MECHANICAL ENGINEERING SCIENCE

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Power Transmission

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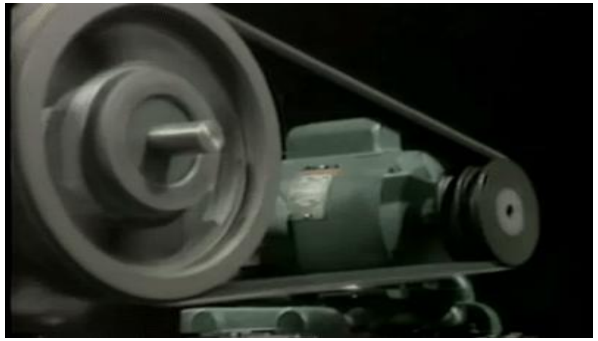
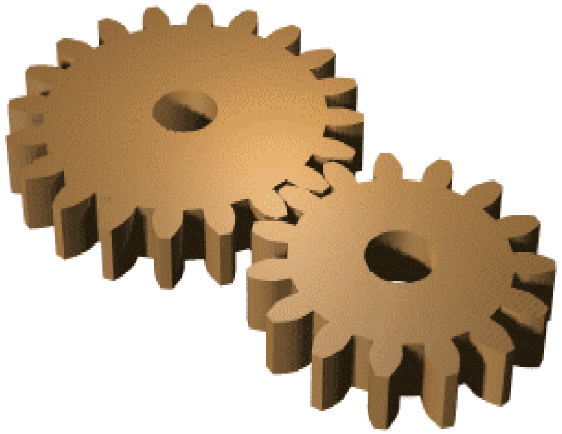
INTRODUCTION TO POWER TRANMISSION DRIVES

- Power transmission drives are mainly used to transmit power from one shaft to another which rotate at the same speed or at different speeds.



- There are two types of drives – **rigid and flexible**.

- In flexible drives, there is an intermediate link such as **belt, rope or chain** between the driving and the driven shafts. Since the link is flexible, the drives are called '**flexible**' drives.
- The rotary motion of the driving shaft is first converted into translatory motion of the belt or chain and then again converted into rotary motion of the driven shaft.



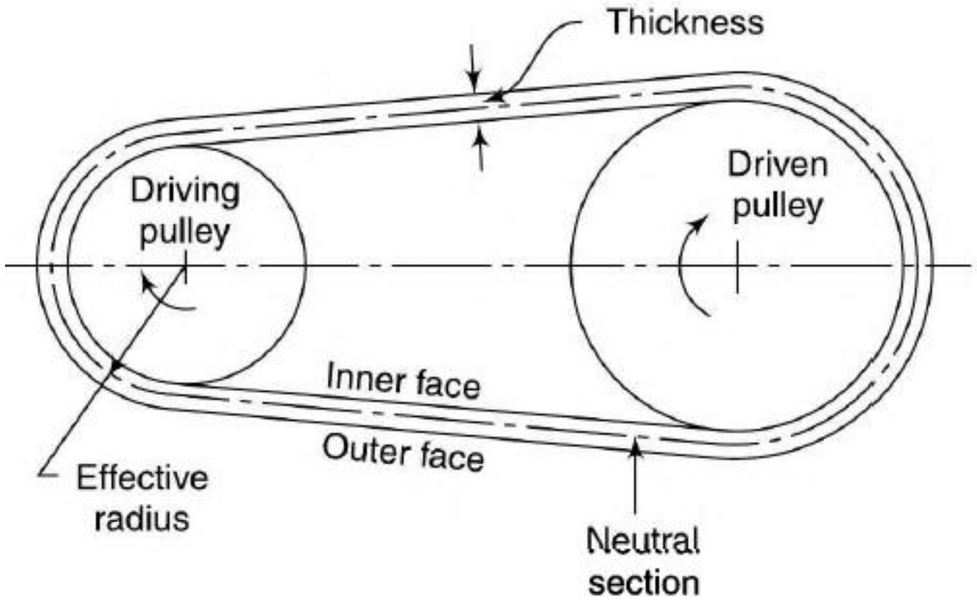
- In rigid drives like **gear** drives, there is direct contact between the driving and the driven shafts through the drive.

- The rotary motion of the driving shaft is directly converted into rotary motion of the driven shaft.

BELT DRIVES

- Belts are used to transmit power between two shafts by means of **friction**.

