Plate clutch

Plate clutch

- Single plate clutch
- Multiplate clutch.

$$T = \mu W R n$$

Mean radius "R"

$$R = \frac{2}{3}\left(\frac{r_2^3 - r_1^3}{r_2^2 - r_1^2}\right) \rightarrow$$ Under uniform pressure

$$R = \frac{r_1 + r_2}{2} \rightarrow$$ Under uniform wear

Weight "W"

$$W = 2\pi C\left[r_2 - r_1\right]$$

where, $C = P_{max} \times r_1$

When maximum Pressure is given

$$W = P\pi\left[r_2^2 - r_1^2\right] \rightarrow$$ When uniform Pressure (or) Average pressure given

Number of plates n for multiplate clutch

$$n = n_1 + n_2 - 1$$

Number of friction surface for single plate clutch

$$n = 2$$

$n_1 \rightarrow$ number of plates on driving shaft

$n_2 \rightarrow$ number of plates on driven shaft

Problem

1) Determine the maximum, minimum pressure and average pressure in a plate clutch, when the axial force is 4 kN. The inside radius of the contact surface is 50 mm and outside radius is 100 mm. Assume uniform wear.

Given data :

$$r_1 = 50\,mm$$

$$r_2 = 100\,mm$$

$$W = 4\,kN = 4 \times 10^3$$

To find :

(i) P_{max}

(ii) P_{min}

(iii) P_{av}

Solution

$$P_{max} = \frac{C}{r_1}$$

$$W = 2\pi C [r_2 - r_1]$$

$$4 \times 10^3 = 2 \times \pi \times C [100 - 50]$$

$$\boxed{C = 12.73}$$

$$P_{max} = \frac{12.73}{50}$$

$$\boxed{P_{max} = 0.2546\,N/mm^2}$$

$$P_{min} = \frac{C}{r_2} = \frac{12.73}{100}$$

$$\boxed{P_{min} = 0.1273\,N/mm^2}$$

$$P_{av} = \frac{W}{\pi\left[r_2^2 - r_1^2\right]} = \frac{4000}{\pi\left[100^2 - 50^2\right]}$$

$$\boxed{P_{av} = 0.169 \ N/mm^2}$$

Result:

$P_{max} = 0.2546 \ N/mm^2$

$P_{min} = 0.1273 \ N/mm^2$

$P_{av} = 0.169 \ N/mm^2$

2) A plate clutch having single driving plate with contact surfaces on each side is required to transmit 110 kW at 1250 rpm. The outer diameter of contact surface 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 friction surface. (b) Assuming same dimension and same total axial thrust. Determine the maximum torque that can be transmitted and the maximum intensity of pressure when the uniform wear condition have been reached.

Given

$P = 110 kW = 110 \times 10^3 W$

$N = 1250 rpm$

$d_2 = 300 mm \Rightarrow r_2 = 150 mm$

$\mu = 0.4$

$P = 0.17 N/mm^2$

Single plate clutch. So, $n = 2$

To find:

(i) d_1

(ii) T_{max}, P_{max}

Solution:

(i) considering uniform pressure

we know that,

$$T = \mu W R n$$

$$P = \frac{2\pi N T}{60} \Rightarrow 110 \times 10^3 = \frac{2 \times \pi \times 1250 \times T}{60}$$

$$\boxed{T = 840.34 N\cdot m}$$

(or)

$$\boxed{T = 840.34 \times 10^3 N\cdot mm}$$

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

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

$$W = P\pi(r_2^2 - r_1^2)$$ → [When uniform pressure given]

$$\boxed{W = 0.17 \times \pi (150^2 - r_1^2)}$$

$$T = \mu W R n$$

$$840.34 \times 10^3 = 0.4 \times 0.17 \times \pi \cancel{(150^2 - r_1^2)} \times \frac{2}{3}\left[\frac{150^3 - r_1^3}{\cancel{150^2 - r_1^2}}\right] \times 2$$

$$\boxed{r_1 = 75.2\ mm}$$

$$d_1 = 2 r_1 = 75.2 \times 2$$

$$\boxed{d_1 = 150.4\ mm}$$

(ii) Considering uniform wear [As given in question, the dimensions are considered from above condition]

$$T = \mu W R n$$

$$R = \frac{r_1 + r_2}{2} = \frac{75.2 + 150}{2}$$

$$\boxed{R = 112.6\ mm}$$

$$W = P\pi (r_2^2 - r_1^2)$$

$$= 0.17 \times \pi (150^2 - 75.2^2)$$

$$\boxed{W = 8996.4\ N}$$

$$T = \mu W R n$$

$$= 0.4 \times 8996.4 \times 112.6 \times 2$$

$$\boxed{T_{max} = 810.4 \times 10^3\ N\text{-}mm}$$

WKt, for maximum pressure

$$W = 2\pi C (r_2 - r_1)$$

$$8996.4 = 2 \times \pi \times c\ (150 - 75.2)$$

$$\boxed{C = 19.14}$$

$$P_{max} = \frac{C}{r_1} = \frac{19.14}{75.2} = 0.2545$$

$$\boxed{P_{max} = 0.2545\ N/mm^2}$$

Result:

(i) $d_1 = 150.4\ mm$

(ii) $T_{max} = 810.4 \times 10^3\ N\text{-}mm$

(iii) $P_{max} = 0.2545\ N/mm^2$

3. An automobile power unit gives a maximum torque of 13.56 N-m. The clutch is of a single plate drive having effective clutch lining of both sides of plate disc. Coefficient of friction is 0.3 and the maximum axial pressure is 8.29×10^4 Pa and external radius of friction surface is 1.25 times of internal radius. Calculate dimensions of clutch plate and the total axial pressure that must be exerted by the clutch spring.

