Solutions for Improvement test - May 2018 ①

Sem : VI   Staff : RPR   Subject : DME II

Sec : A & B   Sub. code : 15ME64

Max. Marks : 50.

1(a) An industrial cone clutch has a minor diameter of 180 mm and a major diameter of 200 mm. The half cone angle is 15°. The material for friction lining has co-eff of friction of 0.35 and an allowable bearing pressure of 0.6 MPa. Determine

a) Axial force capacity

b) Torque capacity

c) power transmitted at 750 rpm.

d) Axial force for engaging cone clutch.

Ans: data

$D_1 = 180\,mm$

$D_2 = 200\,mm$

For uniform wear, $D_m = \frac{D_1 + D_2}{2} = 190\,mm$

$\alpha = 15^\circ$

$\mu = 0.35$

$p = 0.6\,N/mm^2$

to find

a) F_a

b) M_t

c) N

d) F_a'.

a) $\underline{F_a}$

$F_a = \pi D_m p b \sin\alpha$.

where $D_m = D_1 + b\sin\alpha$.

$190 = 180 + b\sin 15^\circ$

$\Rightarrow b = 38.63\,mm$.

$\therefore F_a = 3580.76\,N$.

b) $\underline{M_t}$

$$M_t = \frac{\mu F_a D_m}{2\sin\alpha}$$

$= 460\times10^3$ N-mm.

c) $\underline{N}$

$M_t = 9550\times10^3 \times \frac{N}{n}$.

$\Rightarrow N = 36.12\,KW$.

d) $\underline{F_a^{\prime}}$

$F_a^{\prime} = F_n(\sin\alpha + \mu\cos\alpha)$

$= 8.25\,KN$.

1(b) Design a single plate clutch used in automobile transmission for the following specifications.

Power transmitted = 20 KW.

Speed = 1500 RPM to 2500 RPM (max)

Friction Surface : Molded Asbestos on Steel.

Ans: data

$N = 20 \, KW$.

$n = 1500$ rpm to 2500 rpm (max)

Friction material = Molded Asbestos.

1. Max. torque transmitted (M_t)

$$M_t = 9550 \times 10^3 \times \frac{N}{n}$$

Substituting min. value of n for Max value of M_t,

$$M_t = 9550 \times 10^3 \times \frac{20}{1500}$$

$$= 127.33 \times 10^3 \text{ N-mm}$$

2. diameter of shaft (d)

$$d = \sqrt[3]{\frac{16 M_t}{\pi \tau_{ed}}}$$

assume $\tau_{ed} = 40 \, N/mm^2$ for steel shaft.

$$\therefore d = \left[\frac{16 \times 127.33 \times 10^3}{\pi \times 40} \right]^{\frac{1}{3}}$$

$= 25.3$ mm

Select $d = 30$ mm (T 14.6 / P 14.13).

3. For molded Asbestos,

take $\mu = 0.3$ & $P = 0.5 \, N/mm^2$ (T 19.7/P19.26)

4. Friction lining diameters (D_1 & D_2)

Uniform wear theory

$$F_a = \frac{1}{2}\pi P D_1 (D_2 - D_1) \qquad 19.83 / P19.9$$

&

$$M_t = \frac{1}{2}\mu F_a \cdot D_m \cdot i \qquad 19.84$$

$$\therefore M_t = \frac{1}{2}\mu\left[\frac{1}{2}\pi P D_1 (D_2 - D_1)\right]\frac{D_1 + D_2}{\cancel{2}} \times \cancel{2}$$

$(\because i = 2)$

$$= \frac{\pi \mu P}{4} D_1 (D_2^2 - D_1^2).$$

Assuming $D_2 = 1.5 D_1$,

$$M_t = \frac{\pi \mu P}{4} D_1 (2.25 D_1^2 - D_1^2)$$

$\Rightarrow D_1 = 95.26\,mm$

$\& \; D_2 = 142.9\,mm$

4 5. Axial force exerted by springs (F_a)

$$F_a = \frac{1}{2}\pi P D_1 (D_2 - D_1).$$

$$= 3564.42\,N.$$

Uniform pressure theory

4. Friction lining diameters (D_1 & D_2)

$$F_a = \frac{\pi}{4}(D_2^2 - D_1^2)P. \qquad (19.86b)/P19.9.$$

&

$$M_t = \frac{1}{2}\mu F_a \cdot D_m \cdot i \qquad (19.84)$$

where $D_m = \frac{2}{3}\left(\frac{D_2^3 - D_1^3}{D_2^2 - D_1^2}\right)$.

$$\therefore M_t = \frac{1}{2}\mu\left[\frac{\pi}{4}(D_2^2 - D_1^2)p\right] \times \frac{2}{3}\left(\frac{D_2^3 - D_1^3}{D_2^2 - D_1^2}\right) \times 2$$

$$= \frac{\pi \mu p}{6}(D_2^3 - D_1^3).$$

assuming $D_2 = 1.5 D_1$,

$$127.33 \times 10^3 = \frac{\pi \times 0.3 \times 0.5}{6}\left[3.375 D_1^3 - D_1^3\right]$$

$\Rightarrow D_1 = 88.04$ mm

$D_2 = 132.07$ mm.