- A belt drive consists of three elements – driving and driven pulleys and an endless belt, which envelopes them. The belt is kept in tension so that motion of one pulley is transferred to the other without slip. It is used when the distance between the shafts is large.



BELT DRIVES

- Depending upon the shape of the cross – section, belts are classified as –

  1) Flat belts

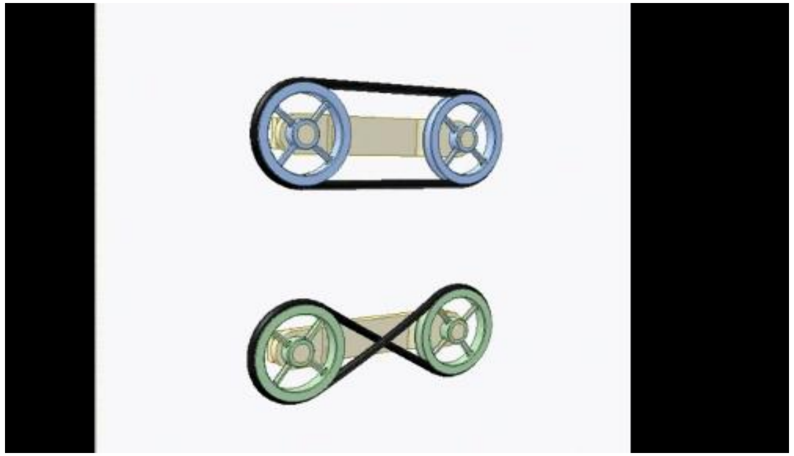
  2) V belts

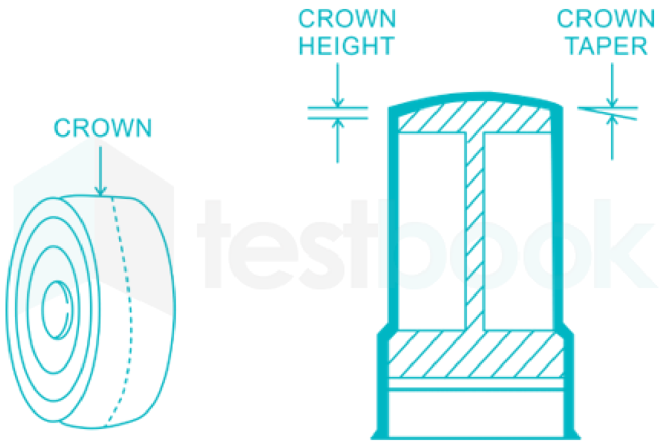
  3) Round belts

BELT DRIVES

Flat belts

- These belts have rectangular cross section and the rim of the pulley is slightly crowned which helps to keep the belt running centrally on the pulley rim.





BELT DRIVES

V - belts

- V – belts have **trapezoidal cross – section**. A groove is made on the rim of the pulley of a V –belt drive to take the advantage of the **wedge action.**

- Some advantages of V – belt are:
  1) Positive drive as slip between belt and pulley is negligible
  2) Higher power transmitting capacity

- Some disadvantages of V – belt are:
  1) Cannot be used for large centre distances
  2) Costlier as compared to flat belts.

BELT DRIVES

Round belts

- There are certain applications where ‘**round**’ belts are used.
- Round belts can operate satisfactorily over pulleys in several different planes. They are suitable for 90 degree twist, reverse bends or serpentine drives.
- They can be stretched over the pulley and snapped into the groove very easily. This makes the assembly and replacement simple.
- Round belts are limited to light duties. They are used in dishwasher drives, sewing machines, vacuum cleaners and light textile machinery.

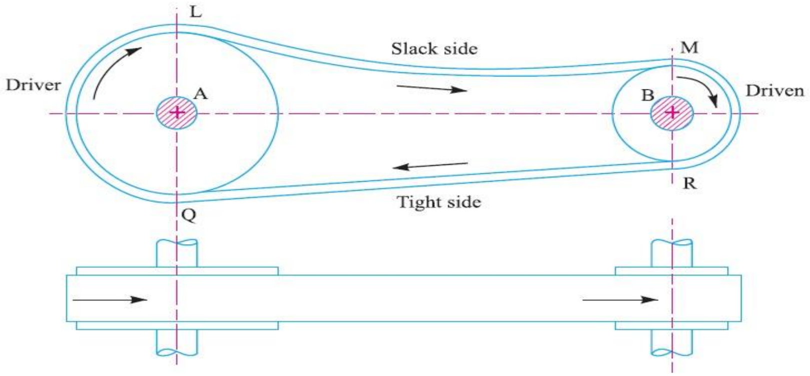
BELT DRIVES

Open belt drive

- An open belt drive is used when the driven pulley is desired to be rotated in the **same direction** as the driving pulley.

