

SUB - Full syllabus
paper - II

total marks 238

Q-1 a)

Let
Angle of Twist of Tube.
= θ

$$\theta = \frac{T_{\text{tube}} \times l_a}{G J_a}$$

$$\theta = \frac{T_a l_a}{G J_a} \quad \text{--- (1)}$$

Angle of Twist for bar.

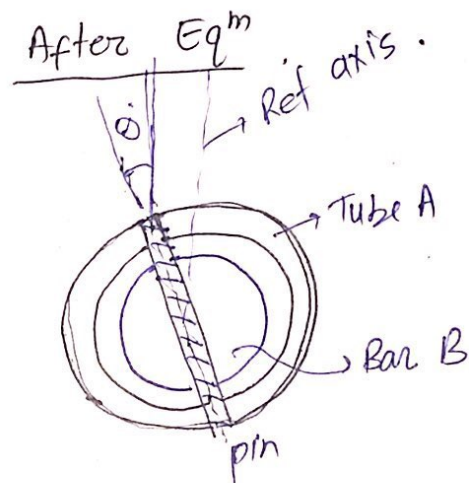
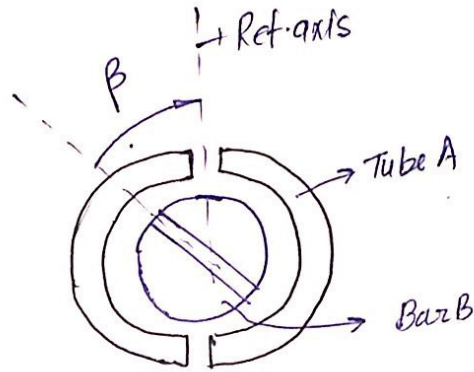
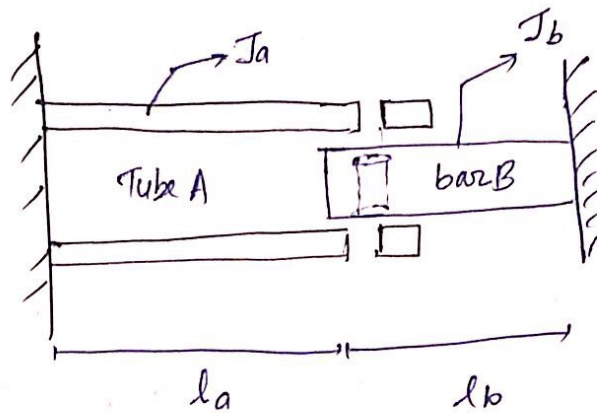
$$\beta - \theta = \frac{T_b l_b}{G J_b} \quad \text{--- (2)}$$

using eqⁿ (1) & (2)

$$\beta - \frac{T_a l_a}{G J_a} = \frac{T_b l_b}{G J_b}$$

$$\frac{T_a l_a}{G J_a} + \frac{T_b l_b}{G J_b} = \beta \quad \text{--- (3)}$$

Assuming that the diameter of both the bar & Tube is approximately same, then we can say the Torque in both the sections will be same
 $[T_a = T_b] = T \text{ [Let]}$



$$q^{(3)} \quad \frac{T}{G} \left[\frac{l_a}{J_a} + \frac{l_b}{J_b} \right] = \beta$$

$$T = \frac{\beta G}{\frac{l_a}{J_a} + \frac{l_b}{J_b}} \quad \text{--- (4)}$$

strain energy stored in Tube (E_a)

$$E_a = \frac{1}{2} T \cdot (\text{angle of Twist})$$

$$= \frac{1}{2} \frac{\beta G}{\left(\frac{l_a}{J_a} + \frac{l_b}{J_b} \right)} \cdot \frac{T l_a}{G J_a}$$

$$= \frac{1}{2} \left(\frac{\beta G}{\frac{l_a}{J_a} + \frac{l_b}{J_b}} \right)^2 \frac{l_a}{G J_a}$$

$$E_a = \frac{1}{2} \left(\frac{\beta}{\frac{l_a}{J_a} + \frac{l_b}{J_b}} \right)^2 \frac{l_a G}{J_a} \quad \underline{\underline{Ans}}$$

strain energy stored in bar (E_b)

$$E_b = \frac{1}{2} T \cdot (\beta) = \frac{1}{2} \frac{T^2 l_b}{G J_b}$$

$$E_b = \frac{1}{2} \left(\frac{\beta G}{\frac{l_a}{J_a} + \frac{l_b}{J_b}} \right)^2 \frac{l_b}{G J_b}$$

$$E_b = \frac{1}{2} \left(\frac{\beta}{\frac{l_a}{J_a} + \frac{l_b}{J_b}} \right)^2 \frac{l_b G}{J_b} \quad \underline{\underline{Ans}}$$

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Q-1(b)

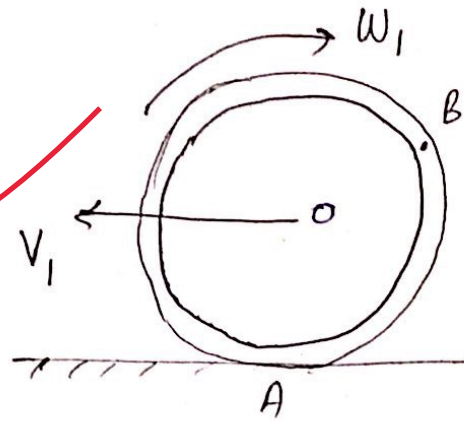
$$m = 1 \text{ kg}$$

$$r = 0.08 \text{ m}$$

$$V_1 = 3 \text{ m/s}$$

$$\omega_1 = 3 \text{ rad/s}$$

$$\mu = 0.6$$

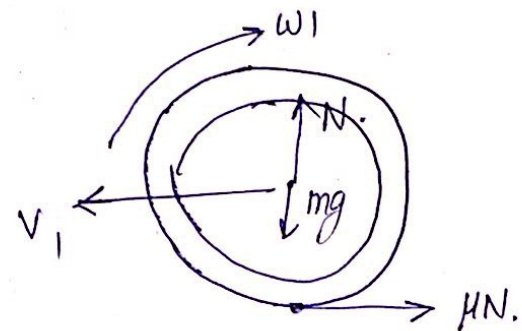


FBD of ring

$$\sum F_y = 0$$

$$N = mg$$

$$N = 1 \times 9.81 = 9.81 \text{ N}$$



$$\text{frictional force} = \mu N$$

$$= 9.81 \times 0.6 = 5.886 \text{ N}$$

Taking Moment about O

$$\mu N \times r = I \cdot \alpha$$

$$5.886 \times 0.08 = 1 \times 0.08^2 \times \alpha$$

$$\alpha = -73.575 \text{ rad/s}^2$$

To stop the spring $\omega = 0$

$$\omega_f = \omega_i + \alpha t$$

$$0 = 3 - 73.575 \times t$$

$$t = 0.0407 \text{ sec}$$

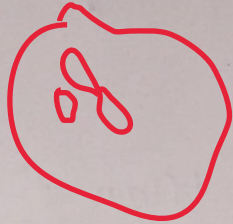
$$\omega_f^2 = \omega_i^2 + 2\alpha\theta$$

$$0 = 3^2 + 2(-73.575)\theta$$

$$\theta = 0.06116 \text{ radi}$$

$$\text{distance } x = \theta \cdot R$$

$$= 4.892 \text{ mm}$$



1 (c)

for Motor

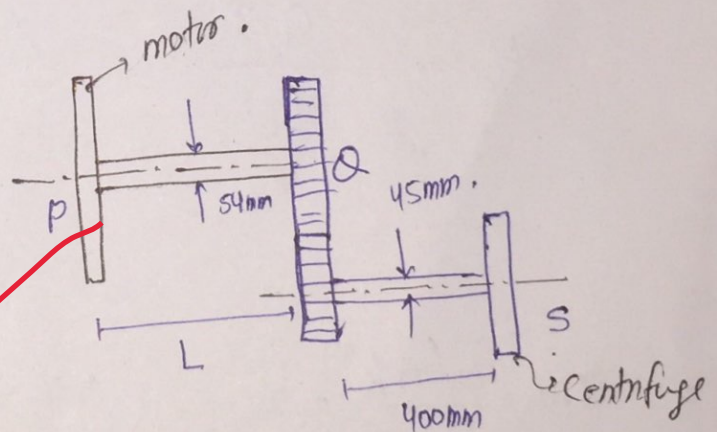
$$m = 37.5 \text{ kg}$$

$$k = 100 \text{ mm}$$

for centrifuge

$$m = 30 \text{ kg}$$

$$k = 140 \text{ mm}$$



the node should be at Q [where Gears are meshing]

So,

Natural frequency of motor shaft = Natural freq of Centrifuge shaft

$$(W_n)_m = (W_n)_c.$$

$$\sqrt{\frac{\text{Stiffness } (K_m)}{I(\text{motor}) (I_m)}} = \sqrt{\frac{\text{stiffness } (K_c)}{I_c}} \quad \text{--- (1)}$$

