 + 2000 \times 3 - 4000 \times 4 \times \cos(30^\circ)}{3}$$

$\Rightarrow \boxed{R_{AH} = -1285.47\ N}$ $\Rightarrow$ i.e. Assumed direction of R_{AH} is wrong.

$\therefore \boxed{R_{AH} = 1285.47\ N\ (\leftarrow)} \quad -(ii)$

$\therefore R_{EH} = 2000 - R_{AH} = 2000 - (-1285.47)$

$\Rightarrow \boxed{R_{EH} = 3285.47\ N} \quad -(iii)$

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value of P

Q- 5'd1

Given

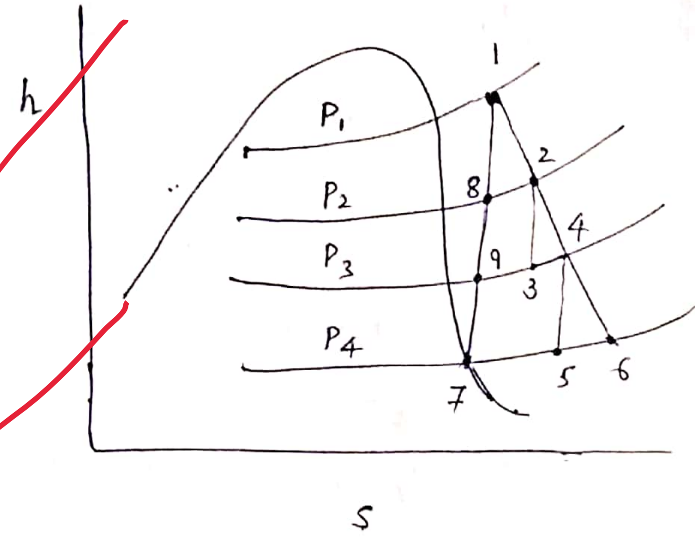
$T_1 = 1520\,K$

$$\frac{P_1}{P_4} = 12$$

$$\Rightarrow \frac{P_1}{P_2} \times \frac{P_2}{P_3} \times \frac{P_3}{P_4} = 12$$

$$\Rightarrow \left(\frac{P_1}{P_2}\right)^3 = 12$$

[as Given pressure Ratio is same across each stage]



$$\Rightarrow \boxed{\left(\frac{P_1}{P_2}\right) = (12)^{1/3} = 2.289} \Rightarrow \text{Each stage}$$

NOW

for 1-7 process

$$\frac{T_7}{T_1} = \left(\frac{P_4}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{1}{12}\right)^{0.4/1.4}$$

$$\Rightarrow \boxed{T_7 = \left(\frac{1}{12}\right)^{2/7} \times 1520 = 747.32\,K}$$

$\therefore$ ~~T6/=C1~~

$$\frac{T_1 - T_6}{T_1 - T_7} = \eta_{isen} = 0.9$$

$$\Rightarrow T_6 = T_1 - 0.9 \times (T_1 - T_7)$$

$$\Rightarrow T_6 = 1520 - 0.9 \times (1520 - 747.32)$$

$$\Rightarrow \boxed{T_6 = 824.588\,K}$$

NOW

$$\frac{T_8}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{1}{2.289}\right)^{0.4/1.4}$$

$$\Rightarrow \boxed{T_8 = 1520 \times \left(\frac{1}{2.289}\right)^{2/7} = 1199.74\,K}$$

~~Power output per stage = $\left(\frac{32}{3} MW\right)$~~

$\therefore$ $P = 32 MW$

$\Rightarrow \dot{m} \times C_p \times (T_1 - T_6) = 32 \times 1000 \Rightarrow \dot{m} = \frac{32000}{1.005 \times (1520 - 824.588)}$

$\Rightarrow \boxed{\dot{m} = 45.786 \ kg/s}$

Total $\Delta T = (T_1 - T_6)$

Assume equal temp drop. in each stage,

$\therefore (\Delta T)_{stage} = \frac{(\Delta T)_{total}}{3} = \frac{(1520 - 824.588)}{3}$

