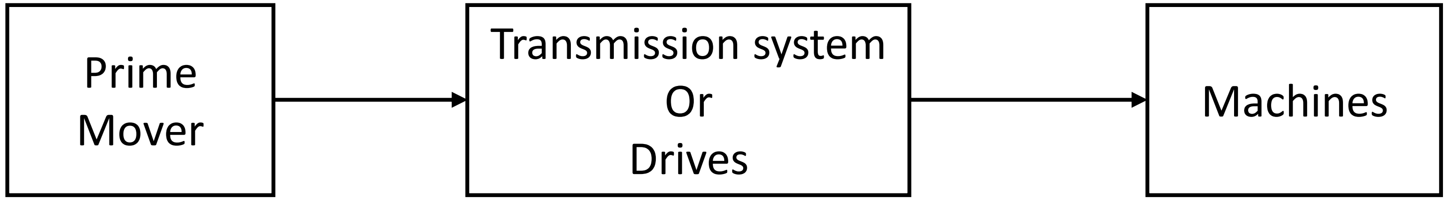
Power transmission

Introduction

A device which converts available source of energy into mechanical energy is called prime mover.
Example: IC Engines, Turbines

Output of an engine/motor/turbine is usually in rotational form. This rotational motion can be transmitted from one mechanical element to the other with the help of certain systems known as TRANSMISSION SYSTEMS or DRIVES.

The system that drives is called a driving system and the system which is driven is called driven or follower system.



The transmission systems are classified on the basis of (i) speed (ii) power and (iii) distance between driver and follower shafts. Power may be transmitted using belts, ropes, gears or chains followed by working conditions.

Drives Classification

i) Belt Drives
ii) Gear Drives
iii) Rope Drives
iv) Chain Drives

Belt Drives

BELTS

A belt is a looped strip of flexible material used to mechanically link two or more rotating shafts. A belt drive offers smooth transmission of power between shafts at a considerable distance. Belts are the cheapest utility for power transmission between shafts that may not be axially aligned.

BELT DRIVES

Belt drives are used as the source of motion to efficiently transmit power or to track relative movement. They run smoothly and with little noise, and cushion motor & bearings against load changes, albeit with less strength than gears or chains

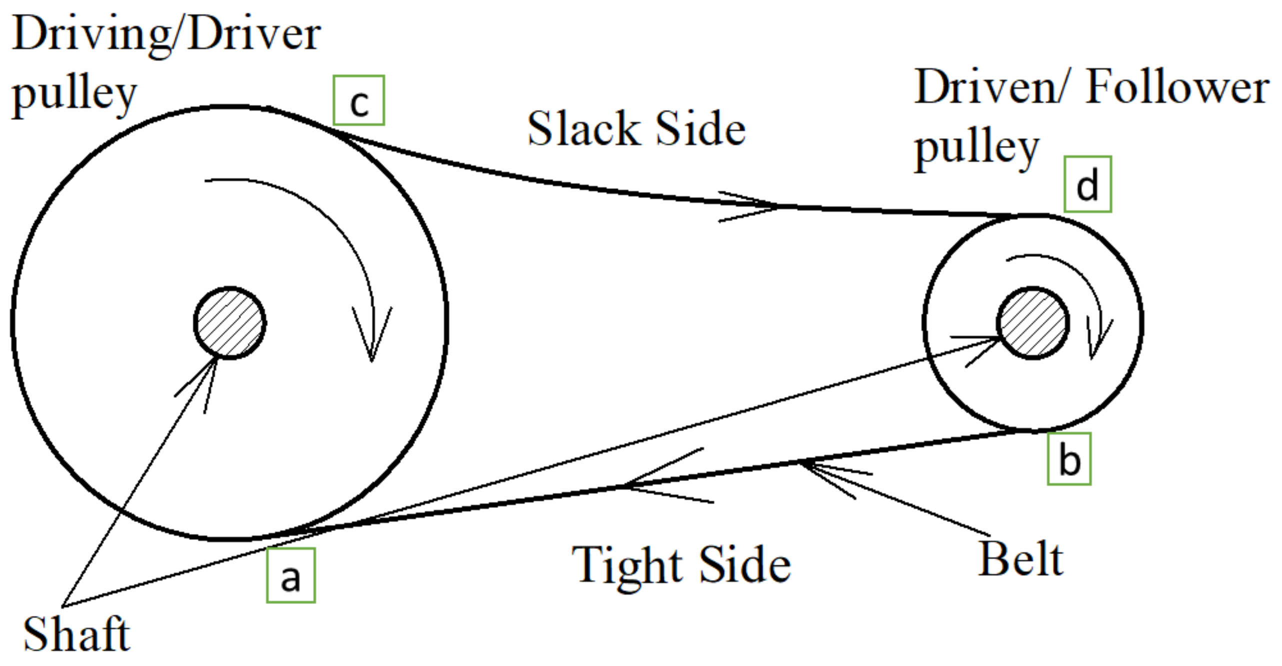
Types of Belt Drives

In a two pulley system, depending upon the direction the belt drives the pulley, the belt drives are divided into two types.