Given:

$T = 13.56$ N.m (or) 13.56×10^3 N.mm

Since it is single plate so, $n = 2$

$\mu = 0.3$

$P_{max} = 8.29 \times 10^4$ Pa

$= 0.0829 \times 10^6$ Pa

$= 0.0829$ N/mm^2

$r_2 = 1.25\, r_1$

To find:

(i) r_1, r_2

(ii) W

Solution:

$$T = \mu W R n$$

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

$$\boxed{R = 1.125 r_1}$$

$$W = 2\pi c (r_2 - r_1)$$

$$C = P_{max} \times r_1$$

$$\boxed{C = 0.0829 \times r_1}$$

$$W = 2 \times \pi \times 0.0829 \times r_1 (1.25 r_1 - r_1)$$

$$\boxed{W = 0.13 r_1^2}$$

$$T = \mu W R n$$

$$13.56 \times 10^3 = 0.3 \times 0.13 r_1^2 \times 1.125 r_1 \times 2$$

$$\boxed{r_1 = 53.66 \text{ mm}}$$

$$r_2 = 1.25 \times 53.66$$

$$\boxed{r_2 = 67.07 \text{ mm}}$$

$$W = 0.13\, r_1^{\,2}$$

$$= 0.13 \times 53.66^2$$

$$\boxed{W = 374.3\ N}$$

Result:

$r_1 = 53.66\ mm$

$r_2 = 67.07\ mm$

$W = 374.3\ N$

4. A motor car develops 5.96 KW @ 2100 rpm. Find the suitable size of clutch plate having friction lining riveted on both sides to transmit power under the following condition

(a) Intensity of pressure on the surface not to exceed 6.87×10^4 Pa

(b) Slip torque and losses due to wear and etc is 35% of engine torque

(c) Coefficient of friction on contact surface is 0.3

(d) Inside diameter of the friction plate is 0.55 times the outside diameter.

Given :

$P = 5.96\ kW = 5.96 \times 10^3\ W$

$N = 2100\ rpm$

$P_{max} = 6.87 \times 10^4\ Pa = 0.0687 \times 10^6\ Pa$

$= 0.0687\ N/mm^2$

$T = 1.35 \times T_e$ [Because, the losses are considered as given in (b) point]

T is 100% Engine Torque & 35% loss. So, considering both 100+35 = 135% ⇒ 1.35

$\mu = 0.3$

$d_1 = 0.55 d_2 \Rightarrow r_1 = 0.55 r_2$

To find:

Single plate clutch so, $n = 2$

(i) r_1, r_2

Solution

$T = \mu W R n$

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

$$5.96 \times 10^3 = \frac{2 \times \pi \times 2100 \times T_e}{60}$$

$$\boxed{T_e = 27.1\ N.m}$$

(or)

$T_e = 27.1 \times 10^3\ N.mm$

$T = 1.35 \times T_e$

$= 1.35 \times 27.1 \times 10^3$

$$\boxed{T = 36.585 \times 10^3\ N.mm}$$

$$W = 2\pi C (r_2 - r_1)$$

$$C = P_{max} \times r_1$$

$$= 0.0687 \times r_1$$

$$= 0.0687 \times 0.55 r_2$$

$$\boxed{C = 0.037785\, r_2}$$

$$W = 2 \times \pi \times 0.037785 r_2 \times (r_2 - 0.55 r_2)$$

$$\boxed{W = 0.1068\, r_2^2}$$

$$R = \frac{2}{3}\left(\frac{r_2^3 - r_1^3}{r_2^2 - r_1^2}\right) = \frac{2}{3}\left[\frac{r_2^3 - (0.55 r_2)^3}{r_2^2 - (0.55 r_2)^2}\right]$$

$$R = \frac{2}{3}\left[\frac{0.833625\, r_2^{\cancel{3}}}{0.6975\, \cancel{r_2^2}}\right]$$

$$\boxed{R = 0.7967742\, r_2}$$

$$T = \mu W R n$$

$$36.585 \times 10^3 = 0.3 \times 0.1068 r_2^2 \times 0.7967742 r_2 \times 2$$

$$\boxed{r_2 = 89.4\,mm} \Rightarrow \boxed{d_2 = 178.8\,mm}$$

$$r_1 = 0.55 \times 89.4$$

$$\boxed{r_1 = 49.2\,mm} \cdot \boxed{d_1 = 98.4\,mm}$$

Result:

(i) $r_1 = 49.2\,mm$ (or) $d_1 = 98.4\,mm$

(ii) $r_2 = 89.4\,mm$ (or) $d_2 = 178.8\,mm$