13

Chapter

TRANSMISSION OF MOTION AND POWER

13.1 INTRODUCTION

The mechanical power is transmitted in machines from one component to another depending upon the requirement. Various types of power and motion transmission systems are available.

13.2 POWER TRANSMISSION ELEMENTS

"In order to transmit power from one machine member to another, either flexible or non-flexible type of elements may be used. By a flexible machine element we mean, in which the centre distance between the driving and the driven member can be changed conveniently, and in the case of non-flexible machine elements the centre distance cannot be changed. These machine members can be classified as shown in Fig. 13.1. The flexible machine elements are used for the transmission of power over comparatively long distances. Since these elements are elastic and usually long, they play an important part in absorbing shock loads and damping out the effects of vibrating forces. In this chapter we shall study the design of flat and V-belts.

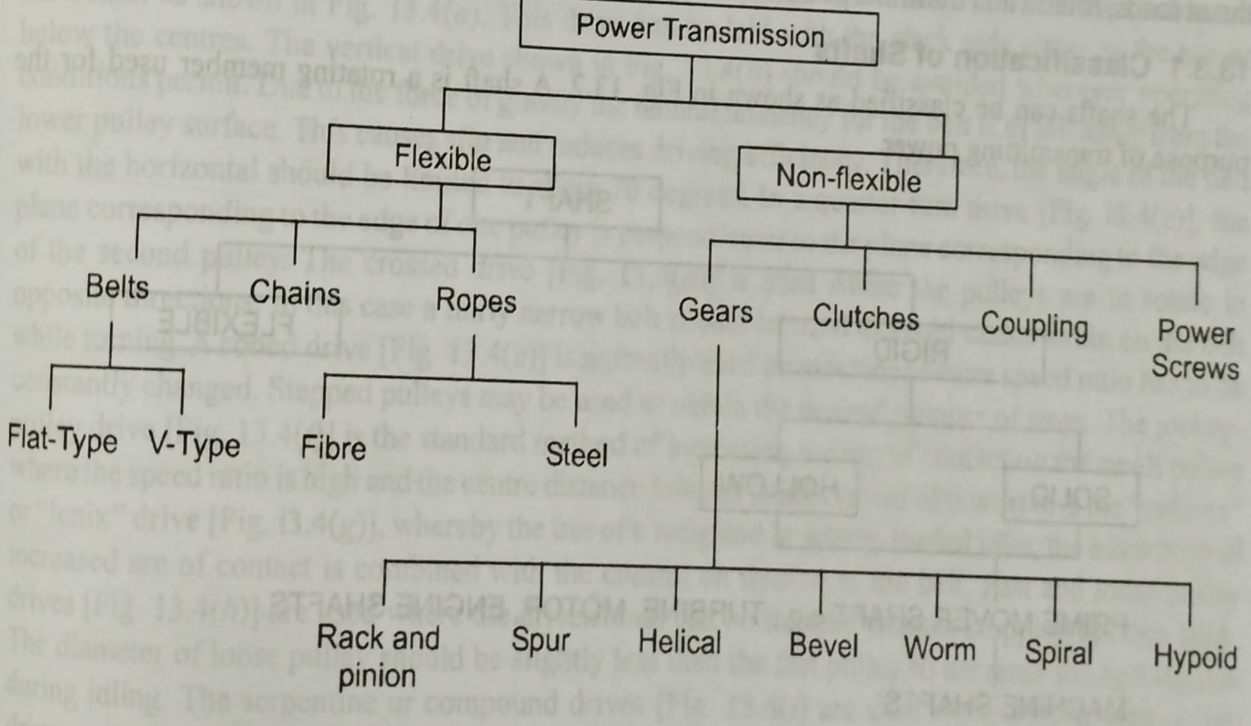

Fig. 13.1 Classification of power transmission elements.

A comparison of the mechanical drives is given in Table 13.1.

