Subject Name & Code:

KINEMATICS AND THEORY OF MACHINES- BE04000171

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Assignment – 3

Q-1: A shaft runs at 80 rpm and drives another shaft at 150 rpm through a belt drive. The diameter of the driving pulley is 600 mm. determine the diameter of the driven pulley in the following cases. a) Neglecting belt thickness. b) Taking belt thickness as 5mm. c) Assuming for case (ii) total slip of 4%. d) Assuming for case (ii) a slip of 2% on each pulley.

Answer:

Given:
$N_1 = 80$ rpm, $N_2 = 150$ rpm, $D_1 = 600$ mm, $t = 5$ mm, slip $s = 4\%$, $s_1 = s_2 = 2\%$

To Find: D_2 for four cases

Formula:

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \text{(a)}$$
$$\frac{N_2}{N_1} = \frac{D_1 + t}{D_2 + t} \text{(b)}$$
$$\frac{N_2}{N_1} = \frac{D_1 + t}{D_2 + t} \times (1 - s/100) \text{(c)}$$
$$\frac{N_2}{N_1} = \frac{D_1 + t}{D_2 + t} \times (1 - s_1/100)(1 - s_2/100) \text{(d)}$$

Solution:

(a) $\frac{150}{80} = \frac{600}{D_2} \Rightarrow D_2 = \frac{600 \times 80}{150} = 320$ mm

(b) $\frac{150}{80} = \frac{605}{D_2 + 5} \Rightarrow D_2 + 5 = \frac{605 \times 80}{150} = 322.67 \Rightarrow D_2 = 317.67$ mm

(c) $1.875 = \frac{605}{D_2 + 5} \times 0.96 \Rightarrow \frac{1.875}{0.96} = 1.953125 = \frac{605}{D_2 + 5}$

$D_2 + 5 = \frac{605}{1.953125} = 309.76 \Rightarrow D_2 = 304.76$ mm

(d) $1.875 = \frac{605}{D_2+5} \times (0.98 \times 0.98) = \frac{605}{D_2+5} \times 0.9604$

$$\frac{1.875}{0.9604} = 1.9523 = \frac{605}{D_2 + 5}$$

$D_2 + 5 = \frac{605}{1.9523} = 309.89 \Rightarrow D_2 = 304.89$ mm

Final Answer:

$$\boxed{320 \text{ mm},\ 317.67 \text{ mm},\ 304.76 \text{ mm},\ 304.89 \text{ mm}}$$

Q-2: Two parallel shafts connected by a crossed belt, are provided with pulleys 480 mm and 640 mm in diameters. The distance between the centre line of the shaft is 3 m. Find by how much the length of the belt should be changed if it is desired to alter the direction of rotation of the driven shaft.

Answer:

Given:
Crossed belt, $D_1 = 480$ mm, $D_2 = 640$ mm, $C = 3$ m = 3000 mm

To Find: Change in belt length when direction of driven shaft is altered (i.e., crossed to open belt)

Formula:
Crossed belt length:

$$L_c = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{(D_1 + D_2)^2}{4C}$$

Open belt length:

$$L_o = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{(D_2 - D_1)^2}{4C}$$

Change: $\Delta L = L_c - L_o$

Solution:

$D_1 + D_2 = 480 + 640 = 1120$ mm
$D_2 - D_1 = 640 - 480 = 160$ mm
$L_c = 2 \times 3000 + \frac{\pi}{2} \times 1120 + \frac{(1120)^2}{4 \times 3000}$
$L_c = 6000 + 1759.29 + \frac{1254400}{12000} = 6000 + 1759.29 + 104.53 = 7863.82$ mm
$L_o = 6000 + 1759.29 + \frac{(160)^2}{12000} = 6000 + 1759.29 + \frac{25600}{12000}$
$L_o = 6000 + 1759.29 + 2.133 = 7761.42$ mm
$\Delta L = 7863.82 - 7761.42 = 102.4$ mm

Final Answer:

$$\boxed{102.4 \text{ mm (decrease in length)}}$$

Q-3: A belt runs over a pulley of 800 mm diameter at a speed of 180 rpm. The angle of the lap is 165° and the maximum tension in the belt is 2kN. Determine the power transmitted if the coefficient of friction is 0.3.

Answer:

Given:
$D = 800$ mm $\rightarrow r = 0.4$ m, $N = 180$ rpm, $\theta = 165^\circ = 2.88$ rad, $T_1 = 2$ kN = 2000 N, $\mu = 0.3$

To Find: Power transmitted

Formula:

$$\frac{T_1}{T_2} = e^{\mu\theta}, v = \frac{\pi DN}{60}, P = (T_1 - T_2)v$$

Solution:

$$\frac{T_1}{T_2} = e^{0.3\times 2.88} = e^{0.864} = 2.373$$
$$T_2 = \frac{2000}{2.373} = 842.8 \text{ N}$$
$$v = \frac{\pi \times 0.8 \times 180}{60} = \frac{452.389}{60} = 7.54 \text{ m/s}$$
$$P = (2000 - 842.8) \times 7.54 = 1157.2 \times 7.54 = 8725.3 \text{ W} = 8.725 \text{ kW}$$

Final Answer:

$$\boxed{8.725 \text{ kW}}$$

Q-4: A casting weights 6 kN and is freely suspended from a rope which makes 2.5 turns round a drum of 200 mm diameter. If the drum rotates at 40 rpm, determine the force required by a man to pull the rope from the other end of the rope. Also, find the power to raise the casting. The coefficient of friction is 0.25.