$\Rightarrow (T_1 - T_2) = 231.804 \ K$

$\Rightarrow \boxed{T_2 = 1520 - 231.804 = 1288.196 \ K}$

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$\therefore$ stage efficiency, $\eta_{stage} = \frac{T_1 - T_2}{T_1 - T_8} \times 100 = \frac{231.804}{1520 - 1199.74} \times 100$

slightly error

$\Rightarrow \boxed{\eta_{stage} = 72.38\%}$

Factor (RF) $= \frac{\eta_{isen}}{\eta_{stage}} = \frac{90}{72.38} = 1.24$

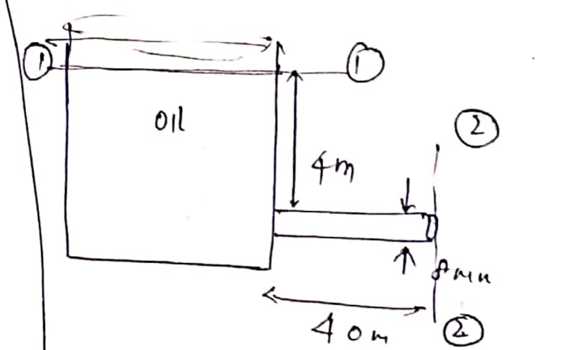
$\boxed{RF = 1.24}$

19-Sol

Major friction loss

$$h_f = \frac{f \times L \times V^2}{2 \times D \times g}.$$

$$f = \frac{64}{Re} \quad (\text{Laminar})$$



Applying Bernoulli's eq. b/w ① & ②

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f + (h)_{entry} + (h)_{exit}$$

Here

$P_1 = P_2 = P_{atm}$

$V_1 \simeq 0$, $Z_2 = 0$, $h_f = \frac{f \times L \times V^2}{2Dg}$, &

$Z_1 = 4 \ m$

$(h_{entry}) = 0.5 \frac{V_2^2}{2g}$, $h_{exit} = \frac{V_2^2}{2g}$

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$$\therefore\ 4 = \frac{V_2^2}{2g} + \frac{f \times L \times V_2^2}{2Dg} + \frac{V_2^2}{2g} + 0.5\frac{V_2^2}{2g}$$

$$\Rightarrow \boxed{4 = 2.5 \times \frac{V_2^2}{2g} + \frac{f \times L \times V_2^2}{2Dg}} \quad (1)$$

Now

$$Re = \frac{V \times D}{\nu}$$

$$\therefore\ 4 = 2.5 \times \frac{V_2^2}{2g} + \frac{64 \times L \times V_2^2}{2 \times D \times g \times Re}$$

$$\Rightarrow 4 = 2.5 \times \frac{V_2^2}{2g} + \frac{64 \times L \times V_2^2}{2D \times g \times \frac{V_2 \times D}{\nu}}$$

$$\Rightarrow 4 = 2.5 \times \frac{V_2^2}{2 \times 9.81} + \frac{64 \times 40 \times V_2 \times 0.00062}{2 \times 9.81 \times \left(\frac{8}{1000}\right)^2}$$

$$\Rightarrow \frac{125}{981} \times V_2^2 + 1264.02 \times V_2 - 4 = 0$$

$$\Rightarrow V_2 = 3.1645 \times 10^{-3}\ m/s$$

$$\Rightarrow \boxed{V_2 = 3.1645\ mm/s}$$

$\therefore$ Discharge, $Q = A \times V_2 = \frac{\pi}{4} \times 8^2 \times 3.1645$

$$\Rightarrow \boxed{Q = 159.065\ mm^3/sec}$$

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Q-6 'a'

Given

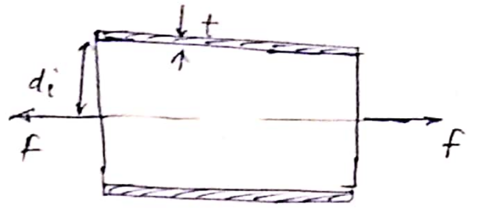
$f = 37$ KN

d_i = Internal diameter = 150 mm

t = thickness = 2.5 mm

$E = 140000$ N/mm^2

$\mu = 0.31$ ⇒ poisson's Ratio



Let P = Internal pressure

∴ Hoop stress, $\sigma_h = \dfrac{Pd_i}{2t} = \dfrac{P\times150}{2\times2.5} = 30\times P$ — (i)

and Longitudinal stress, $\sigma_L = \left(\dfrac{F}{\pi d_m t} + \dfrac{Pd_i}{4t}\right)$ (∵ Due to Axial Force Internal stress becomes negative)

d_m = Mean dia = $d_i + t = 150 + 2.5$
$= 152.5$ mm.

