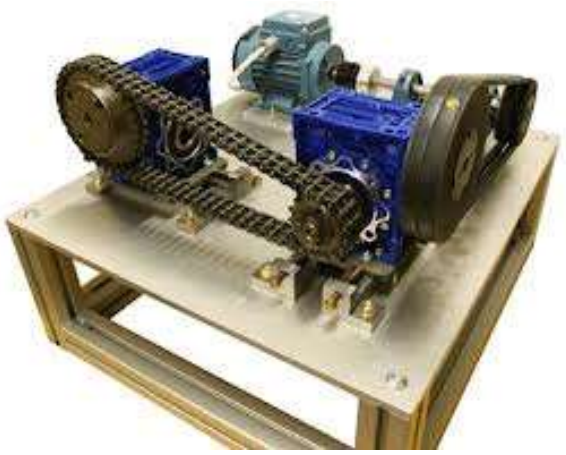
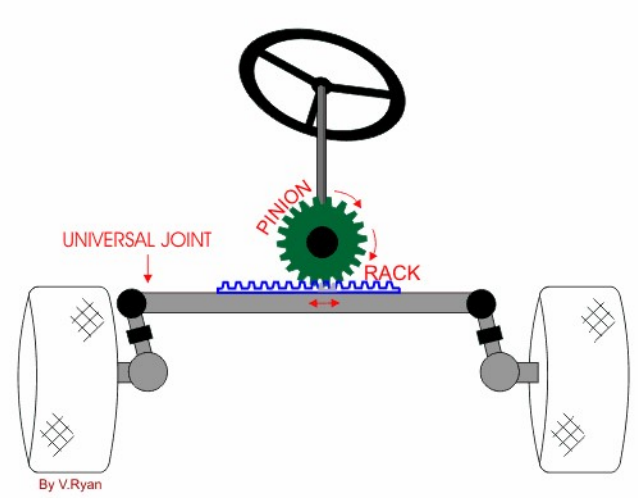
TRANSMISSION OF POWER

Introduction:

- Mechanical energy developed by prime mover has to be transmitted to the required utility by a transmission system.





Methods of Drive

Machines may be driven by any one of the following two methods:

1. **Individual Drive**

2. **Group Drive**

Individual Drive (Self-contained Drive)

- Each machine has its own electric motor(prime mover) and starter.
- The motor may drive the machine shaft through belt, chain, gears etc.
- Used for machines that needs to be operated independently or requiring considerable power.

Group Drive

A very powerful motor drives an overhead shaft (**Main shaft**),

that runs from one end to other end of the shop.

Main shaft in turn drives the individual machine drive shafts.

Group drive is economical in terms of power consumption and maintenance.

Factors for selecting a transmission system

- Distance between driver and driven shaft.
- Operating speed.
- Power to be transmitted.

Types of transmission system

i. **Belt drive**
   - **Flat belt**
   - **V - belt**

ii. **Chain drive.**

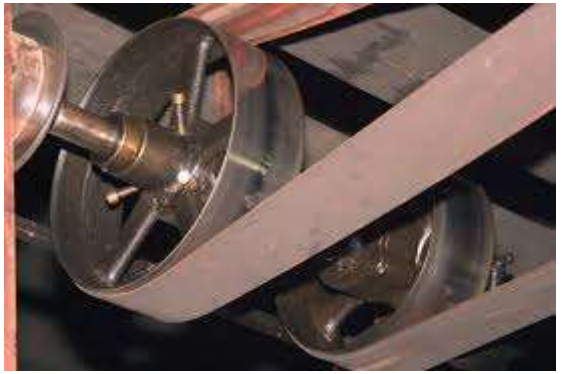
iii. **Gear drive.**

iv. **Rope drive.**

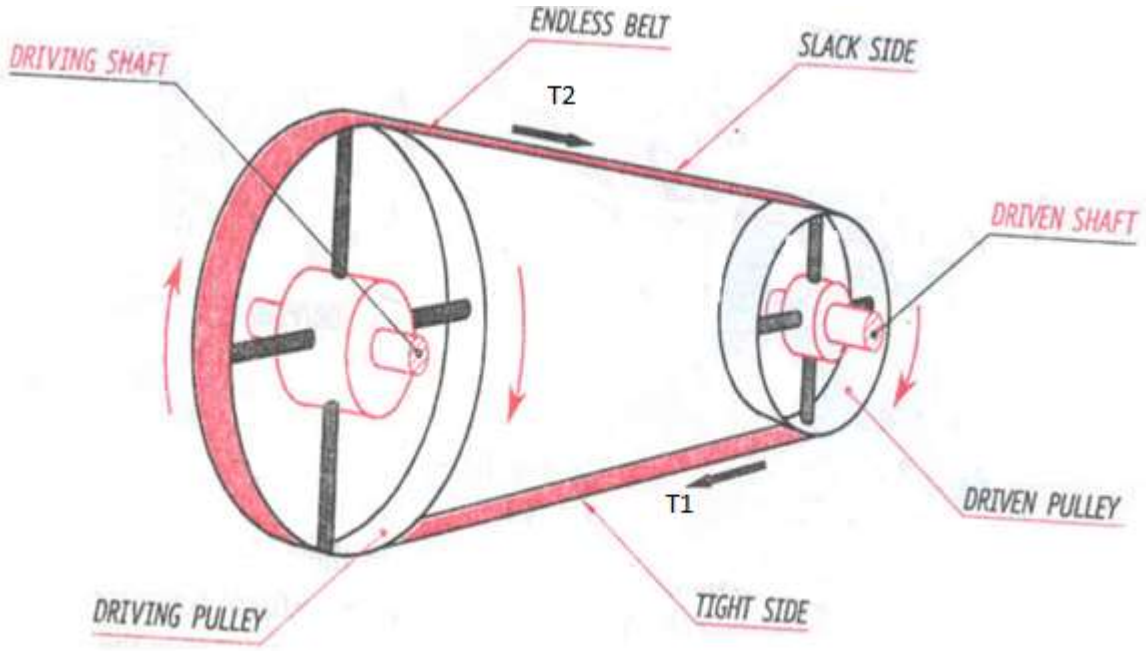
Belt Drive (Friction Drive)

One of the most common and effective devices for transmitting motion from one shaft to another by means of a thin inextensible band running over two pulleys.

