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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SAU1401 AUTOMOBILE ENGINEERING

UNIT I INTRODUCTION

I. INTRODUCTION

Chassis: Different types of chassis and their construction, Chassis dimensions. Frames- Types- Engine: Classification-various components- construction- Eg. Car, MUV, LCU, HGP, Bus, army, Construction Auto emission: Pollution from the automobile, Emission Control Systems – Construction and Operation of PCV Systems, Evaporative Emission Control, Heated Air Intake System, EGR Systems, Catalytic Converters- emission testing- Emission standard of vehicle in India, Euro norms

Classification of automobile

Automobiles can be classified into several types based on several criteria. A brief classification of automobiles is listed below:

Based on purpose

1. Passenger vehicles – These automobiles carry passengers – e.g.: Buses, Passenger trains, cars

2. Goods vehicles – These vehicles are used for transportation of goods from one place to another. e.g.: Goods lorry, goods carrier

Based on capacity:

1. Heavy Motor Vehicle (HMV) – Large and bulky motor vehicles – e.g.: Large trucks, buses

2. Light Motor Vehicle (LMV) – Small motor vehicles – e.g.: Cars, Jeeps

3. Medium Vehicle – Relatively medium sized vehicles – e.g.: Small trucks, mini buses

Based on fuel source:

1. Petrol engine vehicles – Automobiles powered by petrol engine – e.g.: scooters, cars, mopeds, motorcycles

2. Diesel engine vehicles – Automotives powered by diesel engine – e.g.: Trucks, Buses

Introduction of Chassis Frame: Chassis is a French term and was initially used to denote the frame parts or Basic Structure of the vehicle. It is the back bone of the vehicle. A vehicle without body is called Chassis. The components of the vehicle like Power plant,

Transmission System, Axles, Wheels and Tyres, Suspension, Controlling Systems like Braking, Steering etc., and also electrical system parts are mounted on the Chassis frame. It is the main mounting for all the components including the body. So it is also called as Carrying Unit.

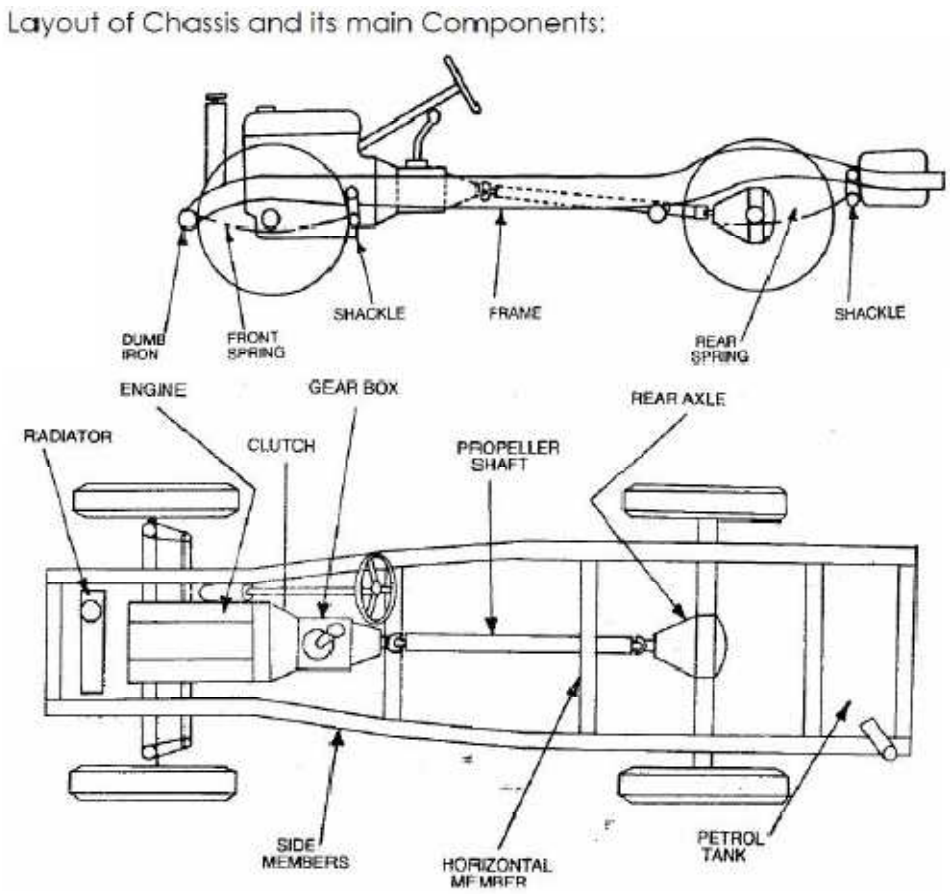


Figure 1.1. Layout of Chassis

Functions of the Chassis Frame

1. To carry load of the passengers or goods carried in the body.
2. To support the load of the body, engine, gear box etc.,
3. To withstand the forces caused due to the sudden braking or acceleration
4. To withstand the stresses caused due to the bad road condition.
5. To withstand centrifugal force while cornering.

Types of Chassis Frames:

There are three types of frames

1. Conventional frame
2. Integral frame
3. Semi-integral frame

1. **Conventional frame:** It has two long side members and 5 to 6 cross members joined together with the help of rivets and bolts. The frame sections are used generally.

a. Channel Section - Good resistance to bending

b. Tabular Section - Good resistance to Torsion

c. Box Section - Good resistance to both bending and Torsion

2. **Integral Frame**: This frame is used now a day in most of the cars. There is no frame and all the assembly units are attached to the body. All the functions of the frame carried out by the body itself. Due to elimination of long frame it is cheaper and due to less weight most economical also. Only disadvantage is repairing is difficult.

3. **Semi - Integral Frame:** In some vehicles half frame is fixed in the front end on which engine gear box and front suspension is mounted. It has the advantage when the vehicle is met with accident the front frame can be taken easily to replace the damaged chassis frame. This type of frame is used in FIAT cars and some of the European and American cars.

Various Loads Acting On the Frame

Various loads acting on the frame are

1. Short duration Load - While crossing a broken patch.

2. Momentary duration Load - While taking a curve.

3. Impact Loads - Due to the collision of the vehicle.

4. Inertia Load - While applying brakes.

5. Static Loads - Loads due to chassis parts.

6. Over Loads - Beyond Design capacity.

Requirements of Bodies for Various Types of Vehicle:

The body of the most vehicles should fulfil the following requirements:

1. The body should be light.

2. It should have minimum number of components.

3. It should provide sufficient space for passengers and luggage.

4. It should withstand vibrations while in motion.

5. It should offer minimum resistance to air.

6. It should be cheap and easy in manufacturing.

7. It should be attractive in shape and colour.

8. It should have uniformly distributed load.

9. It should have long fatigue life

10.It should provide good vision and ventilation.

Integrated Frame and Body

The integrated frame and body type of construction also referred to as unitized construction, combines the frame and body into a single, one-piece structure. This is done by welding the components together, by forming or casting the entire structure as one piece, or by a combination of these techniques. Simply by welding a body to a conventional frame, however, does not constitute an integral frame and body construction. In a truly integrated structure, the entire frame-body unit is treated as a load-carrying member that reacts to all Integrated-type bodies for wheeled vehicles are fabricated by welding preformed metal panels together. The panels are preformed in various load-bearing shapes that are located and oriented so as to result in a uniformly stressed structure. Some portions of the integrated structure resemble frame like components, while others resemble body like panels. This is not surprising, because the structure must perform the functions of both of these elements. An integrated frame and body type construction allows and increases in the amount of noise transmitted into the passenger compartment of the vehicle. However, this disadvantage is negated by the following advantages:

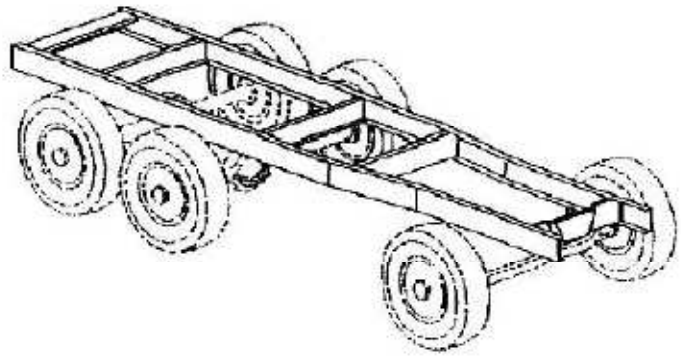


Figure 1.2. Conventional Frame

Substantial weight reduction, which is possible when using a well-designed unitized body. Lower cargo floor and vehicle height. Protection from mud and water required for driveline components on amphibious vehicles. Reduction in the amount of vibration present in the vehicle structure.

Ladder Frame (Truck Frame)

The truck frame allows different types of truck beds or enclosures to be attached to the frame. For larger trucks, the frames are simple, rugged, and of channel iron construction. The side rails are parallel to each other at standardized widths to permit the mounting of stock transmissions, transfer cases, rear axles, and other similar components. Trucks that are to be used as prime

movers have an additional reinforcement of the side rails and rear cross members to compensate for the added towing stresses.

Chassis Frame

There are different types of chassis frame sections 1. Channel section 2. Box section 3. Tubular section The conventional frame is also known as Non-load carrying frame. In this types of frame , the loads on the vehicle are transferred to the suspension by the frame which is the main skeleton of the vehicle. The channel section is used in long members and box section in short members. Tubular section is used now-a-days is three wheelers, scooters, matadors and pickup vans. The frames should be strong enough to bear load while sudden brakes and accidents.

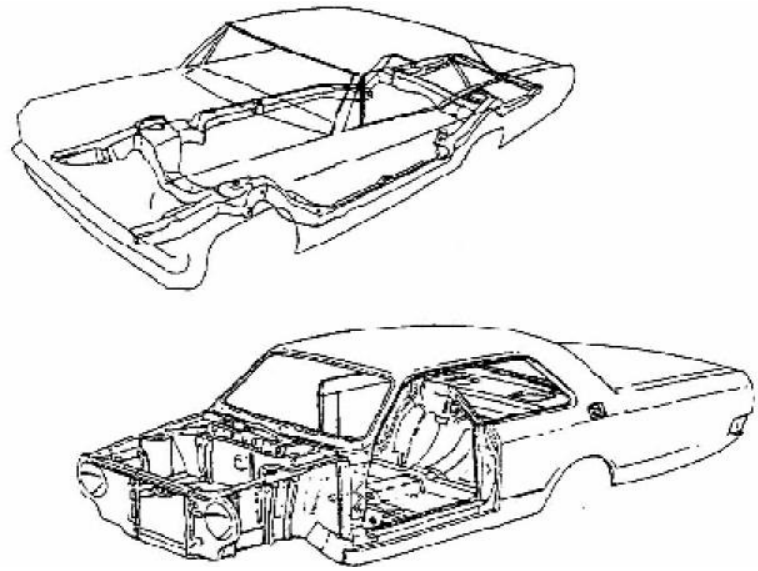


Figure 1.3. Integrated Frame

Frame Construction

The longitudinal members A and the cross members B. The frame is upswept at the rear and front to accommodate the movement of the axle due to springing. It also keeps the chassis height to low. The frame is narrowed down at the front either as shown to have a better steering lock, which gives a smaller turning circle. C are brackets supporting the body. E are dumb irons to act as bearings for spring shackles. They also take the bumper brackets. Brackets E are meant for mounting the springs. The extension of the chassis frame ahead of the front axle is called front overhang, whereas its extension beyond the rear axle is called rear overhang.

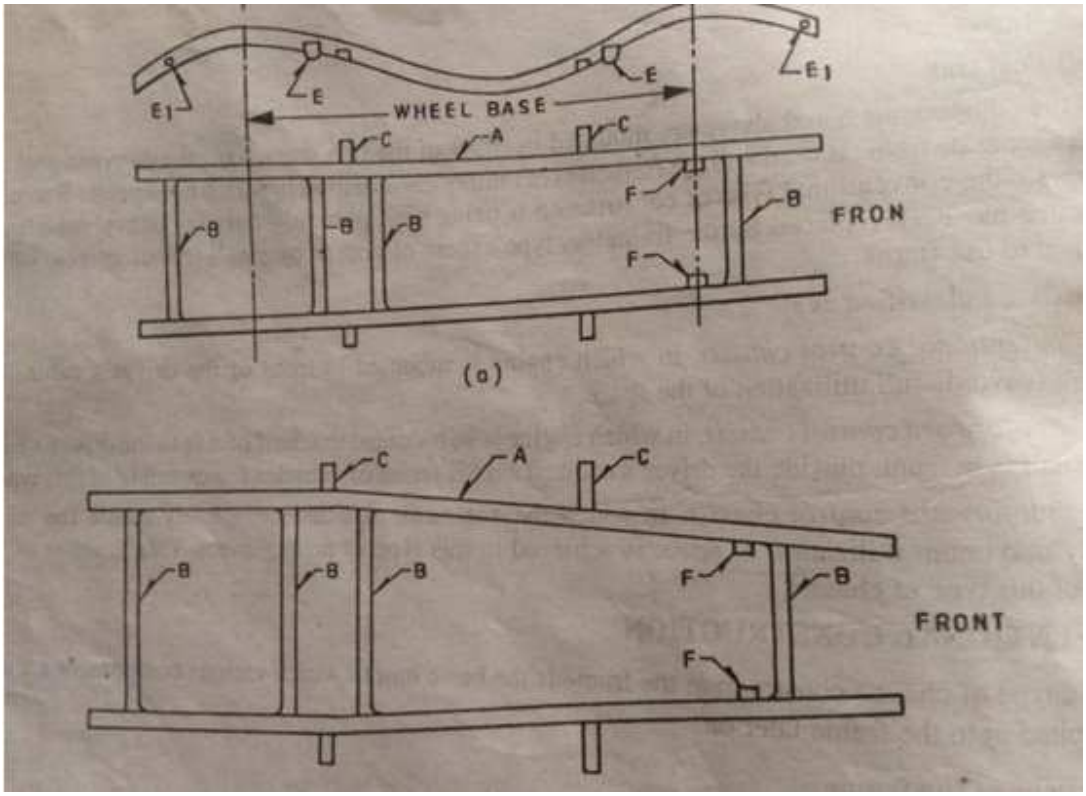


Figure 1.4. Frame Shapes

The commercial vehicles have to carry large loads, framed construction is invariably used for these vehicle, ground clearance is larger and sufficient space is otherwise available for steering the vehicle, the frames for these have only straight members without taper towards the front or upsweeps at the front or rear.

Figure 1.5. Chassis frame for an old Daimler vehicle

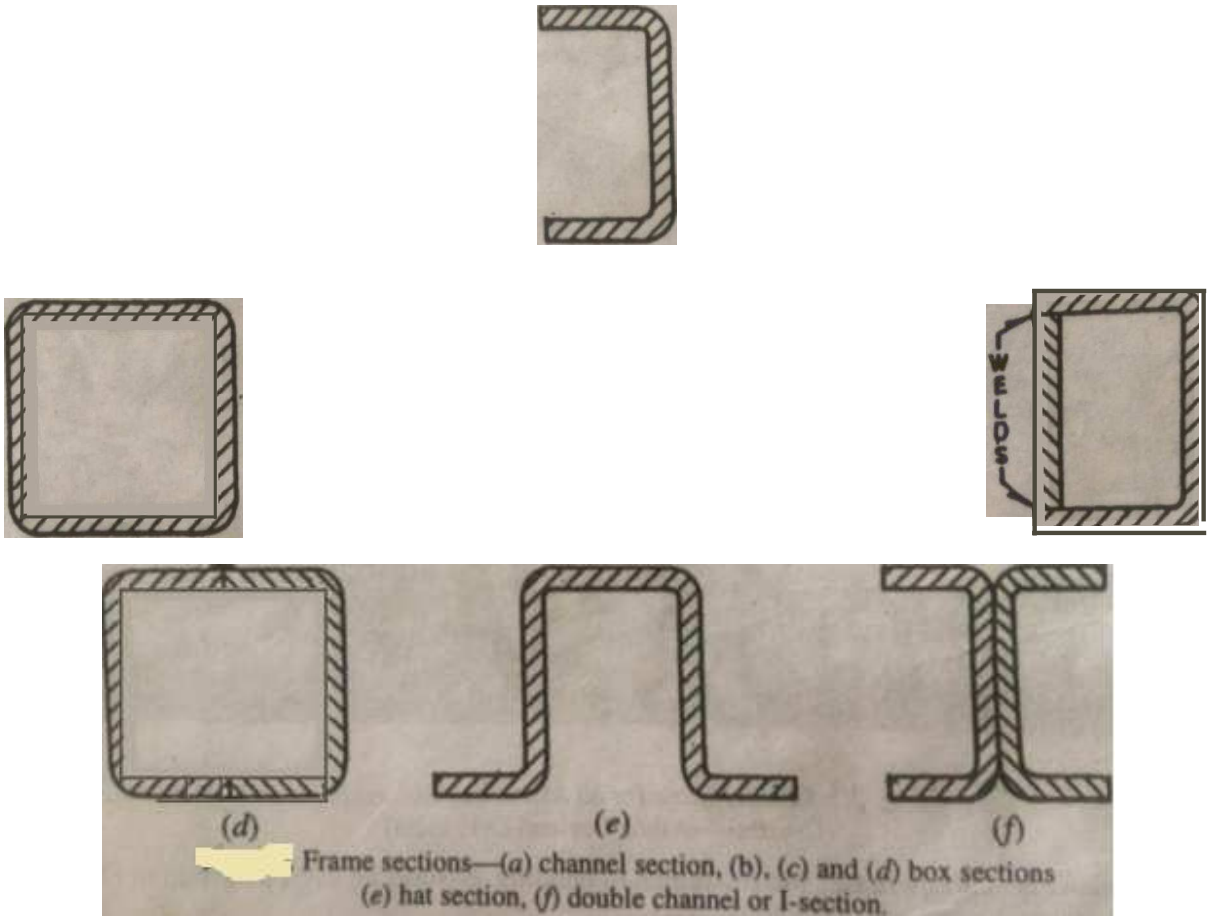


Figure 1.6. Frame Sections

A double frame increases the resistance to bending, ensures an even distribution of the load on the chassis frame and eliminates the need for a sub frame. The Channel section and square box section have bending stiffness as compared to solid square with equal cross-sectional area whose stiffness taken as 1. Due to this reason, both these sections are used extensively for side member. Sometimes the box section is formed by welding a plate to a channel section or by welding two channel section, for cross member. For heavy duty applications, side members may be formed by placing two channel sections back to back.

Articulated Vehicle

This is also heavy goods vehicle consisting of a tractor and semi-trailer. The tractor provides the motive power while the trailer carries the goods. The two units are connected together by means of a fifth-wheel coupling. This type of vehicle has smaller turning circle than the rigid truck. Moreover, the trailer being detachable, the tractor can directly move off after reaching destination with some other trailer unit without having to wait for unloading and reloading.

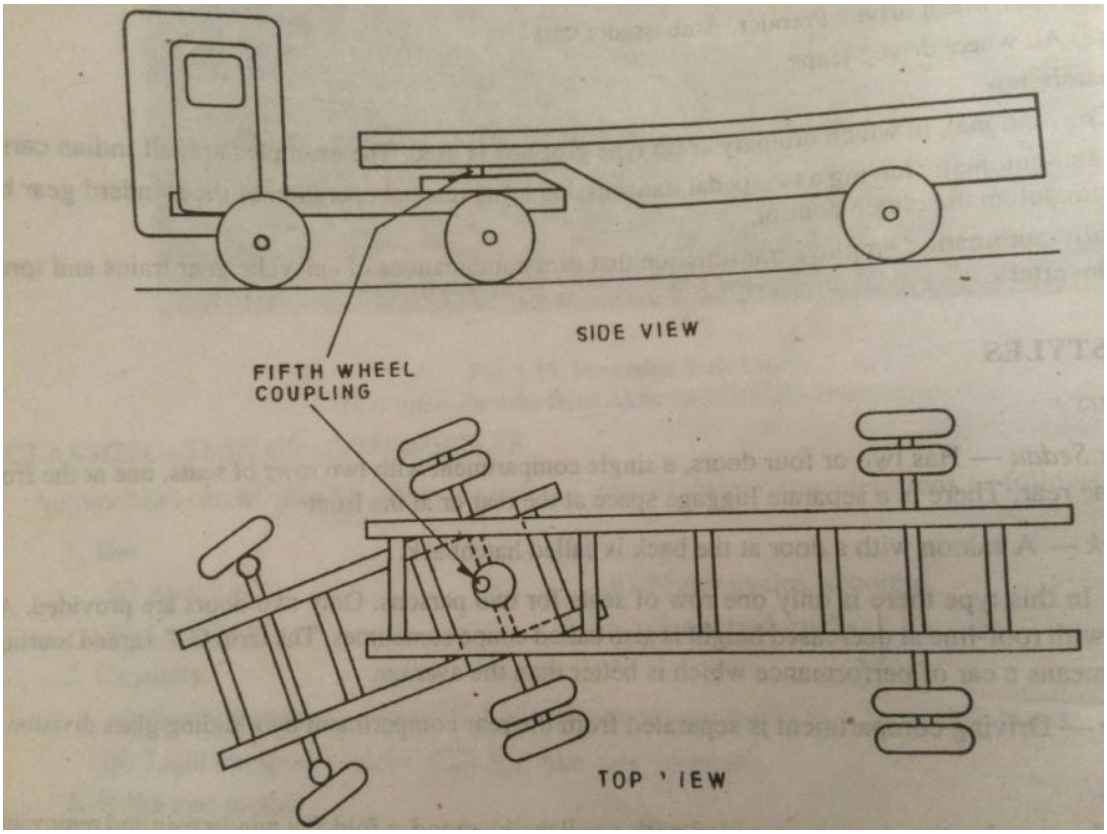


Figure 1.7. Articulated Vehicle

ENGINES

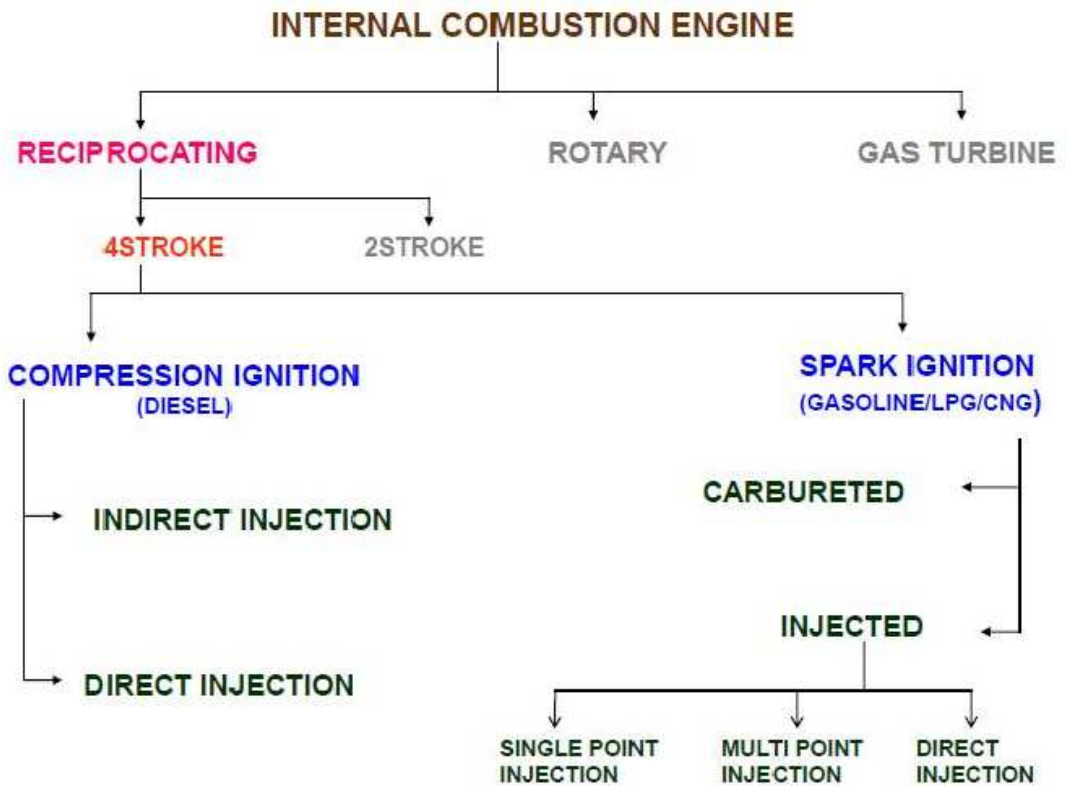
Definition of 'Engine'

An engine is a device, which transforms one form of energy into another form. Normally, most of the engines convert thermal energy into mechanical work and therefore they are called 'heat engines'.

