ME3491 THEORY OF MACHINES

UNIT III NOTES

3.13. Belt and Rope Drives

Power is transmitted from one shaft to another shaft by means of belts, ropes, chains and gears. The salient features of belts and ropes are as follows:

- Belts and ropes are used in cases where the distance between the shafts is large. For small distances, gears are preferred.
- Belts and ropes are flexible type of connectors, i.e., they bend easily.
- Belts and ropes transmit power due to friction between them and the pulleys. If the power transmitted exceeds the force of friction, the belt or rope slips over the pulley.
- Belts and ropes are strained during motion as tensions are developed in them.
- Velocity ratio does not remain constant because of slip and creep.

3.13.1 The amount of power transmitted depends upon the following factors :

1. The velocity of the belt.

2. The tension under which the belt is placed on the pulleys.

3. The arc of contact between the belt and the smaller pulley.

4. The conditions under which the belt is used. It may be noted that (

a) The shafts should be properly in line to insure uniform tension across the belt section.

(b) The pulleys should not be too close together, in order that the arc of contact on the smaller pulley may be as large as possible.

(c) The pulleys should not be so far apart as to cause the belt to weigh heavily on the shafts, thus increasing the friction load on the bearing

(d) A long belt tends to swing from side to side, causing the belt to run out of the pulleys, which in turn develops crooked spots in the belt.

(e) The tight side of the belt should be at the bottom, so that whatever sag is present on the loose side will increase the arc of contact at the pulleys.

(f) In order to obtain good results with flat belts, the maximum distance between the shafts should not exceed 10 metres and the minimum should not be less than 3.5 times the diameter of the larger pulley

3.13.2 Selection of a Belt Drive

Following are the various important factors upon which the selection of a belt drive depends:

1. Speed of the driving and driven shafts,
2. Speed reduction ratio,
3. Power to be transmitted,

4. Centre distance between the shafts,

5. Positive drive requirements,

6. Shafts layout,

7. Space available, and

8. Service conditions

3.13.3. Types of Belt Drives

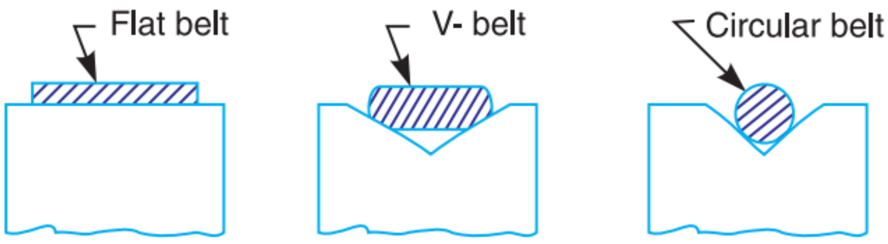
The belt drives are usually classified into the following three groups :

1. Light drives. These are used to transmit small powers at belt speeds upto about 10 m/s, as in agricultural machines and small machine tools.
2. Medium drives. These are used to transmit medium power at belt speeds over 10 m/s but up to 22 m/s, as in machine tools.
3. Heavy drives. These are used to transmit large powers at belt speeds above 22 m/s, as in compressors and generators.

3.13.4 Types of Belts

1. Flat belt. The flat belt, as shown in Figure, is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another when the two pulleys are not more than 8 metres apart.
2. V-belt. The V-belt, as shown in Figure, is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another, when the two pulleys are very near to each other.

3. Circular belt or rope. The circular belt or rope, as shown in Figure, is mostly used in the factories and workshops, where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are more than 8 meters apart.



Flat belt. V-belt. Circular belt.

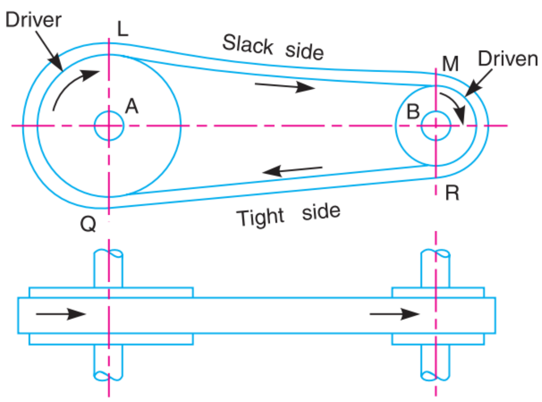
Types of belts.