Table 13.1 Comparison of Mechanical Drives

Type of drive	*Centre distance*	*Speed ratio*	*Shifting*	*Maintenance cost*	*Initial cost*	*Power rating kW*	*Peripheral speed m/s*	*Efficiency percent*
Flat belts	Long	4-10	Yes	Low	1	upto 100	5-30	92-98
V-belts	Short	7-15	No	Low	3	50	5-30	87-97
Roller chains	Short	6-10	No	Medium	5	3500	Upto 25	94-98
Silent chains	Short	5-15	No	Medium	7	3000	Upto 25	94-98
Ropes	Very long	5-10	No	Medium	10	2500	6-15	92-96
Spur gears	Short	upto 10	Yes	Medium	15	10000	25	92-99
Helical gears	Short	upto 10	Yes	Medium	25	35000	25	94-99
Bevel gears	Short	upto 20	No	Medium	30	30000	30	90-98
Worm gears	Short	8-100	No	High	35	100	Upto 35	75-90

13.3 SHAFT AND AXLE

The shaft is one of the most common and basic machine elements. Failure of a shaft usually necessitates a costly and time consuming major overhaul. It is essential, therefore, that the designer be able to provide a suitable shaft design to meet the operating conditions to which the shaft will be subjected. The shaft must not only be strong enough to provide an adequate factor of safety from the static and dynamic stress view points but it must also be sufficiently rigid to prevent harmful torsional and lateral deflections. Provisions must usually be made for the proper positioning of the shaft and the components mounted on it. Finally, the shaft must have such dimensions that its natural frequency of vibration is sufficiently remote from the operating frequency to avoid resonance with its consequent destructive stresses and displacements.

The shaft may be attached to other components either by keys, pins, splines or force-fitted and shrink-fitted. The length of the shaft may be extended by a coupling.

A shaft may be defined as a machine member which is supported on bearings, supports radial and thrust loads, rotates and transmits power. It is subjected to both bending moment and twisting moment.

13.3.1 Classification of Shafts

The shafts can be classified as shown in Fig. 13.2. A shaft is a rotating member used for the purpose of transmitting power.

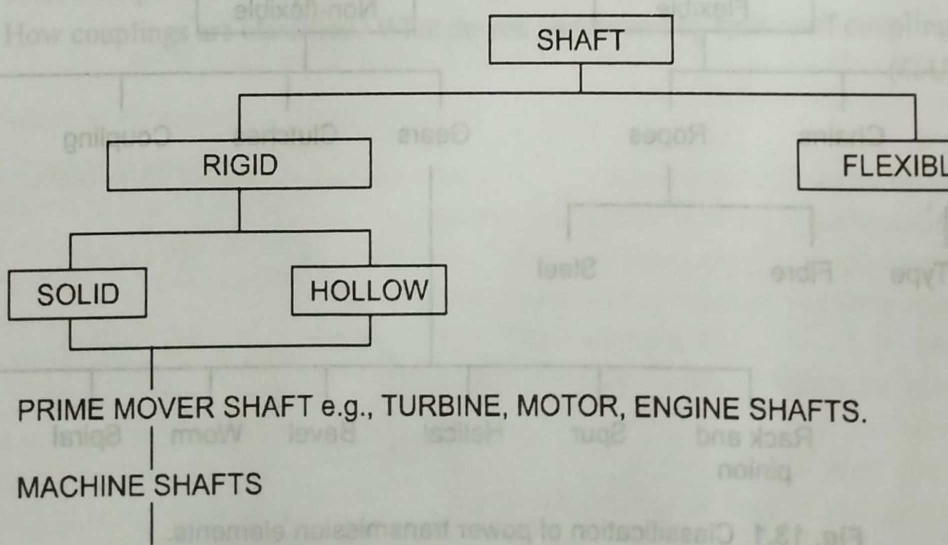

Fig. 13.2 Classification of shafts

A line shaft is a long and continuous shaft used in workshops and factories for the distribution of power. A counter shaft is used in between a line shaft and a machine. A shaft directly coupled to the power source is called a jack shaft. Flexible shafts are used where the axis of rotation of the driving and driven members are not coaxial.

