

Theory of Machine

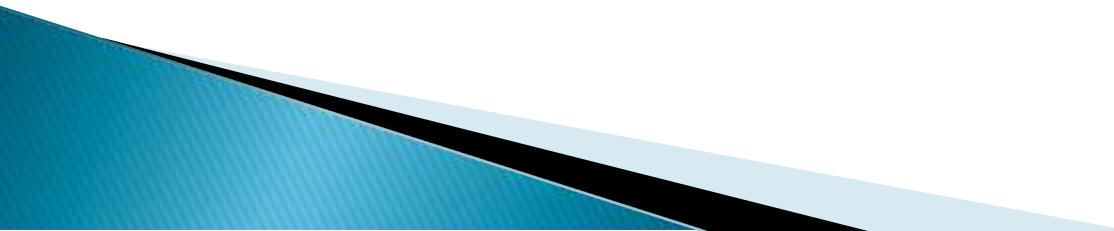
Lecture: Belt Drive and Design

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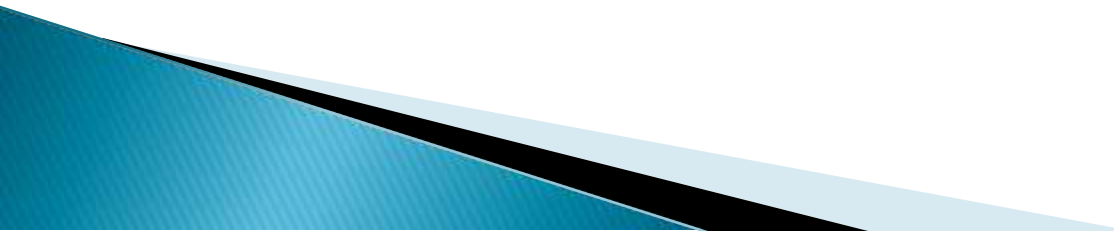
Belt Drive !?



**Belt is a Flexible Mechanical
element
that transmit power from one
shaft to another**



Means of power Transmission

- ▶ Gear Train
 - Ex: Automobile, engines etc.
 - ▶ Chain Drive
 - Ex : Bi-cycle , Motor cycle etc.
 - ▶ Belt Drive
 - Ex: Rice mills, sewing machine etc.
 - ▶ Rope Drive
 - Ex: lift, crane etc.
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Belt Drive and Power Transmission

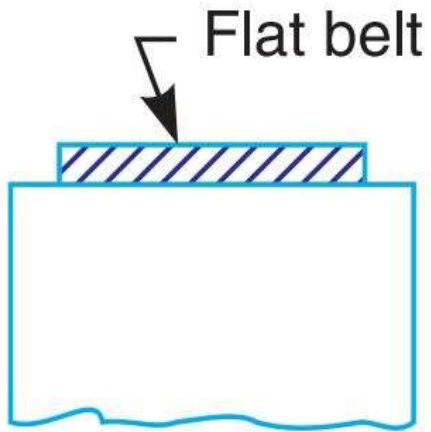
- ▶ **Amount of Power Transmitted by belt Depends on**
 - The velocity of the belt
 - The Tension of the belt
 - The arc of contact between the belt and smaller pulley
 - The condition under which the belt is used



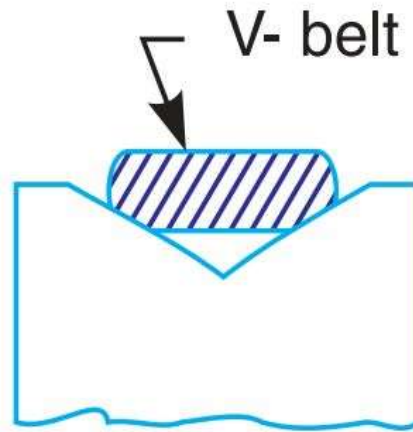
Belt Drive Selection Criteria

1. Speed of the driving and driven shafts,
2. Power to be transmitted,
3. Positive drive requirements,
4. Space available, and
5. Speed reduction ratio,
6. Centre distance between the shafts,
7. Shafts layout,
8. Service conditions.

