4.1 INTRODUCTION OF CHASSIS LAYOUTS

- Chassis is a basic structure of vehicle. Chassis carries all parts of vehicles. Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted.

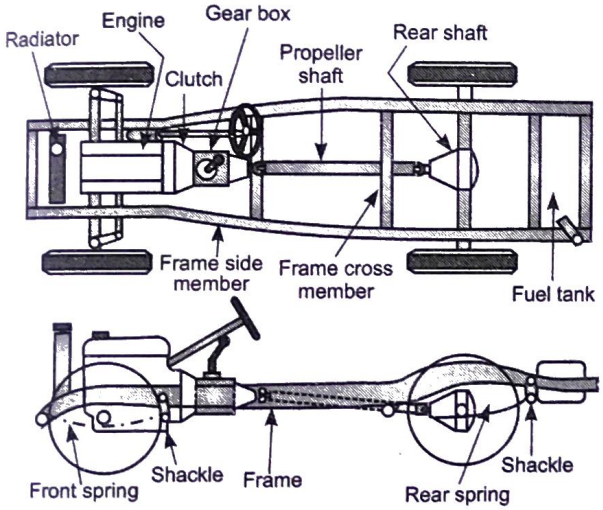


Fig. 4.1 : Chassis and its construction

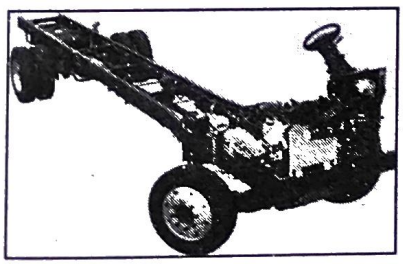


Fig. 4.2

- At the time of manufacturing, the body of a vehicle is flexibly molded according to the structure of chassis. Automobile chassis is usually made of light sheet metal. It provides strength needed for supporting vehicular components and payload placed upon it.
- Automobile chassis helps keep an automobile rigid, stiff and unbending. Auto chassis ensures low levels of noise, vibrations and harshness throughout the automobile.
- Chassis of an automobile generally consists of the following components suitably mounted on it: Engine and the Radiator, Transmission system (clutch, gear box, propeller shaft etc.), Suspension system, Road Wheels, Steering System, Brakes, Fuel Tank.

4.1.1 Types of Chassis (Dec. 11, May 11)

1. Backward control (conventional chassis),
2. Forward control,
3. Semi – forward control

Vehicle Frame

- Function to carry all main components or sub assemblies to make entire automobile systems.
- It is the supporting component of automobile vehicle.
- It is the foundation for carrying the engine, transmission system and steering system by means of spring, axle, rubber pads etc.
- The frame is made of box, tubular channels or U-shaped section, welded or riveted together.

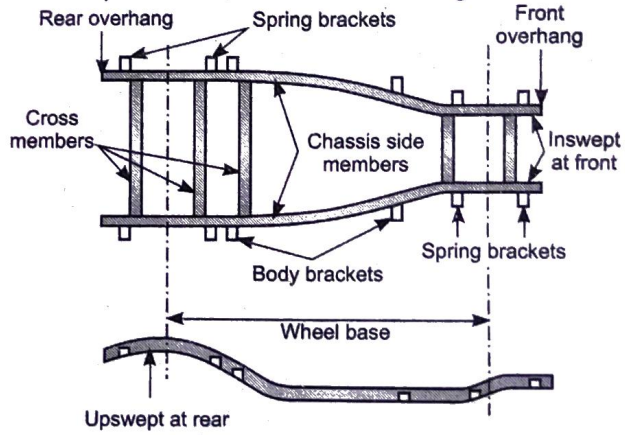


Fig. 4.3

Conventional Frame:

It is used in most of the heavy vehicles. Construction of frame varies according to the type of vehicle generally made from the steel sections. This type of frame has "2 long side members" and "5 to 6 cross members" joined together with the help of rivets or bolts. Cross members are used to increase the strength of the frame.

- They are in swept (Narrow) at the front and are upswept (Broad) at the rear.

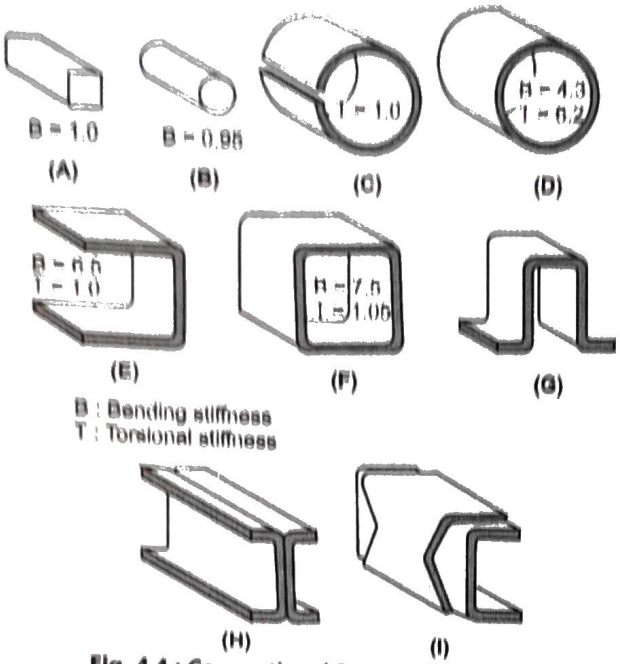


Fig. 4.4 : Conventional frame construction

4.2 STEERING SYSTEM

(May 10, Dec. 11, 13, Aril 17)

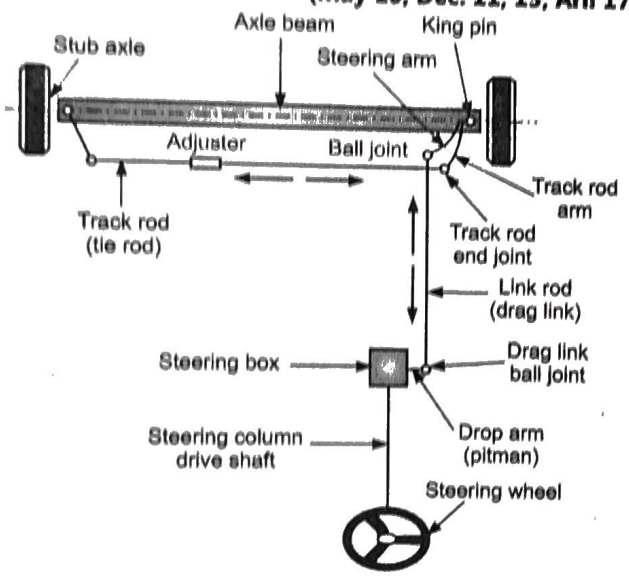


Fig. 4.5 : Steering system

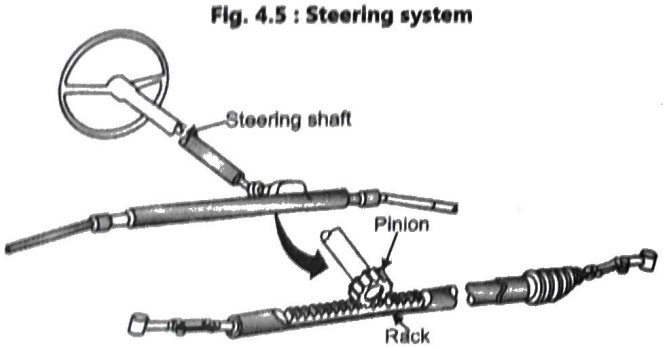


Fig. 4.6

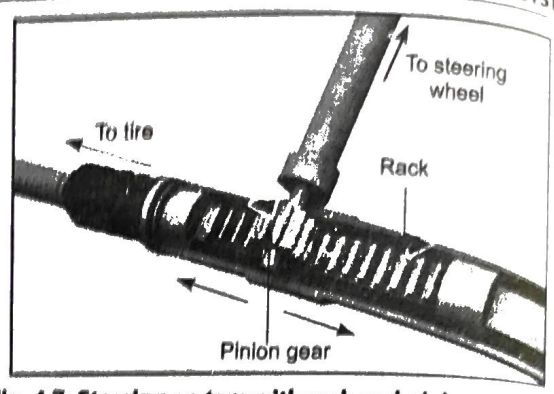


Fig. 4.7: Steering system with rack and pinion gear box

4.2.1 Working of Steering System

- Steering linkage depends upon the type of the vehicle whether it is a car which has independent front suspension or a commercial vehicle having generally a rigid axle type front suspension.
- The purpose of steering system is to allow the driver to control the direction of vehicle by turning the front wheels. This is achieved by means of steering wheel and a steering column.
- A steering column transmits the rotation of the steering wheel to the steering gears.
- The steering gears increase the rotational force of the steering wheel in order to transmit greater torque to steering linkage.
- The steering linkage transmits the steering gear movement to the front wheels of the vehicle.
- The steering system configuration depends on vehicle design which includes drive train and suspension systems, whether it is a commercial vehicle or passenger car. Presently rack and pinion type and recirculating ball types are used. Now a days new rich cars using new mechanisms for steering system.

4.3 SUSPENSION SYSTEM

(May 10, 11, 12, Dec. 10)

The automobile chassis is mounted on the axles through some form of springs. This is done to isolate vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. This will give rise to uncomfortable ride and also cause additional stress in the automobile frame and body.

- All the parts which perform the function of isolating the vehicle from the road shocks are collectively called a suspension system.
- **Suspension :** Types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), shock absorbers (hydraulic and air).

Objective:

- To prevent the road shocks from being transmitted to the vehicle components.
- To safeguard the occupants from road shocks.
- To preserve the stability of vehicle in pitching or rolling while in motion.

4.3.1 Types of Suspension Springs

1. **Steel Springs**
   - Leaf spring
   - Tapered leaf Springs
   - Coil Spring
   - Torsion bar
2. **Rubber Springs**
   - Compression spring
   - Compression-shear spring
   - Steel-reinforced spring
   - Progressive spring
   - Face shear spring
   - Torsion shear spring
3. **Plastic Spring**
4. **Air Spring**
5. **Hydraulic Spring**

1. **Steel Spring :** Leaf Springs- It is very commonly used in vehicles, the shape as semi-elliptical leaf spring are mostly used in suspension of light & heavy commercial vehicles. These are widely used for rear suspension, now a days replaced by coil springs.

