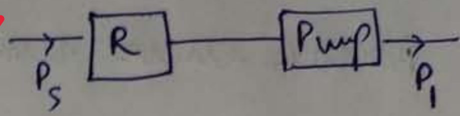
Test 6

total marks= 246

1. (a.) $U_{w_1} = 36$ kmph $= 10$ m/s.

P_1 = Power needed to lift water



$= \rho_w Q g H = 1000 \times \frac{6}{3600} \times 9.81 \times 6$

$= 98.1$ W.

Power needed to be supplied by rotor $= \frac{98.1}{0.5 \times 0.8} = 245.25$ W

$\therefore P_{ac} = 245.25$ W

But, $P_{ac} = C_p \times P_{theoretical} = C_p \frac{1}{2} \rho_a A_b U_{w_1}^3$

$\therefore 245.25 = 0.3 \times \frac{1}{2} \times 1.2 \times A_b \; 10^3$

$\therefore A_b = 1.3625 \text{ m}^2 = \pi R_b^2$

$\therefore$ $\boxed{R_b = 0.658 \text{ m}}$

(i.) Rotor radius $= 0.658$ m $= 658.56$ mm

(ii.) Tip speed ratio $= \lambda = \frac{\omega R}{U_{w_1}} = 1$

$\therefore \omega = \frac{U_{w_1}}{R} = \frac{10}{0.658} = 15.1847$ rad/s

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angular velocity of rotor $= 15.185$ rad/s $= 145$ rpm

1.(b.) $F = ₹16000$

$s = ₹40$ per unit

$v = ₹24$ per unit

Break even units $= x_{BEP} = \frac{F}{S-V} = \frac{16000}{40-24}$

✓ $= 1000$ units

∴(i.) Break even sales $= 40 \times 1000 = ₹40000$ ✓ ✓

(ii.) $P = ₹2000$, let x units are needed

$S = F + V + P$

$(s-v)x = F + P = 16000 + 2000 = 18000$

$x = \frac{18000}{40-24} = 1125$ ✓

1125 units are needed for profit of ₹2000.

✓

(iii.) $S = ₹60000 = sx$

∴ $x = \frac{60000}{40} = 1500$ units

$S = F + V + P \rightarrow P = S - F - V = 60000 - 16000 - 1500 \times 24$

$= 8000$

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∴ Profit $= ₹8000$ ✓

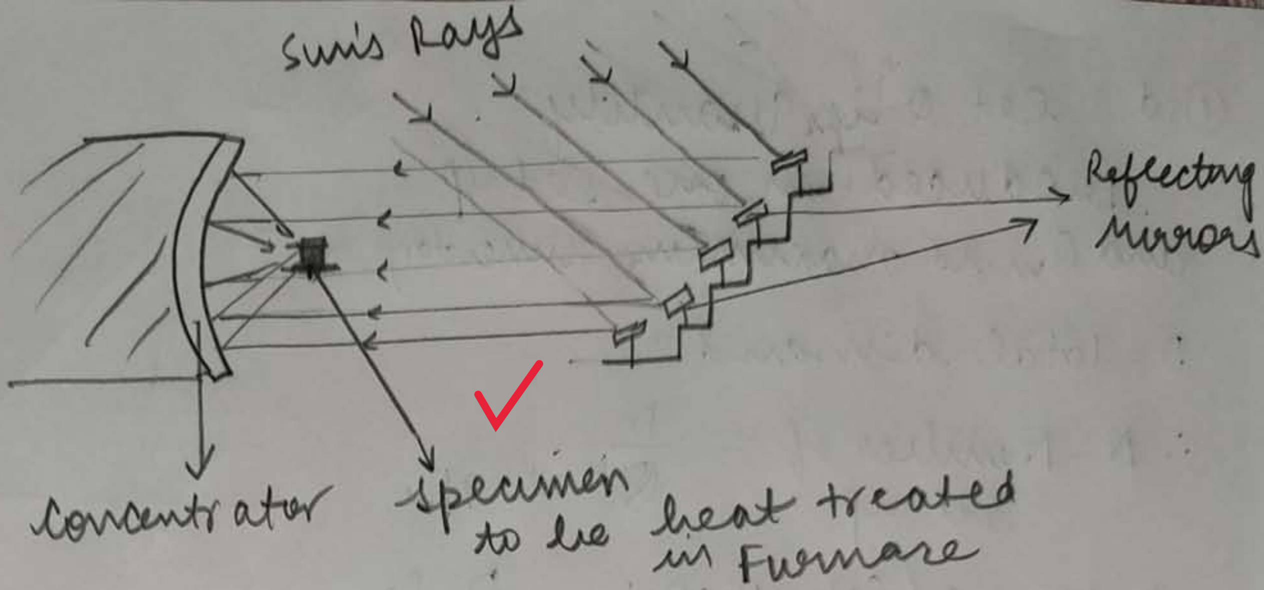
(iv.) $s' = 0.9s = ₹36$

∴ $x' = \frac{F}{s'-V} = \frac{16000}{36-24} = 1333.33$ units

✓

New Breakeven sales $= ₹48000$ ∴ 1334 units is new Break even Point

1. (c.)



