6.6 GEAR DRIVE

In modern mechanical engineering world, gears are the most common means of transmitting power. The size of the gears may be very small as used in watches or it may be very large as used in bridge lifting mechanism etc.

Gears are the toothed wheels used to transmit motion between two shafts, when the centre between them is small. In case of belts and ropes the drive is not positive. There is slip and creep. But the gear drive is a positive and smooth drive which transmits exact velocity ratio. Gears transmit motion by direct contact i.e. they do not use any intermediate link or connector. The gear is defined as a toothed element which is used for transmitting rotary motion from one shaft to another. When teeth are provided on its internal surface, known as *internal gear* or annular wheel or simply annulus. When teeth are provided on its external surface, it is known as *external gear*. The error in tooth meshing may cause undesirable vibration and noise during operation.

Gears are either casted or teeth are cut on a circular plate, known as *gear blank*. The smaller gear is called the *pinion* and bigger one the gear wheel. For small power transmission, the friction wheels as shown in Fig. 27 can be used. These wheels are mounted on the two shafts, having sufficient rough surfaces and passing against each other.

The friction wheel 1 is keyed to the rotating shaft whereas the friction wheel 2 is keyed to the shaft which is to be rotated. When the friction wheel 1 rotates, it will rotate the friction wheel 2 in the

opposite direction as shown in Fig. 27. There will be no slip between the two wheels for small power transmission. For no slip of the two surfaces (i.e. no relative motion between the two surfaces of the friction wheels), their tangential velocities at the contact surfaces should be the same.

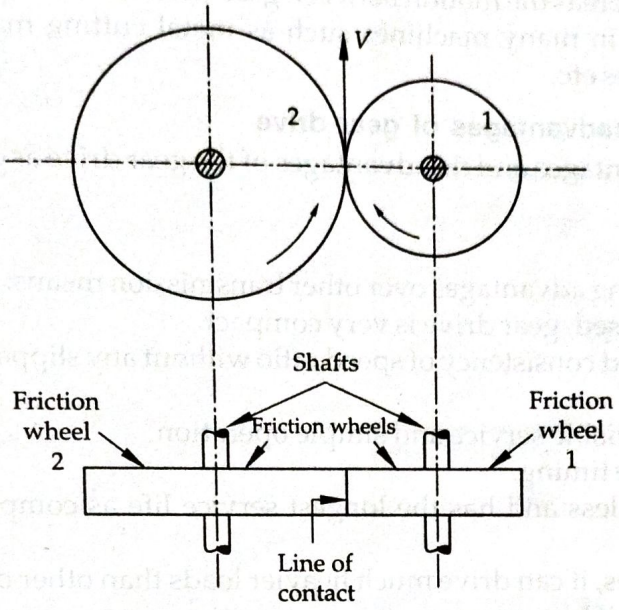


Fig. 27

But in case of large power transmission, the motion between the friction wheels will not be definite due to slippage. So, to prevent the slip between the two surfaces, a number of projections (known as teeth) are provided on the periphery of the wheel 1, which will fit into the corresponding recesses on the periphery of wheel 2 as shown in Fig. 28.

