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* Belt Drive

A belt drive is a frictional drive that transmits power from one shaft to other shafts by using pulleys and an elastic belt.

Types of Belts

1- Flat belt: It is used in factory & workshop for power transmission up to 8m distance.

$$V_1 = V_2$$

$$\frac{\pi D_1 N_1}{60} = \frac{\pi D_2 N_2}{60} \quad \text{Belt drive} \rightarrow \text{Belt + Pulleys + shafts etc}$$

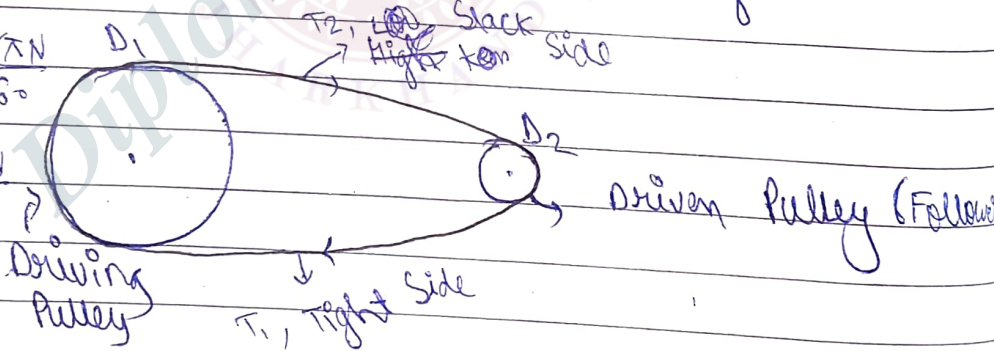
$$D_1 N_1 = D_2 N_2$$

Belt is a part of belt drive

$$V_1 = R_1 \omega_1$$

$$= \frac{D_1}{2} \times \frac{2\pi N}{60}$$

$$= \frac{\pi D_1 N}{60}$$



Belt is used to transmit power from one shaft to another shaft by means of pulleys which rotates at the same speed or different speed and same direction or different direction.

$$DN = C$$

$$N \propto \frac{1}{D}$$

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* Types of Belt

On the basis of velocity

- ① Light Belt drive \rightarrow 10 m/s \rightarrow Lower Power transmission
- ② Medium Belt drive \rightarrow 10-22 m/s \rightarrow Medium Power transmission
- ③ Heavy Belt drive \rightarrow 22 m/s \rightarrow Large Power transmission

- Uses
- ① Light Belt drive \rightarrow Agriculture in ~~machines~~ ^{machine} tool.
 - ② Medium Belt drive \rightarrow Machine tool.
 - ③ Large Belt drive \rightarrow Compression, hydraulic machine.

On the basis of shape

- ① Flat belt \rightarrow Not more than 8m (b/w pulleys)
- ② V-belt \rightarrow For shorter distance
- ③ Circular belt \rightarrow More than 8m

Applications

Flat belt \rightarrow moderate power transmission for
 example factory joint workshop

V-belt \rightarrow

Circular belt \rightarrow for more power transmission.

On the basis of material

Leather belt :- It is made up of leather, the best leather belt are made from ~~12~~ ^{12 to 15 long} ~~leather~~ ^{strips}.
~~Cotton / fabric belt~~ The leather may be either ~~obtained~~ ^{obtained} Oak-tanned, mineral salt tanned in order to increase the thickness of belt, the ~~rubber~~ ^{rubber} belts & ~~strips~~ ^{strips} are.

According to number of layers example :- 1.