5. Axial force exerted by springs

$$F_a = \frac{\pi}{4}(D_2^2 - D_1^2)\,p.$$

$= 3806.2$ N.

2(a) A multiple disc clutch steel on Bronze is to transmit 4 KW at 750 RPM. The inner radius of contact is 40 mm and outer radius of contact is 70 mm. The clutch operates in oil with an expected coeff. of friction 0.1. The average allow. pressure is 350 KN/m² (Low design pressures are used to provide for sufficient size to give good heat dissi-pation capacity). Assume uniform wear.

1) How many total discs of Steel and Bronze are required?

2) what is the average pressure?

3) what axial force is required?

4) what is the actual max. pressure?

Ans: data

$N = 4KW$.

$n = 750 rpm$.

$R_1 = 40 mm$.

$\Rightarrow D_1 = 80 mm$.

$R_2 = 70 mm$

$\Rightarrow D_2 = 140 mm$.

$D_m = \frac{D_1 + D_2}{2}$

$= 110 mm$.

$\mu = 0.1$

$(P_m)_{allow} = 350 KN/m^2$

$= 0.35 N/mm^2$.

to find

1) i_1, i_2

2) P_m

3) F_a

4) P_{max}

1) i_1, i_2

$F_a = \frac{1}{2} \pi P_m D_m (D_2 - D_1)$.

$M_t = \frac{1}{2} \mu F_a \cdot D_m \cdot i$ (f)

Now $M_t = 9550 \times 10^3 \times \frac{N}{n}$

$= 50.93 \times 10^3$ N-mm.

Sub, $i = 2.55$.

Select $i = 4$

$\therefore i_1 = \frac{i}{2} = 2$ (driver plates)

$i_2 = \frac{i}{2} + 1 = 3$. (driven plates)

3) Fa

Using 4 pairs of contact surfaces, a reduced axial force can be used.

$M_t = \frac{1}{2} \mu F_a \cdot D_m \cdot i$

$\Rightarrow F_a = 2315$ N.

2) Pm

$F_a = \frac{1}{2} \pi P_m D_m (D_2 - D_1)$.

$\Rightarrow P_m = 0.223$ N/mm^2.

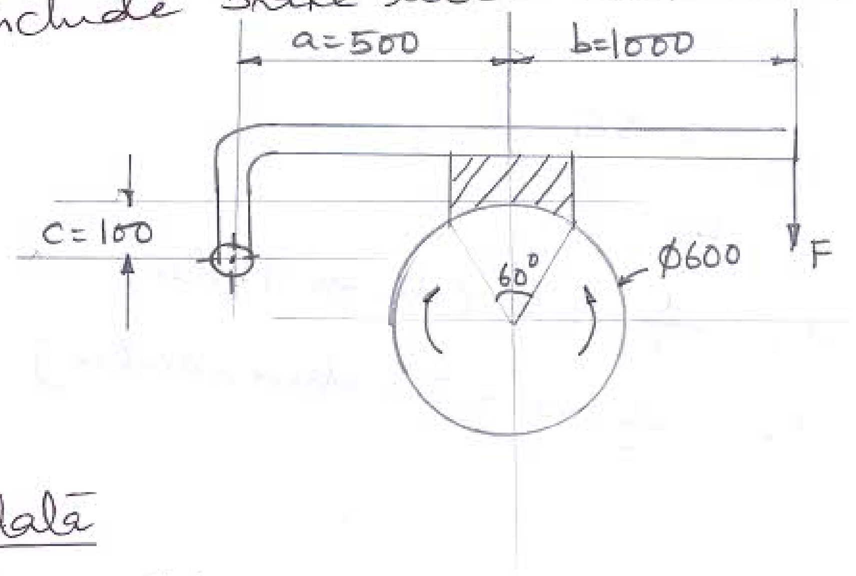
4) Pmax

$P_{max} D_1 = P_m \cdot D_m$

$P_{max} \times 80 = 0.223 \times 110$

$\Rightarrow P_{max} = 0.307$ N/mm^2.

