MODULE 5

CHAIN DRIVES

Selection of roller chains, power rating of roller chains, galling of roller chains, polygonal action, silent chain.

Drives with Higher Pairs

- Friction Drive
  - Flexible Connection Drive
    - Belt
      - Flat Belt
      - Vee Belt
    - Rope
      - Cotton Type
      - Wire Type
  - Direct Drive
    - Roller
    - Cam
- Mesh Drive
  - Flexible Connection Drive
    - Chain
  - Direct Drive
    - Toothed Gears
      - Spur Gears
      - Bevel Gear
      - Spiral or Skew Gears
    - Worm Gears

Classification of power drive can also be done in a different manner as follows :-

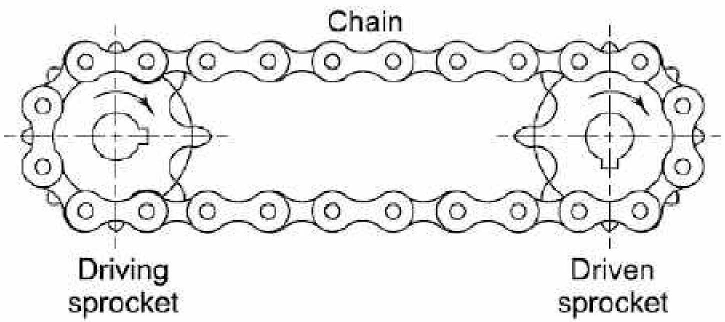
Drives with Higher Pairs

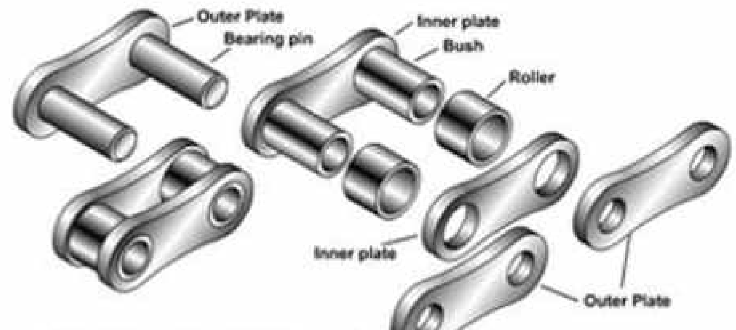
- Flexible Connectiion Drive
  - Belt
  - Rope
  - Chain
- Direct Drive
  - Cam
  - Gears

CHAIN DRIVES

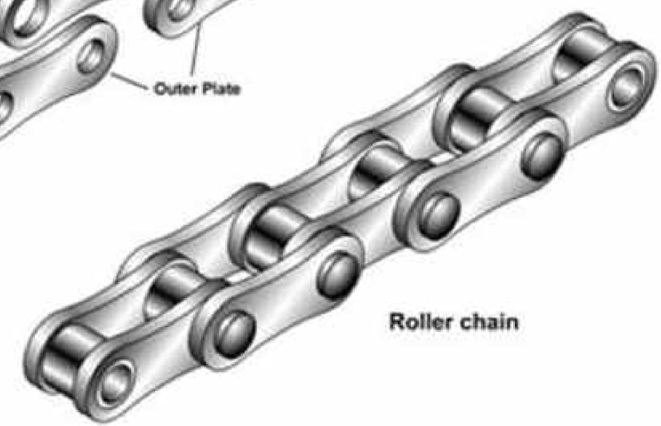
A chain drive consists of endless chain wrapped around two sprockets.

- **Chain**: It is defined as a series of links connected by **pin joints**.
- **Sprocket**: It is a toothed wheel with a special profile for the teeth.