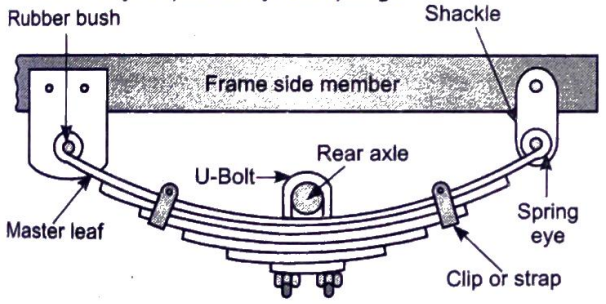


Fig. 4.8

Construction:

- The spring consists of no. of leaves called Blades. These blades are varied in length. The longest length has eye on its both ends, called as Master leaf. All blades are bound together by means of steel straps
- The springs are supported on the axle by means of U-Bolt. One end is bolted on the frame with simple pin with rubber of bronze bushes. Other end is connected to frame with shackle. This will give flexible connection as the length of the spring changes with road projections.

Shock Absorbers

- All the springs are flexible and stiff. So they will not absorbs shocks efficiently and continue to vibrate with the road irregularities. So dampers are provided with the springs which damps the vibrations.
- The shock absorbers absorb the energy of shock converted into vertical movement of axle by providing damping and dissipating the same into heat. So it is control the amplitude and frequency of spring vibrations.

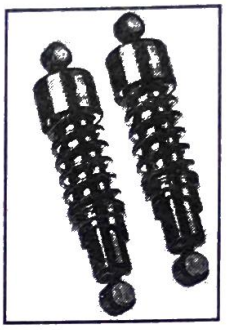


Fig. 4.9

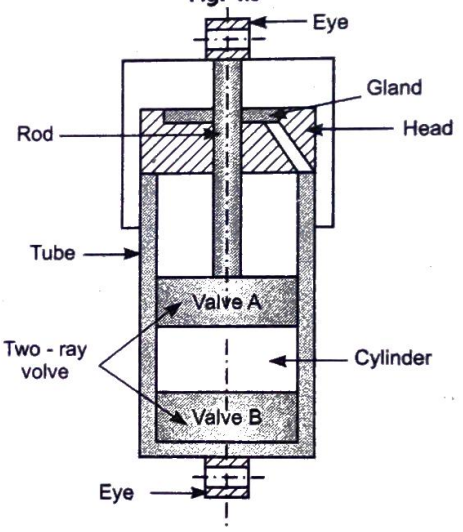


Fig. 4.10 : Telescopic shock absorber

Braking system:

- The brakes are used to slow-down or stop the motion of the moving member whenever required. In other words, brakes are one of the very important control components of vehicle.
- The main function of brake is to stop the vehicle within the smallest possible distance. This is done by converting the kinetic energy of the vehicle into heat energy and this heat dissipated in environment. In braking action, the kinetic energy is converted into heat by friction and the generated heat is ultimately dissipated to the atmosphere.

- **Different Types of Brakes as Follows :**

➢ **Band Brake:** The configuration of this brake is shown in Fig. 4.11. It consists of a flexible band of leather or steel, lined with frictional material which wraps the major circumference of the drum as shown in figure. One end of the band is attached to the fulcrum 'O' of the lever (length L) and other end is fixed to the lever at the distance x. Whenever the brake is to be applied, a force F is applied at the end of the lever which tightens the rotating wheel and braking force is generated. This system is used in material handling equipment.

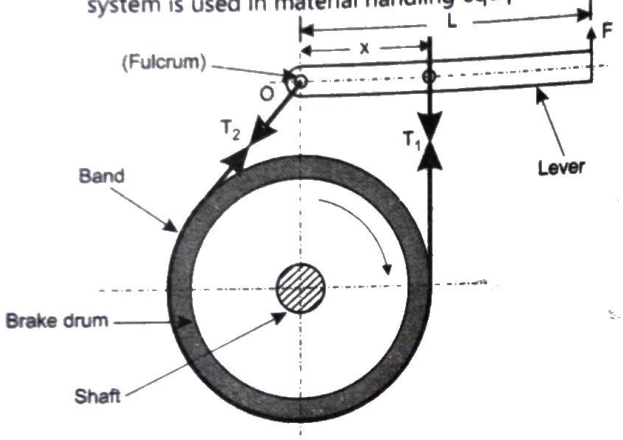


Fig. 4.11 : Simple band brake

➢ **Single Block Brake :** The configuration of this system is shown in Fig. 4.12. It consists of block (shoe) which is pressed against the rim of rotating drum. The block is made of a material having a high coefficient of friction (as asbestos or ferrodo or wooden). The friction between the block and drum causes a tangential braking force to act on the drum. This braking force retards or stops the rotation of the drum. Whenever the braking force is to be applied, the block is pressed against the drum by a force F applied to one end of the lever where the other end of lever is pivoted on a fixed fulcrum 'O'.

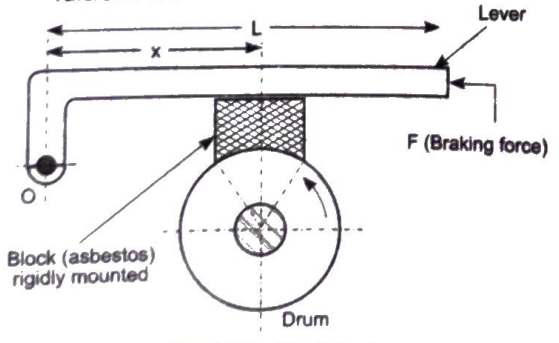


Fig. 4.12 : Block brake

When more braking force is required, a double block brake is used. The advantage of this is, the braking action is doubled with the same applied force F. In addition to this, an unbalanced force created on the shaft because of the single block can be totally eliminated. This system is used with cranes and hoists.

➢ **Band and Block Brake :** The configuration of this system is shown in Fig. 4.13. This consists of a number of wooden blocks secured inside a flexible steel band. When the force F is applied for braking the blocks are pressed against the drum and provides the braking action. Wooden blocks are used as it has higher coefficient of friction and they can be replaced easily if worn out without much cost. Its braking action is more compared with band brake system.

These are used in material handling industries.

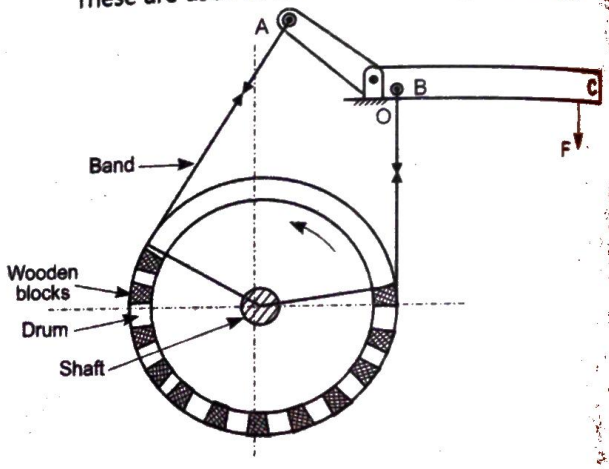


Fig. 4.13 : Band and block brake

➢ **Internal Expanding Shoe Brake:** These brakes are provided internally on the brake drum. The configuration of this system is shown in Fig. 4.14. Two semi-circular shoes are pivoted at the fulcrums O_1 and O_2 and outer surfaces of these shoes are lined with friction material (ferrodo) for providing the friction force during braking. The shoes are kept away from the drum when they are not working (normal condition) with the help of the spring force. Therefore, the drum rotates freely under normal condition as drum inner diameter is higher than the shoe outer diameter.

The braking force required for operating the drum by means of cam-operation (cam operated by hydraulic cylinder, not shown in figure). When the cam is operated, the shoes are pushed outwards against the rim of the drum. Due to friction

between the inner surface of the drum and friction lining, a friction force opposite to the rotation of the drum is exerted and braking takes place.

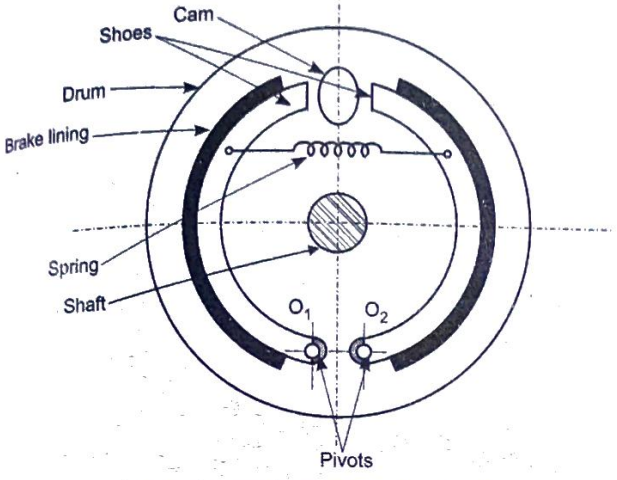


Fig. 4.14 : Internal expanding shoe brake

As the whole assembly is enclosed in a drum, it is not exposed to dust and moisture. This system is universally used in automobile industry for two wheeler, three wheeler and four wheeler as well as for low and high capacity vehicles.

➢ **Disc Brake :** The disc brake is a wheel brake which slows rotation of the wheel by the friction. Most modern cars have disc brakes on the front wheels, and some have disc brakes on all four wheels. This is the part of the brake system that does the actual work of stopping the car.

The main components of a disc brake are:

- The brake pads
- The caliper, which contains a piston
- The rotor, which is mounted to the hub

Friction caused by pushing brake pads against a brake disc with a set of calipers as shown in Fig. 4.15 slows or stops the rotation of the wheel. The brake disc is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon-carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.

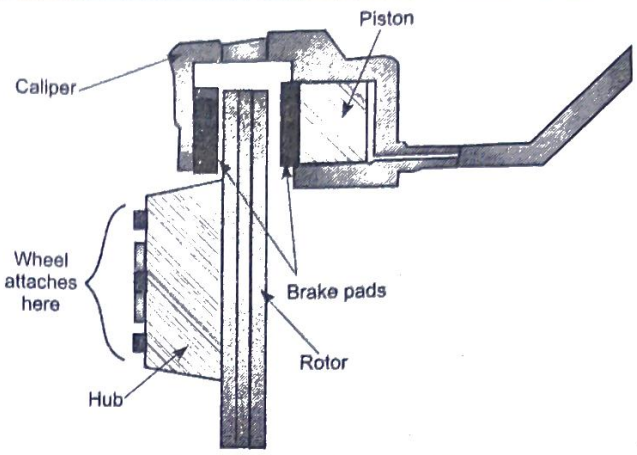


Fig. 4.15 : Parts of disc brake

The disc brake is a lot like the brakes on a bicycle. Bicycle brakes have a caliper, which squeezes the brake pads against the wheel. In a disc brake, the brake pads squeeze the rotor instead of the wheel, and the force is transmitted hydraulically instead of through a cable.