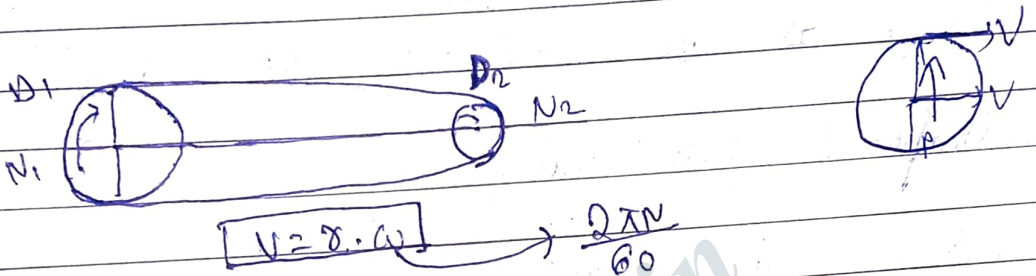
According to the thickness of

(ii) Cotton / fabric belt :- Most of the fabric belts are woven into a strip of a desired width and thickness depending upon requirement. They are impregnated with some oil like the li oil in order to make them water proof. The cotton belts are cheaper and suitable for use in damp atmosphere. It is mostly used in farm machinery. Belt unfair etc.

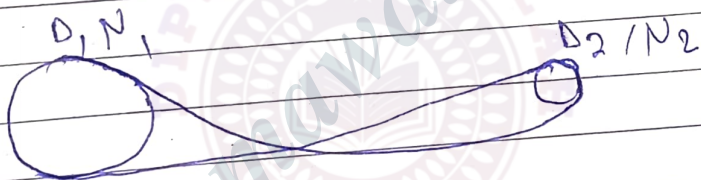
(iii) Balata belt :-
~~Rubber~~ belt :-

* Types of Flat belt drive

Open Belt drive (OBD)



rpm → revolution per minute



$$\begin{aligned}
 V &= \pi DN \\
 &= \pi \cdot d \cdot \omega \\
 &= \frac{\pi}{2} \times \frac{2\pi N}{60} \\
 &= \frac{\pi DN}{60}
 \end{aligned}$$

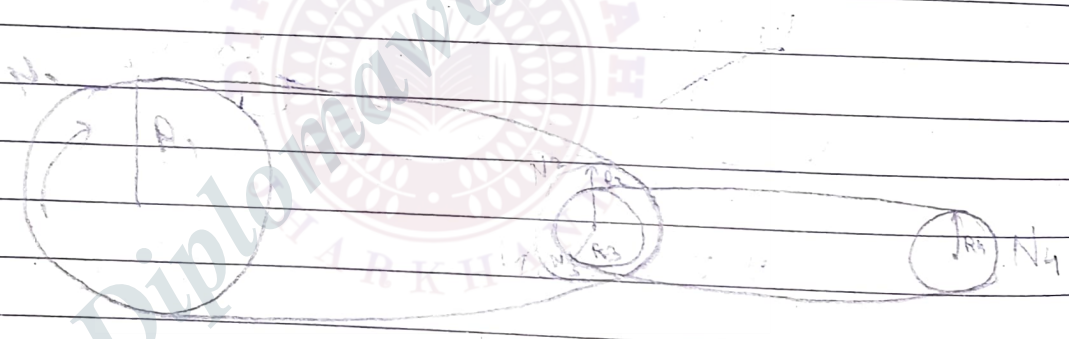


* Idle Pulley / Intermediate Pulley :-

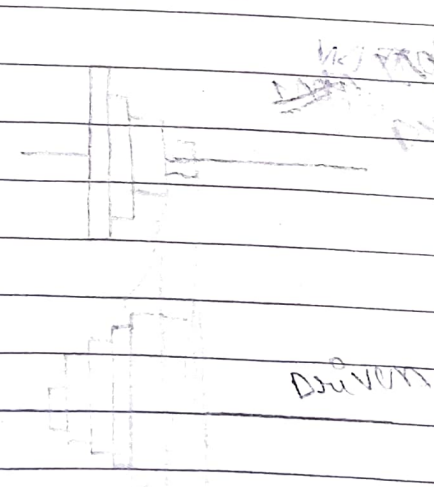
- (i) It is used to change the direction of driver and driven.
- (ii) It also increases the angle of contact.

* Compound belt drive

It is used when power is transmitted from one shaft to another through number of pulleys.



* Stepped / Cone pulley drive



Q. A Solid circular shaft of diameter 50cm and its speed is 200 rpm which rotates a Gross operating machine whose diameter is 250 mm. Find the speed of Gross operating machine and also find the peripheral velocity of solid circular shaft.

