PART-B **POWER TRANSMISSION**

Power is transmitted from the prime mover to machines (Lathe, drilling machines, etc) by means of intermediate mechanisms called 'drives'

There are various drives. But most commonly used among them are

Belt drives

Rope drives

Chain drives

Gear drives.

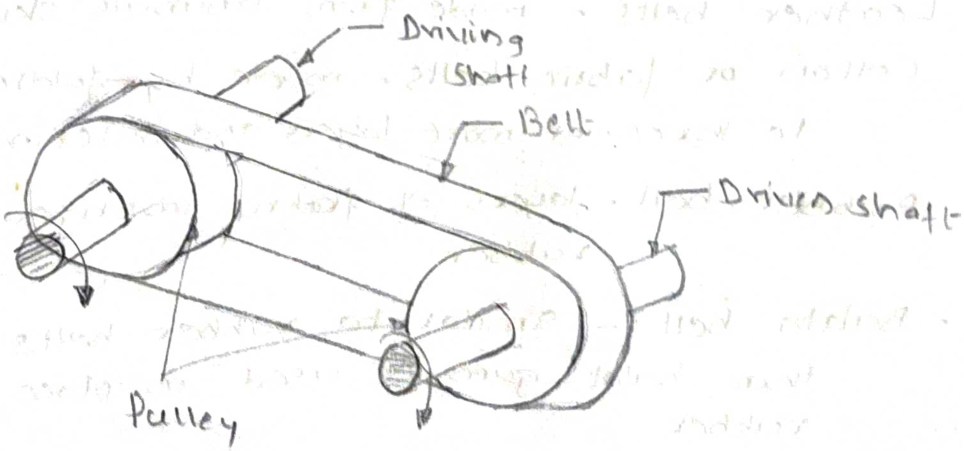
The selection of a particular type of drive depends on the application ie, the amount of power transmitted, distance between two shafts etc.

Prime mover → Intermediate mechanisms or drives → Machines

BELT DRIVES:

Belt drives are used to transmit power or motion from one shaft to the other by means of a thin inextensible belt running over two pulleys.

A pulley is a circular disc having a hole at the centre so as to accomodate a shaft in it. The pulley may rotate at same speeds or at different speeds.



The arrangment consist of two pulleys mounted on two different shafts. one shaft called the 'driving shaft' receives power from the mains and transmits it to another shaft called 'driven shaft'. The pulley mounted on driving shaft is called 'driving pulley' or driver while the other pulley mounted on a shaft to which the power is to be transmitted is called the 'driven pulley' or follower. The belt passing over the pulley is kept in tension so as to avoid slip over the pulley. This helps transmitting power effectively from one shaft to another.

Application of belt drives:

a) To transmit power directly from the prime mover to any device

b) To transmit rotational motion to various parts of the machine

c) Belt drives are ~~generally~~ largely used for general purposes in mills and factories, especially when the distance between two shafts is not very large.

Material used for belts:

The materials used for belt must be strong, flexible and durable. It must have a high co-efficient of friction. Different materials used in manufacturing of belt includes

- Leather belts - made from animals skin.
- Cotton or fabric belts - made by folding canvass to three or more layers and stitching together.
- Rubber belt - layers of fabric impregnated with rubber.
- Balata belt - similar to rubber belts except that balat gum is used in place of rubber.

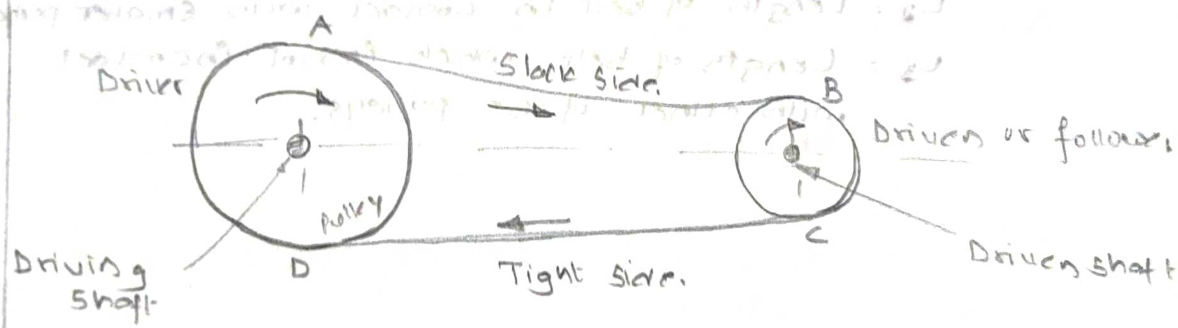
Types of Belt drives:

1. Open belt drive
2. ~~Closed~~ Cross belt drive.

1. Open Belt Drive:

Open belt drives are used to connect two shafts that are parallel and rotating in the same direction.

The driver pulles the belt from the lower side CD, and delivers it to the upperside AB. Therefore tension in the lower side belt CD, will be more than the tension in the upper side belt AB. The lower side because of more tension is known as 'tight side', where as upper side belt, because of low tension is known as 'slack side'. Due to lesser tension on the slack side, the belt sags due to its own weight.



2. Cross belt drive:

Cross belt drives are used to connect two shafts that are parallel and rotating in opposite direction.

In this drive, the driver pulls the belt from one side BD, and delivers it to the other side AC. Thus tension in belt side BD will be more than tension in belt side AC. The belt side BD because of more tension is known as 'tight side', where as belt side AC, because of less tension is known as 'slack side'.

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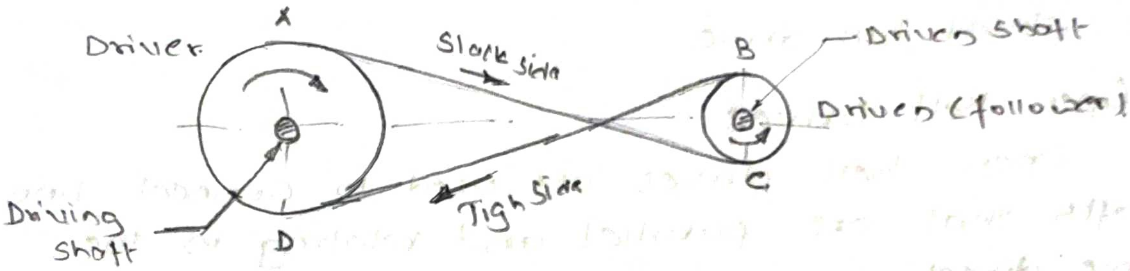


Length of belt:

Length of belt for Open Belt Drive:

Let r_1 = radius of larger pulley

r_2 = radius of smaller pulley

C = centre distance between two pulleys.

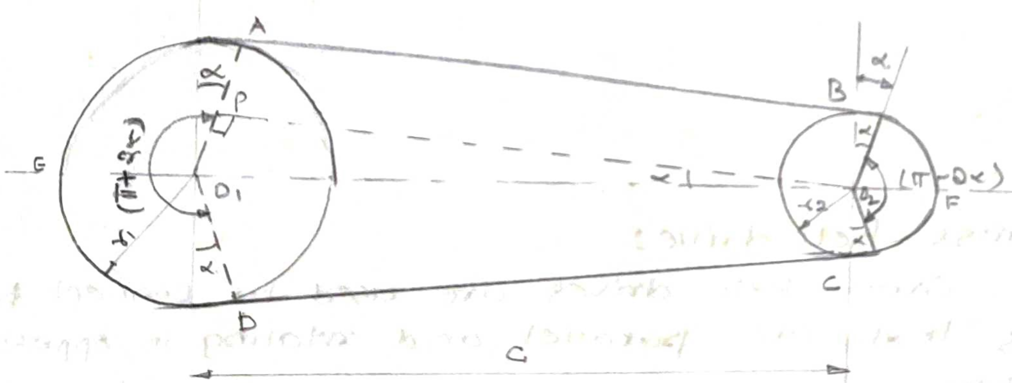
L = Length of belt

$= L_1 + L_2 + L_3$ —— 1

where L_1 = Length of belt in contact with larger pulley.

L_2 = Length of belt in contact with smaller pulley

L_3 = Length of belt, which is not in contact with either of the pulleys.



From geometry of the fig

$L_1 = (\pi + 2\alpha) r_1$ —— 2

$L_2 = (\pi - 2\alpha) r_2$ —— 3

From O_2 draw a line O_2P parallel to belt, which is not in contact with either of the pulleys.

From triangle O_1O_2P

$$O_2P = \sqrt{(O_1O_2)^2 - (O_1P)^2}$$

$$= \sqrt{C^2 - (r_1-r_2)^2}$$

$$= \sqrt{\frac{C^2\left[C^2-(r_1-r_2)^2\right]}{C^2}}$$

$$O_2P = C\left[1-\left(\frac{r_1-r_2}{C}\right)^2\right]^{1/2} \quad \text{—— } 4.$$

Expanding term in brackets using binomial theorem and neglecting higher powers, we have

$$\left[1-\left(\frac{r_1-r_2}{C}\right)^2\right]^{1/2} = 1-\frac{1}{2}\left(\frac{r_1-r_2}{C}\right)^2$$

Equation (4) reduces to

$$O_2P = C\left[1-\frac{1}{2}\left(\frac{r_1-r_2}{C}\right)^2\right]$$

$$\therefore \text{Length } L_3 = 2\,O_2P = 2C\left[1-\frac{1}{2}\left(\frac{r_1-r_2}{C}\right)^2\right] \quad \text{—— (5)}$$

Substituting equation (2), (3) and (5) in (1) we have

$$L = [(\pi+2\alpha)r_1] + [(\pi-2\alpha)r_2] + 2C\left[1-\frac{1}{2}\left(\frac{r_1-r_2}{C}\right)^2\right]$$

$$= \pi r_1 + 2\alpha r_1 + \pi r_2 - 2\alpha r_2 + 2C\left[1-\frac{1}{2}\left(\frac{r_1-r_2}{C}\right)^2\right]$$

$$L = \pi(r_1+r_2) + 2\alpha(r_1-r_2) + 2C - \frac{(r_1-r_2)^2}{C} \quad \text{—— (6)}$$