Stiffness of motor shaft

$$K_m = \frac{G J_m}{L} = \frac{84 \times 10^9 \times \frac{\pi}{32} \times 0.054^4}{L}$$

$$= \frac{70121.987}{L} \quad \text{N.m/Radian}$$

$$K_c = \frac{G J_c}{L_c} = \frac{84 \times 10^9 \times \frac{\pi}{32} \times 0.045^4}{0.4}$$

$$= 84541.362 \text{ N.m/Radian}$$

$$I_m = (m k^2)_{\text{motor}} = 37.5 \times 0.1^2 = 0.375 \text{ kg-m}^2$$

$$I_c = (m k^2)_{\text{centr.}} = 30 \times 0.14^2 = 0.588 \text{ kg-m}^2$$

$$\sqrt{\frac{70121.987}{L \times 0.375}} = \sqrt{\frac{84541.362}{0.588}} \quad \text{eqn (1)}$$

$$L = 1.3 \text{ m}$$

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1 (d)

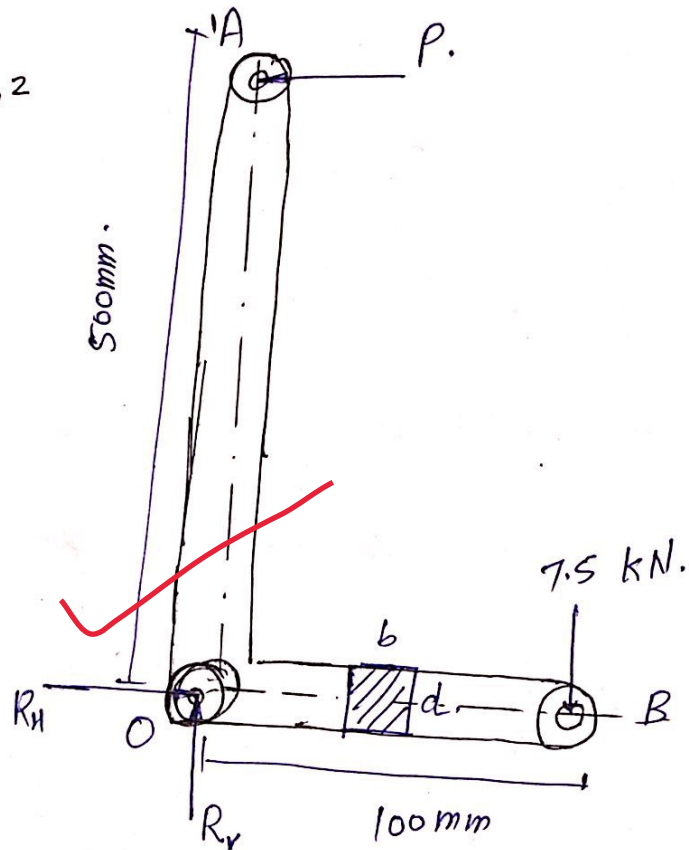
$$\sigma_{yt} = 300 \text{ N/mm}^2$$

$$\text{FOS} = 5$$

$$\sigma_{per} = 10 \text{ N/mm}^2$$

$$\frac{b}{d} = 4$$

$$\frac{L}{d} = 1.5$$



taking Moment about O

$$\sum M_O = 0$$

$$7.5 \times 100 - P \times 500 = 0$$

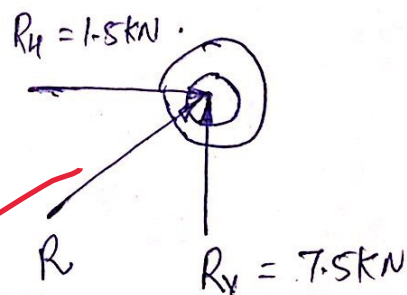
$$P = 1.5 \text{ kN}$$

FBD of pin

Resultant force on pin

$$R = \sqrt{7.5^2 + 1.5^2}$$

$$= 7.648 \text{ kN}$$



Compressive ~~stress~~ stress in pin < permissible bearing strength

$$\frac{R}{\pi d \cdot L} \leq 10$$

$$\frac{7.648 \times 10^3}{\pi \times d \times 1.5d} \leq 10$$

$$d = 12.739 \text{ mm} \quad \underline{\text{Ans}}$$

taking $d = 13 \text{ mm}$ [Rounding off to next higher no]

$$L = 1.5 \times 13 = 19.5 \text{ mm} \quad \underline{\text{Ans}}$$

$$\text{shear stress in pin} = \frac{R}{\frac{\pi}{4} d^2} \quad [\text{average}]$$

$$= \frac{7.648 \times 10^3}{\frac{\pi}{4} 13^2} = 57.619 \text{ MPa} \quad \underline{\text{Ans}}$$

for the level max^m bending Moment will be at O

$$M = 7.5 \times 10^3 \times 100 \text{ N}\cdot\text{mm}$$

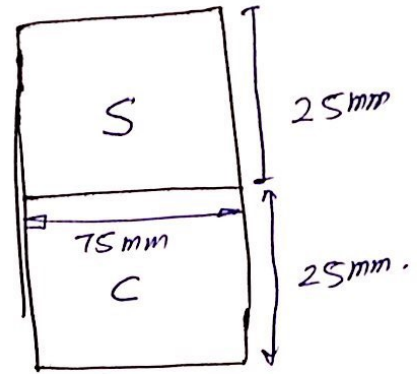
$$\sigma_{\text{per}} = \frac{M y}{I} \Rightarrow \frac{300}{5} = \frac{7.5 \times 10^3 \times 100 \times 6}{b \times \left(\frac{b}{4}\right)^2}$$

$$b = 106.265 \text{ mm}$$

$$d = 26.566 \text{ mm} \quad \underline{\text{Ans}}$$

1 (e)

When they bend independently
both the beam will have same
Radius of Bending R .



$$\frac{y}{R} = \frac{M}{EI} = \frac{E}{R}$$

$$R_1 = R_2$$

$b \rightarrow$ for copper.

$$\frac{E_s \delta_s}{M_s} = \left[\frac{E_b \delta_b}{M_b} \right]_{\text{copp}} \left[\because X/sc \text{ is same} \right]$$

$I_b = I_s$

$$\frac{M_b}{M_s} = \frac{E_b}{E_s}$$

①

$$\frac{M_b}{M_s} = \frac{1}{2}$$

Design based on steel bar.

$$(\sigma_{per})_{\text{steel}} = \frac{M_s y}{I}$$

$$105 = \frac{M_s \times 6}{75 \times 25^2}$$

$$M_s = 820312.5 \text{ N.mm}$$

$$M_b = \frac{1}{2} M_s = 410156.25 \text{ N.mm}$$

stress in ~~brass~~ ^{Copper} σ_c

$$\sigma_c = \frac{M_c Y}{I} = \frac{410156.25 \times 6}{75 \times 25^2}$$
$$= \underline{52.5 \text{ MPa}}$$

$$\sigma_s = 105 \text{ MPa}, \quad \sigma_c = 52.5 < 70$$

↳ Design will be safe.

if we design based on copper

$$\sigma_c = \text{~~70~~ } 70 \text{ MPa}$$

$$\text{then } \sigma_s = 2\sigma_c \quad \left[\because M_s = 2 M_b \right]$$

& section are same.

$$\text{then } \sigma_s = 140 > 105$$

↳ Not safe.

$$\text{hence. } \sigma_s = 105 \text{ MPa} \quad \& \quad \sigma_c = 52.5 \text{ MPa}$$

Total max^m moment of Resistance

$$= 410156.25 + 820312.5$$

$$= \underline{1230468.75 \text{ N}\cdot\text{mm}}$$

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Q-2 (a) Tube

$$D_i = 4 \text{ cm} \Rightarrow R_i = 20 \text{ mm}$$

$$D_o = 6 \text{ cm} \Rightarrow R_o = 30 \text{ mm}$$

Outer Tube,

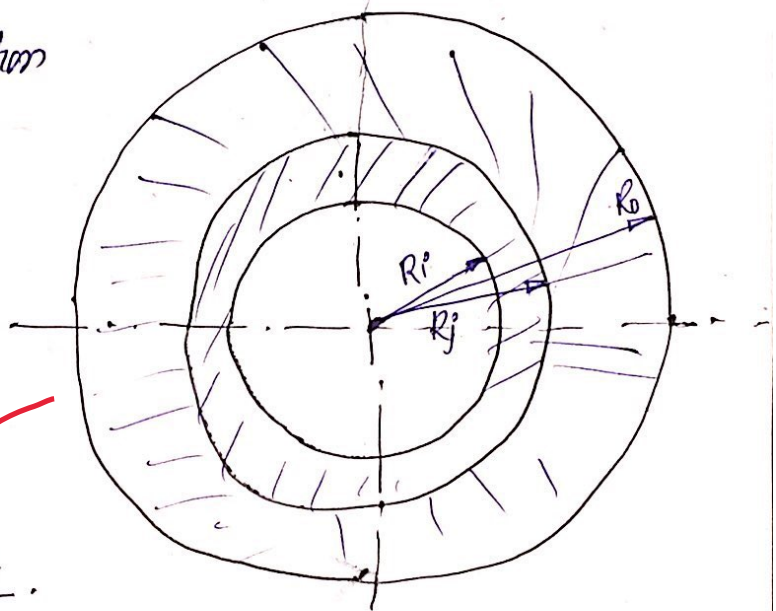
$$D_o = 8 \text{ cm} \Rightarrow R_o = 40 \text{ mm}$$

junction ~~Radius~~ $R_j = 30 \text{ mm}$

Int. pressure $p = 50 \text{ N/mm}^2$

Let us assume the Junction pressure is p .