- While transmitting power, one side of the belt is more tightened known as '**tight side**' as compared to the other known as '**slack side**'.

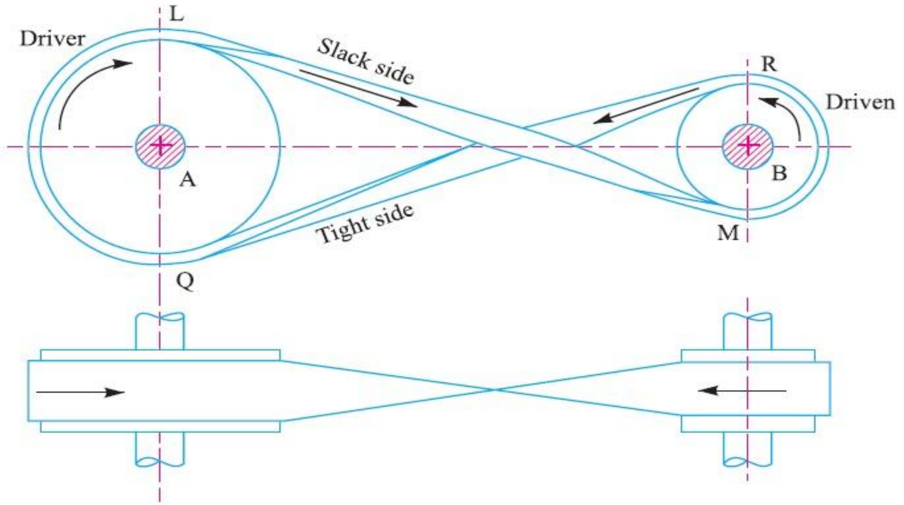
- In case of horizontal drives, it is always desired that the tight side is at the lower side of the two pulleys. This is because the sag of the belt will be more on the upper side than the lower side. This slightly increases the angles of wrap of the belt on the two pulleys.



BELT DRIVES
Crossed belt drive

- A crossed belt drive is adopted when the drive pulley is to be rotated in the **opposite direction** to that of the driving pulley.

- A crossed belt drive can transmit more power than the open belt drive as the angle of wrap is more. However, the belt has to bend in two different planes and it wears out more.



TERMINOLOGIES OF BELT DRIVES

Velocity Ratio of belt drives

It is the ratio of the speed of the driven pulley to that of the driving pulley.

- Let d_1 = Diameter of the driving pulley, d_2= Diameter of the driven pulley,
  N_1= Speed of the driving pulley in rpm, and
  N_2 = Speed of the driven pulley in rpm

- Speed of the belt on driving pulley = $\pi d_1 N_1$

- Speed of the belt on driven pulley = $\pi d_2 N_2$

- Equating both of them, we get, **Velocity Ratio = VR** = $\mathbf{\dfrac{N_2}{N_1} = \dfrac{d_1}{d_2}}$

TERMINOLOGIES OF BELT DRIVES

Velocity Ratio of belt drives

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

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

TERMINOLOGIES OF BELT DRIVES

Slip of belt

- When the frictional grip between the belt and the pulley becomes insufficient, it may cause some forward motion of the driving pulley 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.

- The result of the belt slipping is to reduce the velocity ratio of the system.

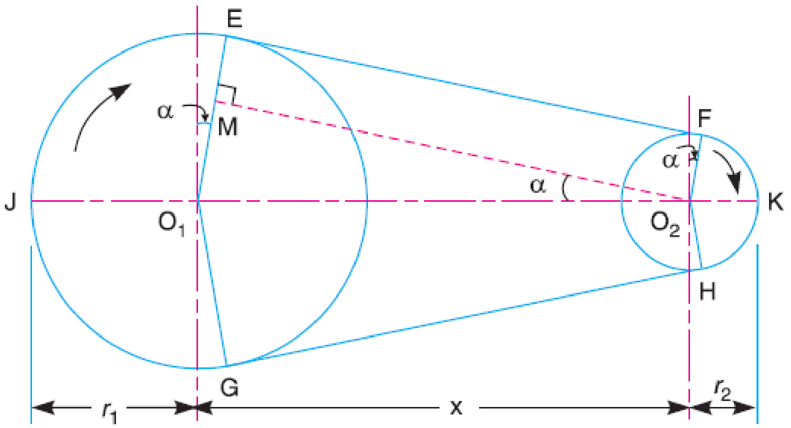
- Let s_1 = % Slip between the driving pulley and the belt, and s_2 = % Slip between the belt and the driven pulley.