3.13.5. Types of Flat Belt Drives

The power from one pulley to another may be transmitted by any of the following types of belt drives:

1. **Open belt drive.**

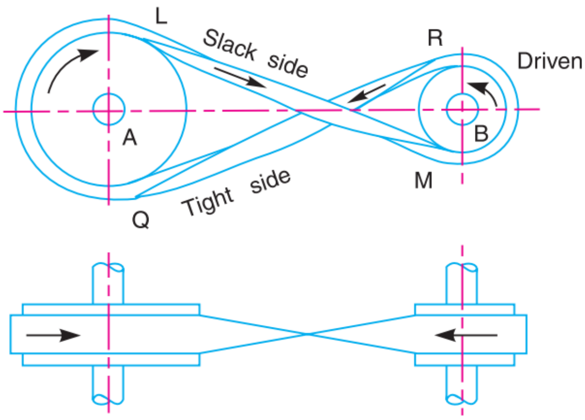
   The open belt drive, as shown in Figure below is used with shafts arranged parallel and rotating in the same direction. In this case, the driver A pulls the belt from one side (i.e. lower side RQ) and delivers it to the other side (i.e. upper side LM). Thus the tension in the lower side belt will be more than that in the upper side belt. The lower side belt (because of more tension) is known as tight side whereas the upper side belt (because of less tension) is known as slack side, as shown in Figure.



Open belt drive.

2.Crossed or twist belt drive.

The crossed or twist belt drive, as shown in Figure, is used with shafts arranged parallel and rotating in the opposite directions.

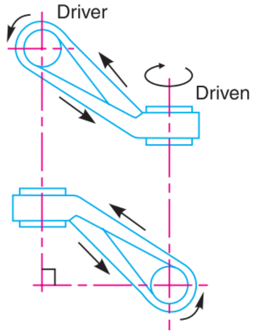


Crossed or twist belt drive.

In this case, the driver pulls the belt from one side (i.e. RQ) and delivers it to the other side (i.e. LM). Thus the tension in the belt RQ will be more than that in the belt LM. The belt RQ (because of more tension) is known as tight side, whereas the belt LM (because of less tension) is known as slack side,

3. Quarter turn belt drive.

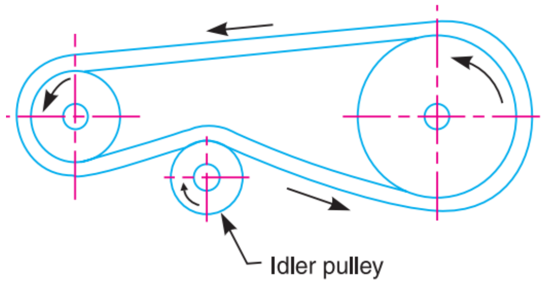
The quarter turn belt drive also known as right angle belt drive, as shown in Figure, is used with shafts arranged at right angles and rotating in one definite direction. In order to prevent the belt from leaving the pulley, the width of the face of the pulley should be greater or equal to 1.4 b, where b is the width of belt. In case the pulleys cannot be arranged, as shown in Figure or when the reversible motion is desired, then a quarter turn belt drive with guide pulley.



Quarter turn belt drive.

4. Belt drive with idler pulleys.

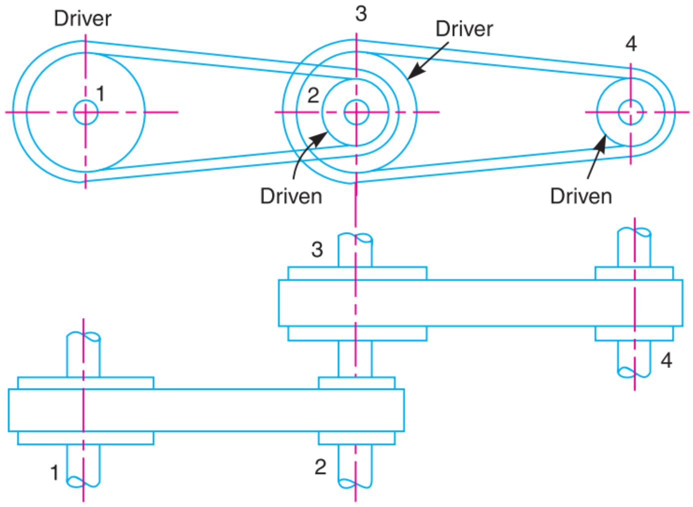
A belt drive with an idler pulley, as shown in Figure is used with shafts arranged parallel and when an open belt drive cannot be used due to small angle of contact on the smaller pulley. This type of drive is provided to obtain high velocity ratio and when the required belt tension cannot be obtained by other means.



Belt drive with single idler pulley.

5.Compound belt drive.