Exploded view of roller chain parts


Roller chain

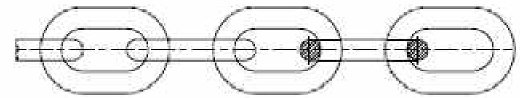
ADVANTAGES OF CHAIN DRIVE

1. They can be used for short as well as long centre distance ,particularly suited for medium centre distance.(wide range of centre distance)
2. Number of shafts can be driven in the same or opposite direction by means of a chain from a single driving sprocket.
3. Chain drives have small overall dimensions than belt drives, resulting in compact unit.
4. A chain doesn't slip and is a positive drive.
5. The efficiency of chain drives is high .for properly lubricated chain; the efficiency of chain drives is from 96% to 98%.
6. A Chain drive doesn't require initial tension. Therefore the forces acting on the shafts are reduced.
7. Chains are easy to replace.
8. Atmospheric conditions and temperature do not affect the performance of chain drives; they do not present any fire hazard.

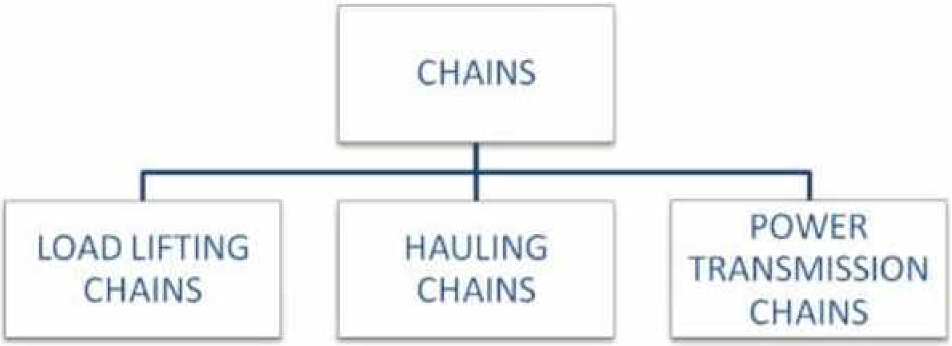
DISADVANTAGES OF CHAIN DRIVE

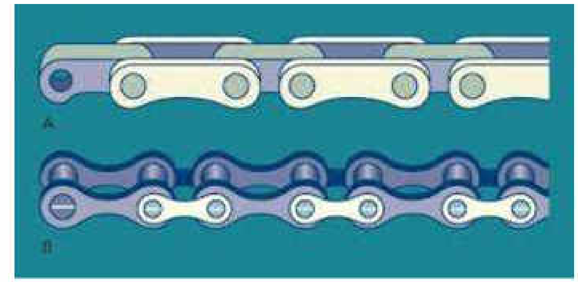
1. Chain drives generate noise.
2. Chain drive requires adjustment of slack, such as a tensioning device. Compared with belt drive, chain drives requires proper maintenance particularly lubrication.
3. Chain drives require housing.
4. Chain drives are not suitable for nonparallel shafts, but bevel and worm gears are suitable.
5. Chain drive is unsuitable where precise motion is required due to polygonal effect.
6. Even though centre distance is not critical as the gear drive, chain drives require precise alignment of shafts.

TYPES OF CHAINS



Link Chain





Load lifting/crane /hoisting chains are used for suspending, raising or lowering loads in material handling equipment.

