Power transmission system

- MPTS
  - +ve Drives / Non-flexible
    - Gears
    - Chain
  - −ive Drives / Flexible
    - Belt
    - Rope drive
      - Fiber
      - Wire

Requirement of the PTS :-

1. To obtain speed reduction
2. To obtain variable speed at driven machine
3. To drive more than one machine by using a single prime mover
4. To transmit power for long distance

Difference b/w flexible power transmission system and non flexible power transmission system :-

Non-flexible	flexible
① Centre distance is small	① Centre distance is large
② velocity ratio is constant	② velocity ratio is not const
③ High cost	③ less cost
④ Pure damping capacity due to direct contact	④ Good damping capacity
⑤ more efficiency	⑤ less efficiency

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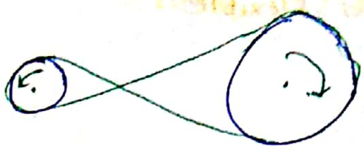
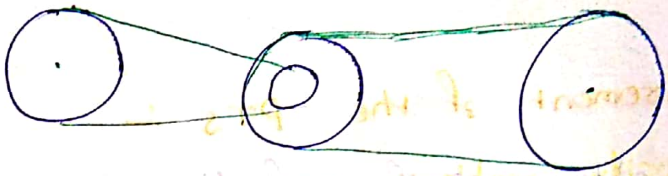
Types of Flat belt drive :-

① open belt

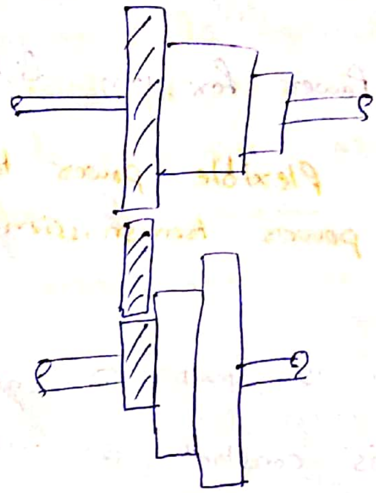
② cross belt



③ compound

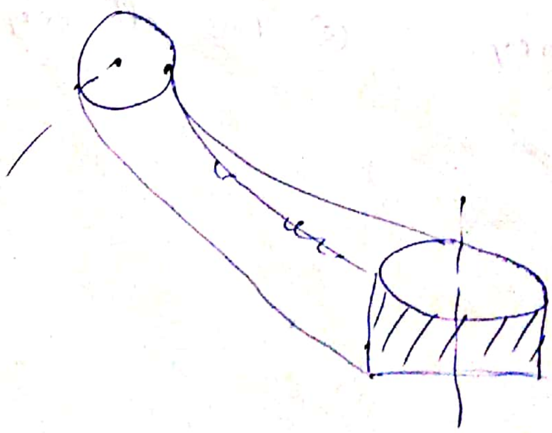


④ stepped



$$V.R = \frac{N_2}{N_1} = \frac{D_1}{D_2}$$

⑤ Quarter turn



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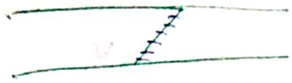
Material used for belt :-

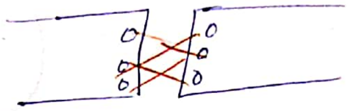
1. Leather belt
2. Fiber/clothe belt
3. Rubber belts