i) Open belt drives

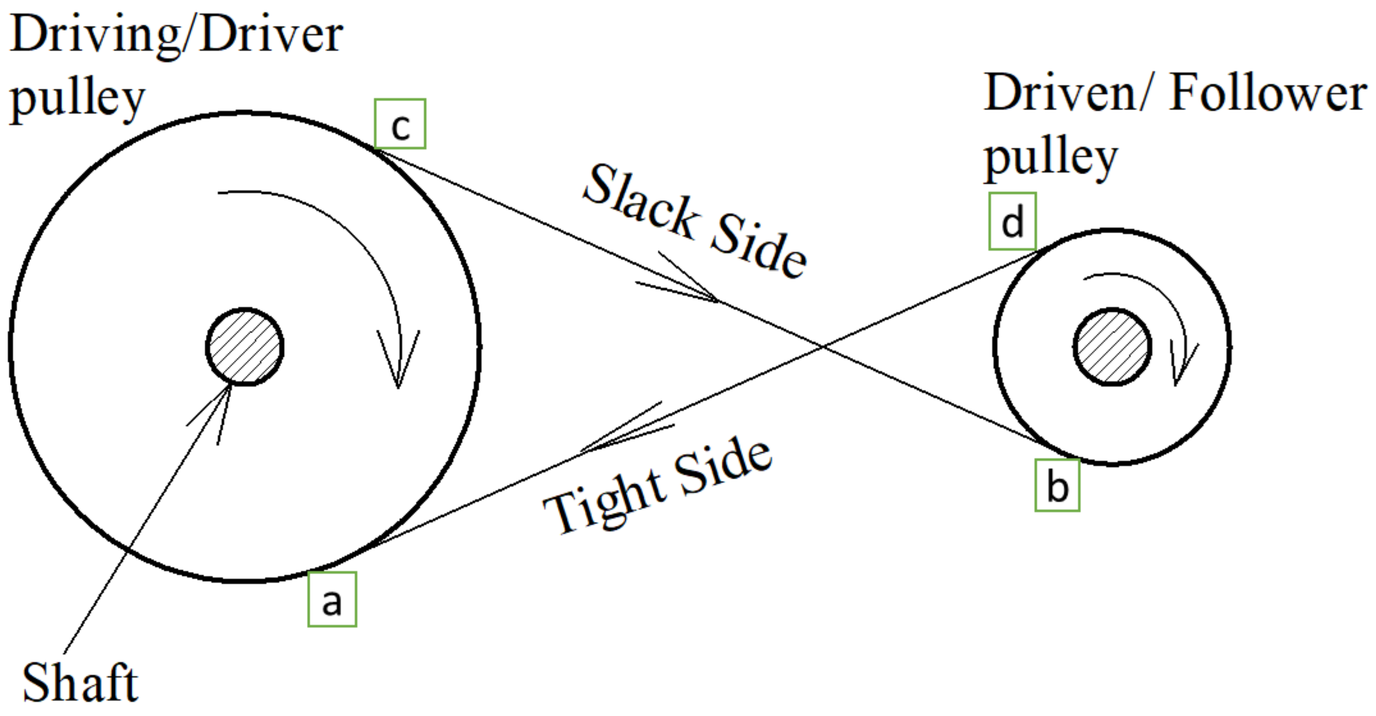
ii) Crossed belt drives

Open belt drives



An open belt drive is used to rotate the driven pulley in the same direction of driving pulley. In the motion of belt drive, power transmission results make one side of pulley more tightened compared to the other side. In horizontal drives, tightened side is always kept on the lower side of two pulleys because the sag of the upper side slightly increases the angle of folding of the belt on the two pulleys.