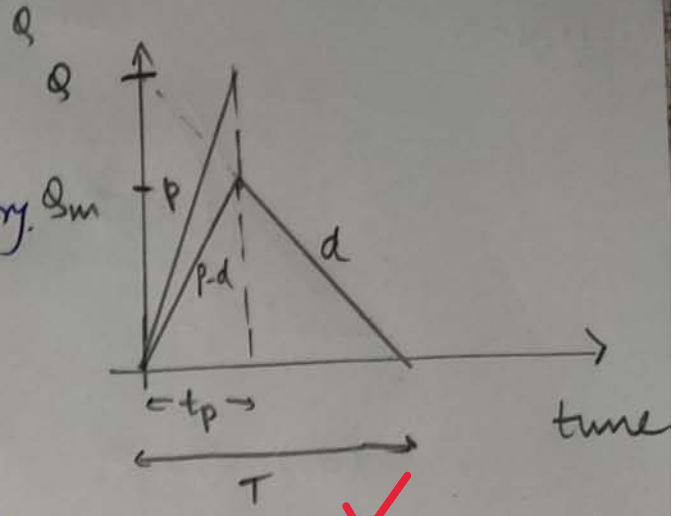
SOLAR FURNACE SCHEMATIC

- Solar furnace uses solar energy to maintain workpiece at high temperature in furnace
- A series of mirrors are placed which reflect sun's ray's to the Concentrator. These are designed in such a way that rays are parallel to each other when they reach the concentrator
- workpiece is kept at focus of concentrator and sun's rays are focussed on it by the concentrator
- Temperature achieved depends on the ~~strength~~ intensity of solar radiation
- It uses solar energy, hence reduces emissions. But it is expensive to make
- To achieve higher temperature, concentrating reflectors can be used instead of plane mirrors.

6

read from solution also

① (d.) Let Q is quantity produced in one set up and Q_m is maximum inventory.



D = Total demand

$\therefore N$ = Number of set up $= \frac{D}{Q}$

$\therefore$ Ordering / Set up cost $= \frac{D}{Q} C_0$

Now,

$Q = p\, t_p$

$Q_m = (p-d)\, t_p$

p = Production rates

d = consumption rate

T = Cycle time

$\therefore \frac{Q_m}{Q} = \frac{p-d}{p} \Rightarrow Q_m = \left(\frac{p-d}{p}\right) Q$

Holding cost $= \left(\frac{0 + Q_m}{2}\right) T\, N\, C_h = \frac{Q_m}{2} C_h = \left(\frac{p-d}{p}\right)\frac{Q C_h}{2}$

$\therefore$ Variable cost = TIC = Set up cost + holding cost

$TIC = \frac{D}{Q} C_0 + \frac{p-d}{p} Q \frac{C_h}{2}$

for minimum Total cost : $\frac{d(TIC)}{dQ} = 0$

$\Rightarrow \frac{p-d}{p} \frac{C_h}{2} - \frac{D}{Q^2} C_0 = 0$

12

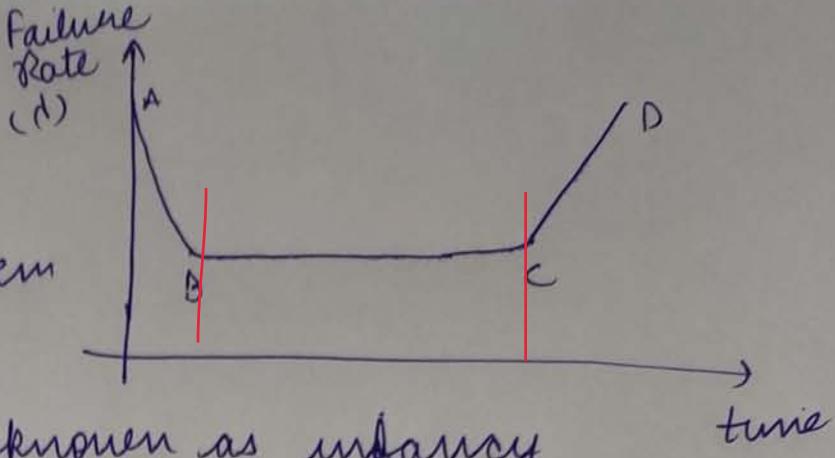
$\Rightarrow Q^* = \sqrt{\frac{2 D C_0}{C_h} \frac{p}{p-d}} = \sqrt{\frac{2 D.C_0}{\left(1-\frac{d}{p}\right) C_h}}$

$\therefore EOQ = \sqrt{\frac{2 D C_0}{\left(1-\frac{d}{p}\right) C_h}}$

Hence proved

① (e.) (i.)