From $\triangle$le O_1O_2P

$$\sin\alpha = \frac{O_1P}{O_1O_2} = \frac{r_1-r_2}{C}$$

84 For small values of α, $\sin\alpha \approx \alpha$

$$\therefore \alpha = \frac{r_1-r_2}{C}$$

Substituting value of $\alpha = \frac{r_1 - r_2}{C}$ in eq (6)

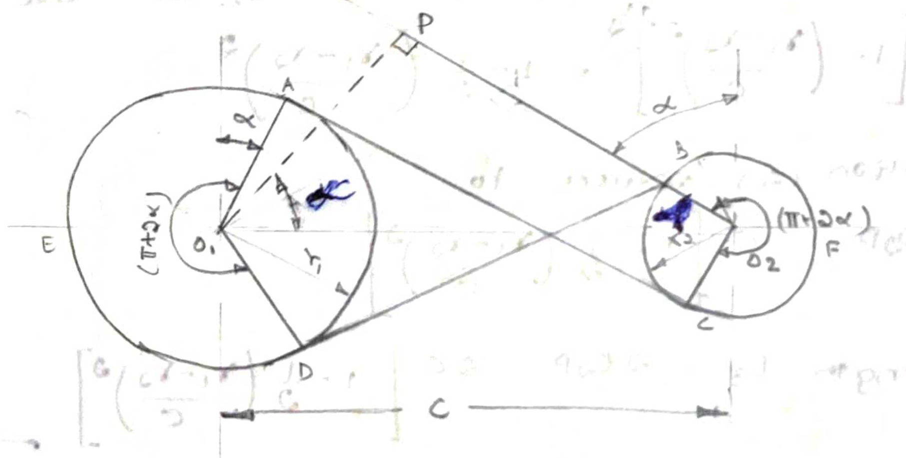
$$L = \pi(r_1 + r_2) + \frac{2(r_1 - r_2)^2}{C} + 2C - \frac{(r_1 - r_2)^2}{C}$$

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

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

The above equation can be used to calculate the length of belt for an open belt drive.

<u>Length of Belt for Cross Belt drive:</u>



Let r_1 = radius of larger pulley

r_2 = radius of smaller pulley

C = Centre distance between two pulleys

L = Length of belt

$\therefore L = L_1 + L_2 + L_3 \quad — (1)$

where, L_1 = Length of belt in contact with larger pulley

L_2 = Length of belt in contact with smaller pulley

L_3 = Length of belt which is not in contact with either of the pulleys.

From geometry of fig

$$L_1 = (\pi + 2\alpha) r_1 \quad — 2$$

$$L_2 = (\pi + 2\alpha) r_2 \quad — 3$$

From O_2 draw line O_2P parallel to the belt, which is not in contact with either of the pulleys.

From triangle $O_1 O_2 P$

$$O_1P = \sqrt{(O_1O_2)^2 - (O_2P)^2}$$

$$= \sqrt{(C^2) - (r_1+r_2)^2}$$

$$= \sqrt{\frac{C^2\left[C^2 - (r_1+r_2)^2\right]}{C^2}}$$

$$= \sqrt{C^2\left[1 - \left(\frac{r_1+r_2}{C}\right)^2\right]}$$

$$O_1P = C\left[1 - \left(\frac{r_1+r_2}{C}\right)^2\right]^{1/2} \quad — 4$$

Expanding the term within brackets by using binomial theorem and neglecting higher power, we have

$$\left[1 - \left(\frac{r_1+r_2}{C}\right)^2\right]^{1/2} = 1 - \frac{1}{2}\left(\frac{r_1+r_2}{C}\right)^2$$

Equation (4) reduces to $O_1P = C\left[1 - \frac{1}{2}\left(\frac{r_1+r_2}{C}\right)^2\right]$

$$\text{Length } L_3 = 2 O_1P = 2C\left[1 - \frac{1}{2}\left(\frac{r_1+r_2}{C}\right)^2\right] \quad — 5.$$

Substituting (2), (3) and (5) in (1) we get

$$L = \left[(\pi+2\alpha)r_1\right] + \left[(\pi+2\alpha)r_2\right] + 2C\left[1 - \frac{1}{2}\left(\frac{r_1+r_2}{C}\right)^2\right]$$

$$= \pi r_1 + 2\alpha r_1 + \pi r_2 + 2\alpha r_2 + 2C - \frac{(r_1+r_2)^2}{C}$$

$$L = \pi(r_1+r_2) + (r_1+r_2)2\alpha + 2C - \frac{(r_1+r_2)^2}{C} \quad — (6)$$

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From Δle O_1O_2P.

$$\sin\alpha = \frac{O_2P}{O_1O_2} = \frac{r_1+r_2}{c}$$

For small values of α, $\sin\alpha = \alpha$

$$\therefore \alpha = \frac{r_1+r_2}{c}$$

Substituting the value of α in eq (6)

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

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

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

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

The above equation can be used to calculate the length of the belt for a cross belt drive.

Velocity Ratio:

Velocity ratio of belt drive is defined as the ratio between the speed of driven pulley (follower) and the speed of driving pulley (driver).

Let d_1 = Diameter of driving pulley (driver)

d_2 = Diameter of driven pulley (follower/driven)

n_1 = Speed of driving pulley and

n_2 = Speed of driven pulley.

Assuming that there is no slip between the belt and the pulley rim, the linear speed at every point on the belt must be same.

$$\text{ie, } \pi d_1 n_1 = \pi d_2 n_2$$

$$d_1 n_1 = d_2 n_2$$

$$\frac{n_2}{n_1} = \frac{d_1}{d_2} \quad \text{ie, } \frac{\text{Speed of driven}}{\text{Speed of driver}} = \frac{\text{diameter of driver}}{\text{diameter of driven}}$$

This ratio is called velocity ratio or speed ratio transmission ratio of belt drives.

Thus, in belt drives, the speeds are inversely proportional to their diameters.

When thickness (t) of the belt is considered, then velocity ratio is given by

$$\frac{n_2}{n_1} = \frac{d_1+t}{d_2+t}$$

Creep:

The phenomenon of creep of belt arises through the difference in tensions on the two sides of belt. Since the belt is made of elastic material, the stretch in belt due to different tensions on two sides of pulley will be different. The part of belt leaving the follower and approaching the driver is tight side and is stretched more than part of the belt leaving driver and approaching follower or the slack side. These uneven extensions and contractions of the belt due to varying tension in it, causes relative motion of belt on the pulley. This relative motion is known as creep in belt.

Slip:

A common phenomenon encountered in belt drive is the 'slipping of belt'. The power transmitted from one shaft to other depends on frictional grip between the belt and the pulley rim. There is always some amount of slip between the belt and the pulley rim that results in a slight reduction in the velocity ratio of belt drive.

Slip may be defined as the relative motion between the pulley and the belt passing over it. It is generally expressed as percentage

∴ velocity ratio (when slip is considered) $= \frac{n_2}{n_1} = \frac{d_1}{d_2}\left(\frac{100-S}{100}\right)$

where $S = \%$ slip.

when thickness t is considered

velocity ratio $= \frac{n_2}{n_1} = \frac{d_1+t}{d_2+t}\left(\frac{100-S}{100}\right)$

Power transmitted by belt drive:

$$P = \frac{(T_1 - T_2)v}{1000} \quad kW$$

where T_1 = Tension in tight side of belt (max. tension) in Newton (N)

T_2 = Tension in slack side of belt in N

d_1 = diameter of driver in m.

d_2 = diameter of follower in m.

v = Velocity $= \frac{\pi d_1 n_1}{60}$ or $\frac{\pi d_2 n_2}{60}$ m/sec.

Ratio of belt tension for flat belt drive:

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

where μ = Co-efficient of friction between belt and pulley

θ = Angle of contact between belt and pulley rim.

Angle of contact θ:

Angle of contact will not be same in case of open and cross belt drive.

a) Open belt drive:

When power is transmitted between two pulleys of different diameters, then angle of contact at the smaller pulley must be taken in to account. consideration. This is because, belt will slip first on the pulley having smaller angle of contact i.e, on the smaller pulley.

Angle of contact on smaller pulley } $\theta_s = \pi - 2\alpha$

$$= \pi - 2\sin^{-1}\left(\frac{r_1 - r_2}{c}\right)$$

Angle of contact on larger pulley } $\theta_L = \pi + 2\alpha$

$$= \pi + 2\sin^{-1}\left(\frac{r_1 - r_2}{c}\right)$$

For equal diameter of pulleys $d_1 = d_2$ and angle of contact $\theta_L = \theta_s = \theta = \pi$ rad.

b) Cross- belt drive:

When two pulleys of different diameters are connected by means of a cross-belt drive, the angle of contact on both the pulleys will be the same

$$\therefore \theta_L = \theta_S = \theta = \pi + 2\alpha$$

$$\therefore \cancel{\theta = \pi + 2\sin^{-1}(}$$

$$\theta = \pi + 2\sin^{-1}\left(\frac{r_1 + r_2}{C}\right)$$

Initial Tension in Belt:

When belt is wound around two pulleys, the two ends of the belt are joined together tightly and are fixed over pulleys so as to maintain a tight grip between the belt and the pulley.

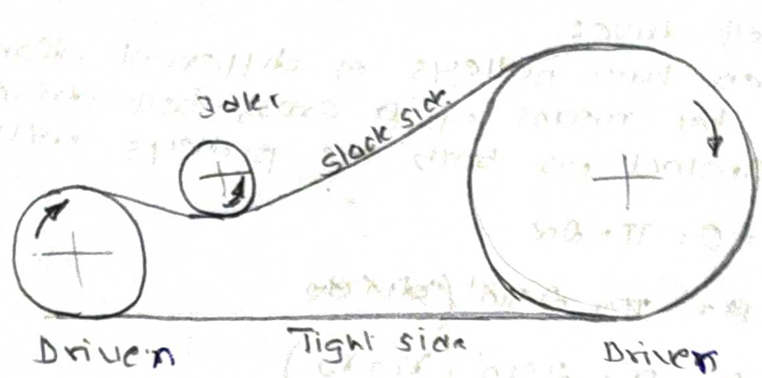
Thus, even when the pulleys are stationary the belt is subjected to some tension and this tension is called initial tension. It is denoted by T_0 and is expressed as

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

Idler Pulley:

In belt drives, when the centre distance between the two shafts is small or when small diameter driven pulleys are used, the arc of contact of belt with the pulley will be small. Due to this, tensions in the belt are reduced and hence there will be a loss in power transmitted. The use of idler or jockey pulley overcomes the problem.