Fig. 4.16 : On automobiles, disc brakes are located within the wheel

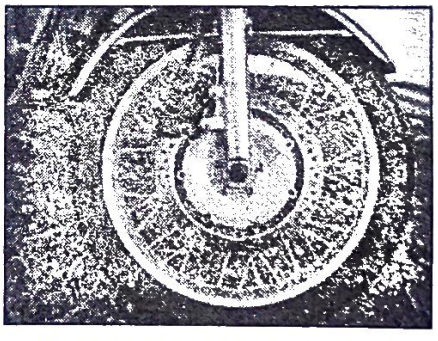


Fig. 4.17 : Motorbike disc brake of W800 Kawasaki

A moving car has a certain amount of kinetic energy, and the brakes have to remove this energy from the car in order to stop it. Brakes convert the kinetic energy to heat generated by the friction between the pads and the disc. Most car disc

brakes are vented. Vented disc brakes have a set of vanes, between the two sides of the disc that pumps air through the disc to provide cooling.

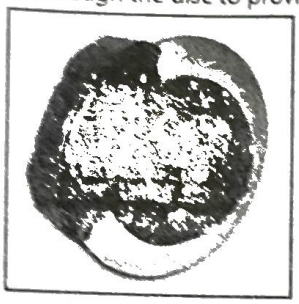


Fig. 4.18 : Disc brake vents

4.4 COOLING SYSTEM OF A VEHICLE

- All the heat produced by the combustion of fuel in the engine cylinders is not converted into useful power at the crank shaft. Its typical distribution for the fuel energy is as following (all values are approximate):
  - ➢ Useful works at the crank shaft = 25 %
  - ➢ Loss to the cylinder walls = 30 %
  - ➢ Loss in exhaust gases = 35 %
  - ➢ Loss in friction = 10 %
- The quantity of heat given to the cylinder wall is considerable and if this heat is not removed from this cylinder it would result in the preignition of the charge. Excess heating will also damage the cylinder material.
- **Methods of Cooling :** There are two methods used for cooling of automobile engines
  1. Air cooling
  2. Water cooling.

4.4.1 Air Cooling

- The basic principle of this method is to have current of air flowing continuously over the heated metal surface from where the heat is to be removed. The heat dissipated upon following factors:
  - ➢ The surface area of metal into contact with air
  - ➢ The mass flow rate of air.
  - ➢ The temperature difference between the heated surface and air.
  - ➢ The conductivity of metal.
- The effective cooling the surface area of the metal which is in contact with the air should be increased. This is done by using fins over the cylinder barrels. These fins are either cast as an integral part of the cylinder or separate finned barrels are inserted over the cylinder barrel. Sometimes, particularly in the case of aero engines, the fins are machined from the forged cylinder blanks.

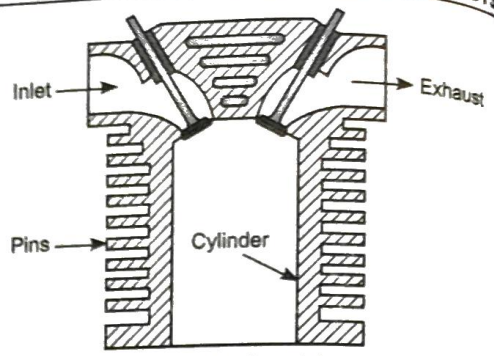
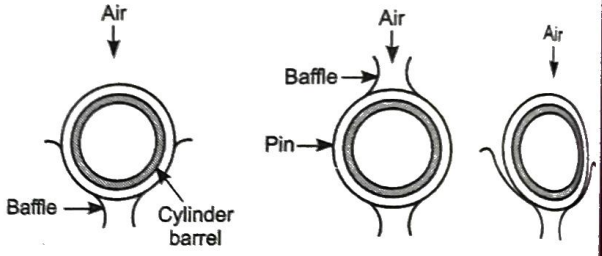


Fig. 4.19 : Cylinder with cast fins

- Use of copper and steel alloys has also been made to improve heat transfer because of their better thermal conductivity.



(a) Normal baffle (b) Complete baffle (c) Short baffle

Fig. 4.20 : Different tapes of baffles

4.4.2 Water Cooling (May 14, Dec. 15, 16)

- In water cooling system, the cooling medium used is water. In this system the engine cylinders are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water which goes to the radiator where it losses its heat to the air.
- Usually some antifreeze is added to the cooling water, due to which it is often referred to as coolant.

Water Cooling Systems are of Two Types :

1. Thermosyphon system
2. Pump circulation system

1. Thermosyphon System:

- A very simple system, which was used in many early automobiles upto nineteen forty. Today this system is obsolete now. It consists of a radiator connected to the engine through flexible hoses. In this system, circulation of water is obtained from the difference in densities of the hot and the cold regions of cooling water.
- The circulating water gets heat from the engine cylinders, due to this cooling is done. The same heat in the water is then dissipated into the atmosphere through the radiator, by mainly conduction and

convention. Therefore, the circulating water becomes cold by the time it reaches the collector tank of the radiator.

- The same water is then circulated through the engine to collect heat from the cylinders. The rate at which water circulates in this system is proportional to the heat output or the load on the engine and not to the engine speed.
- Some of the thermosyphon systems also had fans mounted behind the radiator and driven by belt and pulleys from the crankshaft, to assist the flow of cooling air.

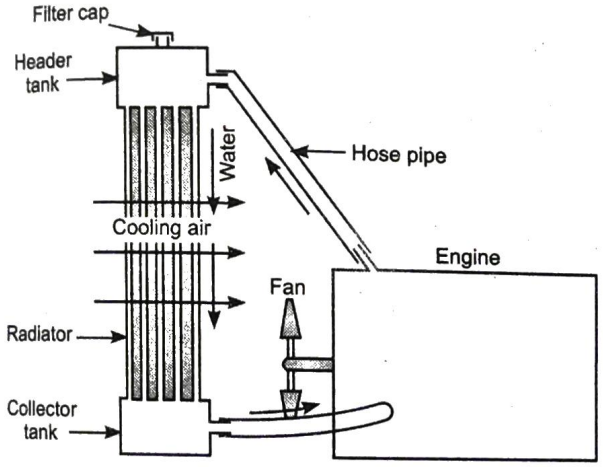


Fig. 4.21 : Thermosyphon system of cooling

The advantages of this system are simplicity and low initial cost.

The Disadvantages are as Follows :

- ➢ As the circulation of coolant is maintained by natural conventional only, the cooling is rather slow. Therefore, to have adequate cooling, the capacity of the system has to be large.
- ➢ Due to the quality of coolant being large, it takes, more time for the engine to reach the operating temperature.
- ➢ Radiator header tank must be located higher than the top of the cylinder coolant jackets, which is no more possible with the modern body styles.

2. Pump Circulation System:

- This system is similar to thermosyphon system the only differences that a pump is used for the circulation of coolant and a thermostat is employed to control the flow of coolant.
- The pump is driven by means of a belt from the engine crankshaft. The drive for the fan is also obtained from the same belt that drives the pump and the generator.

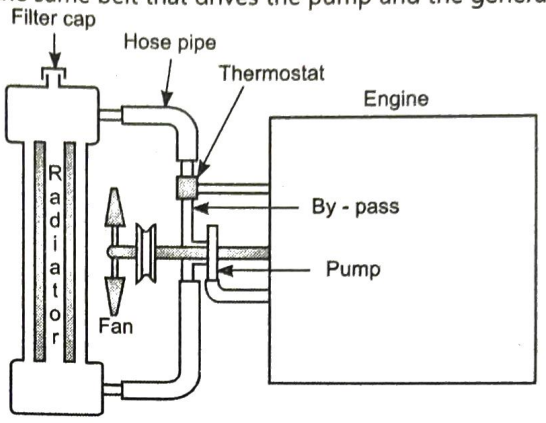


Fig. 4.22 : Pump circulation system

4.5 FUEL INJECTION SYSTEM

4.5.1 Requirements of a Diesel Injection System

The following requirements should be fulfilled by the diesel injection system:

- The fuel should be introduced into the combustion chamber within a precisely defined period of the cycle.
- The amount of the fuel injected per cycle should be metered very accurately. The clearances between the working parts of a fuel pump as well as the size of the orifice are very small.
- The working clearance is as small as 0.001 mm and the nozzle orifice size of even a big engine is as small as 0.625 mm in diameter. If It is enlarged by even 0.075 mm, the output would vary by about 35 per cent. This increased output may result in imbalance, overheating or smoky exhaust.
- The rate of injection should be such that it results in the desired heat release pattern. The quantities of the fuel metered should vary to meet changing speed and load requirements.
- The weight and the size of the fuel injection system must be minimum. It should not be costly to manufacture and expensive to attend to, adjust or repair.
- Pumping elements to move the fuel from fuel tank to cylinder (plus, piping, etc.). Metering elements to measure and supply the fuel according to the requirement of speed and load. Metering controls to adjust the rate of the metering elements for changes in load and speed of the engine.
- Distributing elements to divide the metered fuel equally among the cylinders. Timing controls to adjust the start and the stop injection. Mixing elements to atomize and distribute the fuel within the combustion chamber.