Applications: Mills, Factories and Machine tools.

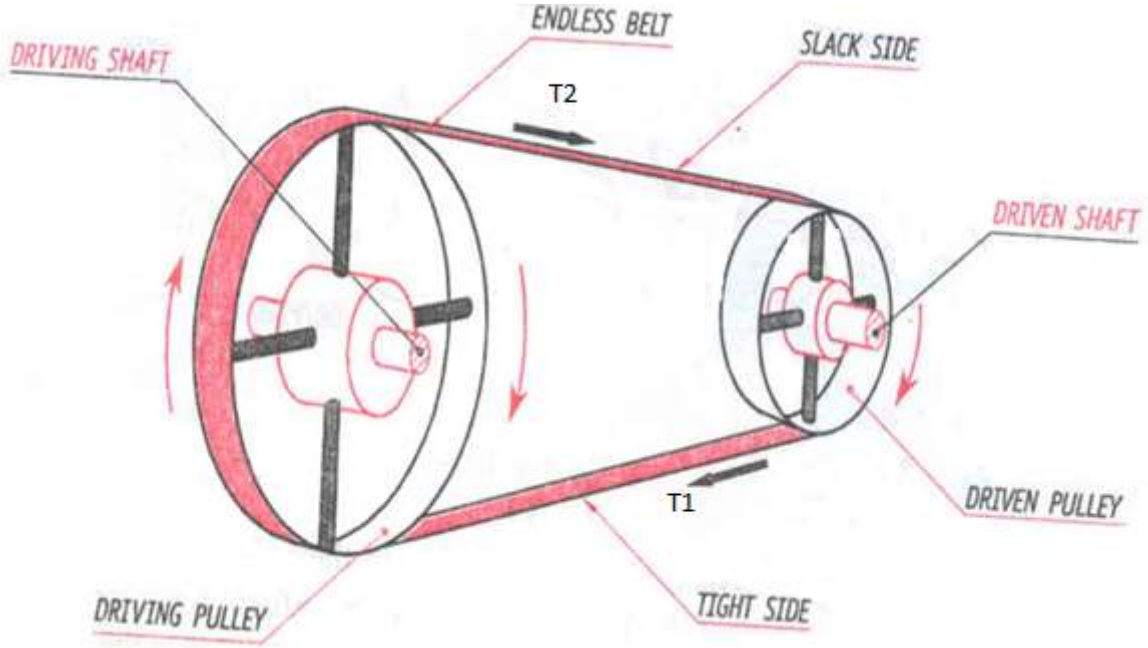


Belt Drive



- Used when power is to be transmitted between two parallel shafts.
- Consists of two pulleys and an endless belt which passes over the two pulleys.
- Rotary motion is transmitted from driving pulley to driven pulley.

Belt Drive



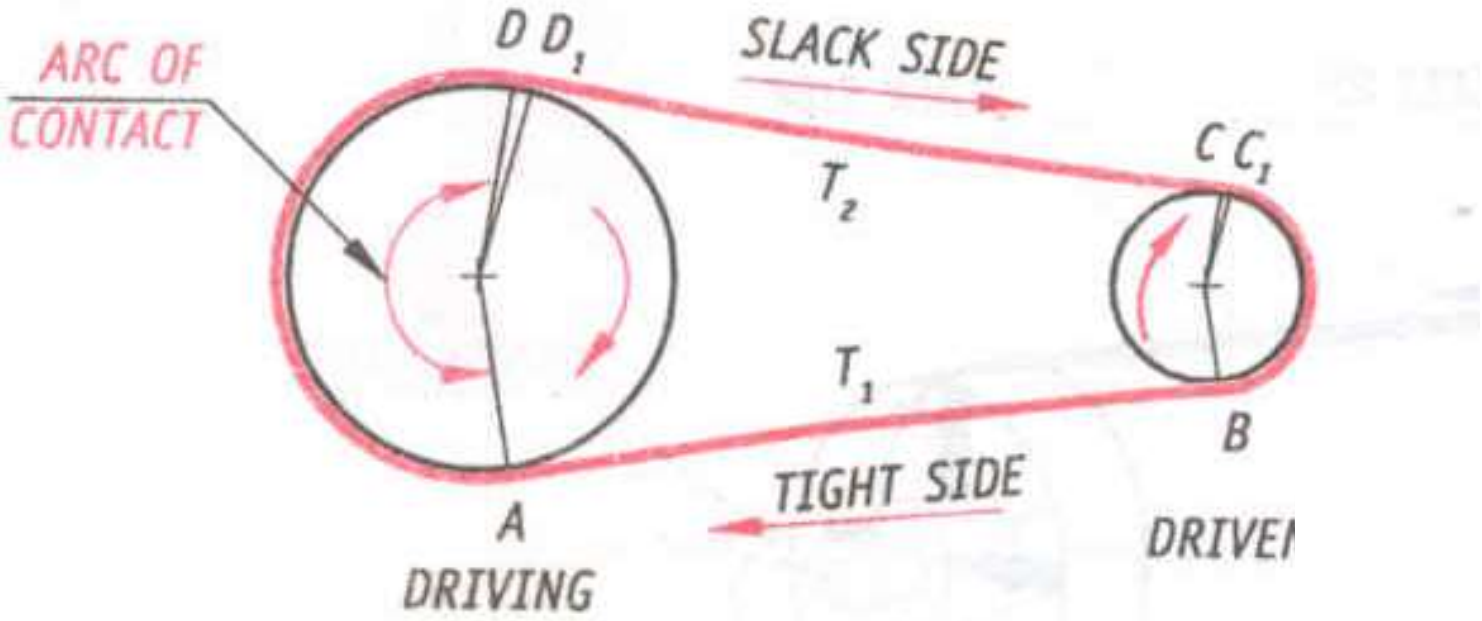
- For the belt to move tension on one side of the belt should be more than the tension on the other side
  - Portion of the belt having high tension is called tight side.
  - Portion of the belt having less tension is called slack side.
  - Friction is a helpful agent.

