Problems Related to Drum Brake

1) In a shoe-brake with leading and trailing shoe the total actuating force of 471 N acts at a distance of 0.15 m from the pivot of the shoes which is 0.075 m from the axis of the drum of of radius 0.09 m. The shoes ~~are arranged~~ have symmetrical lining with coefficient of friction 0.45. If the effective radius of the friction force is 0.1 m, calculate the total braking torque, when

(a) The actuating mechanism gives equal force to shoes

(b) When the actuating mechanism gives the shoe equal displacement

Given data:

$$W = 471\,N \Rightarrow W_l = W_t = W_a = \cancel{235.5\,N}$$

$$m = 0.15\,m$$

$$n = 0.075\,m$$

$$\mu = 0.45$$

$$k = 0.1$$

To find:

(i) T_B [At equal force]

(ii) T_B [At equal displacement]

Solution:

(a) With equal actuating force on each shoe

$$W_l = W_t = W_a = \frac{471}{2} = 235.5\,N$$

Since, Shoe have Symmetrical lining

$\theta = 90^\circ$

So,

$$T_l = \frac{W_a\, m\, \mu_f\, k}{n - \mu_f k}$$

$$= \frac{235.5 \times 0.15 \times 0.45 \times 0.1}{0.075 - (0.45 \times 0.1)}$$

$$\boxed{T_l = 53\,N}$$

$$T_t = \frac{W_a\, m\, \mu_f\, k}{n + \mu_f k}$$

$$T_t = \frac{235.5 \times 0.15 \times 0.45 \times 0.1}{0.075 + (0.45 \times 0.1)}$$

$$\boxed{T_t = 13.25\,N}$$

Total braking Torque $T = T_l + T_t$

$= 52.98 + 13.25$

$= 66.23$

Total braking Torque, $\boxed{T_B = 66.23\,Nm}$

(b) For displacement to be equal W_l & W_t are to be in the inverse ratio of the brake torques obtained from the shoes with equal actuating forces

Hence $$\frac{W_l}{W_t} = \frac{T_{t(1)}}{T_{l(1)}}$$

$$\frac{W_l}{W_t} = \frac{13.25}{53} = 0.25$$

$$\boxed{W_l = 0.25\, W_t}$$

From given data,

Total actuating force = 471

$$W_l + W_t = 471$$

$$0.25 W_t + W_t = 471$$

$$\boxed{W_t = 376.8\, N}$$

~~W~~, $W_l = 0.25 \times W_t$

$= 0.25 \times 376.8$

$$\boxed{W_l = 94.2\, N}$$

Therfore

$$\frac{T_l}{T_{l(1)}} = \frac{W_l}{W_{l(1)}} \qquad T_l = 53 \times \frac{W_l}{W_{l(1)}} = \frac{53 \times 94.2}{235.5}$$

$$\boxed{T_l = 21.2\, N}$$

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$\cancel{T_t = 13.25}$

$$\frac{T_t}{T_{t(1)}} = \frac{W_t}{W_{t(1)}} \Rightarrow \frac{T_t}{13.25} = \frac{376.8}{235.5}$$

$$\boxed{T_t = 21.2 \ N.m}$$

Total Braking Torque $T_B = T_l + T_t$

$$= 21.2 + 21.2$$

$$\boxed{T_B = 42.4 \ N.m}$$

Result:

(i) T_B [At equal force] $= 66.23 \ N.m$

(ii) T_B [At equal displacement] $= 42.4 \ Nm$.

2. A passenger car with all wheel brakes weighting 13342 N makes an emergency stop at 96 km/h. The rolling and air resistance at 96 km/h is 804 N total. The coefficient of adhesion is 0.5. Calculate (a) The retarding force if the brakes are applied to locking point, (b) heat flow per minute at each wheel at the beginning of braking.

Given data:

$W = 13342\,N$

$V = 96\,km/h = \frac{96}{3.6} = 26.66\,m/s$

$R = 804\,N$

$\mu = 0.5$

To find:

(i) Total retarding force

(ii) heat flow per minute at each wheel at the beginning of brake

Solution:

With four wheels brakes,

$$\text{Braking force} = \mu R_F + \mu R_R = \mu W$$

$$= \mu W$$

$$= 0.5 \times 13342$$

$$\boxed{\text{Braking force} = 6671\,N}$$

Total retardation force = Braking force + Total resistance

$= 6671 + 804$

$$\boxed{\text{Total retardation force} = 7475\,N}$$

(ii) Since the data are not sufficient to Calculate R_R & R_F seperately, we take the distribution of braking force on each wheel is considered as equal.

Velocity at begining $V = 26.66\ m/s$.

Work done per second due to braking on each wheel at beginning

$$= \frac{\mu W V}{4}$$

$$= \frac{0.5 \times 13342 \times 26.66}{4}$$

$= 44462.2\ Nm/s.$

$= 44462.2 \times 60\ J/min$

$= 2667732.9\ J/min$

$$\boxed{\text{Heat flow} = 2667.73\ kJ/min}$$

Result: (i) Total retardation force $= 7475\ N$

(ii) Heat flow $= 2667.73\ kJ/min$

3. A truck weighing 78480N has its C.G 1.2m in front of the rear axle, 1.8m behind the front axle and 1.35m above the ground level. The front wheel brakes are having only leading shoes whereas the rear wheel brakes have conventional leading and trailing shoes. Final actuating force are applied to all the shoes which are symmetrically placed.