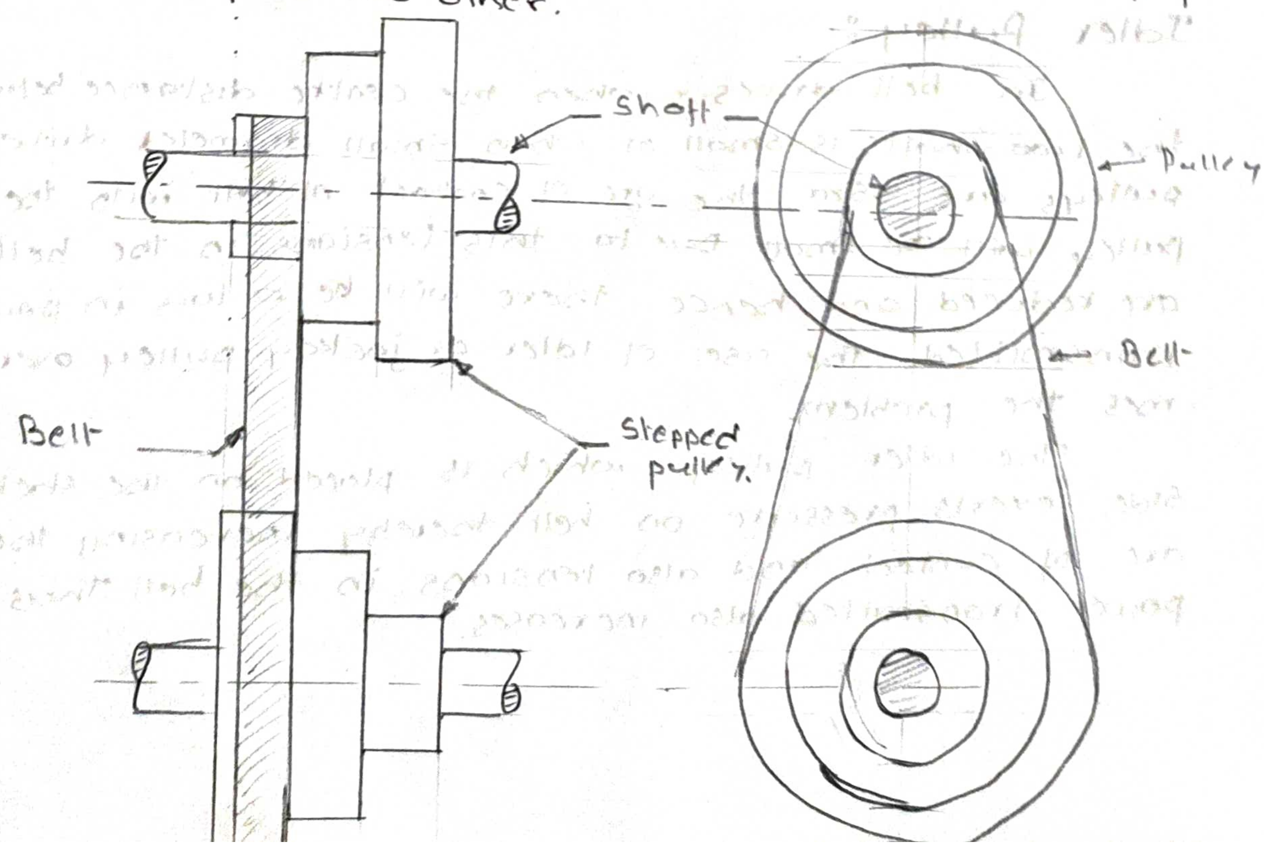
The idler pulley which is placed on the slack side, exerts pressure on belt thereby increasing the arc of contact and also tensions in the belt. Thus power transmitted also increases.



Stepped Pulley:

A stepped pulley or a cone pulley is used for changing the speed of driven shaft, while driving shaft runs at constant speed. The arrangement of belt on stepped pulley is shown in fig.

Stepped pulleys are pulleys having several steps of varying diameters mounted on two parallel shafts, such that smallest step of one pulley is opposite to the largest step of the other as in fig. The velocity ratio of belt drive can be varied by shifting the belt from one step of the pulley to the other.



Fast and Loose Pulley: or Tight & Loose pulley

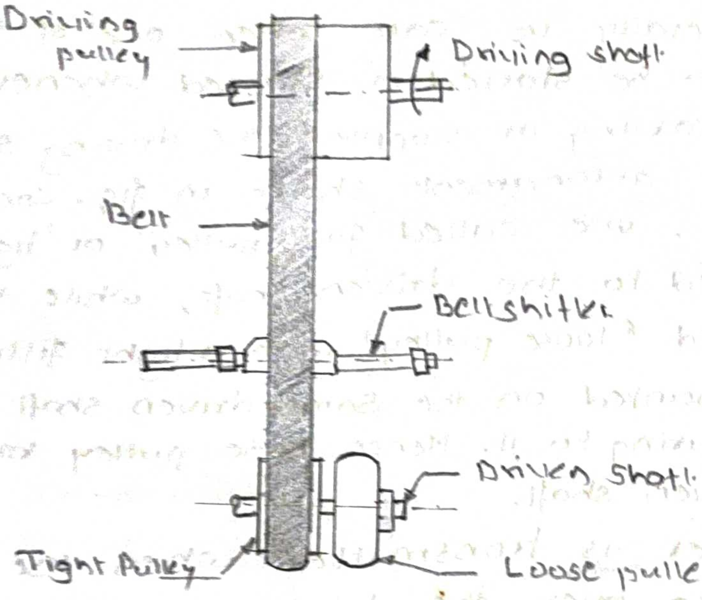
A fast and loose pulley is used in belt drives especially in case when one of the driven shaft is to be started or stopped whenever desired without starting or stopping the driving shaft.

The arrangment shown in fig, consists of two pulleys, one called 'fast pulley' or 'tight pulley' firmly keyed to the driven shaft, while the other pulley called 'loose pulley' with a tight fitting brass bush is mounted on the same driven shaft but without rigidly securing to it. Hence loose pulley rotates freely on the driven shaft.

Power is transmitted when the belt will be running over the driving pulley and tight pulley. But when the driven shaft is to be stopped, the driving shaft need not be disturbed, but the belt on the tight pulley is shifted onto the loose pulley by means of a belt shifter.

The shifting of belt on to the loose pulley, causes the belt on the driving pulley to slip from it, and for this reason, the width of driving pulley is made larger and is the sum of width of tight and loose pulley. The driving pulley has a flat face which helps the belt to occupy different positions whereas the tight and loose pulley have crowned faces, which helps the belt to retain its position when shifted upon them.

Fast & loose pulley



Advantages and Disadvantages of Flat Belt Drives:

Advantages

1. Belt drives can be used when the centre distance between two shafts is large
2. The speeds can be varied by varying the diameter of the pulleys
3. Simplicity
4. Low operating costs
5. Smoothness of operation and ability to absorb shocks due to elasticity of the belt

Disadvantages.

1. Not efficient when the centre distance between two shaft is small.
2. Due to slip in belt drives, exact velocity ratio cannot be maintained
3. Only moderate power can be transmitted
4. The slip between the belt and the pulleys causes the driven pulley to rotate at a lesser speed. This reduces power transmission.
5. Used for transmitting power only between parallel shafts.

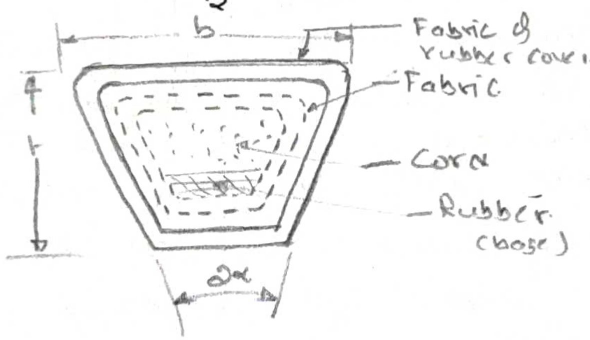
V- Belt drives

V-belts are used to transmit power between two shafts when the centre distance between the shaft is small. V belts are usually endless and trapezoidal in cross-section as shown in fig. a. The included angle for the belt is usually 30°-40°. ~~The~~ The belts are made of fabric and cords (that carry the load) moulded in rubber and covered with fabric and rubber shown in fig.

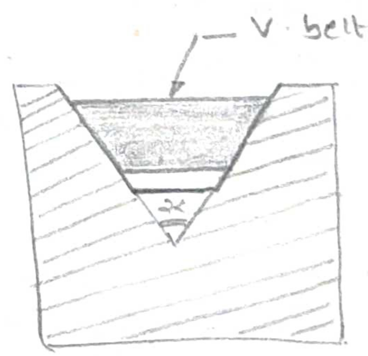
In case of flat belt drives, the belts run over the pulley, whereas in V-belt drive, the rim of the pulley is grooved so as to accomodate the V-belt (fig b). The effect of groove is to increase the grip of the V-belt on the pulley, there by reducing chances of slipping.

For V-belt drive, the ratio of tensions in tight side and slack side of the belt is given by

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



(a) C/s of V-belt



(b) C/s of V-grooved pulley

b = width of belt

t = thickness of belt

2α = grooved angle of pulley

Advantages and Disadvantages of V-Belt over Flat Belts:

Advantages.

1. Transmits more power
2. Slip between the belt and pulley is negligible
3. Can be used to transmit power for short centre distance.
4. Higher velocity ratio.
5. Operation is smooth and quiet.
6. Shaft axis may be horizontal, vertical or Inclined
7. Since V-belts are made endless, there is no joint trouble.