Types of belt drives:

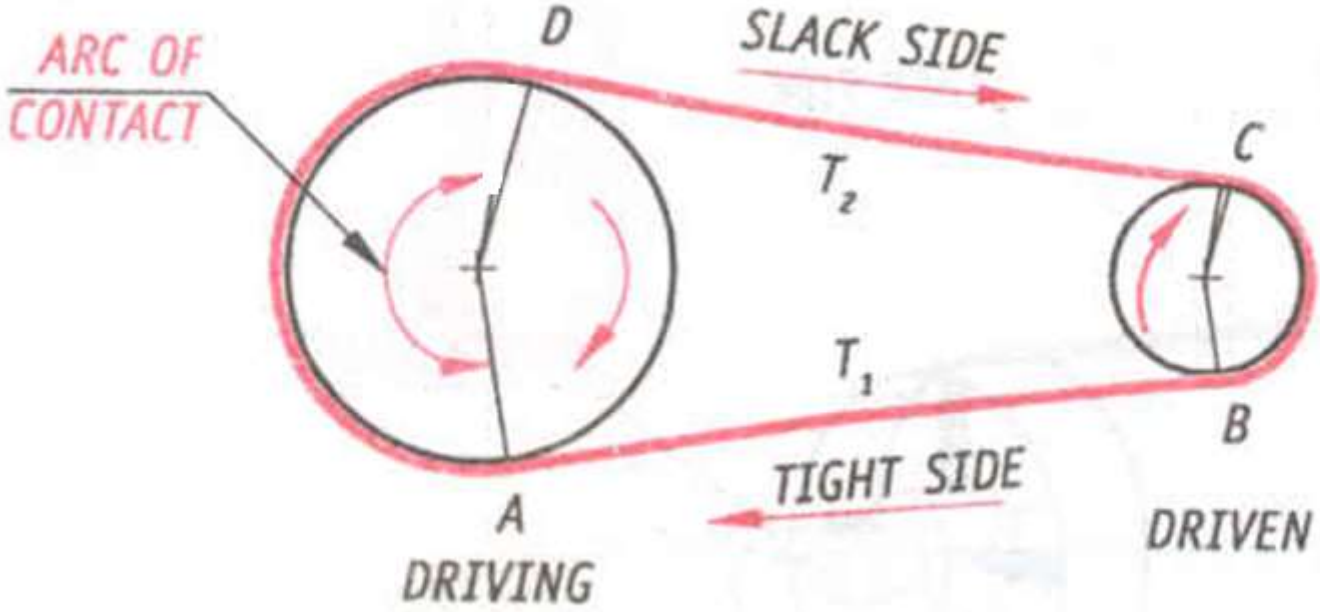
1. Open belt drive

2. Crossed-belt drive

Open belt drive



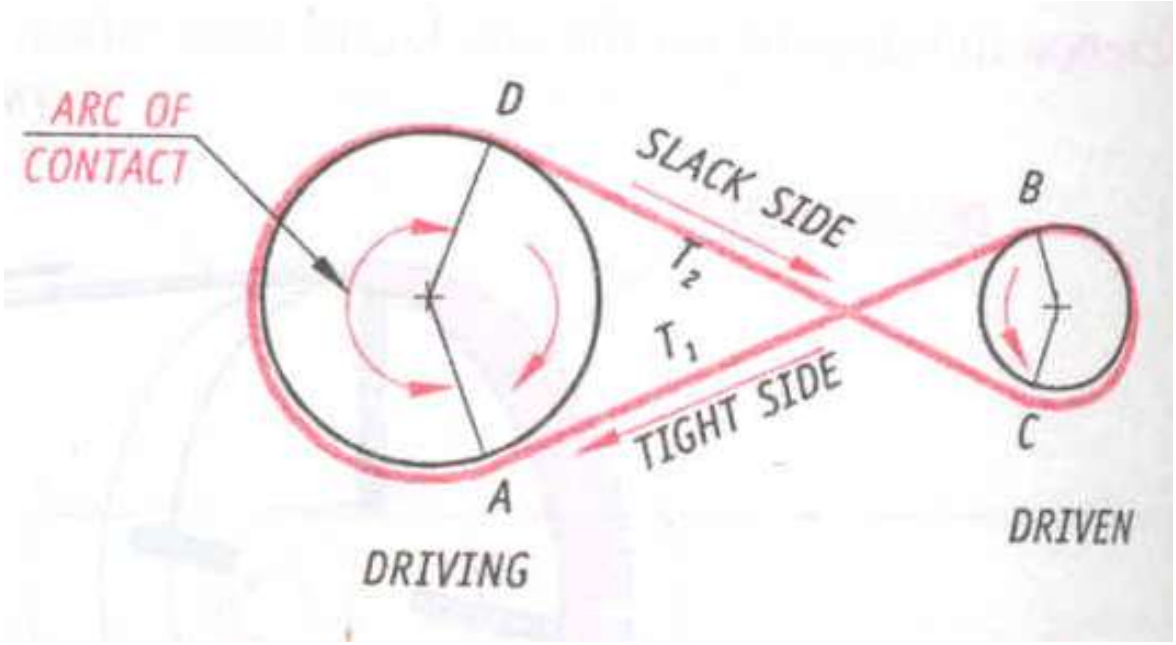
Open belt drive

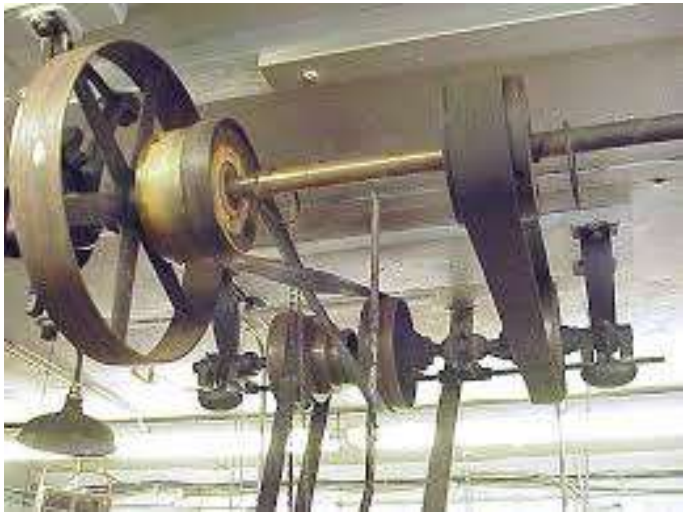


Open belt drive

- Employed when the two parallel shafts have to rotate in the same direction.
- When the shafts are placed far apart, the lower side of the belt should be the tight side and the upper side must be the slack side.
- The shaft axes should be horizontal and should never be vertical.

Crossed belt drive





Crossed belt drive

- Used when two parallel shafts have to rotate in the opposite direction.
- At the junction where the belt crosses, it rubs against itself and wears off.
- To minimize rubbing, speed of belt should be less and the shafts should be at maximum distance apart.
- Power transmitted is more because of larger angle of contact as compared to open belt drive.

Open Belt Drive	Crossed Belt Drive
Driver and driven shafts rotate in same direction.	Driver and driven shafts rotate in opposite direction
As there is no rubbing, life of the belt is more	Due to rubbing, life of the belt reduces.
Requires less length of the belt.	Requires more length of belt.
Lesser power transmission.	Power transmitted is relatively higher.