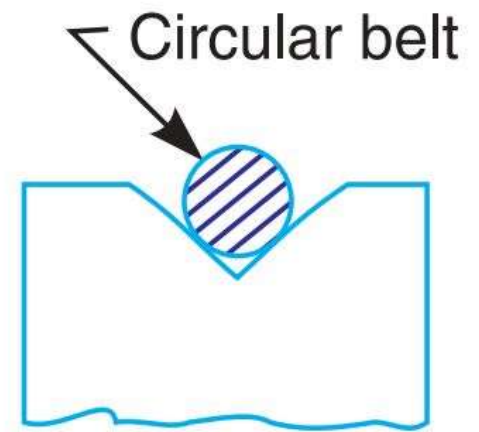
Belt Type



(a) Flat belt.



(b) V-belt.



(c) Circular belt.



V Belt



Round Belt

Belt Material

- ▶ According to the Material Used Belts are classified into
- ▶ 1. Leather Belts
- ▶ 2. Cotton or Fabric Belts
- ▶ 3. Rubber Belts
- ▶ 4. Balata belts
 - Similar to rubber belt except that balata gum is used in place of rubber

Belt Drive type

- ▶ Open Belt Drive: The open belt drive is used with shafts arranged parallel and rotating in the same direction

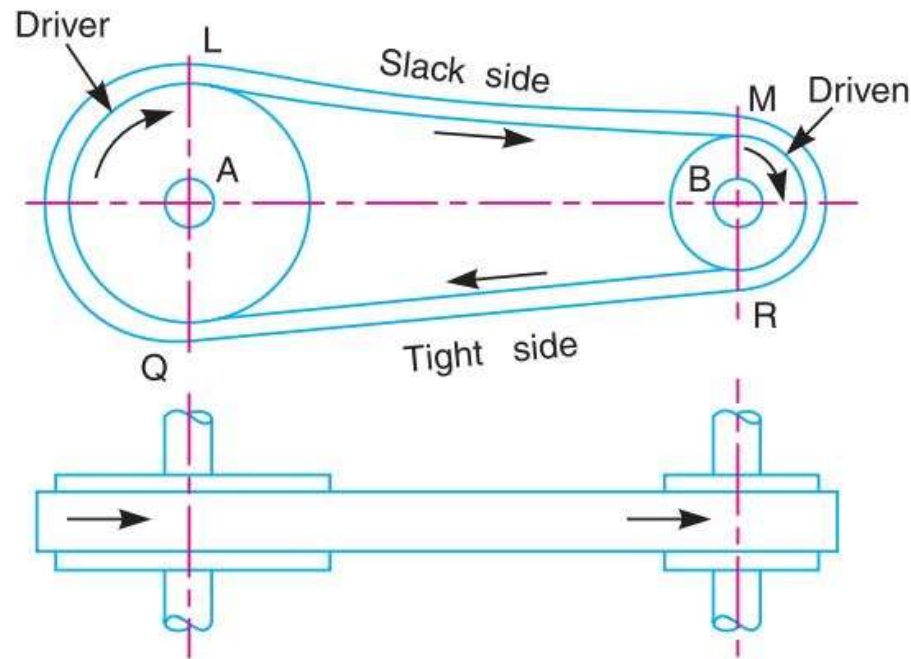


Fig. 11.3. Open belt drive.

Belt Drive type

- ▶ **Crossed Belt Drive:** The crossed belt drive is used with shafts arranged parallel and rotating in the opposite direction

