widely used in differential gears of automobiles, [illegible]

6.8 CLUTCH

It is a device which disconnects the engine from the rest of the transmission and enables the engine to run without moving the vehicle.

6.8.1 Requirements of clutch

(i) *Torque transmission*: The clutch should be able to transmit the maximum torque of the engine under all conditions.

(ii) *Gradual engagement*: The clutch should positively take the drive gradually without the occurrence of sudden jerks.

(iii) *Heat dissipation*: The clutch should be able to dissipate large amount of heat, which is generated during the clutch operation due to friction.

(iv) *Dynamic balancing*: Clutch should be dynamically balanced. It is necessary in high speed engine clutches.

(v) *Vibration damping*: Suitable mechanism should be incorporated within the clutch, to eliminate noise produced in the transmission.

(vi) *Size*: The size of the clutch must be smallest possible so that it should occupy minimum amount of space.

(vii) *Inertia*: The clutch rotating parts should have minimum inertia. Otherwise, when the clutch is released for gear changing, the clutch plate will keep on spinning, causing hard shifting and gear clashing in case of synchronizer.

(viii) *Clutch free pedal play*: To reduce effective clamping load on the carbon thrust bearing and wear on it. So sufficient clutch free pedal play must be provided in the clutch.

(ix) *Ease of operation*: For higher torque transmissions the operation of disengaging the clutch must not be tiresome to the driver.

6.8.2 Function of clutch

The main function of a clutch are:

(i) To engage the engine power to the gear box.
(ii) To disengage the engine power from the gear box.
(iii) To provide a smooth and gradual operation to take up load without jerk.
(iv) To help in shifting the gears in the gear box.

6.8.3 Principle of friction clutches

Suppose there are two discs as shown in Fig. 42. Initially, disc *A* was rotating at the speed of *N* rpm and disc *B* was stationary. It means clutch in not engaged. Now, if a load *W* is applied on the disc *B* to engage it with disc *A* the force of friction comes in between them and disc *B* starts rotating. If the load *W* is increased, the speed of disc *B* starts increasing to attain the value *N* rpm and it is principle of friction clutch.

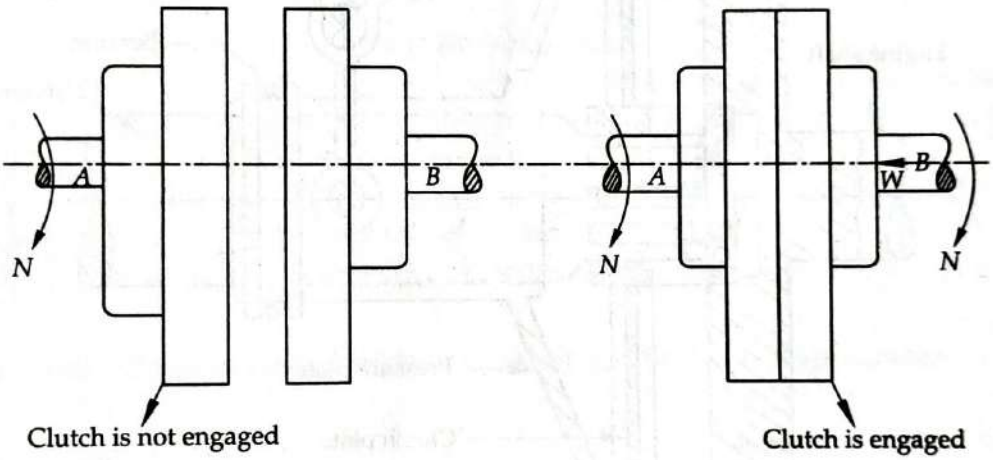
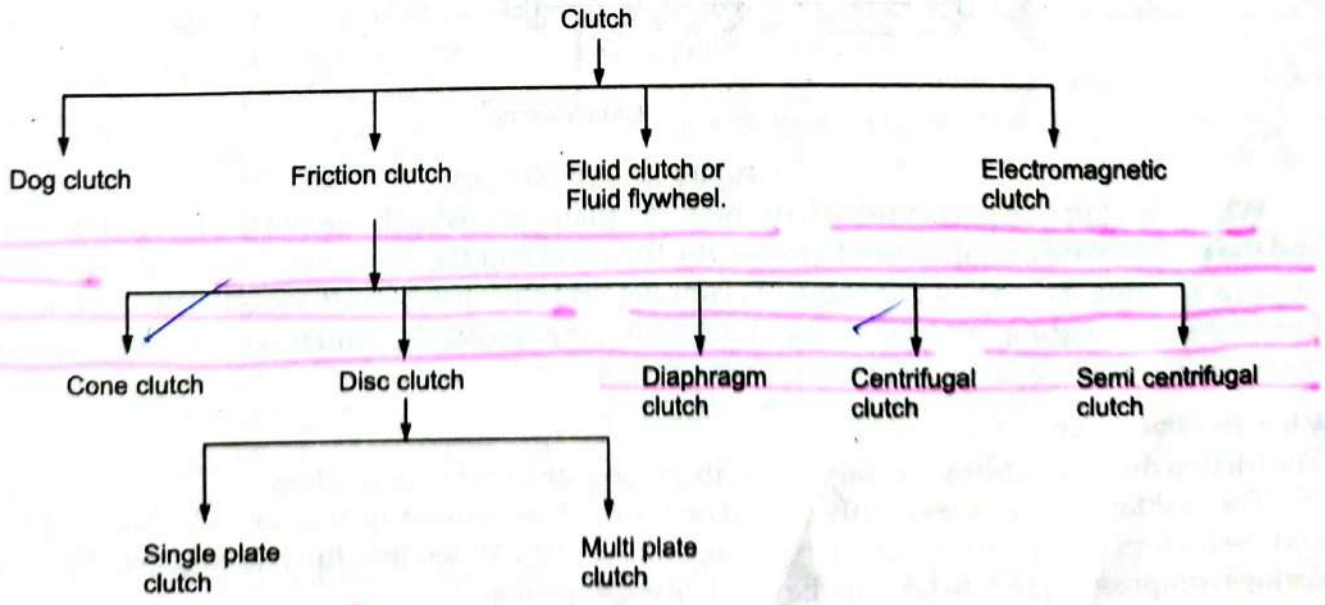


