UNIT. 5.

FRICTION IN MACHINE ELEMENTS.

1) A single plate clutch transmits 25 kw at 900 rpm. The max pressure intensity b/w the plate is 85 kN/m². The ~~radii~~ ratio of radii is 1.25. (A/M.2017)
Both sides of plate are effective and the Co-eff of friction is 0.25. Determine
1) Determine inner dia of plate.
2) axial force engage the force

Given: $P = 25\text{ kW} = 25\times10^3\text{ W}$; $N = 900$, $n = 2$, $P_{max} = 85\text{ kN/m}^2$
$= 85\times10^3\text{ N/m}^2$ $\mu = 0.25$

Sol: Inner dia of plate:

$$P = \frac{2\pi NT}{60} = 25\times10^3 = \frac{2\times\pi\times900\times T}{60}$$

$T = 265.26\text{ N-m}$

intensity press is max.

$P_{max} \cdot r_2 = C$

$C = 85\times10^3\, r_2$ N/mm

axial thrust transmitted to frictional surface

$$W = 2\pi C(r_1 - r_2) = 2\pi\times85\times10^3 r_2 (1.25r_2 - r_2)$$

$= 1.335\times10^5\, r_2^2$

mean radius

$$R = \frac{r_1+r_2}{2} = \frac{1.25r_2 + r_2}{2} = 1.125r_2$$

Torque transmitted $T = \frac{1}{2} n\mu W (r_1+r_2)$

$$265.26 = \frac{1}{2}\times2\times0.25\times1.335\times10^5 (r_2)^2 (1.25r_2 + r_2)$$

$265.26 = 75.104 \times 10^3 r_2^3$

$r_2 = 0.1523 m$ (or) 152 mm.

$r_1 = 1.25 r_2 = 1.25 \times 152.3$

$= 190.375 mm.$

ii) Axial force.

$W = 2\pi C (r_1 - r_2) = 1.335 \times 10^5 (r_2)^2$

$= 1.335 \times 10^5 (0.1523)^2$

$W = 3096.57 N$

2.) A leather faced conical clutch has a cone angle of 30°. If the intensity of pressure between the contact surfaces is limited to 0.35 N/mm² and breadth of conical surface is not to exceed of one-third of mean radius Determine dimensions of contact surfaces to transmit 22.5kW at 2000rpm. Assume uniform wear rate take μ = 0.15. [NOV/DEC-2016]

Given: $2\alpha = 30°$, $\alpha = 15°$, $P_n = 0.35 MPa$

$= 0.35 \times 10^6 N/m^2$, $b = R/3$, $P = 22.5 kW$

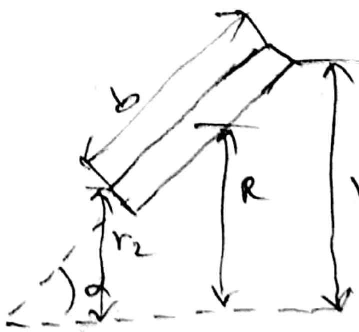
$= 22.5 \times 10^3 W$, $N = 2000 rpm$, $\mu = 0.15$

Sol.

$P = \frac{2\pi N T}{60}$

$22.5 \times 10^3 = \frac{2\pi \times 2000 \times T}{60}$

$T = 107.43 N\text{-}m$



we find that $\dfrac{r_1 - r_2}{b} = \sin\alpha$

$$b = \frac{r_1 - r_2}{\sin\alpha} \qquad \text{here } R = r_1 - r_2$$

$$b = \frac{R}{3} = \frac{1}{3}\left(\frac{r_1 + r_2}{2}\right) = \frac{r_1 + r_2}{6}$$

$$\frac{r_1 + r_2}{6} = \frac{r_1 - r_2}{\sin 15^\circ} \text{ (or) } r_1 + r_2 = 23.18(r_1 - r_2)$$

$$= 23.18\, r_1 - 23.18\, r_2$$

$$24.18\, r_2 = 22.18\, r_1$$

$$r_2 = 0.917\, r_1 \quad \text{——— (1)}$$

uniform wear axial force

$$W = 2\pi C(r_1 - r_2) = 2\pi P_{max} \times r_2 (r_1 - r_2)$$

$$= 2\pi \times 0.35 \times 10^6 \times r_2 (r_1 - r_2)$$

$$= 2.199 \times 10^6 \times r_2 (r_1 - r_2)$$

Torque transmitted for uniform wear is

$$T = \frac{1}{2} \mu W (r_1 + r_2) \operatorname{cosec}\alpha$$

$$107.43 = \frac{1}{2} \times 0.15 \left[2.199 \times 10^6 \times r_2 (r_1 - r_2)\right] \left(r_1 + r_2 \operatorname{cosec} 15^\circ\right]$$

$$= 637221\; r_2 (r_1^2 - r_2^2)$$

$$107.43 = 637221\,(0.917 r_1)\left[r_1^2 - (0.917\, r_1)^2\right)$$

$$107.43 = 92974\, r_1^3$$

$$r_1 = \left(\frac{107.43}{92974}\right)^{1/3}$$

$$r_1 = 0.149\text{ m (or) } 104.9\text{ mm}$$

$r_2 = 0.917 r_1$

$= 0.917 (104.9)$

$= 96.19$ mm.