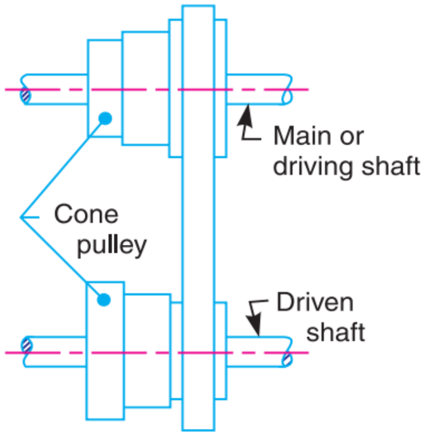
A compound belt drive, as shown in Figure, is used when power is transmitted from one shaft to another through a number of pulleys.



Compound belt brive.

6.Stepped or cone pulley drive.

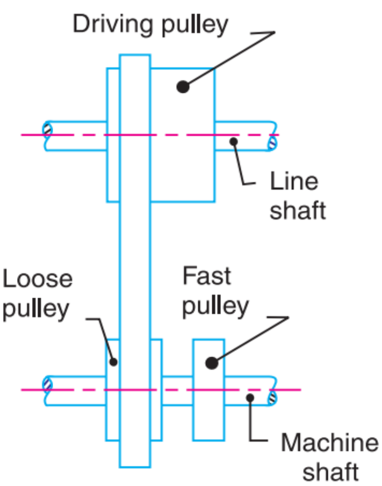
A stepped or cone pulley drive, as shown in Figure, is used for changing the speed of the driven shaft while the main or driving shaft runs at constant speed. This is accomplished by shifting the belt from one part of the steps to the other.



Stepped or cone pulley drive.

7. Fast and loose pulley drive.

A fast and loose pulley drive, as shown in Figure., is used when the driven or machine shaft is to be started or stopped when ever desired without interfering with the driving shaft. A pulley which is keyed to the machine shaft is called fast pulley and runs at the same speed as that of machine shaft. A loose pulley runs freely over the machine shaft and is incapable of transmitting any power. When the driven shaft is required to be stopped, the belt is pushed on to the loose pulley by means of sliding bar having belt forks.



Fast and loose pulley drive.

3.13.6.Velocity Ratio of Belt Drive

It is the ratio between the velocities of the driver and the follower or driven.

It may be expressed, mathematically, as discussed below :

Let d1 = Diameter of the driver, d2 = Diameter of the follower,

N1 = Speed of the driver in r.p.m., and N2 = Speed of the follower in r.p.m.

∴ Length of the belt that passes over the driver, in one minute = π d1 .N1

Similarly, length of the belt that passes over the follower, in one minute = π d2 . N2

Since the length of belt that passes over the driver in one minute is equal to the length of belt that passes over the follower in one minute,

therefore π d1 . N1 = π d2 . N2

$$v_1 = \frac{\pi d_1 . N_1}{60} \text{ m/s}$$

nd peripheral velocity of the belt on the driven or follower pulley,

$$v_2 = \frac{\pi d_2 . N_2}{60} \text{ m/s}$$

When there is no slip, then $v_1 = v_2$.

$$\therefore \quad \frac{\pi d_1 . N_1}{60} = \frac{\pi d_2 . N_2}{60} \quad \text{or} \quad \frac{N_2}{N_1} = \frac{d_1}{d_2}$$

3.13.7. Velocity Ratio of a Compound Belt Dr tio of a Compound Belt Drive

Sometimes the power is transmitted from one shaft to another, through a number of pulleys as shown in Figure.

Consider a pulley 1 driving the pulley 2. Since the pulleys 2 and 3 are keyed to the same shaft, therefore the pulley 1 also drives the pulley 3 which, in turn, drives the pulley 4.

Let d1 = Diameter of the pulley 1, N1 = Speed of the pulley 1 in r.p.m., d2, d3, d4 , and N2, N3, N4= Corresponding values for pulleys 2, 3 and 4. We know that velocity ratio of pulleys 1 and 2

We know that velocity ratio of pulleys 1 and 2,

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

Similarly, velocity ratio of pulleys 3 and 4,

$$\frac{N_4}{N_3} = \frac{d_3}{d_4}$$

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

3.13.8 Slip of Belt

Motion of belts and shafts assuming a firm frictional grip between the belts and the shafts. But sometimes, the frictional grip becomes insufficient. This may cause some forward motion of the driver without carrying the belt with it. This may also cause some forward motion of the belt without carrying the driven pulley with it. This is called slip of the belt and is generally expressed as a percentage