4.5.2 Types of Injection Systems

Diesel injection systems can be divided into two basic types as follows:-

1. Air Injection and
2. Solid injection

1. Air Injection :

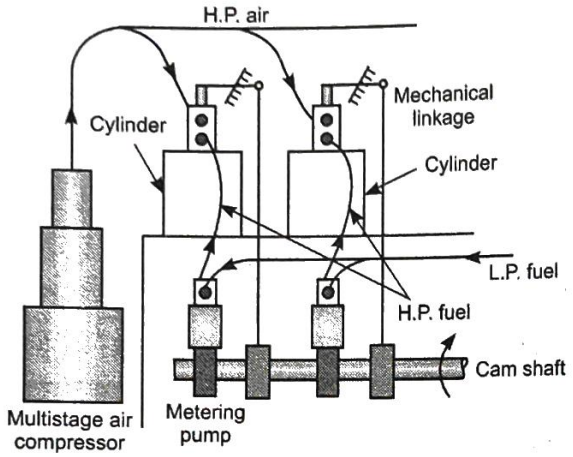


Fig. 4.23 : Air injection system

- The fuel is metered and pumped to the fuel valve by a camshaft driven fuel pump. The fuel valve is opened by means of a mechanical linkage operated by the camshaft which controls the timing of injection.
- The fuel valve is also connected to a high pressure air line fed by a multi-stage compressor which supplies air at a pressure of about 60 to 70 bar.
- When the fuel valve is opened the blast air sweeps the fuel along with it and a well-atomised fuel spray is sent to the combustion chamber.

2. Solid Injection : Injection of fuel directly into the combustion chamber without primary atomisation is termed as solid injection. This is also called airless mechanical injection.

Every solid injection system must have :

(i) A pressurizing unit (the pump), and

(ii) An atomizing unit (the injector)

The Main Types of Modern Fuel Injection System are :

a. Individual Pump and Injector or Jerk Pump System: In the individual pump and injector or the jerk pump system a separate metering and compression pump is used for each cylinder. The pump which meters the fuel also times of injection.

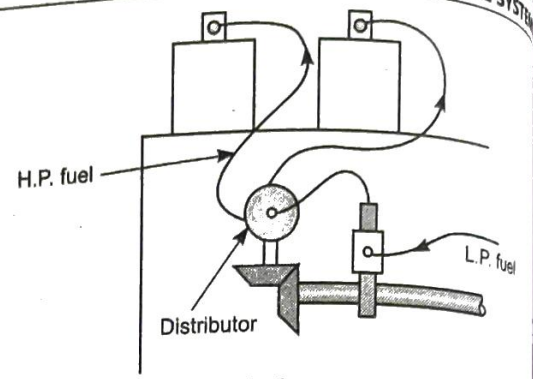


Fig. 4.24 : Individual pump and injector or jerk pump system

b. Common Rail System :

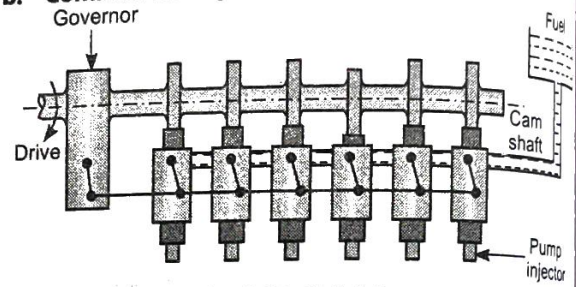


Fig. 4.25 : Unit injector

A high pressure fuel pump delivers fuel to a accumulator, whose pressure is kept constant with the help of a pressure-regulating valve. The high pressure pump usually has a number of plungers and unlike the individual pump system none of the plungers are identified with a particular cylinder. Therefore, the pumping action of the fuel pump is not required to limit to a short period equal to the duration of the injection and the noise and stresses on driving mechanism can be reduced by spreading the pumping action over a long period.

c. Distributor System :

In this system the pump which pressurises the fuel also meters and times it. The fuel pump after metering the required amount of fuel supplies it to a rotating distributor at the correct time for supply to each cylinder. The number of injection strokes per cycle for the pump is equal to the number of cylinders.

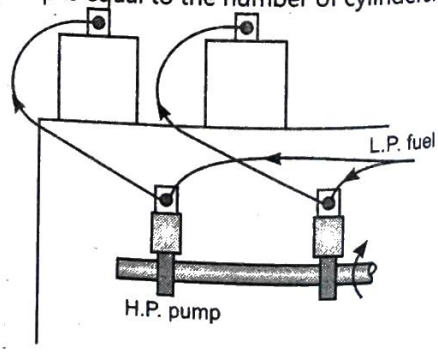


Fig. 4.26 : Distributor system

4.6 FUEL SUPPLY SYSTEMS

4.6.1 Fuel Supply Systems of S. I. Engine (Petrol Engine)

- The basic fuel supply system in an automobile with petrol engine consists of a fuel tank, fuel lines, fuel pump, fuel filter, air cleaner, carburetor, inlet manifold and supply and return pipelines.
- Following are the types of system which have been used for the supply of fuel from the fuel tank to the engine cylinder:-
  1. Gravity system
  2. Pressure system
  3. Vacuum system
  4. Pump system
  5. Fuel injection system
- Out of these the first four systems make use of the carburetor while in the fuel injection system the carburetor has been dispensed with altogether.
- Gravity systems is confined to two wheelers while the pressure & the vacuum systems are obsolete today and the pump systems is being used widely in automobiles. Due to certain advantages, the use of fuel injection system is now universal in modern petrol vehicles.

1. **Gravity System :** In this fuel tank is mounted at the highest position from where the fuel drops into the carburetor float chamber by gravity. The system is very simple and cheap but the placing the fuel tank is important.
2. **Pressure System :** In the pressure system, a hermetically sealed fuel tank is used. The pressure is created in the tank by means of engine exhaust or a separate air pump. For starting, the pump is primed by hand. It is under the pressure thus produced that the fuel flows to the float chamber of the carburetor. There are chances of pressure leak but the advantage lies in the fact that the fuel tank can be placed at any suitable location.
3. **Vacuum System :** This system is based upon the simple fact that the engine suction can be used for sucking fuel from the main tank to the auxiliary fuel tank from where it flows by gravity to the carburetor float chamber.
4. **Pump System :** In this system, a steel pipe carries petrol to the fuel pump which pumps it into the float chamber of the carburetor through a flexible pipe. If the fuel pump is mechanical, it has to be driven from the engine camshaft and hence placed on the engine itself. However, electrically operated fuel pump can be placed anywhere, the rear location (away from the hot engine) reducing the tendency of forming vapour lock. This system is used most commonly in the present day cars.

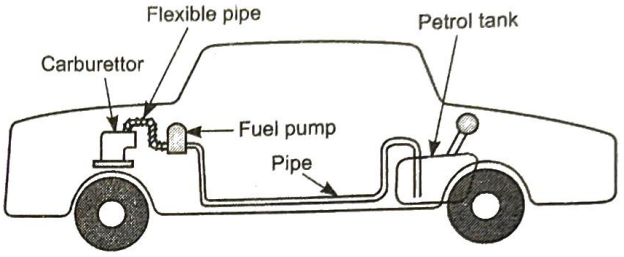


Fig. 4.27 : Pump system of fuel supply

5. **Fuel Injection System :** The petrol injection system has been used successfully on some modern vehicles. In this carburetor is dispensed with altogether. The fuel is atomised by means of an injector nozzle and then delivered into an air stream. Separate fuel injectors are used for each cylinder while the mixture under different load and speed conditions is controlled now electronically. This is the most accurate fuel supply system.

Carburetors :

Functions of Carburetor :

The main functions a carburetor is as follows :

- The keep a small reserve of fuel at a constant head.
- To vaporise the fuel to prepare a homogeneous air fuel mixture.
- To supply correct amount of the air fuel mixture at the correct strength under all conditions of load and speed of the engine.

Simple Carburetor :

- The principle of a carburetor is carburetion, it means automisation and vapourisation. The main components of carburetor are a float chamber, fuel jet, venturi, nozzle and a throttle valve. The float in the float chamber is made of deep drawn brass sheet and its kept hollow for lightness.
- Such floats have a tendency to leak along the joint seams. Due to this reason floats are now made of nylon plastic or expanded synthetic rubber. The needle valve attached to the float lever serves to close or open the fuel inlet to the float chamber depending upon the requirements. The needle valve consists of a cylindrical stem with a conical tip made of steel or else a solid steel stem with a rubber seat tip.

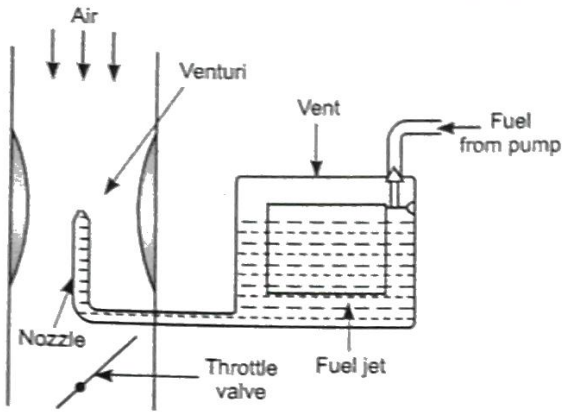


Fig. 4.28 : Simple carburetor

4.6.2 Fuel Supply Systems of C. I. Engine (Diesel Engine)

Fuel supply system in a diesel engine has to perform certain functions.

- **Storing of Fuel :** Fuel tank is usually positioned along the side of the vehicle chassis.
- **Filtering :** Water and dirt must be removed from the diesel for which two filters are employed. Primary filter is usually in the form of a coarse wire gauze and is often optional. It prevents large solid particles and water from going to the fuel feed pump. Secondary filter is used after the fuel feed pump and is meant to remove fine particles of dust, dirt etc. from the diesel which is to go to the injection pump.
- **Delivering of Fuel to Injection Pump :** From the fuel tank the fuel is delivered to the fuel injection pump by means of fuel feed pump. The rate of fuel delivery depends upon the engine requirements.
- **Injecting the Fuel into Engine Cylinders :** Exact amount of fuel is metered, atomized and injected under high pressure to each cylinder in correct sequence and at the correct moment according to the engine requirements. This is done by means of a fuel injection pump in conjunction with injectors for each cylinder. Extra strong steel pipes transmit the metered, pressurized and timed fuel from the fuel injection pump to each injector.
- **Controlling the Engine Speed :** Diesel engine speeds tend to overshoot to dangerous values on reduction of load. This is controlled by means of a governor, which besides limiting maximum speed also regulates the fuel supply under all conditions.

4.7 POWER TRANSMISSION SYSTEM

In Automobile, power transmission is nothing but to transmit the power from crank shaft to the rear wheels. It covers different mechanisms & different system from engine to wheels.

Function of Transmission:

- Vehicle at low speeds, the torque produced by an I. C. engine is very small, which increases with increase of speed, peaks at some optimum speed & starts decreasing beyond that.
- The transmission provides a neutral position so that the engine & road wheels are disconnected so engine is in running condition but power is not transmitted to wheels.
- In reversing condition to transmit power from engine to wheels.

