* Examples on belts

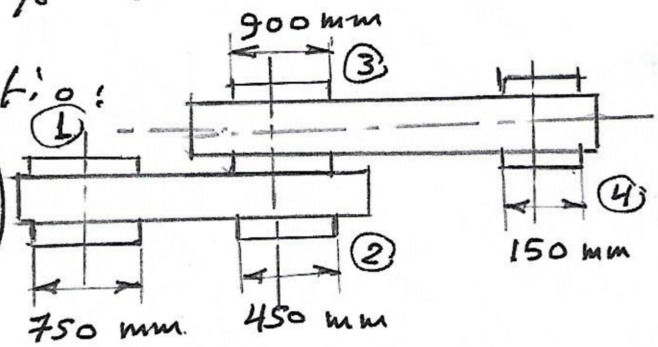
امثلة تطبيقية على الاحزمة

* Example (1) :

An engine running at (150 r.p.m), drives a line shaft by means of a belt. The engine pulley is (750 mm) diameter, and the pulley on the line shaft being (450 mm). A (900 mm) diameter pulley on the line shaft drives a (150 mm) diameter pulley keyed to a dynamo shaft. Find the speed of the dynamo shaft, when theres is a slip of 2% at each drive.

* Solution :

speed ratio:



$$R_V = \frac{N_4}{N_1} = \frac{d_1 * d_3}{d_2 \times d_4}\left(1-\frac{S_1}{100}\right)\left(1-\frac{S_2}{100}\right)$$

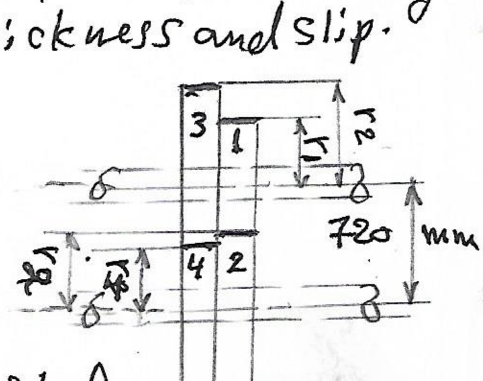
$$\therefore R_V = \frac{N_4}{150} = \frac{750 * 900}{450 \times 150}\left(1-\frac{2}{100}\right)\left(1-\frac{2}{100}\right) = 9.6$$

$$\therefore N_4 = 150 * 9.6 = 1440 \text{ r.p.m}$$

* Example (2)

A shaft which rotates at a constant speed of (160) r.p.m. is connected by belt to a parallel shaft (720) mm aparat. which has to run at 60, 80 r.p.m. The smallest pulley on the driving shaft is (40) mm in radius, Determine the radius of the two stepped pulley by using open belt drive, and neglect thickness and slip.

Solution :



For open Flat belt drive

$$R_{V_1} = \frac{N_2}{N_1} = \frac{r_1}{r_2}$$

But $N_1 = N_3 = 160$ r.p.m

1) for first step

$\because R_{v_1} = \frac{160}{60} = \frac{40}{r_2} \Rightarrow r_2 = \frac{40*60}{160} = \underline{\underline{106.7\ mm}}$

2) for second step

$R_{v_2} = \frac{N_4}{N_3} = \frac{r_3}{r_4} \Longrightarrow r_4 = r_3 * \frac{N_3}{N_4} = r_3 * \frac{160}{80} = \underline{\underline{2r_3}}$

in order to determine r_3 we get to the C. Law.
by using length of belt for pulley 1, 2

$L = \pi(r_1 + r_2) + 2X + \frac{(r_2 - r_1)^2}{X}$

$= 3.14\,(40 + 106) + 2 * 720 + \frac{(106.7 - 40)^2}{720}$

$L = 1907\ mm$

now the length for pulley 3, 4

$L = 1907 = \pi(r_3 + r_4) + \frac{(r_4 - r_3)^2}{X} + 2X$

$1907 = 3.14\,(r_3 + 2r_3) + \frac{(2r_3 - r_3)^2}{720} + 2*720$

$1907 = 9.436\,r_3 + 0.0014\,r_3^2 + 1440$

or $\underbrace{0.0014}_{أ}\,r_3^2 + \underbrace{9.426}_{ب}\,r_3 - \underbrace{467}_{جـ} = 0$ مربع كامل يحل بالدستور

$\therefore r_3 = \frac{-9.426 \pm \sqrt{(9.426)^2 + 4 * 0.0014 * 467}}{2 * 0.0014}$

$= \frac{-9.426 \pm 9.564}{0.0028} = 49.3\ mm$

$\therefore r_4 = 2r_3 = 2 * 49.3 = \underline{\underline{98.6}}\ mm$

$0 = جـ + ب س + أ س^2$

الدستور

$x = \frac{-ب \pm \sqrt{ب^2 + 4 أجـ}}{2أ}$

* Example (3) :