Solu:

$$D_1 = 50 \text{ cm} = \cancel{500 \text{ mm}} \circ$$

Now,

$$\Rightarrow V = R \cdot \omega,$$

$$V = \frac{D_1}{2} \times \frac{2\pi N}{60}$$

$$V = \frac{500}{2} \times \frac{2\pi \times 200}{60}$$

$$V = \frac{500\pi}{3} \text{ cm/s}$$

Now,

$$\Rightarrow D_1 N_1 = D_2 N_2$$

$$\Rightarrow 50 \times 200 = 25 \times N_2$$

$$\Rightarrow \frac{250 \times 200}{25} = N_2$$

$$\Rightarrow 400 \text{ rpm} = N_2$$

$$\Rightarrow N_2 = 400 \text{ rpm}$$

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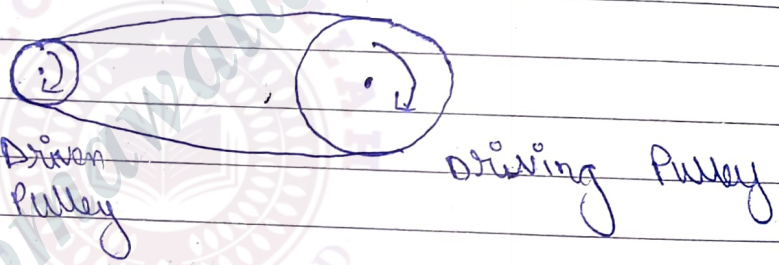


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* Slip :- It is a situation due to which it creates the disturbance in velocity of belt.

The causes of slip are :-

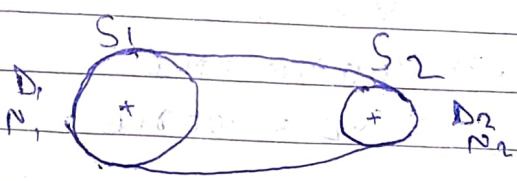
- (i) Friction \downarrow Smooth \uparrow (both the contact b/w belt and pulley)
- (ii) Load / power \uparrow \rightarrow Situation of slipping \uparrow



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Relation b/w the Pulleys

Slip is generally denoted by $S \rightarrow$



Speed ratio

$$\Rightarrow \frac{v_2}{v_1} = \frac{\pi D_1 N_1 (1 - S_1\%)}{\pi D_2 N_2 (1 - S_2\%)}$$

$$v_2 = v_1 (1 - S_2\%)$$

$$\Rightarrow \frac{\pi D_2 N_2}{60} = N_1 (1 - S_2 \%)$$

$$\Rightarrow \frac{\pi D_2 N_2}{60} = \frac{\pi D_1 N_1}{60} (1 - S_2 \%) (1 - S_1 \%)$$

Both have
Fuller
Step

$$\Rightarrow \frac{\pi D_2 N_2}{60} = \frac{\pi D_1 N_1}{60} (1 - S_2 \%) (1 - S_1 \%)$$

$$\Rightarrow D_2 N_2 = D_1 N_1 (1 - S_2 \%) (1 - S_1 \%)$$

$$\Rightarrow \frac{D_2}{D_1} = \frac{N_1}{N_2} (1 - S_1 \%) (1 - S_2 \%)$$

$$= \frac{N_1}{N_2} \left[1 (1 - S_2 \%) - S_1 \% (1 - S_2 \%) \right]$$

$$= \frac{N_1}{N_2} \left[1 - S_2 \% - S_1 \% + S_1 S_2 \% \right]$$

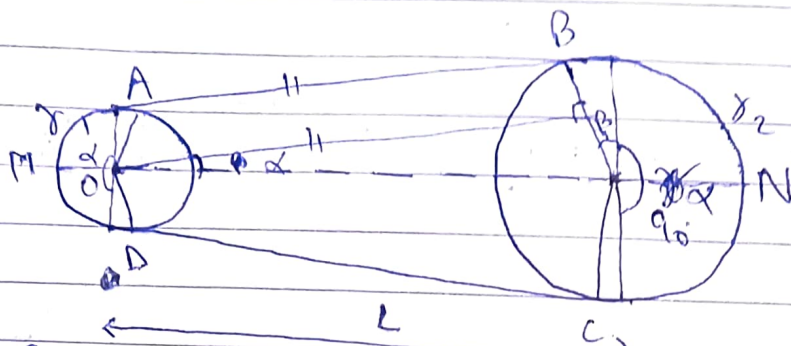
$$= \frac{N_1}{N_2} \left\{ 1 - \left(\frac{S_1 + S_2}{100} \right) + \frac{S_1 S_2}{100 \times 100} \right\}$$