Bathtube curve represents the failure rate of system with time

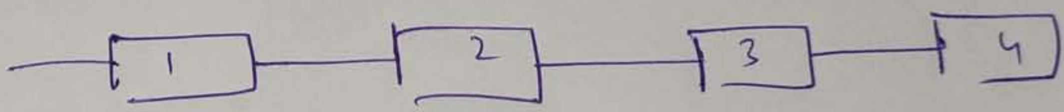


In region AB, also known as infancy region, failure rate ~~decreases~~ is high but decreases with time ✓

In region BC, which is running life of the Part, failure rate is stable ✓

In Region CD, which is wear out phase, failure rate increases as there is more chance of part failure. ✓

(ii.)



$R_{sys} = R_1 \times R_2 \times R_3 \times R_4$ ✓ [system in series]

$R_1 = e^{-\lambda_1 t} = e^{-0.002 t}$

$\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0.002$ hrs

$\therefore R_1 = R_2 = R_3 = R_4 = e^{-0.002 \times 100} = 0.8187$

$\therefore$ System Reliability $= R_{sys} = R_1^4$

$\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4$ ✓

$R_{sys} = 0.4493$

$R_{sys} = R_1^4$

$R_{sys} = e^{-4 \lambda_1 t}$

8

(3.) (a.) Limitations of tidal energy :

1.) Development of Tidal Plants can disrupt marine life

2.) Turbine has to operate under variable head

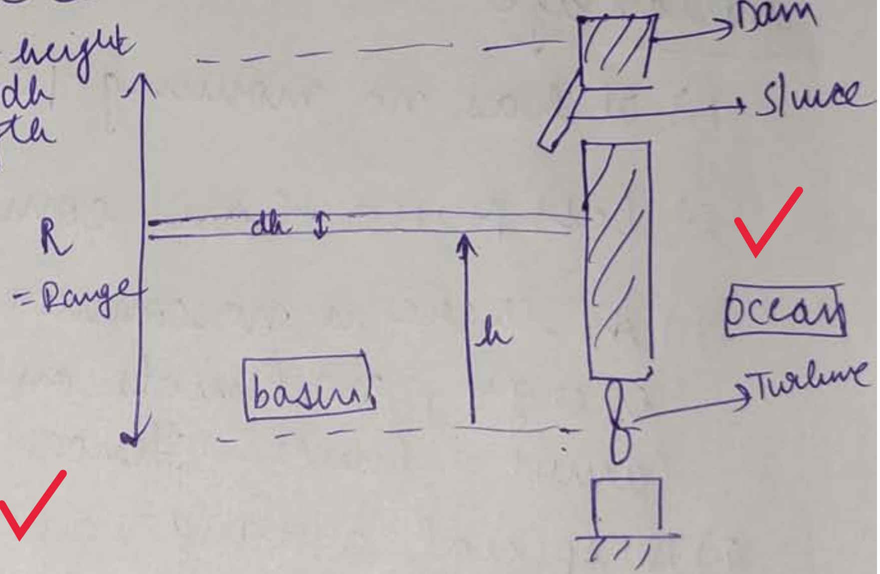
3.) For cost effective and economical system, the Range should be more than 5m.

4.) For low power generation, due to low head, high discharge is needed which requires a number of turbines to be used

5.) The source of tidal energy is generally far away from Population centres, hence distribution and transmission costs are also there.

Let us take an element at height h of dh length

Potential energy available in elemental height dh



$$dw = dm\, g\, h$$

But,

$$dm = \rho A\, dh$$

$$\therefore dw = \rho A g\, h\, dh$$

$$\therefore \text{total energy} = W = \int_{h=0}^{R} \rho A g\, h\, dh = \rho A g \frac{R^2}{2} \text{ (Joules)}$$

Once tidal cycle completes in 6 hrs 12.5 minutes

= 22350 sec

$$\text{Power developed} = P_{avg} = \frac{\rho A g \frac{R^2}{2}}{22350} \text{ watts}$$

$$= \frac{1025 \times 9.81}{2 \times 22350} AR^2 = 0.22495 AR^2$$

$$\therefore \boxed{P_{avg} = 0.225 AR^2}$$ ✓

③ (b.) Fuel cell is a device that converts chemical energy of fuel directly into electrical energy. ✓

There is no intermediate conversion into thermal energy. ✓

Fuel cell generally consists of 2 electrodes (one is fuel electrode, other is oxidizer electrode) and a suitable electrolyte ✓

make a small diagram of fuel cell

Advantages

1.) It has no moving parts and is a static device ✓

2.) Less Noise than convention thermal power plant.