① Considering the effect of Junction pressure only p



(a) On Inner cylinder.

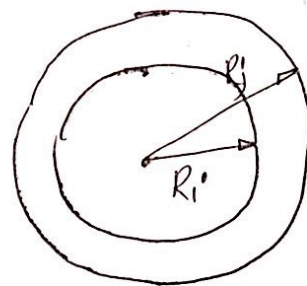
hoop stress @ inner surface

$$\tau_{hi} = \frac{p \cdot 2 R_o^2}{R_o^2 - R_i^2}$$

$$= \frac{-p' \times 2 \times (30)^2}{30^2 - 20^2}$$

$$= -3.6 p' \quad [\text{compressive}]$$

$$\tau_{ho} = \frac{p \cdot (R_o^2 + R_i^2)}{R_o^2 - R_i^2} = \frac{p' \times (30^2 + 20^2)}{30^2 - 20^2} = -2.6 p' \quad (\text{comp})$$



On Outer cylinder

$$\sigma_{hi} = \frac{p'(R_o^2 + R_i^2)}{R_o^2 - R_i^2} = \frac{p'(40^2 + 30^2)}{40^2 - 30^2}$$

$$= 3.571 p'$$

$$\sigma_{ho} = \frac{p' 2 \times R_i^2}{R_o^2 - R_i^2} = \frac{p'(2 \times 30^2)}{40^2 - 30^2} = 2.571 p'$$

② Considering the effect of internal pressure :-

$$\sigma_h = \frac{p R_o^2 R_i^2}{R_o^2 - R_i^2} \left[\frac{1}{R_o^2} + \frac{1}{R_i^2} \right]$$

$$[\sigma_{hi}]_{R=20} = \frac{50 \times 40^2 \times 20^2}{40^2 - 20^2} \left[\frac{1}{40^2} + \frac{1}{20^2} \right]$$

$$= 83.333 \text{ MPa.}$$

$$[\sigma_h]_{R=30} = \frac{50 \times 40^2 \times 20^2}{40^2 - 20^2} \left[\frac{1}{40^2} + \frac{1}{30^2} \right]$$

$$= 46.2962 \text{ MPa.}$$

$$[\sigma_h]_{R=40} = \frac{50 \times 40^2 \times 20^2}{40^2 - 20^2} \left[\frac{1}{40^2} + \frac{1}{40^2} \right]$$

$$= 33.33 \text{ MPa.}$$

Superimposing the Result

@ Inner Tube

$$(\sigma_{hi})_i = -3.6p' + 83.333 \text{ MPa.}$$

$$(\sigma_{ho})_i = -2.6p' + 46.2962 \text{ MPa.}$$

@ outer Tube

$$(\sigma_{hi})_o = 3.571p' + 46.2962$$

$$(\sigma_{ho})_o = 2.571p' + 33.333 \text{ MPa}$$

max^m stress @ inner tube = $(\sigma_{hi})_i$
" " " " " " = $(\sigma_{hi})_o$

$$-3.6p' + 83.333 = 3.571p' + 46.2962$$

$$p' = \underline{5.1640 \text{ MPa.}}$$

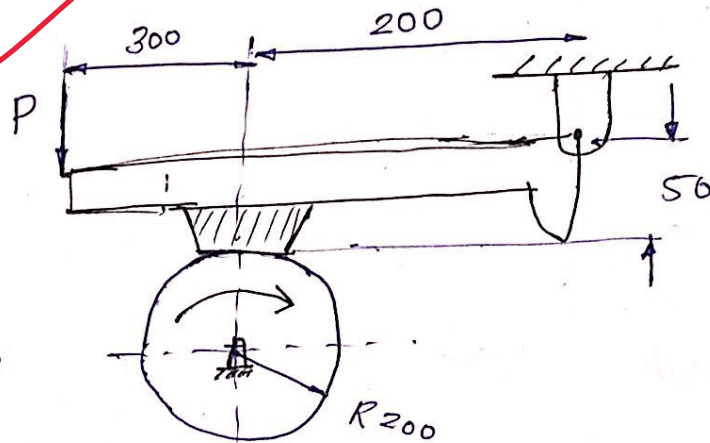
Max^m stress @ ~~inner~~

$$= 3.571p' + 46.2962$$

$$= \underline{64.74 \text{ MPa}}$$

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Q-2 (b)



Torque Capacity

$$T = 250 \text{ N}\cdot\text{m}$$

$$N = 100 \text{ rpm}$$

$$\mu = 0.35$$

For CW Rotation FBD of lever (clockwise)

Torque capacity

$$= \mu N \cdot R$$

$$250 = 0.35 \times N \times 0.2$$

$$N = 3571.42 \text{ N}$$

taking Moment about Hinge.

$$P \times 500 + \mu N \times 50 = N \times 200$$

$$P \times 500 + 0.35 \times 3571.42 \times 50 = 3571.42 \times 200$$

$$P = 1303.56 \text{ N}$$

$$\sum F_x = 0$$

$$\mu N = R_H \rightarrow 0.35 \times 3571.42 = R_H = 1250 \text{ N}$$

$$\sum F_y = 0$$

$$P + R_y = N.$$

$$1303.56 + R_y = 3571.42$$

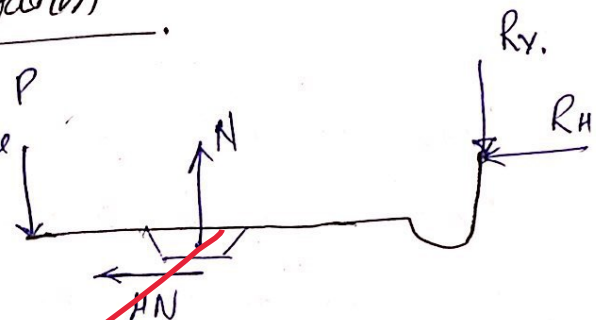
$$R_y = 2267.86 \text{ N}$$

$$\text{Resultant force on hinge} = \sqrt{R_H^2 + R_y^2} = \sqrt{1250^2 + 2267.86^2}$$

$$= 2589.53 \text{ N}$$

② for Anti-clockwise Rotation.

taking Moment about hinge



$$P \times 500 = H \times 50 + N \times 200$$

$$P \times 500 = 0.35 \times 3571.42 \times 50 + 3571.42 \times 200$$

$$P = 1553.56 \text{ N}$$

$$\sum F_x = 0, \quad R_H = -H.$$

$$= -1250 \text{ N [Rightward]}$$

$$\sum F_y = 0, \quad R_y + P = N.$$

$$R_y + 1553.56 = 3571.42$$

$$R_y = 2017.86 \text{ N}$$

$$\text{Resultant force} = \sqrt{R_H^2 + R_y^2} = \sqrt{1250^2 + 2017.86^2}$$

$$= 2373.66 \text{ N}$$

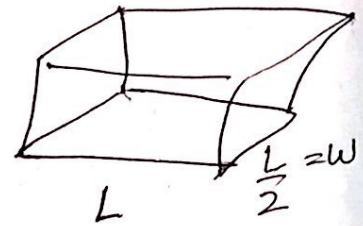
③ Rate of Heat Generation = $T, W = 250 \times \frac{2\pi N}{60}$

$$= 2617.993 \text{ W}$$

(N) Normal pressure force.

$$N = 3571.42 \text{ N.}$$

$$\frac{N}{\text{Area}} = P$$



$$\frac{3571.42}{L \times \frac{L}{2}} = 1.$$

$$L = 84.515 \text{ mm}$$

$$\text{width} = w = \frac{L}{2} = 42.257 \text{ mm}$$

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* Since in both cases [clockwise & Anticlockwise "not"]
the applied pressure force value P comes out to
be positive. Hence the brakes are not
Self locking.