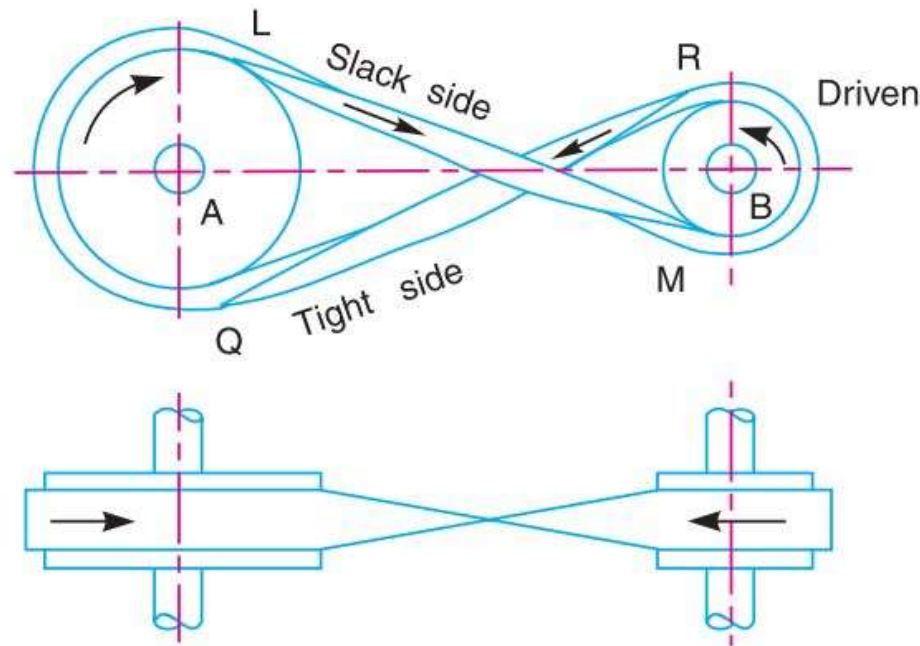
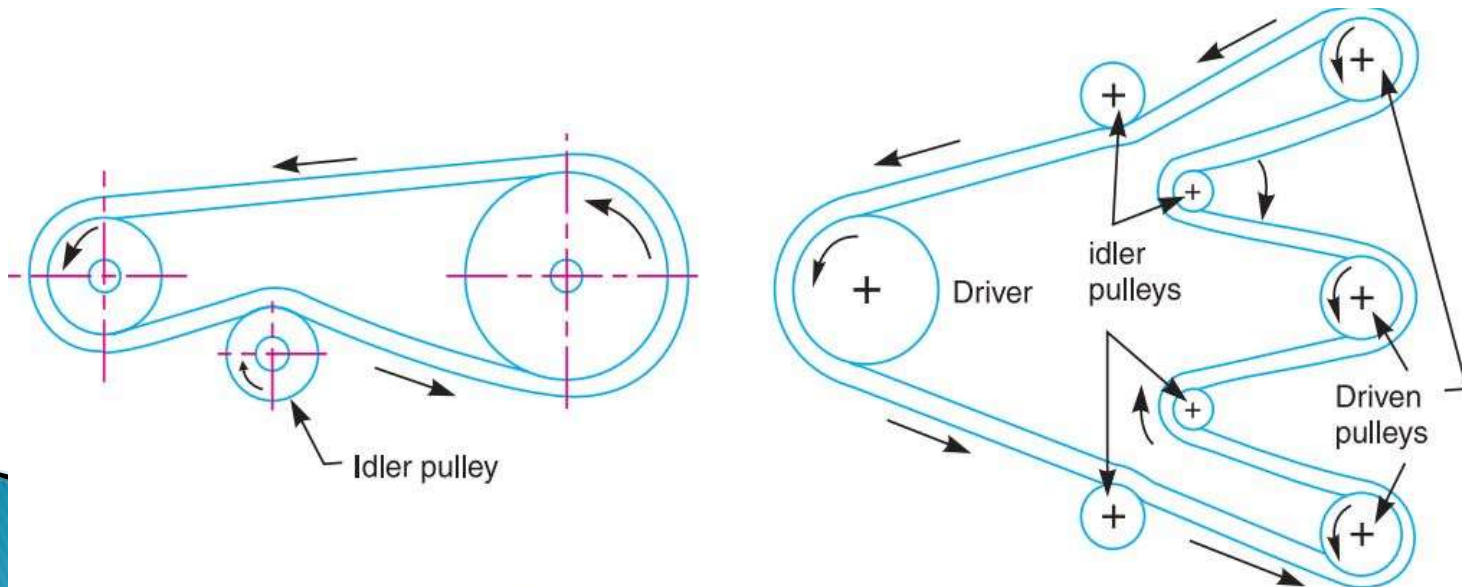


Fig. 11.4. Crossed or twist belt drive.