3.) As there is no conversion ✓ to thermal energy, no limits on efficiency due to Carnot's limit. Hence efficiency ✓ is higher

4.) No special arrangements like cooling tower ~~of~~ for condenser of a ✓ power plant are required in Fuel cell

5.) Can be used as Portable device in space applications. ✓

The classification on chemical nature of electrolyte

1.) Acidic electrolyte Fuel cell ✓
2.) Alkaline electrolyte Fuel cell
3.) Neutral electrolyte Fuel cell.

The classification on electrolyte is

1.) Phosphoric acid fuel cell ✓
13 2.) Alkaline fuel cell
3.) Proton exchange membrane fuel cell
4.) Molten Carbonate fuel cell
5.) Solid oxide fuel cell.

③ (c.)

(i.) actual power developed $= 12 \times 9 = 108\,W$

due to MPPT, load line shifts ✓ to max^m power point

$\therefore P_{max} = 27 \times 6 = 162\,W$ ✓

But efficiency of MPPT is 95%.

Hence actual power developed due to use of MPPT $= 0.95 \times 162$

$= 153.9\,W$ ✓

$\therefore$ Additional power gained due to MPPT

$= 153.9 - 108$

$= 45.9\,W$ ✓

(ii.) cost of MPPT = ₹4200.

Power gained due to MPPT $= 45.9\,W$

$= 0.0459\,kW$ ✓

let PV source work for t hours to recover cost

∴ kWh developed in this period $= (0.0459\,t)$ kWh

cost of electricity $=$ ₹ 3 per kWh ✓

∴ Power saved $= (3 \times 0.0459\,t)$

To recover cost

$4200 = 3 \times 0.0459\,t$

$t = 30501.1$ hours ✓

15 Type text here

$= 1270$ days

(3) (d.)

n = 6

Population (lakh) x	Washing M/C y	xy	x^2
5	28	140	25
7	40	280	49
15	65	975	225
22	80	1760	484
27	96	2592	729
36	130	4680	1296
$\Sigma x = 112$	$\Sigma y = 439$	$\Sigma xy = 10427$	$\Sigma x^2 = 2808$

Let Population (in lakh) is independent variable x and washing machines (in hundred) is dependent variable y

∴ linear regression equation

$$y = a + bx \quad \text{--- (1)}$$

taking summation

$$\Sigma y = na + b\Sigma x$$

~~112 = 6a +~~

$$439 = 6a + 112b \quad \text{--- (2)}$$

Multiply eqn (1) by x

$$xy = ax + bx^2$$

taking summation

$$\Sigma xy = a\Sigma x + b\Sigma x^2$$

$$10427 = 112a + 2808b \quad \text{--- (3)}$$

On solving (2) & (3)

$a = 15.076$ & $b = 3.112$

∴ regression equation

$$y = 15.076 + 3.112\,b$$ ✓

(ii.) Population = 45 lakh

∴ $x = 45$

∴ By linear regression ✓

$y = 15.076 + 3.112 \times 45$

$y = 155.11 = 156$

13

∴ demand of washing machine in 45 lakh population city = 156,000 ✗

✓

do not make silly mistake

(4.) (a.) D = 12000 units/year

p = 2000 units/month. C_o = ₹ 400.

C_h = 0.15 per unit per month. C_u = ₹ 4

shortage cost, C_b = ₹ 20 per year.

annual holding cost = 0.15 × 12 = ₹1.8/unit/year

Consumption rate = $d = \frac{D}{12}$ = 1000 units/month

This is a inventory model with shortage and production build up model

$$EOQ = Q^* = \sqrt{\frac{2DC_o}{C_h} \frac{p}{p-d} \frac{C_b + C_h}{C_b}}$$

$$= \sqrt{\frac{2 \times 12000 \times 400}{1.8} \times \frac{2000}{(2000-1000)} \times \frac{20+1.8}{20}}$$

= ~~3040.9~~ 3409.78

≃ 3410 units

$$\text{Total cost} = TC = D \times C_u + \sqrt{2DC_oC_h\left(\frac{p-d}{p}\right)\left(\frac{C_b}{C_b+C_h}\right)}$$

= 12000 × 4 + 2815.42

= ₹ 50815.42

Let manufacturing time = t_p

$$\therefore t_p = \frac{EOQ}{p} = \frac{3410}{2000} = 1.705 \text{ months}$$

Total cycle time = T

$$\therefore T = \frac{EOQ}{d} = \frac{3410}{1000} = 3.410 \text{ months}$$

Now,

$$Q_{max} = \text{maximum inventory} = \left(\frac{C_b}{C_b + C_h}\right)\left(\frac{p-d}{p}\right) Q$$

$$= \frac{20}{20+1.8} \times \frac{1000}{2000} \times 3410$$

$$= 1564.22$$

$$= 1565 \text{ units}$$

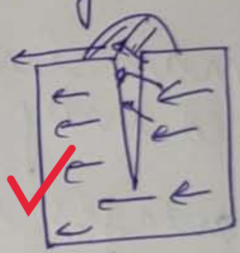
20

$\therefore$ Maximum inventory = 1565 units

(4.) (b.)