Q-2 (C)

$$R_{\min} = 50 \text{ mm}$$

$$h = 40 \text{ mm}$$

~~out stroke~~ - ~~rise~~

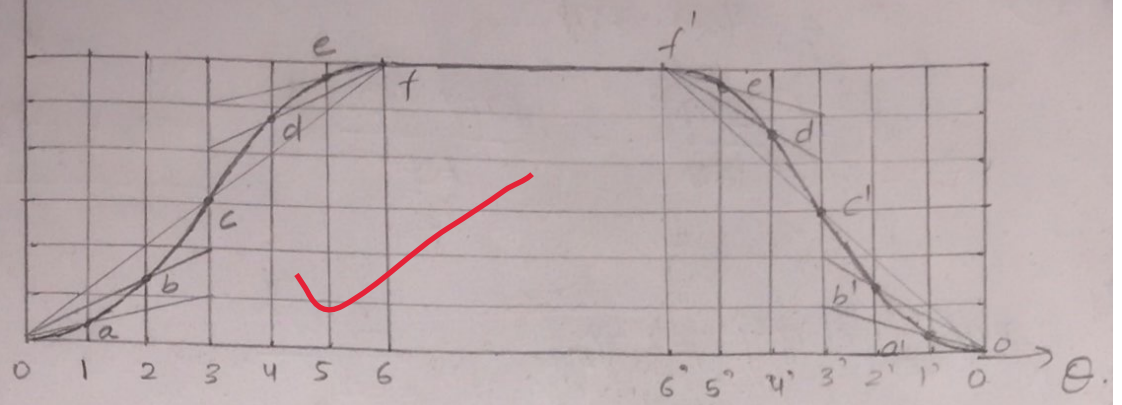
$$\text{rise angle } \theta_0 = 100^\circ$$

$$\text{dwell } \theta_{d1} = \theta_0$$

$$\text{return angle } \theta_R = 90^\circ$$

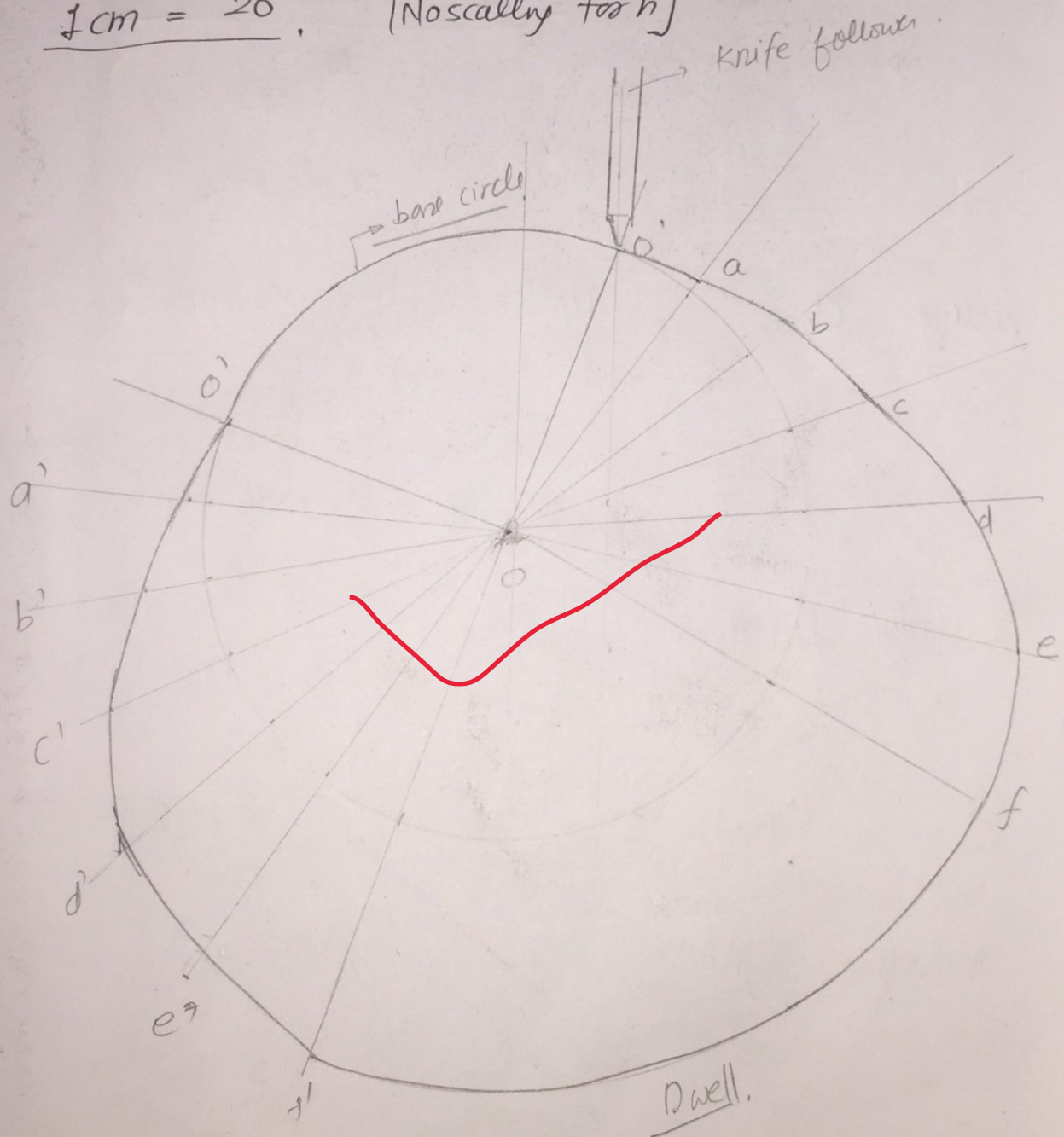
$$\theta_{d2} = 90^\circ$$

Displacement diagram given.



Scale.

$1\text{ cm} = 20^\circ$, [No scaling for h]



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$$N = 900 \text{ rpm}$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 900}{60} = \underline{94.247 \text{ rad/s}}$$

max^m velocity = $V_{\max} = \frac{2\omega h}{\theta_0}$
during rise.

$$= \frac{2 \times 94.2477 \times 0.04}{\frac{100\pi}{180}}$$

$$= \underline{4.32 \text{ m/s}}$$

during $a_{\max} = \frac{4\omega^2 h}{\theta_0^2} = \frac{4 \times 94.2477^2 \times 0.04}{\left(\frac{100\pi}{180}\right)^2}$
 $= \underline{233.28 \text{ m/s}^2}$

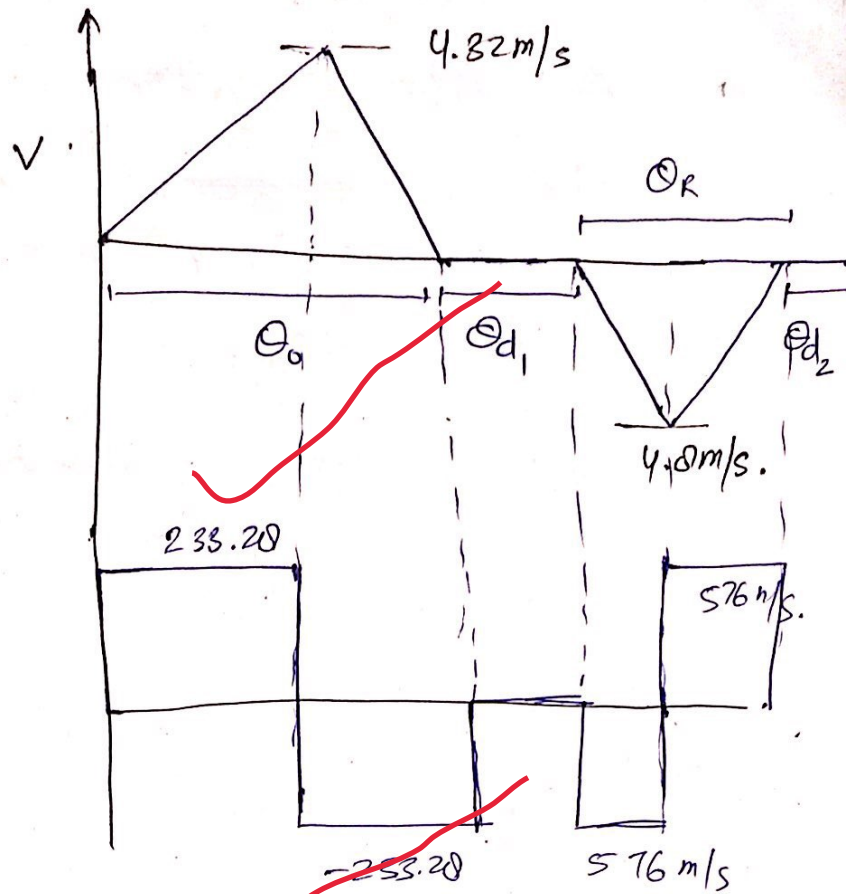
during Return $V_{\max} = \frac{2\omega h}{\theta_R} = 4.8 \text{ m/s}$

$$a_{\max} = \frac{4\omega^2 h}{\theta_R^2} = \underline{576 \text{ m/s}^2}$$

Velocity diagram



Velocity diagram :



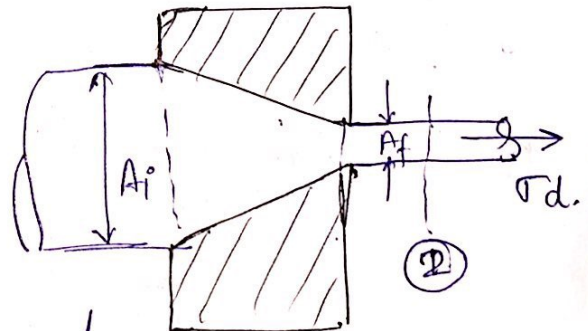
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Q-5 (a)

$$\sigma = K\epsilon^n$$

Assumption

No friction & Redundant work.



drawing stress can be expressed as.

$$\sigma_d = \bar{\sigma}_0 \ln \frac{A_i}{A_f}$$

$\bar{\sigma}_0$ = Avg flow stress.