Fig. 42 Principal of Friction clutch

6.8.4 Types of clutches

Clutch can be classified as follows:



6.8.5 Single plate clutch

It is the most common type of clutch used in motor vehicles. Basically, it consists of only one clutch plate, mounted on the splines of the clutch shaft, as shown in Fig. 43. The flywheel is mounted on the engine crankshaft and rotates with it. The pressure plate is bolted to the flywheel through clutch springs, and is free to slide on the clutch shaft when the clutch pedal is operated. When the clutch is engaged, the clutch plate is gripped between the flywheel and the pressure plate. The friction linings are on both the sides of the clutch plate. Due to the friction between the flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As the clutch plate revolves, the clutch shaft also revolves. Clutch shaft is connected to the transmission (i.e. Gear box). Thus, the engine power is transmitted to the crankshaft to the clutch shaft.

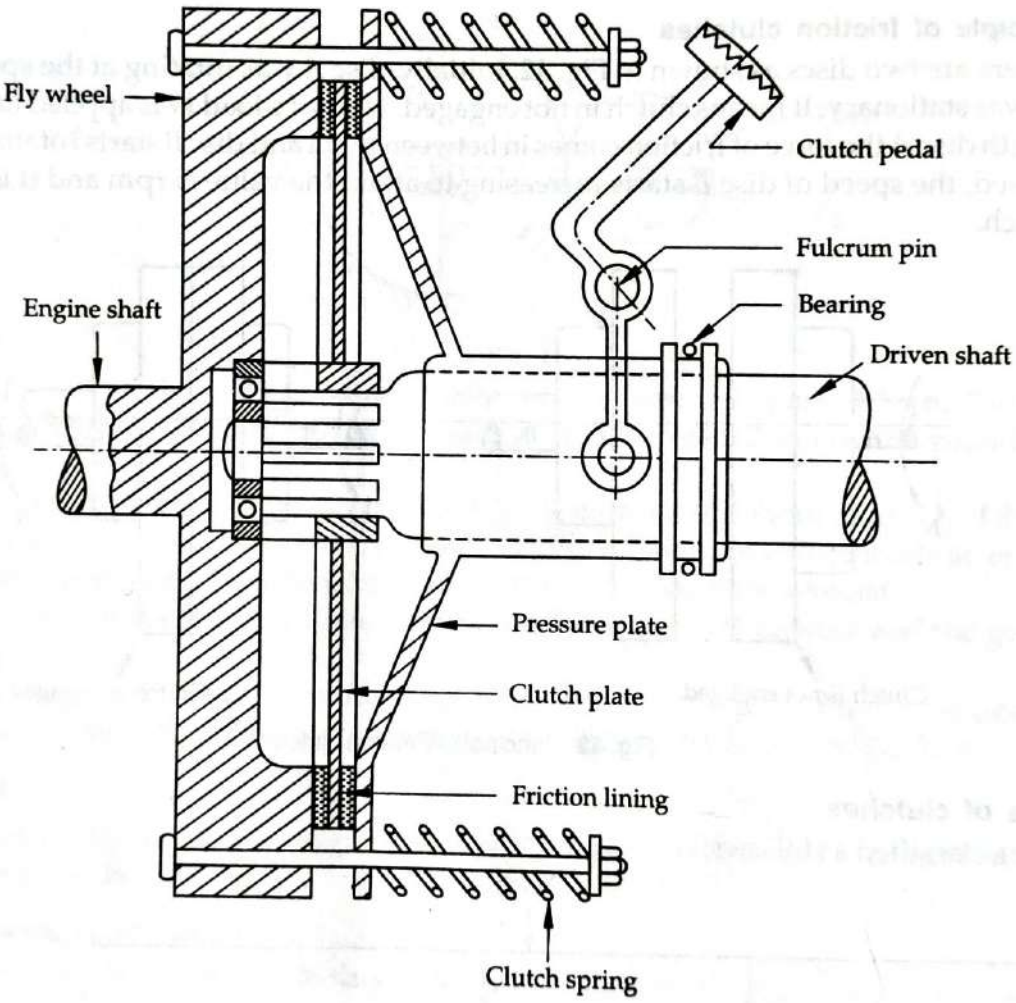


Fig. 43 Single Plate Clutch

When the clutch pedal is pressed, the pressure plate moves back against the force of the springs, and the clutch plate becomes free between the flywheel and the pressure plate. Thus, the flywheel remains rotating as long as the engine is running and the clutch shaft speed reduces slowly and finally it stops rotating. As soon as the clutch pedal is pressed, the clutch is said to be disengaged, otherwise it remains engaged due to the spring forces.

6.8.6 Friction disk

The friction disk has cushion springs and dampening springs hub and plate.

The cushion springs are slightly waved or curled. The cushion springs are attached to the plate, and the friction facings are attached to the cushion springs. When the clutch is engaged, the cushion springs compress slightly to take up the shock of engagement.