Heat engines can be broadly classified into two categories:

Internal Combustion Engines (IC Engines)

External Combustion Engines (EC Engines)



External Combustion and Internal Combustion Engines

External combustion engines are those in which combustion takes place outside the engine whereas in internal combustion engines combustion takes place within the engine. For example, in a steam engine or a steam turbine, the heat generated due to the combustion of fuel is employed to generate high pressure steam, which is used as the working fluid in a reciprocating engine or a turbine. In case of gasoline or diesel engines, the products of combustion generated by the combustion of fuel and air within the cylinder form the working fluid.

Application of IC and EC Engines IC Engines

Gasoline Engine –Automotive, Marine Aircraft

Diesel Engine - Automotive, Marine, Power, Locomative

Gas Engines –Industrial Power

EC Engines

Steam Engines – Locomotives, Marine

Steam Turbine – Power, Large Marine

Classification of Internal Combustion Engines Internal Combustion engines are of two types,

Rotary engines

Reciprocating engines

- Two stroke & four stroke engines
- Petrol & diesel engines

TERMS CONNECTED WITH I.C. ENGINES

Bore: The inside diameter of the cylinder is called bore

Stroke: The linear distance along the cylinder axis between two limiting position s is called stroke.

Top Dead Center (T.D.C.) : the top most position of the piston towards cover end side of the cylinder is called T.D.C.

Bottom dead Center (B.D.C.) : The lowest position of the piston towards the crank end side of the cylinder is called B.D.C.

Clearance Volume : The volume contained in the cylinder above the top of the piston , when the piston is at top dead center , is called the clearance volume.

Swept Volume: The volume swept through by the piston in moving between T.D.C. and B.D.C, is called swept volume or piston displacement.

Compression Ratio: It is the ratio of Total cylinder volume to clearance volume

PETROL ENGINE:

CONSTRUCTION DETAILS

Basic Engine Components and Nomenclature

Even though reciprocating internal combustion engines look quite simple, they are highly complex machines. There are hundreds of components that have to perform their functions

satisfactorily to produce output power. There are two types of engines, viz., spark ignition (S1) and compression-ignition (CI) engine. Let us now go through the important engine components and the nomenclature associated with an engine.

Engine Components

The major components of the engine and their functions are briefly described below.

Cylinder Block:

The cylinder block is the main supporting structure for the various components. The cylinder of a multi-cylinder engine is cast as a single unit, called cylinder block. The cylinder head is mounted on the cylinder block. The cylinder head and cylinder block are provided with water jackets in the case of water-cooling with cooling fins in the case of air-cooling. Cylinder head gasket is incorporated between the cylinder block and cylinder head. The cylinder head is held tight to the cylinder block by number of bolts or studs. The bottom portion of the cylinder block is called crankcase. A cover called crankcase, which becomes a sump for lubricating oil is fastened to the bottom of the crankcase. The inner surface of the cylinder block, which is machined and finished accurately to cylindrical shape, is called bore or face.

Cylinder

As the name implies it is a cylindrical vessel or space in which the piston makes a reciprocating motion. The varying volume created in the cylinder during the operation of the engine is filled with the working fluid and subjected to different thermodynamic processes. The cylinder is supported in the cylinder block.

Piston

It is a cylindrical component fitted into the cylinder forming the moving boundary of the combustion system. It fits perfectly (snugly) into the cylinder providing a gas-tight space with the piston rings and the lubricant. It forms the first link in transmitting the gas forces to the output shaft.

Combustion Chamber

The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber. The combustion of fuel and the consequent release of thermal energy results in the building up of pressure in this part of the cylinder.

Inlet Manifold

The pipe which connects the intake system to the inlet valve of the engine and through which air or air-fuel mixture is drawn into the cylinder is called the inlet manifold.

Exhaust Manifold

The pipe that connects the exhaust system to the exhaust valve of the engine and through which the products of combustion escape into the atmosphere is called the exhaust manifold.

Inlet and Exhaust Valves

Valves are commonly mushroom shaped poppet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder (inlet valve) and for discharging the products of combustion (exhaust valve) from the cylinder.

Connecting Rod

It interconnects the piston and the crankshaft and transmits the gas forces from the piston to the crankshaft. The two ends of the connecting rod are called as small end and the big end. Small end is connected to the piston by gudgeon pin and the big end is connected to the crankshaft by crankpin.

Crankshaft

It converts the reciprocating motion of the piston into useful rotary motion of the output shaft. In the crankshaft of a single cylinder engine there is pair of crank arms and balance weights. The balance weights are provided for static and dynamic balancing of the rotating system. The crankshaft is enclosed in a crankcase.

Piston Rings

Piston rings, fitted into the slots around the piston, provide a tight seal between the piston and the cylinder wall thus preventing leakage of combustion gases

Gudgeon Pin

It forms the link between the small end of the connecting rod and the piston.

Camshaft

The camshaft and its associated parts control the opening and closing of the two valves. The associated parts are push rods, rocker arms, valve springs and tappets. This shaft also provides the drive to the ignition system. The camshaft is driven by the crankshaft through timing gears.

Cams

These are made *as* integral parts of the camshaft and are designed in such a way to open the valves at the correct timing and to keep them open for the necessary duration.

Fly Wheel

The net torque imparted to the crankshaft during one complete cycle of operation of the engine fluctuates causing a change in the angular velocity of the shaft. In order to achieve a uniform torque an inertia *mass* in the form of a wheel is attached to the output shaft and this wheel is called the flywheel.

Two-stroke Engine

As already mentioned, if the two unproductive strokes, viz., the suction and exhaust could be served by an alternative arrangement, especially without the movement of the piston then there will be a power stroke for each revolution of the crankshaft. In such an arrangement, theoretically the power output of the engine can be doubled for the same speed compared to a four-stroke engine. Based on this concept, Dugald Clark (1878) invented the two-stroke engine.

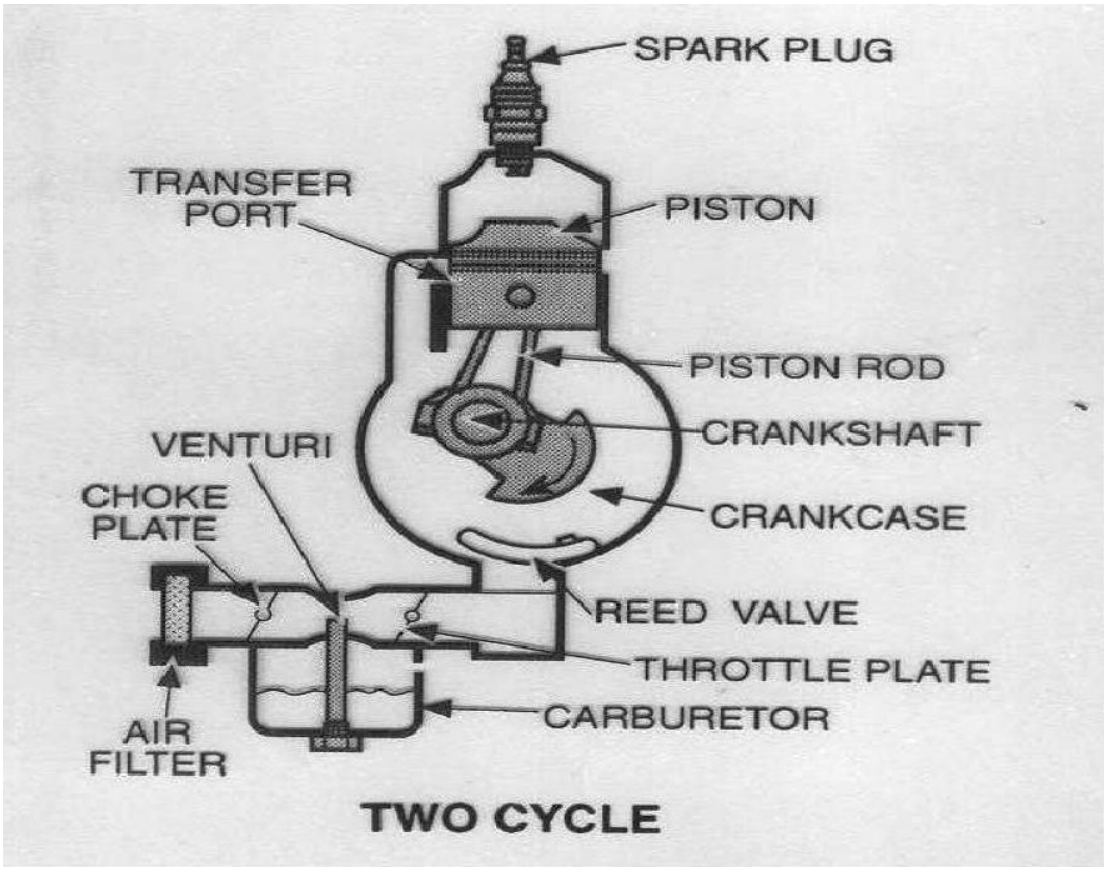


Figure 1.8. Two Stroke Cycle Engine

In two-stroke engines the cycle is completed in one revolution of the crankshaft. The main difference between two-stroke and four stroke engines is in the method of filling the fresh charge and removing the burnt gases from the cylinder. In the four-stroke engine these operations are performed by the engine piston during the suction and exhaust" strokes respectively. In a two-stroke engine, the filling process is accomplished by the charge compressed in crankcase or by a blower. The induction of the compressed charge moves out the product of combustion through exhaust ports. Therefore, no piston strokes are required for these two operations. Two strokes are sufficient to complete the cycle, one for compressing the fresh charge and the other for expansion or power stroke.

Figure shows one of the simplest two-stroke engines, viz., the crankcase scavenged engine. The air or charge is inducted into the crankcase through the spring loaded inlet valve when the pressure in the crankcase is reduced due to upward motion of the piston during compression stroke. After the compression and ignition, expansion takes place in the usual way. During the expansion stroke the charge in the crankcase is compressed. Near the end of the expansion stroke, the piston uncovers the exhaust ports and the cylinder pressure drops to atmospheric pressure as the combustion products leave the cylinder. Further movement of the piston uncovers

the transfer ports, permitting the slightly compressed charge in the crankcase to enter the engine cylinder.

The top of the piston has usually a projection to deflect the fresh charge towards the top of the cylinder before flowing to the exhaust ports. This serves the double purpose of scavenging the upper part of the cylinder of the combustion products and preventing the fresh charge from flowing directly to the exhaust ports. The same objective can be achieved without piston deflector by proper shaping of the transfer port. During the upward motion of the piston from *B* DC the transfer ports close first and then the exhaust ports close when compression of the charge begins and the cycle is repeated.

Comparison of Four-stroke and Two-stroke Engines

The two-stroke engine was developed to obtain a greater output from the same size of the engine. The engine mechanism also eliminates the valve arrangement making it mechanically simpler. Almost all two-stroke engines have no conventional valves but only ports (some have an exhaust valve). This simplicity of the two-stroke engine makes it cheaper to produce and easy to maintain. Theoretically a two-stroke engine develops twice the power of a comparable four stroke engine because of one power stroke every revolution (compared to one power stroke every two revolutions of a four-stroke engine). This makes the two-stroke engine more compact than a comparable four-stroke engine. In actual practice power output is not exactly doubled but increased by only about 30% because of Reduced effective expansion stroke and Increased heating caused by increased number of power strokes that limits the maximum speed.

The other advantages of the two-stroke engine are more uniform torque on crankshaft and comparatively less exhaust gas dilution. However, when applied to the spark-ignition engine the two stroke cycle has certain disadvantages which have restricted its application to only small engines suitable for motor cycles, scooters, lawn mowers, outboard engines etc. In the SI engine, the incoming charge consists of fuel and air. During scavenging, as both inlet and exhaust ports are open simultaneously for some time, there is a possibility that some of the fresh charge containing fuel escapes with the exhaust. This results in high fuel consumption and lower thermal efficiency. The other drawback of two-stroke engine is the lack of flexibility, viz., the capacity to operate with the same efficiency at all speeds. At part throttle operating condition, the amount of fresh mixture entering the cylinder is not enough to clear all the exhaust gases and a part of it remains in the cylinder to contaminate the charge. This results in irregular operation of the engine. The two-stroke diesel engine does not suffer from these defects. There is no loss of fuel with exhaust gases as the intake charge in diesel engine is only air. The two- stroke diesel engine is used quite widely. Many of the high output diesel engines work on this cycle. A disadvantage common to all two-stroke engines, gasoline as well as diesel, is the greater cooling and lubricating oil requirements due to one power stroke in each revolution of the crankshaft. Consumption of lubricating oil is high in two-stroke due to higher temperature.

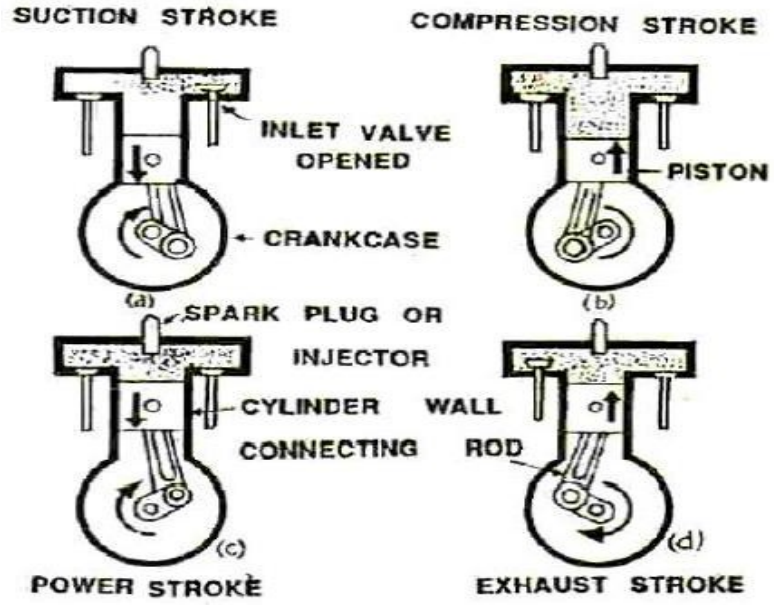


Figure 1.9. Four Stroke Engine

Emissions and Pollutants

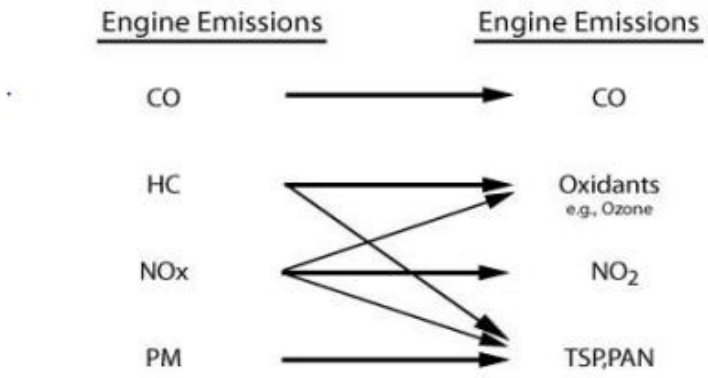


Figure 1.10. Major Pollutants from Engine Emissions

Engine emissions undergo chemical reactions in atmosphere known largely as 'photochemical' reactions and give rise to other chemical species which are hazardous to health and environment. Linkage of engine emissions and air pollutants is shown in Figure. Health Effects of Air Pollutants The effect of pollutants on human health depends on pollutant concentration in the ambient air and the duration to which the human beings are exposed. Adverse health effects of different pollutants on human health are given in Table for short term and long term exposures. Carbon monoxide on inhalation is known to combine with hemoglobin at a rate 200 to 240 times faster than oxygen thus reducing oxygen supply to body tissues and results in CO intoxication. Nitrogen oxides get dissolved in mucous forming nitrous and nitric acids causing

irritation of nose throat and respiratory tract. Long term exposure causes nitrogen oxides to combine with haemoglobin and destruction of red blood cells. Long term exposure resulting in more than 10% of haemoglobin to combine with nitrogen oxides causes bluish coloration of skin, lips fingers etc.

Pollutants	Short-term health effects	Long-term health effects
Carbon monoxide	Headache, shortness of breath, dizziness, impaired judgment, lack of motor coordination	Effects on brain and central nervous system, nausea, vomiting, cardiac and pulmonary functional changes, loss of consciousness and death
Nitrogen dioxide	Soreness, coughing, chest discomfort, eye irritation	Development of cyanosis especially at lips, fingers and toes, adverse changes in cell structure of lung wall
Oxidants	Difficulty in breathing, chest tightness, eye irritation	Impaired lung function, increased susceptibility to respiratory function
Ozone	Similar to those of NO2 but at a lower concentration	Development of emphysema, pulmonary edema
Sulfates	Increased asthma attacks	Reduced lung function when oxidants are present
TSP/Respirable suspended particulate	Increased susceptibility to other pollutants	Many constituents especially poly-organic matter are toxic and carcinogenic, contribute to silicosis, brown lung

Effect of Pollutants on Environment:

a. **Unburned Hydro Carbons (UBHC):** The major sources of UBHC in an automobile are the engine exhaust, evaporative losses from fuel system blow by loss and scavenging in case of 2-stroke petrol engines. Unburned or partially burned hydrocarbons in gaseous form combine with oxides of nitrogen in the presence of sunlight to form photochemical smog The products of photochemical smog cause watering and burning of the eyes and affect the respiratory system, especially when the respiratory system is marginal for other reasons. Some of the high molecular weight aromatic hydrocarbons have been shown to be carcinogenic in animals. Some of the unburned hydrocarbons also serve as particulate matter in atmosphere.

b. **Carbon monoxide:** Carbon monoxide is formed during combustion in engine only when there is insufficient supply of air. The main source is the engine exhaust. The toxicity of carbon monoxide is well known. The haemoglobin the human blood which carries oxygen to various parts of the body has great affinity towards carbon monoxide than for oxygen. When a human is exposed to an atmosphere containing carbon monoxide, the oxygen carrying capacity of the blood is reduced and results in the formation of carboxyl haemoglobin. Due to this the human is subjected to various ill effects and ultimately leads to death. The toxic effects of carbon monoxide are dependent both on time and concentration as shown in the diagram.

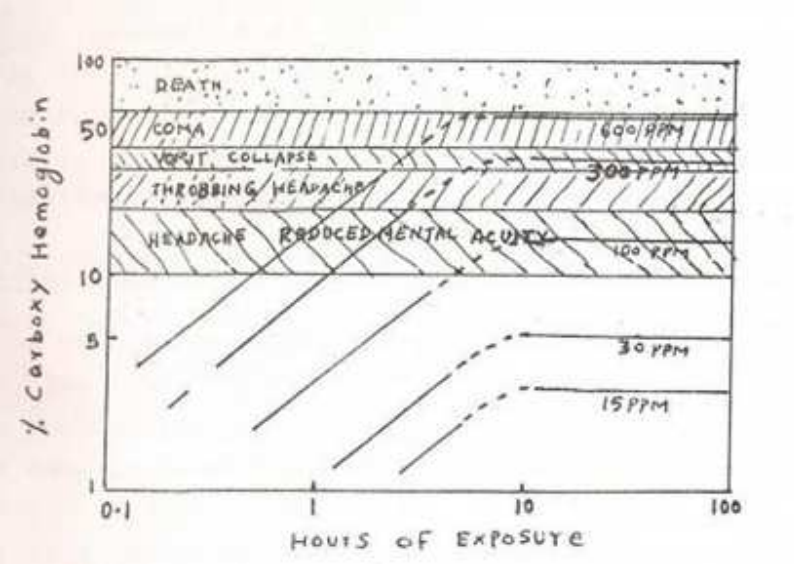


Figure 1.11. Toxicity of Carbon Monoxide

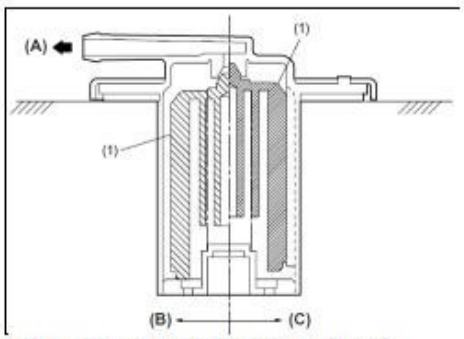
Oxides of nitrogen(NO, NO2, N2O2etc)are formed at higher combustion temperature present in engines and the engine exhaust is the major source. Like carbon monoxide, oxides of nitrogen also tend to settle on the haemoglobin in blood. Their most undesirable effect is their tendency to join with moisture in the lungs to form dilute nitric acid. Because the amounts formed are minute and dilute, their effect is very small but over a long period of time can be cumulatively undesirable, especially when the respiratory problems for other reasons are found.

Particulates: Particulate matter comes from hydrocarbons ,lead additives and sulphur dioxide. If lead is used with the fuel to controlcombustionalmost70% of the lead is airborne with the exhaust gasses. In that30%ofthe particulates rapidly settle to the ground while remaining remains in the atmosphere. Lead is well known toxic compound.

Exhaust emissions : Almost all of 100% of NOx and CO, and 60% of HC are emitted through the engine exhaust or vehicle tailpipe Crankcase emissions: About 20% of HC are emitted via crankcase blow by gases Evaporative Emissions: Fuel evaporation from tank, fuel system, carburettor and permeation through fuel lines constitute another 20% of total HC Exhaust Emission Concentrations SI Engine (Gasoline fuelled) Depending upon engine operating conditions without catalytic control engine out emissions range : CO 0.2 to 5% by volume (v/v) HC 300 to 6000 ppmc1*, v/v NOx 50 to 2000 ppm, v/v *ppmc1= parts per million as methane measured by Flame Ionization Analyzer/Detector(FIA or FID) CO emissions are high under engine idling and full load operation when engine is operating on fuel rich mixtures. HC emissions are high under idling, during engine warm-up and light load operation, acceleration and deceleration. NOx are maximum under full engine load conditions.

CO	0.03 to 0.1 %, v/v
HC	20 to 500 ppmc1
NOx	100 -2000 ppm
PM	0.02 to 0.2 g/m3 (0.2 to 0.5% of fuel consumption bymass)

Modern Evaporative Emission Control Device A-Fuel Cut Valve



(1) Float (A) To canister (B) Valve open (C) Valve closed

Figure 1.12. Fuel Cut Valve

The fuel cut valve is built onto the evaporation pipe of the fuel tank. The rising level of the fuel in the fuel tank causes the float to move up and close the cap hole so that no fuel can flow to the evaporation line.

B-Fuel Tank Cap

The fuel tank cap has a relief valve which prevents development of vacuum in the fuel tank in the event of a problem with the fuel vapour line. When there is no problem with the fuel vapour line, the filler pipe is sealed at the portion (A) and by the seal pressed against the filler pipe end. If vacuum develops in the fuel tank, the atmospheric pressure forces the spring down to open the valve; consequently outside air flows into the fuel tank, thus controlling the inside pressure.