Velocity Ratio of Belt Drive.
(Speed Ratio)

The velocity ratio of a belt drive is defined as the ratio of the speed of the driven pulley to the speed of the driving pulley.

Expression for velocity ratio of belt drive.

Let

d_1= Diameter of the driving pulley (mm),

d_2= Diameter of the driven pulley (mm).

N_1= Speed of the driving pulley (RPM)

N_2= Speed of the driven pulley (RPM)

Assuming there is no relative slip between the pulleys and the portions of the belt which are in contact with them

The linear speed at every point on the belt should be same

The circumferential speeds of the driving and driven pulleys and the linear speed of the belt are equal.

$$\left[\begin{matrix}Linear speed\\ of the belt\end{matrix}\right] = \left[\begin{matrix}Circumferential speed\\ of the driving pulley\end{matrix}\right] = \left[\begin{matrix}Circumferential speed\\ of driven pulley\end{matrix}\right]$$

$$= \Pi d_1 N_1 \qquad = \Pi d_2 N_2$$

$$= d_1 N_1 \qquad = d_2 N_2$$

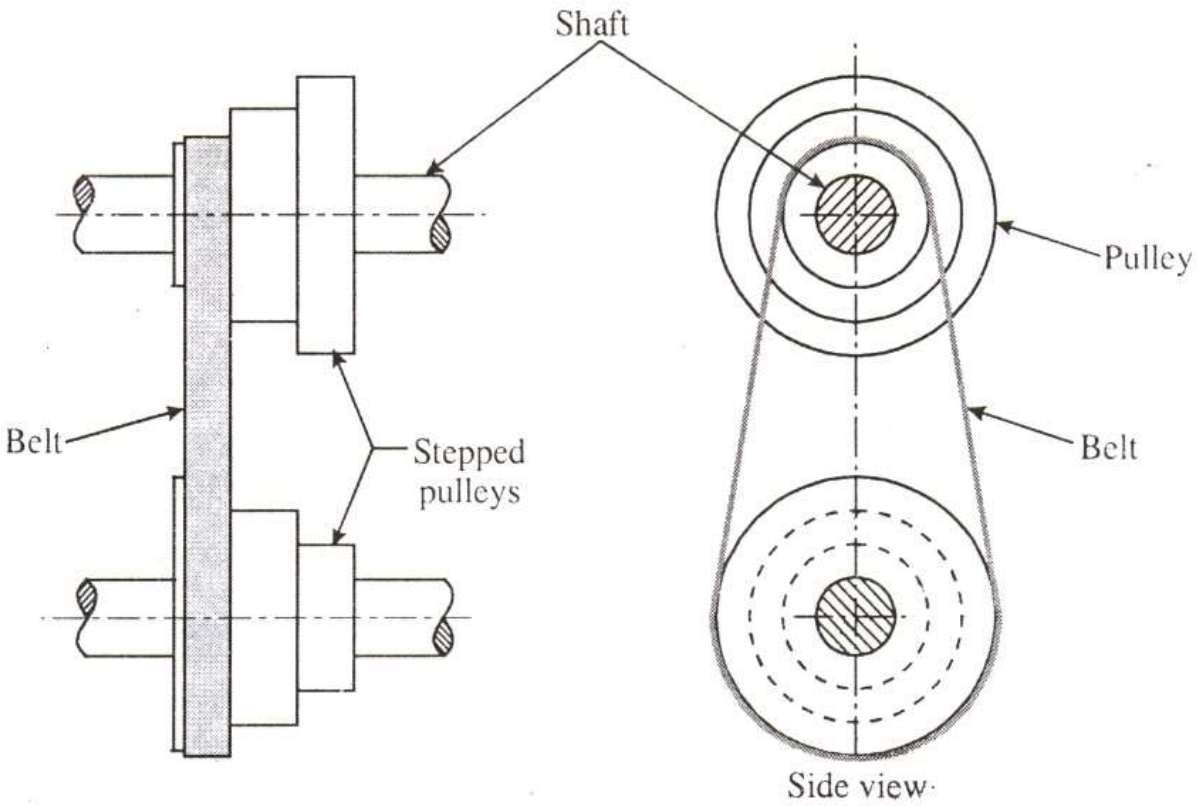
Velocity Ratio = $N_2 / N_1 = d_1 / d_2$

$$\text{Velocity Ratio} = \frac{Speed of the driven pulley}{Speed of the driving pulley} = \frac{Diameter of the driving pulley}{Diameter of the driven pulley}$$