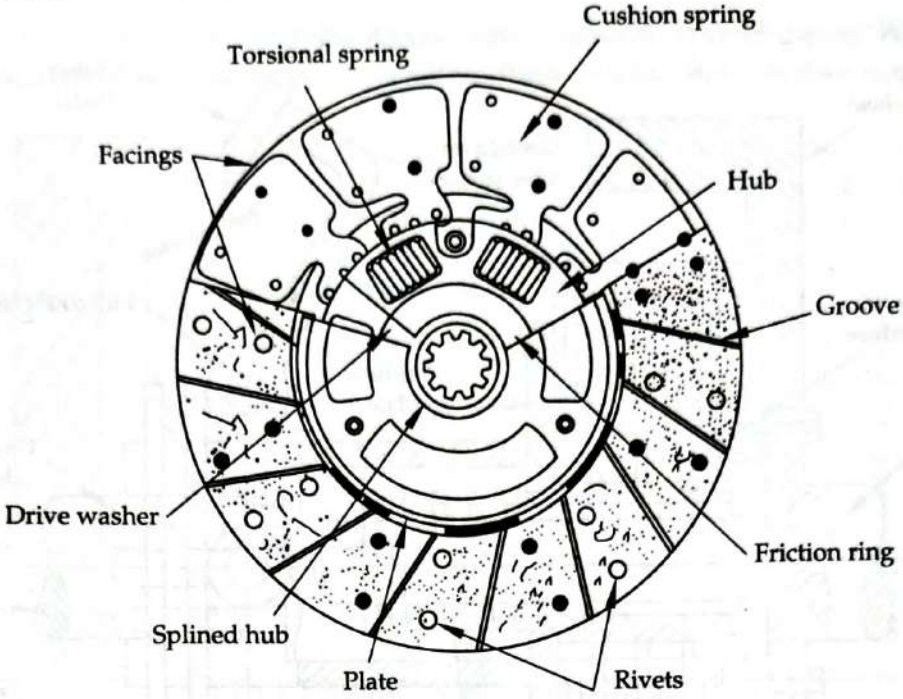


Fig. 44 Friction disk

The dampening springs or torsional springs are heavy coil springs set in a circle around the hub. The hub is driven through these springs. They help to reduce the torsional vibration (The power pluses from the engine) so that the power flow to the transmission is smooth.

There are grooves in both sides of the friction disk facing. These grooves prevent the facing from sticking to the flywheel face and pressure plate when the clutch is disengaged.

The groove breaks any vacuum that might cause the facings to stick to the flywheel or pressure plate.

Material: Cotton and asbestos fibers woven or molded together and impregnated with resins or other binding agent.

6.8.7 Multiplate Clutch

Multiplate clutch consists of more than one clutch plate. As there are many clutch plates, the friction area is increased and hence the capacity of the clutch is also increased. So the clutch can transmit more torque.

A simple diagram of the multiplate clutch is shown in Fig. 45. There are two types of friction plates. One type have grooves or teeth on the outer surface. These grooves are fitted with flywheel and rotate with the flywheel. The other type have grooves or teeth in the inner side and these plate are fitted on spline shaft. Plate with inner and outer splines shown in Fig. 46. The rest of construction is same as single plate clutch. A pressure plate keeps the pressure on the friction plates with the help of spring. There is a clutch lever or pedal which can push back the pressure plate against springs.

The outer teeth plates rotates with the flywheel. The inner teeth plates having friction lining are fitted on the spline shaft.

In the engaged position the spring pressure causes to push the pressure plate on the clutch plates and the inner plates come in contact with the outer plates and rotate. The power is transmitted to the gear box shaft. When the clutch pedal is pressed, it pulls back the pressure plate and the inner plates are released. Hence the clutch is disengaged. When the load from clutch pedal is removed, the spring pressure again come into play and the clutch is engaged.

Advantages

1. Since the number of clutch plates are more, the friction surface area is increased and the clutch can transmit more torque.

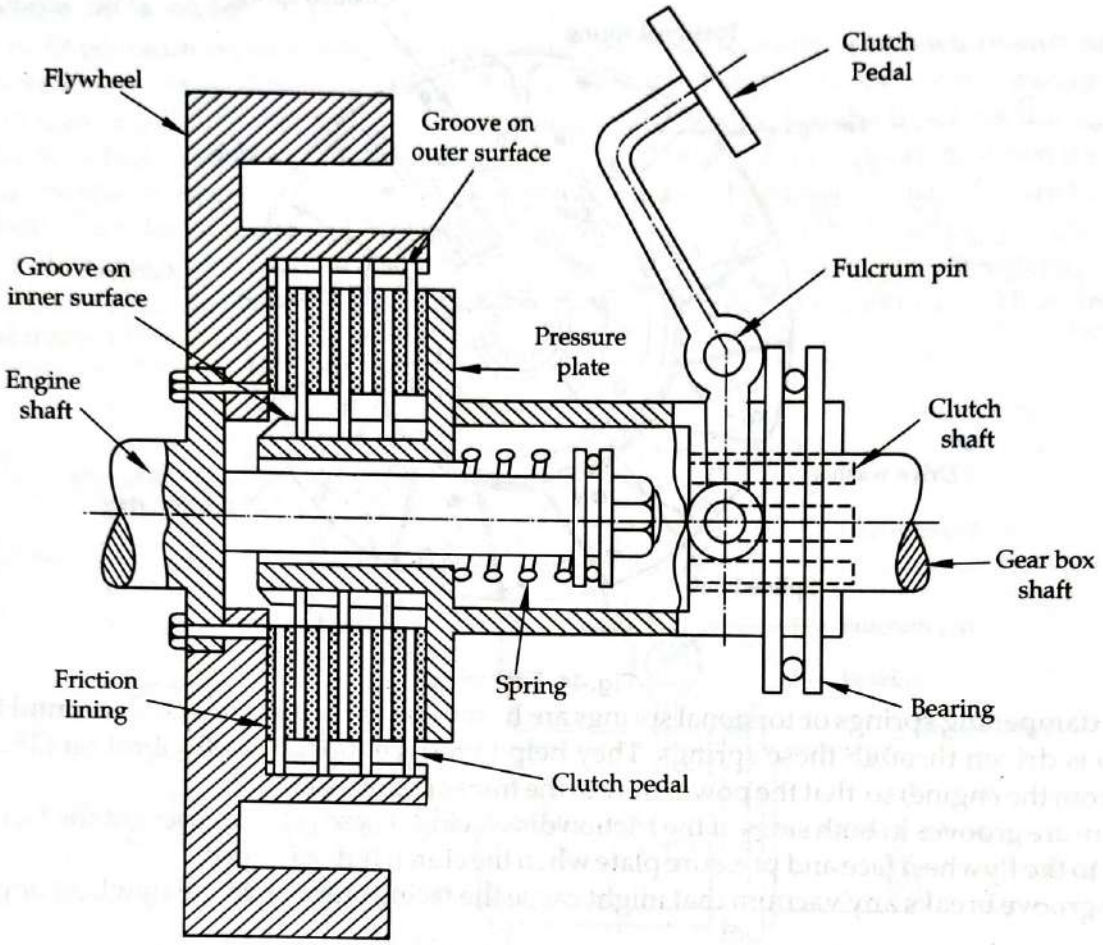


Fig. 45 Multiplate Clutch

2. For the same amount of torque, the torque is divided among many plates and hence smaller plates are required. So the size of clutch is reduced for the same torque.
3. Heat dissipation is easier as there are many surfaces to dissipate heat.

