QUESTION

BASIC PROBLEMS ON PLATE CLUTCH

A single plate friction clutch of both sides effective has 0.3 m outer diameter and 0.16 m inner diameter. The coefficient of friction is 0.2 and it runs at 1000 rpm. Find the power transmitted for uniform wear and uniform pressure distribution cases if the allowable maximum pressure is 0.08 MPa.

Solution: $n' = 2$, outside diameter $D_0 = 0.3$ m $= 300$ mm, inside diameter $D_i = 0.16$ m $=$ 160 mm, $f = 0.2$, $N = 1000$ rpm, $P = ?$, $p = 0.08$ MPa.

We know that power, $$P = \frac{2\pi NT}{60} \qquad \text{...Eq. } (i)$$

But $$T = \frac{1}{2} f F_a D_m n' \qquad \text{........Eq. 13.9(C)/ Pg. 258, DHB}$$

a. Uniform pressure:

Note : Coefficient of friction : μ or f

Axial force, $$F_a = \frac{\pi p}{4}(D_0^2 - D_i^2) \qquad \text{........Eq. 13.9(a)/ Pg. 258, DHB}$$

$$= \frac{\pi \times 0.08}{4}(300^2 - 160^2)$$

$$F_a = 4046.37 \text{ N}$$

Mean diameter, $$D_m = \frac{2}{3}\left[\frac{D_0^3 - D_i^3}{D_0^2 - D_i^2}\right]$$ ....Eq. 13.9(c)/ Pg. 258, DHB

$$= \frac{2}{3}\left[\frac{300^3 - 160^3}{300^2 - 160^2}\right]$$

$$D_m = 237 \text{ mm} = 0.237 \text{ m}$$

$\therefore$ Eq. (*ii*) yields ... $T = \frac{1}{2} \times 0.2 \times 4046.37 \times 0.237 \times 2$

$$T = 191.80 \text{ N-m}$$

$\therefore$ Eq. (*i*) yields .... $P = \frac{2\pi \times 1000 \times 191.80}{60}$

$$P = 20.08 \text{ kW}$$

b. Uniform wear:

Axial force, $$F_a = \frac{\pi}{2} p D_i (D_0 - D_i)$$ ....**Eq. 13.9(d)/ Pg. 258, DHB**

$$= \frac{\pi \times 0.08 \times 160}{2}(300 - 160)$$

$$F_a = 2814.87 \text{ N}$$

Mean diameter, $$D_m = \left[\frac{D_0 + D_i}{2}\right]$$ ....**Eq. 13.9(f)/ Pg. 259, DHB**

$$= \left[\frac{300 + 160}{2}\right]$$

$$D_m = 230 \text{ mm} = 0.230 \text{ m}$$

$\therefore$ Eq. (*ii*) yields ... $T = \dfrac{1}{2} \times 0.2 \times 2814.87 \times 0.230 \times 2$

$$T = 129.48 \text{ N-m}$$

$\therefore$ Eq. (*i*) yields ... $P = \dfrac{2\pi \times 1000 \times 129.48}{60}$

$$P = 13.56 \text{ kW.}$$

QUESTION

A single plate clutch both sides effective is required to transmit 25 kW at 1600 rpm. The outer diameter of the plate is limited to 0.3 m and the intensity of pressure is not to exceed 0.07 MPa. Assuming uniform wear and the coefficient of friction 0.3, determine the diameter of the plate and the axial force necessary to engage the clutch.

[VTU – June/ July 2008 – 10 Marks]

Solution: $n' = 2$, $P = 25$ kW, $N = 1600$ rpm, outside diameter $D_0 = 0.3$ m $=300$ mm, $p = 0.07$ MPa, $f = 0.3$, $D_i = ?$

Unless otherwise stated, uniform wear theory should be used.