Belt Drive type

- ▶ **Belt Drive with Idler pulleys:** is used with shafts arranged parallel and when belt drive cannot be used due to small angle of contact on the smaller pulley.
- ▶ **Idler pulley** is a pulley which does not transmit power but assist power transmission by increasing angle of contact of smaller pulley



(a) Belt drive with single idler pulley.

(b) Belt drive with many idler pulleys.

Belt Drive Type

5. Compound belt drive. A compound belt drive, as shown in Fig. 11.7, is used when power is transmitted from one shaft to another through a number of pulleys.

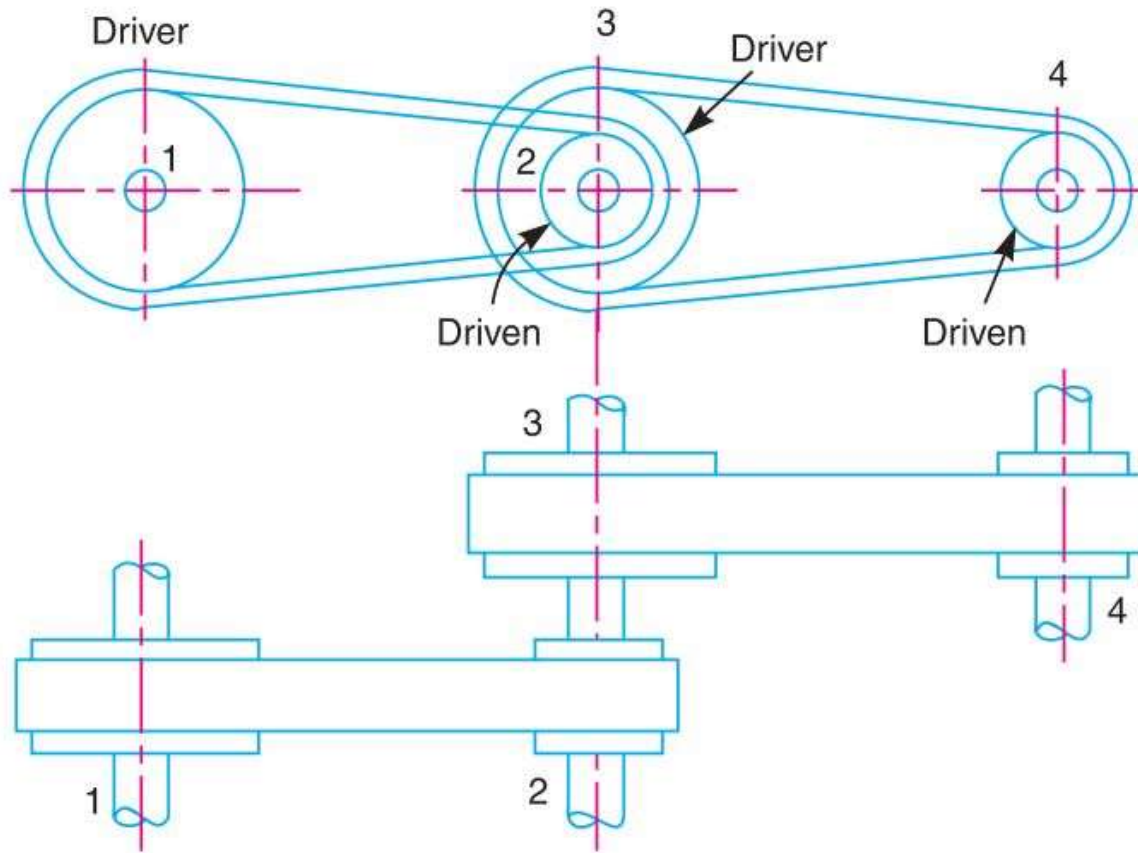


Fig. 11.7. Compound belt drive.

Belt Drive Type

- ▶ **Stepped or Cone pulley Drive:** is used for changing the speed of the driven shaft while main shaft runs at constant speed.