Disadvantages:

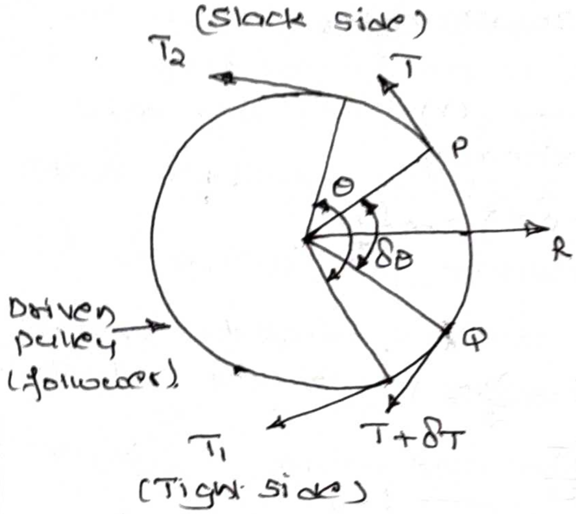
1. Not suitable for large centre distance.
2. V-belts are endless and also pulley has to be provided with grooves. Hence construction of belt and pulley are complicated.

24/04/07

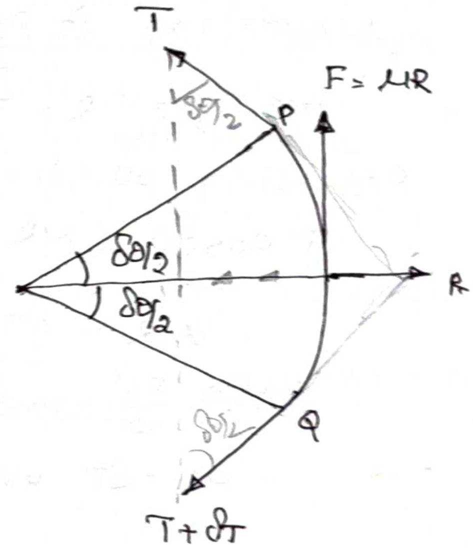
Presentees 44, 27, 50, 16, 15, 56, 49, 37, 12, 045, 01, 11, 07, 34, 47, 40

RATIO OF BELT TENSIONS FOR FLAT BELT DRIVE:

Consider a flat belt wound around a pulley as shown in fig(a). Let the driven pulley rotate in clockwise direction.



(a) Flat belt wound around pulley.



(b) Forces acting on belt element PQ

Let T_1 = Tension on tight side of belt

T_2 = Tension on slack side of belt

Consider a small element PQ of belt.

Let $\delta\theta$ be the angle subtended by the element PQ. The element PQ is in equilibrium under the action of the following forces. (Fig b)

1. Slack side tension (T) acting at P
2. ~~Slack~~ ~~s4~~ Tight side tension $(T+\delta T)$ at Q
3. Normal reaction (R) extended by the pulley on the belt element PQ.
4. Frictional force $(F = \mu R)$ acting perpendicular to the normal reaction R

Resolving all forces horizontally

$$T \cdot \sin\frac{\delta\theta}{2} + (T+\delta T)\sin\frac{\delta\theta}{2} = R$$

87 $$T \cdot \sin\frac{\delta\theta}{2} + T\sin\frac{\delta\theta}{2} + \delta T\sin\frac{\delta\theta}{2} = R$$

$$2T\sin\frac{\delta\theta}{2} + \delta T\sin\frac{\delta\theta}{2} = R$$

Since angle $\frac{\delta\theta}{2}$ is very small

$$\sin\frac{\delta\theta}{2} = \frac{\delta\theta}{2}.$$

$$\therefore R = 2T\frac{\delta\theta}{2} + \delta T.\frac{\delta\theta}{2}$$

Neglecting $\delta T.\frac{\delta\theta}{2}$ for small angles

we get $R = T\,\delta\theta$ —— (1)

Resolving all forces vertically

$$T.\cos\frac{\delta\theta}{2} + \mu R = (T+\delta T)\cos\frac{\delta\theta}{2}$$

$$\mu R = \delta T\cos\frac{\delta\theta}{2}$$

Since $\frac{\delta\theta}{2}$ is small, $\cos\frac{\delta\theta}{2} = 1$

$\therefore \mu R = \delta T$ or $R = \frac{\delta T}{\mu}$ —— (2)

Equating (1) and (2).

$$T.\delta\theta = \frac{\delta T}{\mu}$$

$$\frac{\delta T}{T} = \mu\,\delta\theta$$

Integrating between limits T_2 and T_1 and from 0 to θ respectively.

$$\int_{T_2}^{T_1}\frac{\delta T}{T} = \int_0^{\theta}\mu\,\delta\theta$$

$$\log_e\left(\frac{T_1}{T_2}\right) = \mu\theta$$

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

1. Power is transmitted from a shaft to another by means of a belt drive. The diameter of larger pulley is 600mm and that of smaller pulley is 300mm. The distance between the centers of the two pulley is 3 meter. If axes of two shafts are in the same plane and parallel to each other find the length of belt required for
i) open belt drive and ii) crossed belt drive.

Given: Radius of larger pulley $r_1 = \frac{600}{2} = 300\,mm$

Radius of smaller pulley $r_2 = \frac{300}{2} = 150\,mm$

Centre distance between the axes of the driving and driven shafts $C = 3m = 3000\,mm$

Length of open belt drive

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

$$= 2 \times 3000 + \pi(300 + 150) + \frac{(300 - 150)^2}{3000}$$

$$= 7421.2\,mm$$

Length of ~~belt~~ crossed belt drive:

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

$$= 2 \times 3000 + \pi(300 + 150) + \frac{(300 + 150)^2}{3000}$$

$$= 7481.2\,mm$$

2. An engine is driving a generator by means of a belt. The pulley on the driving shaft has a diameter of 55cm and runs at 276 rpm. If radius of pulley on generator is 15cm, find its speed in rpm.

Engine: Driving System

$d_1 = 55\,cm$

$N_1 = 276\,rpm$

Generator: Driven System

$d_2 = 2r_2 = 2 \times 15 = 30\,cm$

$N_2 = ?$

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

$$N_2 = N_1 \times \frac{d_1}{d_2} = 276 \times \frac{55}{35} =$$

$$N_2 = N_1 \times \frac{d_1}{d_2} = 275 \times \frac{55}{30} = 506 \text{ rpm}$$

3) A motor running at 1750 rpm drives a line shaft at 800 rpm. If the diameter of the pulley on the motor shaft is 160 mm. Find the diameter of the pulley on line shaft.

Given: Motor: Driving System — Line shaft: Driven system

$N_1 = 1750$ rpm. — $N_2 = 800$ rpm

$d_1 = 160$ mm — $d_2 = ?$

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

$$d_2 = d_1 \times \frac{N_1}{N_2} = 160 \times \frac{1750}{800}$$

$$d_2 = 350 \text{ mm}$$

4) A shaft running at 100 rpm is to drive a parallel shaft at 150 rpm. The diameter of pulley on driving shaft is 350 mm. Find the diameter of the driven pulley. Calculate the linear velocity of the belt and also velocity ratio. **VTU Feb 02**

Given: $N_1 = 100$ rpm — $N_2 = 150$ rpm.

$d_1 = 350$ mm — $d_2 = ?$

Linear velocity = ?

Velocity ratio = ?

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

$$\frac{100}{150} = \frac{d_2}{350}$$

$$d_2 = \frac{350 \times 100}{150}$$

$$d_2 = 233.33 \text{ mm}$$

$$\text{Velocity ratio} = \frac{N_1}{N_2} = \frac{100}{150} = \frac{2}{3}.$$

$$\text{Linear velocity} = \frac{\pi d_1 N_1}{60 \times 1000} = \frac{\pi \times 350 \times 100}{60 \times 1000}$$

$$= 1.8326 \text{ m/Sec.}$$

5) The sum of diameters of two pulleys A and B connected by a belt is 900mm. If they run at 700 and 1400 rpm respectively, determine diameter of each pulley.

Given: $d_A + d_B = 900mm$.

$N_A = 700 rpm$

$N_B = 1400 rpm$.

Velocity ratio $= \frac{\cancel{N_A}}{\cancel{N_B}} = \frac{\cancel{700}}{\cancel{1400}} = \frac{1}{2}$

$= \frac{N_A}{N_B} = \frac{d_B}{d_A}$

$\frac{700}{1400} = \frac{d_B}{d_A}$

$d_A = 2 \times d_B$ — (1)

But $d_A + d_B = 900$ — (2)

Substituting eq (1) in eq (2)

$d_B + 2d_B = 900$

$3d_B = 900$

$d_B = 300 mm.$

$\cancel{d_B}\ d_A = 2 \times d_B = 2 \times 300$

$= 600mm.$

6) In an open belt drive running in clockwise direction the tension in tight side is 3000N and the arc of contact is 150°. If the co-efficient of friction is 0.3 find tension on slack side of belt.

Given: $T_1 = 3000N$, $\theta = 150°$, $\mu = 0.3$. $T_2 = ?$

$\theta = 150° = \frac{150 \times \pi}{180} = 2.6179$

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

$T_2 = \frac{T_1}{e^{\mu\theta}} = \frac{3000}{e^{0.3 \times 2.6179}} = 1367.81 N$

7) In a cross belt drive, the difference in tension between tight and slack side is 1200 N. If the angle of contact is 160° and co-efficient of friction is 0.28. Find initial tension in belt. VTU Jan04

Given: $T_1 - T_2 = 1200\,N$

$\theta = 160° = 160 \times \frac{\pi}{180} = 2.7925$ radians.

Ratio of tensions

$$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.28 \times 2.7925}$$

$$\frac{T_1}{T_2} = 2.1856$$

$$T_1 = 2.1856\, T_2$$

we know that,

$$T_1 - T_2 = 1200\,N$$

$$2.1856\, T_2 - T_2 = 1200$$

$$T_2 = 1012.14\,N$$

∴ Slack side tension $T_2 = 1012.14\,N$.

Tight side tension $T_1 = 1200 + T_2 = 2212.145\,N$

Initial tension in belt $= \frac{T_1 + T_2}{2} = \frac{1012.14 + 2212.145}{2}$

$$= \frac{3224.285\,N}{2}$$

$$= 1612.14\,N$$

(*) In a crossed belt drive the differences in tensions between tight side and slack side of the belt is 1000 N. Find the tension on the slack and tight sides, if angle of contact is 160° and the co-efficient of friction is 0.3

Ans: $T_1 = 1763.35\,N$ $\quad T_2 = 763.35\,N$.

8. A flat open belt drive consists of pulleys of diameter 1000 mm and 500 mm with centre distance of 1500 mm. The coefficient of friction between the pulley and the belt is 0.3, when maximum tension in the belt is 700 N, find the effective pull of belt drive.