$$= \frac{N_1}{N_2} \left\{ 1 - \left(\frac{S_1 + S_2}{100} \right) \right\}$$

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

2 Calculation of the length

OBS



β (wrap angle) α (Contact angle)

$\alpha \uparrow$ Friction Power \uparrow

The distance b/w the centres of pulley (b/w r_1 & r_2) is denoted L

Length of the belt

Total length of belt

$$= AB + BNC + CD + DMA$$

$$\because AB = CD$$

$$= 2\sqrt{L^2 - (r_2 - r_1)^2} + (\pi + 2\alpha)r_2 + (\pi + 2\beta)r_1$$

$$L_{\text{total}} = 2L \left[1 - \left(\frac{r_2 - r_1}{L} \right)^2 \right]^{1/2} + (\pi + 2\alpha)r_2 + (\pi + 2\beta)r_1$$

$$L_{\text{total}} = 2L + \pi(r_1 + r_2) + \frac{(r_1 + r_2)^2}{L}$$

Where,

r_1 & r_2 = radii of pulley
 L = Distance b/w the pulley

$r_1 \rightarrow$ Big pulley

Types of Belt Drive

On the basis of ~~shape~~ Surface Contact

- (a) Flat Belt Drive. (moderate amount of power transmission)
- Uses a flat belt running over pulleys.
 - Suitable for long-distance power transmission upto 8m \rightarrow b/w pulleys.
 - Offers smooth and quiet operation but has lower friction.
 - Clay machinery, baking machinery etc.

- (b) V-Belt Drive
- Uses a V-shaped belt that fits into pulley grooves.
 - Provides higher friction and grip.
 - Used for short-distance and high speed applications.
 - Ex:- Electric motor \downarrow b/w pulleys.

- (c) Circular (Round) Belt Drive (Ex:- Game)
- Uses a belt drive with circular cross-section.
 - Suitable for light loads and flexible applications.
 - More than 8m
 - Used where great amount of power is transmitted.

- (d) Timing (Toothed) Belt Drive
- Has teeth on the inner side to prevent slipping.
 - Used for precise power transmission in engines and conveyors.

On the basis of velocity

Light drives

- (a) Slow - Speed Belt Drive (less than 10 m/s)
- used in low-power transmission applications
 - Common in agricultural machinery, conveyor systems etc.
 - Example :- Cotton belt in a small medium drives workshop.

- (b) Medium - Speed Belt Drive (10 - 22 m/s)
- Found in machine tool, textile tools etc.
 - Provide balance b/w efficiency and wear.
 - Example :- V-belt drive in industrial lathes.

- (c) Heavy drives / High - Speed Belt Drive (Above 22 m/s)
- Uses in high-speed applications where smooth and efficient power transmission is required.
 - Ex :- Flat belt drive (up to 8 m/s).