The multiplate clutch is used in heavy transport vehicles and racing cars as it can transmit high torque. It is also used in motor cycles since it takes lesser space.

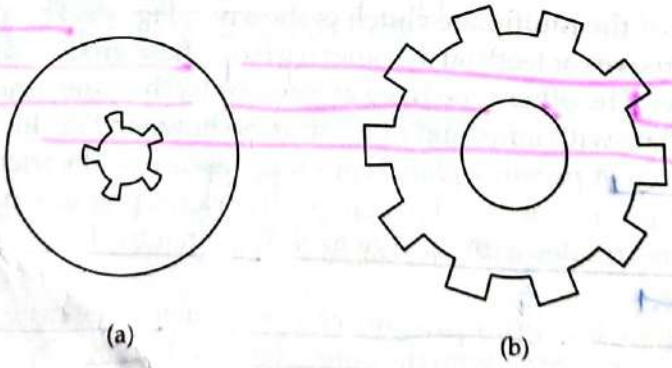


Fig. 46 Plates with (a) Inner Splines and (b) Outer splines of multiplate clutch

6.8.8 Cone clutch

Figure 47 shows a simplified diagram of the cone clutch.

Cone clutch consists of friction surfaces in the form of cones. The engine shaft consists of a female cone. The male cone is mounted on the splines clutch shaft. It has friction surfaces on the conical portion. The male cone can slide on the clutch shaft. When the clutch is engaged the friction surfaces

of the male cone are in contact with that of the female cone due to the force of spring. When the clutch pedal is pressed, the male cone slides against the spring force and the clutch is disengaged.

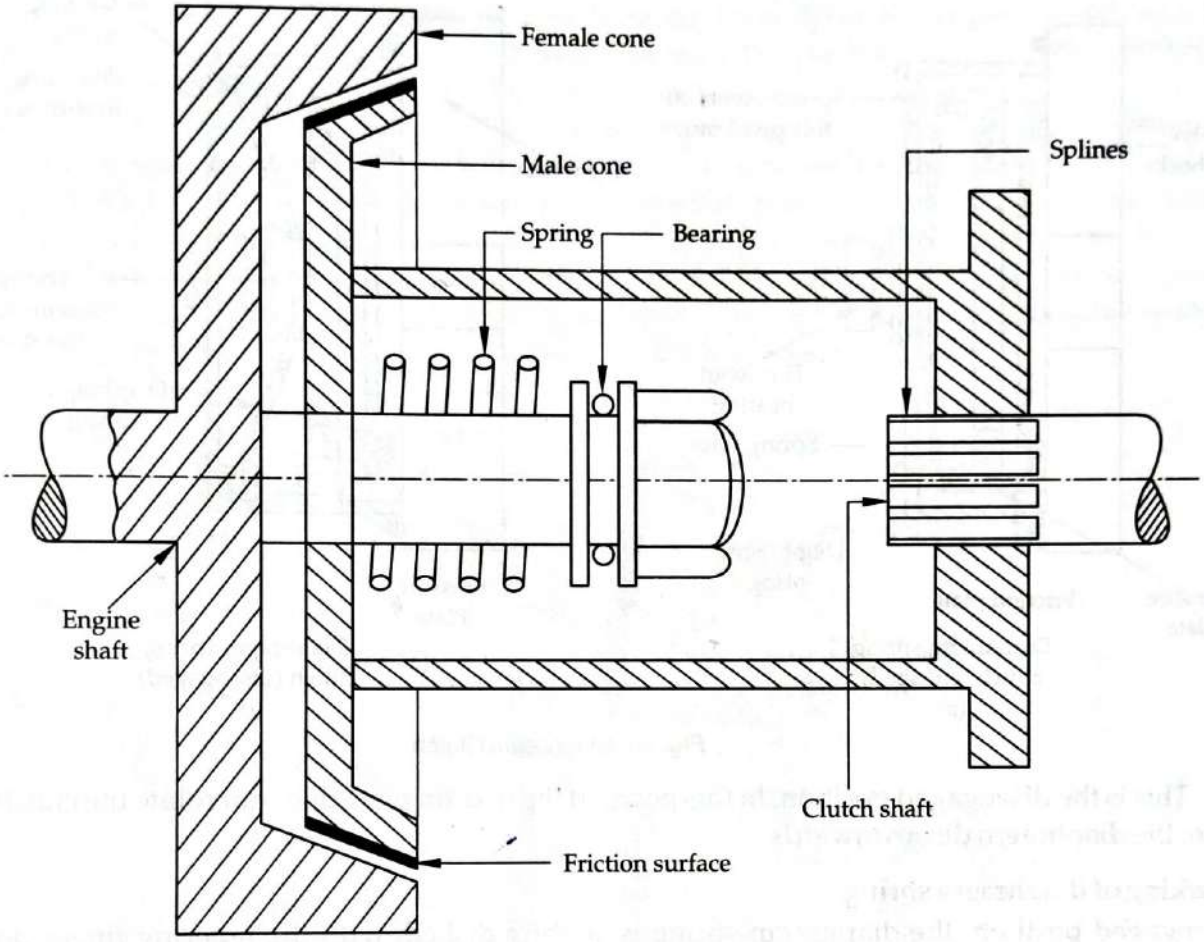


Fig. 47 Cone clutch

The only advantage of the cone clutch is that the normal force acting on the contact surfaces in this case is greater than the axial force, as compared to the simple single plate clutch in which the normal force acting on the contact surfaces (friction surfaces) is equal to the axial force.