- Velocity ratio is then given by,

$$\frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}\left(1 - \frac{s}{100}\right)$$ where $s = s_1 + s_2$, *i.e.* total percentage of slip

TERMINOLOGIES OF BELT DRIVES

Length of an Open belt drive



- Let r_1 and r_2 = Radii of the larger and smaller pulleys,
  x = Distance between the centres of two pulleys (*i.e.* O_1O_2), and
  L = Total length of the belt.

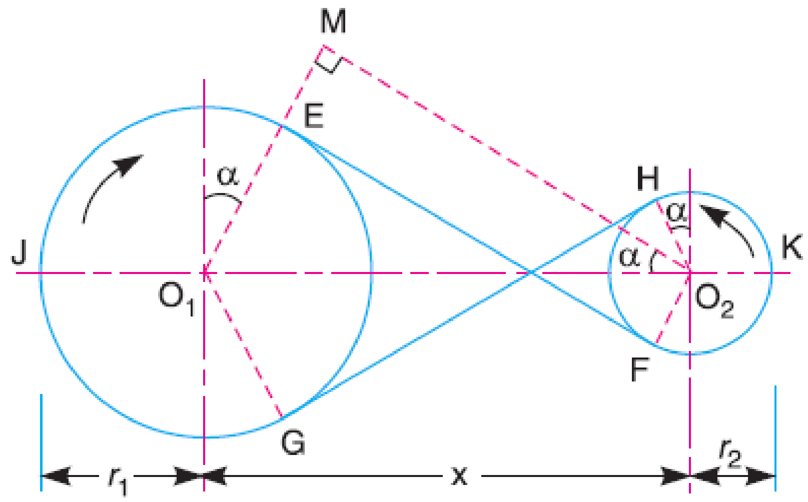
- Length of the belt is given by,

$$L_0 = \pi\,(r_1 + r_2) + 2\,x + \frac{(r_1 - r_2)^2}{x}$$

TERMINOLOGIES OF BELT DRIVES

Length of a Crossed belt drive

- Let r_1 and r_2 = Radii of the larger and smaller pulleys,
  x = Distance between the centres of two pulleys (*i.e.* O_1O_2), and
  L = Total length of the belt.