4.8 CLUTCH (Dec. 10, May 10, 11, 12, 17)

- Clutch is a device used to engage and disengage two co-axial shafts while at rest or in relative motion gradually. The gradual engagement of driven shaft limits torque demanded from the driving shaft.
- A good clutch should fulfill the following requirements:
  - ➢ The force required to disengage should be as minimum as possible.
  - ➢ The operation of engaging should be possible at any speed of the driving shaft.
  - ➢ The heat generated during engaging should be minimum.
  - ➢ The engaging mechanism should not rupture or introduce more stresses in the clutch material.

Need:

- To transmit power smoothly.
- Once the clutch is engaged, must transmit power without slipping.
- To overcome self inertia of vehicle.
- For gradual engagement of rotary motion from engine to the gear box shaft.
- These are also used to disengage drive from engine to gear box for changing of different gears.
- At the time of stopping of vehicle the clutch is utilized to disengage engine from drive wheels and enable smooth stopping of the vehicle.
- Clutch also takes the care of speed and torque fluctuations for engine crank shaft to gear box input shaft science clutch is made from friction materials

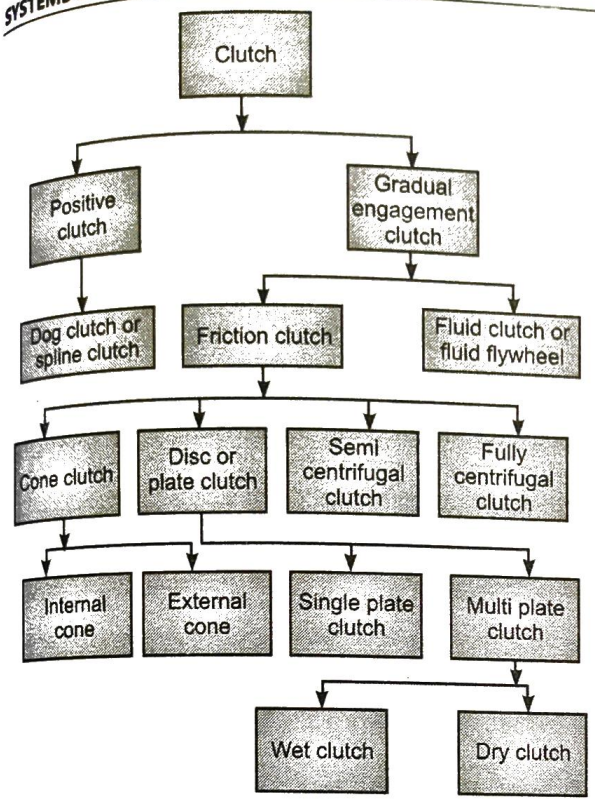


Fig. 4.29

The clutches are classified as positive type and friction type.

1. Positive Clutch

- The configuration of the system is shown in Fig. 4.30. The member A is fixed to the driving shaft and member B is fixed to the driven shaft.
- The member B is splined such that it can move axially by a shifting device that engages it by means of a square groove in the flange. Once engaged, the whole system rotates as a solid mass.
- This is used when power is transmitted continuously and without slip. Such drive is used for transmitting power from electric motor to ball mill, pumps, etc.

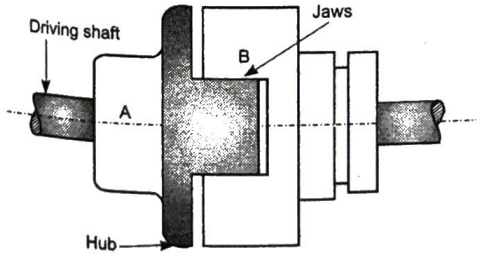


Fig. 4.30

2. Friction Clutches

These clutches are used for engaging and disengaging the driven shaft from the driving shaft very frequently. These are extensively used in automobile industry.

Different types of friction clutches are discussed below.

a. Single Plate Clutch :

- It consists of two flanges with friction lining on one flange (mounted on driven shaft). In this system, one flange is rigidly keyed to the driving shaft and other is free to move along the splines provided on the driven shaft.
- During normal working (when the driven shaft is also rotating), the clutch remains in engaged condition. In this case, the required force (F) is provided by a spring (not shown) which forces the driven flange to move towards driving flange to make the contact between two friction plates. The torque is transmitted by means of frictional force between the two plates.
- When it is required to be disengaged the driven shaft, the axial force (F) is released and driven shaft moves along the axis and friction plates are separated. It is universally used in automobiles.

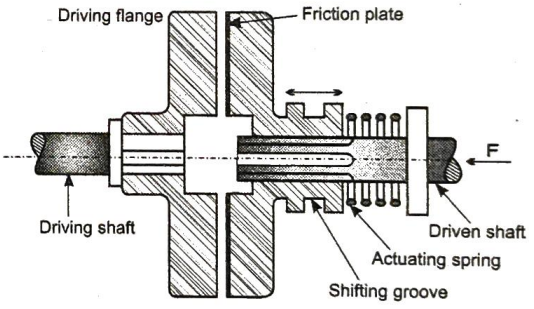


Fig. 4.31 : Single plate clutch

b. Multiplate Clutch :

- The arrangement is shown in Fig. 4.32. In this system, the number of plates used are more than two (mostly 4 to 8). The working of this is just similar to single plate clutch except the torque transmitted to the driven shaft is much higher compared with single plate as surface area in multiplate is much higher. Therefore, the power transmitting capacity is much higher than single plate for the same size.
- All the clutch plates are dipped in oil bath to dissipate heat quickly as heat generated is large. It is used commonly in two wheelers as it is more compact. The system used (mounted on engine shaft) also acts as a flywheel in two-wheelers.

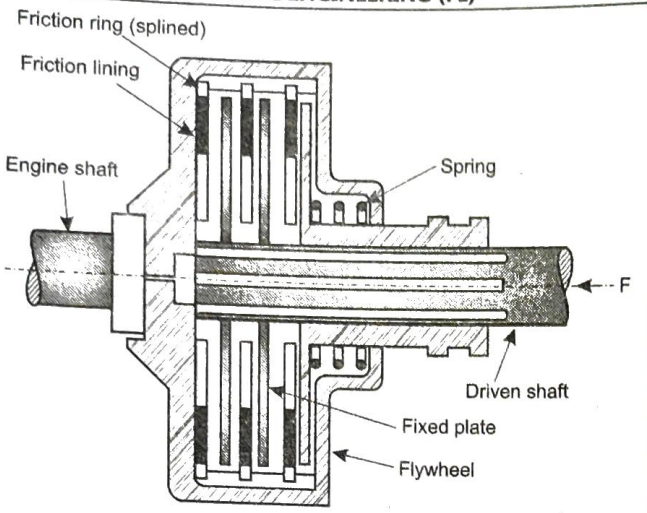


Fig. 4.32 : Multiplate friction clutch

c. Cone Clutch :

- The operation of this clutch is similar to single plate friction clutch except the engaging flanges are made conform as shown in Fig. 4.33. The driven member resting on the feather key in the driven shaft can be shifted along the shaft by a forked lever A (as shown in the figure) for bringing the friction surfaces in contact.
- The torque is transmitted from driving shaft to driven shaft due to friction resistance set-up at contact surface. The spring shown in figure keeps the clutch faces in contact providing required force.
- The cone angle provided lies between 10 to 15 depending upon the frictional material selected. Higher friction factor of the material requires less cone angle.

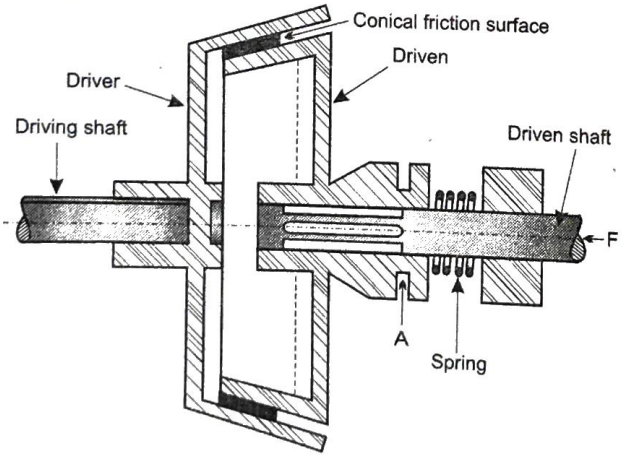


Fig. 4.33 : Cone clutch

- This clutch gives better contact compared with single plane plate because of inclined surface. This clutch is simple in construction and easy to disengage. Presently, this clutch is rarely used as its exposure to the dust and tends to bind the two cones rigidly and becomes difficult to disengage them.

d. Centrifugal Clutch :

- The configuration of this clutch is it consists of number of shoes on the inside of a rim of a pulley. The outer surfaces of the shoes are provided with a layer of frictional material. These shoes are held against spider as shown in figure on the driving shaft by means of springs.
- During revolving the driving shaft, the weight of the shoe sets up centrifugal force. When the centrifugal force is less than spring force, then the clutch is not engaged and driven shaft does not get any torque. But when the centrifugal force exceeds the spring force, the shoe moves outward and comes in contact with driven member and presses against it and driven shaft starts rotating.

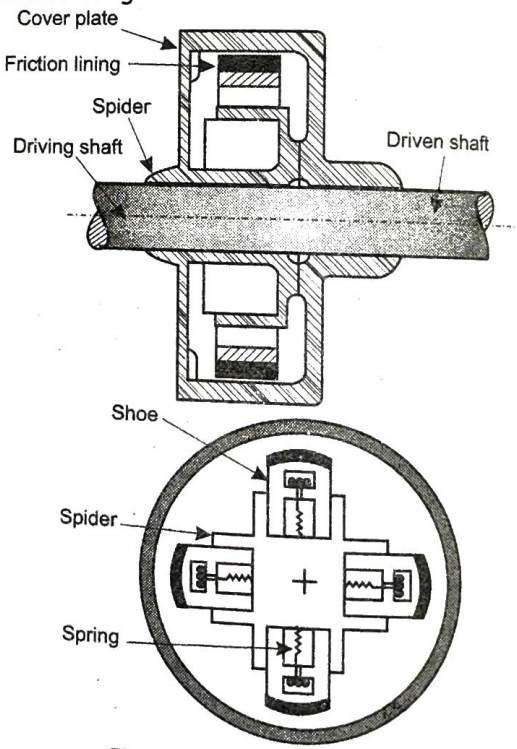


Fig. 4.34 : Centrifugal clutch

- This was very successfully used in LUNA which was easy to operate. Some minimum speed of driving shaft (which can be changed by an accelerator) is required to engage the clutch and start the vehicle.