Eg: link chain, leaf chain

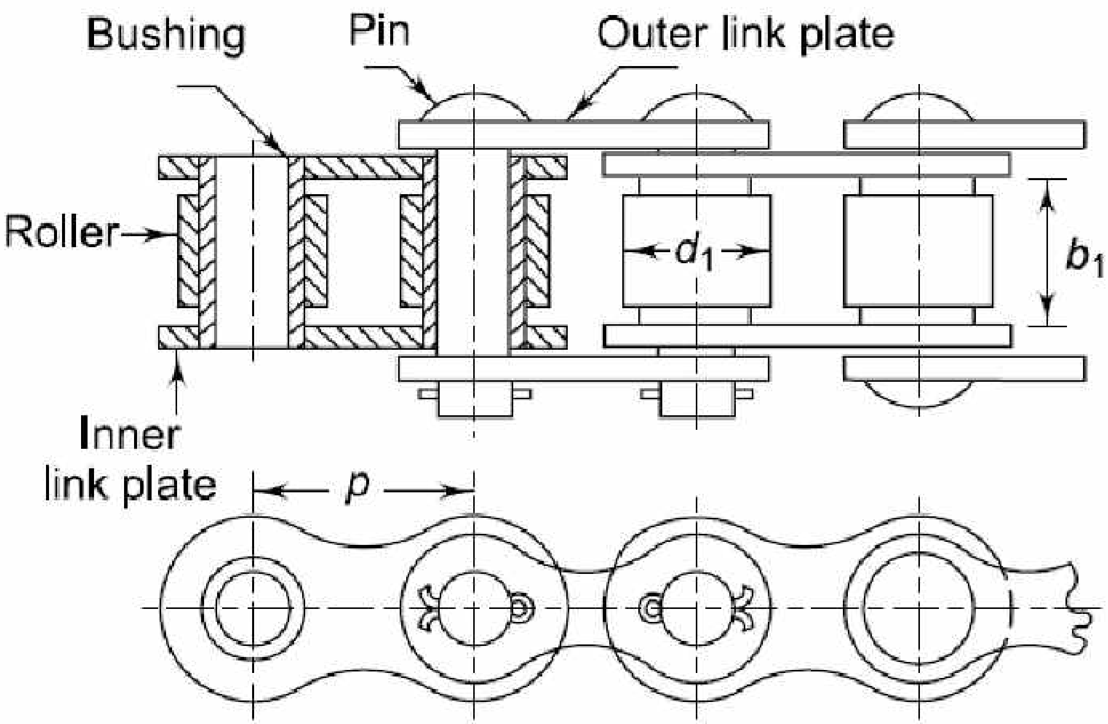
Hauling chains/conveyor or tractive chains are used for carrying materials continuously by sliding, pulling or carrying in conveyors.

Eg: Block chain, laminated metal chain

Power transmission chains are used for transmitting power from one shaft to another.

Eg: Roller chain-duplex chain, silent chain

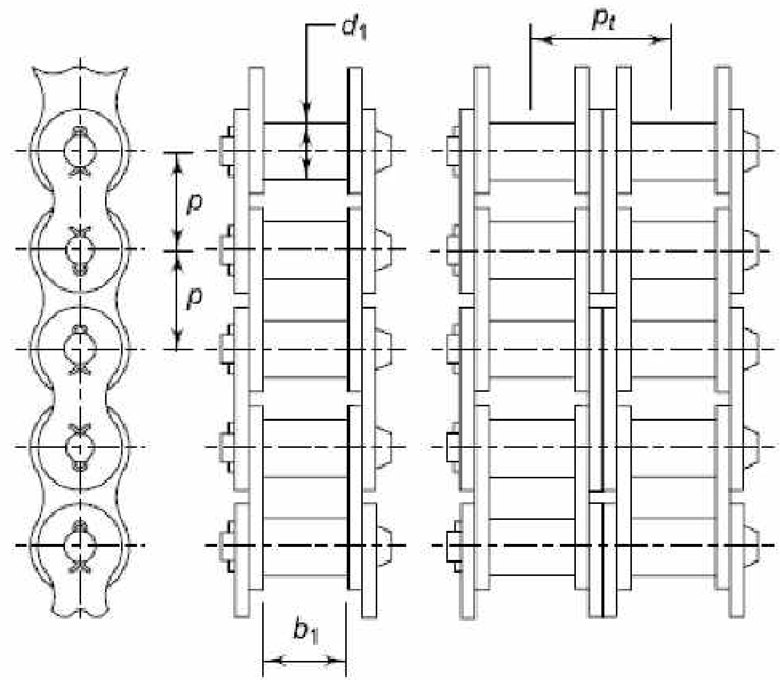
CONSTRUCTION OF ROLLER CHAIN



Construction of Roller Chain

(i) Pin
(ii) Bushing
(iii) Roller
(iv) Inner link plate
(v) Outer link plate

The pitch (p) of the chain is the linear distance between the axes of adjacent rollers. Roller chains are standardized and manufactured on the basis of the pitch. These chains are available in single-strand or multi-strand constructions such as simple, duplex or triplex chains as shown in Fig.