Given: $D_1 = 1000\,mm$ $\quad D_2 = 500\,mm$ $\quad C = 1500\,mm$

$r_1 = 500\,mm$ $\quad r_2 = 250\,mm$ $\quad \mu = 0.3.$

$T_1 = 700\,N$

For an open belt drive

$$\sin\alpha = \frac{r_1 - r_2}{C}$$

$$\alpha = \sin^{-1}\left(\frac{r_1 - r_2}{C}\right)$$

$$= \sin^{-1}\left(\frac{500-250}{1500}\right)$$

$$\alpha = 9.59$$

The angle of lap is always considered for smaller pulley

$$\therefore \quad \theta = 180 - 2\alpha = 180 - 2 \times 9.59$$

$$= 160.82^{\circ}$$

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

$$T_2 = \frac{T_1}{e^{\mu\theta}} = \frac{700}{e^{0.3 \times 160.82 \times \frac{\pi}{180}}} =$$

$$T_2 = 301.6\,N$$

Effective pull in belt drive $= T_1 - T_2$

$= 700 - 301.6$

$= 398.42\,N$

9) In a belt drive, the angle of lap on the driven pulley is 160° and the co-efficient of friction between the pulley and the belt material is 0.28. If width of belt is 200mm and the max tension in the belt not to exceed 50N/mm width. Find the initial tension in belt drive.

Given: $\theta = 160° = 160 \times \frac{\pi}{180}$ radians, $\mu = 0.28$.

Belt width = 200mm.

Max tension = 50 N/mm width.

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

$$\frac{T_1}{T_2} = e^{0.28 \times \frac{160 \times \pi}{180}}$$

$$\frac{T_1}{T_2} = 2.187$$

Maximum initial tension,

$T_1 = 50$ N/mm width of belt

$= 50 \times 200$

$= 10000N$.

$$\therefore T_2 = \frac{\cancel{2.18}}{\cancel{T_1}} = \frac{T_1}{2.18} = \frac{10,000}{2.187}$$

$$= 4572.47N$$

Initial Tension $T_0 = \frac{T_1 + T_2}{2} = \frac{10000 + 4572.47}{2}$

$$= 7286.235 \text{ N}$$

10) The driven pulley of 400mm diameter of a belt drive runs at 200rpm. The angle of lap is 165° and the co-efficient of friction between the belt material and the pulley is 0.25. Find the power transmitted if the initial tension is not to exceed 10KN

Given : $N_2 = 200$ rpm. $\theta = 165°$ $\mu = 0.25$

$T_0 = 10$ kN $P = ?$ $D = 400$ mm $= 0.4$ m

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

$$= e^{0.25 \times \frac{165 \times \pi}{180}}$$

$$\frac{T_1}{T_2} = 2.054$$

$$T_1 = 2.054\, T_2.$$

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

$$10 \times 10^3 = \frac{T_1 + T_2}{2}$$

$$10 \times 10^3 = \frac{2.054 T_2 + T_2}{2}$$

$$T_2 = 6548.08 \text{ N}$$

$$T_1 = 13449.756 \text{ N}$$

$$V = \frac{\pi D N}{60 \times 1000} = \frac{\pi \times 0.4 \times 200}{60}$$

$$= 4.188 \text{ m/sec.}$$

$\therefore$ Power transmitted $= \frac{(T_1 - T_2) V}{1000}$

$$= \frac{(13449.756 - 6548.08) \times 4.188}{1000}$$

$$P = 28.91 \text{ kW}$$

11) A V-belt drive is used to transmit power between two shafts. The power transmitted is 8000 W at

94 a speed of 800 rpm. If the semi groove angle of the V-belt is 20°, the mean radius of grooved pulley is 500 mm, and the angle of lap is 160° Calculate tensions on either sides of belt. (Assume μ to be 0.25)

Given: $P = 8000\,W = 8\,KW$ $N = 300\,rpm.$, $\alpha = 20'$, $r = 500\,mm$

$\theta = 160' = \frac{\pi \times 160}{180} = 2.79$ radians $r = 0.5\,m.$

$T_1 = ?$ $T_2 = ?$

Velocity of V-belt $= V = \frac{\pi d N}{60} = \frac{\pi (2r) N}{60}$

$$= \frac{\pi \times 2 \times 500 \times 300 \times 10^{-3}}{60}$$

$$= 15.70\,m/sec.$$

Ratio of belt tensions $: \frac{T_1}{T_2} = e^{\frac{\mu\theta}{\sin\alpha}}$

$$= e^{\frac{0.25 \times 2.79}{\sin 20'}}$$

$$= 7.68.$$

$$T_1 = 7.68\,T_2$$

Power transmitted $P = \frac{(T_1 - T_2) V}{1000}$

$$8 = \frac{(7.68T_2 - T_2) \times 15.70}{1000}$$

$$T_2 = 76.28\,N$$

$$T_1 = 585.83\,N$$

VTU Mar 99

12. An engine shaft running at 200rpm is required to drive a generator at 300rpm by means of flat drive. Pulley on the driving shaft has 500 mm diameter. Determine diameter of the pulley on the generator shaft if the belt thickness is 8mm and slip is 4%.

Given: Driving - Engine shaft Driven - Generator

$N_1 = 200\,rpm$ $N_2 = 300\,rpm$

$d_1 = 500\,mm$ $d_2 = ?$

$t = 8\,mm$ $S = 4\%$

~~Velocity ratio~~ $\cancel{\frac{n_1}{n_2}} = \cancel{\frac{(d_2+t)}{(d_1+t)}}\left(\cancel{\frac{100-s}{100-s}}\right)$

$$\cancel{\frac{200}{300}} = \cancel{\frac{(d_2+8)}{(500+8)}}\left(\cancel{\frac{100-4}{100}}\right)$$

$$\cancel{\frac{2}{3}} = \cancel{(d_2+8)\times 1.8897\times10^{-3}}$$

$$\cancel{(d_2+8)} = \cancel{35277}$$

$$d_2 =$$

Velocity ratio $\frac{n_2}{n_1} = \frac{(d_1+t)}{(d_2+t)}\left(\frac{100-s}{100}\right)$

$$\frac{300}{200} = \frac{(500+8)}{(d_2+8)}\left(\frac{100-4}{100}\right)$$

$$(d_2+8) = \frac{508}{300}\left(\frac{100-4}{100}\right)\times 200$$

$$d_2 = 325.12 - 8$$

$$d_2 = 317.12\text{ mm}$$

Diameter of the driven (generator) pulley $d_2 = 317.12$ mm

VTU Aug 01

13) In a belt drive, the angle of lap on driven pulley is 160° and the coefficient of friction is 0.3. If the maximum tension in the belt is 10000N, Find the initial tension in the belt drive.

Given: $\theta = 160°$, $\mu = 0.3$, $T_1 = 10000$N

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

∴ Slack side tension $T_2 = \frac{T_1}{e^{\mu\theta}} = \frac{10000}{e^{0.3\times\frac{160\times\pi}{180}}}$

$$= 4326.79\text{N}$$

Initial Tension $T_0 = \frac{T_1+T_2}{2} = \frac{10000+4326.79}{2} = 7163.39\text{N}$

14) In a belt drive, ratio of tension is 2 and the slack side tension is 500N. If the speed and diameter of the driven pulley are 200 rpm and 1.2m respectively, find the power transmitted by belt. VTU Jan 03

Given: $\frac{T_1}{T_2} = 2$, $T_2 = 500N$

$N_2 = 200rpm$ $d_2 = 1.2m = 1200mm$.

Tight side tension $T_1 = 2T_2 = 2 \times 500$

$= 1000N$

Linear velocity of belt $v = \frac{\pi d_2 N_2}{60 \times 1000}$

$= \frac{\pi \times 1200 \times 200}{60 \times 1000}$

$= 12.56$ m/sec

Power transmitted by the belt

$P = \frac{(T_1 - T_2)v}{1000}$

$= \frac{(1000 - 500) \times 12.56}{1000}$

$= 6.28$ kW

15) Two parallel shafts 6m apart are provided with 300mm and 400mm diameter pulleys and are connected by a cross belt. The direction of rotation of follower pulley is to be reversed by changing over to an open belt drive. How much length of belt should be changed? VTU Feb 05

Given: $C = 6m = 6000mm$. $d_1 = 400mm$ $d_2 = 300mm$

$r_1 = 200mm$ $r_2 = 150mm$.

Length of belt for cross belt drive.

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

$= 2 \times 6000 + \pi(200 + 150) + \frac{(200 + 150)^2}{6000}$

$= 13119.974$ mm

Length of open belt drive

Length $L_o = 2C + \pi(r_1+r_2) + \frac{(r_1-r_2)^2}{C}$

$= 2\times6000 + \pi(200+150) + \frac{(200-150)^2}{6000}$

$= 13099.565$

Change in length of belt $\Delta L = L_c - L_o$

$\Delta L = 13119.97 - 13099.56$

$= 20.41$ mm

16) Two pulley are connected by a cross belt, the velocity ratio of the drive being 3. The driver runs at 1000rpm and has a diameter of 1.2m. Find the speed and diameter of driven pulley.

VTU Jan 05

Given: Cross belt drive.

Velocity ratio $\frac{n_1}{n_2} = 3$ $n_1 = 1000$rpm

$d_1 = 1.2$m $= 1200$mm

Velocity ratio $\frac{n_1}{n_2} = 3$

$\frac{1000}{n_2} = 3$

$n_2 = 333.33$ rpm.

$\frac{n_1}{n_2} = \frac{d_2}{d_1}$

$d_2 = d_1 \times \frac{n_1}{n_2} = 1200 \times 3$

$d_2 = 3600$ mm $= 3.6$m.

Speed of driven pulley $= 333.33$ rpm

Diameter of driven pully $= 3.6$m.