We know that, $$T = \frac{1}{2} f F_a D_m n'$$ ....**Eq. 13.9(c)/ Pg. 258, DHB**

$$\text{But } P = \frac{2\pi NT}{60}$$

$$25 \times 10^3 = \frac{2\pi \times 1600 \times T}{60}$$

$$T = 149.21 \text{ N-m}$$

- Axial force, $F_a = \frac{\pi}{2} pD_i(D_0 - D_i)$ ....Eq. 13.9(d)/ Pg. 258, DHB

$$= \frac{\pi \times 0.07 \times D_i}{2} (D_0 - D_i)$$

$$F_a = 0.1099\, D_i\, (D_0 - D_i) \qquad \text{...Eq. } (ii)$$

- Mean diameter, $D_m = \left[\frac{D_0 + D_i}{2}\right]$ ....Eq. 13.9(f)/ Pg. 258, DHB

∴ Eq. (*i*) yields ... $149.21 \times 10^3 = \frac{1}{2} \times 0.3 \times 0.1099\, D_i\, (D_0 - D_i) \times 2 \times \left[\frac{D_0 + D_i}{2}\right]$

$$9.05 \times 10^6 = (D_0^2 - D_i^2)\, D_i$$

$$9.05 \times 10^6 = (300^2 - D_i^2)\, D_i$$

$$D_i = 221.80 \text{ mm} \approx 230 \text{ mm}$$

(roots: 221.80, –341.34, 119.53)

And Eq. (*ii*) yields ... $F_a = 0.1099 \times 230 \times (300 - 230)$

$$F_a = 1769.40 \text{ N.}$$

<u>QUESTION</u>

A multiple disc clutch is composed of 5 steel and 4 bronze disks. The clutch is required to transmit a maximum torque of 240 N-m. Assume a factor of safety of 2.5 for slippage and full engine torque. If $p = 0.35$ MPa and $f = 0.25$, calculate the diameters of friction lining.

Solution: $n_1 = 5$, $n_2 = 4$, $T = 240$ N-m $= 240 \times 10^3$ N-mm, $FOS = 2.5$, $p = 0.35$ MPa, $f = 0.25$, D_i, $D_0 = ?$

Here frictional torque, $T_f = T\beta = T \times FOS$ ....**Eq. 13.9(g)/ Pg. 259, DHB**

$$= (240 \times 10^3) \times 2.5$$

$$T_f = 6 \times 10^5 \text{ N-mm}$$

We know that, $T = T_f = \frac{1}{2} f F_a D_m n'$ ....**Eq. 13.9(c)/ Pg. 258, DHB**

- But $F_a = \frac{\pi}{2} p D_i (D_0 - D_i)$ ....**Eq. 13.9(d)/ Pg. 258, DHB**

$$= \frac{\pi \times 0.35 \times D_i}{2} (D_0 - D_i)$$

$$F_a = 0.5497\, D_i\, (D_0 - D_i) \qquad \text{...Eq. } (ii)$$

- $D_m = \left[\frac{D_0 + D_i}{2}\right]$ ....**Eq. 13.9(f)/ Pg. 259, DHB**

- $n' = n_1 + n_2 - 1$

$$= 5 + 4 - 1$$

$$n' = 8$$

$\therefore$ Eq. (i) yields ... $6 \times 10^5 = \frac{0.25 \times 8}{2} \times [0.5497 D_i (D_0 - D_i)] \times \left[\frac{D_0 + D_i}{2}\right]$

$$= 0.2749\,(D_0^2 - D_i^2)\,D_i$$

$$2.18 \times 10^6 = (D_0^2 - D_i^2)\,D_i \qquad \text{...Eq. } (iii)$$

Since there are two unknown in Eq. (*iii*), the problem can't be solved unless some assumption is made for the diameters. We have seen that in the previous problem, $D_i / D_0 \leq 0.577$.

Hence assuming $D_i / D_0 = 0.5$, we have

$$2.18 \times 10^6 = (1 - 0.5^2) \times 0.5\, D_0^3$$

$$D_0 = 179.8 \text{ mm} \approx 180 \text{ mm}$$

And $D_i = 0.5 \times 180 = 90$ mm.