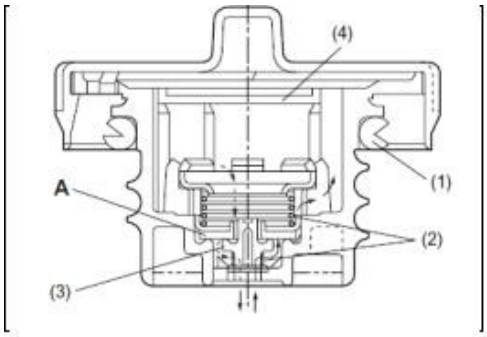
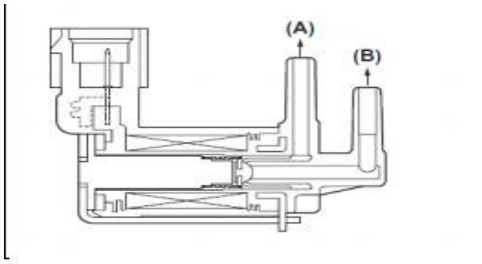


Figure 1.13. Fuel Tank Cap

Purge Control Solenoid Valve

The purge control solenoid valve is on the evaporation line between the canister and intake manifold. The valve is installed under the intake manifold.

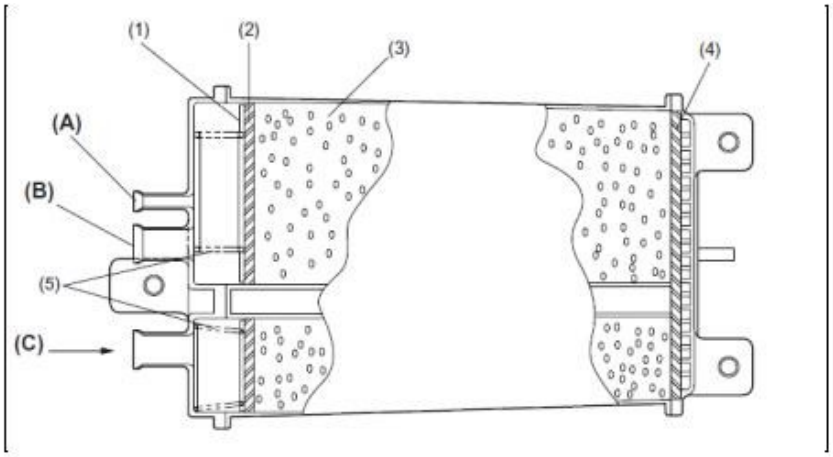


A- To Canister, B- To intake manifold

Figure 1.14. Fuel Tank Cap

Charcoal Canister

The charcoal filled in the canister temporarily stores fuel vapours. When the purge control solenoid valve is opened by a signal from the ECM, the external fresh air entering the canister carries the fuel vapours into the intake manifold.



(1) Grid
(2) Filter
(3) Activated charcoal
(4) Filter
(5) Spring

(A) To purge control solenoid valve
(B) From fuel tank
(C) Air

Figure 1.15. Charcoal Canister

Positive Crankcase Ventilation

The principle of PCV system

All the gas engines have crankcase ventilation equipment. There are two kinds of crankcase ventilation types: natural ventilation and positive ventilation. Figure shows the first type. It is dependent on the back pressure which formed when automobile is running, so the crankcase's inner mixture gas can be extracted and fresh air can be entered by means of air cleaner and throttling valve at the exit of exhaust pipe. Because natural ventilation type is not good for environment, so the PCV system can be used on gas engine widely.

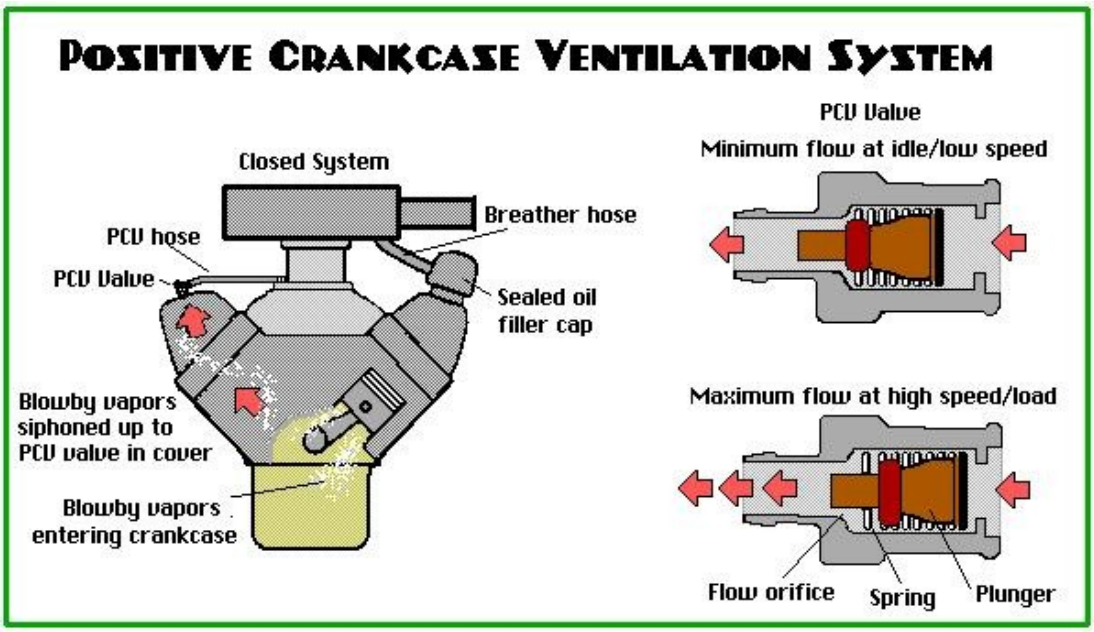


Figure 1.16. Positive Crankcase Ventilation

Positive Crankcase Ventilation is a system that was developed to remove harmful vapours from the engine and to prevent those vapours from being expelled into the atmosphere. The PCV system does this by using manifold vacuum to draw vapours from the crankcase into the intake manifold. Vapour is then carried with the fuel/air mixture into the combustion chambers where it is burned. The flow or circulation within the system is controlled by the PCV Valve. The PCV Valve is effective as both a crankcase ventilation system and as a pollution control device. PCV systems have been standard equipment on all new cars since the early sixties. Prior to 1963 PCV was only used in California. There are a variety of PCV systems used on various makes and models of cars produced since 1963, but all function essentially the same. PCV systems can be described as either open or closed. The two systems are quite similar. However, the closed system in use since 1968 is more effective at air pollution control. The systems differ in the manner in which fresh air enters the crankcase and excessive vapour is expelled.

Open PCV Systems The open system draws fresh air though vented oil filler cap. This presents no problem as long as the vapour volume is minimal. However, when the crankcase vapour becomes excessive it is forced back through the vented oil filler cap and into the open atmosphere. The open PCV system, though successful at removing contaminated vapours from the crankcase, is not completely effective as a pollution control device. Closed PCV Systems The closed PCV system draws fresh air from the air filter housing. The oil filler cap in this system is NOT vented. Consequently, excess vapour will be carried back to the air filter housing and from there into the intake manifold. The closed system prevents vapour, whether normal or excessive, from reaching the open atmosphere. The closed system is very effective as an air pollution control device.

Evaporative Emission control:

Construction and Operation

1) Refuelling Valve The refuelling valve consists of chamber A, chamber B, and the restrictor passage. A constant atmospheric pressure is applied to chamber A. During refuelling, the internal pressure of the fuel tank increases. This pressure causes the refuelling valve to lift up, allowing the fuel vapours to enter the charcoal canister. The restrictor passage prevents the large amount of vacuum that is created during purge operation or system monitoring operation from entering the fuel tank, and limits the flow of the vapour gas from the fuel tank to the charcoal canister. If a large volume of vapour gas recirculates into the intake manifold, it will affect the air-fuel ratio control of the engine. Therefore, the role of the restrictor passage is to help prevent this from occurring.

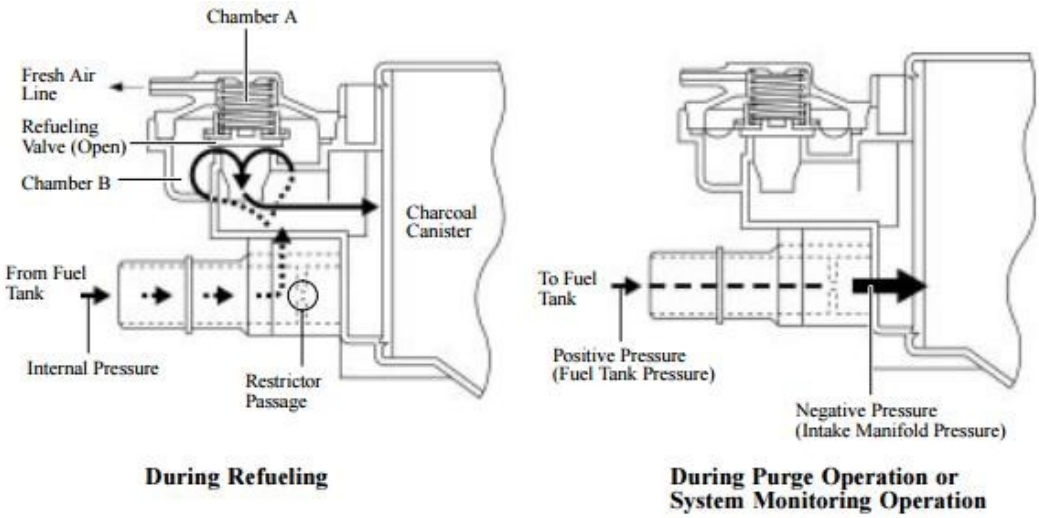


Figure 1.17. Refueling

Pump module

Pump module consists of the canister vent valve, pressure sensor, vacuum pump, and pump motor. The canister vent valve switches the passages in accordance with the signals received from the ECM. A DC type brushless motor is used for the pump motor. A vane type vacuum pump is used. D13N16 D13N15 Pressure Sensor Charcoal Canister Fresh Air Fresh Air Canister Vent Valve Pressure Sensor.

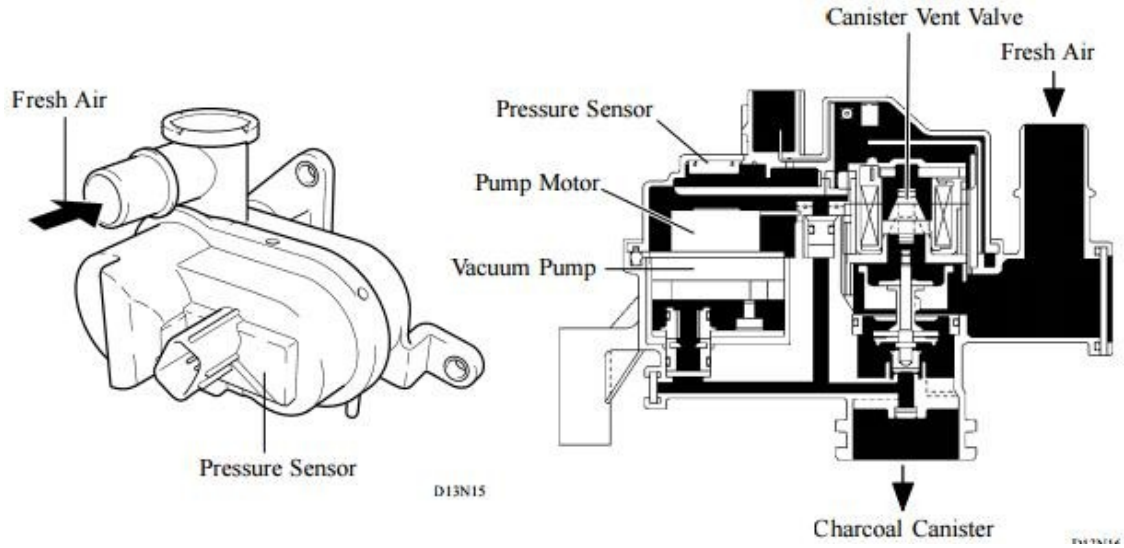


Figure 1.18. Pump Module

Purge Flow Control

When the engine has reached predetermined parameters (closed loop, engine coolant temp. above 80°C (176°F), etc), stored fuel vapours are purged from the charcoal canister whenever the EVAP valve is opened by the ECM. The ECM will change the duty ratio cycle of the EVAP valve, thus controlling purge flow volume. Purge flow volume is determined by intake manifold pressure and the duty ratio cycle of the EVAP valve. Atmospheric pressure is allowed into the charcoal canister to ensure that purge flow is constantly maintained whenever purge vacuum is applied to the charcoal canister.

Catalytic converter

The catalytic converter assembly consists most of these components, inlet/outlet pipes/flanges, steel housing, insulation material, seals, inlet/outlet cones, substrate(s), coating and sensor boss.

- A steel housing provides protection and structure support for substrate; insulation material (mat or wire mesh) provides heat insulation and support between steel housing and substrate; seals are there to protect mat material from been burned by the exhaust gas.

The substrate is often called a "catalyst support". It is a ceramic honeycomb or a stainless steel foil honeycomb in modern catalytic converters. The ceramic substrate was invented by Rodney

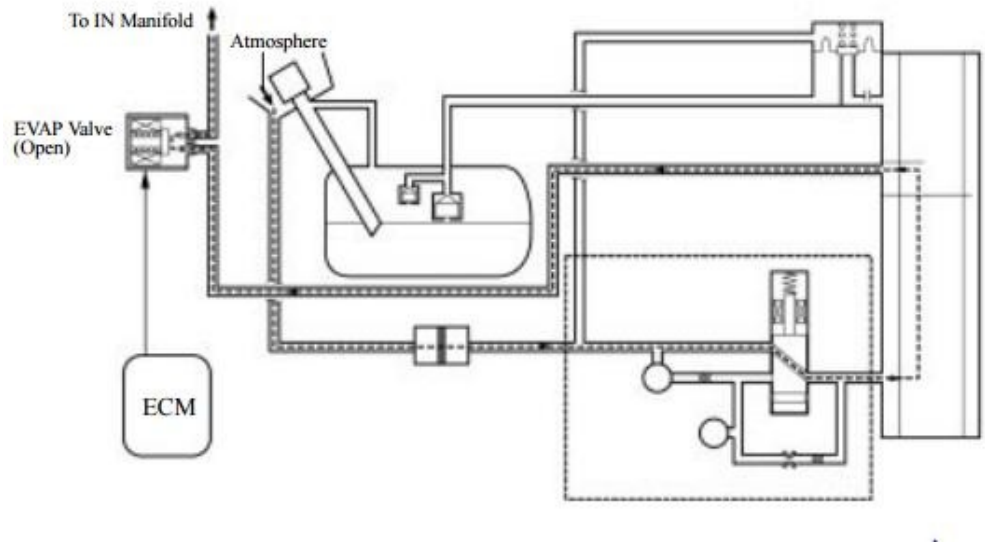


Figure 1.19. Purge Flow Control

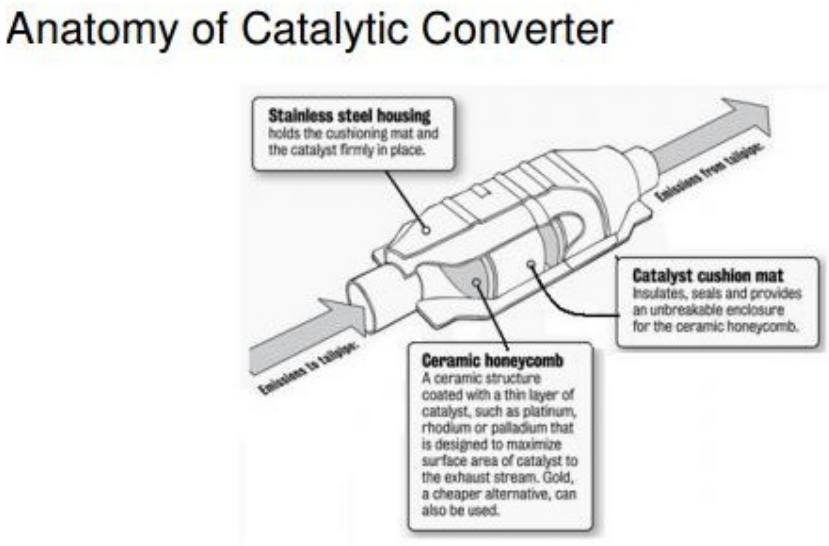


Figure 1.20. Principle of Catalytic convertor

- Bagley, Irwin Lachman and Ronald Lewis at Corning, in use to increases the amount of surface area available to support the catalyst.
- The washcoat is used to make converters more efficient, often as a mixture of silica and alumina. When a washcoat is added to the substrate, it forms a rough, irregular surface, which has a far greater surface area than the flat core surfaces do, which then gives the substrate a larger surface area, providing more sites for active precious metal – the catalytic which is added to the washcoat (in suspension) before being applied to the substrate.
- The catalyst itself is most often a precious metal. Platinum is the most active catalyst and is widely used. However, because of unwanted additional reactions and/or cost, Palladium and rhodium are two other precious metals that are used. Platinum and rhodium are used as a reduction catalyst, while platinum and palladium are used as an oxidization catalyst.

Cerium, iron, manganese and nickel are also used, although each has its own limitations. There are several well known canning methods that are available in production in automotive industry. Clamshell or Shoebox – It's just what the word is, the converter can has a upper and a lower two piece structure, they are welded together in the fixture with substrate and the supporting mat mount material sandwiched between them.

- Stuffed – This application is usually a round shape. The catalytic substrate is pre-wrapped with supporting mat material and stuff (pushed with a tool) into the shell (tube), which has smaller diameter than the diameter of supporting mat wrapped substrate.
- Swaged – This application usually is also a round shape. The catalytic substrate is rewrapped with supporting mat material and placed (pushed with a tool) into the shell (tube), which has bigger diameter than the diameter of supporting mat wrapped substrate, then the shell diameter is reduced with a tool (swaging machine).
- Tourniquet – Pre-wrapped substrate with supporting mat is wrapped and pulled tied with a steel sheet and is welded together by the sheet material overlapping end along the seam.

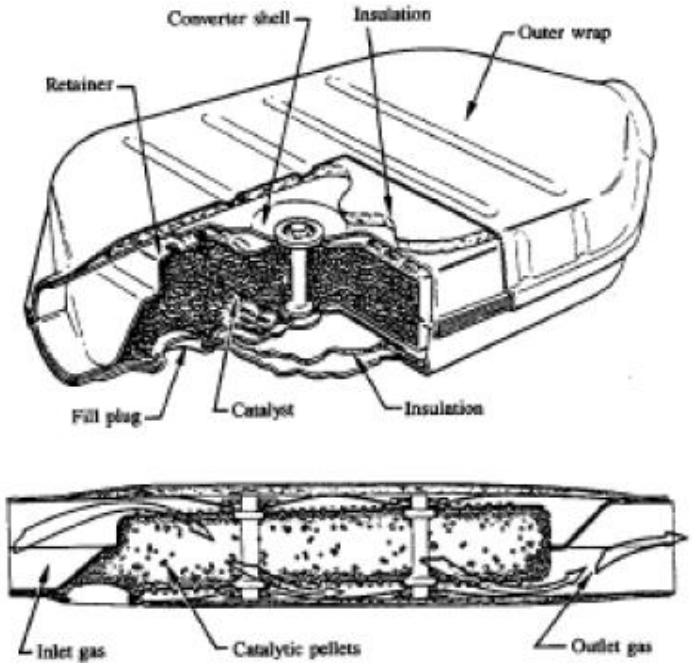


Figure 1.21. Cross section of a Catalytic convertor

- Spin-formed – Pre-measured substrate with supporting mat wrapped and pushed into the outer metal shell (tube), the tube is then fixed on the spinning machine and spinning along the axis of the substrate, and a programmed spin tool thereby forms the metal shell into shape as shown.

Two-way Converter

Two-way catalytic converter is widely used on diesel engines to reduce hydrocarbon and carbon monoxide emissions, and they were also used on spark ignition (gasoline) engines in USA market automobiles through 1981, when the two-way converter's inability to control

NOx led to its supersession by three-way converters. A two-way catalytic converter has two simultaneous tasks:

- Oxidation of carbon monoxide to carbon dioxide: 2CO + O2 → 2CO2
- Oxidation of un-burnt and partially-burnt hydrocarbons to carbon dioxide and water: CxH2x+2 + [(3x+1)/2] O2 → xCO2 + (x+1) H2O (a combustion reaction)

Three-way Converter

Since 1981, three-way catalytic converters have been used in vehicle emission control systems in North America and many other countries on road going vehicles. A three-way catalytic converter has three simultaneous tasks:

- Oxidation of carbon monoxide to carbon dioxide: 2CO + O2 → 2CO2
- Oxidation of un-burnt hydrocarbons (HC) to carbon dioxide and water: CxH2x+2 + [(3x+1)/2]O2 → xCO2 + (x+1)H2O
- Reduction of nitrogen oxides to nitrogen and oxygen: 2NOx → xO2 + N2 These three reactions occur most efficiently when the catalytic converter receives the exhaust gas from an engine running slightly above the stoichiometric point. Below shows the necessary mixing rate of the most common fuels.

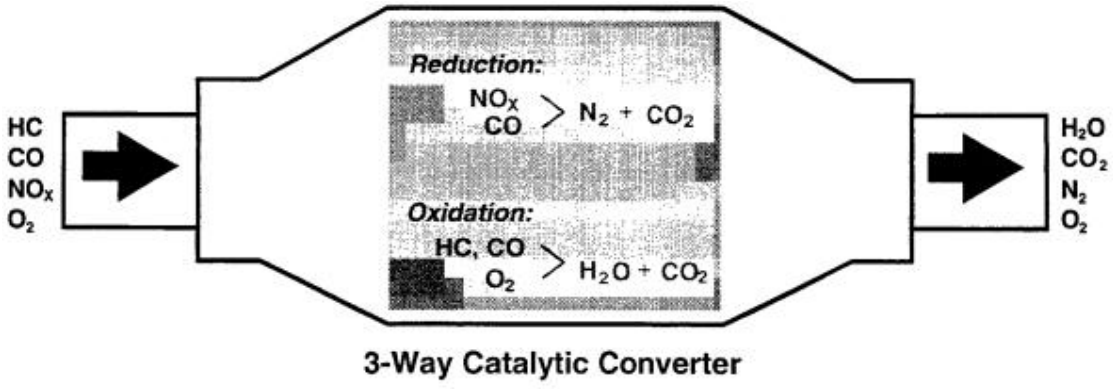


Figure 1.22. 3-Way Catalytic convertor

Diesel Particulate Filters (DPF)

Diesel particulate filters remove particulate matter found in diesel exhaust by filtering exhaust from the engine. In order to meet the stringent particulate emissions that are required for diesel light duty vehicles starting with the 2007 model year, the highest efficiency particulate filter is required. The filters are commonly made from ceramic materials such as cordierite, aluminum titanate, mullite or silicon carbide.

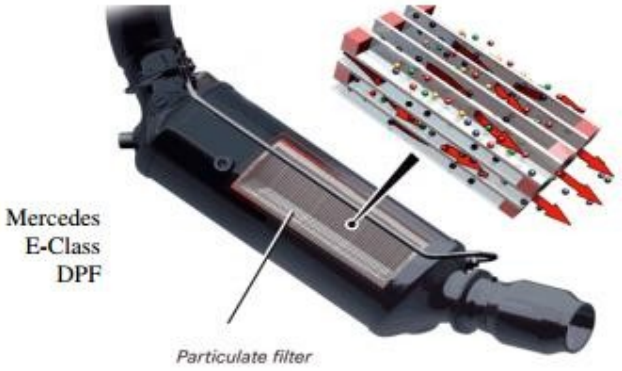


Figure 1.23. Diesel Particulate Filter

The basis for the design of wall flow filters is a honeycomb structure with alternate channels plugged at opposite ends. As the gasses passes into the open end of a channel, the plug at the opposite end forces the gasses through the porous wall of the honeycomb channel and out through the neighboring channel. The ultrafine porous structure of the channel walls results in greater than 90% percent collection efficiencies of these filters. Wall flow filters capture particulate matter by interception and impaction of the solid particles across the porous wall. The exhaust gas is allowed to pass through in order to maintain low pressure drop.

Measurement of Smoke

Smoke meters, also referred to as **opacity meters**, detect and measure the amount of light blocked in smoke emitted by diesel engines from cars, trucks, ships, buses, motorcycles, locomotives and large stacks from industrial operations. The smoke meter readout displays the smoke density giving a measure of the efficiency of combustion. This makes the smoke meter an excellent diagnostic tool to ensure proper maintenance of diesel engines for improved fuel economy and protection of the environment.