2(b) Design a block brake shown in figure to transmit 30KW at 750rpm. Design should include brake lever and brake shoe. (8)



dala

$N = 30KW$

$n = 750 rpm$

$2\theta = 60^{\circ}$

$= 60 \times \frac{\pi}{180}$

$= \frac{\pi}{3}$ rad.

$M_t = 9550 \times 10^3 \times \frac{N}{n}$

$= 382 \times 10^3$ N-mm.

Tangential force $F_\theta = \frac{M_t}{r} = \frac{382 \times 10^3}{300}$

$= 1273.33$ N.

For CW rotation of drum,

$$F = \frac{F_\theta \cdot a}{a+b} \left(\frac{1}{\mu'} - \frac{c}{a}\right).$$

$$\mu' = \mu \left[\frac{4 \sin\theta}{2\theta + \sin 2\theta}\right]$$

Select molded Asbestos as friction material &

$\mu = 0.3$ & $P = 0.2$ N/mm^2 $\left(\frac{T19.12}{P19.25}\right)$

$$\mu' = 0.3\left[\frac{4\sin 30^\circ}{\frac{\pi}{3}+\sin 60^\circ}\right]$$

$$= 0.313.$$

For CW rotation of drum,

$$F = \frac{F_\theta \cdot a}{a+b}\left(\frac{1}{\mu'} - \frac{c}{a}\right)$$

$$= 1271.16\ N.$$

For CCW rotation of drum,

$$F = \frac{F_\theta \cdot a}{a+b}\left(\frac{1}{\mu'} + \frac{c}{a}\right).$$

$$= 1440.93\ N.$$

Therefore, design the brake lever & brake shoe for

$F = 1441\ N.$

<u>Design of brake lever</u>

Select 1030 steel as the material for lever and assume the c/s to be rectangular with its depth equal to twice its width ($d = 2b$).

σ_y for 1030 steel $= 441\ MPa$ (T1.1B / P1.13).

Select $FS = 2$.

$\therefore$ allow. stress $(\sigma) = \frac{\sigma_y}{FS} = \frac{441}{2} = 220.5\ MPa.$

Since the lever is subjected to BM,

$$\sigma_b = \frac{M_b}{Z_b}.$$

here $M_b = F \times b$ (Refer the sketch)

$$= 1441 \times 10^3\ N\text{-mm}.$$

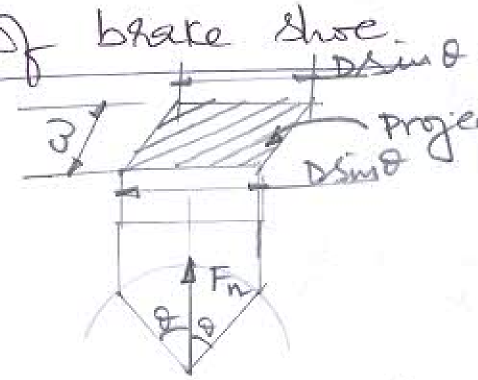
$$Z_b = \frac{bd^2}{6} = \frac{d^3}{12} \quad \left(\because b = \frac{d}{2}\right).$$

$$\therefore 220.5 = \frac{1441 \times 10^3}{\left(\frac{d^3}{12}\right)}$$

$\Rightarrow d = 42.8$ mm say 44 mm

$\therefore b = 22$ mm

Design of brake shoe.



F_n = (projected area of shoe) × P.

$\therefore \frac{F_\theta}{\mu} = (D \sin\theta \times \omega) \times P$.

$\Rightarrow \omega = 67.8$ mm say 68 mm.

3(a) A simple band brake of drum diameter 60mm has one end of band passing through the lever fulcrum. Determine the torque capacity for a force of 100 N at the lever end. The lever length is 250mm and the lever arm is 200 mm. Angle of contact is 210° and co-eff. of friction is taken as 0.2. Find the time required to bring to rest a drum having M.I of 850 kg-m² and 60 rpm. Find also no. of revolutions of drum, before it is brought to rest. consider CCW rotation of drum.