Answer:

Given:
$W = 6$ kN = 6000 N, $n = 2.5$ turns, $D = 200$ mm $\rightarrow r = 0.1$ m, $N = 40$ rpm, $\mu = 0.25$

To Find: Force P at other end, Power to raise casting

Formula:

$$\frac{T_1}{T_2} = e^{\mu\theta}, \theta = 2\pi n = 2\pi \times 2.5 = 5\pi \text{ rad}$$
$$v = \frac{\pi DN}{60}, P = (T_1 - T_2)v$$

Solution:

$\theta = 5\pi = 15.708$ rad
$\frac{6000}{P} = e^{0.25\times 15.708} = e^{3.927} = 50.75$
$P = \frac{6000}{50.75} = 118.23$ N
$v = \frac{\pi \times 0.2 \times 40}{60} = \frac{25.133}{60} = 0.419$ m/s
Power $= (6000 - 118.23) \times 0.419 = 5881.77 \times 0.419 = 2464.5$ W $= 2.465$ kW

Final Answer:

$$\boxed{P = 118.23 \text{ N, Power} = 2.465 \text{ kW}}$$

Q-5: The force required just to move a body on a rough horizontal surface by pulling is 320 N inclined at 30° and by pushing 380 N at the same angle. Find the weight of the body and the coefficient of friction.

Answer:

Given:
$P_{\text{pull}} = 320$ N at 30°, $P_{\text{push}} = 380$ N at 30°

To Find: Weight W, coefficient of friction μ

Formula:
Pulling: $P\cos\theta = \mu(W - P\sin\theta)$
Pushing: $P\cos\theta = \mu(W + P\sin\theta)$

Solution:

$\cos 30° = 0.866$, $\sin 30° = 0.5$

Pulling: $320 \times 0.866 = \mu(W - 160) \rightarrow 277.12 = \mu(W - 160)$ …(1)
Pushing: $380 \times 0.866 = \mu(W + 190) \rightarrow 329.08 = \mu(W + 190)$ …(2)

Divide (2) by (1): $\frac{329.08}{277.12} = \frac{W+190}{W-1}$

$$1.1875 = \frac{W + 190}{W - 160}$$

$$1.1875W - 190 = W + 190$$

$0.1875W = 380 \rightarrow W = 2026.67$ N

From (1): $277.12 = \mu(2026.67 - 160) = \mu \times 1866.67$

$$\mu = 0.1485$$

Final Answer:

$$\boxed{W = 2026.67 \text{ N}, \mu = 0.1485}$$

Q-6: A body is to be moved up an inclined plane by applying a force parallel to the plane surface. It is found that a force of 3 KN is required to just move it up the plane when the angle of inclination is 10° whereas the force needed increase to 4 KN when the angle of inclination is increased to 15°. Determine the weight of the body and the coefficient of friction.

Answer:

Given:
$F_1 = 3$ kN = 3000 N at $\alpha = 10^\circ$
$F_2 = 4$ kN = 4000 N at $\alpha = 15^\circ$
Force parallel to plane

To Find: Weight W, coefficient of friction μ

Formula:
Up the plane: $F = W\sin\ \alpha + \mu W\cos\ \alpha$

Solution:

For 10°: $3000 = W\sin\ 10^\circ + \mu W\cos\ 10^\circ = W(0.1736 + 0.9848\mu)$ …(1)
For 15°: $4000 = W\sin\ 15^\circ + \mu W\cos\ 15^\circ = W(0.2588 + 0.9659\mu)$ …(2)

Divide (2) by (1):

$$\frac{4000}{3000} = \frac{0.2588 + 0.9659\mu}{0.1736 + 0.9848\mu}$$

$$1.333 = \frac{0.2588 + 0.9659\mu}{0.1736 + 0.9848\mu}$$

$$1.333(0.1736 + 0.9848\mu) = 0.2588 + 0.9659\mu$$

$$0.2314 + 1.312\mu = 0.2588 + 0.9659\mu$$

$$1.312\mu - 0.9659\mu = 0.2588 - 0.2314$$

$0.3461\mu = 0.0274 \rightarrow \mu = 0.0792$

From (1): $3000 = W(0.1736 + 0.9848 \times 0.0792) = W(0.1736 + 0.0780) = W \times 0.2516$

$$W = \frac{3000}{0.2516} = 11923.7 \text{ N} = 11.92 \text{ kN}$$

Final Answer:

$$\boxed{W = 11.92 \text{ kN}, \mu = 0.0792}$$