4.9 GEAR BOX

Need of Gearbox for Following Reasons:

- Provide the torque needed to move the vehicle under a variety of road and load conditions. It does this by changing the gear ratio between the engine crankshaft and vehicle drive wheels.

- Be shifted into reverse so the vehicle can move backward.
- Be shifted into neutral for starting the engine.

Classification :

- Selective Gear Transmission
  - ➢ Sliding mesh Gear Box
  - ➢ Constant Mesh Gear box
  - ➢ Synchromesh Gear box
- Planetary Gear transmission
  - ➢ Epicyclic gear type
  - ➢ Automatic transmission
  - ➢ Fluid type or torque converter
  - ➢ Electric type

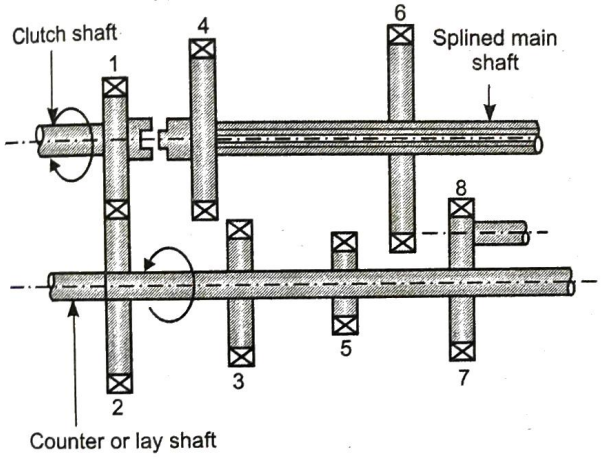


Fig. 4.35 : Sliding mesh gear box

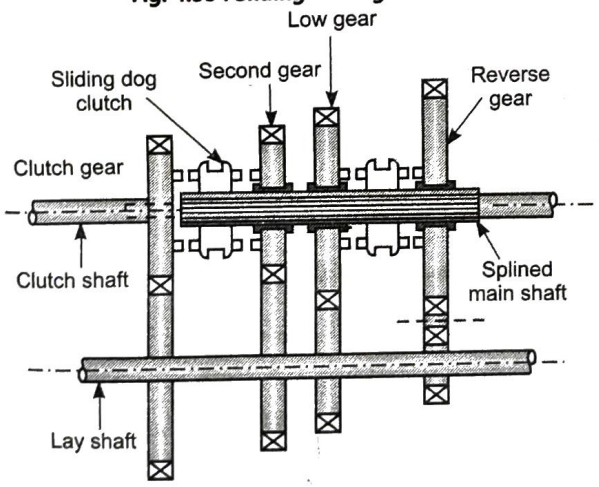


Fig. 4.36 : Constant mesh gear box

Simple Gear Trains

- A gear train is a set or system of gears arranged to transfer rotational torque from one part of a mechanical system to another. Gear trains consists of driving gears, intermediate or "idler" gears and transfer gears. The driving gear is where energy is input into the system of gears.
- The intermediate gears transfer that torque and may reduce or increase it according to the gear ratios involved. The transfer gear passes the modified torque onto the next component in the machine, whether it is a wheel, a winch, a counter or anything that needs power. Fig. 4.37 shows a simple gear train in which there is only one gear for each axis.
- Velocity ratio of a pair of gears is the inverse proportion of the diameters of their pitch circle, and the diameter of the pitch circle equals to the number of teeth divided by the diameteral pitch.

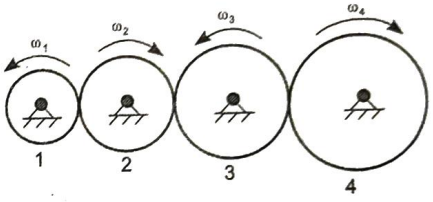


Fig. 4.37

- It is necessary for two mating gears to have the same diameteral pitch so that to satisfy the condition of correct meshing. Thus, we infer that the velocity ratio of a pair of gears is the inverse ratio of their number of teeth.

  For the simple gear trains shown in Fig. 4.37, we have

$$\frac{\omega_1}{\omega_2} = \frac{N_2}{N_1}, \quad \frac{\omega_2}{\omega_3} = \frac{N_3}{N_2}, \quad \frac{\omega_3}{\omega_4} = \frac{N_4}{N_3}$$

  where N represents the number of teeth.

  These equations can be combined to give the velocity ratio of the first gear in the train to the last gear:

$$\frac{\omega_1}{\omega_4} = \frac{N_2N_3N_4}{N_1N_2N_3} = \frac{N_4}{N_1}$$

- The tooth numbers in the numerator are those of the driven gears, and the tooth numbers in the denominator belong to the driver gears. Gear 2 and 3 both drive and are, in turn, driven. Thus, they are called idler gears. Since their tooth numbers cancel, idler gears do not affect the magnitude of the input-output ratio, but they do change the directions of rotation.
- The gear ratio is independent of the size of the intermediate wheels which are called Idlers. For an odd number of externally geared wheels, the direction of rotation of the last wheel is the same as the first. For an even number of wheels the direction of rotation of the last wheel is opposite to that of the first.

- One of the most common uses of Gear Trains is in the gear boxes of cars. In the simplest form of the crash gear box, a collection of spur gears were arranged to give different ratios of input to output speed and in the case of the reverse gear, change the direction of the output rotation.

IMPORTANT FORMULAE

The following formulae are used for solving the examples.

1. P_c (circular pitch) = $\frac{\pi D_p}{T}$, where D_p is pitch circle diameter and T is number of teeth.
2. p_d (diameteral pitch) = $\frac{T}{D_p} = \frac{1}{m}$
3. m (module) = $\frac{1}{p_d} = \frac{D_p}{T} = \frac{p_c}{\pi}$ $\therefore p_c = \pi m$ and $D_p = mT$.
4. Therefore, $p_c \cdot p_d = \frac{\pi D_p}{T} \times \frac{T}{D_p} = \pi$.

   When two gears are in mesh, then $P_{c1} = P_{c2}$, $P_{d1} = P_{d2}$ and $m_1 = m_2$.
5. Velocity ratio = $\frac{N_1}{N_2} = \frac{D_2}{D_1} = \frac{T_2}{T_1}$ = Gear tooth ratio.
6. L (centre distance)

   $= \frac{D_{p1} + D_{p2}}{2} = \frac{T_1 \cdot m + T_2 \cdot m}{2}$

   $= \frac{m}{2}(T_1 + T_2)$
7. P (power transmitted) = $\frac{F\pi DN}{1000 \times 60}$ kW = $\frac{2\pi TN}{1000 \times 60}$ kW

   where T (torque) = F·R

   where F is the force.

Note : If D or D_p is used, it is the pitch diameter of the gear.

SOLVED EXAMPLES

Example 4.1 : *A pinion with 25 teeth rotating at 1000 r.p.m. drives a gear which rotates at 200 r.p.m. The module is 5 mm. Find the following :*

(a) Circular and diameteral pitch.

(b) Pitch circle diameters of pinion and gear.

(c) The centre distance.

(d) Velocity ratio.

Solution :

The data given is

$T_1 = 25$, $N_1 = 1000$ r.p.m., $N_2 = 200$ r.p.m.

$m = 5$ mm

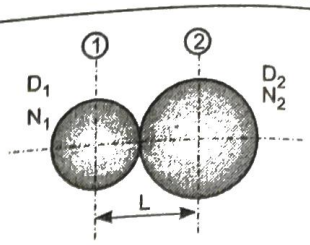


Fig. 4.38

(a) The circular pitch is given by

$$P_c = \pi \cdot m = \pi \times 5 = 15.7 \text{ m}$$

The diameteral pitch is given by

$$P_d = \frac{\pi}{p_c} = \frac{\pi}{15.7} = \mathbf{0.2 \text{ teeth/mm}}$$

(b) D_1 (pitch circle diameter of pinion)

$$= mT_1 = 5 \times 25 = 125 \text{ mm}$$

For the gears in mesh.

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \quad \therefore D_2 = D_1 \times \frac{N_1}{N_2} = 125 \times \frac{1000}{200} = \mathbf{625 \text{ mm}}$$

(c) $L = \frac{D_1 + D_2}{2} = \frac{125 + 625}{2} = \mathbf{375 \text{ mm}}$

(d) Velocity ratio $= \frac{N_1}{N_2} = \frac{1000}{200} = \mathbf{5}$

Example 4.2 : *A pair of spur gears consists of 20 teeth pinion meshing with gear of 100 teeth. The module is 4 mm. Find out the following:*

(a) Circular and diameteral pitch.

(b) The centre distance.

(c) Pitch circle diameter of the pinion and gear.

(d) The velocity ratio and gear ratio.

(e) Centre distance.

Solution :

The given data is :

$T_1 = 20$, $T_2 = 100$, $m = 4$ mm.

(a) The circular pitch is given by

$$P_c = \frac{\pi D}{T} = \pi \times m \text{ as } m = \frac{D}{T}$$

$$= \pi \times 4 = \mathbf{12.57 \text{ mm}}$$

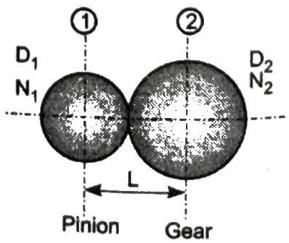


Fig. 4.39

The diameteral pitch is given by $p_d = \frac{1}{m} = \frac{1}{4}$

$= \mathbf{0.25\ teeth/mm}$

(b) $D_1 = T_1 \times m = 20 \times 4 = 80$ mm, $D_2 = T_2 \times m$

$= 100 \times 4 = 400$ mm.

where D_1 and D_2 are pitch circle diameters.