Hartridge smoke meter

The arrangement is shown in the fignre. This consists of two optically identical tubes, one containing clean air and other the moving sample of the smoke. The clean air tube is taken as reference. A light source and photo-electric cell mounted facing each other on swinging arms. Movement of the change-over knob alters their position from 0-100. indicating the light absorbed by the smoke in hartridge iuiits. A small fan blows air into the clean aii'-tube. The aii' flow the open ends of the tube across the surfaces of the light source and the photo-electric cell, to provide cooling and to protect them against sooting by the smoke.

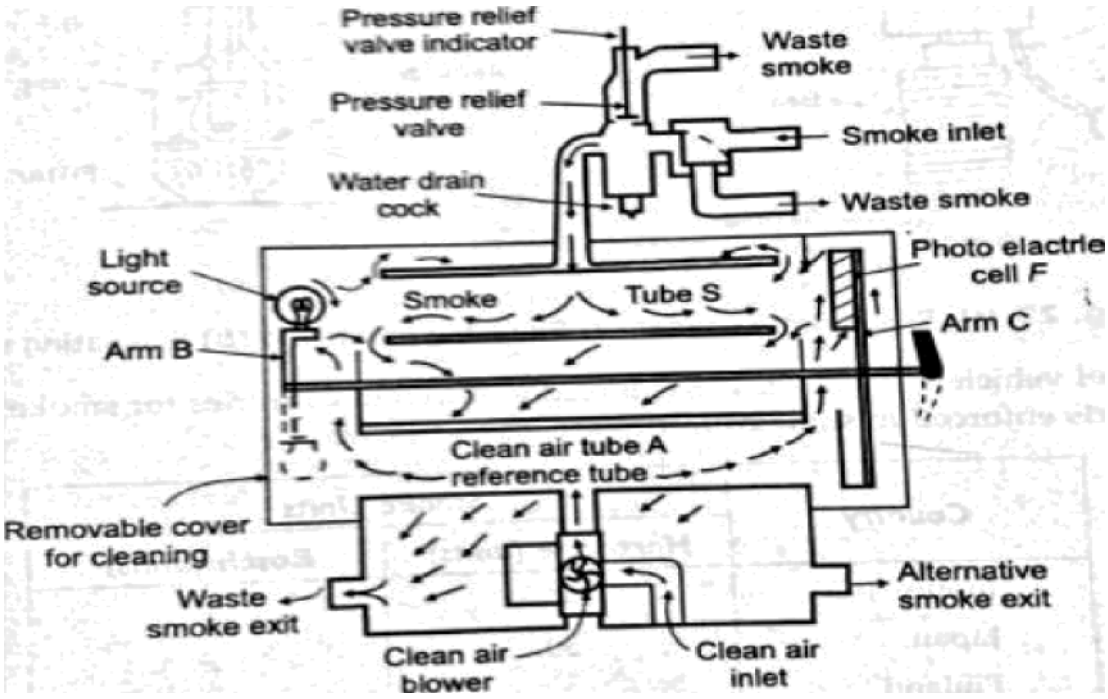


Figure 1.24. Hartridge smoke meter

The sampling probe is coiinected cial to a tapping on the exhaust pipe. The smoke meter is switched on and control lever set to bring the clean air tube between light and cell. The smoke meter dial shoiild read zero otherwise the meter is to adjusted to read zero. The control lever valve, the meter gives continuous and direct reading of the smoke density.

Bosch smoke meter

The bosch meter is widely accepted for measuring the diesel engine smoke. This concists of sampling piinip and evaluating init shown in the figure given below. The sampling pump is used to draw nearly 300CC of exhaust gas by means of spring operated pump and released by pneumatic operation of a diaphragm. The gas sample is drawn is through the filter paper' darkening to give precise assessment of the intensity of the spot. The intensity of the spot is measured on a scale of 10 arbitary units called arbitrary units, called Bosch siiioke units for white to black.

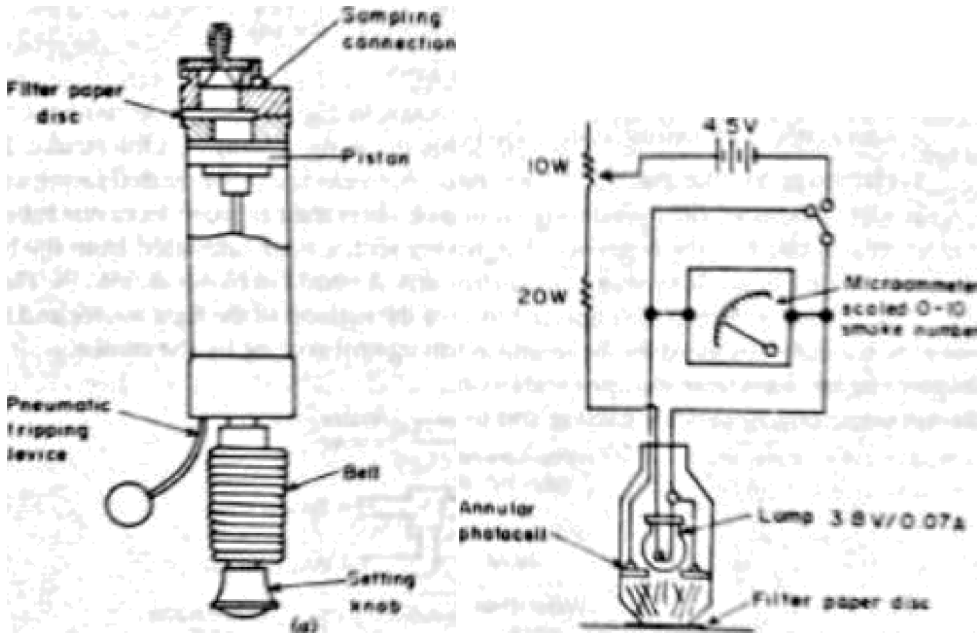


Figure 1.25. Bosch smoke meter

Method of controlling emissions:

To reduce atmospheric pollution, two different approaches are followed:

1. To reduce the formation of pollutants in the emission by redesigning the engine system, fuel system, cooling system and ignition system.
2. By destroying the pollutants after these have been fomied.

In petrol engine, the main pollutants which are objectionable and are to be reduced are HC,

CO and NOx. These methods are

a. Modifications in the engine design.

b. Modifying the fuel used.

c. Exhaust gas treatment devices.

d. Evapoiative emissive control devices.

Emission measuring equipment:

Infra-red Absorption Gas analyser for measuring CO

Principle:

Inha-red radiation is absorbed by a wide range of gas molecules, each of which has characteristics absorption specmim. Fig below shows the arrangement of this analyser. The detector cells are hlled with the gas that to be measured (CO of COC), so that they absorb the radiation in the wave length band associated with that gns. The energy absorbed in the detector cells causes the cell pressure to rise. The reference cell is present in the sample then inha-red will be absorbed in the sample cell and less infra-red will be absorbed in the detector

cell. This cell leads to a differential pressure in the detector cells which can be measured and related to the gas (CO) concentration. The calibration is carried out by passing gasses of known composition through the sample cell.

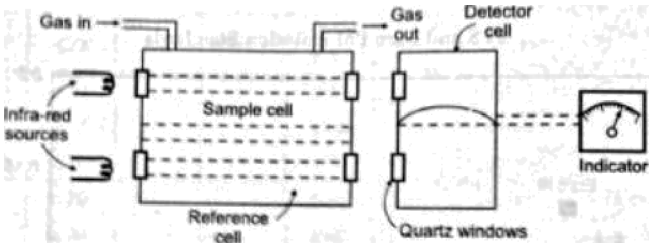


Figure 1.26. Infra-red Absorption Gas analyser

The below figure shows the absorption spectra of CO and C 2 i s shows that, infra-red radiation is absorbed by both in the region of 4.4p. This means aat when Co2 is present in the sample, it will affect the reading of CO and vice versa. This problem is eliminated by using a filter cell between the infra-red sources and the sample and reference cells. If the CO is to be measured. then the filter cell is filled with CO and any CO in the sample should not lead to any inha-red absorption. The windows of the analyser should be made of such materials fmica or euartz) which are transoarent to infra-red radiation.

Flame ionisation detector for measuring HC-emissions

Principle: When hydro-carbons are burned, electrons and positive ions are formed. If unbumed hydrocarboiis are burned in the elecnic field, then the current dow corresponds very closely to the number of carbon atoms pfeseiit.Flame ionisation detector is shown in figure given below. The sample is mixed with the fuel and burned in air. The fiiel should not cause any iouisation so a hydrogen-helium mixture is used. The air should be of high privity for reducing the risk of introducing hydrocarbons. The fuel and sample flows are to be regrrlated as the response of the iusnaunent is directly proportional to the flow rate of sample as the iiifluences the burner temperature. The dow is regulated by maintaining fixed pressure difference across the device.

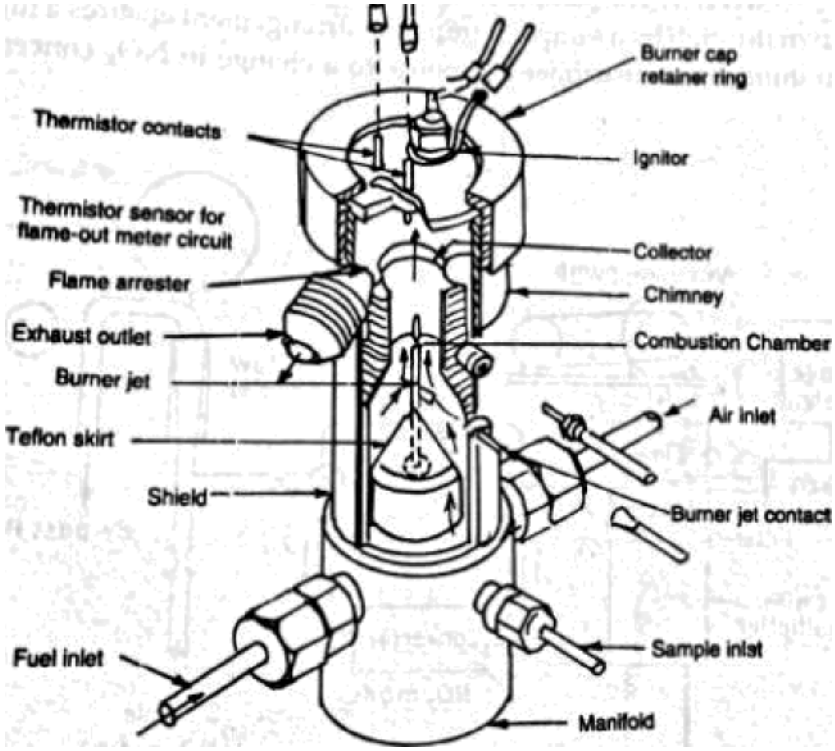


Figure 1.27. Flame ionisation detector

The buiuer jet aiid annular collector from the electrodes and a potential of aborit 100V is applied between them. The signals are mnplified and calibration is achieved by zeroing instrument with a sample containing pure N2

Chemiluminescence of measuring NO:

Principle: Chemiluminescence techniqiie depends on the emission of light. NO (uifiic oxide) reacts with 03 to produce NO, in activated NO, which emits in due course as it converts to noimnl state (NOT).

The below figure represents the key element of NO,, (NO + NOT analyser. The vacuum pump controls the pressure a ae reaction chamber and responsible for drawing in O, and exhaust sample. The O, is generated by an electric discharge in Ot at low pressure and flow of O3 is controlled by O2 supply pressure and the critical dow orifice. The sample can be either by-pass or flow through the N 2-convenor. The sample flow rate is regulated by two critical flow rate orifices. The bypass How is dmwn through by a sample pump. This arrangement ensures a high dow rate of sample gas, so as to minimise the insmiinent response to change in NO concentration in the sample.

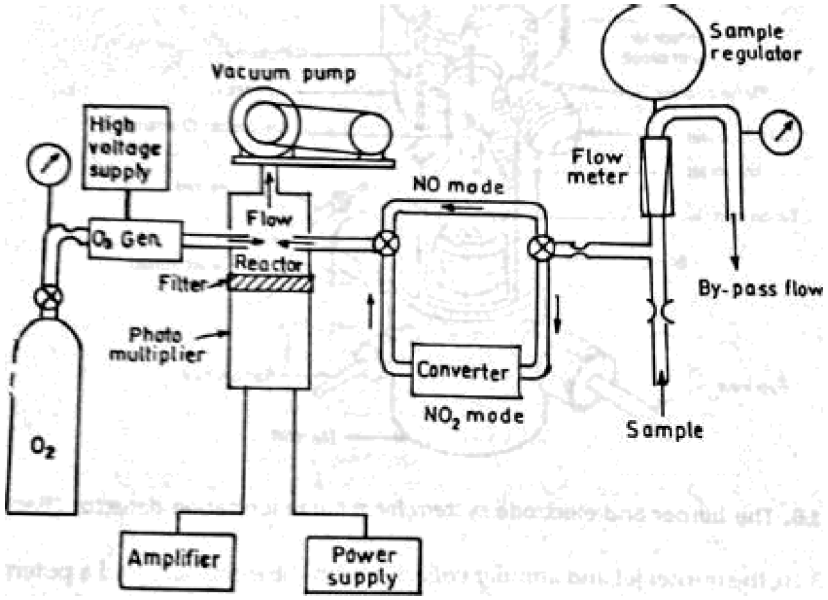


Figure 1.28. Chemiluminescence detector

The flow of the sample into the reactor is controlled by the pressure differential across the critical flow orifice upstream of the NOT converter. This pressure differential is controlled by a differential pressure regulator. The light emission in the reactor is measured by a photo multiplier and then amplified.

Exhaust Gas Recirculation

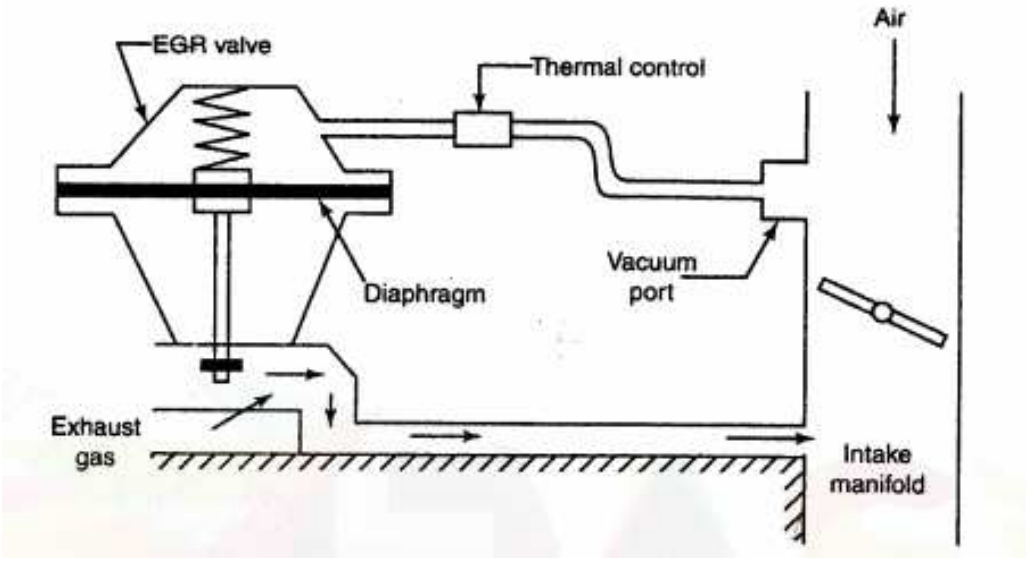


Figure 1.29. Exhaust Gas Recirculation

In internal combustion engines, exhaust gas recirculation (EGR) is a nitrogen oxide (NO*x*) emissions reduction technique used in petrol/gasoline and diesel engines. EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. This dilutes the O_2 in the incoming air stream and provides gases inert to combustion to act as absorbents

of combustion heat to reduce peak in-cylinder temperatures. NO_x is produced in high temperature mixtures of atmospheric nitrogen and oxygen that occur in the combustion cylinder, and this usually occurs at cylinder peak pressure. Another primary benefit of external EGR valves on a spark ignition engine is an increase in efficiency, as charge dilution allows a larger throttle position and reduces associated pumping losses.

In a gasoline engine, this inert exhaust displaces some amount of combustible charge in the Cylinder, effectively reducing the quantity of charge available for combustion without affecting the air-fuel ratio. In a diesel engine, the exhaust gas replaces some of the excess oxygen in the pre-combustion mixture. Because NO_x forms primarily when a mixture of nitrogen and oxygen is subjected to high temperature, the lower combustion chamber temperatures caused by EGR reduces the amount of NO_x the combustion generates. Gases re-introduced from EGR systems will also contain near equilibrium concentrations of NO_x and CO; the small fraction initially within the combustion chamber inhibits the total net production of these and other pollutants when sampled on a time average. Chemical properties of different fuels limit how much EGR may be used. For example methanol is more tolerant to EGR than gasoline

Emission Standards of vehicle in India:

The first emission norms were introduced in India in 1991 for petrol and 1992 for diesel vehicles. These were followed by making the Catalytic converter mandatory for petrol vehicles and the introduction of unleaded petrol in the market.

On 29 April 1999 the Supreme Court of India ruled that all vehicles in India have to meet Euro I or India 2000 norms by 1 June 1999 and Euro II will be mandatory in the NCR by April 2000. Car makers were not prepared for this transition and in a subsequent judgement the implementation date for Euro II was not enforced. In 2002, the Indian government accepted the report submitted by the Mashelkar committee. The committee proposed a road map for the roll out of Euro based emission norms for India. It also recommended a phased implementation of future norms with the regulations being implemented in major cities first and extended to the rest of the country after a few years.

Based on the recommendations of the committee, the National Auto Fuel policy was announced officially in 2003. The roadmap for implementation of the Bharat Stage norms were laid out till 2010. The policy also created guidelines for auto fuels, reduction of pollution from older vehicles and R&D for air quality data creation and health administration.

Overview of the emission norms in India

- 1991 – Idle CO Limits for Petrol Vehicles and Free Acceleration Smoke for Diesel Vehicles, Mass Emission Norms for Petrol Vehicles.
- 1992 – Mass Emission Norms for Diesel Vehicles.
- 1996 – Revision of Mass Emission Norms for Petrol and Diesel Vehicles, mandatory fitment of Catalytic Converter for Cars in Metros on Unleaded Petrol.
- 1998 – Cold Start Norms Introduced.

- 2000 – India 2000 (Equivalent to Euro I) Norms, Modified IDC (Indian Driving Cycle), Bharat Stage II Norms for Delhi.
- 2001 – Bharat Stage II (Equivalent to Euro II) Norms for All Metros, Emission Norms for CNG & LPG Vehicles.
- 2003 – Bharat Stage II (Equivalent to Euro II) Norms for 13 major cities.
- 2005 – From 1 April Bharat Stage III (Equivalent to Euro III) Norms for 13 major cities.
- 2010 – Bharat Stage III Emission Norms for 2-wheelers, 3-wheelers and 4-wheelers for entire country whereas Bharat Stage – IV (Equivalent to Euro IV) for 13 major cities for only 4-wheelers. Bharat Stage IV also has norms on OBD (similar to Euro III but diluted)
- 2020 – From April 2020 for the whole country to adopt Bharat Stage VI norms for cars, skipping Bharat Stage V

Standard	Reference	Date	Region
India 2000	Euro 1	2000	Nationwide
Bharat Stage II	Euro 2	2001	NCR*, Mumbai, Kolkata, Chennai
		2003.04	NCR*, 11 cities†
		2005.04	Nationwide
Bharat Stage III	Euro 3	2005.04	NCR*, 11 cities†
		2010.04	Nationwide
Bharat Stage IV	Euro 4	2010.04	NCR*, 13 cities‡
		2015.07	Above plus 29 cities mainly in the states of Haryana, Uttar Pradesh, Rajasthan and Maharastra [3231]
		2015.10	North India plus bordering districts of Rajasthan (9 States) [3232]
		2016.04	Western India plus parts of South and East India (10 States and Territories) [3232]
		2017.04	Nationwide [3232]
Bharat Stage V	Euro 5	n/a [a]	
Bharat Stage VI	Euro 6	2020.04	Nationwide [3827]

Ineffectiveness of present pollution control system

Presently, all vehicles need to undergo a periodic emission check (3 months/ 6 months) at PUC Centres at Fuel Stations and Private Garages which are authorised to check the vehicles. In addition, transport vehicles need to undergo an annual fitness check carried out by RTOs for emissions, safety and road-worthiness. The objective of reducing pollution not achieved to a large extent by the present system. Some reasons for this are: – Independent centres do

not follow rigorous procedures due to inadequate training – Equipment not subjected to periodic calibration by independent authority – Lack of professionalism has led to malpractice – Tracking system of vehicles failing to meet norms non-existent

Comparison between Bharat Stage and Euro norms

The Bharat Stage norms have been styled to suit specific needs and demands of Indian conditions. The differences lie essentially in environmental and geographical needs, even though the emission standards are exactly the same. For instance, Euro-III is tested at sub-zero temperatures in European countries. In India, where the average annual temperature ranges between 24 and 28 °C, the test is done away with. Another major distinction is in the maximum speed at which the vehicle is tested. A speed of 90 km/h is stipulated for BS-III, whereas it is 120 km/h for Euro-III, keeping emission limits the same in both cases In addition to limits, test procedure has certain finer points too. For instance, the mass emission test measurements done in g/km on a chassis dynamometer requires a loading of 100 kg weight in addition to unloaded car weight in Europe. In India, BS-III norms require an extra loading of 150 kg weight to achieve the desired inertia weight mainly due to road conditions here.

Non-existence of CO_2 limits

Various groups and agencies have criticised the government and urged the government of India to draft mandatory fuel efficiency standards for cars in the country, or at least to make the CO_2 emissions labelling mandatory on all new cars in the country. The auto companies should inform the customers about a vehicle's emissions.

Lag behind Euro standards

There has been criticism of the fact that the Indian norms lag the Euro norms. As of 2014, only a few cities meet Euro IV or Bharat Stage IV standards that are nine years behind Europe. The rest of India gets Bharat Stage III standard fuel and vehicles, which are 14 years behind Europe. Also, there was a suggestion from some bodies to implement Euro IV norms after Euro II norms, skipping the Euro III norms totally. This is because the Euro III norms are only a small improvement over Euro II, whereas Euro IV norms mark a big leap over Euro II. According to a study conducted by the Desert Research Institute and the Indian Institute of Technology Delhi, the only way to stabilise fine particulates (PM2.5) at the 2011 levels despite the five-fold rise in vehicular density is nationwide implementation of Bharat V standards by 2015.

Cycle beating

For the emission standards to deliver real emission reductions it is crucial that the test cycles under which the emissions have to comply as much as possible reflect normal driving situations. It was discovered that manufacturers of engine would engage in what was called 'cycle beating' to optimise emission performance to the test cycle, while emissions from typical driving conditions would be much higher than expected, undermining the standards and public health. In one particular instance, research from two German technology institutes

found that for diesel cars no 'real' NO_x reductions have been achieved after 13 years of stricter standards.

Need for uniform emissions standards across the country

The practice of limiting improved emissions standards only to a few cities and to a smaller proportion of urban population has been criticized as violating the fundamental right to healthy life for all. This also does not allow Lorries to move to cleaner fuel and technology and they heavily pollute cities during transit and aggravate pollution in cities. Many persons and establishments try to purchase Bharat Stage III vehicles and fuel from outside city limits in order to take advantage of lower prices, even though these are used in cities.