17) In a belt drive velocity ratio is 3. The driving pulley runs at 400 rpm. The diameter of driven pulley is 300mm. Find the speed of driven pulley and the diameter of driving pulley

VTU Jan 06

Given: $\frac{n_1}{n_2} = 3$ $n_2 = 400$ rpm $d_2 = 300$ mm

Velocity ratio $\frac{n_1}{n_2} = \frac{d_2}{d_1}$

$$\frac{n_1}{n_2} = 3$$

$$\frac{400}{n_2} = 3$$

∴ Speed of driven pulley, $n_2 = 133.33$ rpm

$$\frac{n_1}{n_2} = \frac{d_2}{d_1} = 3$$

$$\frac{300}{d_1} = 3$$

Dia of driver pulley $d_1 = 100$ mm

18) Two pulleys are connected by a belt drive. The tensions in the slack and tight sides are 800N and 1200N respectively. The diameter of the driven pulley is 1m and its speed is 240 rpm. Determine power transmitted. VTU Jan07

Given: $T_1 = 1200N$ $T_2 = 800N$, $d_2 = 1m = 1000mm$. $n_2 = 240$ rpm

Linear velocity $V = \frac{\pi d_2 n_2}{60 \times 1000}$

$$= \frac{\pi \times 1000 \times 240}{60 \times 1000}$$

$$= 12.56 \text{ m/sec}$$

Power $P = \frac{(T_1 - T_2)V}{1000}$

$$= \frac{(1200 - 800)}{1000} \times 12.56$$

$$= 5.024 \text{ kW}$$

GEAR DRIVES:

Gear drives are used to transmit power or motion from one shaft to the other by means of gears

Gear:

A wheel provided with teeth is called a Gear. In other words, gears are toothed wheels used to transmit power or motion from one shaft to another, where the distance between two shaft is very small.

Gears are generally used for

1. To reverse the direction of rotation
2. To increase or decrease the speed of rotation
3. To move rotational motion to a different axis.
4. To keep the rotation of two axes synchronized.

Types of Gears:

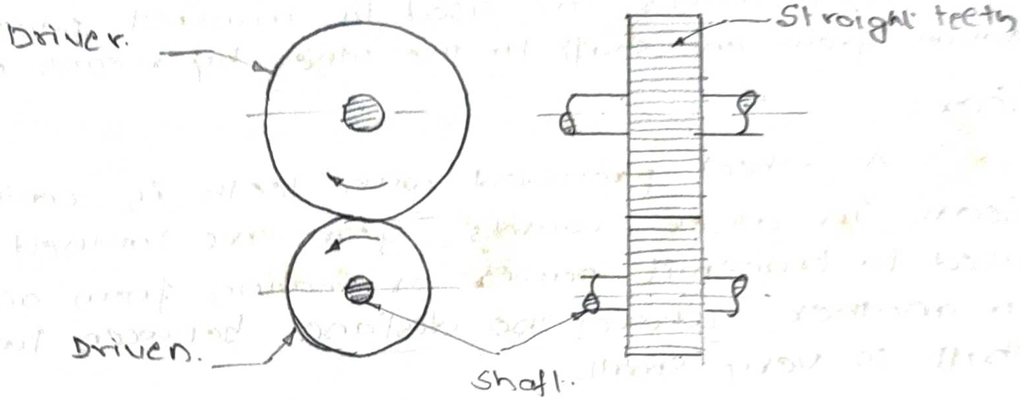
Gears are commonly classified based on position of axis of the shaft on which gear is mounted. The most commonly used gears are

1. Spur Gear
2. Bevel Gear
3. Helical Gear
4. Worm gear and
5. Rack and pinion.

1. SPUR GEAR:

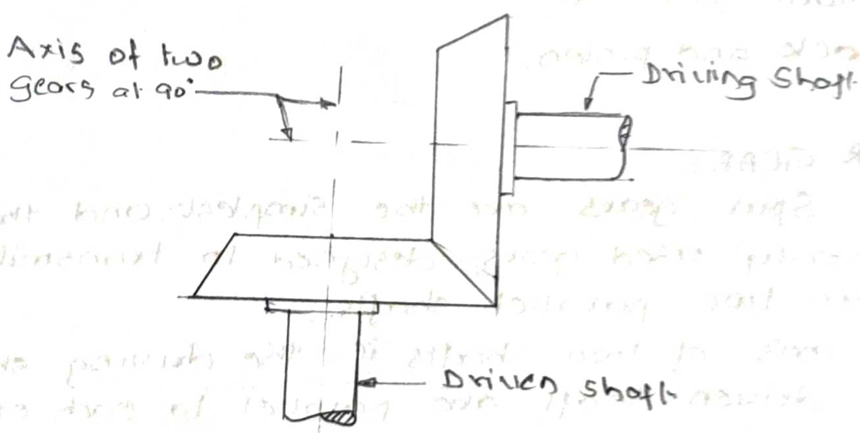
Spur gears are the simplest and the most commonly used gears designed to transmit motion between two parallel shafts.

- The axis of two shafts ie, the driving shaft and the driven shaft are parallel to each other.
- The teeth are cut straight on the periphery
97 (circumference) of the wheel and they are parallel to the axis of the wheel.
- Ex: Machine tools, Gear boxes, Wind-up alarm clock, watches and precision measuring measurements etc.



2. Bevel Gears:

- Bevel gears are used for transmitting power between two intersecting shafts.
- Usually mounted on shafts that are 90° apart, but can be designed to work at other angles as well.
- Teeth are cut on the outside of the conical surface and vary in cross-section throughout their length. Since dia of cone is greatest at its base, the teeth will be thicker at the base.
- Teeth on bevel gears can be straight, spiral or hypoid.

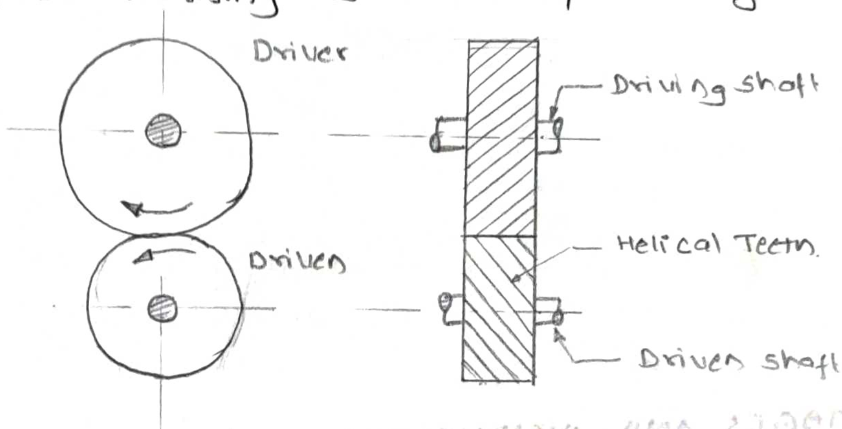


3. HELICAL GEARS:

- Helical gears are used to transmit power or motion between two parallel or non-parallel but non-intersecting shafts.
- In helical gears, teeth are curved, each being helical in shape and hence the name helical gears.

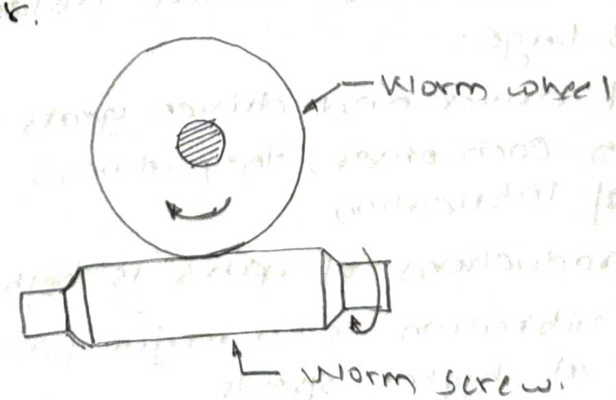
- When two teeth on helical gear engage, the contact starts at one end of the teeth and gradually spreads as the gears rotate, until two teeth are in full engagment. This gradual engagment makes gears ~~what~~ run much more smoothy and quietly than spur gears.

Ex: Automobile power transmission where smooth and quiet running is necessary at higher speeds



WORM GEARS:

- Worm gears are used to transmit power or motion between two shafts having their axis at right angles and non-intersecting.
- Worm gear is a type of screw gearing that consists of a screw meshing with a helical gear. The screw is called the worm and gear wheel meshing with wheel is called worm gear or worm wheel.
- Applications: Used when large gear reductions are needed. It is common for worm gear to have reductions of 20:1 and even up to 300:1 or greater.



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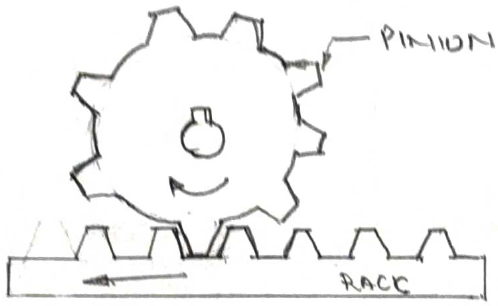
4. RACK AND PINION:

- A rack is a gear, having teeth cut along a straight line, while pinion is a gear with teeth cut along its periphery.
- With the help of rack and pinion, rotary motion can be converted in to linear motion.



ADVANTAGES AND DISADVANTAGES OF GEAR DRIVES:

Advantages:

1. Used to transmit power or motion between parallel, non-parallel, intersecting and non intersecting shafts
2. Preferred to other drives, when the centre distance between two shafts is very small.
3. Power can be transmitted with a constant speed ratio.
4. Higher power transmission efficiency
5. Used for Low, medium or high power transmission.

Disadvantages:

1. Not suitable when the centre distance between two shafts is large.
2. The teeth of driver and driven gears come in contact with each other, they always require some kind of lubrication
3. Cost for productions of gears is high
4. Noise and vibration is a major problem when they rotate at higher speeds
5. Damage to single teeth affects the whole arrangement.

Comparison between Belt drives and Gear drives

Belt drives	Gear drives
1. They are non-positive drives, as there is a reduction in power transmission due to slip.	1. They are positive drives
2. Efficient when centre distance between two shaft is greater.	2. Efficient when centre distance between two shaft is very small.
3. Used to transmit power between two parallel shafts.	3. Used to transmit power between, parallel, non-parallel, intersecting and non-intersecting shafts.
4. Due to slip exact velocity ratio cannot be maintained.	4. Due to absence of slip constant velocity ratio can be maintained
5. Only moderate power can be transmitted	5. Can be used for low, medium or high power transmission.
6. Power transmission efficiency is low.	6. High power transmission efficiency.
7. Lubrication is not required.	7. Requires some kind of lubrication.