(A.) Magnetic Particle Testing

- It is one of the most widely used methods
- Surface preparation is not as essential as other processes
- The component to be tested must be of Ferro magnetic material (like Fe, Co, Ni)
- This method uses small magnetic particles (iron fillings) and magnetic field to detect flaws
- we magnetize the component, an if any surface cracks are present, the magnetic field will leak and iron fillings will be accumulated
- Accumulated particles are visible and thus an invisible crack can be identified



→ Magnetic Particles should have high Permeability and low Retentivity

adv

1.) direct visual method
2.) No surface preparation needed

disadv

1.) can only be used for Ferro Magnetic materials
2.) cannot be used for sub surface cracks

used to inspect products from forging, welding

(B.) Eddy current Inspection

This method is based on peincipal of electro magnetic induction.

Electric currents called eddy currents are generated in a conductive material due to induced magnetic field

Defects ~~cauce~~ cause interruption in flow of eddy current and these changes can affect voltage which is monitored using equipments

Due to crack, secondary magnetic field is interrupted

The main limitation of process is it can be used only for conducting work piece

Advantages is that it can detect small cracks and can be used even in complex components

(C) Radiography

This method uses X Ray radiation of check material's defect and internal feature

X Ray Radiation is passed through work piece onto a film.

The image formed on film shows internal features. Darker areas represent voids in

16 See the Part

→ This is used to check internal defects from casting which cannot be done in Magnetic particle Inspection

→ The thickness of work limits this process and a risk of radiation is a concern

(4.) (c.) $\beta = 30°$ $\rho_g = 0.3$

$\overline{H_g} = 16282.8$ kJ/m²-day

$\overline{H_d} = 4107.6$ kJ/m²-day

$\overline{H_t} = ?$

$$\frac{\overline{H_t}}{\overline{H_g}} = \overline{R} = \overline{R_b}\left(1 - \frac{\overline{H_d}}{\overline{H_g}}\right) + \overline{R_d}\left(\frac{\overline{H_d}}{\overline{H_g}}\right) + \overline{R_r}\,\rho_g$$

$\beta = 30°$

$$\therefore \overline{R_d} = \frac{1+\cos\beta}{2} = 0.933$$

$$\overline{R_r} = \frac{1-\cos\beta}{2} = 0.0669$$

$$\therefore \overline{R_d}\left(\frac{\overline{H_d}}{\overline{H_g}}\right) = 0.933 \times \frac{4107.6}{16282.8} = 0.2354$$

$$\overline{R_r}\,\rho_g = 0.0669 \times 0.3 = 0.02$$

Now,

$$n = 365 - 31 - 30 + 14 = 318$$

$$\delta = 23.45 \sin\left[\frac{360}{365}(284+n)\right] = -18.91°$$

$$\phi = 28.35' = 28.583°$$

ω_s = Sunset hour angle $= \cos^{-1}\left[-\tan\delta \tan\phi\right] = 79.24°$

$= 1.383$ rad

tilt factor $= R_b = \frac{\cos\theta}{\cos\theta_z} = \frac{\sin\delta \sin(\phi-\beta) + \cos\delta\cos(\phi-\beta)\cos\omega}{\sin\delta \sin\phi + \cos\delta\cos\phi\cos\omega}$

average tilt factor $= \overline{R_b}$

$$\overline{R_b} = \frac{2\int_0^{\omega_s} \frac{24}{\pi}\left[\sin\delta\sin(\phi-\beta) + \cos\delta\cos(\phi-\beta)\cos\omega\right] d\omega}{2\int_0^{\omega_s} \frac{24}{\pi}\left[\sin\delta\sin\phi + \cos\phi\cos\delta\cos\omega\right] d\omega}$$

$$\overline{R_b} = \frac{\omega_s \sin\delta \sin(\phi-\beta) + \cos\delta\cos(\phi-\beta)\sin\omega_s}{\omega_s \sin\delta\sin\phi + \cos\delta \cos\phi \sin\omega_s}$$

$$= \frac{1.383 \sin(-18.91)\sin(-1.417) + \cos(-18.91)\cos(-1.417)\sin(79.24)}{1.383\sin(-18.91)\sin(28.583) + \cos(-18.91)\cos(28.583)\sin(79.24)}$$

$$= \frac{0.9402}{0.6017} = 1.5626$$

$\therefore \overline{R_b} = 1.5626$

$$\therefore \frac{H_t}{H_g} = 1.5626\left(1 - \frac{4107.6}{16282.8}\right) + 0.2354 + 0.02$$

$$= 1.4238$$

20

$\therefore H_t = 23183.59 \text{ KJ/m}^2\text{-day}$

5. (a) (i.) Flexible Manufacturing System (FMS) is a highly automated manufacturing system which consists of multiple CNC machines, automated material handling and controlled by computer system ✓