- Length of the belt is given by,

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

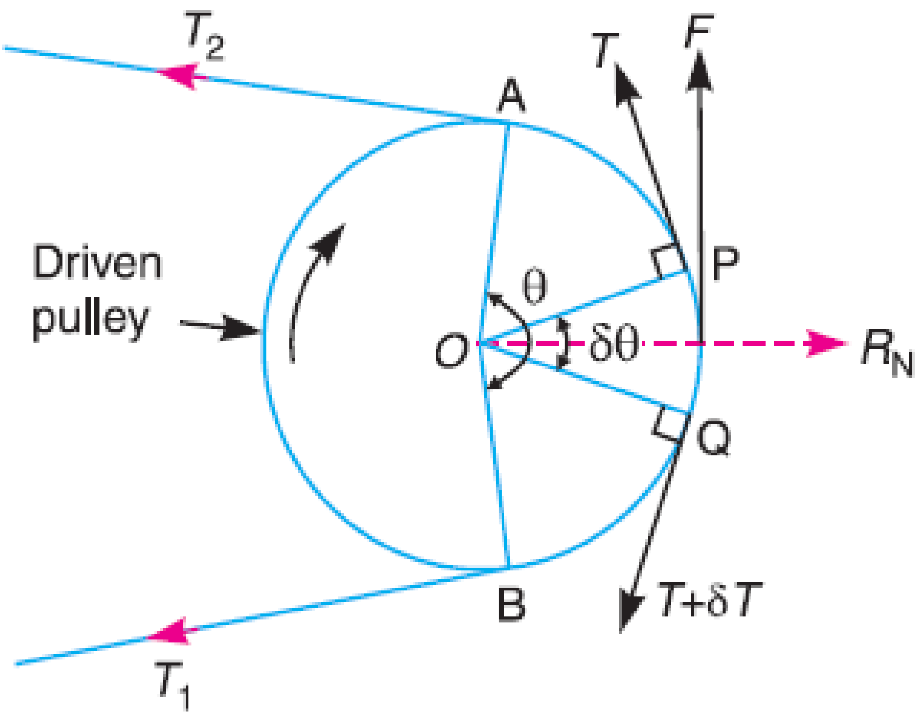
TERMINOLOGIES OF BELT DRIVES

Ratio of Belt Tensions for a Flat Belt Drive

- Let T_1 = Tension in the belt on the tight side,
  T_2 = Tension in the belt on the slack side, and
  θ = Angle of contact in radians
  μ = coefficient of friction between the belt and the pulley

- The ratio belt tensions is given by,

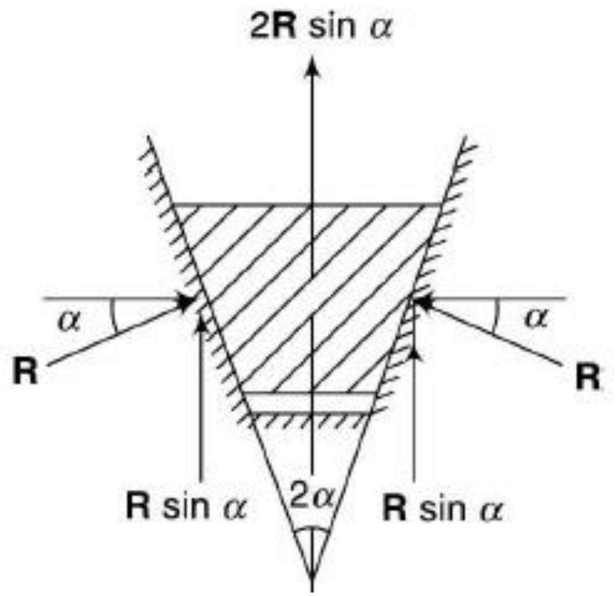
$$\frac{T_1}{T_2} = e^{\mu\theta}$$



TERMINOLOGIES OF BELT DRIVES

Ratio of Belt Tensions for a V - Belt Drive

- Let T_1 = Tension in the belt on the tight side,
  T_2 = Tension in the belt on the slack side, and
  θ = Angle of contact in radians
  μ = coefficient of friction between the belt and the pulley
  α = semi grove angle



- The ratio belt tensions is given by,

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

TERMINOLOGIES OF BELT DRIVES

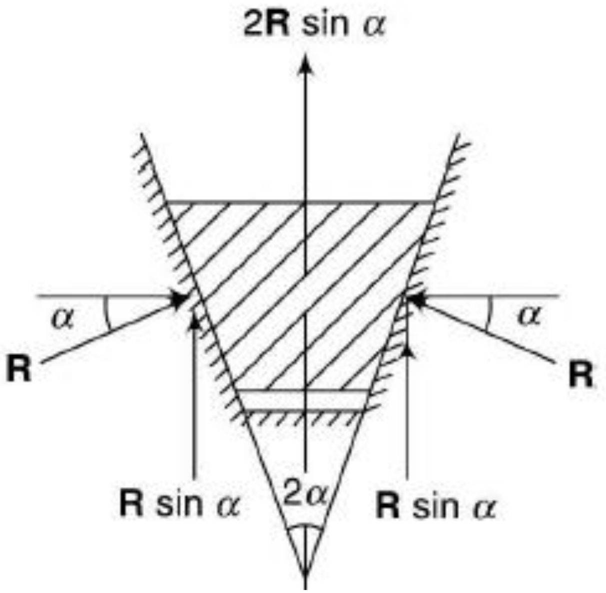
Ratio of Belt Tensions for a V - Belt Drive

- The expression for ratio of belt tensions is similar to that for a flat belt drive except that μ is replaced by μ/sin α, i.e., the coefficient of friction is increased by 1/sin α.

- Therefore, for identical materials of belt and pulleys, the coefficient of friction of V – belt is far greater than that of flat belt.

- Consequently, the power transmitting capacity of V – belt is much more than that of flat belt. Therefore, V – belts are more powerful.

- Due to increased frictional force, the slip is less in V – belt compared with flat belt.