TEXT / REFERENCE BOOKS

1. Kirpal Singh, "Automobile Engineering Vol 1 and 2 "12th edition Standard Publishers 2011

2. Banga T.R. & Nathu Singh, "Automobile Engineering"3rd edition Khanna Publications. 2012

3. Rajput R.K. "A Text–Book of Automobile Engineering", Laxmi Publications Private Limited, 2008.

4. Heldt.P.M. Automotive Chassis, 3rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler "Advanced vehicle technology"2nd edition Edward Arnold publication 2002

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UNIT II DRIVE LINE

2. DRIVE LINE

Classification of clutches, Single plate, Multi plate, Cone diaphragm spring, centrifugal, clutch materials, electromagnetic, vacuum operated, fluid flywheel, necessity of gear box, manual gear box – Constant mesh, synchromesh, geared automatic transmission , torque converter, epicycle, continuous variable transmission, electronic transmission control, overdrive, propeller shaft, constant velocity joint, Differential and final drive, Non-slip differential.

CLUTCHES & POWER TRANSMISSION

The purpose of the clutch is to allow the driver to couple or decouple the engine and transmission. When clutch is in engaged position, the engine power flows to the transmission through it (clutch). When gears are to be changed while vehicle is running, the clutch permits temporary decoupling of engine and wheels so that gears can be shifted. In a scooter, the clutch is operated by hand where as in a car the clutch is operated by foot. It is necessary to interrupt the flow of power before gears are changed. Without a clutch, it will be very difficult.

REQUIREMENTS OF A CLUTCH

1. Pick up its load smoothly without grab or clatter.
2. Have a driven disc of low moment of inertia to permit easy shifting.
3. Damp out any vibration of the crankshaft to prevent gear clatter.
4. Require little pedal pressure to operate it.
5. Be easy to adjust and service.
6. Be cheap to manufacture.

BASIC PRINCIPLE OF THE FRICTION TYPE CLUTCH

To understand the working principle of clutch, let's take two sanding discs, first one driven by a power drill corresponds to the flywheel of a car, driven by the engine. If a second sanding disc is brought into contact with the first, friction makes it revolve too but more slowly. But when the second disc pressed against the first disc which is connect to the power drill, as the pressure increases the two discs revolve as one. This is how a friction clutch works.

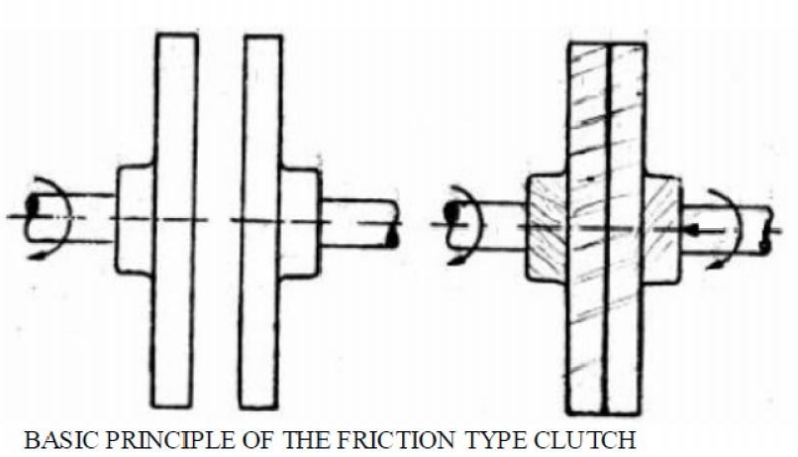

Figure 2.1. Principle of Friction Clutch

TYPES OF CLUTCHES

(i) Positive Clutches (ii) Friction clutches

Positive Clutches: In this type of clutch, the engaging clutch surfaces interlock to produce rigid joint they are suitable for situations requiring simple and rapid disconnection, although they must be connected while shafts are stationery and unloaded, the engaging surfaces are usually of jaw type. The jaws may be square jaw type or spiral jaw type. They are designed empirically by considering compressive strength of the material used.

The merits of the positive clutches are

. (i) Simple

(ii) No slip

(iii) No heat generated compact and low cost

Friction Clutches: Friction Clutches work on the basis of the frictional forces developed between the two or more surfaces in contact. Friction clutches are usually – over the jaw clutches due to their better performance. There is a slip in friction clutch.

The merits are

(i) They friction surfaces can slip during engagement which enables the driver to Pick up and accelerate the load with minimum shock.

(ii) They can be used at high engagement speeds since they do not have jaw or teeth

(iii) Smooth engagement due to the gradual increase in normal force.

Different types of clutches are as follows:

1. Friction clutch:

(a) Single plate clutch.

(b) Multiplate clutch:

(1) Wet clutch.

(2) Dry clutch.

(c) Cone clutch.

(1) External clutch.

(2) Internal clutch.

2. Centrifugal clutch.

3. Semi-centrifugal clutch.

4. Diaphragm clutch.

(a) Tapered finger type.

(b) Crown spring type.

5. Positive clutch.

(a) Dog and Spline clutch.

6. Hydraulic clutch.

7. Electro-magnetic clutch.

8. Vacuum clutch.

9. over running clutch or free-wheel unit.

SINGLE PLATE CLUTCH: -

A single plate friction clutch consisting of a clutch disk between the fly wheel and a pressure plate. Both the pressure plate and the flywheel rotate with the engine crankshaft or the driving shaft. And both sides of clutch disc are faced with friction material (usually of ferrodo).The clutch disc is mounted on the hub which is free to move axially along the splines of the driven shaft but not turnable towards the transmission input shaft.

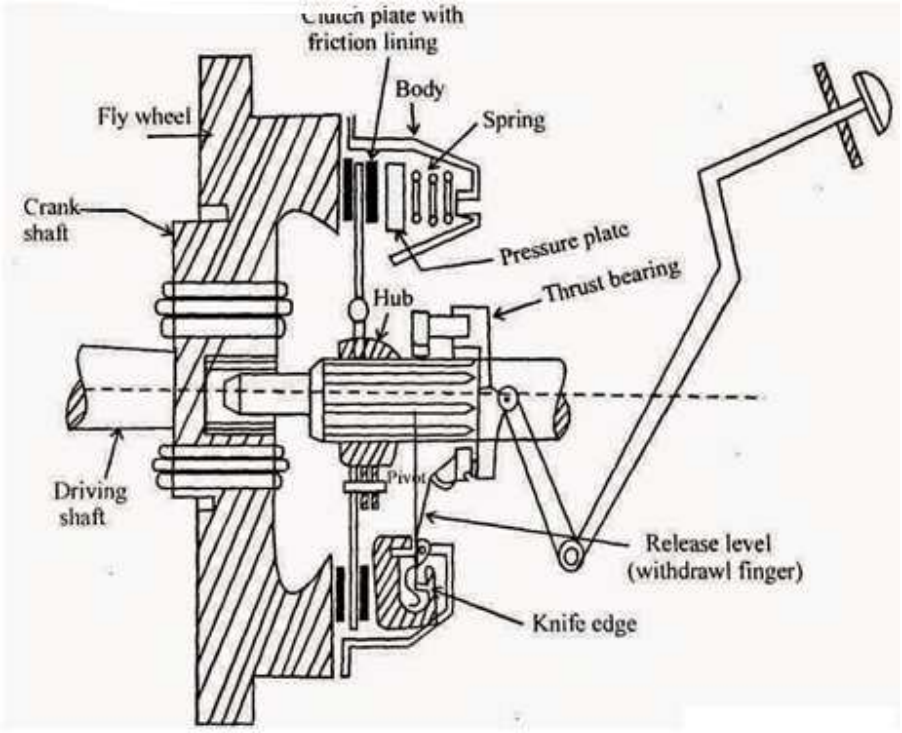

Figure 2.2. Single plate Clutch

Single plate clutch

The pressure plate pushes the clutch plate towards the flywheel by a set of strong springs which are arranged radially inside the body. The three levers (also known as release levers or fingers) are carried on pivots suspended from the case of the body. These are arranged in such a manner so that the pressure plate moves away from the flywheel by the inward movement of a thrust bearing. The bearing is mounted upon a forked shaft and moves forward when the clutch pedal is pressed. By pressing the clutch pedal down, the thrust bearing moves towards the flywheel by means of linkage force, and press the longer end of the lever inwards. Due to this, the lever turns on their suspended pivot and forces the pressure plate to move away from the flywheel this action compresses the clutch springs which in turn moves the pressure plate away from the clutch plate and remove the pressure from the clutch plate. This enables the clutch plate to move back from the flywheel and thus, the driven shaft becomes stationary. By moving the foot back from the clutch pedal, the thrust bearing moves back and allows the spring to extend which pushes the clutch plate backwards the flywheel. This engages the flywheel and the clutch plate which starts the motion of the driven shaft.

MULTI COIL SPRING SINGLE PLATE CLUTCH CONSTRUCTION

A typical clutch actuated by a number of coil springs on a pitch circle nears the periphery is shown. The driven shaft which normally is a forward extension of gearbox primary shaft is supported at its front end in ball bearing in a hole in the center of flywheel web, which is spigot

and bolted on to a flange at the rear end of the crankshaft. In this clutch, the coil springs force the pressure plate forwards to clamp the driven plate between it and the rear face of the flywheel. Three lugs extend rearwards from periphery of pressure plate both to rotate the pressure plate and to cause it to rotate with the rest of the assembly. The driven plate of course is splined onto the shaft. There are three release levers pressing the coil springs at the outer end. The inner ends of the levers can be forced forward by means of thrust bearing made of graphite and slide along the clutch shaft when clutch pedal is depressed. The driven plate mounted between flywheel and pressure plate makes the clutch shaft to rotate to transmit power. It has the clutch facing made of friction materials around the periphery of disc.

WORKING

When the clutch is engaged, the clutch plate is gripped between the flywheel and pressure plate. The friction linings are on both sides of clutch plate. Due to friction between flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As clutch plate revolves the clutch shaft also revolves. Thus, engine power is transmitted to the clutch shaft. When the clutch pedal is pressed the pressure plate moves back against the spring force and clutch plate becomes free between flywheel and pressure plate. Thus flywheel remains rotating as long as the clutch pedal is pressed, the clutch is said to be disengaged and clutch shaft speed reduces slowly and finally it stops rotating.

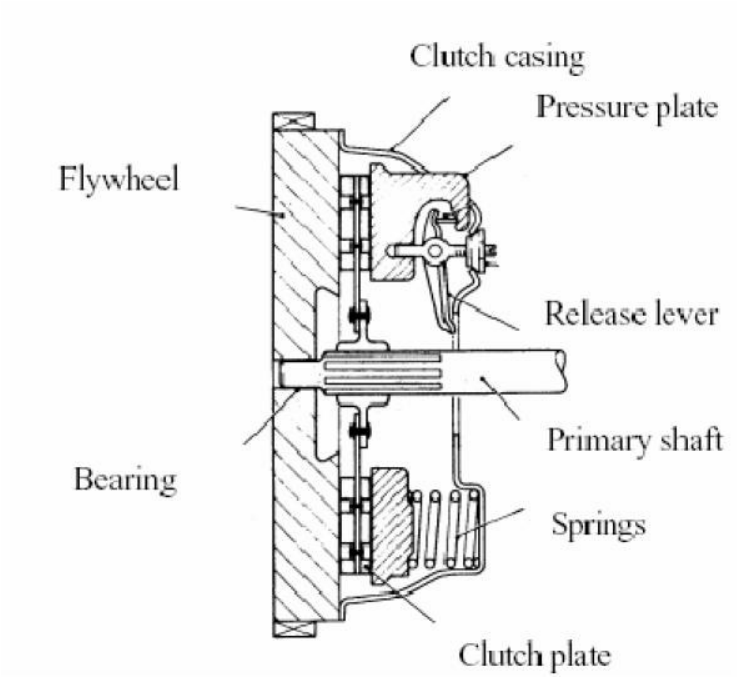

Figure 2.3. Multi coil spring single plate clutch

DIAPHRAGM SPRING SINGLE PLATE CLUTCH

Diaphragm spring pressure plate assemblies are widely used in most modern cars. The diaphragm spring is a single thin sheet of metal which yields when pressure is applied to it. When pressure is removed the metal springs back to its original shape. The center portion of the diaphragm spring is slit into numerous fingers that act as release levers. During disengagement of the clutch the fingers are moved forward by the release bearing.

The spring pivots over the fulcrum ring and its outer rim moves away from the flywheel. The retracting spring pulls the pressure plate away from the clutch plate thus disengaging the clutch. When engaged the release bearing and the fingers of the diaphragm spring move towards the transmission. As the diaphragm pivots over the pivot ring its outer rim forces the pressure plate against the clutch disc so that the clutch plate is engaged to the flywheel.

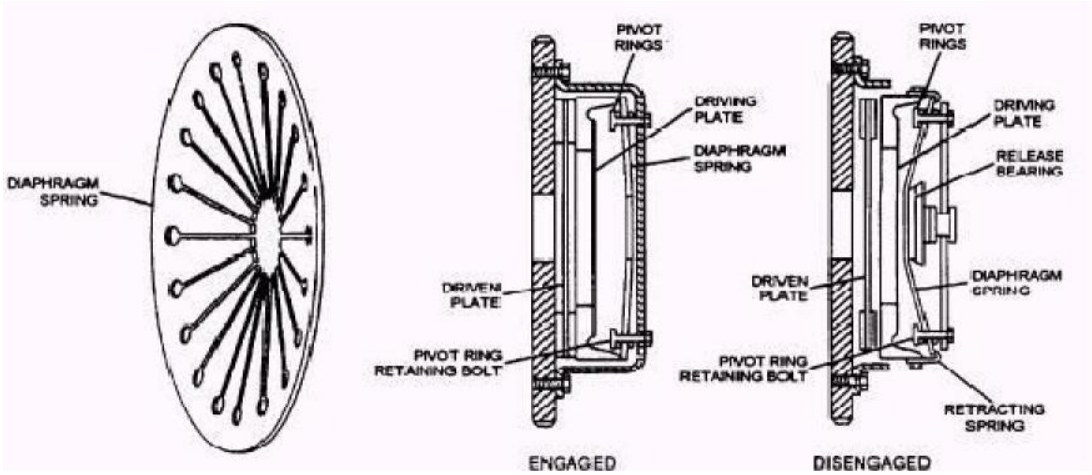

Figure 2.4. Diaphragm clutch

ADVANTAGES OF DIAPHRAGM SPRING CLUTCH

1. It is more compact than other designs.
2. It is easier to balance rotationally and is less subjected to unwanted effects due to centrifugal force at high rotational speeds.
3. It gives uniformly distributed pressure on pressure plate.
4. It needs no release levers.
5. Minimum effort is sufficient to disengage the clutch.
6. It provides minimum number of moving components and hence minimum internal friction is experienced.
7. This is very commonly used in cars, light Lorries and mini trucks but is not much used in heavy vehicles

MULTIPLATE CLUTCH

The multi-plate clutch is an extension of single plate type where the number of frictional and the metal plates are increased. The increase in the number of friction surfaces obviously increase capacity of the clutch to transmit torque, the size remaining fixed. Alternatively, the overall diameter of the clutch is reduced for the same torque transmission as a single plate clutch. This type of clutch is, used in some heavy transport vehicles, in epicyclic gearboxes and racing cars where high torque is to be transmitted. Besides, this finds applications in case of scooters and motorcycles, where space available is limited.

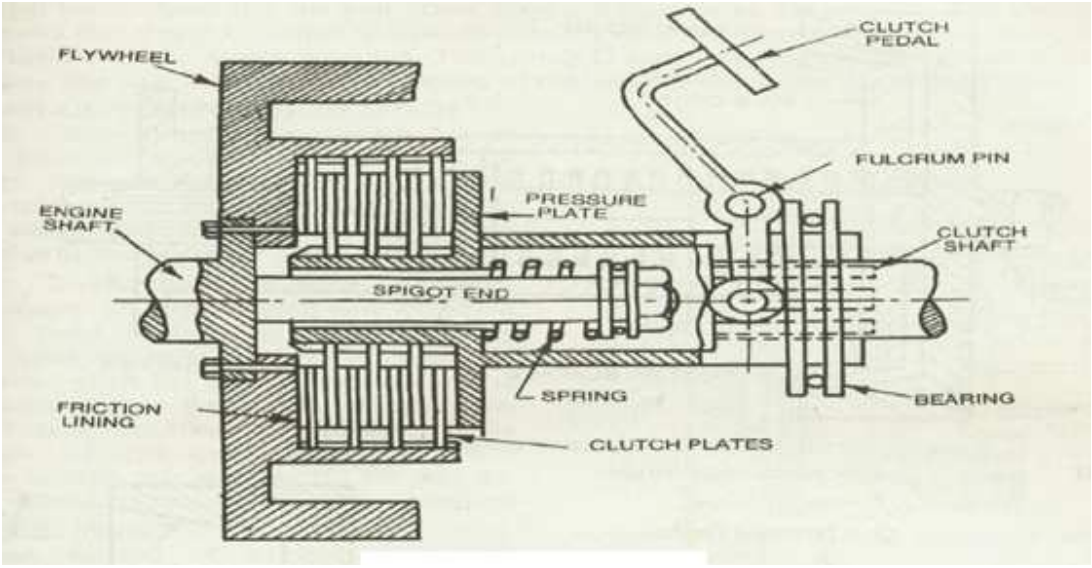

Figure 2.5. Multi plate Clutch

Extension of flywheel is a drum; which on its inner circumference is splined to carry a number of thin metal plates. These must consequently revolve with drum but are able to slide axially. Interleaved with these outer plates are a number of inner plates that are splined to an inner drum which is coupled rotationally to the gearbox shaft. The clutch is disengaged by pulling inner drum right against spring force. The plates of multi-plate clutch were at one time made alternately of steel and phosphor bronze but now are all of steel or one set may be lined with a friction material. With metal contact lubrication is essential and so clutch is made oil-tight and partly filled with oil. The oil tends to make the plates drag when clutch is disengaged and so some mean should be provided to avoid this drag.

DRY MULTIPLATE CLUTCH

Multi plate clutches are also made to work dry, without any oil. The driving plates are then lined on each side with a friction fabric. In such clutches, the driving plates are sometimes carried on a number of studs screwed into the web of flywheel in the same way as the outer plate of a Single

Plate Clutch is carried. This construction is inconvenient when oil is used. Several small springs can be used instead of a single spring.

AUTOMATIC CLUTCH

Many attempts have been made to produce motor vehicles that can be controlled by the accelerator pedal and brakes only. This can be done in several ways. A centrifugal clutch which automatically disengages itself when the speed falls below and which re-engages when the speed rises above some predetermined values may be used. Alternatively, a fluid coupling, fluid torque converter may be employed.

CENTRIFUGAL CLUTCH

In this type of clutches the springs are eliminated altogether and only the centrifugal force is used to apply the required pressure for keeping the clutch in engagement position. The advantage of the centrifugal clutch is that no separate clutch pedal is required. The clutch is operated automatically depending upon the engine speed. This means that car can be stopped in gear without stalling the engine. Similarly while starting, the driver can first select the gear, put the car into the gear and simply press the accelerator pedal. This makes the driving operation very easy.

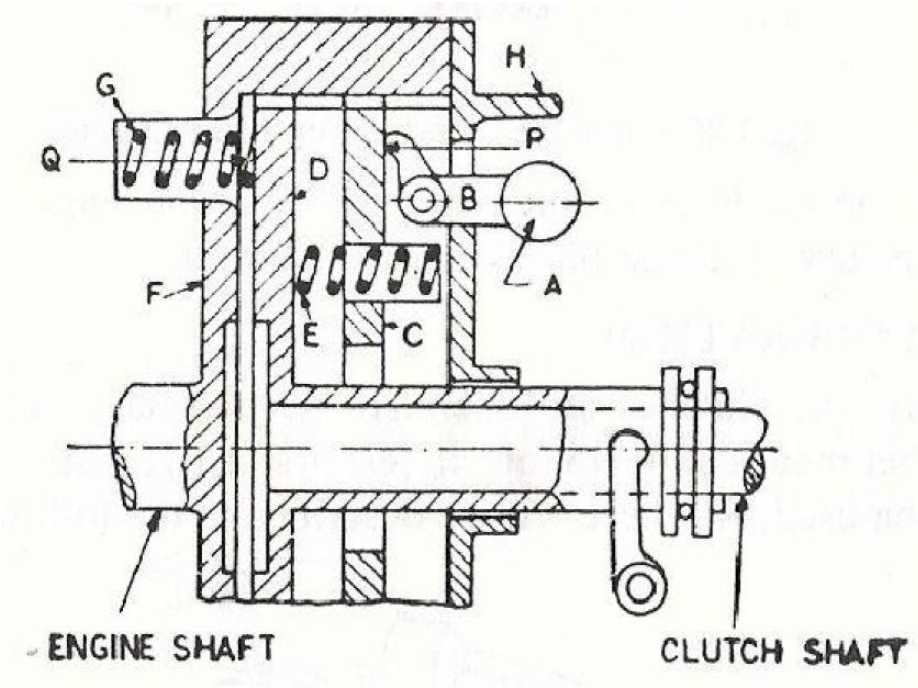

Figure 2.6. Centrifugal Plate Clutch

Centrifugal Clutch

Figure shows a schematic diagram of a centrifugal clutch. As the speed increases, the weight A fly off, thereby operating the bell crank lever B that presses the plate C. This force is transmitted to the plate D by means of springs E. The plate D containing friction lining is thus pressed

against the flywheel F thereby engages the clutch. Spring G serves to keep the clutch disengaged at low speed say 500 rpm. The stop H limits the amount of centrifugal force. The operating characteristics of this type of clutch will be then as shown in figure. Force P is proportional to the centrifugal force at a particular speed, while force Q exerted by spring G is constant at all speeds. The firm line in the figure shows that net force on the plate D for various engine speeds. At the upper end the curve is made flat by means of stop H.

SEMI CENTRIFUGAL CLUTCH

It uses both centrifugal and spring force for keeping it in an engaged position. The springs are designed to transmit torque at normal speed, while centrifugal force assists in torque transmission at high speed. This clutch consists of three hinged and weighted levers and three clutch springs alternately arranged at equal spaces on the pressure plate. At low speeds the springs keep the clutch engaged and the weighted levers do not have any pressure on pressure plate. At high speeds when power transmission is high, weights fly off and the levers also exert pressure on plate, keeping the clutch firmly engaged.

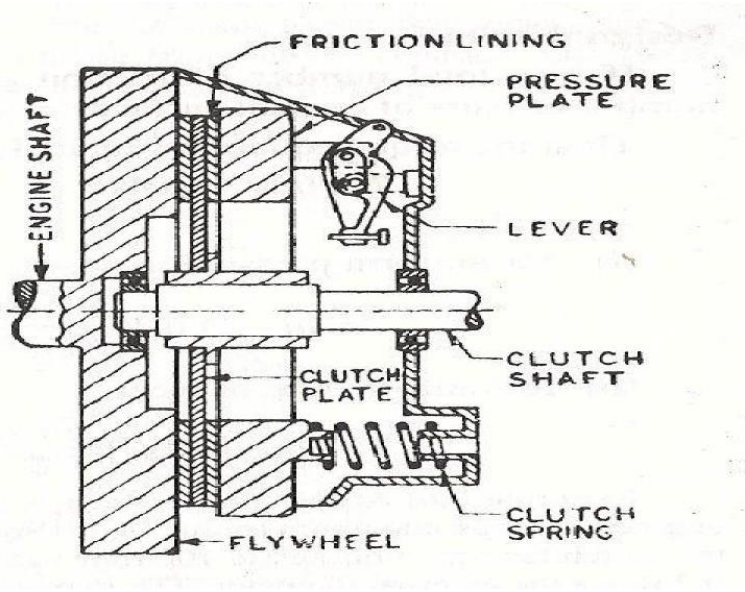

Figure 2.7. Semi Centrifugal Plate Clutch

Semi centrifugal clutch

When the speed decreases the weights do not exert any pressure on the pressure plate. Only spring pressure is exerted on pressure plate which keeps the clutch engaged. An adjusting screw is provided at the end of the lever by means of which the centrifugal force on pressure plate can be adjusted. At low speeds pressure on the spring is sufficient to transmit the torque required.

However at high speeds, the centrifugal force due to weight moves about the fulcrum thereby pressing the pressure plate. The centrifugal force is proportional to the square of speed so that adequate pressure level is attained. Graph shows the variation of force on the pressure plate as

speed increases. At low speeds spring along applies the force on the pressure plate. But when speed of the engine raises the centrifugal force also applied by the weights.