(c) Velocity ratio (V.R.) is given by V.R. $= \frac{D_2}{D_1} = \frac{400}{80} = 5$,

Gear ratio = Velocity ratio = 5

$$L = \frac{D_1 + D_2}{2} = \frac{80 + 400}{2} = \mathbf{240\ mm}$$

Example 4.3 : *A pair of spur gears is used to have a gear ratio of 4.5. The centre distance between the gears is 495 mm. The module is 6 mm. Find the number of teeth on the pinion and gear.*

Solution :

The given data is

$$\frac{N_1}{N_2} = 4.5,\ L = 495 \text{ mm and } m = 6 \text{ mm}$$

$$L = \frac{D_1 + D_2}{2} = \frac{m}{2}(T_1 + T_2)$$

and $D = mT$, where T is the number of teeth

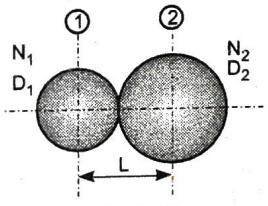


Fig. 4.40

$$\therefore \quad 495 = \frac{6}{2}(T_1 + T_2)$$

$$\therefore \quad T_1 + T_2 = 165 \quad \text{... [a]}$$

$$\frac{N_1}{N_2} = 4.5$$

$$\therefore \quad \frac{T_2}{T_1} = 4.5 \text{ as } \frac{N_1}{N_2} = \frac{T_2}{T_1} \quad \text{... [b]}$$

From equations [a] and [b], we get

$$T_1 + 4.5\,T_1 = 165$$

$$\therefore \quad T_1 = \frac{165}{5.5} = 30$$

$$\therefore \quad T_2 = 165 - 30 = \mathbf{135}$$

4.10 PROPELLER SHAFT

It is the shaft which connects the transmission output shaft to the differential mechanism at the rear wheels. In other words the shaft which transmits the engine power from slip joint (sliding joint) to wheels throw differential, this power is used to move the vehicle from one place to another.

Functions:

- It transmits rotary motion of the gearbox output shaft to the differential.
- It transmits motion at some angle which varies frequently.

Construction:

- It is made up of a steel hollow tube, which is connected with slip join and two universal joints.
- Having diameter 50 to 70mm and thickness from 1.5 to 7.5 mm.
- The slip joint is made on the propeller shaft with external splines on shaft and internal splines on the sleeve.

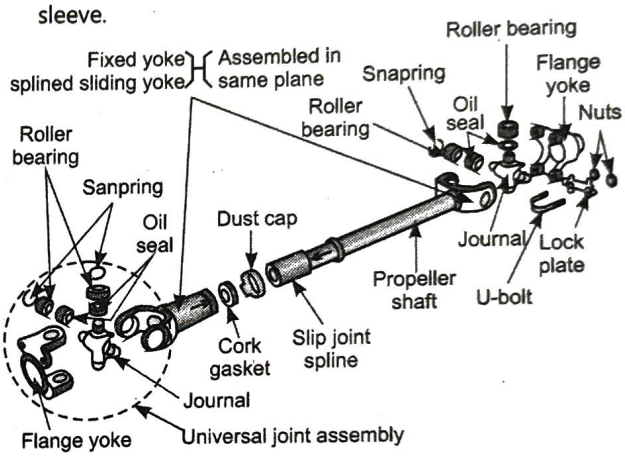


Fig. 4.41 : Components of propeller shaft

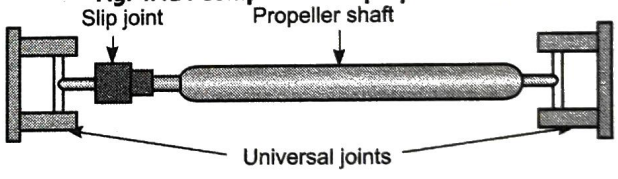


Fig. 4.42 : Propeller shaft

Universal Joint:

- A joint is a particular type of connection between two shafts, whose axes are inclined to each other. The Hooke's joint is simple type of universal joint which is widely used in vehicles. The construction of this joint is very simple. This type of joint is efficient for small angles of propeller shaft movement up and down, upto 18°.
- The angular movements between the two shafts are possible due to universal joint (Hook's Joint). The Hooke's joint uses needle roller bearing to support the cross in the yokes. This results in increase of joint efficiency.

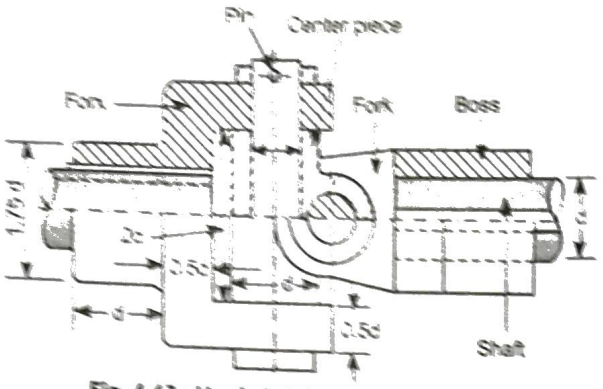


Fig. 4.43 : Hooke's joint or universal joint

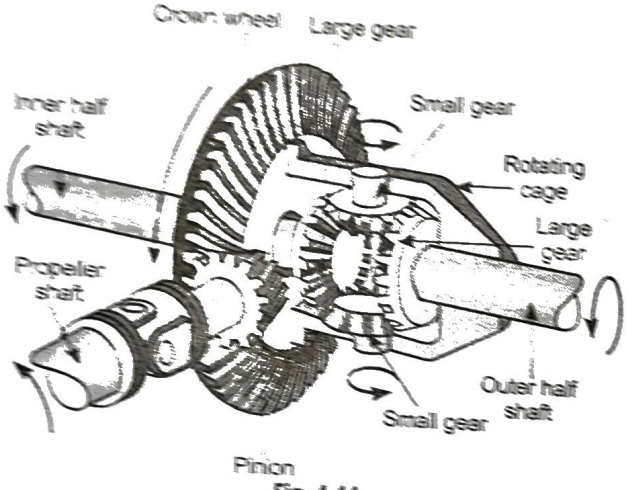


Fig. 4.44

Differential Gearbox:

- When the car is taking a turn, the outer wheels will have to travel greater distance as compared to inner wheels in this case differential works.
- The less rotation of inner wheel and more rotation to outer wheel is possible by only using different gears in differential. Or inner wheel steady and outer wheel in running condition. Due to every vehicle required differential.

Function:

- Reduce speed and increase torque
- Change the direction of torque as gearbox output shaft is longitudinal
- i.e. it turns the drive of propeller shaft to that of the wheels.

Construction:

- The driving gear wheel with less no. of teeth called bevel pinion
- The driving conical gear called as crown wheel.

Working:

- The propeller shaft has a small bevel pinion which is in mesh with the crown wheel at right angle this crown wheel rotates the rear axles. The axles are two half shafts.
- The rotation of propeller shaft is converted at right angles to the rear axles.
- The crown wheel size is larger than the size of the pinion bevel gear hence the speed of crown wheel is lower than bevel pinion.

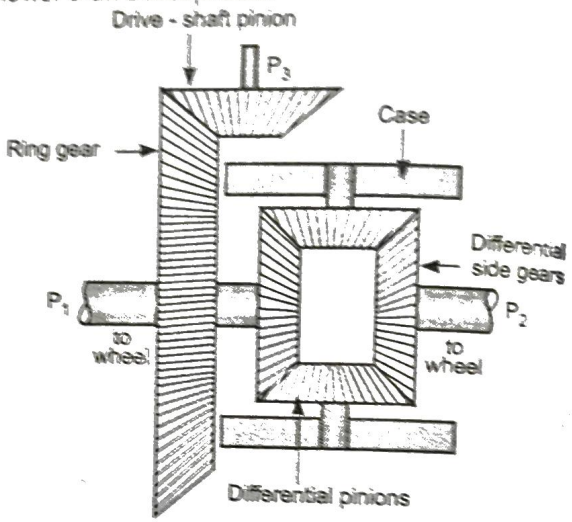
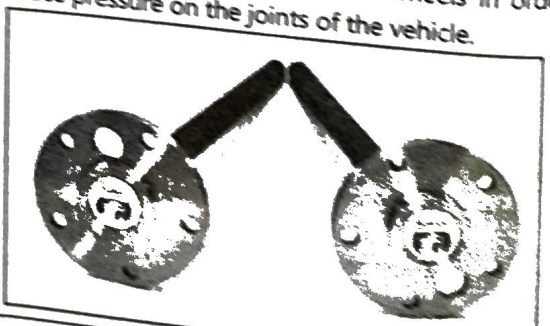


Fig. 4.45

Axles

- An axle is a straight shaft that is fixed in location and is used to mount rotating wheels or gears. The wheel or gear can be attached to it with a built-in bearing or bushing. A bearing or bushing fits inside the center of the wheel and allows it to rotate without affecting the axle itself. The purpose of an axle is to secure the wheels or gears to specific locations relative to other wheels or gears. On wheeled vehicles, the axle may be fixed to the wheels, rotating with them. e.g. bicycles, or fixed to its surroundings, with the wheels rotating around the axle as a spindle.
- In a vehicle, the axle absorbs braking and acceleration forces, as well as the actual weight of the vehicle. It forms a central part of the structural strength of the vehicle, and it must be able to absorb the weight and transfer the forces away from the wheels in order to reduce pressure on the joints of the vehicle.



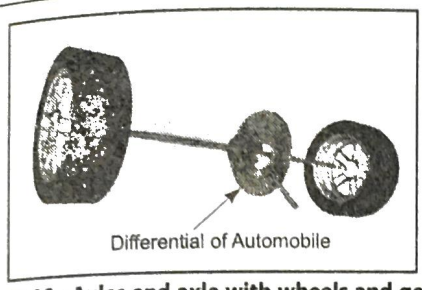


Fig. 4.46 : Axles and axle with wheels and gears

There are Three Different Kinds of Axles in Vehicles :

1. Straight (single drive and non-drive) axle
2. Split axle
3. Tandem axle.

1. **In a Straight or Single Drive Axle**, there is one shaft connecting the two parallel wheels. The wheels are both secured in place onto the axle. The rotation rate and direction is fixed by the axle. The benefits of this type are the ability to keep the wheel position consistent and distribute the weight of heavy loads evenly. Straight axles are used on trains, for the rear axles of commercial trucks, and on heavy duty off-road vehicles.

- **A Non-Driving Axle,** such as the front beam axle in heavy duty trucks and vans, serves only as a suspension and steering component. This axle does not have drive but used along with drive axles in order to increase the vehicle load bearing capacity.