Types of belt joints :-

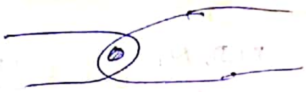
1. Cemented joint



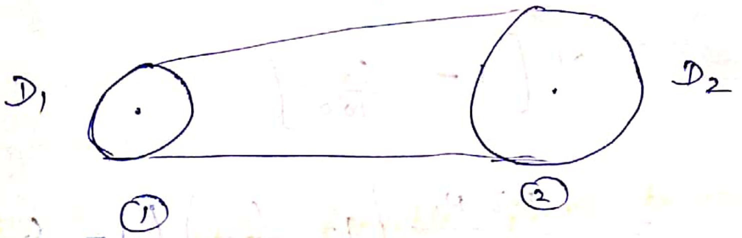
2. Laced joint



3. Hinged joint

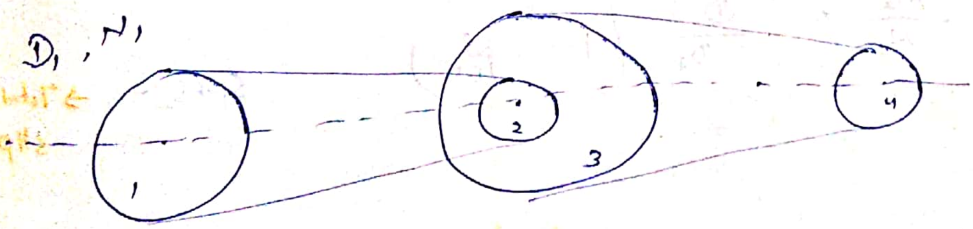


Velocity ratio :-



1. if no slip : $\frac{\pi D_1 N_1}{60} = \frac{\pi D_2 N_2}{60}$

$$\Rightarrow V.R = \frac{N_2}{N_1} = \frac{D_1}{D_2}$$



$$V.R = \frac{N_4}{N_1} = \frac{N_4}{N_3} \times \frac{N_2}{N_1} \quad \{ \because N_2 = N_3 \}$$

$$V.R = \frac{N_4}{N_1} = \frac{D_3}{D_4} \times \frac{D_1}{D_2}$$

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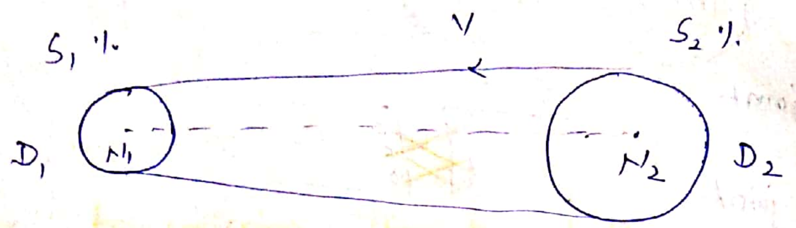
Slip in the belt drive :-

① It reduces the velocity ratio in the belt drives

Let S_1 and S_2 is the percentage slip in the driving & driven pulley



V (Belt velocity at pulley 1) $= \frac{\pi D_1 N_1}{60} - \frac{\pi D_1 N_1}{60} \times \frac{S_1}{100}$

Velocity at driven $= V - V \cdot \frac{S_2}{100}$

$= V\left[1 - \frac{S_2}{100}\right]$

$$\frac{\pi D_2 N_2}{60} = \frac{\pi D_1 N_1}{60}\left(1 - \frac{S_1}{100}\right)\left(1 - \frac{S_2}{100}\right)$$

$$\Rightarrow \frac{N_2}{N_1} = \frac{D_1}{D_2}\left[1 - \frac{S_1}{100} - \frac{S_2}{100} + \frac{S_1 S_2}{100 \times 100}\right]$$ (Neglect)

$$\Rightarrow \frac{N_2}{N_1} = \frac{D_1}{D_2}\left[1 - \left(\frac{S_1 + S_2}{100}\right)\right]$$

$$\Rightarrow \frac{N_2}{N_1} = \frac{D_1}{D_2}\left(1 - \frac{S}{100}\right)$$

$S_1 + S_2 = S \rightarrow$ Total slip

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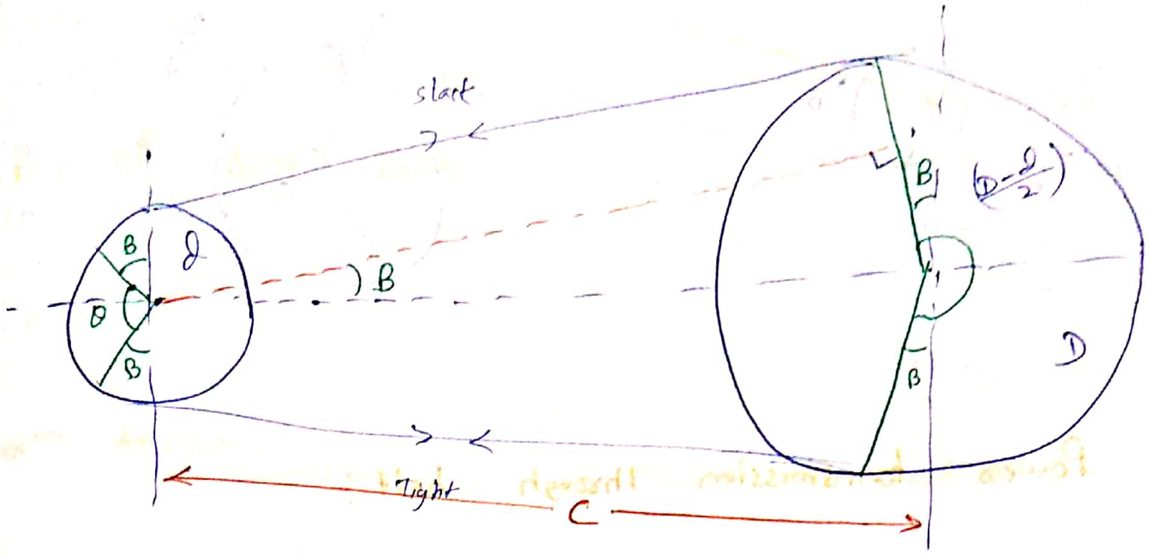
open belt drive :-