$$\therefore \sigma_L = \left(\frac{F}{\pi d_m t} + \frac{Pd_i}{4t}\right)$$

$$\Rightarrow \sigma_L = \frac{37\times1000}{\pi\times152.5\times2.5} + \frac{P\times150}{4\times2.5}$$

$$\Rightarrow \boxed{\sigma_L = 30.8917 + 15\times P} \quad \text{— (ii)}$$

∴ Longitudinal strain, $\varepsilon_L = \left(\dfrac{\sigma_L}{E} - \mu\dfrac{\sigma_h}{E}\right)$

$$\Rightarrow \varepsilon_L = \frac{30.8917 + 15\times P}{140000} - 0.31\times\frac{30\times P}{140000}$$

$$\cancel{\Rightarrow \varepsilon_L = \frac{30.8917}{140000} + \frac{15}{140000}}$$

$$\Rightarrow \boxed{\varepsilon_L = \frac{1}{140000}\left[30.8917 + \cancel{24.3}\,5.7\times P\right]} \quad \text{— (iii)}$$

Circumferential strain

$$\varepsilon_h = \frac{\sigma_h}{E} - \mu\frac{\sigma_L}{E}$$

$$\Rightarrow \varepsilon_h = \frac{1}{140000}\times\left[30P - 0.31\times30.8917 - 15\times P\times0.31\right]$$

$$\varepsilon_h = \frac{1}{140000} \times \left[\frac{\cancel{34.65}}{25.35} p - 9.5764\right]$$

$\therefore$ Volumetric strain, $\varepsilon_v = 2 \times \varepsilon_h + \varepsilon_L$

$$\Rightarrow \varepsilon_v = \frac{2}{140000} \times \left(\frac{\cancel{34.65}}{25.35} \times p - 9.5764\right) + \frac{1}{140000}\left[30.8917 \cancel{\ } + 5.7p\right]$$

$$\Rightarrow \boxed{\varepsilon_v = \frac{1}{140000}\left[\frac{\cancel{45}}{56.4} \times p + 11.7389\right]}$$

$\therefore$ Bulk Modulus, $K = \dfrac{\Delta p}{\varepsilon_v}$

$$\Rightarrow K = \frac{0.1}{\frac{1}{140000} \times \left[56.4 \times (-0.1) + 11.7389\right]}$$

$$\Rightarrow \boxed{K = 2295.495 \ N/mm^2}$$

2225N/mm2

$\boxed{Q - 6'b'}$

Given

$V_{max} = 2 \ m/s$

$\mu = 2.5 \ Ns/m^2 \Rightarrow$ viscosity.

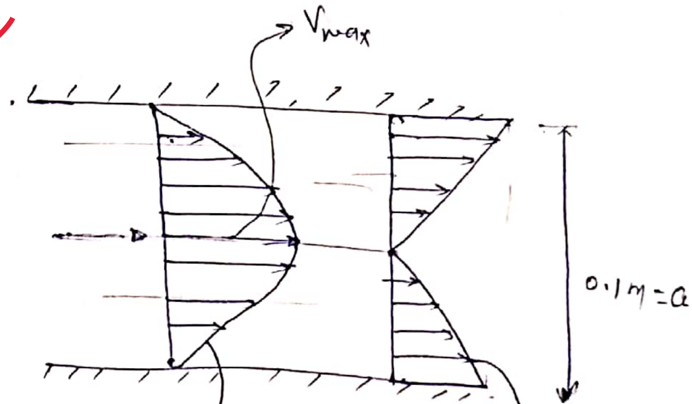
① For fixed plate

Maxm velocity is at centre

and

$$\frac{V_{max}}{V_{avg}} = 1.5$$

$$\Rightarrow \boxed{V_{avg} = \frac{V_{max}}{1.5} = \frac{2}{1.5} = \frac{2 \times 2}{3} = 1.333 \ m/s}$$