ELECTROMAGNETIC CLUTCH

- Figure shows an electromagnetic clutch.
- In this type of clutch, the flywheel consists of winding from the battery or dynamo.
- when the current passes through the winding. it produced an electromagnetic field which attracts the pressure plate.
- Thereby engaging the clutch.
- When the supply is cut-off the clutch is disengaged.
- The gear lever consists of a clutch release switch.
- When the driver holds the gear lever to change the gear, the switch is operated
- Cutting off the current to the winding which causes the clutch disengaged.
- At low speed when the dynamo output is low, the clutch is not firmly engaged.
- Therefore, three springs are also provided on the pressure plate which helps the
- Clutch engaged firmly at low speed also.
- This type of clutch is used in some Renult cars**.**

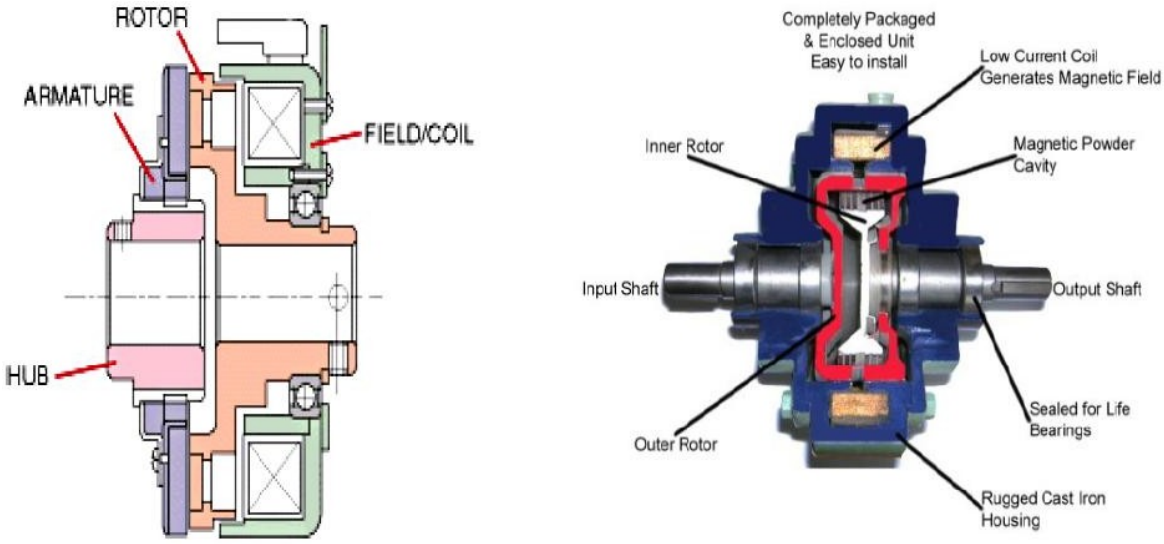

Figure 2.8. Electromagnetic clutch

CLUTCH LINKAGE

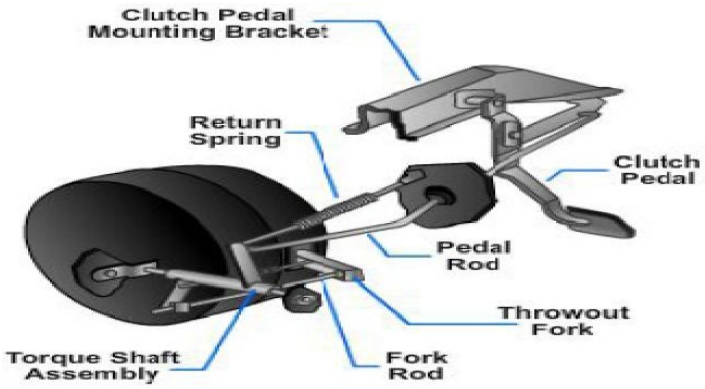

Figure 2.9. Clutch linkage

A clutch linkage mechanism uses levers and rods to transfer motion from the clutch pedal to the clutch fork. One configuration is shown in Figure When the pedal is pressed, a pushrod shoves on the bell crank and the bell crank reverses the forward movement of the clutch pedal. The other end of the bell crank is connected to the release rod. The release rod transfers bell crank movement to the clutch fork. It also provides a method of adjustment for the clutch.

FLUID COUPLING

It is a device for transmitting rotation between shafts by means of the acceleration and deceleration of a hydraulic fluid (such as oil). Also known as hydraulic coupling. Structurally, a fluid coupling consists of an impeller on the input or driving shaft and a runner on the output or driven shaft. The two contain the fluid. Impeller and runner are bladed rotors, the impeller acting as a pump and the runner reacting as a turbine. Basically, the impeller accelerates the fluid from near its axis, at which the tangential component of absolute velocity is low, to near its periphery, at which the tangential component of absolute velocity is high. This increase in velocity represents an increase in kinetic energy. The fluid mass emerges at high velocity from the impeller, impinges on the runner blades, gives up its energy, and leaves the runner at low velocity.

Fluid coupling clutch

Hydraulic fluid couplings transfer rotational force from a transmitting axis to a receiving axis. The coupling consists of two toroids -doughnut-shaped objects -in a sealed container of hydraulic fluid. One toroid is attached to the driving shaft and spins with the rotational force. The spinning toroid moves the hydraulic fluid around the receiving toroid. The movement of the fluid turns the receiving toroid and thus turns the connected shaft.

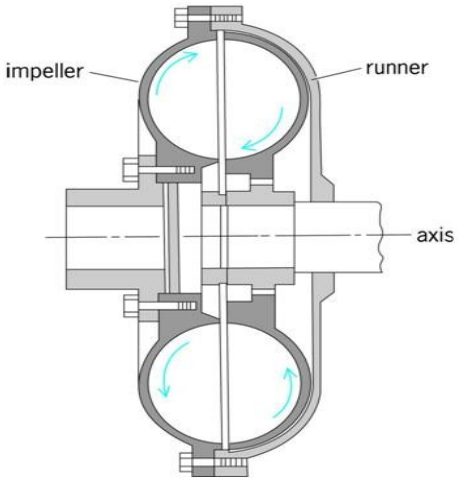

Figure 2.10. Clutch linkage

TORQUE CONVERTER

BASIC PRINCIPLE OF TO RQUE CONVERTER

On automatic transmissions, the torque converter takes the place of the clutch found on standard shift vehicles. It is there to allow the engine to continue running when the vehicle comes to a stop. The principle behind a torque converter is like taking a fan that is plugged into the wall and blowing air into another fan which is unplugged. If you grab the blade on the unplugged fan, you are able to hold it from turning but as soon as you let go, it will begin to speed up until it comes close to the speed of the powered fan. The difference with a torque converter is that instead of using air, it uses oil or transmission fluid, to be more precise.

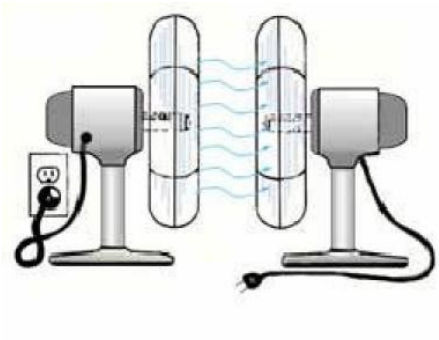

Figure 2.11. Basic principle of torque converter

TORQUE CONVERTER

Most cars with automatic transmission use a form of fluid drive known as torque converter as the name implies, it converts the torque or tuning effort of engine into higher torque needed by cars at low road speed. An increase in torque has same effect as changing to a lower gear; so a TC is also a gear reducer, acting like an extra set of gears before engine drive reaches gear box. Like fluid flywheel, TC has an engine driven impeller and a turbine connected to GB input shaft. It is also able to deliver a higher torque than that engine produces, because it is also able to deliver a

higher torque and a small vane wheel known as reactor (stator). A one way clutch (ORC) lock reactor to gear box casing at lower engine speed. In a fluid flywheel, oil returning from turbine tends to curb the speed of impeller. But in TC, the vanes of locked reactor direct oil along a torque favorable path back to the centre of impeller enabling it to give extra thrust to turbine blades.

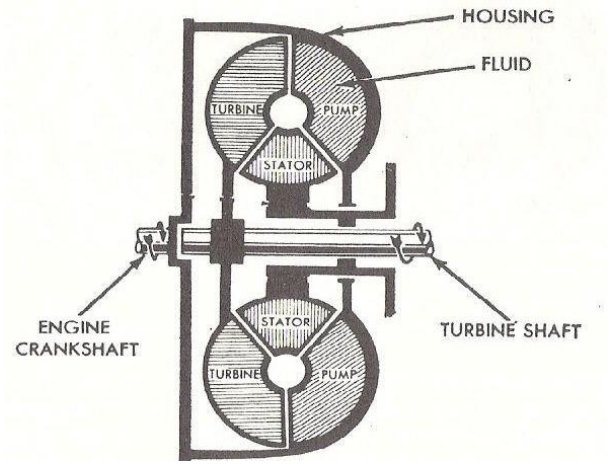

Figure 2.12. Torque converter

At pull away speeds, Torque Converter double the effort produced by engine. As engine picks up speed, this 2:1 increase in torque is reduced until at cruising speed, there is no torque increase at all. The reactor is spun round by oil at some rate as turbine. TC now acts like a fluid flywheel with reactor „freewheeling" and having no torque increasing effort. Neither FC nor TC can be epicycle transmission which aloe gear changing without disconnecting. An alternative used on few models, is to provide a friction clutch in addition to TC. This enables a synchromesh gear box to be used, as friction clutch disconnects engine when gears are being changed.

NECESSITY OF GEAR BOX IN AN AUTOMOBILE

The gear box is necessary in the transmission system to maintain engine speed at the most economical value under all conditions of vehicle movement. An ideal gear box would provide an infinite range of gear ratios, so that the engine speed should be kept at or near that the maximum power is developed whatever the speed of the vehicle.

FUNCTION OF A GEAR BOX

1. Torque ratio between the engine and wheels to be varied for rapid acceleration and for climbing gradients.
2. It provides means of reversal of vehicle motion.
3. Transmission can be disconnected from engine by neutral position of gear box.

TYPES OF GEAR BOX PROGRESSIVE TYPE GEAR BOX

Usually this gear boxes are used in motor cycles. In this gear boxes the gears pass through the intervening speeds while shifting from one speed to another. There is a neutral position between two positions. These gear boxes are a combination of sliding and constant mesh gear boxes. The various gear speeds are obtained by sliding the dog clutch or gear to the required position.

EPICYCLIC (OR) PLANETARY TYPE GEAR BOX

The epicylic or planetary type transmission uses no sliding dogs or gears to engage but different gear speeds are obtained by merely tightening brake-bands on the gear drums, which simplify gear changing. A planetary gear set consists of ring gear or annular wheel, sun gear and planet gears with carrier. In order to obtain different speeds any one of these three units can be held from rotation by means of brake bands.

SELECTIVE TYPE GEAR BOX

It is the transmission in which any speed may be selected from the neutral position. In this type of transmission neutral position has to be obtained before selecting any forward or reverse gear. Some selective type gear boxes are,

1. Constant mesh gear box with positive dog clutch.
2. Constant mesh gear box with synchromesh device.
3. Sliding mesh gear box.

SLIDING MESH GEAR BOX

It is the simplest and oldest type of gear box.

1. The clutch gear is rigidly fixed to the clutch shaft.
2. The clutch gear always remains connected to the drive gear of countershaft.
3. The other lay shaft gears are also rigidly fixed with it.
4. Two gears are mounted on the main shaft and can be sliding by shifter yoke when shifter is operated.
5. One gear is second speed gear and the other is the first and reverse speed gears. All gears used are spur gears.
6. A reverse idler gear is mounted on another shaft and always remains connected to reverse gear of counter shaft.

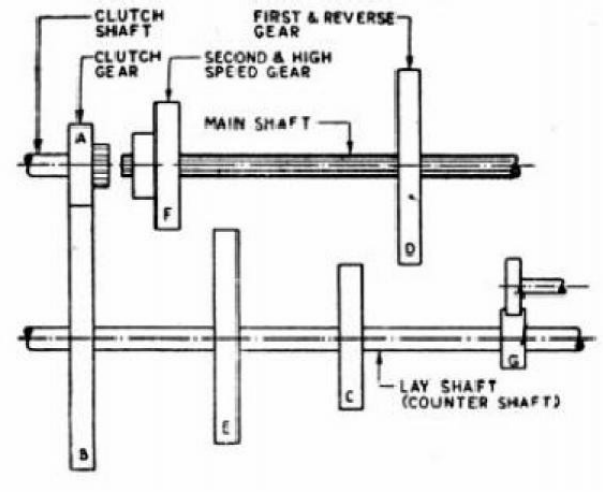

Figure 2.13. Sliding mesh gearbox

FIRST GEAR

By operating gearshift lever, the larger gear on main shaft is made to slide and mesh with first gear of countershaft. The main shaft turns in the same direction as clutch shaft in the ratio of 3:1.

SECOND GEAR

By operating gear shaft lever, the smaller gear on the main shaft is made to slide and mesh with second gear of counter shaft. A gear reduction of approximately 2:1 is obtained.

TOP GEAR

By operating gearshift lever, the combined second speed gear and top speed gear is forced axially against clutch shaft gear. External teeth on clutch gear mesh with internal teeth on top gear and the gear ratio is 1:1.

REVERSE GEAR

By operating gearshift lever, the larger gear of main shaft is meshed with reverse idler gear. The reverse idler gear is always on the mesh with counter shaft reverse gear. Interposing the idler gear, between reverse and main shaft gear, the main shaft turns in a direction opposite to clutch shaft.

NEUTRAL GEAR

When engine is running and the clutch is engaged, clutch shaft gear drives the drive gear of the lay shaft and thus lay shaft also rotates. But the main shaft remains stationary as no gears in main shaft are engaged with lay shaft gears.

CONSTANT MESH GEARBOX

In this type of gearbox, all the gears of the main shaft are in constant mesh with corresponding gears of the countershaft. The gears on the main shaft which are bushed are free to rotate. The

dog clutches are provided on main shaft. The gears on the lay shaft are, however, fixed. When the left Dog clutch is slid to the left by means of the selector mechanism, its teeth are engaged with those on the clutch gear and we get the direct gear. The same dog clutch, however, when slid to right makes contact with the second gear and second gear is obtained. Similarly movement of the right dog clutch to the left results in low gear and towards right in reverse gear. Usually the helical gears are used in constant mesh gearbox for smooth and noiseless operation.

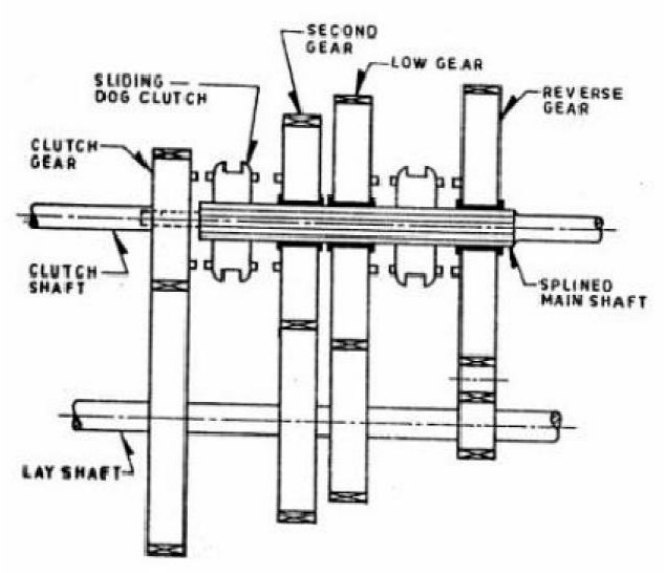

Figure 2.14. Constant mesh gearbox

SYNCHROMESH GEARBOX

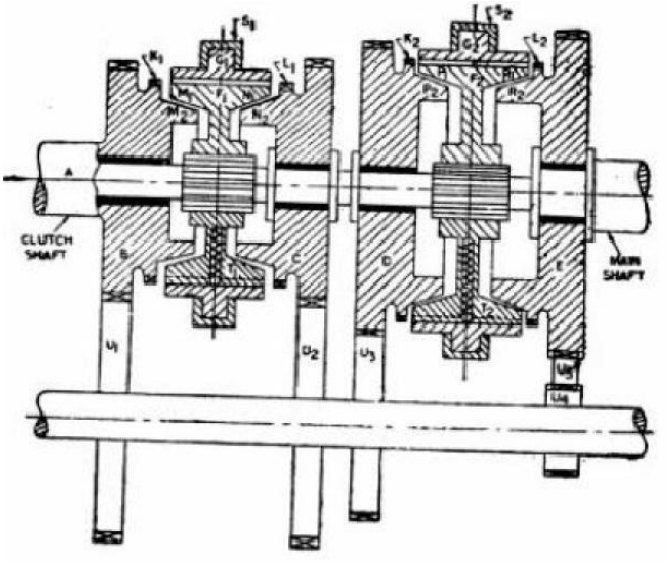

Figure 2.15. Synchromesh Gearbox

This type of gearbox is similar to the constant mesh type gearbox. Instead of using dog clutches here synchronizers are used. The modern cars use helical gears and synchromesh devices in gearboxes, that synchronize the rotation of gears that are about to be meshed.

SYNCHRONIZERS

This type of gearbox is similar to the constant mesh type in that all the gears on the main shaft are in constant mesh with the corresponding gears on the lay shaft. The gears on the lay shaft are fixed to it while those on the main shaft are free to rotate on the same. Its working is also similar to the constant mesh type, but in the former there is one definite improvement over the latter. This is the provision of synchromesh device which avoids the necessity of double-declutching. The parts that ultimately are to be engaged are first brought into frictional contact, which equalizes their speed, after which these may be engaged smoothly.

Synchromesh gearbox

Figure shows the construction and working of a synchromesh gearbox. In most of the cars, however, the synchromesh devices are not fitted to all the gears as is shown in this figure. They are fitted only on the high gears and on the low and reverse gears ordinary dog clutches are only provided. This is done to reduce the cost. In figure A is the engine is the engine shaft, Gears B, C, D, E are free on the main shaft t and are always in mesh with corresponding gears on the lay shaft. Thus all the gears on main shaft as well as on lay shaft continue to rotate so long as shaft A is rotating. Members F1 and F2 are free to slide on splines on the main shaft. G1 and G2 are ring shaped members having internal teeth fit onto the external teeth members F1 and F2 respectively. K1 and K2 are dogteeth on B and D respectively and these also fit onto the teeth of G1 and G2. S1 and S2 are the forks. T1 and T2 are the balls supported by spring. These tend to prevent the sliding of members G1 (G2) on F1 (F2). However when the force applied on G1 (G2) slides over F1 (F2). These are usually six of these balls symmetrically placed circumferentially in one synchromesh device. M1, M2, N1, N2, P1, P2, R1, R2 are the frictional surfaces.

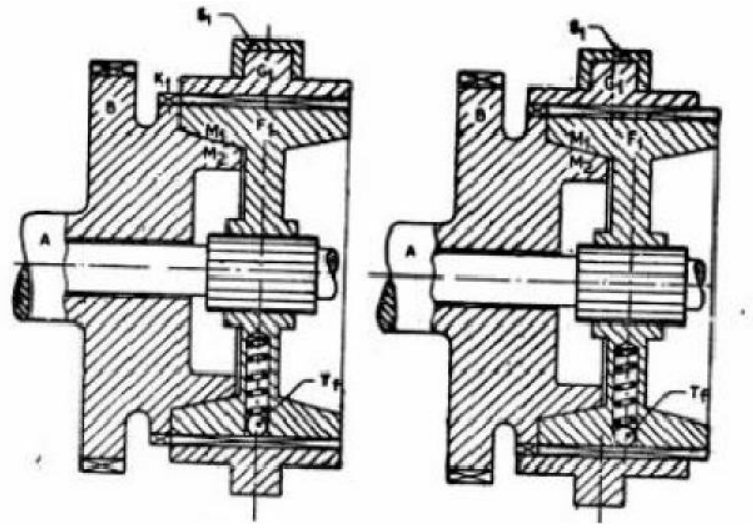

Figure 2.16. Synchronizer

To understand the working of this gearbox, consider figure which shows in steps how the gears are engaged. For direct gear, member G1 and hence member F1 (through spring- loaded balls) is slid towards left till cones M1 and M2 rub and friction makes their speed equal. Further pushing the member G1 to left causes it to overdrive the balls and get engaged with dogs K1. Now the drive to the main shaft is direct from B via F1 and the splines. However, if member G1 is pushed too quickly so that there is not sufficient time for synchronization of speeds, a clash may result. Likewise defect will arise in case springs supporting the balls T1 have become weak. Similarly for second gear the members F1 and G1 are slid to the right so that finally the internal teeth on G1 are engaged with L1. Then the drive to main shaft will be from B via U1, U2, C, F1 and splines. For first gear, G2 and F2 are moved towards left. The drive will be from B via U1, U2, D, F2 and splines to the main shaft. For reverse gear, G2 and F2 are slid towards right. In this case the drive will be from B via U1, U2, U5, E, F2 and splines to the main shaft. A synch's purpose is to allow the collar and the gear to make frictional contact before the dog teeth make contact. This lets the collar and the gear synchronizes their speeds before the teeth need to engage, like this: The cone on the blue gear fits into the cone-shaped area in the collar, and friction between the cone and the collar synchronize the collar and the gear. The outer portion of the collar then slides so that the dog teeth can engage the gear.

EPICYCLIC GEAR TRAIN

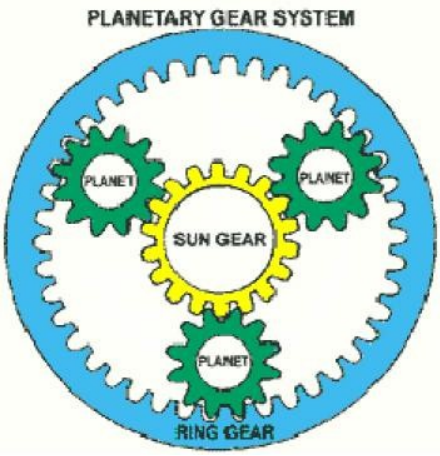

Figure 2.17. Epicyclical Gear Train

One form of the "all-spur" type of planetary transmission is illustrated in diagram. It comprises three adjacent independent gears A, B, D, Concentric with the driving and driven shafts S and S‟, which are telescoped, and three corresponding pinions A‟, B‟, D‟, forming a rigid planetary unit. There are usually three such units, spaced uniformly around the gears mounted on the driving and driven shafts. Gear A is the driving and gear D the driven member. Low forward speed is obtained in a simple manner by holding the planet carrier from rotation, by means of a brake drum provided on it for the purpose. Power then enters at gear A and is transmitted through the pairs of back gears A‟, D‟, to gear D, hence no planetary motion is involved in the low speed forward drive. The low- speed reduction ratio is a‟d / ad‟. For high forward speed the

driving shafts is coupled to the driven shaft by means of a friction clutch incorporated in the assembly, which gives a direct drive. For the reverse motion gear B, which is free on the driving shaft, is held from rotation. Assume that the planet carrier rotates left-handedly, causing pinion B‟ to roll on B. For one left-handed revolution of the planet carrier, the gear cluster A‟, B‟, D‟, makes b/b‟ left-hand revolutions around its own axis. The reduction ratio then is d (b-a) / a (d-b). It will be seen at once that this reduction is positive if b >a and d > b.