Brake drum diameter = 0.25m

Distance of shoe pivots from the drum axis = 0.2m

Distance of line of action of the actuating from drum axes = 0.1m

Effective radius for the resultant force = 0.46m

Coefficient of friction = 0.4

Diameter of road wheel = 0.92m

Coefficient of adhesion for the road = 0.5

Calculate (a) The magnitude of actuating force on each shoe, and (b) The maximum deceleration possible without any skidding of wheels

Given data:

$W = 78480$ N

$d_a = 0.25$ m

$m = 0.2$ m

$n = 0.1$ m

$k = 0.16$ m

$\mu_f = 0.4$

$d = 0.92$ m $\Rightarrow r = 0.46$ m

$\mu = 0.5$

To find:

(i) W_a

(ii) f

Solution:

Total braking Torque on the drum due to 6 leading and 2 Trailing shoes present in 4 wheels.

$$= 6\,T_l + 2\,T_t$$

$$= 6\,\frac{W_a \mu_f k m}{n - \mu_f k} + \frac{2\,W_a \mu_f k m}{n + \mu_f k}$$

$$\boxed{\text{Total braking Torque} = W_a \mu_f k m \left(\frac{6}{n - \mu_f k} + \frac{2}{n + \mu_f k}\right)} \rightarrow (1)$$

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When brakes are applied to 4 wheels, the total braking force $= \mu W = (W/g) f$

Hence

Braking Torque on wheels $= \mu W r$. ↳ (2)

(1) = (2)

$$\mu W r = W_a \mu_f k m \left[\frac{6}{n - \mu_f k} + \frac{2}{n + \mu_f k} \right]$$

$$0.5 \times 78480 \times 0.46 = W_a \times 0.4 \times 0.16 \times 0.2 \times \left[\frac{6}{0.1 - (0.4 \times 0.16)} + \frac{2}{0.1 + (0.4 \times 0.16)} \right]$$

$$\boxed{W_a = 7884.2 \text{ N}}$$

b) For all wheel brake, we have

$$\mu = \frac{f}{g} \Rightarrow 0.5 = \frac{f}{9.81}$$

$$\boxed{f = 4.905 \text{ m/s}^2}$$

Result:

$W_a = 7884.2$ N

$f = 4.905$ m/s^2

4) A passenger car of all up weight 14322.6N is fitted with four wheel brakes and slowed uniformly from 86.5 km/h to 48 km/h in a distance of 152.5 m while running down an incline of 1 in 15. Calculate the amount of heat generated in KJ during this operation and mention the methods employed to transfer this heat to the atmosphere. If the front wheels shares 55% of the braking forces, Calculate the mean lining pressure in N/m^2 on the front wheel brakes from the following data:

Brake lining width = 0.05 m

Effective wheel diameter = 0.686 m

Brake drum diameter = 0.318 m

Lining area per drum = $0.0321 \, m^3$

Coefficient of friction between drum and lining = 0.35

What is the lining contact angle in each drum?

Given data:

$W = 14322.6\ N$

$U = \cancel{86\ km}\ 86.5\ km/hr = 24.03\ m/s$

$V = 48\ km/hr = 13.3\ m/s$

$S = 152.5\ m$

$\sin\theta = \frac{1}{15}$

Brake line width = 0.05 m

wheel diameter = 0.686 m

Brake drum diameter = 0.318 m

Lining area per drum = $0.0321\ m^2$

$\mu_f = 0.35$

To find:

(i) Heat generated.

(ii) Mean Lining pressure

(iii) Lining contact angle.

Solution:

Retardation of vehicle $f = \frac{U^2 - V^2}{2S}$

$$= \frac{24.03^2 - 13.3^2}{2 \times 152.5}$$

$$\boxed{f = 1.31\ m/s^2}$$

Total braking force while running down an incline $\Rightarrow F = W\sin\theta + \left(\frac{W}{g}\right) f$

$$F = \frac{14322.6}{15} + \frac{14322.6}{9.81} \times 1.31$$

$$\boxed{F = 2867.4\ N}$$

Work done in braking the vehicle = Braking force [F] × Stopping distance [S]

$= 2867.4 \times 152.5$

$= 437284.6\ Nm$

$1\ N.m = 1\ J$

work done $= 437.2846\ kN.m$

~~Work done~~ $= 437.28\ kJ$

$\boxed{\text{Heat equivalent to this work} = 437.28\ kJ}$

(ii)

Given that front wheel shares 55% of braking force. Hence braking force on each front wheel is

$$= \frac{2867.4 \times 0.55}{2}$$

$\boxed{\text{Braking force on each front wheel} = 788.5\ N}$

Braking Torque = Braking force × wheel radius

$= 788.5 \times 0.343$

$\boxed{\text{Braking Torque on each wheel} = 270.47\ Nm}$

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Braking Torque on each drum = $2\mu_f P r$

$$~~250~~ \quad 270.47 = 2\mu_f P \times r$$

$$270.47 = 2 \times 0.35 \times P \times 0.159.$$

$$\boxed{P = 2430 N}$$

Area of lining (half side of drum) $= \frac{0.0321}{2}$

$= 0.01605 m^2$

Average lining pressure $= \frac{2430}{0.01605}$

$$\boxed{\text{Average lining pressure} = 151408 \ N/m^2}$$

Area of lining = Width × Radius × Arc Subtended at the center

$$0.01605 = 0.05 \times 0.159 \times \frac{\alpha \pi}{180}$$

$$\boxed{\alpha = 115.6^\circ}$$

∴ Lining contact in each drum $= \alpha \times 2$

$= 115.6 \times 2$

$$\boxed{\text{Lining contact in each drum} = 231.3^\circ}$$

Result: (i) Heat generated = 437.28 kJ

(ii) Average lining pressure = 151408 N/m^2

(iii) Lining contact in each drum = 231.3°