The advantages are optimized inventory, reduced labor costs and improved productivity ✓

It consists of automatic CNC machines and material handling by conveyors, AGV and RGVs ✓

(ii.) Types of flexibility

1.) Routing flexibility ⇒ when more than one machine can complete the same operation ✓

2.) Machine flexibility ⇒ when one machine can perform many operations ✓

6

(5) (b.) $\rho_{alloy} = w_1 \rho_A + w_2 \rho_2$

atomic weight of alloy = M

$M = w_A M_A + w_B M_B = 0.125 \times 61.4 + 0.875 \times 125.7$ ✗

$= 117.6625 \frac{gm}{mol}$ ✗ check solution

Density of alloy = ρ

$\therefore \frac{1}{\rho} = \frac{w_A}{\rho_A} + \frac{w_B}{\rho_b} \Rightarrow \frac{1}{\rho} = \frac{0.125}{4.27} + \frac{0.875}{6.35}$

$\therefore \rho = 5.9855 \frac{gm}{cm^3} = 5.9855 \times 10^6 \frac{gm}{m^3}$ ✓ ✓

let n atoms in a unit cell

$n = \frac{m}{M} = \frac{n}{N_0}$

$\rho = \frac{m}{V_{cell}} = \frac{Mn}{N_0 V_{cell}}$ ✓

$m = \frac{Mn}{N_0}$

$n = \frac{\rho N_0 V_{cell}}{M} = \frac{5.9855 \times 6.023 \times 10^{23} \times 0.395^3 \times 10^{-27} \times 10^6}{117.6625}$

$\simeq 1.88 \simeq 2$ ✓

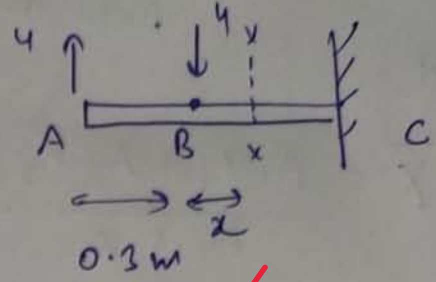
6 $\therefore$ crystal structure is face centered cubic (FCC) ✗

for FCC-n-4,

BM in BC

(5.) (c.) $M_x = 4(0.3+x) - 4x$

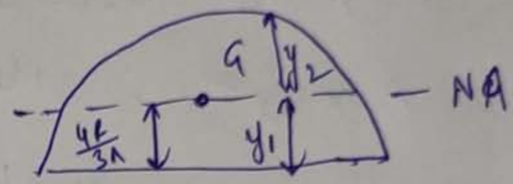
$= 4\times0.3 = 1.2$ kN-m [sagging]



Constant B.M. in BC portion

∴ compression in top fiber, tension in bottom fiber

R = 25 mm



$\frac{4r}{3\pi} = 10.61$ mm

$I_{semicircle} = 0.11 R^4 = 42968.75$ mm

M = 1.2 kN-m
= 1.2×10^6 N-mm

∴ Max^m compressive stress

$y = y_2 = 25 - 10.61 = 14.39$ mm

$$\sigma = \frac{My}{I} = \frac{1.2\times10^3\times10^3 \times 14.39}{42968.75} = 401.87 \frac{N}{mm^2}$$

= 401.87 MPa [C.]

Max^m Tensile stress

$$\sigma = \frac{M}{I}\cdot y = \frac{1.2\times10^6\times10.61}{42968.75} = 296.31 \frac{N}{mm^2}$$

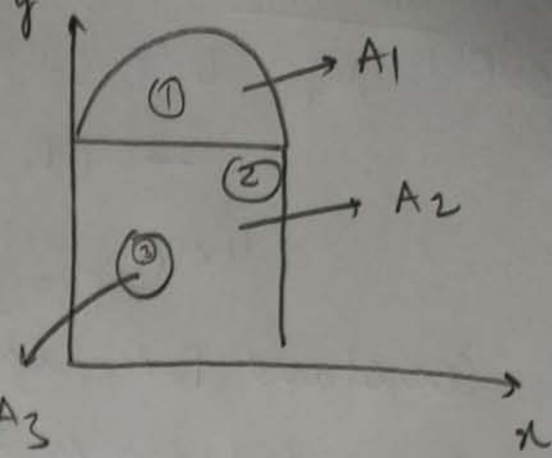
= 296.31 MPa [T]

12

(5.) (a.)