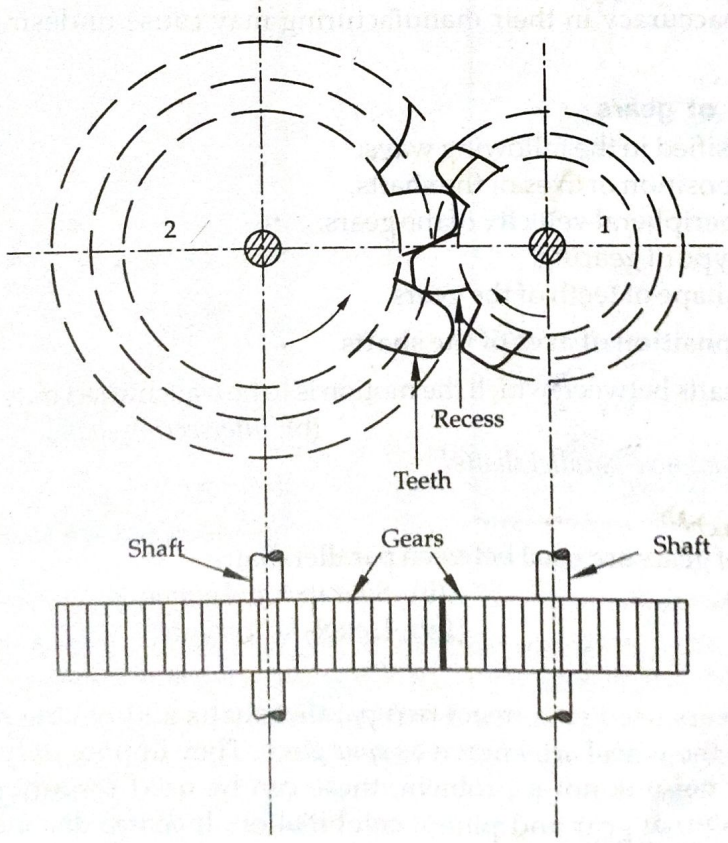


Fig. 28

Hence the teeth and corresponding recesses will mesh with each other and slip between them will be prevented.

The friction wheel with teeth cut on it is known as *gear wheel* or gear. The motion between the two friction wheel is rolling whereas the motion between gear wheels is sliding.

Uses: Gears are used in many machines such as metal cutting machine tools, automobiles, hoists, rolling mills, watches etc.

6.6.1 Advantages and disadvantages of gear drive

The following are the advantages and disadvantages of the gear drive as compared to belt, rope and chain drives:

Advantages

Gear drives has the following advantages over other transmission means:

1. Due to short distances used, gear drive is very compact.
2. It gives positive drive and consistency of speed ratio without any slippage, i.e. it transmit constant velocity ratio.
3. It has high efficiency, reliable service and simple operation.
4. It can be used for precise timing.
5. Its maintenance cost is less and has the longest service life as compared to other mechanical drives.
6. Due to its unlimited sizes, it can drive much heavier loads than other drives.
7. It can be used for transmit large power.
8. It can drive loads subjected to shock at speeds up to 20 m/s.

Disadvantages

Gear drives has the following disadvantages:

1. It is not suitable for large centre distances because the drive will become bulky.
2. Its manufacturing is complex, so special tools and equipment are needed and hence it is costlier.
3. The errors and inaccuracy in their manufacturing may cause undesirable noise and vibration during operation.

6.6.2 Classification of gears

The gears can be classified in the following ways:

1. According to the position of axes of the shafts.
2. According to the peripheral velocity of the gears.
3. According to the type of gearing.
4. According to the shape of teeth of the gears.

1. According to the position of axes of the shafts

The axes of the two shafts between which the motion is to be transmitted may be:

(a) *Parallel shafts* (b) *Intersecting shafts*

(c) *Non-intersecting and non-parallel shafts.*

(a) Parallel shafts

The following types of gears are used between parallel shafts:

(i) *Spur gear* (ii) *Spur rack and pinion*

(iii) *Helical gear* (iv) *Double helical gear*

(v) *Herring bone gears*

(i) *Spur gears:* The gears used to connect two parallel shafts and having straight teeth which are parallel to the axis of the wheel are known as *spur gears*. They impose only radial loads. These are slow speed gears. If noise is not a problem, these can be used for any speed. The most usual arrangement is an external gear and pinion combination. If centre distance is to be reduced, the

internal gear with external pinion combination is also used. Gears rotate in opposite direction in case of external gearing and in same direction in case of internal gearing. Figure 29 shows the spur gears. These are generally used in lathes for speed change mechanism.

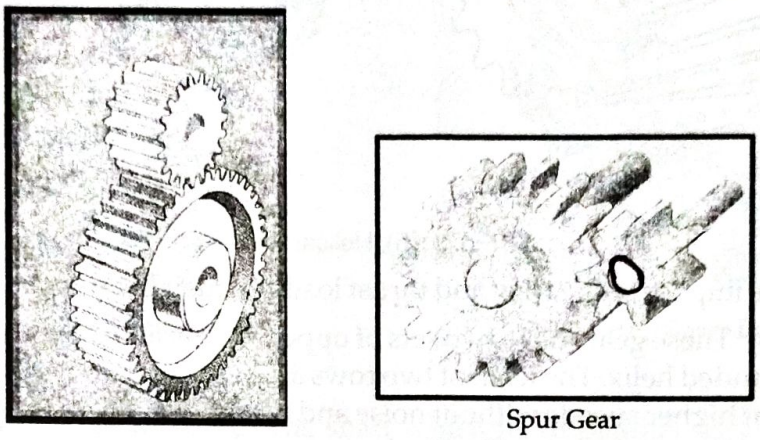


Fig. 29 Spur gear

(ii) *Spur Rack and pinion:* Spur Rack is a special case of a spur gear. It has infinitely large pitch diameter. The spur rack and pinion combination converts rotary motion into translatory motion or vice-versa. Figure 30 shows the rack and pinion.