* Selection of Belt Drive

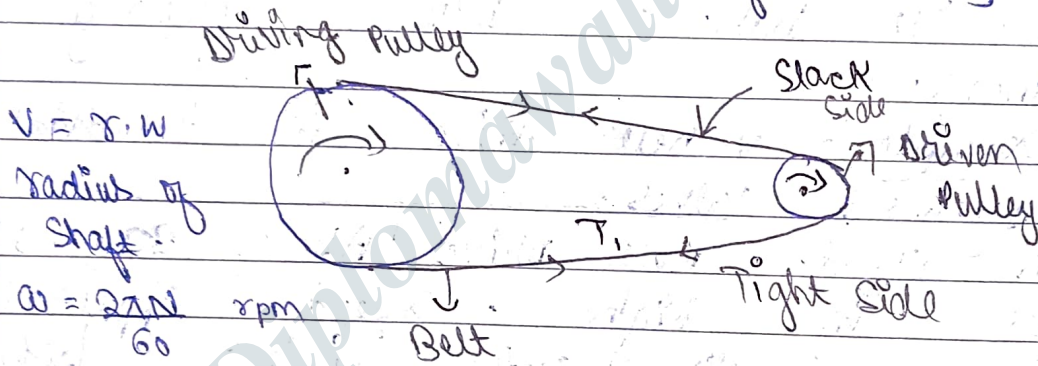
1. Identify Application Requirements

Type	Advantages	Applications
Flat Belt	High speed, low noise, flexible	Light-duty power transmission
V-Belt	High friction, compact design, efficient	Industrial machinery, HVAC systems

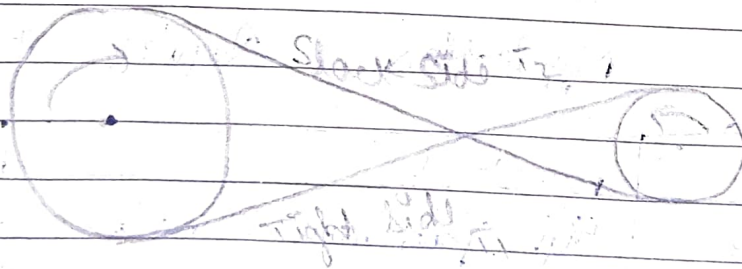
Timing belt	No Slippage, precise motion, maintenance-free	Robotics, CNC Machine, automated
Poly-V belt	High-Speed, high power, Compact	Automotive, Conveyors, high speed machines

* Types of Flat Belt drives

- Open belt drive: Open belt drive is used to rotate the driven pulley in the same direction of driving pulley.



- Cross belt drive: A crossed belt drive is used to rotate driven pulley in the opposite direction of driving pulley.



The position of belt is cross and the rotation of driven pulley is opposite to driving pulley.

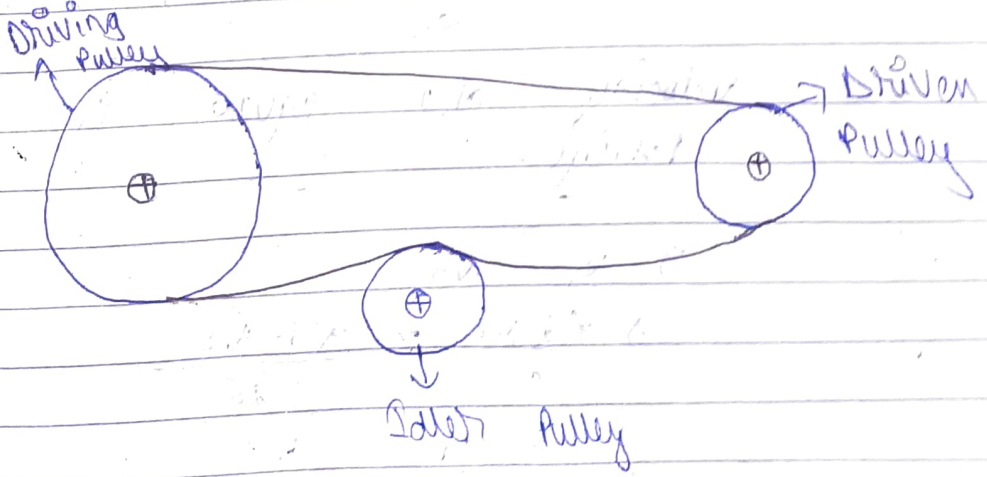
Pulley

- Compound Belt Drive: When a power is transmitted from one shaft to another shaft through a number of pulleys.

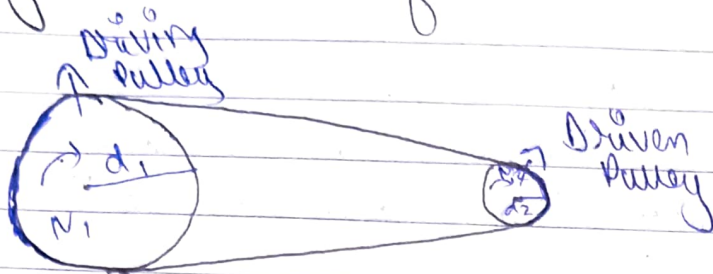
In this belt drive, a large amount of power is transmitted.