13.3.2 Axle

An axle is a stationary member used as a support for rotating elements such as wheels, idler gears, and so on. A spindle is a short shaft. For example, the wheels of a cycle are supported on axles. In some cases, the axle may also rotate, as in the case of railway bogies. An axle does not transmit power. It only supports transverse loads.

A spindle normally refers to a machine tool. It is generally hollow and is subjected to both bending moment and twisting moment.

13.4 BELTS DRIVE

13.4.1 Flat Belts Drive

A flat belt drive is shown in Fig. 13.3. Belts are used for power transmission from one pulley to another.

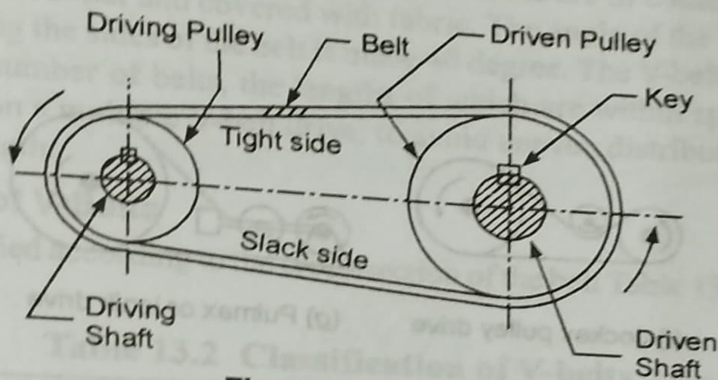

Fig. 13.3 Belt Drive

The layout of a flat belt drive may be of many types. The simplest drive is where the centres are horizontal as shown in Fig. 13.4(*a*). This drive can be laid with the slack side either at the top or below the centres. The vertical drive shown in Fig. 13.4(*b*) should be avoided wherever operating conditions permit. Due to the force of gravity the natural tendency for the belt is to fall away from the lower pulley surface. This causes slip and reduces driving efficiency. Therefore, the angle of the belt with the horizontal should be limited to about 70 degrees. In a quarter-turn drive [Fig. 13.4(*c*)], the plane corresponding to the edge of one pulley is perpendicular to the plane corresponding to the edge of the second pulley. The crossed drive [Fig. 13.4(*d*)] is used where the pulleys are to rotate in opposite directions. In this case a fairly narrow belt should be used to avoid undue strain on the belt while turning. A coned drive [Fig. 13.4(*e*)] is normally used on machines where speed ratio has to be constantly changed. Stepped pulleys may be used to obtain the desired number of steps. The jockey-pulley drive [Fig. 13.4(*f*)] is the standard method of increasing the arc of contact on the small pulley where the speed ratio is high and the centre distance low. An improvement of this drive is the "pulmax" or "lenix" drive [Fig. 13.4(*g*)], whereby the use of a weighted or spring-loaded idler, the advantage of increased arc of contact is combined with the control on tension in die belt. Fast and loose pulley drives [Fig. 13.4(*h*)] are used where die driven shaft can be stopped without stopping the line shaft. The diameter of loose pulley should be slightly less than the fast pulley to decrease the belt tension during idling. The serpentine or compound drives [Fig. 13.4(*i*) are used where one driving pulley drives a number of different shafts at varying speeds. This requires an endless belt to drive from both the sides. For power to be transmitted at right angles, the right angled drive [Fig. 13.4(*j*)] is used. For a short centre drive, a reverse drive [Fig. 13.4(*k*)] should be preferred over the crossed drive.