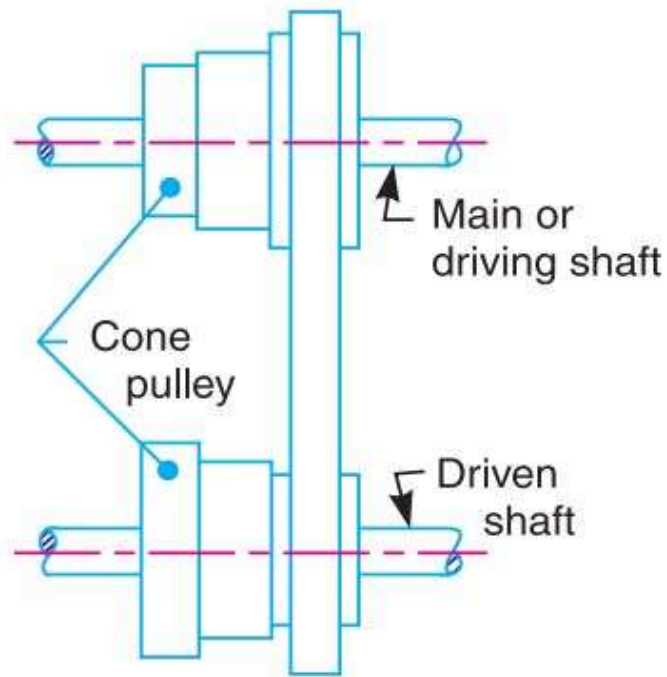


Fig. 11.8. Stepped or cone pulley drive.

Belt Drive Type

▶ Fast and loose pulley Drive:

- **Fast pulley:** pulley keyed to the driven shaft
- **Loose pulley:** pulley not keyed to the driven shaft. It can freely rotate

When needed belt slid over to the loose pulley. Then driven shaft can be stopped without stopping driver shaft

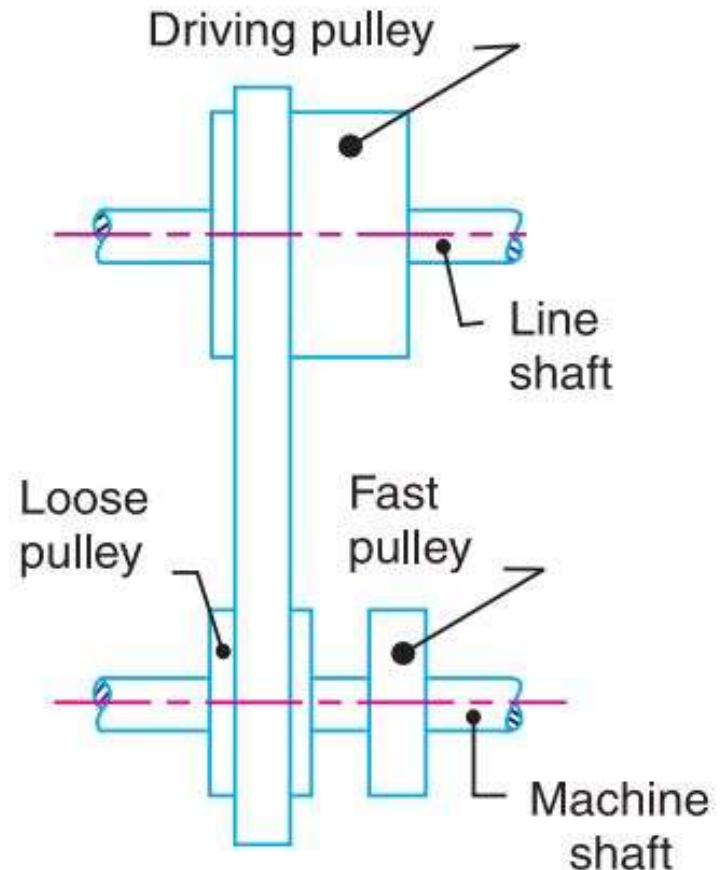


Fig. 11.9. Fast and loose pulley drive.

