د/ابراهيم سالم 31-12-2017

Kafrelsheikh University
Faculty of Engineering
3ed year Mechanical Power

~~January 2017~~
Time allowed
3 hours

Mechanical Design

1. (15 Marks)

A cylindrical helical spring is made of 0.6 cm diameter wire, number of coils 20, and mean diameter 7.5 cm. Find the tensile load which may be applied on the spring if the shear stress must not exceed 18 kgf/cm^2. How much will be the deflection in this case.

G = 8 kgf/cm^2, K = 1 + 1.5/c, c = D/d $\frac{8kPD}{\pi d^3} \leq \tau_d$ $\lambda = \frac{8PD^3 i}{GD^4}$

Answer:

② $d = 6\ mm$, $i = 20$, $D = 7.5\ Cm$, $P = ??$, $\tau = 18\ kgf/mm^2$

$\lambda = ??$, $G = 8 \times 10^5\ kgf/Cm^2$

$\tau_{max} = \frac{8PDK}{\pi d^3}$, $K = 1 + 1.5/c = 1.12$

$\therefore P = \frac{1800 \times \pi \times (0.6)^3}{8 \times 7.5 \times 1.12} = 18\ kgf$ #.

$\lambda = \frac{8PD^3 i}{G d^4} = \frac{8 \times 18 \times (7.5)^3 \times 20}{8 \times 10^5 \times (0.6)^4} = 11.7\ Cm.$

2. (15 Marks)

A plate clutch having a single driving plate with contact surfaces on each side is required to transmit 110 kW at 1250 r.p.m. The outer diameter of the contact surfaces is to be 300 mm. The coefficient of friction is 0.4.

(a) Assuming a uniform pressure of 0.17 N/mm^2; determine the inner diameter of the friction surfaces.

(b) Assuming the same dimensions and the same total axial thrust, determine the maximum torque that can be transmitted and the maximum intensity of pressure when uniform wear conditions have been reached.

p.r = C, T = n.μ.W.R ,

$$R = \frac{2}{3}\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right]$$

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Solution. Given : $P = 110$ kW $= 110 \times 10^3$W ; $N = 1250$ r.p.m. ; $d_1 = 300$ mm or $r_1 = 150$ mm ; $\mu = 0.4$; $p = 0.17$ N/mm^2

(a) Inner diameter of the friction surfaces

Let d_2 = Inner diameter of the contact or friction surfaces, and

r_2 = Inner radius of the contact or friction surfaces.

We know that the torque transmitted by the clutch,

$$T = \frac{P \times 60}{2\,\pi\,N} = \frac{110 \times 10^3 \times 60}{2\,\pi \times 1250} = 840 \text{ N-m}$$

$$= 840 \times 10^3 \text{ N-mm}$$

Axial thrust with which the contact surfaces are held together,

$$W = \text{Pressure} \times \text{Area} = p \times \pi\,[(r_1)^2 - (r_2)^2]$$

$$= 0.17 \times \pi\,[(150)^2 - (r_2)^2] = 0.534\,[(150)^2 - (r_2)^2] \qquad ...(i)$$

and mean radius of the contact surface for uniform pressure conditions,

$$R = \frac{2}{3}\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right] = \frac{2}{3}\left[\frac{(150)^3 - (r_2)^3}{(150)^2 - (r_2)^2}\right]$$

$\therefore$ Torque transmitted by the clutch (T),

$$840 \times 10^3 = n.\mu.W.R$$

$$= 2 \times 0.4 \times 0.534\,[(150)^2 - (r_2)^2] \times \frac{2}{3}\left[\frac{(150)^3 - (r_2)^3}{(150)^2 - (r_2)^2}\right] \qquad ...(\because n = 2)$$

$$= 0.285\,[(150)^3 - (r_2)^3]$$

or $\quad (150)^3 - (r_2)^3 = 840 \times 10^3 / 0.285 = 2.95 \times 10^6$

$\therefore \quad (r_2)^3 = (150)^3 - 2.95 \times 10^6 = 0.425 \times 10^6$ or $r_2 = 75$ mm