AUTOMATIC OVER DRIVE PRINCIPLE OF THE OVER DRIVE

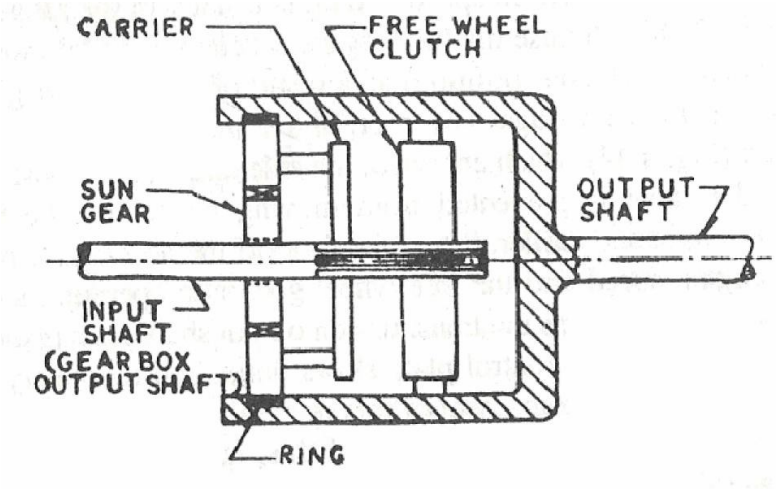

Figure 2.18. Over Drive

The principle of the overdrive is illustrated in figure, which shows a simple epicyclic gear train. In this the gear box output shaft is connected to the planet carrier ring while the annulus or ring gear is attached to the outer race of the free- wheel unit and from this to the output shaft; the latter drives the propeller shaft through the front universal coupling. The sun wheel is the reaction member of the gear train and when it is locked to the gear box output -or overdrive input-shaft the planet carrier which is driven by the gear bow shaft rotates about the sun wheel carrying with it the pinion wheels which in turn, drive the annulus gear and with it the output shaft to the propeller shaft. The annulus rotates more slowly than the planet carrier thus giving a lower gear ratio than for direct drive. The position in which the sun wheel is locked to the gear box shaft, which has just been described, gives the overdrive requirements.

OVER DRIVE OPERATIONS DIRECT DRIVE CONDITIONS

To obtain direct drive the overdrive gear must be locked in some manner so as to rotate as one solid unit. This is done by connecting the sun gear solidly with the planet carrier. The drive from the gear box shaft is then taken through the locked epicyclic gear train and thence through the free- wheel to the overdrive output shaft. Therefore, when in direct drive the propeller shaft side can rotate faster than the gear box shaft. Since, however, the direct drive is only used at speeds below about 28 to 30 mph, this advantage is only realized at these at these lower speeds.

COMPLETE OVERDRIVE

Having explained the principle of this overdrive, the purposes of the various components should be better understood by reference to the illustration of a complete overdrive, as used on cars fitted with three-speed gear boxes. The annulus or ring gear and the outer race of the free-wheel are splined to the overdrive main shaft.

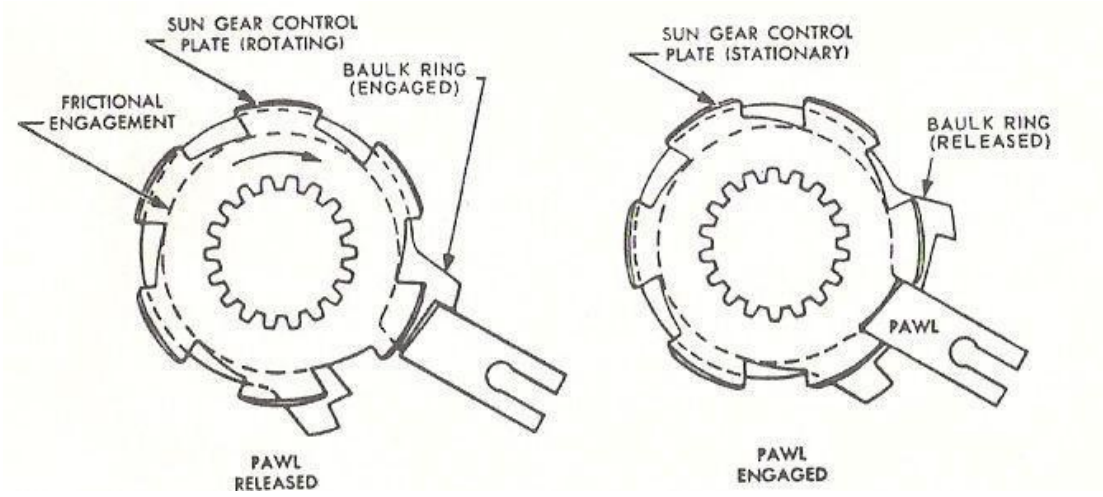

Figure 2.19. Complete Over Drive

The overdrive unit includes a device to lock the sun gear and hold of stationary. To do this a centrifugal governor, driven by the overdrive output shaft is used to close the contacts of an electrical circuit which contains the windings of the solenoid. When the road speed of the car increases to about 28 to 30 m.p.h., the governor closes the contacts and thus energizes the solenoid which forces its plunger outwards and therefore pushes the pawl member towards a notched ring around the overdrive input shaft; this pawl is shown as the gear plate. Since if would not be advisable for the pawl to engage with one of the notches in the gear plate during the rotation of the plate the pawl of not allowed, initially, to enter a notch, being prevented from doing so by a baulk ring which is a friction fit to the gear plate.

To obtain a smooth engagement of the pawl it is necessary to decelerate the overdrive input shaft, momentarily, by releasing the accelerator pedal, so that the engine begins to slow down. Since the momentum of the car will cause the ring gear still to rotate, the ring gear will rotate the pinions, driving the sun gear and baulk ring in a reverse direction. This movement of the baulk ring allows the pawl to move from the step and engage one of the gear plate notches, thus bringing the overdrive into operation. The engagement, after the accelerator pedal release, is so quick that the gear plate rotates only about one-third of a turn before full engagementnot of the pawl with a notch. This method of engagement depends upon synchronizing the pawl movement with the momentary stopping of the gear plate. To release the overdrive the accelerator should be released so that the road speed falls by 2 to 4 mph below the cut-in speed; so that the governor's contacts open and the solenoid actuated pawl is released; the direct drive is then re-engaged, automatically.

TEXT / REFERENCE BOOKS

1. Kirpal Singh, “Automobile Engineering Vol 1 and 2 ”12th edition Standard Publishers 2011

2. Banga T.R. &Nathu Singh, “Automobile Engineering”3rd edition Khanna Publications. 2012

3. Rajput R.K. “A Text–Book of Automobile Engineering”, Laxmi Publications Private Limited, 2008.

4. Heldt.P.M. Automotive Chassis, 3rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler “Advanced vehicle technology”2nd edition Edward Arnold publication 2002

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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SAU1401 AUTOMOBILE ENGINEERING

UNIT III FRONT AXLE, STEERING SYSTEM, REAR AXLE, WHEEL AND TYRES

3. FRONT AXLE, STEERING SYSTEM, REAR AXLE, WHEEL AND TYRES

Purpose and requirement front axle, steering geometry- castor, camber, king pin inclination ,toe-in, toe out, centre point steering; types of steering mechanism, steering linkages, power steering, Live and dead axles, live axle arrangement, wheel construction, alloy wheel, wheel alignment and balancing, types of tyres , tyre construction, thread design.

Requirements of Steering System:

a. It must keep the wheel at all times in to rolling motion without rubbing on the road.

b. This system should associate to control the speed.

c. It must light and stable.

d. It should also absorb the road shocks.

e. It must easily be operated with less maintenance.

f. It should have self-centering action to some extent.

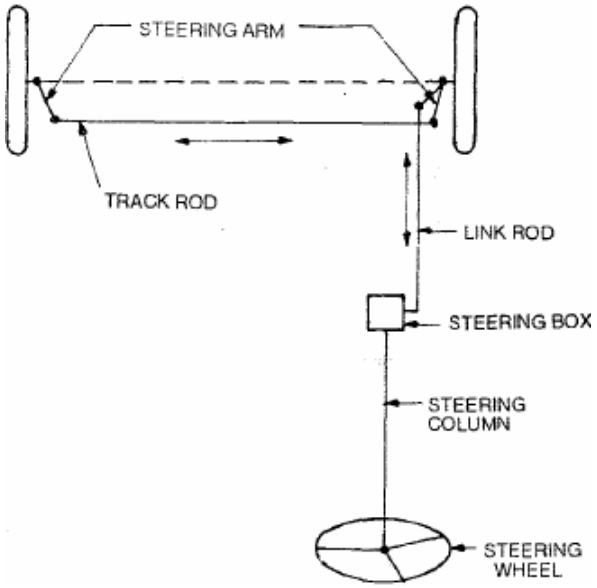

Figure 3.1. Steering Principle

Functions of Steering System:

1. It helps in swinging the wheels to the left or right.
2. It helps in turning the vehicle at the will of the driver.
3. It provides directional stability.
4. It is used to minimize the tyre wear and tear.
5. It helps in achieving self-centering efforts.

6. It absorbs major part of the road shocks.

The following are the main components of steering system are

1. Steering Wheel
2. Steering column or shaft
3. Steering Gear
4. Drop Arm or Pitman Arm
5. Drag Link
6. Steering Arm
7. Track-Arms
8. Track Rod or Tie-Rod
9. Adjusting Screws Types of Steering Gear Boxes:

1. Worm and Wheel Steering Gear.
2. Worm and Roller Steering Gear.
3. Re-circulating Ball type Steering Gear.
4. Rack and Pinion type Steering Gear.
5. Cam and Roller Gear type Steering Gear.
6. Cam and Peg Steering Gear.
7. Cam and Double lever Steering Gear.
8. Worm and Sector Type Steering Gear.

1. Worm and Wheel Type: This type of steering gear has a square cut screw threads at the end of the steering column; which forms a worm, at the end of it a worm wheel is fitted and works rigidly with it. Generally covered shaft is used for the worm wheel. The worm wheel can be turned to a new position the drop arm can be readjusted to the correct working position.

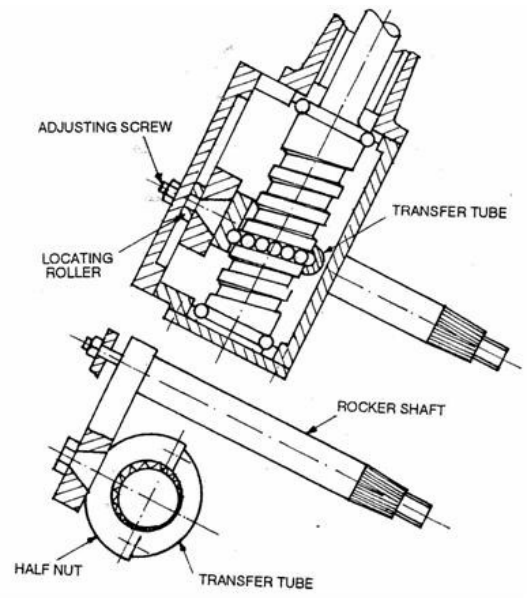

Figure 3.2. Worm and Wheel Steering Gear

2. Re-circulating Ball Type: In this type of gear box the endless chain of balls are provided between the worm and nut members. The nut form a ring of rack having an axial movement. So that the sector on the rocker shaft racks, the balls roll continuously between the worm and nut. Being provided with return chambers at the ends of the worm. This method reduces friction between worm and nut members. This type of steering gear is used for heavy vehicles.

3. Rack and Pinion Type: This is common manual type of steering gear box is used in most of the vehicles. In this type of steering a pinion is provided the bottom end of the steering column. The teeth of the pinion wheel in mesh with corresponding teeth provided on the rack, the end of which are connected to the stub axle through the rod. The rotating motion of the pinion operates the rack in FORE and AFT direction which in turn operates the stub axle.

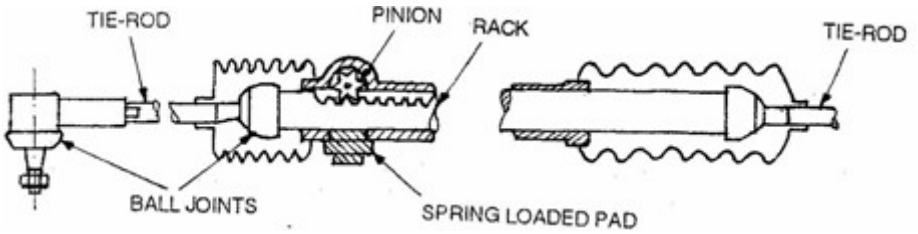

Figure 3.3. Rack and Pinion Type Steering Gear

4. Cam and Lever Type: The cam and lever steering uses one or two lever studs fitted in taper roller bearing. When the worm in the form of helical groove rotates the stub axle and it also rotates along with it. This imports a turning motion to the drop arm shaft.

5. Worm and Sector Type: In this type the worm on the end of the steering shaft meshes with a sector mounted on a sector shaft. When the worm is rotated by rotation of the steering wheel, the sector also turns rotating the sector shaft. Its motion is transmitted to the wheel through the linkage. The sector shaft is attached to the drop arm or pitmen arm.

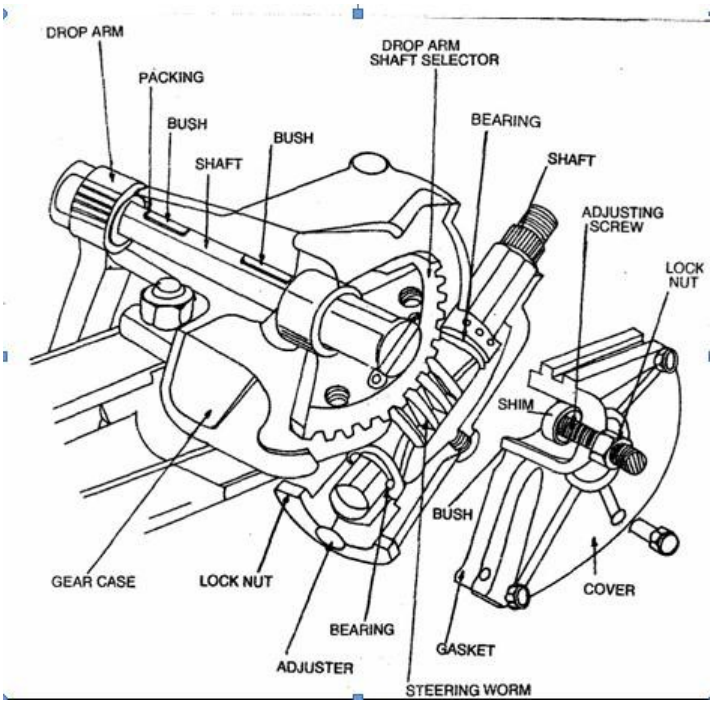

Figure 3.4. Worm and Sector Type Steering Gear

Slip Angle: The angle between direction of the motion of the vehicle and the center plane of the tyre is known as Slip Angle. It ranges from 8º to 10º.

Under steer: When the front slip angle is greater than that of rear, the vehicle tends to steer in the direction of side force. Then it is known as under steer. This provides greater driving stability, especially when there is a side wind.

Over Steer: When the rear slip angle is greater than that of front slip angle, the vehicle tends to moves away from the direction of center path. This is known as over stear. This is advantageous when the vehicle moving on the road having many bends curves.

Steering Gear Ratio or Reduction Ratio: It has been defined as the " number of turns on the steering wheel required to produce on turn of steering gear cross shaft to which the pitman arm is attached. Generally it varies between 14'.1 and 24'.1.

Turning Radius: It is the radius of the circle on which the outside front wheels moves when the front wheels are turned to their extreme outer position. This radius is 5 to 7.5 m for buses and trucks.

Wheel Alignment: It returns to the positioning of the front wheels and steering mechanism that gives the vehicle directional stability, reduce the tyre wear to a minimum.

Factors effects the wheel alignment:

1. Factors pertaining to wheel:-
    a. Balance of wheels(Static and Dynamic) b.Inflation of tyre. c.Brake adjustments.
2. Steering Linkages.
3. Suspension System
4. Steering Geometry –a. caster b. camber c. king pin inclination d. toe-in and toe-out etc.,

Steering Geometry: It refers to the angular relationship between the front wheels and parts attached to it and car frame.

The steering Geometry includes

1. Caster angle
2. Camber angle
3. King-pin inclination
4. toe-in
5. toe-out etc.,

Caster Angle: This is the angle between backward or forward tilting of the king pin from the vertical axis at the top. This is about 2º to 4º. The backward tilt is called as positive caster. The forward tilt is called negative caster.

Camber: The angle between wheel axis to the vertical line at the top is called camber angle. It is approximately ½º to 2º.

King-pin inclination: It is the angle between vertical line to the king pin axis. The inclination tends to keep wheels straight ahead and make the wheels to get return to the straight position after completion of a turn. The inclination is normally kept 7º to 8º.

Toe-in: It is the amount in minimum at the front part of the wheel points inwards approximately 3 to 5 mm. It prevents side slipping excessive tyre wear, proper rolling of front wheels and steering stability.

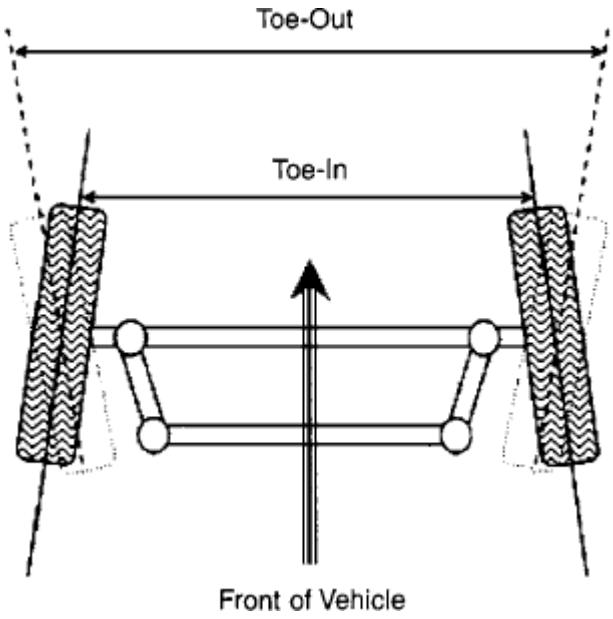

Figure 3.5. Toe-in Toe-out

Toe-out: It is the difference in angles between two front wheels and vehicle frame during turning. It is used to prevent dragging of tyre during turn. Reversible steering: When the deflection of road wheels is transmitted through the steering wheel to road surface, the system is called Reversible. If every imperfection of road surface causes the steering to rotate, it causes much strain on the part of the driver to control the vehicle. It causes much strain on the part of the driver to control the vehicle. Therefore such of the reversibility is not desired. But, some degree of reversibility desired, so that the wheel becomes straight after taking a curve.

Steering Mechanism: There are two types of steering gear mechanisms 1. Davis Steering gear 2. Ackermann Steering gear

1. **Davis Steering Gear:** The Davis Steering gear has sliding pair, it has more friction than the turning pair, therefore the Davis Steering Gear wear out earlier and become inaccurate after certain time. This type is mathematically Accurate. The Davis gear mechanism consists of cross link KL sliding parallel to another link AB and is connected to the stub axle of the two front wheel by levers ACK and DBK pivoted at A and B respectively. The cross link KL slides in the bearing and cross pins at its ends K and L. The slide blocks are pivoted on these pins and move with the turning of bell crank levers as the steering wheel is operated. When the vehicle is running straight the gear is said to be in its mid-position. The short arms AK and BL are inclined an angle 90 t α to their stub axles AC and BD respectively. The correct steering depends upon the suitable selection of cross arm angle α, and is given by

Tan α = b/2l Where b= AB = distance between the pivots of front axle. l=wheel base

2. **Ackermann Steering System:** It has only turning pair. It is not mathematically accurate except in three positions. The track arms are made inclined so that if the axles are extended

they will meet on the longitudinal axis of the car near rear axle. This system is called ackermann steering.

Steering Defects And Their Causes And Remedies:

1. Wheel wobble: The oscillation of the front wheels at low speeds is called wheel wobble.

Causes	**Remedies**
a. In Correct Dynamic Balancing of wheels.	a. Correct the wheel balance
b. Uneven Tyre pressure	b. Check the tyre pressure
c. The camber may be incorrect or Uneven	c. Adjust suitably.
d. The ball joints may be worn out.	d. Replace with a new one
e. Excessive caster	e. Adjust
f. Steering gear or wheel bearing may be loosen.	f. Adjust or Replace
g. Tyre may worn unevenly	g. Replace

2. **High Speed shimmy:** The oscillation of the front wheels at high speed is called high speed shimmy.

a. Wheel Rim may be buckled	- Straighten or replace
b. Front wheel bearing may loose or worn out	- Tighten or Replace
c. Faulty shock Absorber	- Replace
d. Incorrect toe-in	- Adjust
3. Excessive backlash in steering:	
a. Steering gear base may be loose	-Tighten
b. Drop arm may be loose on splines	- Replace
c. Front wheel stub axle bearing loose or worn out -	Tighten or Replace
d. Loose steering Linkages	- Tighten Properly

4. **Steering Wander:** The moving of Vehicle slightly in one side is known as wandering

a. Tyre pressure in two sides is not equal	- Check and correct
b. Steering knuckle bearing tight	-Adjust
c. Badly worn Tyre	- Replace
d. Incorrect Toe-in	- Correct it.

5. **Hard Steering: When the effort required for steering is more it is called hard steering.**

   a. Low Tyre pressure - Correct pressure

   b. Excessive caster - Adjust

   c. Steering gear too tight - Adjust

   d. Incorrect wheel Alignment - Adjust

Steering Mechanisms

The fundamental problem in steering is to enable the vehicle to traverse an arc such that all four wheels travel about the identical center point. In the days of horse-drawn carriages, this was accomplished with the fifth-wheel system depicted in Fig.

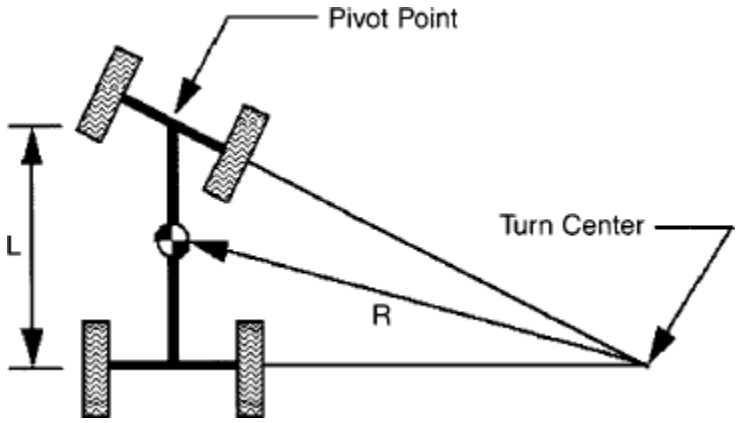

Figure 3.6. Steering Mechanisms

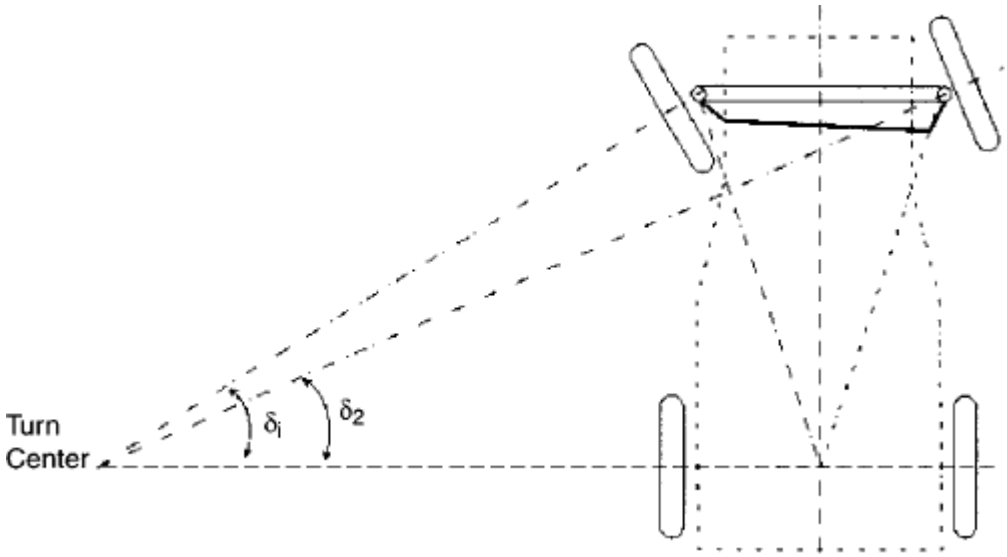

Figure 3.7. Steering Linkage

Steering Linkage

Steering linkage is a series of arms, rods, and ball sockets that connect the steering mechanism to the steering knuckles. The steering linkage used with most manual and power steering mechanisms typically includes a pitman arm, center link, idler arm, and two tie-rod assemblies. This configuration of linkage is known as parallelogram steering linkage and is used on many passenger vehicles

Pitman Arm

The pitman arm transfers steering mechanism motion to the steering linkage . The pitman arm is splined to the steering mechanism's output shaft (pitman arm shaft). A large nut and lock washer secure the pitman arm to the output shaft. The outer end of the pitman arm normally uses a ball-and-socket joint to connect to the center link.