Types of pulleys

- Stepped cone pulley (Speed cone)
- Fast and loose pulley

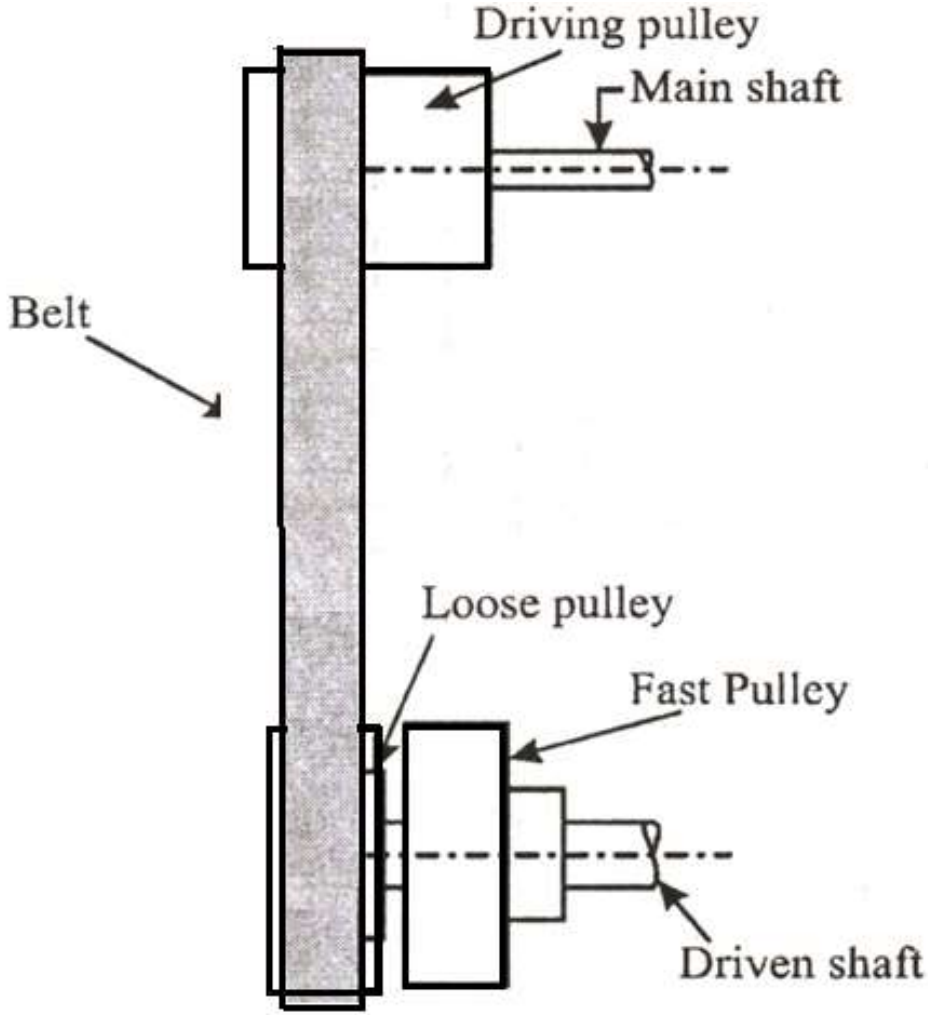
Stepped cone pulley

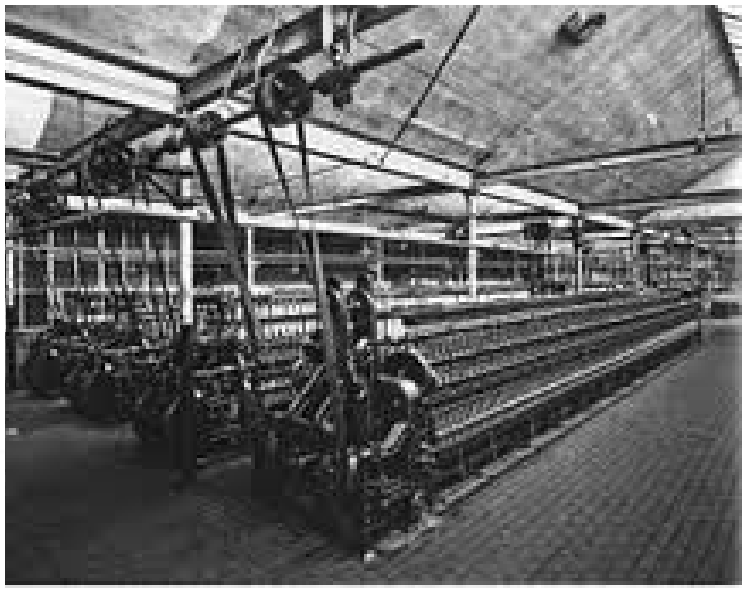


Stepped cone pulley

- When speed of the driven shaft is to be changed very frequently.
- One set of stepped cone pulley is fixed on the driving shaft and another similar pulley in reverse direction on the driven shaft.
- By shifting the belt from one pair of pulleys to another different speeds of the driven shaft can be obtained.
- Used in lathe, drilling m/c etc.

Fast and Loose pulley





Fast and Loose pulley

- When several machines obtain the drive from a common main driving shaft, it may be required to run some machines intermittently without having to **Start** or **stop** the main driving shaft. Fast and Loose pulley arrangement enables individual machines to be started or stopped at will.
- It has a Fast pulley which is securely **keyed** to the driven shaft and a Loose pulley (with bush / bearing) which is free to rotate on the driven shaft.

Working

When the belt is on the fast pulley

- Power transmitted to the driven shaft.