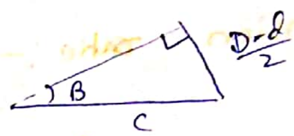


→ slack is up so θ is more $\left(\frac{T_1}{T_2} = e^{\mu\theta}\right) \Rightarrow \left(\frac{T_1}{T_2}\right)$ is more

hence power transmission is more

→ but in chain drive, slack is down b/c to avoid the ~~cont~~ rubbing b/w slack & tight

$$\sin \beta = \frac{D-d}{2c}$$



Angle of contact :-

Driving pully : $\theta_s = 180 - 2\beta$

$$= 180 - 2\sin^{-1}\left(\frac{D-d}{2c}\right)$$

Driven pully : $180 + 2\beta$

→ if the material of both pulley is same then we design on the basis of lower pulley because at smaller pulley angle of rap is small

Length of open belt (L_c) :-

$$L_c = 2c + \frac{\pi(D+d)}{2} + \frac{(D-d)^2}{4c}$$

Length of cross belt (L_c) :-

$$L_c = 2c + \frac{\pi(D+d)}{2} + \frac{(D+d)^2}{4c}$$

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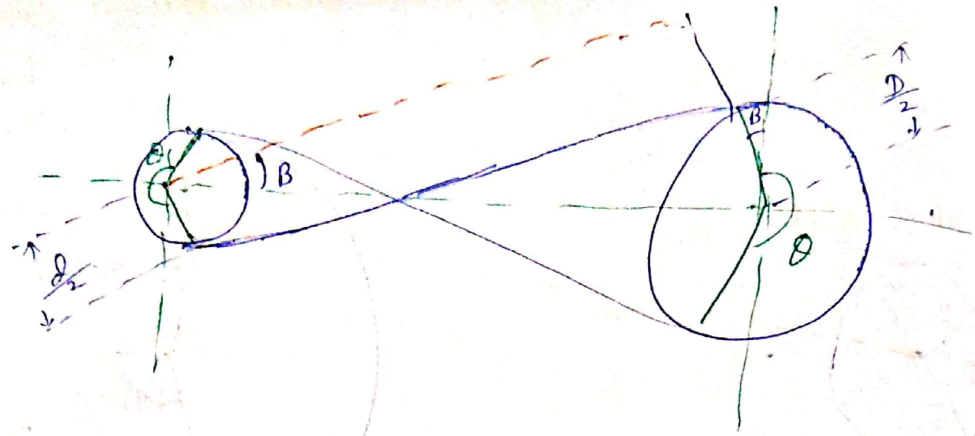
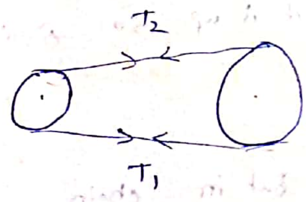
and thus, it is a positive drive.

- No effect of …



Power transmission through belt :-



$$P = F \cdot V$$

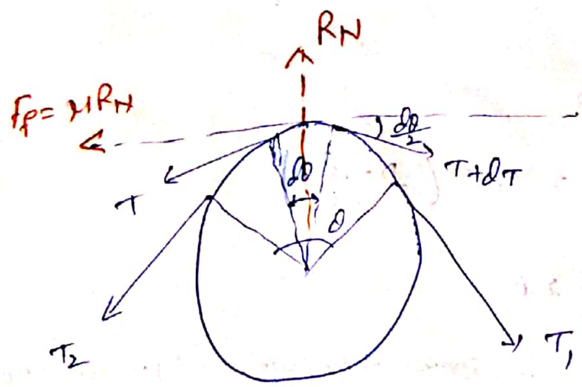
$$= (T_1 - T_2)V$$

$$= T_2\left(\frac{T_1}{T_2} - 1\right)V$$

$$= T_2\left(e^{\mu\theta} - 1\right)V$$

$\theta \rightarrow$ wrap/contact angle in radian

Tension ratio :-



$\Sigma F_V = 0$

$$R_N = T\sin\left(\frac{d\theta}{2}\right) + (T+dT)\sin\left(\frac{d\theta}{2}\right).$$