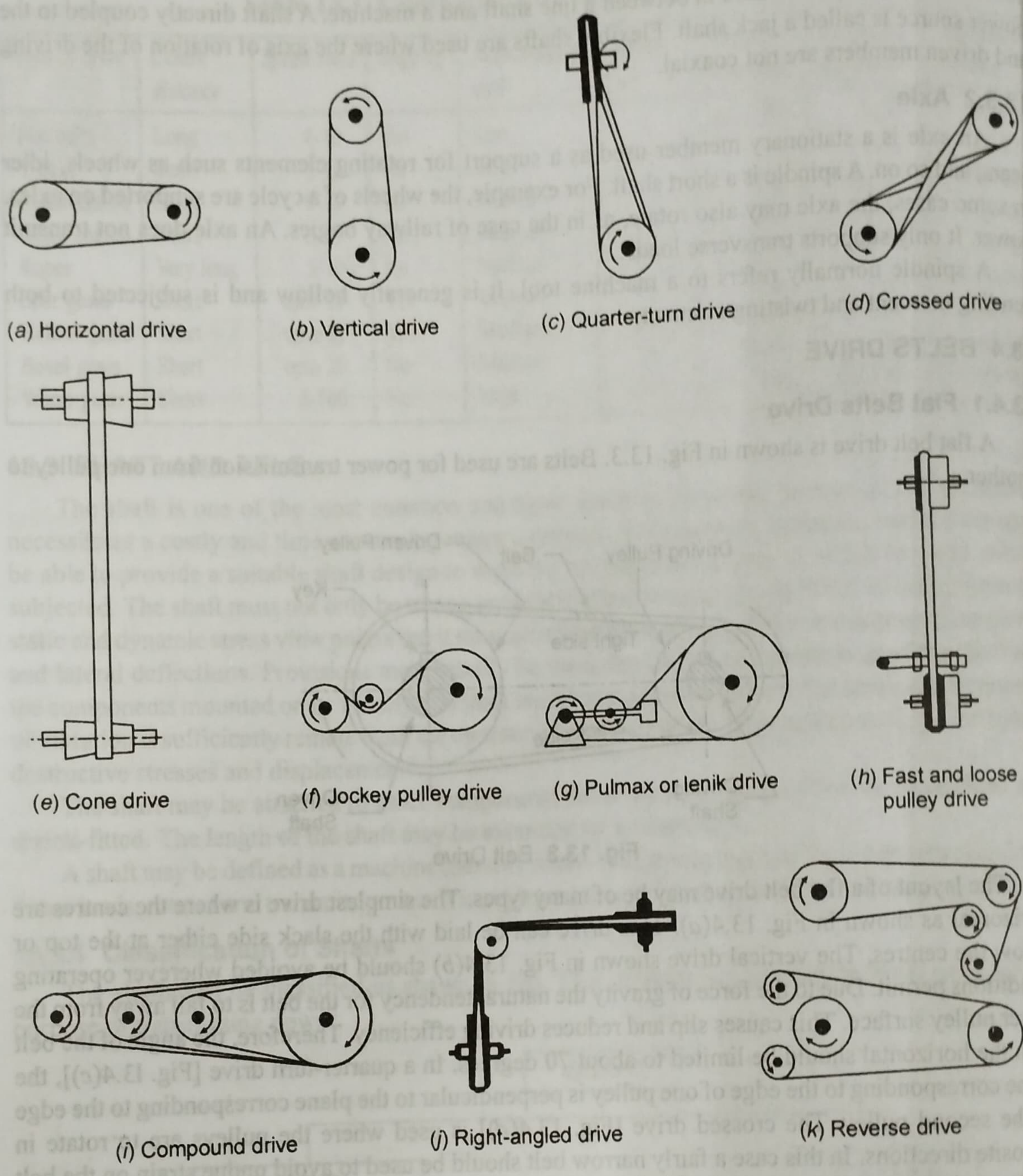

Fig. 13.4 Types of flat belt drive

13.4.2 Types of Flat Belts

Flat belts are made of leather, fabric, rubberized fabric, non-reinforced rubber and reinforced leather. Flat belts are of three types as shown in Fig. 13.5.