When the driven shaft is to be brought to rest,

- Belt is shifted from fast pulley to loose pulley

Initial Tension in the belt

when the drive is on, the increase in tension on the tight side must always be equal to the decrease in tension on the slack side as there is no stretching of the belt.

$$\therefore \quad T_1 - T_0 = T_0 - T_2$$

$$T_1 + T_2 = 2T_0$$

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

Slip in Belt Drives

Sliding of the belt which causes a relative motion between the pulley surface and the belt is called slip.

Slip occurs:

- **when the coefficient of friction between the belt and pulley surface decreases owing to stretching of the belt.**
- **when the smoothness of the pulley surface is more.**
- **when the differences between tensions in the tight and slack sides is very large.**

Effect of slip on the Velocity Ratio

$$\therefore \quad \frac{N_2}{N_1} = \frac{d_1}{d_2} \times \left[\frac{100 - S}{100}\right]$$

S=Total % slip

Creep in Flat belt drive

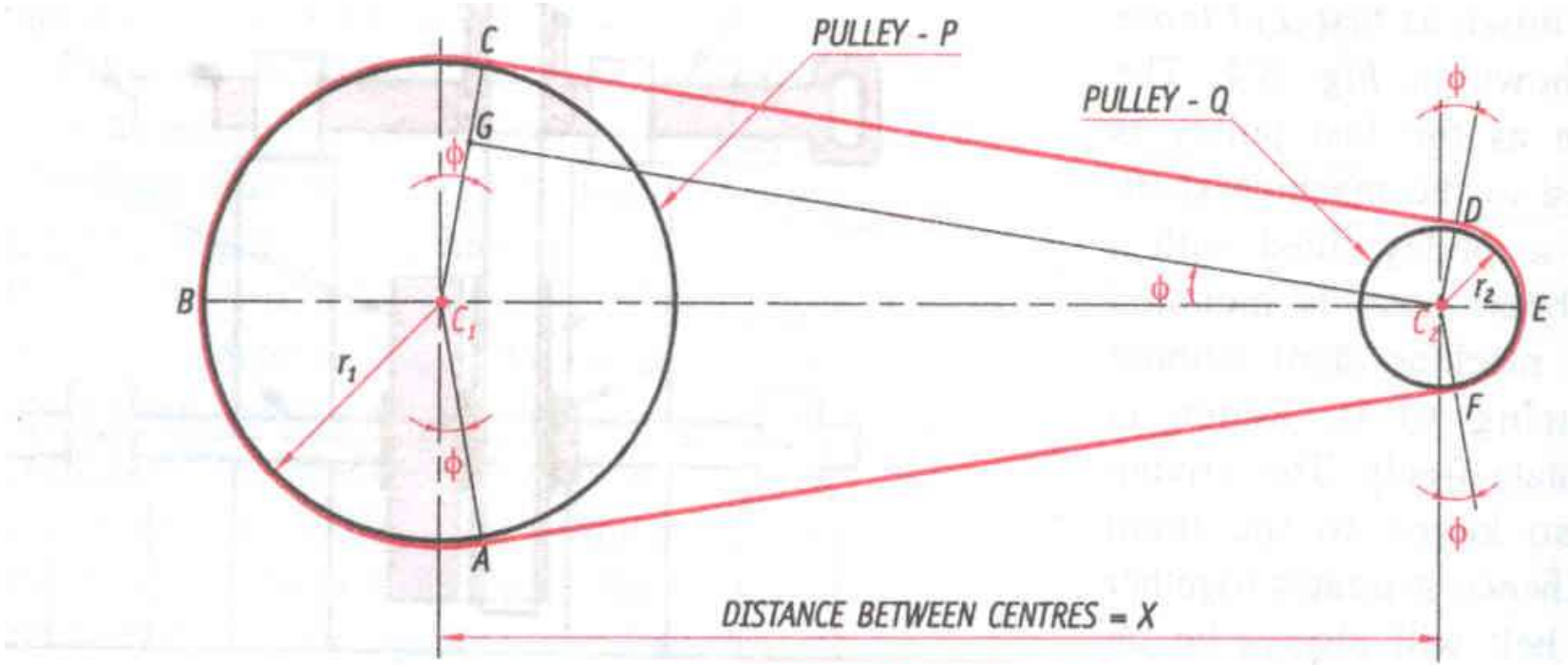
The phenomena of *alternate stretching* and *contraction* of the belt which results in a relative motion between the belt and the pulley surface is called creep.

This results in:

- Loss of power.
- Decrease in the velocity ratio.