Find the power transmitted by a belt running over a pully of (600) mm diameter at (200) r.p.m. The coefficient of friction between the belt and pulley is ($\mu = 0,25$). angle of lap (160°), and maximam tension in the belt is (2500 N)

Solution : given date are

$d = 600\ mm = 0,6\ m$, $N_1 = 200\ r.p.m$, $\mu = 0,25$,

$\theta = 160° = 160 * \frac{\pi}{180} = 2,793\ rad$, $T_1 = 2500\ N$

$\therefore P = (T_1 - T_2) * V$, W

$$V = \frac{\pi d_1 n_1}{60} = \frac{3,14 * 0,6 * 200}{60} = 6.284\ m/s$$

$$2,3 \log\left(\frac{T_1}{T_2}\right) = \mu\theta = 0,25 * 2,793 = 0,6982$$

$$\therefore \log\left(\frac{T_1}{T_2}\right) = \frac{0,6982}{2,3} = 0,3036$$

$$\therefore \frac{T_1}{T_2} = 2.01 \qquad \rightarrow \text{anti} \log(0,3036.)$$

$$\therefore T_2 = \frac{T_1}{2.01} = \frac{2500}{2.01} = 144\ N$$

$$\therefore P = (2500 - 144) * 6.284 = 7.89\ W$$

* Example (4) :

Two pulleys, one (450) mm diameter and the other 200mm diameter are on parallel shafts (1.95) m aparat and are Connected by a crossed belt, find the length of the belt required, and the angle of contact between the belt and each pulley, and what power can be transmitted by the belt, when the larger pulley rotates at (200) r.p.m, If the maximum permissible tension in the belt is (1 kN), and the coefficient of friction between the belt and pulley is ($\mu = 0,25$), $d_2 = 200$ mm

Solution: given date are

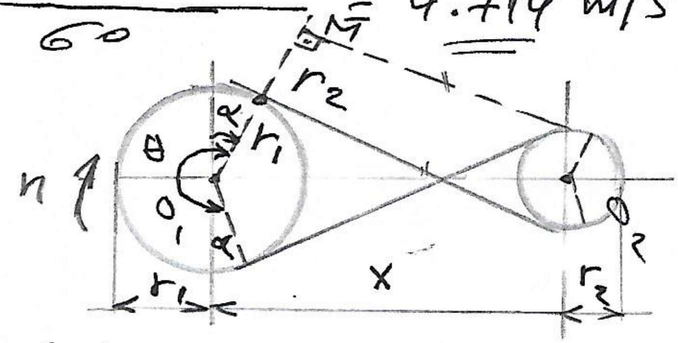
$d_1 = 450$ mm $= 0,45$ m, $r_1 = 0,225$ m, $d_2 = 200$ mm

$r_2 = 0,1$ m, $X = 1.95$ m, $N_1 = 200$ r.p.m, $T_{\times} = 1000$ N

$\mu = 0,25$, cross belt drive.

1) $P = (T_1 - T_2) * V \rightarrow$ transmitted power.

$$V = \frac{\pi d_1 n_1}{60} = \frac{3,14 * 0,45 * 200}{60} = 4.714 \text{ m/s}$$



2) length of cross belt drive

$$l = \pi(r_1 + r_2) + 2X + \frac{(r_1 + r_2)^2}{X}$$

$$= 3.14(0,225 + 0,1) + 2 * 1.95 + \frac{(0,225 + 0,1)^2}{1.95} = 4.975 \text{ m}$$

3) Angle of contact $\rightarrow \theta$ between belt and pulley

$$\theta = 180 + 2\alpha$$

$$\sin\alpha = \frac{r_1 + r_2}{X} \rightarrow \text{from right } \Delta\, O_1 O_2 M$$

$$= \frac{0,225 + 0,1}{1.95} = 0,1667,$$

$\therefore \alpha = 9.6°$

$\therefore \theta = 180^\circ + 2\alpha = 180^\circ + 2 \times 9.6^\circ = 199.2^\circ$

$\therefore \theta = 199.2^\circ * \frac{\pi}{180} = 3.477$ rad. زاوية فعلية

* for determing T_2 in slack side.

$2.3 \log \left(\frac{T_1}{T_2}\right) = \mu \theta = 0,25 * 3.477 = 0,8692$

$\therefore \log \frac{T_1}{T_2} = \frac{0,8692}{2,3} = 0,378$

$\therefore \frac{T_1}{T_2} = 2,387$ (anti log 2,387)

$\therefore T_2 = \frac{T_1}{2,387} = \frac{1000}{2,387} = 419\ N$

$\therefore P = (T_1 - T_2) \times V = (1000 - 419) \times 4.714 = 2740 W$

Example (5):

A shaft rotating at (200) r.p.m drives another shaft at (300) r.p.m and transmits (6) kw power through a belt. The belt is (100) mm wide and (10) mm thick. The distance between the shafts is (4 m). The smaller pulley is (0,5) m in diameter. Calculate the stress in the belt, if it is an open belt drive, and coefficient of friction between belt and pulley (0,3).