Since $\sigma = K\epsilon^n$ [strain hardening will occur]

$$\bar{\sigma}_0 = \frac{K\epsilon^n}{n+1}$$

at the limiting condition.

the stress in the extruded wire should be less than the yield stress ~~at~~ it is necessary to be less than UTS.

then ϵ^n (1) can be written as.

$$K\epsilon^n = \frac{K\epsilon^n}{n+1} \ln \frac{A_i}{A_f}$$

$$\boxed{\frac{A_i}{A_f} = e^{n+1}}$$

@ UTS $n = 6$

$$\% \text{ Reduction} = \frac{A_i - A_f}{A_i} = 1 - \frac{A_f}{A_i} = \left[1 - \frac{1}{e^{n+1}} \right] \times 100$$

$$A_i - A_f = A_i \left(1 - \frac{1}{e^{n+1}} \right)$$

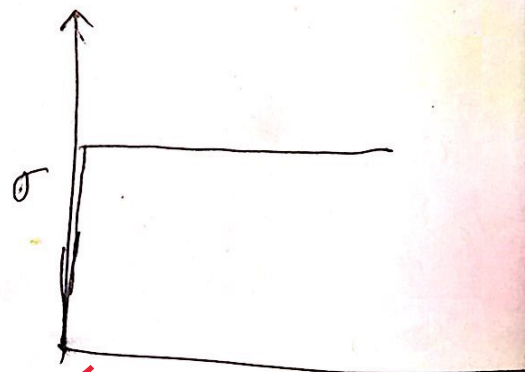
For perfectly plastic material

No strain strain hardening

$$n = 0$$

$$\frac{A_i}{A_f} = e$$

$$\% \text{ Reduction} = \frac{A_i - A_f}{A_i} = 1 - \frac{1}{e} = 63.21\%$$



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Q-5 (b)

Deptt	Prod. A	Prod. B	Capacity
Welding	2 hrs	2.5 hrs	1000 hrs
M/cing	3 hrs	1.5 hrs	1200 hrs
Assembly	1.5 hrs	4 hrs	1200 hrs
Profit	Rs 120	Rs 100	

Let $x_1 \rightarrow$ No of product A produced

$x_2 \rightarrow$ " " " " B "

$$Z_{\max} = 120x_1 + 100x_2$$

$$2x_1 + 2.5x_2 \leq 1000 \quad \text{--- (I)}$$

$$3x_1 + 1.5x_2 \leq 1200 \quad \text{--- (II)}$$

$$1.5x_1 + 4x_2 \leq 1200 \quad \text{--- (III)}$$

$$x_1, x_2 \geq 0$$

Solving I & II - C

$$C \equiv (333.33, 133.33)$$

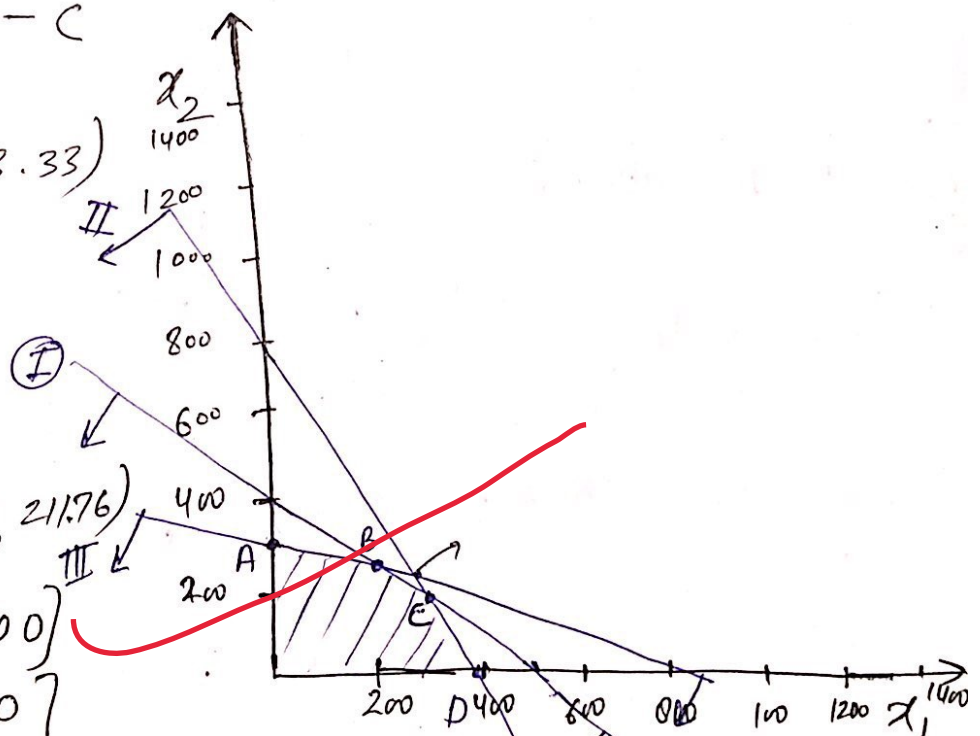
~~Solving I & II - C~~

Solving I - III

$$B \equiv (235.29, 211.76)$$

$$A \equiv (0, 300)$$

$$D [400, 0]$$



$$(Z_{\max})_C = 333.33 \times 120 + 133.33 \times 100$$

$$= \underline{53332.6}$$

$$(Z_{\max})_C = 235.29 \times 120 + 211.76 \times 100$$

$$= \underline{49410.0}$$

① optimum ($\max^m$) will be at C

• let $x_1 = 334$

$$3x_1 + 1.5x_2 \leq 1200$$

$$x_2 = 132 \text{ unit}$$

$$Z_{\max} = 120 \times 334 + 132 \times 100$$

$$= \underline{53280 \text{ Rs. Am}}$$

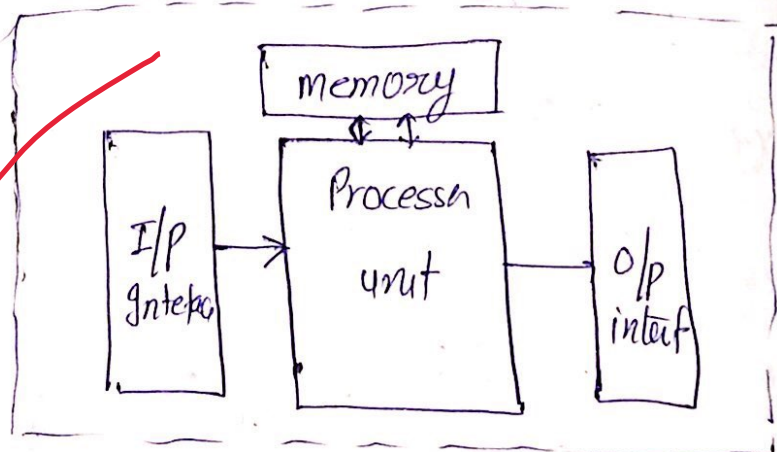
12

② ~~let $x_1 = 333$~~

$$2 \times 333 + 2.5x_2 \leq 1000$$

5C) Micro controller

- Micro controller is a heart of the embedded system.



Micro controller

It consist of memory, processing unit and Input output interface mounted on same chip.

- Microcontroller is tank specific and used to perform specified task.
- all the components are situated on a single chip so the structure of microcontroller are compact.
- Microcontroller are less flexible but rigid to perform specified task.
- they used in, Washing M/c, cutting fluid controller, automatic temperature control. etc.

Task perform by I/O Interface

- * the I/O interface are the interface through which the communication is done with the physical device
- * Let us assume the input variable changes its value to some other value. so processing unit consist of program, ALU unit & Mathematical relation that perform processing and give the signal to O/P interface hence. output state variable is change as per the instruction provided
- * I/P may have a sensor & output may consist of an actuator which perform the specified task Required.

07

Q-5(d)

$$R = 0.92$$

$$A = 0.98$$

Reliability $R = e^{-\lambda t}$

$\lambda \rightarrow$ failure rate

$$\text{Available time} = 6000 \times 0.98$$

$$= 5880 \text{ hour}$$

$$R = e^{-\lambda t}$$

$$0.92 = e^{-\lambda \times 5880}$$

$$\ln 0.92 = -5880 \lambda$$

$$\lambda = 1.418 \times 10^{-5}$$

$$\text{MTBF} = 70519.14 \text{ hour}$$

(01)

5 (d) (ii) Reactive Maintenance

- It is also called breakdown maintenance (or) Run till failure maintenance.
- In this maintenance the system is used without maintenance until that component fails.

This maintenance Technique is applied to the Non critical component. failure of those equipments does not affect the system. After the failure the component is replaced by new one.