Ans: **data**

$D = 600\ mm$

$r = 300\ mm$

$F = 100\ N$

$\theta = 210^\circ$

$= 210 \times \frac{\pi}{180}$

$= 3.66\ rad$

$\mu = 0.2$

$I = 850\ kg\text{-}m^2$

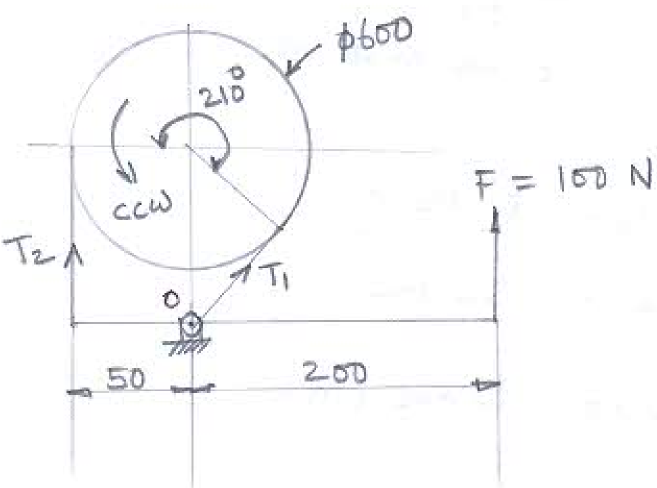
$n_1 = 60\ rpm$

to find

1) M_t

2) time (t) required to bring the drum to rest.

3) No. of revs (n) made by the drum before coming to rest.



1) M_t

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$$= e^{(0.2 \times 3.66)}$$

$$= 2.08$$

For equilibrium position of lever, taking moments about 'O',

$$T_2 \times 50 = F \times 200$$

$$= 100 \times 200$$

$T_2 = 400\ N.$

$T_1 = 832\ N.$

Torque transmitted $M_t = (T_1 - T_2)\, r$

$= 129.6 \times 10^3\ N\text{-}mm.$

2) time (t)

we have $M_t = I\alpha.$

$M_t = 129.6 \times 10^3\ N\text{-}mm$

$= 129.6\ N\text{-}m.$

$\therefore\ 129.6 = 850 \times \alpha$

$\Rightarrow\ \alpha = 0.152\ rad/sec^2.$

Now $\omega_2 = \omega_1 - \alpha t.$

where $\omega_1 = \frac{2\pi n_1}{60}$

$= \frac{2\pi \times 60}{60}$

$= 6.28\ rad/sec.$

here $\omega_2 = 0.$

$\therefore\ 0 = 6.28 - (0.152t)$

$\Rightarrow\ t = 41.33\ sec.$

3) No. of revolutions (n)

$\omega_2^2 - \omega_1^2 = -2\alpha\theta$

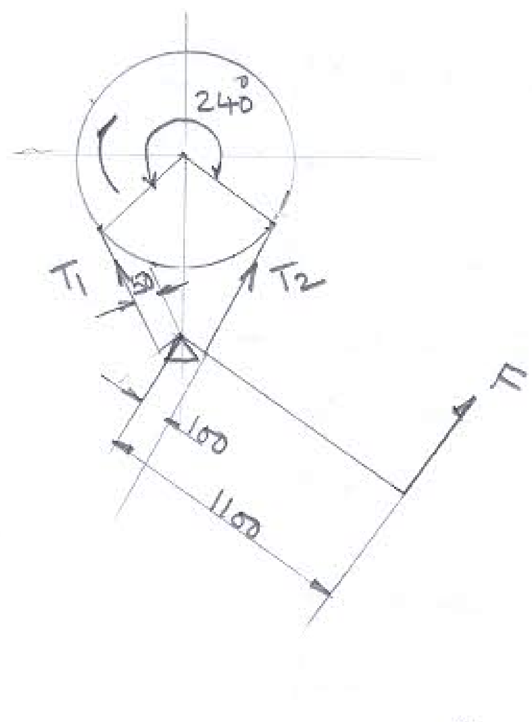
$= -2\alpha(2\pi n).$

$0 - \left(\frac{2\pi \times 60}{60}\right)^2 = -2 \times 0.152\ (2\pi n)$

$\Rightarrow\ n = 20.66$ rev's.

3(b) A differential band brake operates on a sheave (13)
of 500mm diameter. The drum rotates at 300RPM
and absorbs 35KW. co-eff. of friction is 0.25.

1. Determine the force F required for CW rotation of drum.
2. What width of band 5mm thick is required for the brake, if the tensile stress is not to exceed 60MPa.
3. Design the lever arm, if the max. force coming on it is twice the force calculated in (1). Select 1030 steel and a FS of 4 based on ultimate strength.
4. Design the fulcrum pin.



Ans:- data

$D = 500$ mm.

$n = 300$ rpm.

$N = 35$ KW

$\mu = 0.25$.

$\theta = 240°$

$= 240 \times \frac{\pi}{180}$

$= 4.19$ rad.

to find

1) F for CW rotation of drum.