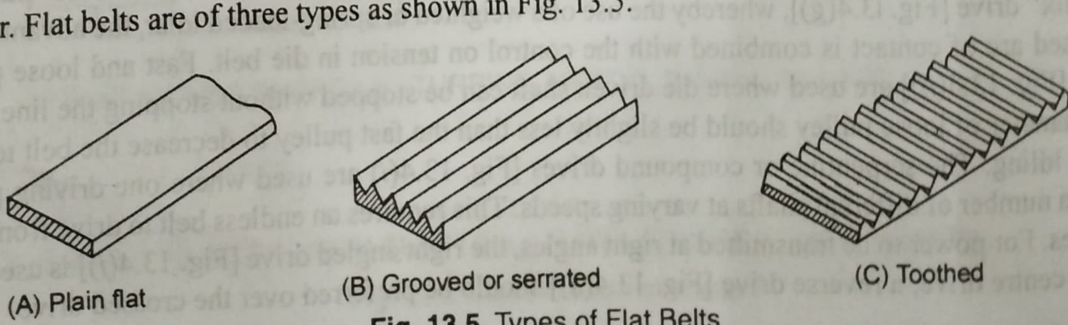

Fig. 13.5 Types of Flat Belts

1. **Plain flat.** They are of rectangular cross-section with no teeth or groove, as shown in Fig. 13.5(*a*).
2. **Grooved or Serrated.** They have longitudinal grooves of V-section adjacent to each other made on inside periphery of the belt, as shown in Fig. 13.5(*b*). The power transmission capacity increases due to angle formed by V-grooves.
3. **Toothed belts.** They have teeth on the internal periphery of the belt along length, as shown in Fig. 13.5(*c*), which fit into the similar size of teeth on the pulley. They are used for positive drive, *e.g.*, camshaft of an engine.

13.4.3 V-Belts Drive

A V-belt drive consists of one or more V-belts mounted on grooved pulleys. The profiles of the belts end of pulley grooves are such that the belts come into contact with the sides of the pulley grooves only and not with the base of the grooves. The shape of a V-belt is shaped roughly like a trapezium. V-belts are suitable for speed ratios upto 7 and belt speeds upto 25 m/s. These belts are made endless and give a more positive and noiseless drive. The slip of the belt is also less and the wedging action of the belt results in offsetting the decrease in the arc of contact. V- belts are made of fabric and cords moulded in rubber and covered with fabric. The angle of the V-belt, *i.e.* the included angle obtained by extending the sides of the belt is made 40 degree. The V-belts are used as a matched set, *i.e.* a set of selected number of belts, the lengths of which are within specified limits enabling them to be used together on a multiple V-belt drive, to avoid uneven distribution of load. A V-belt is specified by the inside length.

13.4.4 Classification of V-Belts

The V-belts are classified according to the cross-section of the belt Table 13.2 gives the dimensions of various types of belts.

Table 13.2 Classification of V-belts

Type of Belt	*IS Code No.*	*Cross-section symbol*	*Nominal Top width, a, mm*	*Nominal thickness, t, mm*	*Angle of V-Belt, 2β degree*
Industrial purposes	IS : 2494 — 1974	A	13	8	
		B	17	11	40
		C	22	14	
		D	32	19	
		E	38	23	
Automotive fan	IS : 5635—1970	FB 10	10	8	
		FB 13	13	11	40
Agricultural machinery	IS : 8777—1978	HI	25.4	12.7	
		HJ	31.8	15.1	
		HK	38.1	17.5	40
		HL	44.5	19.8	
		HM	50.8	22.2	

The cross-section of V-belts is shown in Fig. 13.6.