② Preventive Maintenance

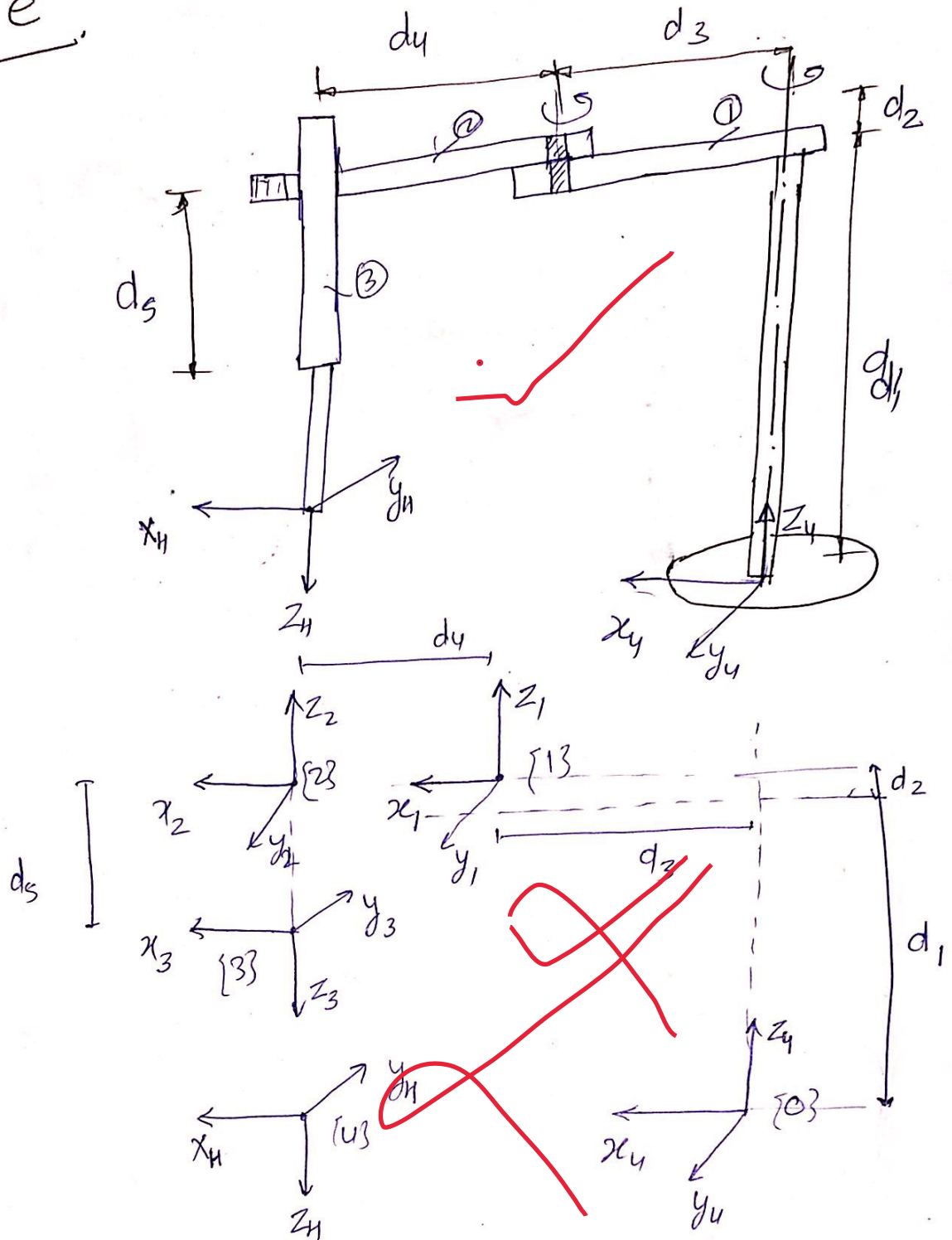
- It is fixed Routine maintenance.
- Maintenance is done after a fixed period of time to check & ~~inspect~~ to decrease the possibility of failure
- This maintenance is provided for critical component that may affect the whole system
- this maintenance technique may sometimes give the excessive maintenance to the component

③ Predictive Maintenance

- In this maintenance Technique the failure is predicted of the component and before this the Maintenance is provided
- It reduces the excessive maintenance
- It is a good technique of maintenance provided for critical component.

06

5e.



Link.	a_i	α_i	d_i	θ_i	q_i
0-1	d_3	0	$d_1 + d_2$	θ_1	θ_1
1-2	d_4	0	0	θ_2	θ_2
2-3	0	180	d_5	0	d_5
3-4	0	0	0	θ_3	θ_3

00

Assignment of frames

{1} - frame {1} is assigned at the distal end of link 1 and align Z_1 axis to the rotation axis and X axis is towards the perpendicular to both Z axis that given $a_1 = d_3$, $d_1 = d_1 + d_2$, $\alpha_1 = 0$

{2} - ~~frame {2}~~ is assigned at the distal end of link 2 and ~~align~~ align Z_2 axis to the rotation axis and X axis is towards perpendicular to both Z axis this given

$$a_2 = d_4, \alpha_2 = 0, d_2 = 0$$

{3} - frame {3} is assigned at distal end of link 3. align ~~Z axis~~ Z axis to the Translation axis & X axis is perpendicular to both Z axis. that given $a_3 = 0$, $\alpha_3 = 180^\circ$, $d_3 = d_5$

In all {1} {2} {3} Y axis is assigned using Right handed ~~orthogonal~~ frame.

refer solution

6 (a)

(i) Alumina (Al_2O_3)

- used in Abrasive of Grinding wheel
- Used in spark plug of an ~~IX~~ Engine.
- Used in paint for Reflective coating
- Use for composite fibre (↑ strength & stability @ Temp)
- Insulating material.

Diamond

- Used as cutting tool material with flooded cooling fluid [Cutting of Non ferrous Alloys]
- Diamond dust used in Grinding wheel Abrasives
- used to polishing some precious metals
- Use to form the Tungsten wire.

Zirconia (ZrO_2)

- It can also be work as abrasive
- It is very hard ceramic used ~~in~~ ~~in~~ in making protective coating
- used in ~~dental~~ making dental inserts
- Used in nuclear power plant to reduce the movement of neutron.

u. Silica (SiO_2)

- Used in casting process, silica mixed with clay and water to make diatom
- use to make the Glom
- It is also used in the equipment used in water filtration.

③ SiC :

- Works as an insulator for high Temp ~~pressures~~ pressure
- Use to make glom
- used as a protective of cast Aluminum.
- Used in seals
- making crucible for foundry
- Tubes for injection moulding.

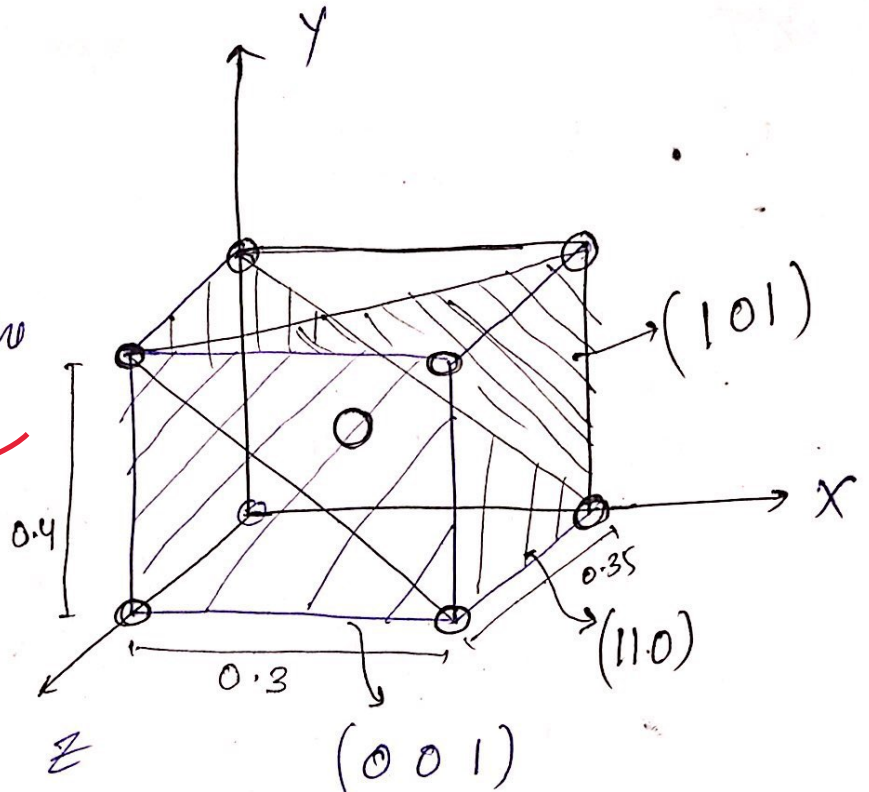


* 6(a) (ii)

from the figure

Since all atoms are at corner and 1 atom at the mid position.