2) w if h = 5mm & σ_d = 60MPa.

3) b & d for 1030 steel if FS = 4 based on σ_u.

4) dia. of fulcrum pin (d) if τ_d = 80MPa.

1) F

taking moments about 'O',

$$F \times 1100 + (T_2 \times 100) = (T_1 \times 50)$$

$$\frac{T_1}{T_2} = e^{\mu\theta} = e^{(0.25 \times 4.19)} = 2.85.$$

Also $M_t = 9550 \times 10^3 \times \frac{N}{n}$.

$$= 1.114 \times 10^6 \text{ N-mm.}$$

$$M_t = (T_1 - T_2) \times 250$$

$$1.114 \times 10^6 = (2.85 T_2 - T_2) \times 250$$

$$\Rightarrow T_2 = 2408 \text{ N.}$$

$$T_1 = 6864 \text{ N.}$$

$$F \times 1100 + (2408 \times 100) = (6864 \times 50)$$

$$\Rightarrow F = 93 \text{ N.}$$

2) $\underline{\omega}$ if h = 5mm & σ_d = 60 N/mm^2

width of band $(\omega) = \frac{T_1}{h \sigma_d} = \frac{6864}{5 \times 60} = 22.88$ mm

select ω = 23mm.

3. b & d (C/s dimensions)

Assume the C/s of lever to be rectangular with depth equal to twice its width ($d = 2b$).

Since the lever is subjected to B.M,

$$\sigma_b = \frac{M_b}{Z_b}$$

σ_u for 1030 steel $= 586$ MPa.

FS $= 4$ (given)

$$\therefore \sigma_b = \frac{586}{4} = 146.5 \text{ MPa}$$

here Force $= 2 \times F$
$= 184.9$ N.

$$M_b = 184.9 \times 1100$$
$$= 203.39 \times 10^3 \text{ N-mm}$$

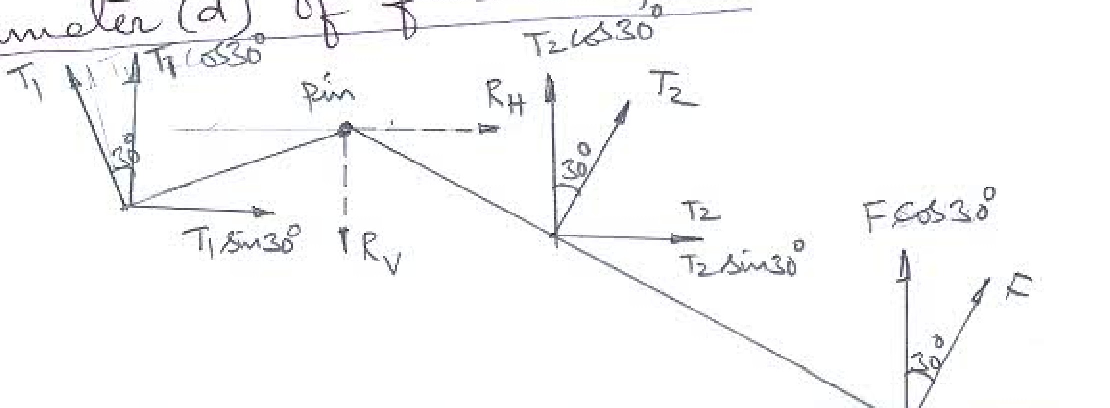
$$Z_b = \frac{bd^2}{6} = \left(\frac{d^3}{12}\right) \text{mm}^3$$

Now
$$146.5 = \frac{203.39 \times 10^3}{\left(\frac{d^3}{12}\right)}$$

$\Rightarrow d = 25.~~54~~$ mm. say 26 mm.

$\therefore b = 13$ mm

4) diameter (d) of fulcrum pin.



To find the diameter of fulcrum pin, the resultant force acting on the pin should be determined. (16)

Sum of vertical components $(\Sigma V) = (T_1 + T_2 + F)\cos 30^\circ$

$= 8110\ N.$

Sum of horizontal components $(\Sigma H) = (T_1 - T_2 - F)\sin 30^\circ$

$= 2182\ N.$

Resultant force acting on pin $(R) = \sqrt{(\Sigma V)^2 + (\Sigma H)^2}$

$= 8398.4\ N.$

Since the pin is subjected to double shear,

$$2 \times \frac{\pi d^2}{4} \times \tau = 8398.4$$

$$\Rightarrow d = 8.17\ mm$$

select dia. of pin $(d) = 9\ mm$