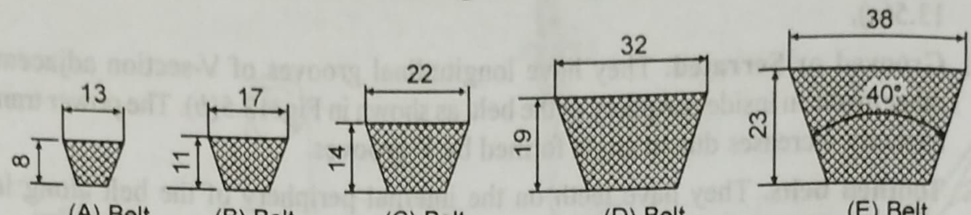

Fig. 13.6 V Belt Cross-Sections

13.5 ROPES DRIVE

For transmission of power in cases where centre distance between driver and driven shafts is quite large, rope drive is used. Ropes are made from cotton, manila, sisal, and steel wire. Steel wire ropes are made either with fibre core or steel core. The rope drive is used in cranes, elevators, aerial ropeways, drilling and mines.

13.6 PULLEYS FOR BELTS

They are used to transmit power with the help of belts. A pulley is a circular machine element having a hole in the centre with a keyway that fits on the shaft. The outer rim is plain or arced (crowned) for flat belts. For a grooved pulley, the number of grooves can be one or more than one. Toothed belts use a pulley that have teeth on its outer periphery to fit in the teeth of the belt for positive power transmission. Various types of pulleys are shown in Fig. 13.7.

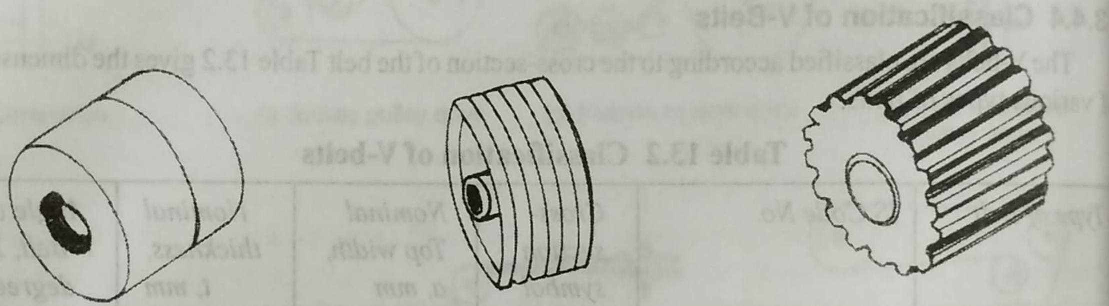

Fig. 13.7 Various Types of Pulleys

Small pulley can be made of forged steel, but large pulleys are made of cast iron.

13.6.1 Flat Belt Pulleys

Flat belt pulley has its outer periphery almost flat. A slight camber is given to make the outer periphery slightly convex (Fig. 13.8). This helps in keeping the belt positioned centrally on the pulley. Flat pulleys are of many types, e.g. solid, webbed, straight armed, curved armed, built up, stepped, fast and loose. Each type is described in the following sections.

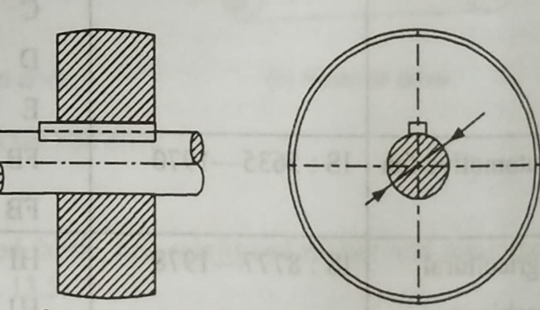

Fig. 13.8 Solid Pulley

1. Solid Pulley. Small pulleys are made solid as shown in Fig. 13.8. The hole is of the shaft size according to the fit required and has a keyway or a collar to fit by a screw.

2. Webbed Pulley. Medium sized pulleys are made webbed to reduce weight and save material (Fig. 13.9). Sometimes the web is provided with holes to decrease weight and save material.