Crystal structure



BCO [Body centred ~~orthorhombic~~ orthorhombic]

[$\therefore a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$]

= Hence crystal structure is BODY CENTERED ORTHORHOMBIC

$\rho = 8.95 \text{ g/cm}^3$

$$\rho = \frac{N \cdot A}{N_A \cdot V}$$

$$8.95 = \frac{2 \times A}{6.022 \times 10^{23} \times 0.3 \times 0.35 \times 0.4 \times 10^{-21}}$$

Atomic weight A = 113.10 g/mole

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6(b)

Pressurized Gating	Non pressurized Gating
- Chock area is situated at the gate (entry of casting) - Velocity of liquid metal entering casting is high → high Turbulence and splashing → Low possibility of air aspiration defect. → pressure gating is done for ferrous material → because ferrous material have less affinity to make oxide	- chock area is at the end of sprue. → velocity of liquid metal entering casting is low → low Turbulence and splashing → high possibility of air aspiration defect → It is done for non ferrous material → Non ferrous material are less viscous & high affinity to make metal oxide.

(ii)

For cylindrical side riser

$$h = d.$$

Let us assume the volume of both the risers = 1 m^3

for cylindrical side riser.

$$V = 1 \text{ m}^3$$

$$A = \frac{\pi}{4} d^2 + \pi d \times h + \frac{\pi}{4} d^2$$

$$= \frac{\pi d^2}{2} + \pi d^2$$

$$= \frac{3\pi d^2}{2}$$

$$[\because d = h]$$

$$t_{cy} = K \cdot \left(\frac{V}{A} \right)^2$$

$$= K \left(\frac{1}{\frac{3\pi d^2}{2}} \right)^2$$

$$= \frac{2K}{3\pi \times (1.003)^2}$$

$$= \frac{(0.10092)K}{3}$$

$$= 0.03273K$$

$$1 = \frac{\pi}{4} d^3$$

$$d = 1.003 \text{ m}$$

For cube

$$V = 1 \text{ m}^3$$

$$a^3 = 1 \text{ m}^3 \quad \underline{a = 1 \text{ m}}$$

$$V = 1 \text{ m}^3$$

$$A = 6 \times a^2 = 6$$

$$t_{\text{cube}} = K \cdot \left(\frac{V}{A} \right)^2$$

$$= K \times \left(\frac{1}{6} \right)^2$$

$$= 0.02777K$$

$$\frac{t_{cy}}{t_c} = \frac{0.03273}{0.02777}$$

$$= 1.1786$$

③

$$I^2 = -400 [V - 50]$$

$$V_a = 25 + 5I$$

Power output can be written

$$P = V_a \cdot I$$

$$P = V_a \cdot \sqrt{-400(V_a - 50)}$$

$$P = (25 + 5l) \cdot \sqrt{400(50 - 25 - 5l)}$$

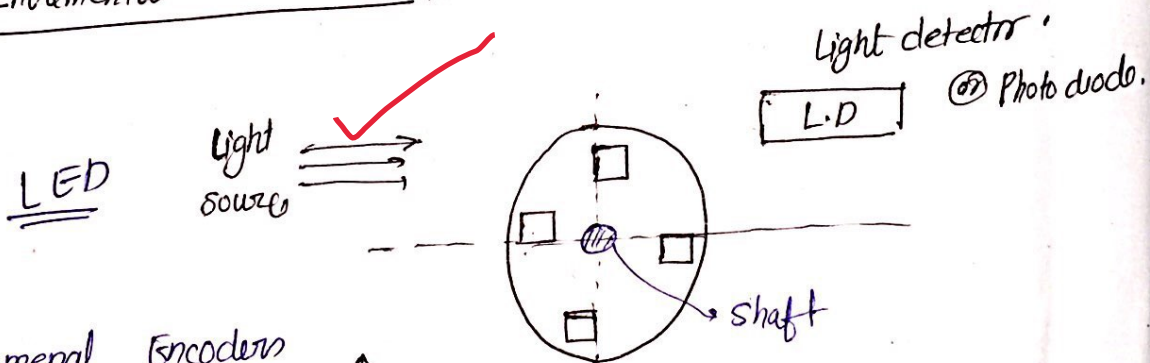
$$= (25 + 5l) \cdot \sqrt{400(25 - 5l)}$$

for max^m power.

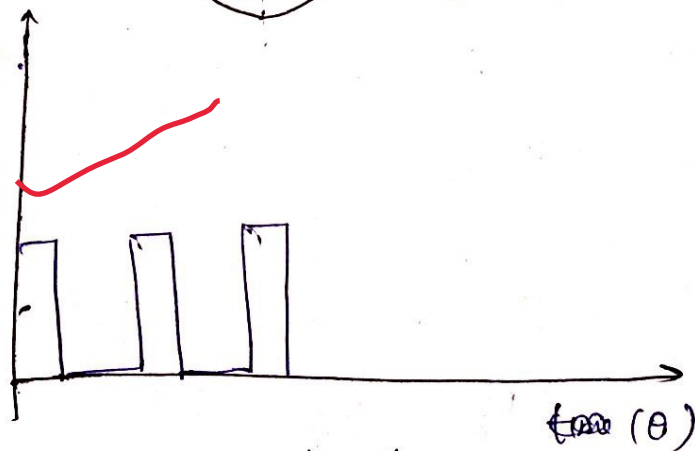
$$\frac{dP}{dl} = 0 = \sqrt{400(25 - 5l)} \cdot (5) + \frac{(25 + 5l) \cdot \sqrt{400} \cdot (-5)}{\sqrt{25 - 5l}}$$

$$l = 1.666 \text{ mm}$$

6© Incremental Encoder



- Incremental Encoders are the Transducer @ sensing device that are used to sense the position of the shaft



→ It is a position sensor and also measures the speed.

(2)

Construction:

- It consists of a disc on which Rectangular holes are there which are situated equidistant from one another.
- It is having a light source and a light detector as shown.

Principle of operation

- Initially when Rectangular blocks are come in front of LED the light is passed through the disc in that particular position a pulse is generated by the light detector that senses the position of shaft.
- the output of the shaft in pulse form of pulses as shown
- with the help of pulse frequency we can also calculate the speed of shaft.

$$\text{Resolution} = \frac{360^\circ}{N} \quad N - \text{No of holes.}$$

- to reduce the Resolution N should be high but we can't increase N after certain limit else the plate strength will decrease.
- and also incremental encoder can not tell the direction of rotation of shaft
- so we prefer absolute encoders

② Absolute Encoders:

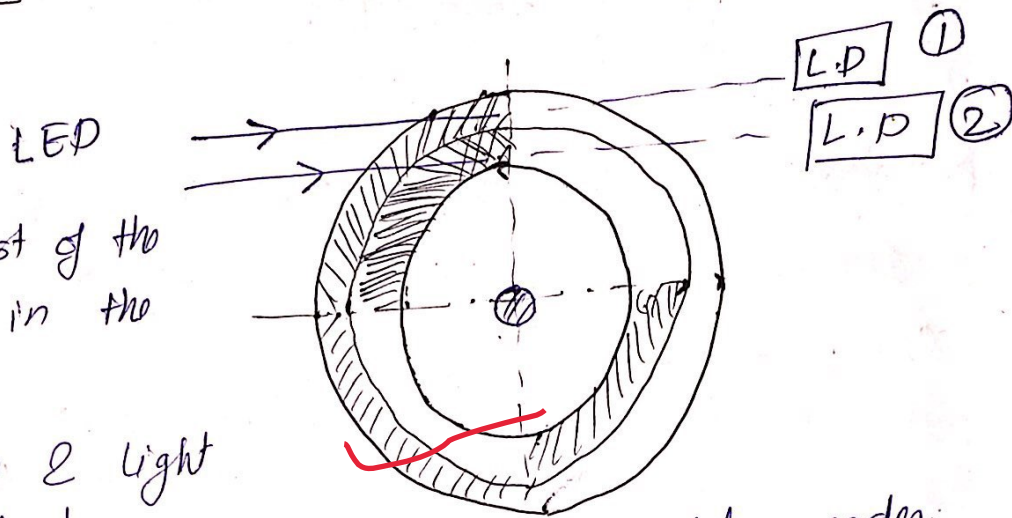
They provide accurate information about the direction of the shaft rotation.

Absolute encoders Generate binary code output for a particular position.

Construction

- It consist of the Track in the disc

→ LED & Light Detector.



2 Track Absolute encoder

Principle of operation

→ It consist of Track on which coating is done. Coated part does not allow light to pass as a result that will generate signal as OFF when on non coated part as ON.

→ It also Generate a binary code for a particular operation, of shaft

	b_1	b_2
$0 \leq \theta \leq 90$	0	0
$90 \leq \theta \leq 180$	0	1
$180 < \theta < 270$	1	0
$270 < \theta < 360$	0	0

06

* 8 Track Absolute encoder are now used.

$$\text{Resolution} = \frac{360}{2^n}$$

$n \rightarrow$ No of Tracks.

8(a)

M/C

	A	B	C	D	E
V	5	11	10	12	4
W	2	4	6	3	5
X	3	12	5	14	6
Y	6	14	4	11	7
Z	7	9	8	12	5

Applying Hungarian Method (Flood Technique)

(N) \ ~~Row~~ \ ~~Reduction~~ Since it is maximization - prob first it should be converted into minimization. for that we subtract each element

9	3	4	2	10
12	10	8	11	9
11	2	9	0	0
0	0	10	3	7
7	5	6	2	9

each element from max^m value.