Simple Chain

Duplex Chain

DESIGNATION OF ROLLER CHAINS

Roller chain designated as 16A: American standard (ANSI)

It consists of two parts – a number followed by a letter.

The number in 2 digits expresses the pitch in sixteenth of an inch.

The pitch of 16 A Chain is (16/16) inch or 1 inch ie 25.4 mm. The letter A indicates American standard ANSI series.

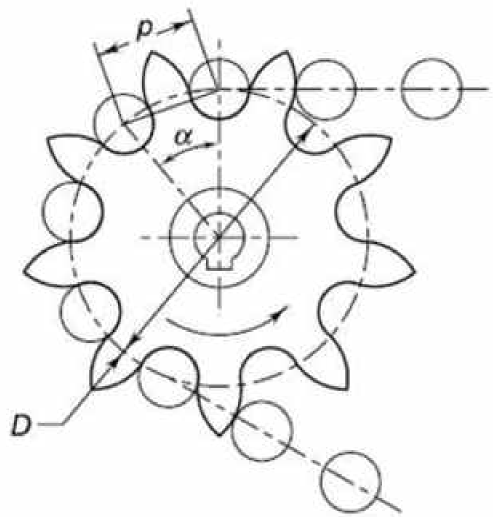
16A-1←16 A chain with simple construction (single strand)

GEOMETRICAL RELATIONSHIPS

The engagement of chain on sprocket wheel is shown in figure.

- D ←Pitch circle diameter of sprocket
- α ←pitch angle

Note: The pitch circle dia of the sprocket is defined as the dia of an imaginary circle that passes through the centres of link pins as the chain is wrapped on the sprocket.



$$\alpha = \frac{360}{z}$$

where z is the number of teeth on the sprocket. From the figure, it can be proved that

$$\sin\left(\frac{\alpha}{2}\right) = \frac{(p/2)}{(D/2)} \quad \text{or} \quad D = \frac{p}{\sin\left(\frac{\alpha}{2}\right)}$$

$$\therefore \qquad D = \frac{p}{\sin\left(\frac{180}{z}\right)}$$

The velocity ratio i of the chain drives is given by,

$$i = \frac{n_1}{n_2} = \frac{z_2}{z_1}$$

where

n_1, n_2 = speeds of rotation of driving and driven shafts (rpm)

z_1, z_2 = number of teeth on driving and driven sprockets.

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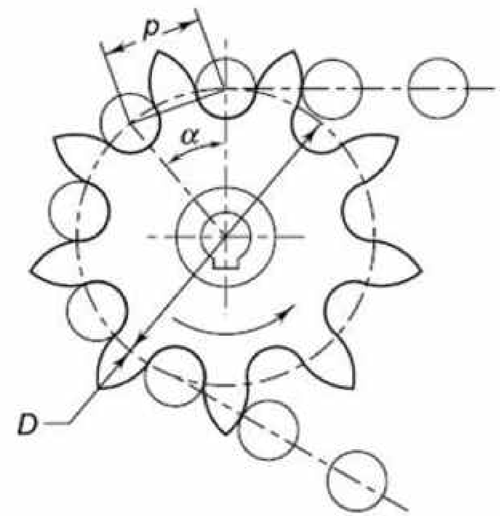


The average velocity of the chain is given by,

$$v = \frac{\pi D n}{60 \times 10^3} \qquad \therefore \qquad v = \frac{zpn}{60 \times 10^3}$$

where v is the average velocity in m/s.