$A_1 + A_2 - A_3 = 6713.27 \text{ cm}^2$

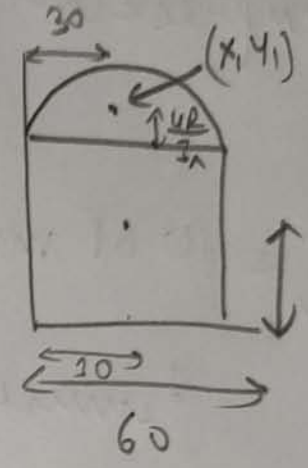
$$\bar{X} = \frac{A_1 x_1 + A_2 x_2 - A_3 x_3}{A_1 + A_2 - A_3}$$ ✓



$A_1 = \pi R^2 = \pi (30)^2$
$= 2827.43 \text{ cm}^2$

$A_2 = 60 \times 70 = 4200 \text{ cm}^2$ ✓

$A_3 = \pi \times 10^2 = 314.16 \text{ cm}^2$



$x_1 = 30 \text{ cm}$ $\quad y_1 = 70 + \frac{4R}{3\pi} = 82.73 \text{ cm}$

$x_2 = 30 \text{ cm}$ $\quad y_2 = \frac{70}{2} = 35 \text{ cm}$

$x_3 = 15 \text{ cm}$ $\quad y_3 = 30 \text{ cm}$

$$\therefore \bar{X} = \frac{2827.43 \times 30 + 4200 \times 30 - 314.16 \times 15}{6713.27}$$ ✗

$= 30.70 \text{ cm}$ ✗

$$\bar{Y} = \frac{A_1 y_1 + A_2 y_2 - A_3 y_3}{A_1 + A_2 - A_3} = \frac{2827.43 \times 82.73 + 4200 \times 35 - 314.16 \times 30}{6713.27}$$

5

$= 55.34 \text{ cm}$ ✗

calculation mistake

$\therefore$ centroid $\rightarrow (30.70, 55.34)$

(5.)(e.) The desired properties are

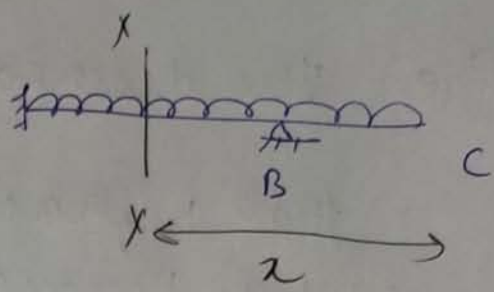
1.) High Refractoriness ✓
2.) High Permeability
3.) High Flowability ✓
4.) High dry strength
5.) High hot strength, green strength ✓
6.) Good hardness
7.) High collapsibility
8.) Good cohesion with sand and adhesion with flask surface ✓

Adhesives used are

Saw dust to increase Permeability
Chacoal black to increase flowability ✓

8

(6.) (a.)



Let reaction at B is R_B

using double integration method

$$EI\frac{d^2y}{dx^2} = \frac{wx^2}{2} \Big/ -R(x-2)$$

integrating

$$EI\frac{dy}{dx} = \frac{wx^3}{6} + C_1 \Big/ -R\frac{(x-2)^2}{2}$$

at Fixed end, slope = 0

$\therefore$ at $x = L$, $\frac{dy}{dx} = 0$

$$\therefore 0 = \frac{wL^3}{6} + C_1 - R\frac{(L-2)^2}{2}$$

$$\therefore C_1 = \frac{R(L-2)^2}{2} - \frac{wL^3}{6} = \frac{R(L-2)^2}{2} - \frac{500}{3}$$

$$\therefore EI\frac{dy}{dx} = \frac{wx^3}{6} + C_1 \Big/ -\frac{R(x-2)^2}{2}$$

integrating

$$EIy = \frac{wx^4}{24} + C_1x + C_2 \Big/ -R\frac{(x-2)^3}{6}$$

at fixed end, defection is 0

$\therefore$ at $x = L$, $y = 0$

$$\therefore 0 = \frac{wL^4}{24} + C_1L + C_2 - R\frac{(L-2)^3}{6}$$

$$\therefore C_2 = \frac{R(L-2)^3}{6} - C_1 L - \frac{wL^4}{24}$$

$$\therefore EIy = \frac{wx^4}{24} + C_1 x + C_2 - \frac{R(x-2)^3}{6}$$

Now,

at $x = 2$, at point B, deflection is 0

[as prop is present]