$b = \frac{R}{3} = \frac{r_1 + r_2}{6}$

$= \frac{104.9 + 96.19}{6}$

$= 100.5$ mm

4) An open belt running over two pulleys 240 mm & 600mm diameter connects two parallel shafts 3 metres apart and transmits 4 kw. from the smaller pulley that rotates at 300rpm. $\mu = 0.3$, and the safe working tension is 10 N/mm width. Determine 1) minimum width of belt. 2) initial belt tension 3) length of belt required.

Given data: $d_2 = 240mm = 0.24m$, $d_1 = 600mm = 0.6m$

$x = 3m$, $P = 4kW = 4000W$, $N_2 = 300rpm$, $\mu = 0.3$,

$T_1 = 10 N/mm$ width. (NOV/DEC-2006)

Sol.

(i) Min width of belt.

$v = \frac{\pi d_2 N_2}{60} = \frac{\pi \times 0.24 \times 300}{60}$

$= 3.77 m/s.$

Power transmitted $P = (T_1 - T_2) v$

$4000 = (T_1 - T_2) \times 3.77$

$T_1 - T_2 = 1061 N$

for open belt

$\sin\alpha = \frac{r_1 - r_2}{x} = \frac{d_1 - d_2}{2x}$

$= \frac{0.6 - 0.24}{2 \times 3} = 0.06$

$\alpha = \sin^{-1} 0.06 = 3.44°$

Angle of contact $\theta = 180 - 2\alpha \times \frac{\pi}{180}$

$= (180 - 2 \times 3.44) \times \pi/180$

$= 3.022$ rad

$\frac{T_1}{T_2} = e^{\mu\theta} \Rightarrow e^{0.3 \times 3.022}$

$= 2.478$

$T_1 = 2.478 T_2$

$T_1 = 1779 N$ & $T_2 = 718 N$

$b = \frac{T_1}{10} = \frac{1779}{10} = 177.9$ mm

Initial belt load.

$T_0 = \frac{T_1 + T_2}{2} = \frac{1779 + 718}{2}$

$= 1248.5 N.$

3) An electric motor driven power screw moves a nut in a horizontal plane against a force of 75 kN at a speed of 300 mm/min. The screw has a single square thread of 6 mm pitch on a major Dia of 40 mm. The coeff of friction at the screw threads is 0.1 estimate power of motor. (NOV/DEC - 2017)

Given: $W = 75\text{ kN} = 75\times10^3\text{ N}$; $V = 300\text{ mm/min}$, $P = 6\text{ mm}$

$d_o = 40\text{ mm}$, $\mu = \tan\phi = 0.1$

Sol. mean dia of screw.

$$d = d_o - \frac{P}{2} = 40 - \frac{6}{2} = 37\text{ mm}$$

$$\tan\alpha = \frac{P}{\pi d} = \frac{6}{\pi\times37} = 0.0516$$

tangential force required

$$P = W\tan(\alpha+\phi)$$

$$= W\left[\frac{\tan\alpha+\tan\phi}{1-\tan\alpha\tan\phi}\right]$$

$$= 75\times10^3\left[\frac{0.0516+0.1}{1-0.0516\times0.1}\right] = 11.43\times10^3\text{ N}$$

torque required to operate screw

$$T = P\times d/2 = 11.43\times10^3\times\frac{37}{2} = 211.45\times10^3\text{ N.mm}$$

$$= 2111.45\text{ Nm.}$$

The screw moves at a speed of ~~300rpm~~ 300 mm/min at pitch screw is 6 mm,

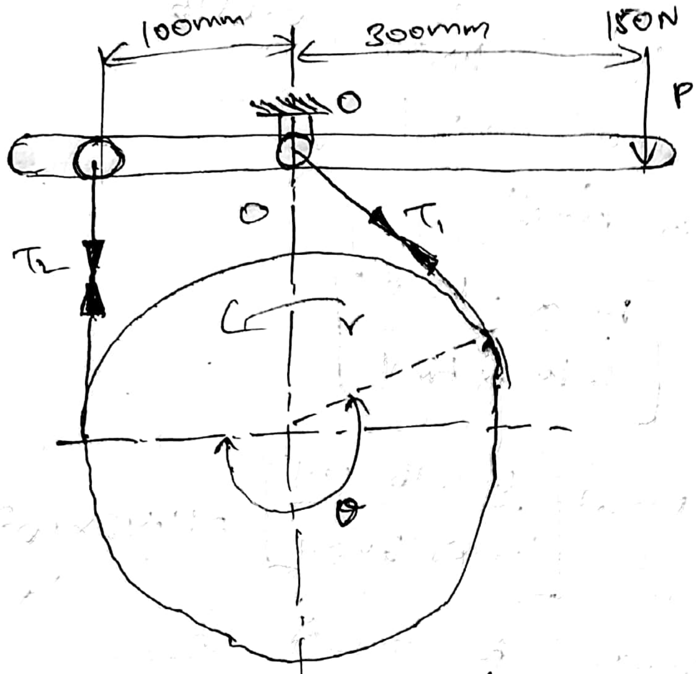
$$N = \frac{\text{Speed in mm/min}}{\text{Pitch in mm}} = \frac{300}{6} = 50\ rpm$$