GEAR TRAINS:

When two or more gears are used to transmit power, the arrangment is then called 'gear train.' The nature of 'train' ie, the number of gears used depends upon the desired velocity ratio and relative position of axis of shafts.

Gear trains classified as

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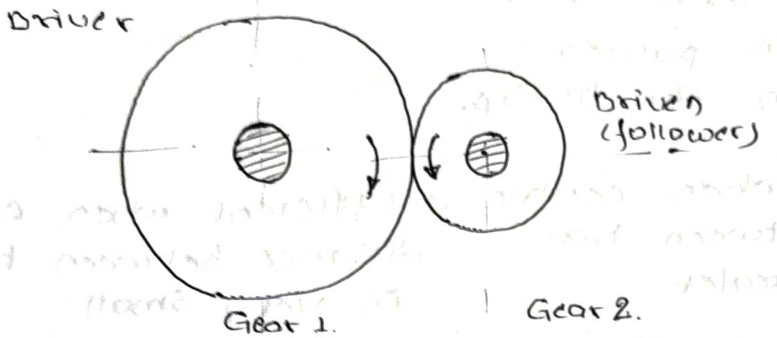
1. Simple Gear Train
2. Compound Gear Train.
3. Reverted gear Train
4. Epicyclic Gear Train.

1. SIMPLE GEAR TRAIN:

A Simple gear train is one in which each shaft carries only one gear. Fig shows simple gear train in which gear 1 drives gear 2.



Velocity ratio of gear drive is defined as the ratio between the speed of the driven gear (follower) and the speed of the driving gear (driver).

Let d_1 = pitch circle dia of the driving gear.

d_2 = pitch circle dia of the driven gear

T_1 = Number of teeth on driving gear.

T_2 = Number of teeth on driven gear.

n_1 = Speed of driving gear

n_2 = Speed of driven gear.

Assuming that there is no slip between mating teeth, the linear speed of the driving gear must be same as that of driven gear.

Hence, $\pi d_1 n_1 = \pi d_2 n_2$

$$d_1 n_1 = d_2 n_2$$

$$\frac{n_2}{n_1} = \frac{d_1}{d_2}$$

$$\text{Velocity Ratio} = \frac{\text{Speed of driven}}{\text{Speed of driver}} = \frac{\text{Dia of driver}}{\text{Diameter of driven}}$$

The circular pitch for both mating (meshing) gears remains same. Pitch circle of driver = Pitch circle of driven

$$\frac{d_1}{d_2} = \frac{T_1}{T_2} \qquad \therefore \frac{n_2}{n_1} = \frac{d_1}{d_2} = \frac{T_1}{T_2}$$

$$p_c = \frac{\pi d_1}{T_1} = \frac{\pi d_2}{T_2}$$

$$\frac{d_1}{d_2} = \frac{T_1}{T_2}$$

There are certain cases, when power is to be transmitted between two shafts that are at large distances. This can be done by providing one or more intermediate gears. These intermediate gears are called "<u>idle gears</u>"

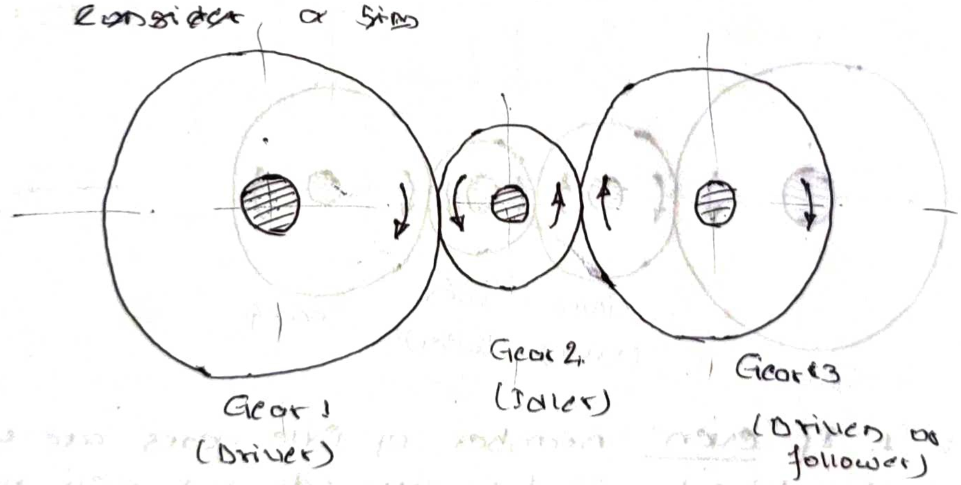
- The idle gears does not affect the velocity ratio but only serve to fill up the space between the driver and the driven gears.
- Helps in achieving the required direction of rotation for the driven wheel.

Gear Train with one Idler:

Consider a simple gear train with one idler gear as in fig. Let gear 1 rotate in clockwise direction. Therefore Gear 1 drives gear 2. Hence gear 2 rotates in counter clockwise direction. Next gear 2 drives gear 3. Hence gear 3 rotates in opposite (ie, clockwise) direction to that of gear 2.

~~Gear Train with Two Idler:~~

~~Consider a sim~~



Gear Train with Two Idler:

Consider a simple gear train with 2 idler gears as in fig. The rotation of each gear is shown in fig.

Let n_1, n_2, n_3 and n_4 be the speeds and T_1, T_2, T_3 and T_4 be the number of teeth on gear 1, 2, 3 and 4 respectively.

100 Gear 1 drives Gear 2.

$\therefore$ velocity ratio $= \frac{n_2}{n_1} = \frac{T_1}{T_2}$

Gear 2 drives Gear 3

∴ Velocity ratio = $\frac{n_3}{n_2} = \frac{T_2}{T_3}$

Similarly gear 3 drives gear 4

Velocity ratio = $\frac{n_4}{n_3} = \frac{T_3}{T_4}$

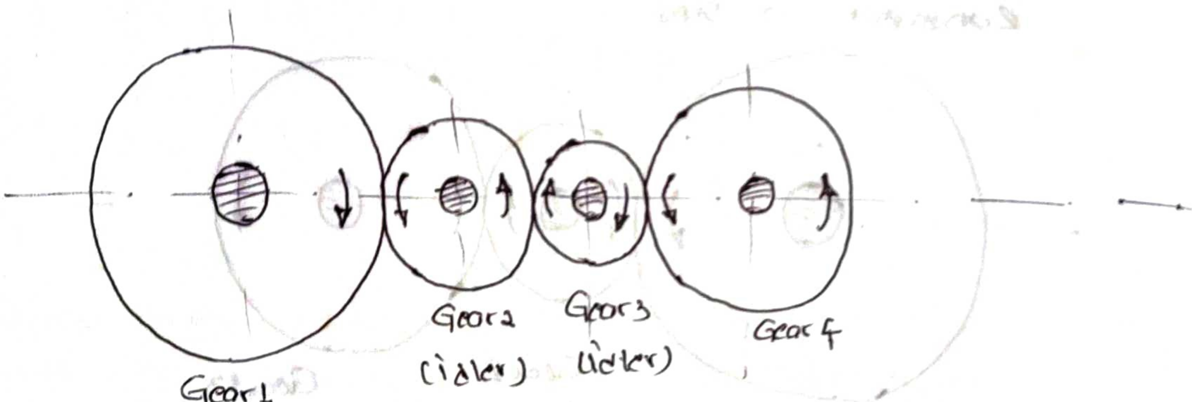
The velocity ratio of gear train is obtained by

$$\text{Velocity ratio} = \frac{n_2 \times n_3 \times n_4}{n_1 \times n_2 \times n_3} = \frac{T_1 \times T_2 \times T_3}{T_2 \times T_3 \times T_4}$$

$$= \frac{n_4}{n_1} = \frac{T_1}{T_4}.$$

$$\text{Velocity ratio} = \frac{\text{Speed of last gear}}{\text{Speed of first gear}} = \frac{\text{No of teeth on first gear}}{\text{No of teeth on last gear}}$$

From above equation, idlers gears do not affect velocity ratio



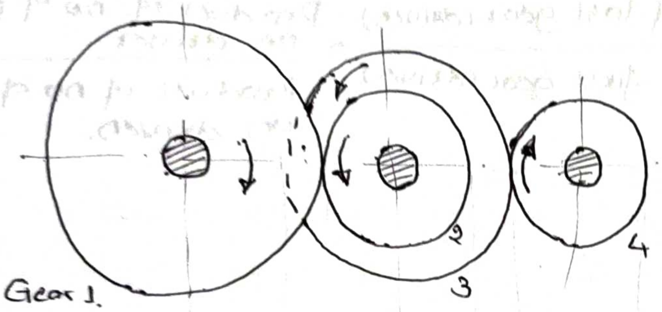
Note: 1. If "even" number of idle gears are used, the first (driver) and last gear (driven) will rotate in opposite direction

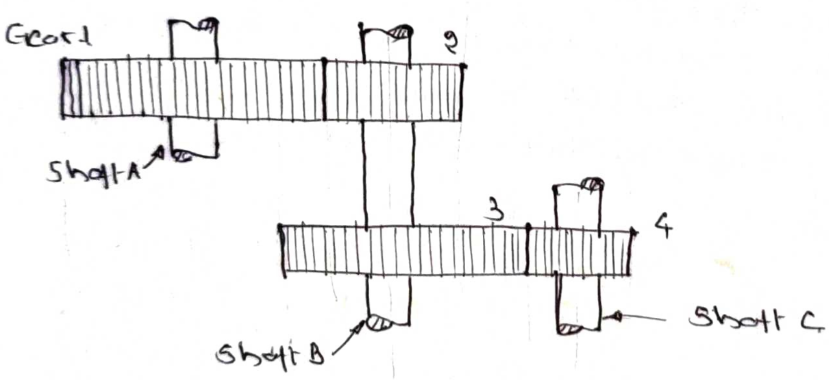
2. If "odd" number of idle gears are used, the first (driver) and the last gear (driven) will rotate in same direction.

COMPOUND GEAR TRAIN:

A compound gear train is one in which each shaft carries two or more gears.

Whenever distance between the two shafts is large and at the same time, higher or much less speed is required, compound gears are provided with intermediate shafts.