$$\therefore 0 = \frac{w}{24} 2^4 + C_1 \times 2 + C_2$$

$$\Rightarrow 0 = \frac{w}{24} \times 2^4 + 2\left[\frac{R(L-2)^2}{2} - \frac{w \times L^3}{6}\right] + \frac{R(L-2)^3}{6} - C_1 L - \frac{wL^4}{24}$$

$$0 = \frac{w}{24} 2^4 + 2\left[\frac{R(L-2)^2}{2} - \frac{500}{3}\right] + \frac{R(L-2)^3}{6} - 10\left[\frac{R(L-2)^2}{2} - \frac{500}{3}\right] - \frac{w \times 10^4}{24}$$

$$0 = R(L-2)^2 + \frac{R(L-2)^3}{6} - 5R(L-2)^2 + \frac{2}{3} - \frac{1000}{3} + \frac{5000}{3} - \frac{1250}{3}$$

$$R\left[\frac{8^3}{6} - 4 \times 8^2\right] = -\frac{2752}{3}$$

$$\Rightarrow -\frac{512R}{3} = -\frac{2752}{3}$$

$$\boxed{R = 5.375 \text{ kN}}$$

(ii.) for deflection of free end

$x = 0$

$$\therefore EI\, y = C_2 = \frac{R(8)^3}{6} - \left[\frac{R8^2}{2} - \frac{500}{3}\right] \times 10 - \frac{1 \times 10^4}{24}$$

$$EI\, y = R\left[\frac{8^3}{6} - 5 \times 8^2\right] + \frac{5000}{3} - \frac{1250}{3}$$

$$16.69 \times 10^6\, y = \frac{34}{3} \times 10^3 \text{ m}$$

$$y = 6.79 \times 10^{-4} \text{ m}$$

$$y = 0.679 \text{ mm}$$

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good

(6.) (b.) $R = 150$ mm. $K = 350$ MPa $D = 300$ mm

$\mu = 0.1$ $n = 0.26$

$h_0 = 10$ mm

$h_f = 6$ mm $\Delta h = 4$ mm

$$\cos\alpha = 1 - \frac{\Delta h}{D} = 1 - \frac{4}{300} = 0.1635 \text{ rad}$$

$$H_0 = 2\sqrt{\frac{R}{h_f}} \tan^{-1}\left(\sqrt{\frac{R}{h_f}}\,\alpha\right)$$

$$= 2\sqrt{\frac{150}{6}} \tan^{-1}\left[\sqrt{\frac{150}{6}} \times 0.1635\right]$$

$$= 6.85$$

$$H_n = \frac{1}{2}\left[H_0 - \frac{1}{\mu}\ln\left(\frac{h_0}{h_f}\right)\right]$$

$$= \frac{1}{2}\left[6.85 - \frac{1}{0.1}\ln\left(\frac{10}{6}\right)\right]$$

$$= 0.87$$

$$H_n = 2\sqrt{\frac{R}{h_f}} \tan^{-1}\left[\sqrt{\frac{R}{h_f}}\,\theta_n\right]$$

$$\theta_n = 0.0175 \text{ rad}$$

$$h_n = h_f + 2R(1-\cos\theta_n) = 6.0459 \text{ mm}$$

at neutral point, Pressure $= P_n$

$$P_n = \sigma_0' \frac{6.0459}{6} e^{\mu \times 0.87}$$

$$\sigma_0' = \frac{K\epsilon_n^n}{1+n} = \frac{350 \times 0.839}{1.26} = 233.26 \text{ MPa}$$

$$P_n = 233.26 \times \frac{6.0459}{6} \times e^{0.87 \times 0.1}$$

Pressure at neutral point $= P = 256.41$ MPa ✗

Roll pressure at exit = Roll pressure at entry $= \sigma_0' = 233.26$ MPa

(ii.)

for roll to begin to slip, neutral point shifts to exit ✓

$\therefore \sigma_n = \sigma_0' \Rightarrow \sigma_b = 256.41 - 233.26$
$= 23.15$ MPa

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$\therefore$ Back tension of 23.15 MPa is applied to make roll slip ✗

6. (c.)

(i.) for complete solubility

- EN should be similar
- less than ±15% difference in size
- same crystal structure

Cu → FCC

Cu - Ni

size diff = $\frac{0.1246^3 - 0.1278^3}{0.1278^3}$

= 7.3%

Size difference betn Cu - Al = $\frac{0.1431^3 - 0.1278^3}{0.1278^3}$

= 40.38%

Not possible

Size diff betn Cu - Pd = 24.8% Not possible

∴ Cu-Ni form with complete solubility.

(ii.) Cu can form substitutional solid solution with incomplete solubility

with Zn

with Fe

with Cr

with Co

reason?

read from solution also

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good

(iv) for interstitial solid solution, size of other element must be much small.

Hence it form interstitial solid soln with C, H and O