Angular speed $\omega = \frac{2\pi N}{60} = \frac{2\pi \times 50}{60} = 5.24\ r/s.$

Power of motor $= T.\omega = 211.45 \times 5.24$

$= 1108\ W.$

5. A simple band brake shown in fig. (M/J.2013) is applied to a shaft carrying a flywheel of mass 450kg. & radius of gyration 500mm. The shaft speed is 320 rpm. The drum diameter is 250mm. and $\mu = 0.2$. The angle of lap of the band on the drum is 225°. Determine.



1) brake torque when a force of 150N is applied.

2) the no of turns of flywheel before it comes.

3) time taken by flywheel to come rest.

Given data: $m = 450\ kg$, $k = 500mm = 0.5m$

$N = 320rpm$, $\mu = 0.2$, $\theta = 225° = 225 \times \pi/180$

$= 3.927\ rad$

$P = 150N$

Soln:

i) Brake torque applied

Tension ratio $\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25 \times \pi}$

$= 2.19$ (or) $T_1 = 2.19 T_2$

Taking moments about fulcrum

$P \times 300 = T_1 \times 100$ (or) 150×300

$= T_1 \times 100$

$T_1 = 450 N$

From eqn: $T_1 = 2.19 T_2$ (or) $450 = 2.19 T_2$

$T_2 = 205.48 N$

Braking Torque $T_B = (T_1 - T_2) r$

$= (450 - 205.48) \times 0.125$

$= 30.565 Nm.$

2) No of turns of fly wheel before come rest

$KE = \frac{1}{2} I\omega^2$

$= \frac{1}{2} mk^2 \omega^2$

$= \frac{1}{2} \times 450 \times (0.50)^2 \left[\frac{2\pi \times 320}{60}\right]^2$

$= 63165.5 Nm$

K.E of flywheel $= T_B \times \omega$

$= T_B \times 2\pi n$

$63165.5 = 30.565 \times 2\pi n$

$n = 328.9$ rev.

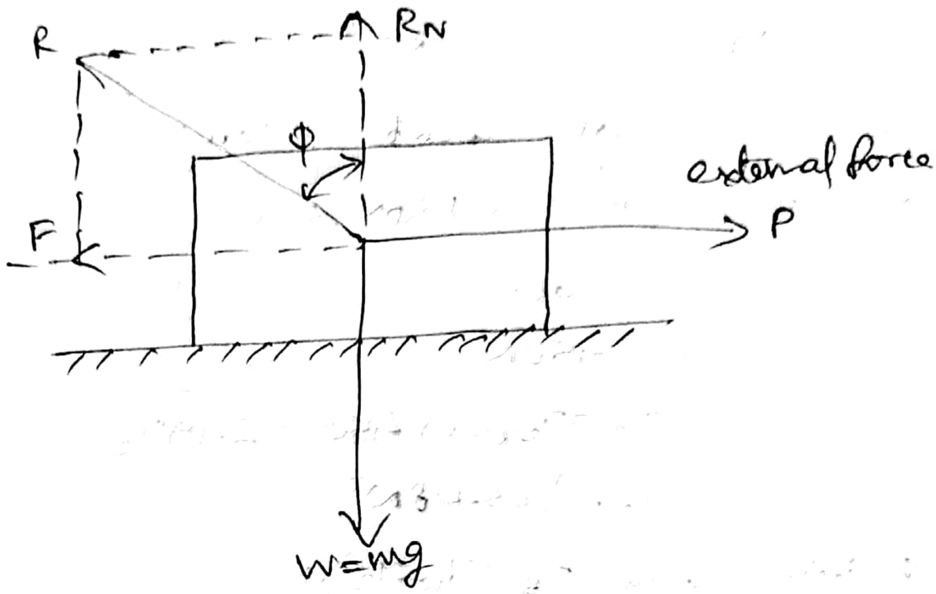
3) Time taken by the flywheel to come rest.

Time taken $= \frac{n}{N} = \frac{328.9}{320} = 1.028 \text{ min}$

$= 61.67 s$

6) (A/M. 2018).

Angle of friction & friction co-eff.



$F = \mu W = \mu R_N$

R_N - Normal reaction

1) weight of body w.
2) Applied horizontal force (P)
3) Reaction R_N b/w body A & B.

$F \propto R_N$ (or) $F = \mu R_N$ $\mu = F/R_N$

where μ = constant.

$\tan\phi = \frac{F}{R_N} = \frac{\mu R_N}{R_N}$ (or) $\boxed{\tan\phi = \mu}$

φ is known as limiting angle of friction (or) angle of friction