Applying Row Reduction.

7	1	2	0	8
4	2	0	3	1
11	2	9	0	0
8	0	10	3	7
5	3	4	0	7

Applying Column Reduction

3	1	2	0	7
0	2	0	3	0
7	2	9	0	7
4	0	10	3	6
1	3	4	0	6

smallest element 1

2	0	1	0	8
0	2	0	4	0
6	1	0	0	6
4	0	10	4	6
0	2	3	0	5

smallest element 1

1	3	0	5	5
5	3	0	5	0
5	1	7	0	5
3	0	9	4	5
0	3	3	1	5

$$\text{Return} = 10 + 5 + 14 + 14 + 7$$

$$= \text{Rs } 50 \quad \text{Am. } 20$$

8 (b)

$$\text{Total cost / piece} = C$$

$$C = \text{Machining cost} + \text{tooling cost}$$

$$C = C_m + C_f$$

$$\text{machining cost} = T_m [L_m]$$

$$T_m \rightarrow \text{M/c time / piece}$$

$$T_m = \frac{L}{f N} = \frac{L \pi D}{f 1000 V} = \frac{\pi D L}{1000 f V}$$

$$C_m = T_m \cdot L_m = \frac{\pi D L}{1000 f V} L_m$$

$$\text{Tooling cost } C_g = \frac{\text{Grinding Time} [\text{labour cost}]}{Z}$$

$$= \frac{T_g [L_m]}{Z}$$

$Z \rightarrow$ no of piece produce per regrind

Neglecting depreciation.

$$Z = \frac{T}{T_m}$$

$T \rightarrow$ Tool life

~~XL~~

$$V T^n = C$$

$$T = \left[\frac{C}{V} \right]^{\frac{1}{n}} \quad \& \quad T_m = \frac{\pi D L}{1000 f V}$$

$$Z = \frac{C^{\frac{1}{n}} 1000 f V}{V^{\frac{1}{n}} \pi D L}$$

$$C_g = \frac{T_g L_m V^{\frac{1}{n}} \pi D L}{C^{\frac{1}{n}} 1000 f V} = \frac{T_g L_m \pi D L V^{\frac{1}{n}-1}}{C^{\frac{1}{n}} 1000 f}$$

$$\text{total cost } C = C_g + C_m$$

$$C = \frac{T_g L_m \pi D L}{C^{\frac{1}{n}} 1000 f} \left[V^{\frac{1}{n}-1} \right] + \frac{\pi D L}{1000 f} \cdot \frac{L_m}{V}$$

$$\text{for minimum cost } \frac{dC}{dV} = 0$$

$$\frac{dC}{dV} = \frac{T_g L_m \pi D L}{C^{\frac{1}{n}} 1000 f} \left(\frac{1}{n} - 1 \right) V^{\left(\frac{1}{n} - 2 \right)} + \frac{\pi D L L_m}{1000 f V^2} = 0$$

$$\frac{T_g L_m}{C^{1/n}} \left(\frac{1}{n} - 1 \right) \frac{V_o^{1/n}}{V_o^2} - \frac{L_m}{V_o^2} = 0$$

$V \rightarrow V_o \rightarrow$ optimum velocity

$$\frac{T_g L_m}{C^{1/n}} \left(\frac{1}{n} - 1 \right) V_o^{1/n} = L_m$$

$$V_o^{1/n} = \frac{C^{1/n} L_m}{C_g \left(\frac{1}{n} - 1 \right)}$$

$$V_o^{1/n} = \frac{C}{\frac{C_g}{L_m} \left(\frac{1}{n} - 1 \right)}$$

$$V_o = \frac{C}{\left[\frac{C_g}{L_m} \left(\frac{1}{n} - 1 \right) \right]^n} = \frac{C}{T_{op}^n}$$

optimum $T_{op} = \frac{C_g}{L_m} \left(\frac{1}{n} - 1 \right)$ H.P.

20

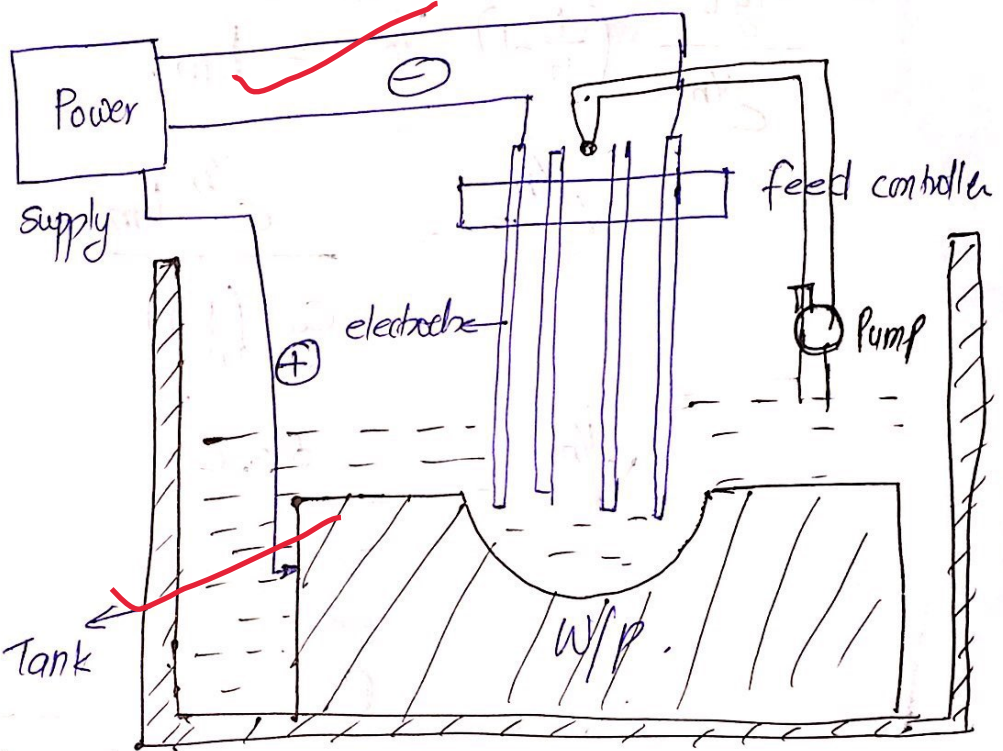
8-© (ii) ECM:

Electrochemical machining is reversed process of electroplating. It is the process of non conventional

Machining on which Chemical Reaction take place between the electrode tool and work piece.
→ high flow rate of electrolyte is provided that wash away the ~~rusted~~ metal.

Construction

→ It consist of ~~sub~~ tank on which the work piece electrolyte and the metal removal take place. Tank it.



→ It consist of

Copper @ brass electrode worked on a tool.

Fig: ECM process

Principle of Operation & Working

- As chemical Reaction start the work piece is works as Anode and tool as cathode. Electrons flow through the tool to W/P due to which metal ions move towards the electrode.
- these metallic ions are washed away by the high flow rate of the electrolyte on which the entire process

is taking place.

Main removed $M \propto ZIt$

$$Z = \frac{e}{F}$$

F - Faradays const.

$$e = \frac{A}{\text{valency}}$$

$$\frac{\text{Volume removed}}{t} = \underline{\underline{MRR}}$$

$$S. MRR = \frac{eI}{F}$$

$$\boxed{MRR = \frac{eI}{FS}}$$

10

⑫ \ Gap = 2mm Application.

- ① Nozzles ✓
- ② ~~turbine~~ blades
- ③ Aerospace parts
- ④ casting dies ✓

⑪ Gap = 2mm.

over voltage = 2.5V

$S = 50 \Omega \cdot \text{mm}$ ✓

feed rate = 0.25 mm/min.

$S = 7.8 \text{ g/cc}$ ✓

valency = 2, $A = 56$

$$s = \frac{MRR}{\pm} = \frac{e}{F \cdot s}$$

$$s = \frac{56}{2 \times 96500 \times 7.8} = 3.72 \times 10^{-5} \frac{\text{cm}^3}{\text{Amp-sec}}$$

$$\text{feed rate} = s \cdot J.$$

$J \rightarrow$ current density

$$J = \frac{I}{A} = \frac{\Delta V}{RA} = \frac{\Delta V}{sL A} = \frac{\Delta V}{sL}$$

$$J = \frac{\Delta V}{s \cdot L}$$

~~$$\frac{100 \times 100 \times 0.25}{60} \times \frac{0.025}{60} = \frac{\Delta V}{7.8 \times 0.2} \times$$~~

~~$$\Delta V = 6.5 \text{ Volt}$$~~

~~Supply voltage = $\Delta V + V$~~

~~$$= 6.5 + 2.5 = 9 \text{ Volt}$$~~

$$\text{feed} = s \cdot J.$$

$$\frac{0.25 \times 10^{-1}}{60} = 3.72 \times 10^{-5} \times \frac{\Delta V}{7.8 \times 0.2}$$

$$\Delta V = 17.473 \text{ Volt}$$

Applied ~~voltage~~ = $\Delta V + \text{over voltage} = 17.473 + 2.5$

Supply ~~voltage~~ = 19.973 Volt

02