Length of belt

- ▶ Length of Open belt drive = $\pi(r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{x}$
- ▶ Contact Angle

$$\alpha = \frac{r_1 - r_2}{x}$$

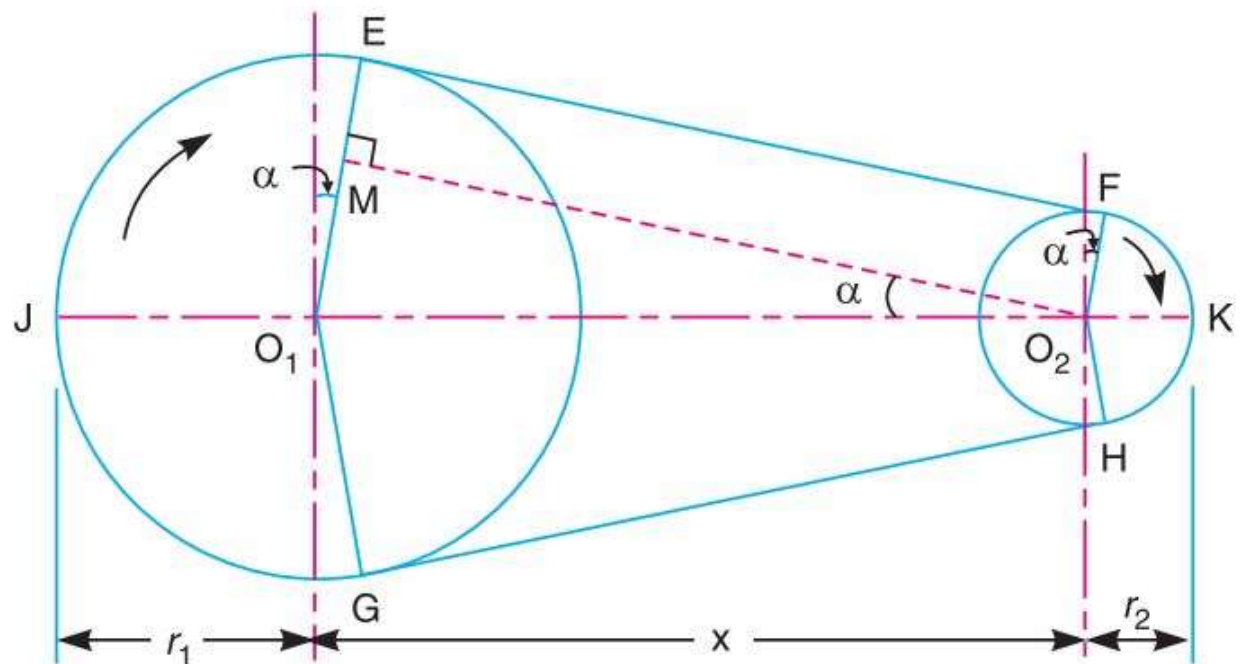


Fig. 11.11. Length of an open belt drive.

Length of belt

- ▶ Length of Crossed belt drive = $\pi(r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{x}$
- ▶ Contact Angle