The length of the chain is always expressed in terms of the number of links, or

$$L = L_n \times p$$

where

L = length of the chain (mm)

L_n = number of links in the chain

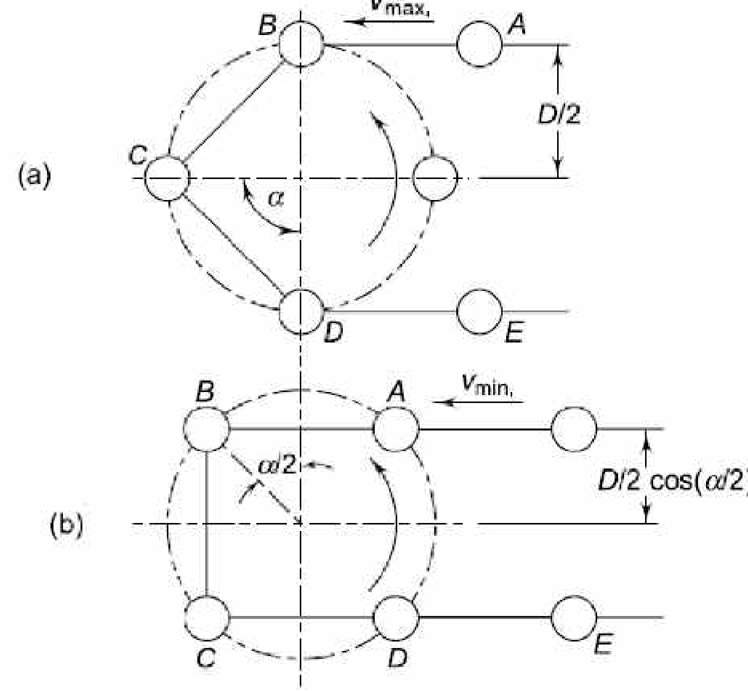
POLYGONAL EFFECT

The chain passes around the sprocket as a series of chordal links. This action is similar to that of a non-slipping belt wrapped around a rotating polygon. The chordal action is illustrated in Fig. , where the sprocket has only four teeth. It is assumed that the sprocket is rotating at a constant speed of n rpm. In Fig. the chain link AB is at a distance of $\left(\frac{D}{2}\right)$ from the centre of the sprocket wheel and its linear velocity is given by,

$$v_{\max.} = \frac{\pi D n}{60 \times 10^3} \text{ m/s} \qquad \text{(a)}$$

As the sprocket rotates through an angle $\left(\frac{\alpha}{2}\right)$, the position of the chain link AB is shown in Fig. (b). In this case, the link is at a distance of $\frac{D}{2} \times \cos\left(\frac{\alpha}{2}\right)$ from the centre of the sprocket and its linear velocity is given by,

$$v_{\min.} = \frac{\pi D n \cos\left(\frac{\alpha}{2}\right)}{60 \times 10^3} \text{ m/s} \qquad \text{(b)}$$



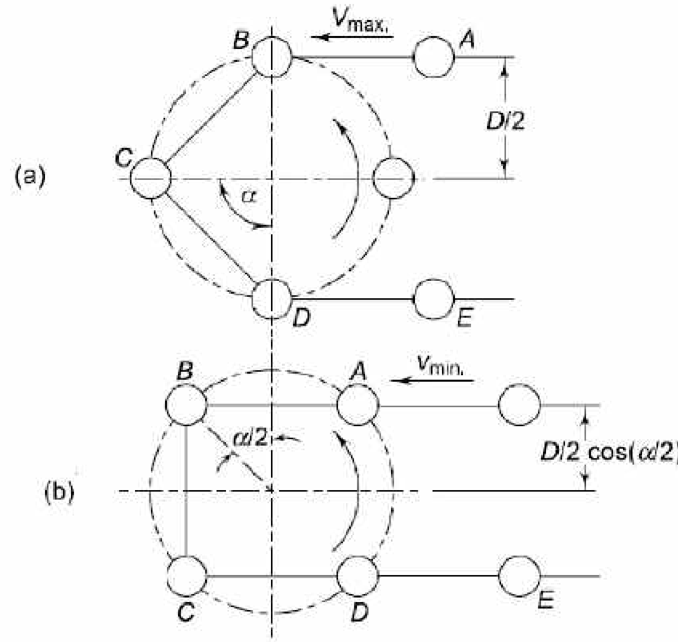
Polygonal action of Chain

It is evident that the linear speed of the chain is not uniform but varies from $v_{max.}$ to $v_{min.}$ during every cycle of tooth engagement. This results in a pulsating and jerky motion. The variation in velocity is given by