And Discharge, $Q = V_{avg} \times A$

$$\Rightarrow Q = 1.333 \times 0.1 \times 1$$

$$\Rightarrow \boxed{Q = 0.1333 \ m^3/sec} \text{ per meter width}$$

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(ii) for parallel plates

velocity distribution, $u = -\frac{1}{2\mu}\frac{\partial p}{\partial x}(ay-y^2)$

at $y = \frac{a}{2}$, $u = V_{max}$

$\therefore V_{max} = -\frac{1}{2\mu}\left(\frac{\partial p}{\partial x}\right)\left[a \times \frac{a}{2} - \left(\frac{a}{2}\right)^2\right]$

$\Rightarrow V_{max} = -\frac{1}{2\mu}\frac{\partial p}{\partial x}\frac{a^2}{4}$

$\Rightarrow \frac{\partial p}{\partial x} = \frac{-2\times\mu\times4\times V_{max}}{a^2} = \frac{-8\times2.5\times2}{0.1^2}$

$\Rightarrow \boxed{\frac{\partial p}{\partial x} = -4000\ N/m^3}$

Also

Shear stress at plate, $\tau_o = -\frac{\partial p}{\partial x}\left(\frac{a}{2}\right)$

$\Rightarrow \tau_o = 4000 \times \frac{0.1}{2}$

$\Rightarrow \boxed{\tau_o = 200\ N/m^2}$

(iii)

$\frac{\partial p}{\partial x} = -4000$

$\Rightarrow \frac{(P_2-P_1)}{(x_2-x_1)} = -4000$ $\Rightarrow (P_1-P_2) = 4000\times30$

$\Rightarrow \boxed{(P_1-P_2) = 120000\ Pa}$

(iv)

Velocity at $y = 0.03\ m$

$u = -\frac{1}{2\mu}\left(\frac{\partial p}{\partial x}\right)(ay-y^2) \Rightarrow$ parabolic variation

$\Rightarrow u = -\frac{1}{2\times2.5}\times(-4000)\times(0.1\times0.03-0.03^2)$

$\Rightarrow \boxed{u = 1.68\ m/s}$

and shear stress at $y = 0.03\ m$

$\tau = \mu\frac{\partial u}{\partial y} = \mu\times-\frac{1}{2\mu}\frac{\partial p}{\partial x}\times(a-2y) \Rightarrow$ Linear variation

$\Rightarrow \tau = -\frac{1}{2}\times(-4000)\times(0.1-2\times0.03)$

$\Rightarrow \boxed{\tau = 80\ N/m^2}$

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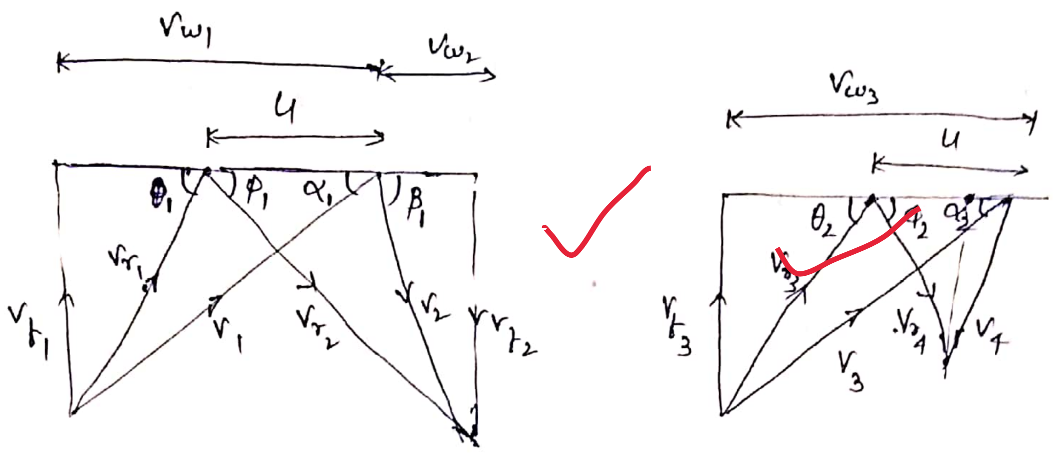
$\boxed{Q-6'C'}$



First row — second row

Given $\alpha_1 = 22^\circ$, $(\Delta h)_{isen} = 200\ kJ/kg$,

$u = 150\ m/s$, $\eta_{nozzle} = 0.9$, $\dot{m} = 3\ kg/s$

Here

$$\dot{m}\left(h_1 + \frac{V_{inlet}^2}{2}\right) = \dot{m}\left(h_2 + \frac{V_1^2}{2}\right)$$