This type of clutch is practically obsolete (due to some) disadvantage. If the angle of cone is made smaller than about 20° the male cone tends to bind or join in the female cone and it becomes difficult to disengage the clutch.

6.8.9 Diaphragm clutch

This clutch has a diaphragm spring Fig, 48, in place of coil springs.

It has no need for any release lever. This is an advantage because the spring itself acts as a series of levers.

Figure 49(a) shows the flywheel, diaphragm spring, and friction plate of the diaphragm spring clutch. It shows the engaged position. Here the friction plate is pressed by the pressure plate against the flywheel.

Figure 49(b) shows the flywheel, diaphragm spring pressure plate and friction plate. It shows

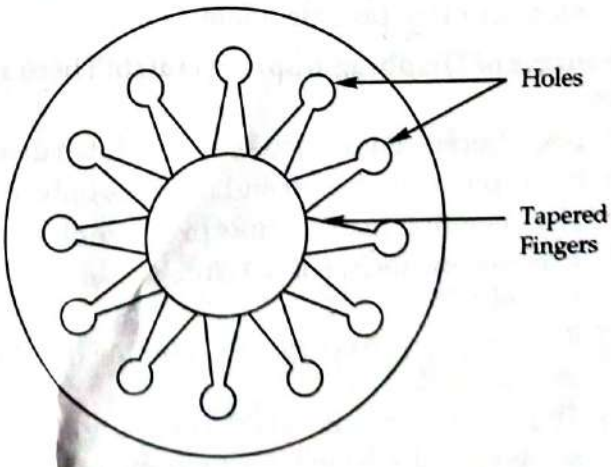


Fig. 48 Diaphragm Spring

the friction plate in a released position. It is free to rotate when the pressure of the pressure plate is removed.

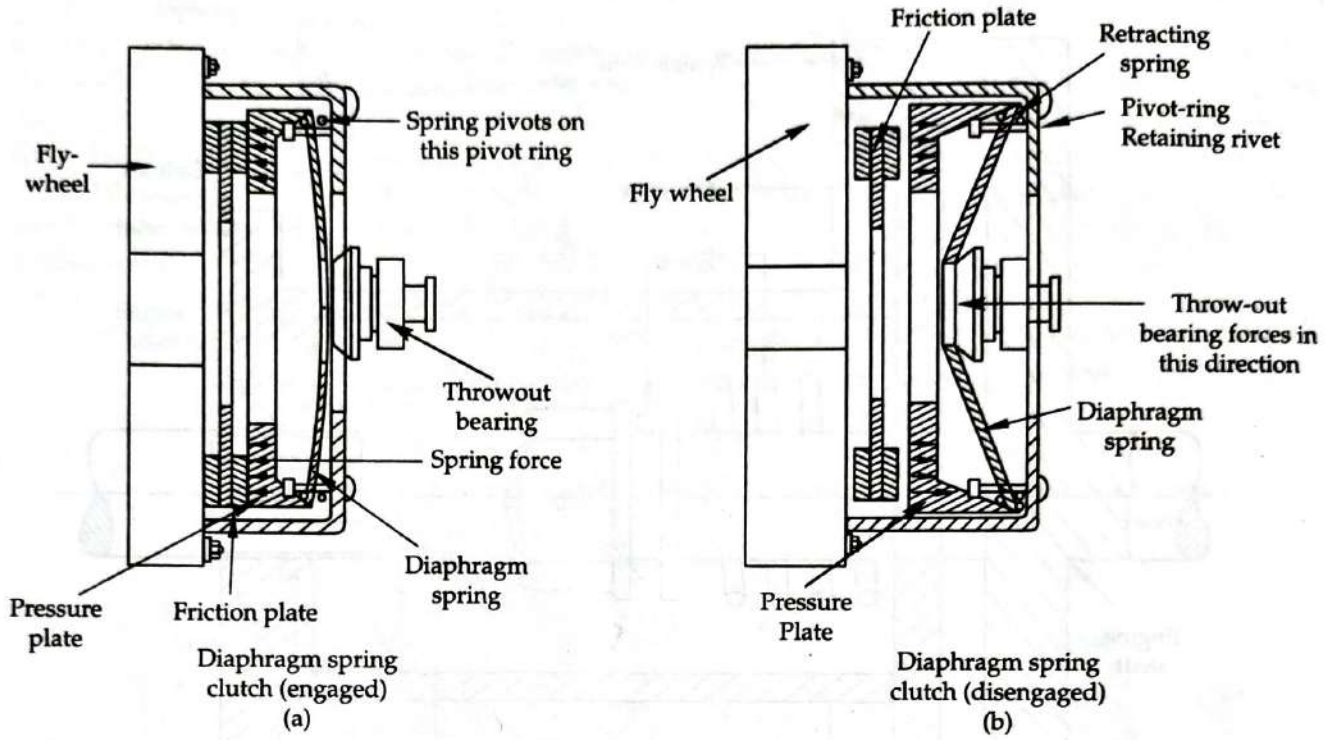


Fig. 49 Diaphragm Clutch

This is the disengaged position. In this position the friction plate does not rotate the clutch shaft. Here the diaphragm dishes inwards.

Working of diaphragm spring

In engaged position, the diaphragm spring is slightly dished, with the tapering finger pointing slightly away from the flywheel.

This position places spring force against the pressure plate around the entire circumference of the diaphragm spring.

The diaphragm spring is shaped to exert this initial force.

When the throwout bearing is moved inward against the spring fingers, the spring is forced to pivot about the inner pivot ring, dishing in the opposite direction. The outer circumference of the spring now lifts the pressure plate away through a series of retracting springs placed about the outer circumference of the pressure plate.