TERMINOLOGIES OF BELT DRIVES

Power Transmitted

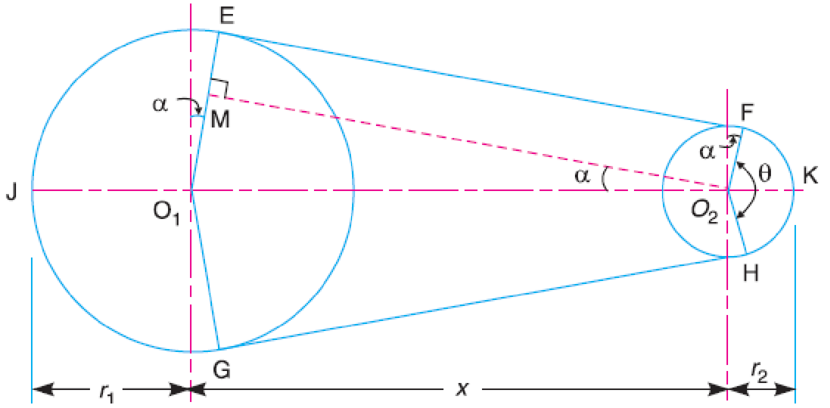
- Let T_1 = Tension in the belt on the tight side,
  T_2 = Tension in the belt on the slack side
  v = linear velocity of the belt = $(\pi \times d \times N)/60$ in m/s
  P = Power transmitted

- Then, P = Net force × Distance moved/second

$$P = (T_1 - T_2) \times V \quad \text{watts}$$

TERMINOLOGIES OF BELT DRIVES

Determination of Angle of Contact



- When the two pulleys of different diameters are connected by means of an open belt as shown in Fig., then the angle of contact or lap (θ) at the smaller pulley must be taken into consideration.

- Let r_1 and r_2 = Radii of the larger and smaller pulleys,
  x = Distance between the centres of two pulleys (*i.e.* O_1O_2)

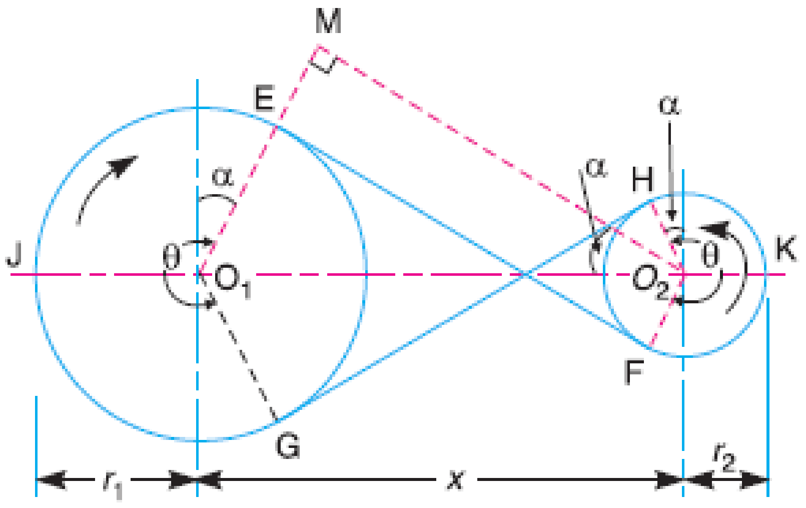
- From Figure,

$$\sin\alpha = \frac{O_1 M}{O_1 O_2} = \frac{O_1 E - ME}{O_1 O_2} = \frac{r_1 - r_2}{x} \qquad \ldots(\because ME = O_2 F = r_2)$$

- Angle of contact or lap, $\theta = (180^\circ - 2\,\alpha)\dfrac{\pi}{180}$ rad

TERMINOLOGIES OF BELT DRIVES

Determination of Angle of Contact



- A little consideration will show that when the two pulleys are connected by means of a crossed belt as shown in Fig., then the angle of contact or lap (θ) on both the pulleys is same.
- Let r_1 and r_2 = Radii of the larger and smaller pulleys,
  x = Distance between the centres of two pulleys (*i.e.* O_1O_2)
- From figure,

$$\sin\alpha = \frac{O_1M}{O_1O_2} = \frac{O_1E + ME}{O_1O_2} = \frac{r_1 + r_2}{x}$$

- Angle of contact or lap $\theta = (180^\circ + 2\alpha)\dfrac{\pi}{180}$ rad

THANK YOU

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