In gear train, gear 1 and gear 4 are mounted on seperate shafts, but gear 2 and gear 3 are mounted on a single shaft B. Hence gear 2 and 3 are called compound gears. Since gear 2 and 3 are keyed to same spindle, they rotate at same speed.

Let N_1, N_2, N_3 and N_4 be speeds and T_1, T_2, T_3 and T_4 be the number of teeth on gear 1, 2, 3 and 4 respectively.

Gear 1 drives Gear 2.

$$\therefore \text{Velocity ratio} = \frac{N_2}{N_1} = \frac{T_1}{T_2} \quad \text{--- (1)}$$

Similarly gear 3 drives Gear 4.

[0] $$\therefore \text{Velocity ratio} = \frac{N_4}{N_3} = \frac{T_3}{T_4} \quad \text{--- (2)}$$

Multiply eq (1) and (2)

$$\text{Velocity ratio} = \frac{n_2}{n_1} \times \frac{n_4}{n_3} = \frac{T_1}{T_2} \times \frac{T_3}{T_4}.$$

Since, $n_2 = n_3$ since gear 2 and gear 3 are keyed to same spindle.

$$\therefore \text{Velocity ratio} = \frac{n_4}{n_1} = \frac{T_1 \times T_3}{T_2 \times T_4}$$

$$\therefore \left.\begin{matrix}\text{Velocity} \\ \text{ratio}\end{matrix}\right\} = \frac{\text{Speed of last gear (driven)}}{\text{Speed of first gear (driver)}} = \frac{\text{Product of no of teeth on driver}}{\text{Product of no of teeth on driven.}}$$

Simple Problems on Gear Drives:

1. Two gear wheels having 80 teeth and 30 teeth mesh with each other. If the smaller gear wheel runs at 480 rpm, find the speed of larger wheel.

$n_1 = ?$ $\quad n_2 = 480$ rpm

$T_1 = 80$ $\quad T_2 = 30$

Velocity ratio of simple gear train $\Big\}$ $\dfrac{n_2}{n_1} = \dfrac{T_1}{T_2}$

$$n_1 = \frac{T_2}{T_1} \times n_2$$

$$= \frac{30}{80} \times 480$$

$$= 180 \text{ r.p.m}$$

2. A gear wheel of 20 teeth drives another gear wheel having 36 teeth running at 200 rpm. Find the speed of driving wheel and the velocity ratio.

$T_1 = 20$ $\quad T_2 = 36$

$n_1 = ?$ $\quad n_2 = 200$ rpm

V.R. = ?

Velocity ratio of simple gear train $\Big\}$ $= \dfrac{n_2}{n_1} = \dfrac{T_1}{T_2}$

$$n_1 = \frac{T_2}{T_1} \times n_2$$

$$= \frac{36}{20} \times 200$$

$$n_1 = 360 \text{ rpm}$$

Velocity ratio $= \dfrac{n_1}{n_2}$

$$= \frac{36\cancel{0}}{20\cancel{0}}$$

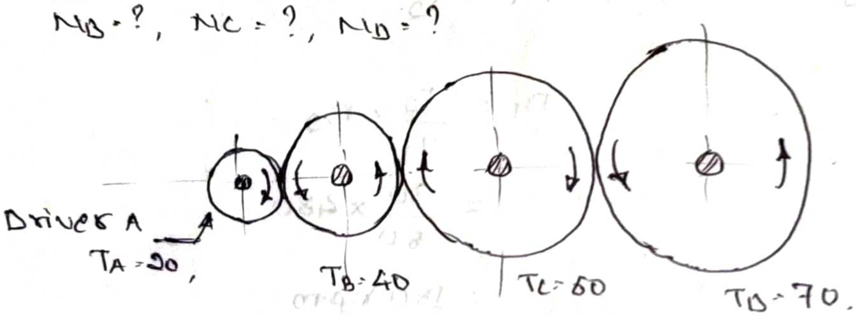
$$= 1.8 : 1$$

3. A simple gear train is made up of four gears A, B, C and D having 20, 40, 60 and 70 teeth respectively. If gear A is the main driver rotating at 500 rpm clockwise. Calculate the following

1. Speeds of intermediate gears
2. Speed and direction of the last follower.
3. Train value.

$N_A = 500$ rpm, $T_A = 20$, $T_B = 40$, $T_C = 60$, $T_D = 70$

$N_B = ?$, $N_C = ?$, $N_D = ?$



Gear A drives B.

$$\frac{N_B}{N_A} = \frac{T_A}{T_B}$$

$$N_B = N_A \times \frac{T_A}{T_B}$$

$$= 500 \times \frac{20}{40}$$

$$= 250 \text{ rpm.}$$

Gear B drives Gear C.

$$\frac{N_C}{N_B} = \frac{T_B}{T_C}$$

$$N_C = N_B \times \frac{T_B}{T_C}$$

$$= 250 \times \frac{40}{60}$$

$$= 166.67 \text{ rpm}$$

Gear C drives Gear D

$$\frac{N_D}{N_C} = \frac{T_C}{T_D}$$

$$N_D = N_C \times \frac{T_C}{T_D}$$

$$= 166.67 \times \frac{60}{70}$$

$$= 142.86 \text{ rpm.}$$

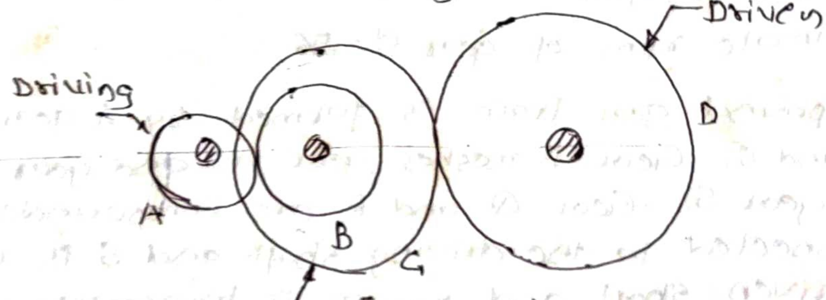
$$\text{Velocity ratio} = \frac{N_D}{N_A}$$

$$= \frac{142.86}{500}$$

$$= 0.28572$$

4. A compound gear train consists of 4 gears A, B, C and D and they have 20, 30, 40 and 60 teeth respectively. A is keyed to the driving shaft and D is keyed to the driven shaft, B and C are compound gears, B meshes with A, and C meshes with D. If A rotates at 180 rpm find the rpm of D. (VTU July/August 2003 & July/Aug 2006)

$T_A = 20$, $T_B = 30$, $T_C = 40$, $T_D = 60$. $N_A = 180$ rpm.



Velocity ratio of compound gear train

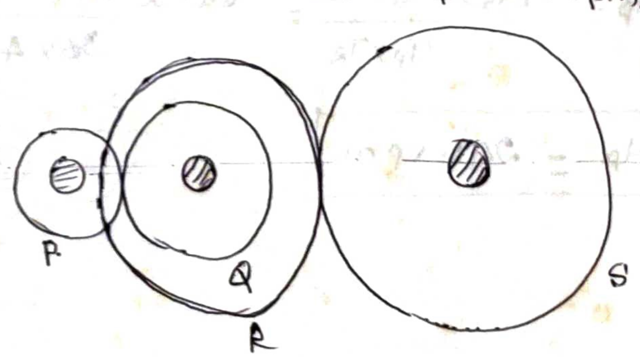
$$\frac{N_D}{N_A} = \frac{T_A \times T_C}{T_D \times T_B}$$

$$N_D = N_A \times \frac{T_A \times T_C}{T_D \times T_B} = 180 \times \frac{20 \times 40}{60 \times 30}$$

$$N_D = 80 \text{ r.p.m.}$$

5) A compound gear consists of 4 gears P, Q, R, S having 20, 40, 60 and 80 teeth respectively. The gear P is keyed to the driving shaft, gear S to driven shaft, Q and R are compound gears, Q meeting with P, and R meshes S. If P rotates at 150 rpm, what is rpm of gear S. Show gear arrangement. (VTU, Jan/Feb 2004)

$T_P = 20$, $T_Q = 40$, $T_R = 60$, $T_S = 80$, $N_P = 150$ rpm.



$$\frac{N_S}{N_P} = \frac{T_P \times T_R}{T_Q \times T_S}$$

$$n_S = n_P \times \frac{T_P \times T_R}{T_Q \times T_S}$$

$$= 150 \times \frac{20 \times 60}{40 \times 80}$$

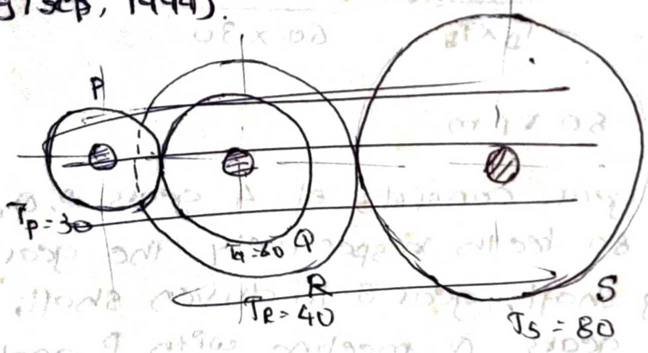
$$= 56.25 \text{ rpm.}$$

Approximate rpm of gear S = 56

6. A compound gear train is formed by 4 gears P, Q, R and S. Gear P meshes gear Q, and gear R meshes gear S. Gear Q and R are compounded. P is connected to the driving shaft and S is connected to the driven shaft and power is transmitted. The details of gears are given below

Gears	P	Q	R	S
No of teeth	30	60	40	80

If gear S were to rotate at 60 rpm. Calculate the speed of P. Represent gear arrangement schematically. (VTU Aug/Sep, 1999).



$T_P = 30$
$T_Q = 60$
$T_R = 40$
$T_S = 80$
$N_S = 60$ rpm
$N_P = ?$

$$\frac{N_S}{N_P} = \frac{T_P \times T_R}{T_Q \times T_S}$$

$$N_P = N_S \times \frac{T_Q \times T_S}{T_P \times T_R} = 60 \times \frac{\overset{2}{\cancel{60}} \times \overset{2}{\cancel{80}}}{\cancel{30} \times \cancel{40}}$$

$$\boxed{N_P = 240 \text{ rpm.}}$$