Advantage of Diaphragm spring clutch: There are some advantage of Diaphragm spring clutch as follows:

(i) Less effort is required to keep the clutch disengaged.
(ii) It is compact in design and requires only a small sized housing.
(iii) The operating load is uniform on the clutch plate.
(iv) Accurate balancing of the clutch assembly eliminates vibrations, this balance is maintained at all times.
(v) Engine speeds have no effect on the diaphragm spring clamping thrust whereas coil spring tend to bend.
(vi) The diaphragm acts as both clamping spring and release levers therefore many extra parts like struts eyebolts, lever etc are eliminated in the diaphragm spring.

6.8.10 Centrifugal clutch

It is an automatic clutch. No clutch pedal is required to control the clutch operation. It is controlled by the centrifugal forces.

The engagement and disengagement operation depends upon the engine speed which is controlled by the accelerator. This clutch is based on the principle that when centrifugal force is applied on a mass, the force tries to throw the mass centrally outside.

A simple feed diagram of centrifugal clutch is shown in Fig. 50. In centrifugal clutch, springs are not used to keep clutch engaged. A bell crank lever is used with a mass *M* and it press the intermediate plate. There is a spring between the intermediate plate and clutch plate. The movement of the intermediate plate presses the spring, ultimately presses the clutch plate on the flywheel against the spring. The clutch plate has friction lining on it. This makes the clutch engaged. A spring is also there which is of low rigidity and disengage the clutch plate from flywheel at low speed of engine. No release lever is required as the clutch operation is automatic.

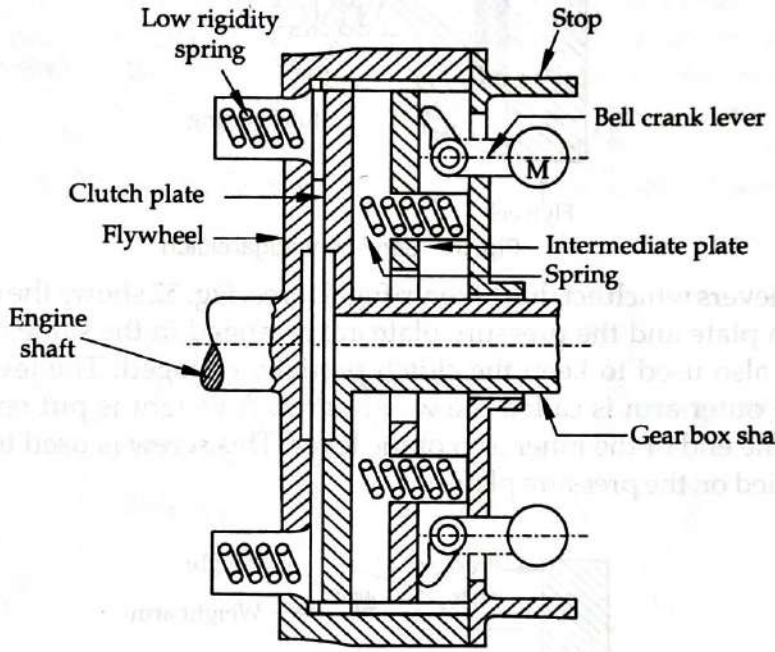


Fig. 50 Centrifugal clutch

To disengage the clutch, the pressure on the accelerator pedal is removed. By this way, the engine speed is decreased and the mass *M* comes into its original position. This the pressure on the intermediate plate is removed and the clutch is in disengaged position.

Advantages

1. The clutch operation is automatic
2. Clutch pedal is not required to operate the clutch
3. The vehicle can be stopped and started in gear.

6.8.11 Semi-Centrifugal clutch

The semi Centrifugal clutch is useful for high torque transfer. The semi-centrifugal clutch uses centrifugal force as well as spring force for keeping it in engaged position. The springs are designed to transmit the torque at normal speeds, while the centrifugal force assists in torque transmission at higher speeds.

The construction of the semi-centrifugal clutch is almost similar to single plate clutch. The only difference being the construction of operating fingers. A simple diagram of a semi-centrifugal clutch is shown in Fig. 51.

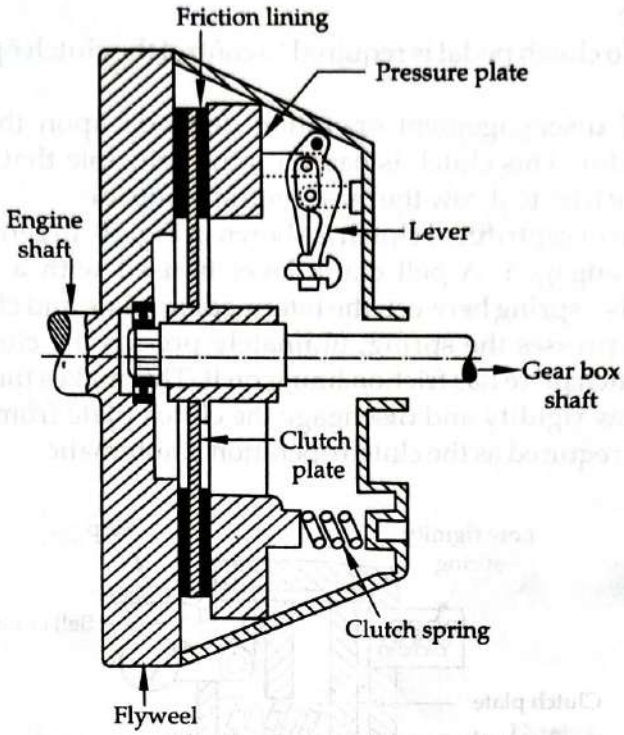


Fig. 51. Semi-centrifugal clutch

There are three levers which act due to centrifugal force. Fig. 52 shows the diagram of a lever. The flywheel, the clutch plate and the pressure plate are arranged in the same manner as single plate clutch. Springs are also used to keep the clutch partially engaged. The levers are hinged on the pressure plate. The outer arm is called the weight arm. A weight is put on this arm. There is an adjusting screw at the end of the inner arm of the lever. This screw is used to adjust the amount of pressure being applied on the pressure plate.