Length of a belt

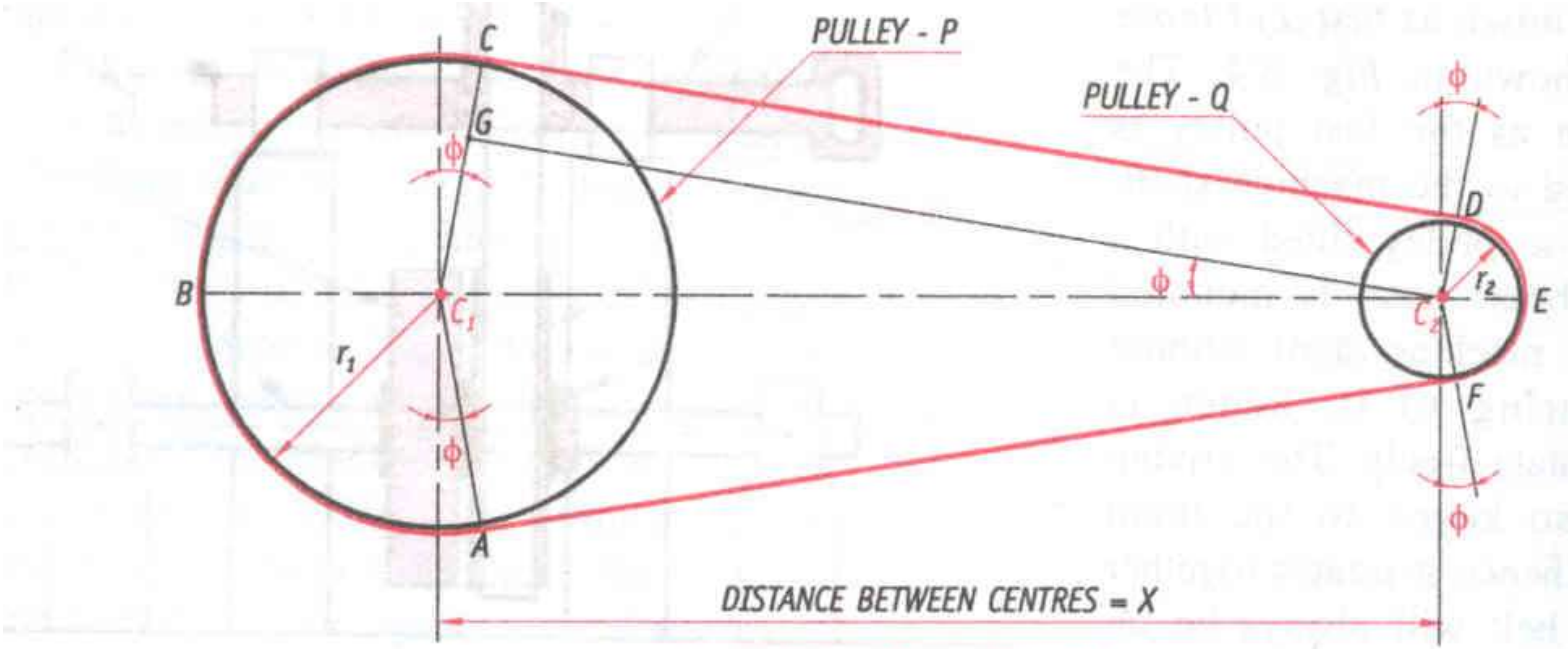
Open belt drive:



$$L = \Pi(r_1 + r_2) + \frac{(r_1 - r_2)^2}{X} + 2X$$

Arc of contact

Open belt drive

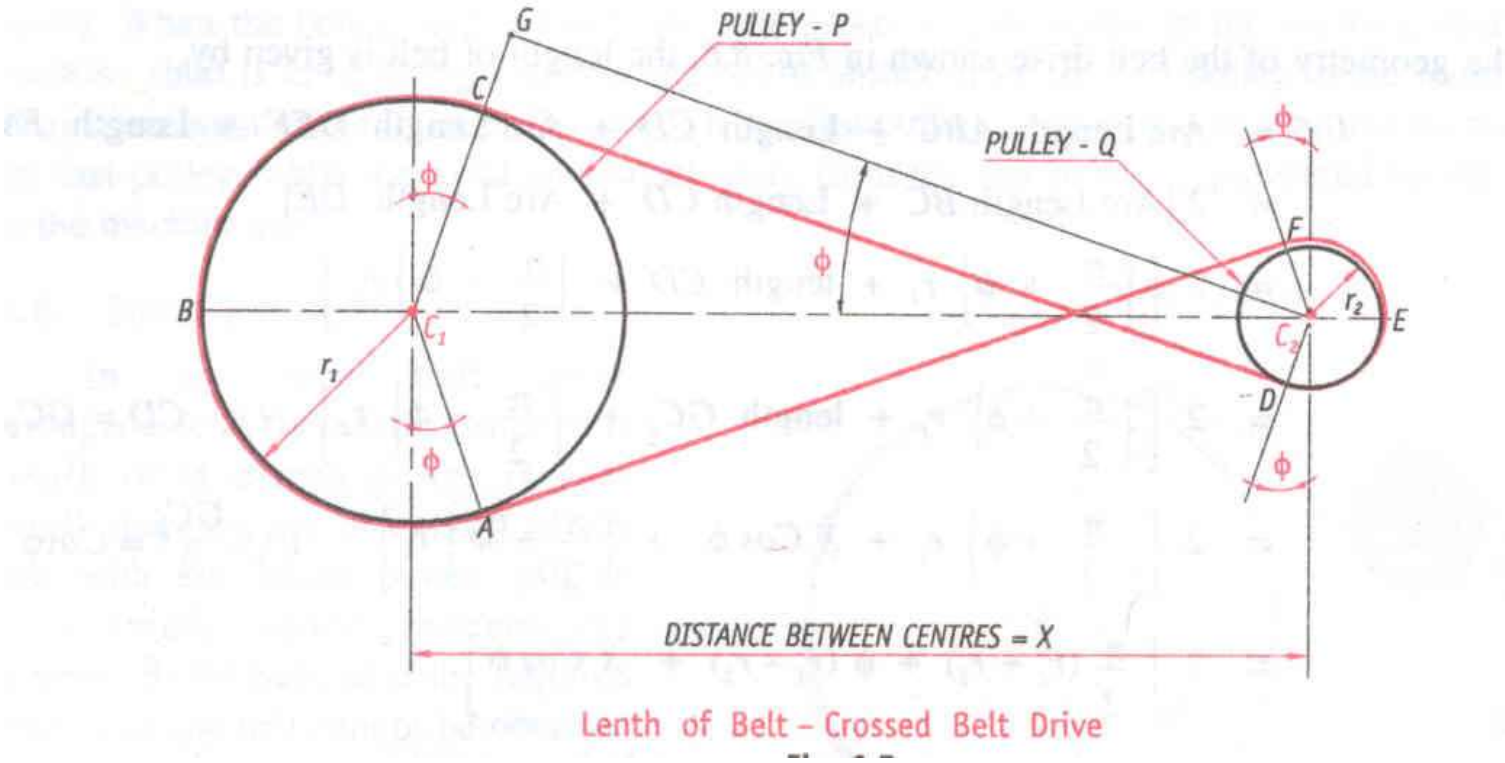


Angle of lap = θ = π – 2ϕ

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

Length of a belt

Crossed belt drive:

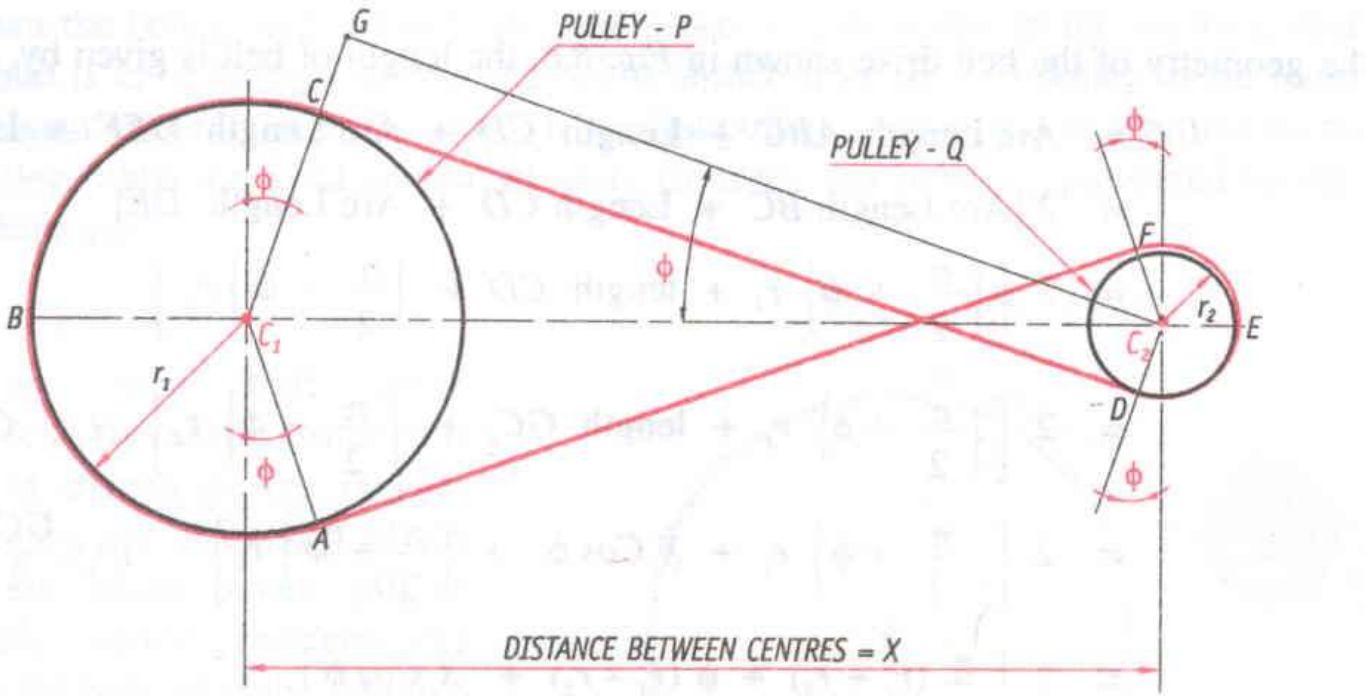


Lenth of Belt – Crossed Belt Drive

$$L = \Pi(r_1 + r_2) + \frac{(r_1 + r_2)^2}{X} + 2X$$

ARC OF CONTACT

Crossed belt drive



Lenth of Belt – Crossed Belt Drive

Angle of lap = θ = π +2ϕ

$$\text{ø} = \sin^{-1}\frac{(r_1 + r_2)}{X}$$

Power transmitted by a Belt drive

If ***v*** is the linear velocity of the belt **m/min** and T_1 and T_2 are the tensions on the tight and slack sides of the belts expressed in **Newton**, then

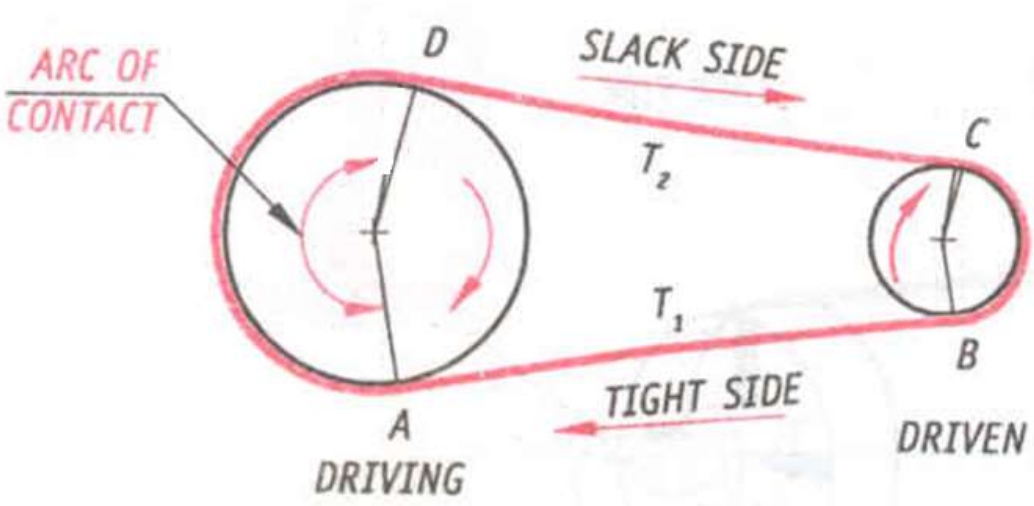
$$\text{Work transmitted per second} = \frac{(T_1 - T_2) \times v}{60} \quad W$$

$$\text{Power transmitted} = \frac{(T_1 - T_2) \times v}{60 \times 1000} \quad kW$$

Where v= Πd1N1 = Πd2N2

d1, d2 are the diameters in metres & N1, N2 are the RPM's of driver & driven pulleys respectively

Ratio of Tensions in Flat Belt Drive



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

where,

θ = Arc of contact in radians

μ = Coefficient of friction

T_1 and T_2 are the tensions on the tight and slack sides of the belts expressed in **Newtons**

Disadvantages of flat belts

- Not suitable for small center distance
- Exact velocity ratio cannot be maintained
- Slip & creep causes loss of power
- Large power cannot be transmitted effectively