- Belt Drive with idler Pulley: When in an open belt drive (OBD) the belts are very loose ~~and~~ which are connected in parallel then a pulley is used to complete an angle of contact to prevent from slip.



velocity ratio of belt drive



$d_1 \rightarrow$ Diameter of driving pulley.
 $N_1 \rightarrow$ Speed of driving pulley in r.p.m.
 $d_2 \rightarrow$ Diameter of driven pulley.
 $N_2 \rightarrow$ Speed of driven pulley in r.p.m.

length wrapped in driving pulley = length wrapped in driven pulley.

$$\rightarrow \pi d_1 N_1 = \pi d_2 N_2$$

$$\rightarrow \boxed{\frac{N_2}{N_1} = \frac{d_1}{d_2}}$$

or

$$v_1 = \frac{\pi d_1 N_1}{60} \text{ m/s} \quad \text{--- (i)}$$

$$v_2 = \frac{\pi d_2 N_2}{60} \text{ m/s} \quad \text{--- (ii)}$$

velocity are equals in both pulleys.

$$\rightarrow v_1 = v_2$$

$$\rightarrow \frac{\pi d_1 N_1}{60} = \frac{\pi d_2 N_2}{60}$$

$$\rightarrow \frac{N_2}{N_1} = \frac{d_1}{d_2}$$

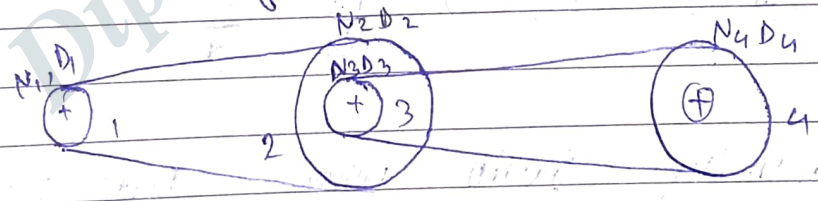
* Materials for belts

- The usual requirements of materials for machine elements are strength and durability. So belt materials used should be strong and durable to use.
- In addition belt drives ~~are used also~~ must have such properties as flexibility and high coefficient of friction.

In general, four different materials are used for flat belts:

- (i) Leather
- (ii) Rubber
- (iii) Woven cotton
- (iv) Woven wool

* Velocity ratio of compound belt drive



we know velocity ratio b/w 1 & 2

$$\frac{N_1}{N_2} = \frac{D_2}{D_1} \quad \text{--- (i)}$$

And,

$$\frac{N_3}{N_4} = \frac{N_2}{D_3} \times \frac{D_4}{N_2} \quad \text{--- (ii)}$$

from eq (i) & (ii)

$$\frac{N_1}{N_2} \times \frac{N_3}{N_4} = \frac{D_2}{D_1} \times \frac{D_4}{D_3}$$

When Gear 2, 3 are connected with single shaft then their RPM is same,

$$N_2 = N_3$$

$$\rightarrow \frac{N_1}{N_2} \times \frac{N_3}{N_4} = \frac{d_2 \times d_4}{d_1 \times d_3}$$

$$\Rightarrow \frac{N_1}{N_4} = \frac{d_2 \times d_4}{d_1 \times d_3}$$

* Slip

Slip is defined as insufficient frictional grip b/w pulley (driver / driven) and belt. Slip is the difference b/w the linear velocities of pulley (driver / driven) and belt.

Velocity ratio $\Rightarrow \frac{N_1}{N_2} = \frac{d_2}{d_1}$

velocity ratio when belt having thickness

$$\frac{N_1}{N_2} = \frac{d_1 + t}{d_2 + t}$$

where $\rightarrow V_1 = V_2$

No slip.