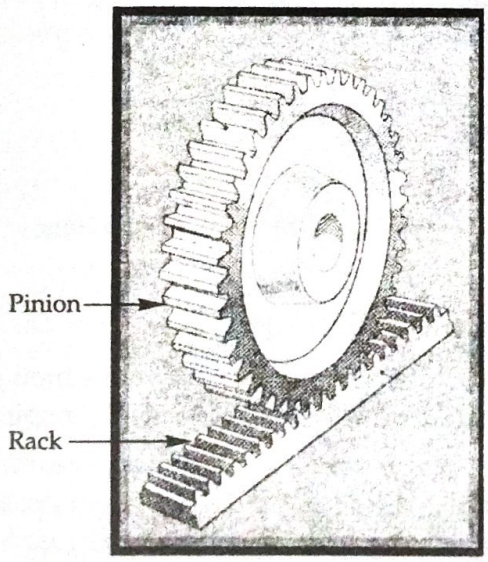


Fig. 30 Rack and pinion

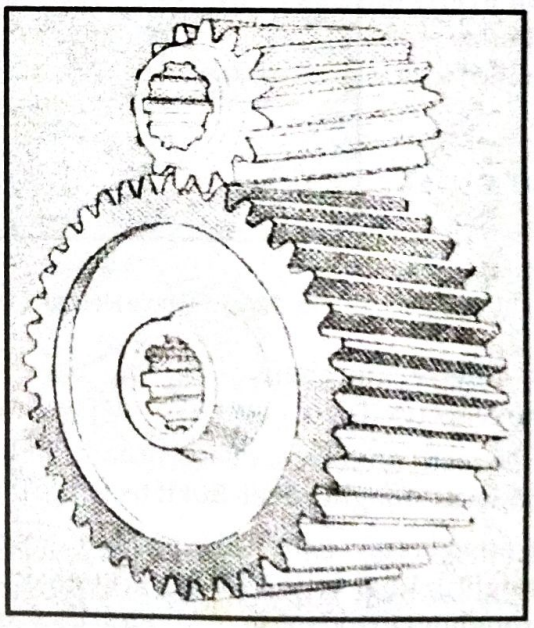


Fig. 31(a) Single helical

(iii) *Helical gears:* Figure 31 shows the helical gear. In helical gears, teeth are inclined to the axis of the shaft and are in form of helix. Two meshing gears have the same helix angle but have teeth of opposite hands i.e. a right hand pinion meshes with a left hand gear and a left hand pinion meshes with a right hand gear. These gears are considered for high speed and can take higher loads as compared to equal size spur gear.

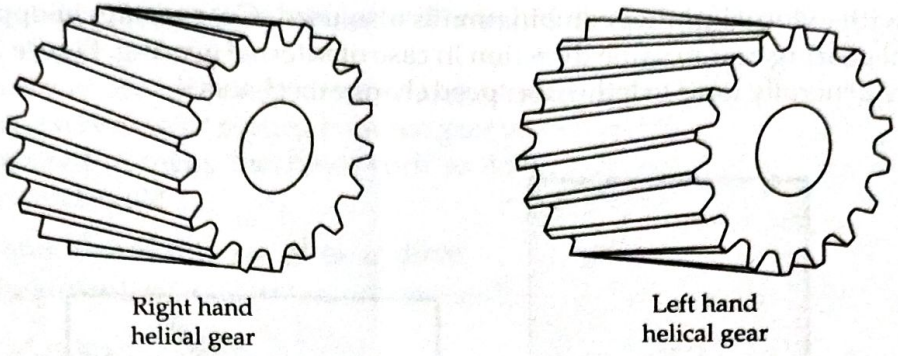


Fig. 31(b) Helical Gear

Single helical gears impose both radial and thrust loads on their bearings.

(iv) *Double helical gears:* These gears have two sets of opposed helical teeth i.e. one has right handed helix and other a left handed helix. The teeth of two rows are separated by a groove used for tool run-out. These can be run at higher speeds without noise and vibrations. There is no axial thrusts on the bearings. Double helical gear is shown in Fig. 32 (a).

(v) *Herring bone gears:* These gears are shown in Fig. 32(b). These are essentially the same as the double helical gears but in these gears, there in no space separating the two opposed sets of helical teeth. These are used in turbines.