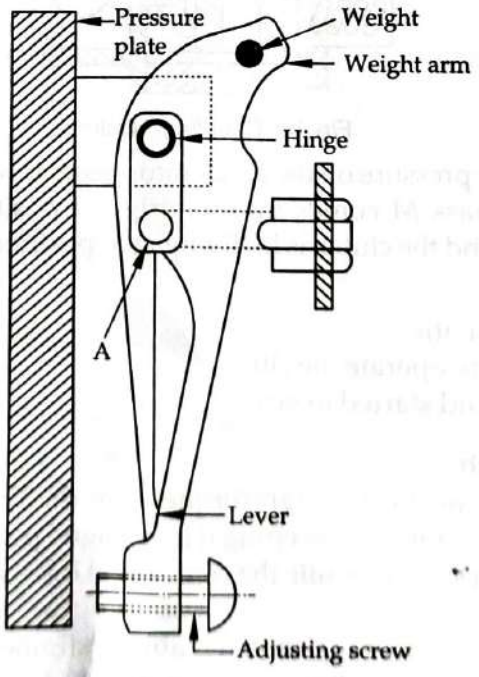


Fig. 52 Lever of semi-centrifugal clutch

When the clutch pedal is pressed, the clutch is disengaged. After releasing the clutch pedal, the spring pressure pushes the pressure plate and the clutch is engaged. The clutch starts working at the normal speed. When the speed increases, the centrifugal force moves the weight arm outwards and the inner arm of the lever start pressing the pressure plate. By this way, the sufficient amount of torque is transmitted at higher speed. When the speed is lowered, the weight arm starts to fall and inner arm is retracted. As the spring stiffness is less as compared to single plate clutch, the load required on clutch pedal is less for disengagement.

So after applying a little load on clutch pedal, the clutch is disengaged.

Advantage

For high torque transmission, less effort is required for clutch operation as compared to single plate clutch.

6.8.12 Dog clutch

This type of clutch is used to lock two shafts together or to lock a gear to a shaft. It consists of a sleeve having two set of internal splines shown in Fig. 53. It slides on a splined shaft with smaller diameter splines. The bigger diameter splines match with the external dog clutch teeth on driving shaft. When the sleeve is made to slide on the splined shaft, it teeth match with the dog clutch teeth of the driving shaft. Thus the sleeve turns the splined shaft with the driving shaft. The clutch is said to be engaged. for disengaging the clutch, the sleeve is moved back on the splined shaft to have no contact with the driving shaft.

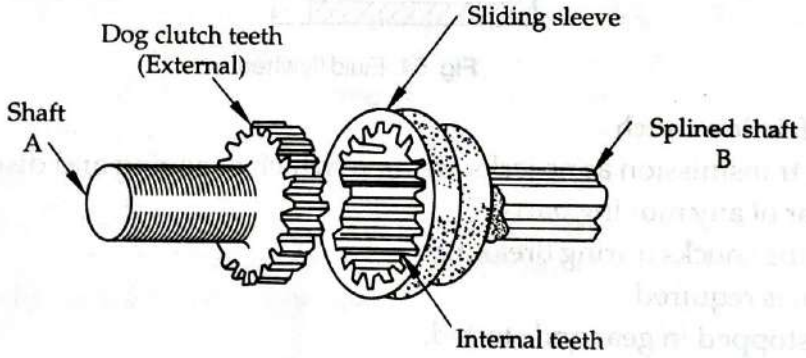


Fig. 53 Lever of semi-centrifugal clutch

6.8.13 Fluid flywheel

It is known as fluid clutch or hydraulic coupling. It also works on the principle of centrifugal action. As centrifugal clutch, it also does not require any clutch pedal. In place of friction lining in centrifugal clutch, fluid is the power transmitting medium in fluid flywheel It is used in the vehicles having automatic transmission.

Fig. 54 show the simplified diagram of a fluid flywheel. It consists of a driving member and a driven member. The driving member is called impeller and it is attached to the engine shaft. The driven member is called runner and it is attached to the gear box shaft. Both the shafts are aligned. Both impeller and runner are kept in a casing. Oil is filled in this oil tight casing. Both the members do not have any direct contact with each other. When the engine shaft starts to rotate, the impeller begins to rotate with the engine shaft. The centrifugal force is applied on the oil in the impeller. Due to this force, the oil is forced outwards when this high speed oil strikes the outer vanes of the impeller, it is turned towards the runner. The runner starts to rotate, as the oil strikes the runner vanes. More the engine speed, more is centrifugal force and more is the torque transmission to gear box shaft. Now the clutch is fully engaged. When the engine speed is reduced, the oil pressure is decrease and the clutch starts to disengage it self. It should be noted that the clutch operation depends only on engine speed which is controlled by accelerator and no clutch pedal is required.