Small angle $\sin\frac{d\theta}{2} \simeq \frac{d\theta}{2}$

$\Sigma F_H = 0$

$$(T+dT)\cos\left(\frac{d\theta}{2}\right) = T\cos\left(\frac{d\theta}{2}\right) + \mu R_N \quad \text{— (ii)}$$

$$\int_{T_2}^{T_1} \frac{dT}{T} = \int_0^{\theta} \mu\, d\theta \Rightarrow \ln\left(\frac{T_1}{T_2}\right) = \mu\theta$$

$$\boxed{\frac{T_1}{T_2} = e^{\mu\theta}}$$

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Note:-

① If the material of the pullies are same. the design of the belt is done on the basis of smaller pulley because θ is less

② If the material of the pullies are different the design of belt is based on smaller $\mu\theta$

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$\mu\theta \downarrow \Rightarrow \frac{T_1}{T_2} \downarrow \rightarrow T_1\downarrow \rightarrow P\downarrow$

Max^m tension :-

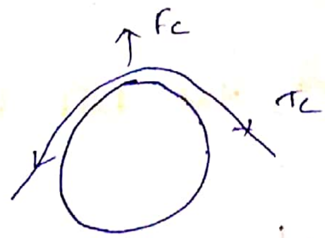
$$\sigma_{induce} \leq \sigma_{permissible}$$

$$\frac{T_1}{bt} \leq \sigma_{per}$$

$$\Rightarrow T_1 \leq \sigma_{per} \cdot bt$$

$$\Rightarrow T_1 \leq T_{max} \quad \Rightarrow \boxed{T_{max} = \sigma_{per} \cdot b \cdot t}$$

Centrifugal tension :- It is the additional tension develop in the belt to counter act the effect of centrifugal force



$T_C = mv^2$

m = mass of belt per unit length

v = peripheral velocity

Tight side tension = $T_1 + T_C$

slack side tension = $T_1 + T_C$

→ Due to centrifugal action power transmission is decreases

$P = (T_1 - T_2)\, v$

$= T_1 \left(1 - \frac{T_2}{T_1}\right) v$

$= T_1 \left(1 - \frac{1}{e^{\mu\theta}}\right) v$

$= T_1 K V$

if centrifugal tension $(T_C) = 0$

$T_{max} = T_1$

centrifugal tension $(T_{max}) = T_1 + T_C$

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$T_c = 0$, $P = T_{max} \cdot k' \cdot V$

$$P = (T_{max} - T_c)\, k' \cdot V$$

→ Power transmission of the belt drive decreases in presents of centrifugal tension hence centrifugal tension is harmful with respect to power transmission capacity of a belt drive

Condition for max^m Power transmission :-

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

$$= T_1 \left(1 - \frac{1}{e^{\mu\theta}}\right) \cdot V$$

$$= T_1 \cdot k' \cdot V$$

$$= (T_{max} - T_c)\, k' V$$

$$= (T_{max} - mv^2)\, k' \cdot V$$

$$\Rightarrow P = f(V)$$

$$P = (T_{max} V - mV^3)\, k'$$

for max^m Power $\frac{dP}{dv} = 0$

$$\frac{dP}{dv} = (T_{max} - m \cdot 3V^2)\, k' = 0$$

$$\Rightarrow T_{max} = 3mV^2$$

$$\Rightarrow V^2 = \frac{T_{max}}{3m}$$

$$\Rightarrow T_{max} = 3T_c$$

$$\boxed{T_c = \frac{T_{max}}{3}}$$

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$$T_{max} = T_1 + T_c$$

$$3T_c = T_1 + T_c$$

$$\Rightarrow 2T_c = T_1$$

$$\Rightarrow \boxed{T_c = \frac{T_1}{2}}$$

Initial tension in the belt :-

$$T_0 = \frac{T_1 + T_2 + 2T_c}{2}$$

According to C.G. Barth ; $\sqrt{T_1} + \sqrt{T_2} = \sqrt{T_0}$

Law of Belting :-

The law of belting states – " The centreline of the belt when it approaches a pulley must lie in the mid plane of that pulley."

Note: ① It is observed that max^m^ stress in the belt is induced in the tight side of belt when it passes over a small pulley.

② In Horizontal belt drive, the upper side should be loose side.

Assignment Ques^n^ A flat belt drive is required to transmit 8 kW of power from a shaft rotating at 240 rpm to another shaft rotating at 160 rpm. The Belt is 8 mm thick. The diameter of the smaller pulley is 600 mm and the two shafts are 5 m apart. The coefficient of friction is 0.25. If the maximum stress in the belt is limited to 3 N/mm², find the width of the belt for

(i) An open belt drive.

(ii) A cross-belt drive.

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