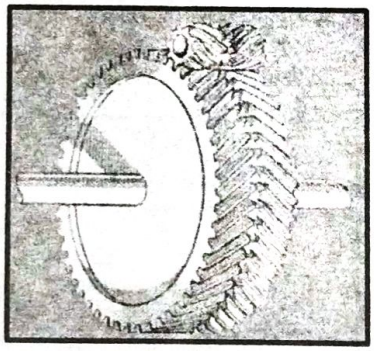


Fig. 32(a) Double Helical

Fig. 32(b) Herring Bone Gear

(b) Intersecting shafts

The gears used to connect two intersecting shafts are known as *bevel gears.*

If the teeth on the gears are straight radial to the point of intersection of shaft axes then gears are known as straight bevel. But if teeth are inclined then gears are known as *helical bevel* (or spiral bevel).

(i) *Straight bevel gears:* Figure 33(a) shows the straight bevel gears. In straight bevel gears, teeth are straight, radial to the point of intersection of the shaft axis. There is variation in cross-section throughout their length. Although they are made for a shaft angle of 90°, can be produced for almost any angle. Straight bevel gears make the line contact similar to spur gears. These can be internal bevel gears also similar to internal spur gears. Two such gears of the same size with shaft angle of 90° are known as *mitre gears.*

(ii) *Spiral bevel gears:* In these bevel gears, the teeth are inclined. These are most suitable for high speeds. These can run more quietly and can take up more load than straight bevel gears, but the thrust loads are greater. These are used for the drive to the differential of an automobile. Spiral bevel gear is shown in Fig. 33(b).

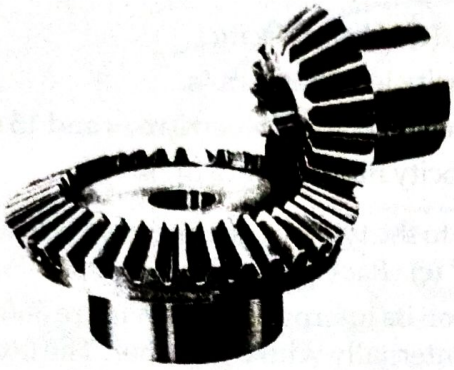


Fig. 33(a) Straight Bevel Gear

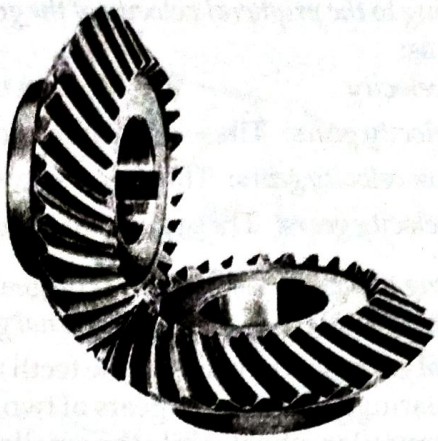


Fig. 33(b) Spiral Bevel Gear

(c) Non-parallel, Non-intersecting shafts

The axis of such shafts cross in space. The shaft which lie in parallel may skewed at any angle between 0° and 90°. The following main types of gears are used between such shafts:

(i) *Spiral gears* (ii) *Hypoid gear* (iii) *Worm gears*

(i) *Spiral gears:* These are also called *crossed helical gears*. There in no difference between these gears and helical gears until they are mounted in mesh with each other. A pair of meshed crossed helical gears usually have the same hand. The teeth of these gears have point contact with each other and are used for *low loads*.

(ii) *Hypoid gears*: These are similar to spiral bevel gears with the difference that the axes of the shafts do not intersect. The term 'offset' is the distance between a hypoid pinion axis and the axis of the hypoid gear. Hypoid gears become spiral bevel gears, if the offset is zero. The shaft angle is usually 90° but other angles are not possible. The tooth action between such gears is a combination of rolling a sliding along a straight line. Hypoid gear is shown in Fig. 34.