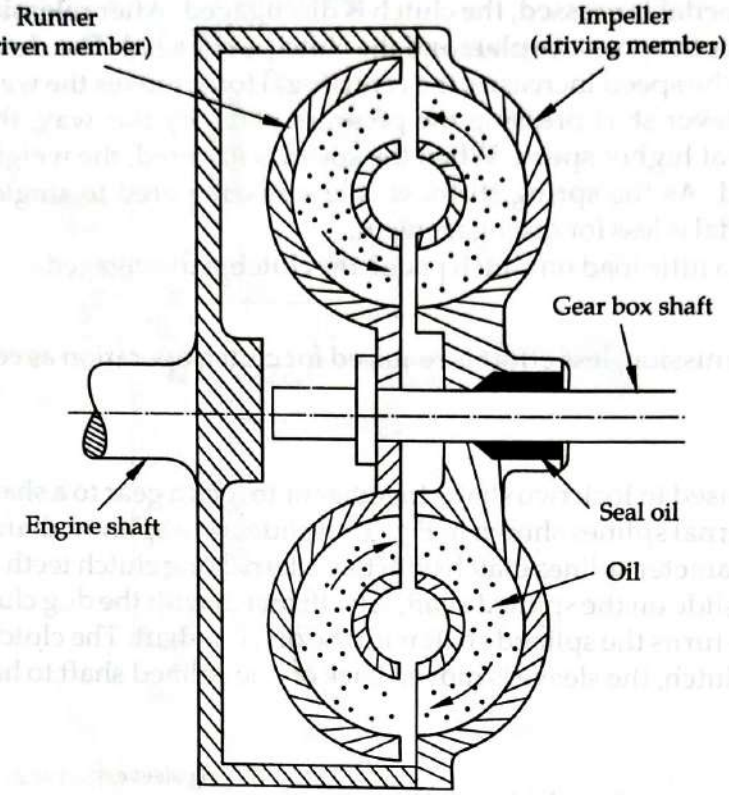


Fig. 54 Fluid flywheel

Advantages over friction clutch

1. Smooth power transmission as no jerks are there which engaging and disengaging the clutch.
2. There is no wear of any moving parts.
3. It also absorbs the shocks during breaking.
4. No clutch pedal is required.
5. Vehicle can be stopped in gear and started.

Disadvantage

1. Gear changing is difficult when used with ordinary gear box.
2. It may causing vibrations.

6.8.14 Electromagnetic clutch

Engine flywheel has winding which is supplied with current from battery or dynamo. Clutch plate is lined with friction material or surfaces and is free to slide on splines on the clutch shaft.

When the current passes through the winding, it produces an electromagnetic field which attracts the pressure plate hence the clutch engaged. When the supply to winding is cut-off, the clutch is disengaged.

There is a clutch release switch in the gear lever. This switch is operated as soon as the driver holds the gear lever to change the gear, cutting off current to the winding and thus causing clutch disengagement. Electromagnetic type of clutch is best suited where remote operation is desired since no linkages are required to control its engagement. Major disadvantage is its higher initial cost and heat capacity since the clutch operating temperature is limited by the temperature rating of the insulation of the magnetic coil.

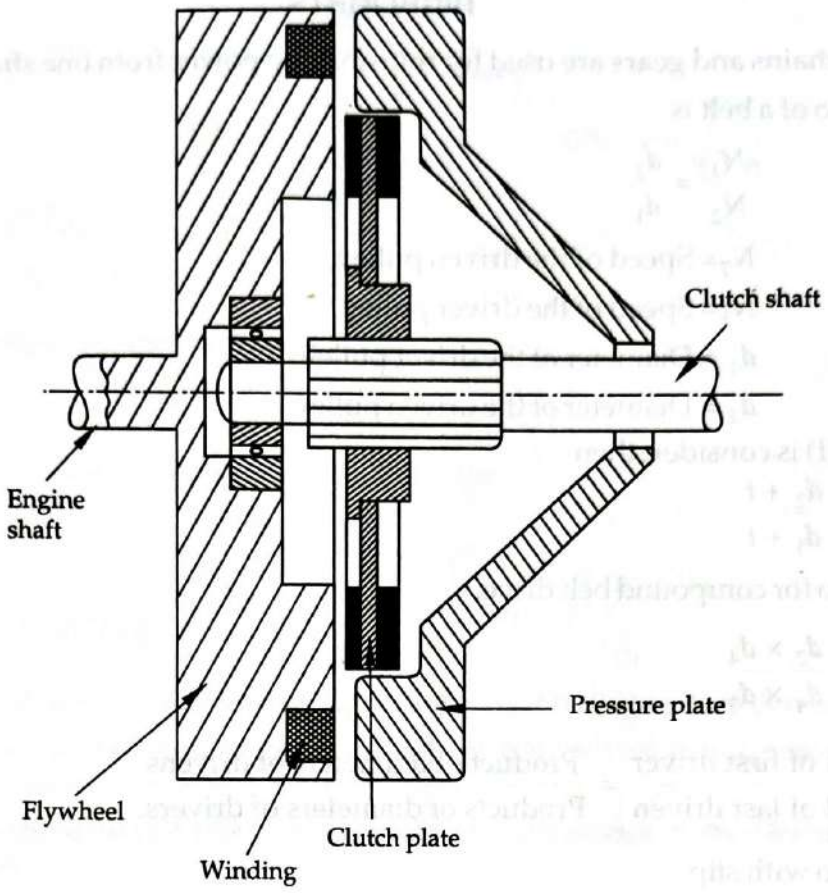


Fig. 55

6.8.16 Clutch linkages

The function of the linkage is to transmit the force applied to the clutch pedal to the thrust bearing and to provide part of the mechanical advantage or leverage necessary to make clutch operation possible with a reasonable amount of foot pressure.

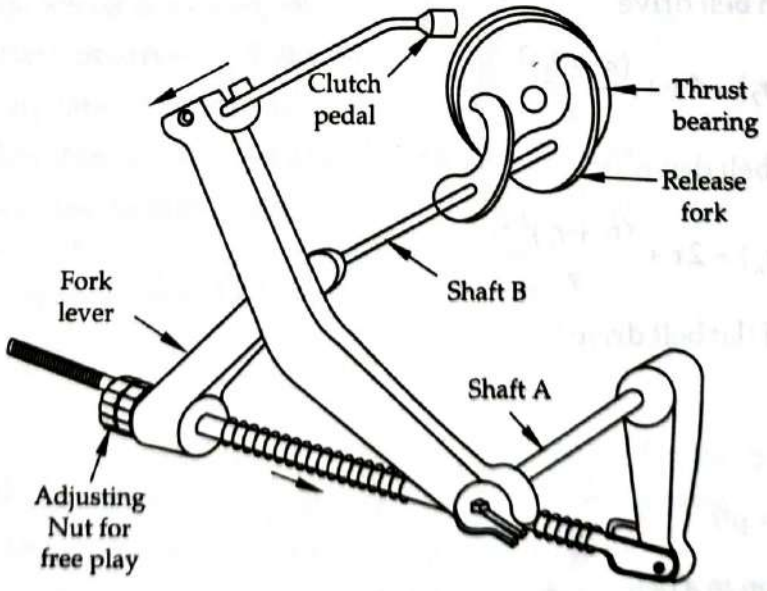


Fig. 55 Clutch linkage