Crossed belt drives



A crossed belt drive is used to rotate driven pulley in the opposite direction of driving pulley. Higher the value of wrap enables more power can be transmitted than an open belt drive. However, wear of the belt is important concern. To avoid excessive wear, the centre distance between the shafts must be greater than 20b where b is the width of belt and the drive should operate at low velocity.

Velocity ratio of belt drives

The ratio between the velocities of driver pulley and driven pulley is known as velocity ratio or transmission ratio.

Let d_1 = Speed of driver pulley

d_2 = Speed of driver pulley

N_1 = Speed of driver pulley

N_2 = Speed of driver pulley

Linear speed of belt on driver = Linear speed of belt on driven

i.e., $\pi d_1 N_1 = \pi\, d_2 N_2$

$$\frac{N_2}{N_1} = \frac{d1}{d_2}$$

$$\frac{(\text{Speed of a driven})}{(\text{Speed of a driver})} = \frac{(\text{Diameter of driver pulley})}{(\text{Diameter of driven pulley})}$$

Considering the thickness of belt

$$\frac{N2}{N1} = \frac{(d_1 + t)}{(d_2 + t)}$$

Advantages of belt drives:

- Belt drives are simple are economical.
- They don’t need parallel shafts.
- Belts drives are provided with overload and jam protection.
- Noise and vibration are damped out. Machinery life is increased because load fluctuations are shock-absorbed.
- They are lubrication-free. They require less maintenance cost.
- Belt drives are highly efficient in use (up to 98%, usually 95%).
- They are very economical when the distance between shafts is very large.

Disadvantages of belt drives:

- In Belt drives, angular velocity ratio is not necessarily constant or equal to the ratio of pulley diameters, because of slipping and stretching.
- Heat build-up occurs. Speed is limited to usually 35 meters per second. Power transmission is limited to 370 kilowatts.
- Operating temperatures are usually restricted to –35 to 85°C.
- Some adjustment of centre distance or use of an idler pulley is necessary for wearing and stretching of belt drive compensation.

Problem 1

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

Solution :

Engine : Driving system

$d_1 = 55$ cm

$N_1 = 276$ rpm

Generator : Driven system

$d_2 = 2r_2$

$= 2 \times 15 = 30$ cm

$N_2 = ?$

Velocity Ratio $\dfrac{N_2}{N_1} = \dfrac{d_1}{d_2}$

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

$$= \frac{55}{30} \times 276$$

$$= 506 \text{ r.p.m}$$

Problem 2

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 that of the pulley on the line shaft.

Solution :

Motor : Driving system

$N_1 = 1750$ rpm

$d_1 = 160$ mm

Line shaft : Driven system

$N_2 = 800$ rpm

$d_2 = ?$

Velocity Ratio $\dfrac{N_2}{N_1} = \dfrac{d_1}{d_2}$

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

$$= 160 \times \frac{1750}{800}$$

$$= 350 \text{ mm}$$

Problem 3

A shaft running at 100 rpm is to drive a parallel shaft at 150 rpm. The pulley on the driving shaft is 35 cm in diameter. Find the diameter of the driven pulley. Calculate the linear velocity of the belt and also the velocity ratio.

Solution :

Driving Shaft :

$N_1 = 100$ rpm

$d_1 = 35$ cm

Driven Shaft :

$N_2 = 150$ rpm

$d_2 = ?$

Linear Velocity of the Belt = ?

Velocity Ratio = ?

(a) Velocity Ratio $= \dfrac{N_2}{N_1}$

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

$$= \frac{3}{2}$$

Velocity Ratio = 3 : 2

(b) Now $\dfrac{N_2}{N_1} = \dfrac{d_1}{d_2}$

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

$$= 35 \times \frac{100}{150}$$

$$= \textbf{23.33 cm}$$

(c) Linear Velocity of the belt $= \pi d_1 N_1$

$$= \pi \times \frac{35}{100} \times 100$$

$$= \textbf{109.95 m / min}$$

Problem 4

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

Solution :

$d_A + d_B = 900$ mm $\quad N_A = 700$ rpm $\quad N_B = 1400$ rpm

Velocity Ratio $\dfrac{N_B}{N_A} = \dfrac{d_A}{d_B}$

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

$$\therefore \quad d_A = 2d_B$$

But $\quad d_A + d_B = 900$

Substituting d_A from equation *1* in equation *2*

ie., $\quad 2d_B + d_B = 900$

$$d_B = \mathbf{300 \text{ mm}}$$

$$d_A = 2d_B$$

$$= 2 \times 300$$

$$= \mathbf{600 \text{ mm}}$$

Thank you