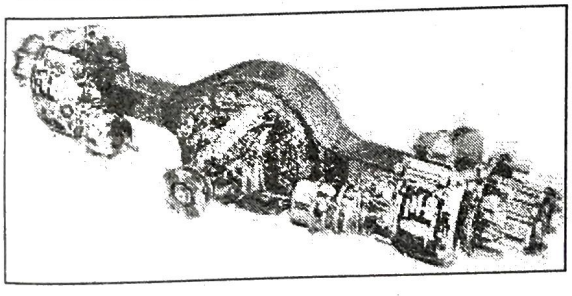


Fig. 4.47: Single drive axle

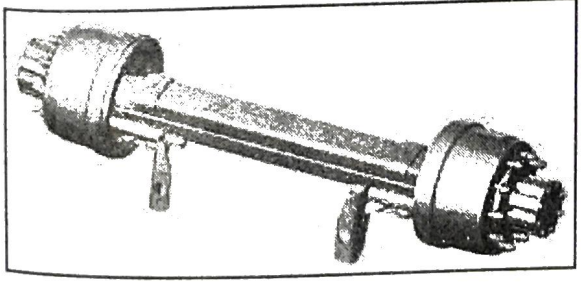


Fig. 4.48 : Non-drive axle

2. **In a Split-Axle,** each wheel is attached to a separate shaft. The purpose of this split is to provide a fixed position for the wheel, but also to allow each wheel to move independently of the other. This type is used on passenger cars. Split axles permit the use of a differential, allowing the left and right drive wheels to be driven at different speeds as the automobile turns, improving traction and extending tire life.

3. **A Tandem Axle** is a group of two or more axles situated close together. Vehicles used in mining and tractor applications are often required to carry extremely heavy loads, such configuration provides a greater weight capacity than a single axle. This is shown in Fig. 4.49.

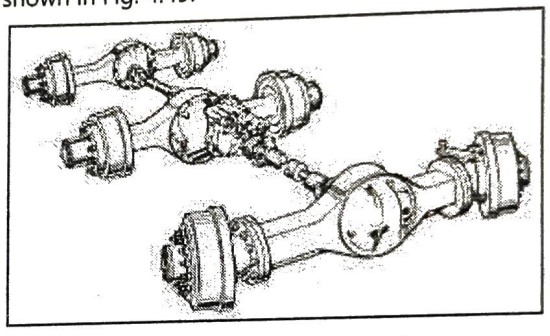


Fig. 4.49 : Tandem drive axle

4.11 VEHICLE SAFETY (Dec. 11, 13, May 12, 13)

It is related design of vehicle safety the active safety is important. At a time of vehicle design to consider all conditions of active safety is consider.

Following Factor under Active Safety :

- There should be more glass area with minimum blind spots. This will increase the efficiency of driver for parking and driving in heavy traffic.
- Good mirrors will enable the driver to see potential hazards when reversing parking or changing lines. Mirrors are to be adjusted from inside of car. Heated mirrors should be preferred to avoid fogging in bad weather.
- Headlights should be designed in such a way that there is adequate intensity of lights. They should give a good view of road ahead to the driver. In some cars wipers or water jets employed to help cleaning the headlights.

- The instrument panel should be designed in such a way that the driver must be able to read all the meters very easily.
- All controls should be easily accessible to the driver noise from engine and running noises.
- Driver's seat should be comfortable and adjustable according to the drivers requirements.
- The vehicle noise should be minimum. The suspension for engine, front axle and gear box should be insulated against noise from engine and running noises.
- The suspension system and steering system should be properly designed to get better holding of roads and improved characteristics while cornering.

Now a day's ABS (Antilock braking system) is applied for better steering and controlling of vehicle.

Passive Safety

- It comes under design automobile vehicle for minimum injury at the time of accidents.
- Passive safety features are the features by which there is minimum, injury and crashing for occupants at the time of accidents.
- Some of passive safety features help to absorb crash forces collision of vehicle. The following points come under passive safety features.
  - ➢ There should have rigid boxes for occupants with weaker ends which crumble on collision thereby absorbing the energy of impact and bringing the vehicle to stop instantly. Fig. 4.50 shows the rigid safety cell of Audi 100 car with its crumple zones at the front and rear sides.
  - ➢ For protecting against side sweeps the doors of the vehicle must be/should be strengthened by using steel bars.
  - ➢ To reduce the risk of spilled fuel and consequent fire in case of near end collision fuel tank should be located at suitable positions.
  - ➢ In case of accident it is very important to consider the doors closing after car comes to rest otherwise there are channels of person to thrown out and being killed are increased so the doors should be fitted with safety lock.
  - ➢ Various switches controls etc. should be so shaped that they are not protruding excessively so as to cause injury to the occupants at the front at the time of front side collision.
  - ➢ To minimize the leg injuries to occupants of front seats, a knee bolster must be provided. Knee bolster is an energy absorbing crushable barrier under the dashboard that stops occupant knees from striking hard components and surfaces below and behind the dash.
  - ➢ Seat belts should be worn both by passengers as well as drivers.

4.12 SEAT SYSTEM

- Car seat is designed to support legs, lower and upper back, and head. The front seats have three main parts: the seat back (squab), seat base (cushion), and the head rest.
- Components of seats are usually made from foam for comfort. Most suitable foam for balancing comfort, support, safety, and recycling properties are considered.
- Cushioning agent is important while considering mobile cars may transmit vibrations near the human spine's resonant frequency of 3Hz.
- The seats can usually be adjusted for position forward or back on metal railings and may move up and down to adjust to different body types. This movement is accomplished either by manual latches or by electric levers.
- There may be a release lever to allow the squab to lean forward for access to back seats in some automobiles.
- Adjustments of seat deal with concerns such as providing leg room, supplying back support, and giving head support. Available amenities include electric adjustments, choice in fabric covering, and temperature control. Important advancements in this area are of top concern to manufacturers, government officials and, of course, consumers.
- The head support is connected to the top of the squab by two metal circular tube shafts that are permanently attached to the head.

4.13 SEAT BELT SYSTEM (Dec. 11, May 12, 17)

The seat belt restraint system contains some or all of these components

- Shoulder guide loop,
- Webbing
- Non-locking retractor
- Automatic locking retractor
- Emergency locking retractor
- Vehicle sensitive retractors
- Webbing sensitive retractors
- Buckle
- Buckle release
- Tongue (latch plate)
- Selvage

4.14 AIRBAGS SYSTEM (May 12, 17)

- Airbags are inflatable cushions designed to protect automobile occupants from serious injury in the case of a collision.
- The air bag is part of an inflatable restraint system, also known as an air cushion restraint system (ACRS) or an air bag supplemental restraint system (SRS), because the air bag is designed to supplement the protection offered by seat belts.
- Seat belts are still needed to hold the occupant securely in place, especially in side impacts, rear impacts, and rollovers.
- Upon detecting a collision, air bags inflate instantly to cushion the exposed occupant with a big gas-filled pillow.
- A typical air bag system consists of an air bag module (containing an inflator or gas generator and an air bag), crash sensors, a diagnostic monitoring unit, a steering wheel connecting coil, and an indicator lamp.
- These components are all interconnected by a wiring harness and powered by the vehicle's battery. Air bag systems hold a reserve charge after the ignition has been turned off or after the battery has been disconnected.
- Depending on the model, the backup power supply lasts between one second and ten minutes. Since components vital to the system's operation might sit dormant for years, the air bag circuitry performs an internal "self-test" during each startup, usually indicated by a light on the instrument panel that glows briefly at each startup.
- The crash sensors are designed to prevent the air bag from inflating when the car goes over a bump or a pothole, or in the case of a minor collision. The inflator fits into a module consisting of a woven nylon bag and a break-away plastic horn pad cover.
- Side-impact air bags are used in the car door panels and deployed towards the window during impact to protect the head.
- Foam padding around the door structure would also be used to cushion the upper body in a side impact. Head and/or knee bolsters (energy absorbing pads) to complement the air bag system are also being investigated.

4.15 ANTILOCK BRAKE SYSTEM (ABS)

- These types of brakes are called as Anti-skid Brake system. Because of these brakes, reduces the risk of tires skidding under heavy load condition and allows driver to maintain steering control of the vehicle. Antilock brake system operates under heavy load braking or on slipping surface conditions.
- ABS calculates the required slip rate of the wheels accurately based on the vehicle speed and the speed of the wheels and then controls the brake fluid pressure to achieve the target slip rate.
- Although Antilock brake system prevents complete locking of the wheels in practice it allows some wheel slip in order to attain the best possible braking.
- At the time of applying brake on brake pedal by driver in conventional braking system is different than ABS.
- Modern ABS consists of an Electronic Control Unit (ECU). An individual sensor is connected to each wheel of car. All sensors are controlled by electrically driven hydraulic pump and an accumulator. Function of accumulator is to star hydraulic fluid to maintain high pressure in the braking system. An accumulator is charged with N_2 (Nitrogen gas).
- ECU controls and monitors the antilock function and when required.
- In some ABS, a lateral accelerator sensor is also provided to monitor the lateral (side) movement of the

vehicle while taking a turn. This also ensures proper braking out the time of turning.

- Electrically driven hydraulic pump is called as Hydraulic Booster. It has four outlet brake lines connecting to each wheel.

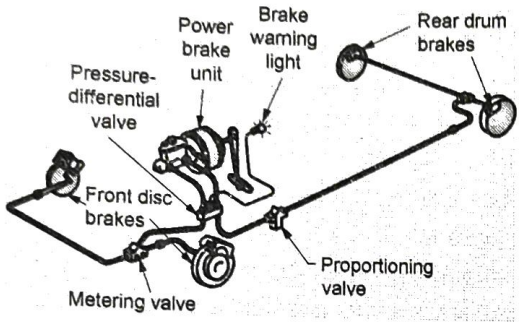


Fig. 4.50

Working of ABS

The sensor of each wheel provides the varying voltage signal to the E.C.U. of brake system E.C.U. Computes the voltage signal and compares it with programmable information and determines whether a wheel is about to lock or skid.

EXERCISE

1. How to prepare chassis layouts.
2. What are different steering systems? Explain any one.
3. Compare mechanical and electronics steering.
4. How suspension system works? Explain any one.
5. Explain any two braking system with figure.
6. What is the purpose of cooling system? Explain any one.
7. Write short notes on fuel supply system.
8. Explain with sketch different fuel injection system.
9. Explain with sketch working of single plate clutch.
   a. Draw block diagram of universal joints
   b. Write short notes on differential gear box
   c. Compare active and passive safety arrangements