$\Rightarrow \boxed{V_{inlet} = 0}$

$$\therefore \quad \dot{m} h_1 = \dot{m} h_2 + \frac{\dot{m} V_1^2}{2}$$

$$\Rightarrow \frac{V_1^2}{2} = \Delta h$$

$$\Rightarrow V_1 = \sqrt{2 \Delta h}$$

$$\Rightarrow V_1 = \sqrt{2 \times 200 \times 0.9 \times 1000}$$

$$\Rightarrow \boxed{V_1 = 600\ m/s}$$

$$\therefore \boxed{V_{w_1} = V_1 \cos\alpha_1 = 600 \times \cos 22^\circ = 556.31\ m/s}$$

$$\boxed{V_{t_1} = V_1 \sin\alpha_1 = 600 \times \sin 22^\circ = 224.76\ m/s}$$

$$\therefore \tan\theta_1 = \frac{V_{t_1}}{(V_{w_1} - u)}$$

$$\Rightarrow \theta_1 = \tan^{-1}\left(\frac{224.76}{556.31 - 150}\right)$$

$$\Rightarrow \boxed{\theta_1 = 28.95^\circ}$$

Blades are symmetrical

$$\boxed{\theta_1 = \phi_1 = 28.95^\circ}$$

Also

$$V_{r_1} = \sqrt{V_{f_1}^2 + (V_{w_1} - u)^2}$$

$$\Rightarrow V_{r_1} = \sqrt{(224.76)^2 + (553.31 - 150)^2}$$

$$\Rightarrow \boxed{V_{r_1} = 464.33 \text{ m/s}}$$

Assuming no loss.

$$\therefore \boxed{V_{r_1} = V_{r_2} = 464.33 \text{ m/s}}$$

$$\therefore V_{w_2} = V_{r_2} \cos\phi_1 - u$$

$$\Rightarrow V_{w_2} = 464.33 \times \cos(28.95^\circ) - 150$$

$$\Rightarrow \boxed{V_{w_2} = 256.308 \text{ m/s}}$$

$$\therefore V_{f2} = V_{r_2} \sin\phi_1 = 464.33 \times \sin(28.95^\circ)$$

$$\Rightarrow \boxed{V_{f2} = 224.76 \text{ m/s}}$$

$$\therefore V_2 = \sqrt{V_{w_2}^2 + V_{f2}^2} = \sqrt{(256.308)^2 + (224.76)^2}$$

$$\Rightarrow \boxed{V_2 = 340.897 \text{ m/s}}$$

$$\therefore \tan\beta_1 = \frac{V_{f2}}{V_{w_2}}$$

$$\Rightarrow \beta_1 = \tan^{-1}\left(\frac{224.76}{256.308}\right)$$

$$\Rightarrow \boxed{\beta_1 = 41.25^\circ}$$

~~Ho~~ $\therefore$ Specific power output by First row

$$= (V_{w_1} + V_{w_2}) \times u$$

$$\boxed{W_{\text{First row}} = \frac{(553.31 + 256.308) \times 150}{1000} = 121.89 \text{ KJ/Kg}}$$

Now

$$V_3 = V_2 = 340.897 \text{ m/s}$$

$\therefore$ $V_{w_3} = V_3 \cos \alpha_2 = 340.897 \times \cos(22)$

$$\Rightarrow \boxed{V_{w_3} = 316.074 \text{ m/s}}$$

$\therefore$ Specific work output by second row

$$W_{2nd\,row} = V_{w_3} \times u = \frac{316.074 \times 150}{1000} \text{ KJ/kg}$$

$$\Rightarrow \boxed{(W_{2nd\,row}) = 47.41 \text{ KJ/kg}}$$

$\therefore$ Total specific power output per stage

$$= W_{First\,row} + W_{2nd\,row}$$

$$= 121.89 + 47.41$$

$$\boxed{W_{stage} = 169.3 \text{ KJ/kg}}$$

And

$$\boxed{\begin{aligned}(W_{stage}) &= \dot{m} \times (W_{stage})_{specific} \\ &= 3 \times 169.3 \\ &= 507.9 \text{ KW.}\end{aligned}}$$

your approach is correct please refer solution slightly deviation in calculation & ans

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