and $\quad d_2 = 2r_2 = 2 \times 75 = 150$ mm **Ans.**

(b) Maximum torque transmitted

We know that the axial thrust,

$$W = 0.534\,[(150)^2 - (r_2)^2] \quad \text{... [From equation } (i)]$$

$$= 0.534\,[(150)^2 - (75)^2] = 9011 \text{ N}$$

and mean radius of the contact surfaces for uniform wear conditions,

$$R = \frac{r_1 + r_2}{2} = \frac{150 + 75}{2} = 112.5 \text{ mm}$$

∴ Maximum torque transmitted,

$$T = n.\mu.W.R = 2 \times 0.4 \times 9011 \times 112.5 = 811 \times 10^3 \text{ N-mm}$$

$$= 811 \text{ N-m } \textbf{Ans.}$$

Maximum intensity of pressure

For uniform wear conditions, $p.r = C$ (a constant). Since the intensity of pressure is maximum at the inner radius (r_2), therefore

$$p_{max} \times r_2 = C \quad \text{or} \quad C = p_{max} \times 75 \text{ N/mm}$$

We know that the axial thrust (W),

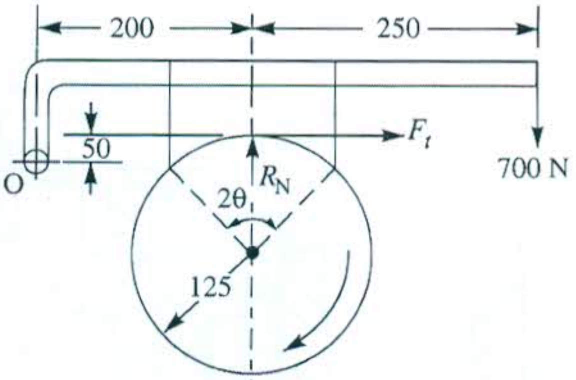
$$9011 = 2\pi C (r_1 - r_2) = 2\pi \times p_{max} \times 75\,(150 - 75) = 35\,347\, p_{max}$$

$$\therefore \quad p_{max} = 9011 / 35\,347 = 0.255 \text{ N/mm}^2 \quad \textbf{Ans.}$$

3. (15 Marks)

A single block brake is shown in **Fig. 1**. The diameter of the drum is 250 mm and the angle of contact is 90°. If the operating force of 700 N is applied at the end of a lever and the coefficient of friction between the drum and the lining is 0.35, determine the torque that may be transmitted by the block brake.

$$\mu' = \frac{4\mu \sin\theta}{2\theta + \sin 2\theta}$$



All dimensions in mm.

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Solution. Given : $d = 250$ mm or $r = 125$ mm ; $2\theta = 90° = \pi / 2$ rad ; $P = 700$ N ; $\mu = 0.35$

Since the angle of contact is greater than 60° , therefore equivalent coefficient of friction,

$$\mu' = \frac{4\mu \sin\theta}{2\theta + \sin 2\theta} = \frac{4 \times 0.35 \times \sin 45°}{\pi/2 + \sin 90°} = 0.385$$