$$\alpha = \frac{r_1 + r_2}{x}$$

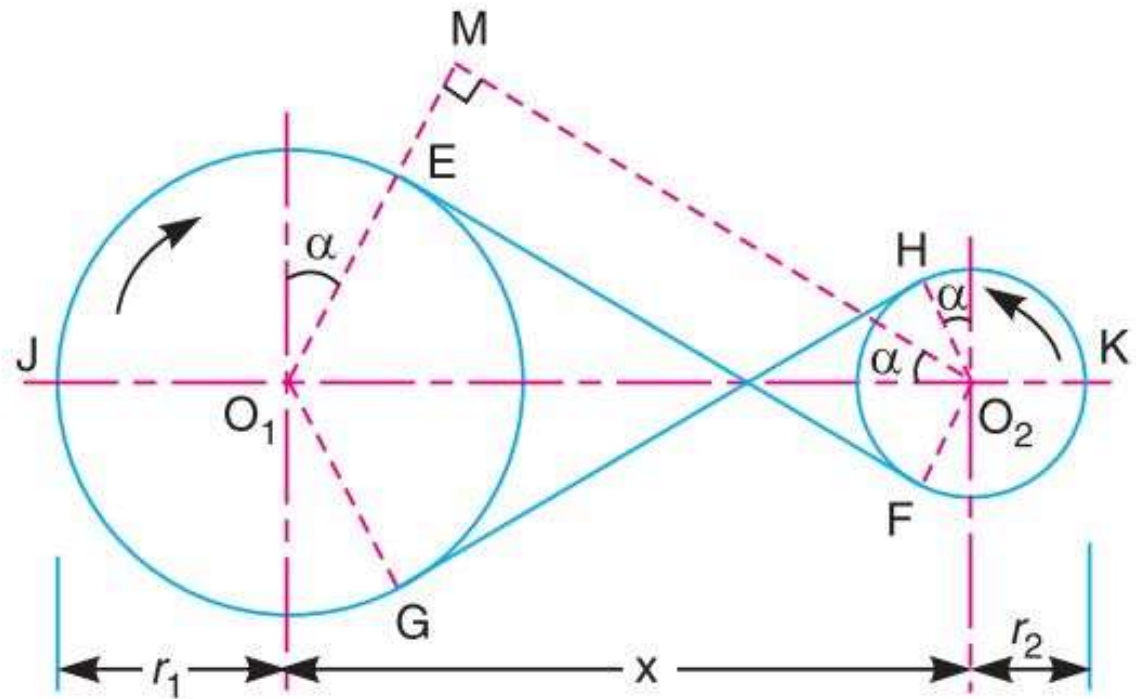


Fig. 11.12. Length of a cross belt drive.

Advantage of V belt over Flat Belt

1. The V-belt drive gives compactness due to the small distance between the centres of pulleys.
2. The drive is positive, because the slip between the belt and the pulley groove is negligible.
3. Since the V-belts are made endless and there is no joint trouble, therefore the drive is smooth.
4. It provides longer life, 3 to 5 years.
5. It can be easily installed and removed.
6. The operation of the belt and pulley is quiet.
7. The belts have the ability to cushion the shock when machines are started.
8. The high velocity ratio (maximum 10) may be obtained.
9. The wedging action of the belt in the groove gives high value of limiting ratio of tensions. Therefore the power transmitted by V-belts is more than flat belts for the same coefficient of friction, arc of contact and allowable tension in the belts.
10. The V-belt may be operated in either direction with tight side of the belt at the top or bottom. The centre line may be horizontal, vertical or inclined.

Problems

Example 11.3. *A shaft which rotates at a constant speed of 160 r.p.m. is connected by belting to a parallel shaft 720 mm apart, which has to run at 60, 80 and 100 r.p.m. The smallest pulley on the driving shaft is 40 mm in radius. Determine the remaining radii of the two stepped pulleys for **1.** a crossed belt, and **2.** an open belt. Neglect belt thickness and slip.*

Problems

Example 11.4. Find the power transmitted by a belt running over a pulley of 600 mm diameter at 200 r.p.m. The coefficient of friction between the belt and the pulley is 0.25, angle of lap 160° and maximum tension in the belt is 2500 N.

Example 11.6. Two pulleys, one 450 mm diameter and the other 200 mm diameter are on parallel shafts 1.95 m apart 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.

What power can be transmitted by the belt when the larger pulley rotates at 200 rev/min, if the maximum permissible tension in the belt is 1 kN, and the coefficient of friction between the belt and pulley is 0.25 ?

Example. 11.7. A shaft rotating at 200 r.p.m. drives another shaft at 300 r.p.m. and transmits 6 kW through a belt. The belt is 100 mm wide and 10 mm thick. The distance between the shafts is 4m. The smaller pulley is 0.5 m in diameter. Calculate the stress in the belt, if it is **1.** an open belt drive, and **2.** a cross belt drive. Take $\mu = 0.3$.

Problems

Example 11.19. *A compressor, requiring 90 kW is to run at about 250 r.p.m. The drive is by V-belts from an electric motor running at 750 r.p.m. The diameter of the pulley on the compressor shaft must not be greater than 1 metre while the centre distance between the pulleys is limited to 1.75 metre. The belt speed should not exceed 1600 m/min.*

Determine the number of V-belts required to transmit the power if each belt has a cross-sectional area of 375 mm², density 1000 kg/m³ and an allowable tensile stress of 2.5 MPa. The groove angle of the pulley is 35°. The coefficient of friction between the belt and the pulley is 0.25. Calculate also the length required of each belt.