Slip at driver, s_1 , expressed in % of driver speed
 $s_1 \% =$

$$S_1\% = \frac{V_1 - V_b}{V_1} \times 100$$

Now,

V_1 = Velocity of ^{driven} pulley
 V_b = velocity of belt

And,

$$S_2\% = \frac{V_b - V_2}{V_b} \times 100$$

V_b = belt velocity

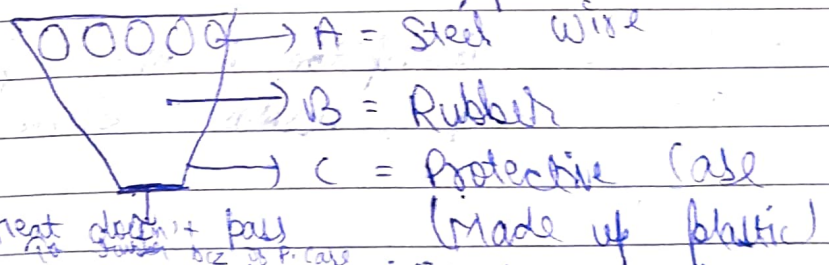
V_2 = driven pulley velocity

* Creep

- Uneven extensions and contractions of belt when it passes from tight side to slack side. There is a relative motion between belt and pulley surface, this phenomenon is called creep of belt.

* Constructional features of a V-belt.

(to rigidity not flexibility)



next class + pass
 to student by P. case

Rubber is used to Damping.

vibration and

Protective Case ^{used} \rightarrow When a belt moves with continuous loading, it creates heat on ~~an~~ which can affect the rubber of v-belt. Therefore, we use protective case to prevent rubber from heat.

* Advantages of v-belt over Flat Belt.

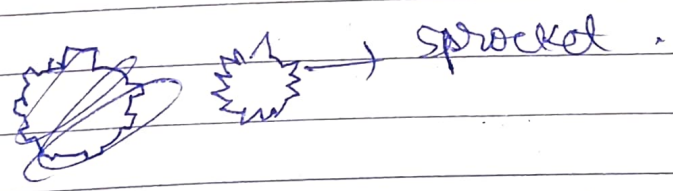
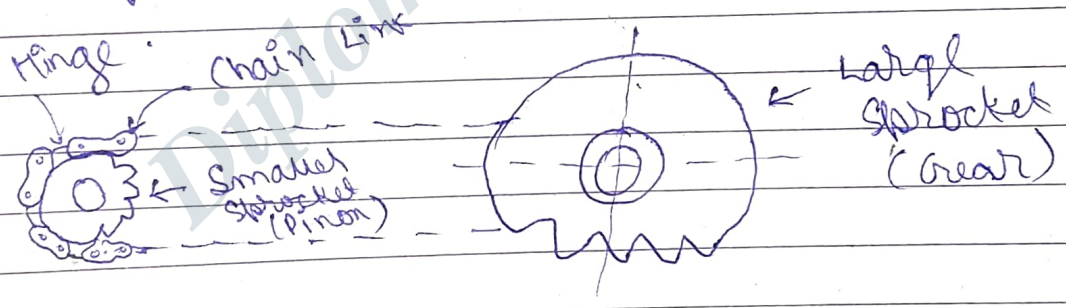
- Higher power transmission :- The v-shaped design provides greater surface contact with the pulley, enabling higher power transmission with less slip.
- Compact design :- V-belts can be used in smaller spaces due to their smaller cross-section.
- Better grip on pulleys :- ~~The~~ ~~the~~ grip ~~with~~ b/w the belt & pulleys is better than flat belt.
- Lower noise levels :- V-belt operates with less noise compared to flat belts.
- Shock absorption :- The flexibility of v-belts can help absorb shock load on the system.

* Chain Drive

- Chain drive is the ^{type of mechanical} ~~type of~~ power transmission system that uses chains to transfer power from one place to another place.
- Chain drive consists of two or more sprockets and chain itself.

- 1. Chain
- 2. Sprocket.

- 1. Chain :- It is the series of link connected with pin joint.
- 2. Sprocket :- It is the toothed wheel with a specific.



Demerit :- It makes more noise. Actually, it is made up of mechanical component i.e., rigid component i.e., that's why it makes more noise.