$$(v_{max.} - v_{min.}) \propto \left[1 - \cos\left(\frac{\alpha}{2}\right)\right]$$

or

$$(v_{max.} - v_{min.}) \propto \left[1 - \cos\left(\frac{180}{z}\right)\right]$$



Polygonal action of Chain

As the number of teeth (z) increases to ∞, cos (180/z) or cos (180/∞), i.e., cos (0°) will approach unity and ($v_{max.} - v_{min.}$) will become zero. Therefore, the variation will be zero. In order to reduce the variation in chain speed, the number of teeth on the sprocket should be increased. It has been observed that the speed variation is 4% for a sprocket with 11 teeth, 1.6% for a sprocket with 17 teeth, and less than 1% for a sprocket with 24 teeth.

GEAR VS SPROCKET

1. The teeth of the gears have involute profile, while circular arcs are used for the profile of sprocket teeth.
2. A gear meshes with another gear. A sprocket meshes with an intermediate link namely chain, which in turn meshes with another sprocket.
3. The face width of gear is usually more with respect to its diameter. The sprockets are comparatively thin so as to fit between inner link plates of the chain.

POWER RATING OF ROLLER CHAINS

The power transmitted by the roller chain can be expressed by the elementary equation

$$\mathrm{kW} = \frac{P_1 v}{1000}$$

where

P_1 = allowable tension in the chain (N)

v = average velocity of chain (m/s)

However, it is not easy to determine the allowable tension in the chain. It depends upon a number of factors, such as the type of chain, pitch of the chain link, number of teeth on the smaller sprocket, chain velocity, the type of power source and driven machinery and the system of lubrication.

In practice, the power rating of the roller chain is obtained on the basis of four failure criteria. 1. Wear 2.Fatigue 3.Impact 4.galling

Wear

1. The wear of the chain is caused by the articulation of pins in the bushings which results in elongation of the chain or chain length is increased.
2. This makes the chain ride out on the sprocket teeth, resulting in a faulty engagement.
3. When the elongation is excessive, it becomes necessary to replace the chain.
4. The permissible elongation of the chain is 1.5 to 2.5%.

FATIGUE

1. As the chain passes around the sprocket wheel, it is subjected to a tensile force, which varies from a max on tight side to a min on loose side.
2. The chain link is subjected to one complete cycle of fluctuating stresses during every revolution of the sprocket wheel which results in fatigue failure.

IMPACT

1. The engagement of the rollers with the teeth of the sprocket results in impact which leads to breakage of roller or bushing.
2. By increasing the number of teeth on the sprocket or reducing chain tension and speed we can reduce the magnitude of the impact force.

GALLING

1. Galling is a stick slip phenomenon between the pin and the bushing
2. When the chain tension is high, welds are formed at the high spots of the contacting area.
3. Such microscopic weld immediately broke down due to relative motion of contacting surface and eventually leads to excessive wear even in presence of the lubricant.

The manufacturer's catalogue give extensive detail like charts and tables for the power rating of the chain .they are based on four criteria of failure discussed above. Since the chain manufacturing is a specialised industry, it is necessary for the designer to select a proper chain from these catalogues.

For a given application, the kW rating of the chain is determined by the following relationship:

kW rating of chain

$$= \frac{(\text{kW to be transmitted}) \times K_s}{K_1 \times K_2}$$

where

K_s = service factor

K_1 = multiple strand factor

K_2 = tooth correction factor