Let R_N = Normal force pressing the block to the brake drum, and

F_t = Tangential braking force = $\mu' . R_N$

Taking moments above the fulcrum O, we have

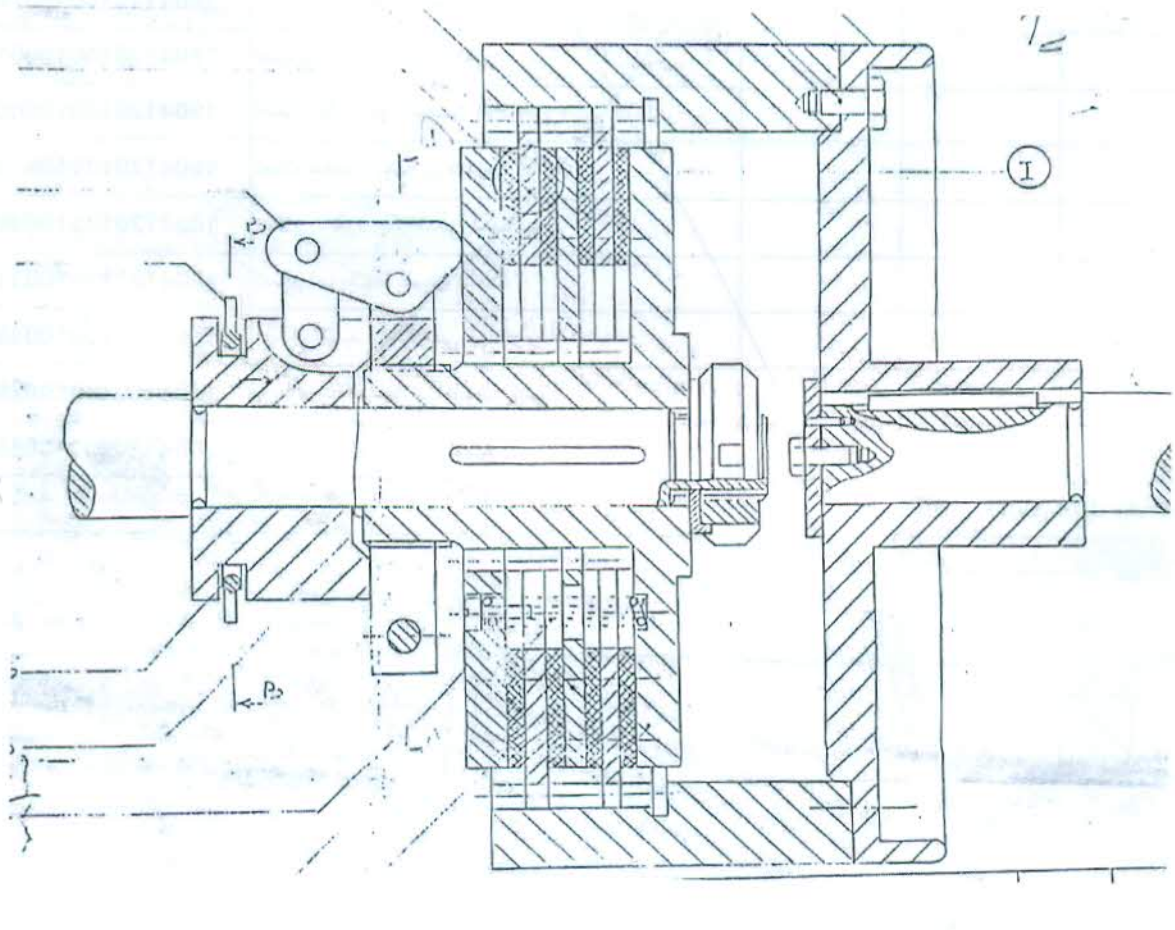
$$700\,(250 + 200) + F_t \times 50 = R_N \times 200 = \frac{F_t}{\mu'} \times 200 = \frac{F_t}{0.385} \times 200 = 520\ F_t$$

or $520\ F_t - 50\ F_t = 700 \times 450$ or $F_t = 700 \times 450 / 470 = 670$ N

We know that torque transmitted by the block brake,

$$T_B = F_t \times r = 670 \times 125 = 83\ 750 \text{ N-mm} = 83.75 \text{ N-m} \ \textbf{Ans.}$$

4. (20 Marks)



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5. (30 Marks)

The kinematic scheme of a power transmission system is shown in **Fig. 3**. A is the electric motor, B is a friction safety coupling (containing double cone friction surfaces) which limits the transmitted torque. C is two steps toothed gear reducer. The first step consists of a pair of spur gears. Make a complete constructional drawing showing the very fine constructional details of the **shaft I**, showing the safety coupling, pinion gear, rolling contact bearings, sealing devices, and lubrication device.

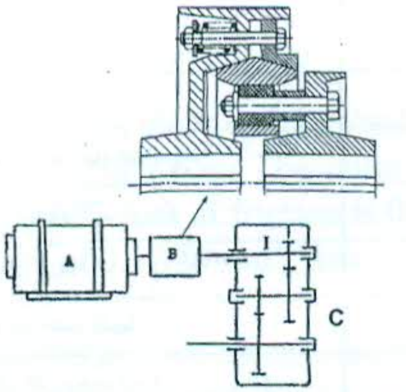

Fig. 3