Solution: give data

$N_1 = 200$ r.p.m, $N_2 = 300$ r.p.m, $P = 6$ kW → for ②

$b = 100$ mm, $t = 10$ mm, $X = 4$ m, $d_2 = 0,5$ m, $\mu = 0,3$

$\sigma = \frac{T_1}{A} = \frac{T_1}{b \times t}$

$P = (T_1 - T_2) \times V$

$P_1 = P_2 = P$ on both pulleys

$$V_2 = \frac{\pi d_2 N_2}{60} = \frac{3,14 * 0,5 \times 300}{60} = 7.855 \, m/s$$

where;

$$R_v = \frac{N_2}{N_1} = \frac{d_1}{d_2} \Rightarrow d_1 = \frac{N_2 d_2}{N_1} = \frac{300 * 0,5}{200} = 0,75 \, m$$

angle of contact on small pulley → for open b-drive.

$$\theta = 180 - 2\alpha$$

$$\tan\alpha = \frac{r_1 - r_2}{x} = \frac{0,75 - 0,5}{4} = 0,03125$$

0,37

$$\therefore \alpha = 1.8^\circ$$

$$\therefore \theta = 180 - 2 * 1.8^\circ = 176.4^\circ$$

$$\therefore \theta = 176.4^\circ * \frac{\pi}{180} = 3.08 \, rad$$

$$2,3 \log\left(\frac{T_1}{T_2}\right) = \mu\theta = 0,3 * 3,08 = 0,924$$

$$\log\frac{T_1}{T_2} = \frac{0,924}{2,3} = 0,4017$$ By (Anti log)

$$\therefore \frac{T_1}{T_2} = 2,52 \Rightarrow T_1 = 2,52 \, T_2 \quad \text{--- (1)}$$

From power $P = (T_1 - T_2) * V$

$$6 * 10^3 = (T_1 - T_2) * 7.825$$

$$\therefore T_1 - T_2 = \frac{6 * 10^3}{7.825} = 764 \, N \quad \text{--- (2)}$$

by sub (1) in (2) → we get

$$2,52 T_2 - T_2 = 764$$

$$\therefore T_2 = 503 \, N, \quad T_1 = 2,52 * 503 = 1267 \, N$$

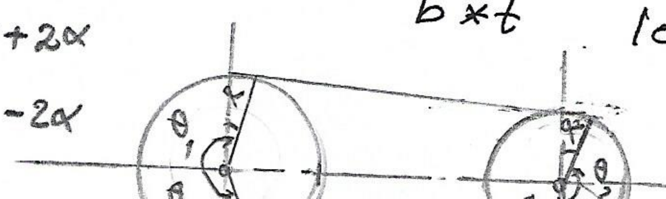
For the stress :

$$\sigma = \frac{T_1}{A} = \frac{T_1}{b * t} = \frac{1267}{10 * 100} = 1,267 \, N/mm^2$$

$$= 1,267 \, Mpa$$

$\theta_1 = 180 + 2\alpha$

$\theta_2 = 180 - 2\alpha$



* Example (6):

A leather belt is required to transmit (7.5) kW from a pulley (1.2) m in diameter. running at (250) r.p.m. The angle embraced is ($\theta = 165°$) and the coefficent of friction between the belt and the pulley is ($\mu = 0,3$). if the safe working stress for the leather belt is ($\sigma = 1.5$ Mpa), density كثافة of leather ($\rho = 1$ Mg/m^3) and thickness of belt ($t = 10$ mm). determine the width of the belt taking Centrifugal tension into account.

· answer = $\boxed{b = 65,8 \text{ mm}}$.

Home work → b = ?

$\sigma = \frac{T}{A} = \frac{T}{b \times t}$ Stress. الإجهاد

$A = b * t$ مساحة الجسم

$m = Volum * \rho = A * l * \rho$ الكثافة الكتلة

$T_c = m r \omega^2 = m . V^2$ قوة الطرد المركزي

$V = \frac{\pi d n}{60} = \frac{3,14 * 1,2 * 250}{60} = 15,71$ m/s

$P = (T_1 - T_2) * V \Rightarrow 7500 = (T_1 - T_2) * 15.71$

$\therefore T_1 - T_2 = \frac{7500}{15,71} = 477.4$ N --- (1)

$2,3 \, Log\left(\frac{T_1}{T_2}\right) = \mu . \theta = 0,3 * \frac{\pi * 165}{180} = 0,864$

$\therefore Log\left(\frac{T_1}{T_2}\right) = \frac{0,864}{2,3} = 0,3756 \Rightarrow \frac{T_1}{T_2} = 2375$ --- (2) Anti log.

from (1) and (2) $\Rightarrow T_1 = 824,6N, \; T_2 = 347.2N$

$m = V * \rho = A \times L * \rho = b * t * L * \rho = b \times 0,01 * 1 * 1000 = 10 b$ kg.

$Tc = m * V^2 = 10 b * (15.71)^2 = 2468 b N$

$\therefore T = \sigma * b * t = 15000 b$ --- (3)