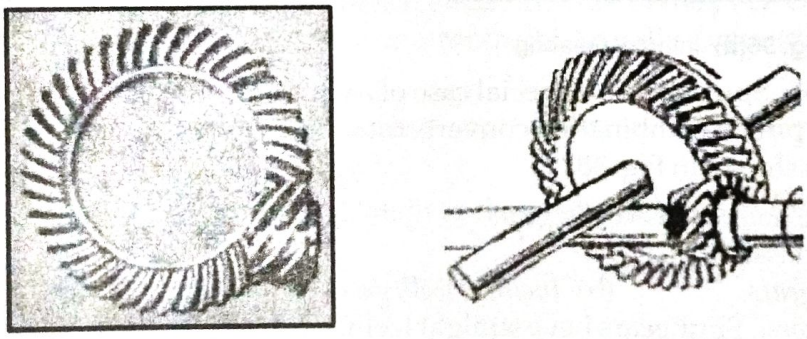
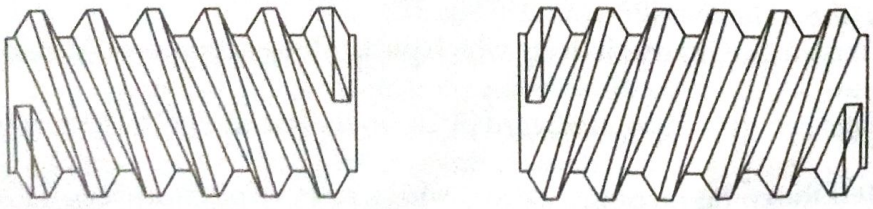


Fig. 34 Hypoid Gear

(iii) *Worm gears:* In such gears one gear has screw threads. Due to this factor, they are quiet, vibration free and give a smooth run. These gears are used with shaft angles of 90°, but other angles are not possible. (Fig. 35).



Right hand worm Left hand worm

Fig. 35 Worm Gear

2. *According to the pripheral velocity of the gears:* The gears, according to the peripheral velocity may be classified as:

(a) *Low velocity* (b) *Medium velocity, and* (c) *High velocity*

(a) *Low velocity gears:* These gears have peripheral velocity less than 3 m/s.

(b) *Medium velocity gears:* These gears have peripheral velocity in between 3 m/s and 15 m/s.

(c) *High velocity gears:* These gears have peripheral velocity more than 15 m/s.

3. *According to the types of gearing:* The gears, according to the types of gearing may be classified as:

(a) *Internal gearing* (b) *External gearing* (c) *Rack and pinion*

(a) *Internal gearing:* In this case, the teeth are provided on its internal surface. Figure 36(a) shows the internal gearing, in which the gears of two shafts mesh internally with each other. The larger wheel is known as annular wheel while the smaller wheel the pinion. The motion of the two gears is always same.

(b) *External gearing:* In this case the teeth are provided on the external surface. When the gears of the two shafts mesh externally with each other, it is known as *external gearing*. In this case the motion of the two gears is always opposite. The larger gear is known as *spur wheel* and smaller is known as pinion. External gearing is shown in Fig. 36 (b).

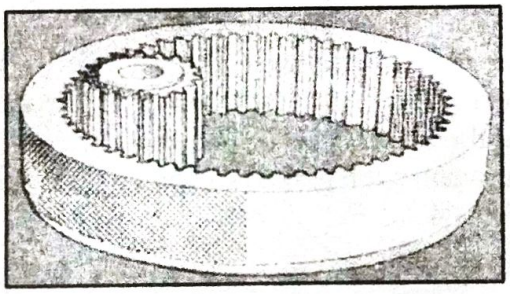


Fig. 36(a) Internal Gearing

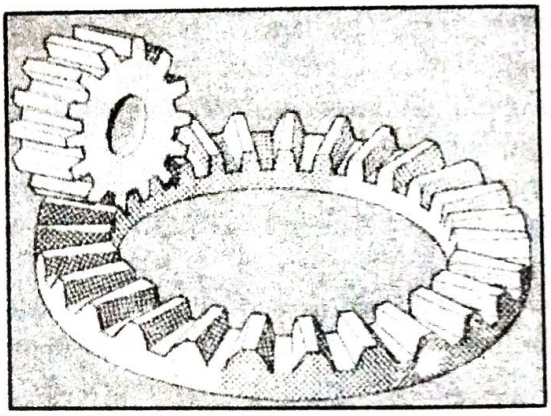


Fig. 36(b) External Gearing

(c) *Rack and pinion:* Spur Rack is a special case of a spur gear. It has infinitely large pitch diameter. The spur rack and pinion combination converts rotary motion into translatory motion or vice-versa. Rack and pinion is shown in Fig. 30.

4. *According to the shape of teeth of the gears*

The gears may be classified as:

(a) *Straight teeth gears* (b) *Inclined teeth gears* (c) *Curved gears*

(a) *Straight teeth gears:* Spur gears have straight teeth.

(b) *Inclined teeth gears:* Helical gears have inclined teeth (which are inclined to the wheel rim surface).

(c) *Curved teeth gears:* Spiral gears have the curved teeth over the rim surface.