Center Link

The parallelogram steering linkage uses a center link, otherwise known as an intermediate rod, track rod, or relay rod, which is simply a steel bar that connects the steering arms (pitman arm, tie-rod ends, and idler arm) together. The turning action of the steering mechanism is transmitted to the center link through the pitman arm.

Idler Arm

The center link is hinged on the opposite end of the pitman arm by means of an idler arm . The idler arm supports the free end of the center link and allows it to move left and right with ease. The idler arm bolts to the frame or subframe.

Ball Sockets

Ball sockets are like small ball joints; they provide for motion in all directions between two connected components. Ball sockets are needed so the steering linkage is NOT damaged or bent when the wheels turn or move up and down over rough roads. Ball sockets are filled with grease to reduce friction and wear. Some have a grease fitting that allows chassis grease to be inserted with a grease gun. Others are sealed by the manufacturer and cannot be serviced.

Tie-Rod Assemblies

Two tie-rod assemblies are used to fasten the center link to the steering knuckles. Ball sockets are used on both ends of the tie-rod assembly. An adjustment sleeve connects the inner and outer tie rods. These sleeves are tubular in design and threaded over the inner and outer tie rods. The adjusting sleeves provide a location for toe adjustment. Clamps and clamp bolts are used to secure the sleeve. Some manufacturers require the clamps be placed in a certain position in relation to the tie rod top or front surface to prevent interference with other components.

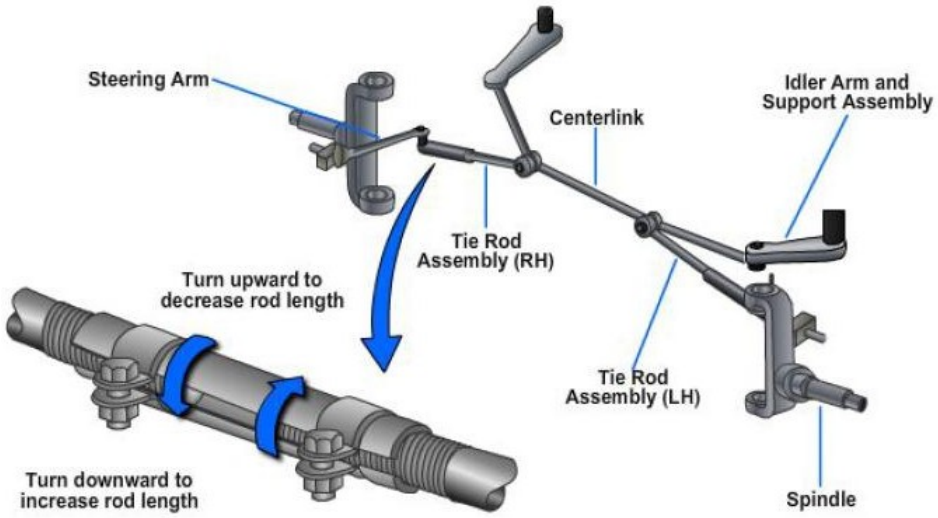

Figure 3.8. Tie Rod Assembly

Draglink

The steering system most commonly used on four-wheel drive vehicles has a draglink. The draglink connects the pitman arm to the spindle at a point near the spindle; the tie rod will connect the two steer wheels together. The objective is to keep the tie rod as close to parallel with the axle as possible.

Power Steering:

Power steering reduces much strain on the part of the driver while negotiating sharp curves. It makes easy to turn sharp corners. It is usually arranged to be operative when the effort of steering wheel exceeds a pre-determined value. It is fitted on heavy commercial vehicles and medium cars. Steering Linkages: Steering Linkage is a connection of various links between the steering gear box and the front wheels. The motion of the pitman arm and steering gear box is transferred so the steering knuckles of the front wheels through the steering linkages. The swinging movement of the pitman arm from one side to the other side gives angular movement to the front wheel through the steering linkages. Power steering systems normally use an engine-driven pump and hydraulic system to assist steering action. Pressure from the oil pump is used to operate a piston and cylinder assembly. When the control valve routes oil pressure into one end of the piston, the piston slides in its cylinders. Piston movement can then be used to help move the steering system components and front wheels of the vehicles. The components that are common to all power steering systems are the power steering pump, the control valve, and power steering hoses. The power steering pump is engine-driven and supplies hydraulic fluid under pressure to the other components in the system. There are four basic types of power steering pumps: vane, roller, slipper, and gear types.

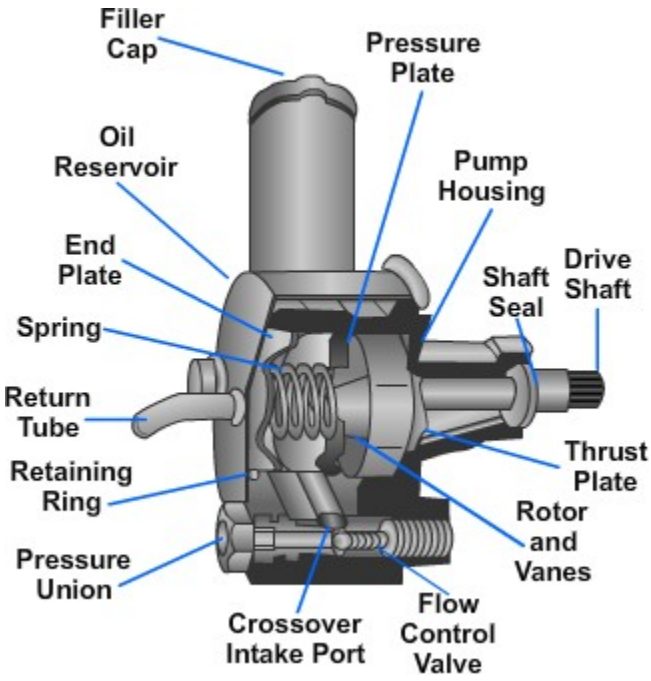

Figure 3.9. Power steering system

A belt running from the engine crankshaft pulley normally powers the pump. During pump operation, the drive belt turns the pump shaft and pumping elements. Oil is pulled into one side of the pump by vacuum. The oil is then trapped and squeezed into a smaller area inside the pump. This action pressurizes the oil at the output as it flows to the rest of the system. A pressure relief flow valve is built into the pump to control maximum oil pressure. This action prevents system damage by limiting pressure developed throughout the different engine speeds. The control valve, a rotary or spool type valve which is actuated by steering wheel movements, is designed to direct the hydraulic fluid under pressure to the proper location in the steering system. The control valve may be mounted either in the steering mechanism or on the steering linkage, depending on which system configuration is used.

Bleeding a Power Steering System

Anytime you replace or repair a hydraulic component (pump, hoses, and power piston), you should bleed the system. Bleeding the system assures that all of the air is out of the hoses, the pump, and the gearbox. Air can cause the power steering system to make a buzzing sound. The sound will occur as the steering wheel is turned right or left. To bleed out any air, start the engine and turn the steering wheel fully from side to side. Keep checking the fluid and add as needed. This will force the air into the reservoir and out of the system.

Steering Wheel Play

The most common of all problems in a steering system is excessive steering wheel play. Steering wheel play is normally caused by worn ball sockets, worn idler arm, or too much clearance in the steering gearbox. Typically, you should not be able to turn the steering wheel more than 1 1/2 inches without causing the front wheels to move. If the steering wheel rotates excessively, a serious steering problem exists. An effective way to check for play in the steering linkage or rack-and-pinion mechanism is by the dry-park test. With the full weight of the vehicle on the front wheels, have someone move the steering wheel from side to side while you examine the steering system for looseness. Start your inspection at the steering column shaft and work your way to the tie-rod ends. Ensure that the movement of one component causes an equal amount of movement of the adjoining component.

Condition for True Rolling

True rolling occurs only when the direction of motion of the vehicle is perpendicular to the wheel axis i.e. the wheel is subjected to forward force. When wheel is subjected to side force that acts parallel to the wheel axis, a true scrub action is produced. When the wheel is subjected to both forward and side forces, the movement is compounded of true rolling and lateral distortion . This condition occurs when the wheels are being steered, i.e. the **direction of**

From the figure, $\cot \phi = \frac{c+x}{b} = \frac{c}{b} + \frac{x}{b} = \frac{c}{b} + \cot \theta$

where, θ = Angle of inside lock.

ϕ = Angle of outside lock.

a = Wheel track, also known as tread of vehicle.

b = Wheel base of the vehicle.

c = Distance between the pivot centres.

d = Length of track rod.

and x = Projected distances from instantaneous centre to the inner pivot centre.

Therefore, $\cot \phi - \cot \theta = \frac{c}{b}$

motion is neither parallel nor perpendicular to the axis of rotation. On a circular path, true rolling condition occurs when the projected axes of several wheels all moving in different curved paths intersect at a single point called the instantaneous centre. When these projected axes do not intersect at a single point, a degree of tyre scrub results. Whenever a vehicle takes a turn, the front wheels must turn in a definite manner both in relation to each other and to the axis of the rear wheels so that the lateral slip may be avoided and true rolling for all the wheels is obtained. For this, as explained above, all the wheels must always rotate about the instantaneous centre. Since the rear wheels have a common and fixed axis, it is quite obvious that this common centre, 0, would lie somewhere on its extension This equation gives the fundamental condition to be satisfied by all types of steering mechanism if true rolling for all the wheels is to be obtained avoiding any lateral slip. The steering linkage used in the vehicles must maintain the proper angles with the wheels when taking a turn. But practically it is not possible to maintain absolutely correct angles for the wheels for all turning angles.

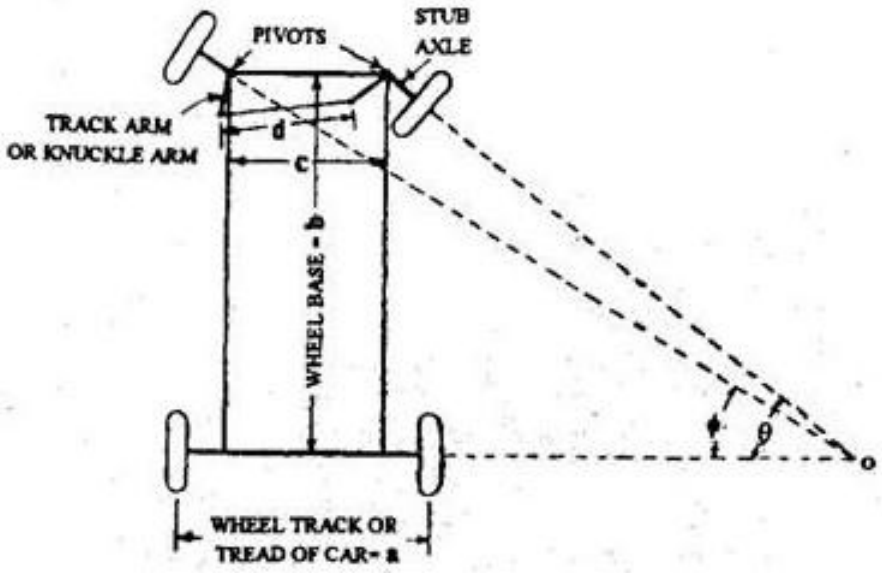

Figure 3.10. True Rolling

Turning Circle Radius.

When a vehicle takes a turn without experiencing any lateral slip, all the wheels rotate about a common centre along different turning circles

Turning circle radius of the outer front wheel, $R_{of} = \frac{b}{\sin \phi} + \frac{a-c}{2}$

Turning circle radius of the inner front wheel, $R_{if} = \frac{b}{\sin \theta} - \frac{a-c}{2}$

Turning circle radius of the outer rear wheel, $R_{or} = b \cot \phi + \frac{a-c}{2}$

Turning circle radius of the inner rear wheel, $R_{ir} = b \cot \theta - \frac{a-c}{2}$

Ackermann Steering System: It has only turning pair. It is not mathematically accurate except in three positions. The track arms are made inclined so that if the axles are extended they will meet on the longitudinal axis of the car near rear axle. This system is called ackermann steering.

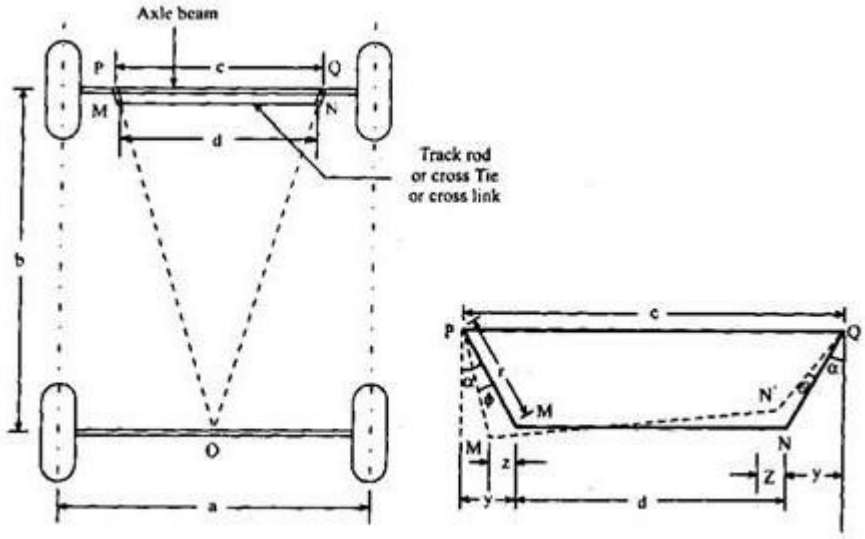

Figure 3.11. Ackermann Principle

Then $\sin(\alpha + \theta) = \frac{y+z}{r}$ and $\sin(\alpha - \phi) = \frac{y-z}{r}$

Hence, $\sin(\alpha + \theta) + (\alpha - \phi) = \frac{2y}{r} = 2 \sin \alpha$

With the help of above equations, the variables θ and ϕ can be calculated for correct steering. Problems can also be solved through semi-graphical method.

Tire Construction

Most modern passenger vehicles and light trucks use tubeless tires that do NOT have a separate inner tube. The tire and wheel form an airtight unit. Many commercial and construction vehicles use inner tubes, which are soft, thin, leak-proof rubber liners that fit inside the tire and wheel assemblies. However, in the last few years tubeless tires have been introduced to commercial and construction vehicles, reducing the need for tube type tires. Tires perform the following two basic functions:

- They must act as a soft cushion between the road and the metal wheel.
- They must provide adequate traction with the road surface.

Tires must transmit driving, braking, and cornering forces to the road in all types of weather. At the same time, they should resist puncture and wear. Although there are several tire designs, the six major parts of a tire are as follows

- Tire beads (two steel rings encased in rubber that holds the tire sidewalls against the wheel rim).
- Body plies (rubberized fabric and cords wrapped around beads. forming the carcass or body of the tire).
- Tread (outer surface of the tire that contacts the road surface).
- Sidewall (outer surface of the tire extending from bead to tread; it contains tire information).
- Belts (used to stiffen the tread and strengthen the plies; they lie between the tread and the inner plies).
- Liner (a thin layer of rubber bonded to the inside of the plies: it provides a leakproof membrane for tubeless tires).

There are many construction and design variations in tires. A different number of plies may be used and run at different angles. Also, many different materials may be used.

The three types of tires found on late model vehicles are bias-ply, belted bias, and radial.

Bias-Ply Tire

A bias-ply tire is one of the oldest designs, and it does NOT use belts. The position of the cords in a bias-ply tire allows the body of the tire to flex easily. This design improves the cushioning action, which provides a smooth ride on rough roads. A bias-ply tire has the plies running at an angle from bead to bead. The cord angle is also reversed from ply to ply, forming a crisscross pattern. The tread is bonded directly to the top ply. A major disadvantage of a bias-ply tire is that the weakness of the plies and tread reduce traction at high speeds and increase rolling resistance.

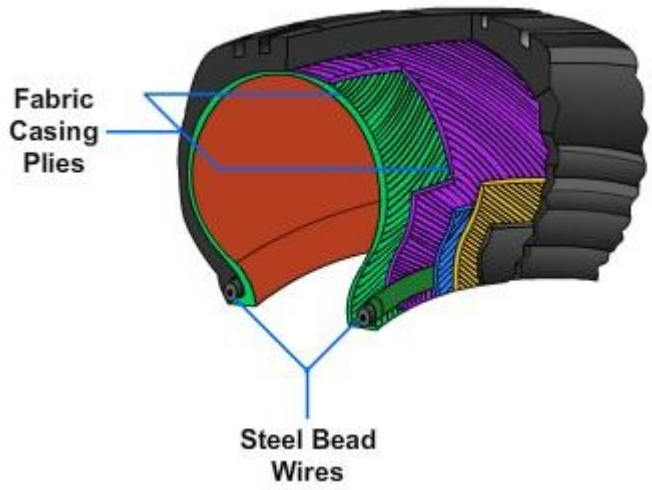

Figure 3.12. Bias-Ply Tire

Belted Bias Tire

A belted bias tire provides a smooth ride and good traction, and offers some reduction in rolling resistance over a bias-ply tire. The belted bias tire is a bias-ply tire with stabilizer belts added to increase tread stiffness. The belts and plies run at different angles. The belts do NOT run around

to the sidewalls but lie only under the tread area. Two stabilizer belts and two or more plies are used to increase tire performance.

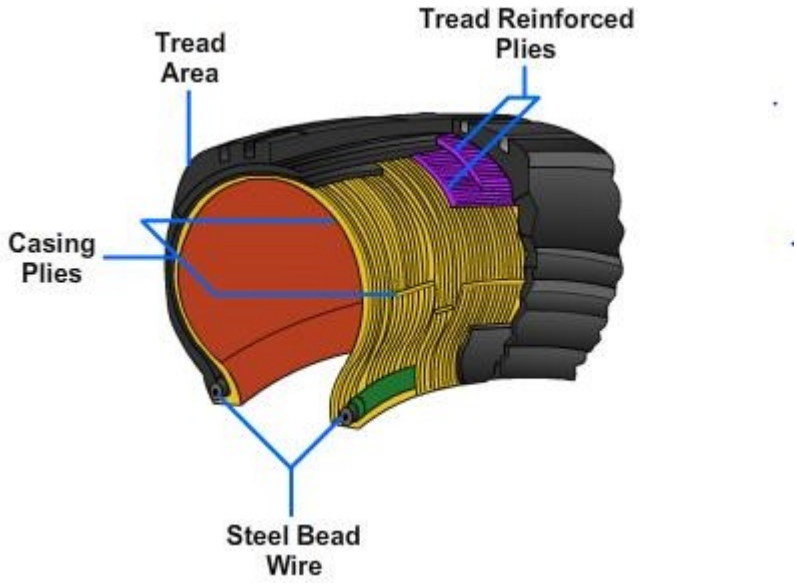

Figure 3.13. Belted Bias Tire

Radial Ply Tire

The radial ply tire has a very flexible sidewall, but a stiff tread. This design provides for a very stable footprint (shape and amount of tread touching the road surface) which improves safety, cornering, braking, and wear. The radial ply tire has plies running straight across from bead to bead with stabilizer belts directly beneath the tread. The belts can be made of steel, flexten, fiberglass, or other materials.

Wheels

Wheels must have enough strength to carry the weight of the vehicle and withstand a wide range of speed and road conditions. Automobiles and light trucks are equipped with a single piece wheel. Larger vehicles have a lock ring (side ring) that allows for the easy removal of the tire from the wheel and, when in place, it provides a seat for one side of the inflated tire.

A standard wheel consists of the RIM (outer lip that contacts the bead) and the SPIDER (center section that bolts to the vehicle hub). Normally the spider is welded to the rim. Common wheel designs are as follows:

- Drop center
- Semidrop center
- Safety
- Split

Drop Center Wheel

The drop center wheel is made in one piece and is commonly used on passenger vehicles because it allows for easier installation and removal of the tire. Bead seats are tapered to match a corresponding taper on the beads of the tire.

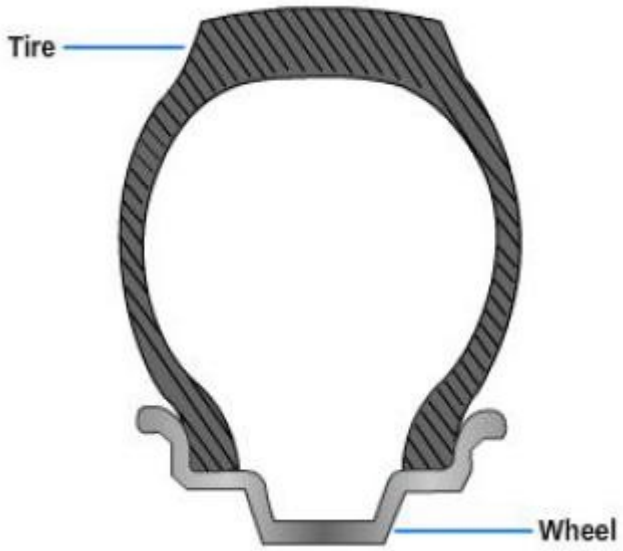

Figure 3.13. Drop Center Wheel

Semidrop Center Wheel

The semidrop center wheel has a shallow well, tapered-head seat to fit the taper of the beads of the tire. It also has a demountable flange or side ring which fits into a gutter on the outside of the rim, holding the tire in place.

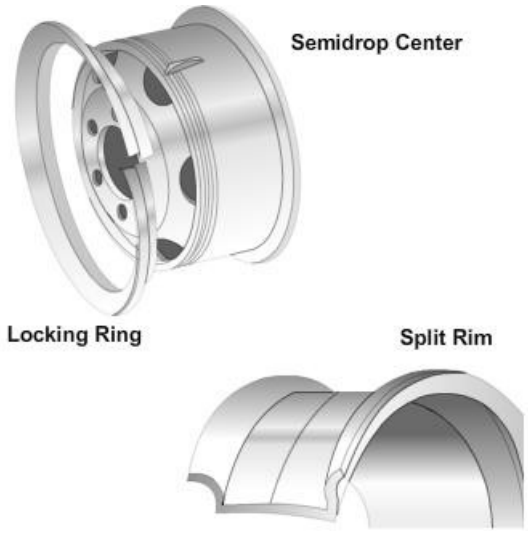

Figure 3.14. Semidrop Center Wheel

Safety Wheel

A safety wheel is similar to the drop center wheel. The major difference is that the safety wheel has a slight hump at the edge of the bead ledge that holds the bead in place when the tire goes flat.

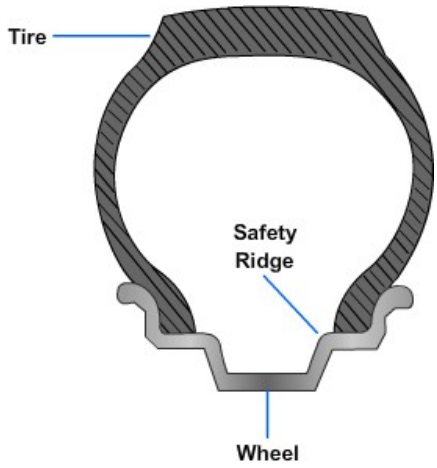

Figure 3.15. Safety Wheel

Split Wheel (2 Piece Wheel)

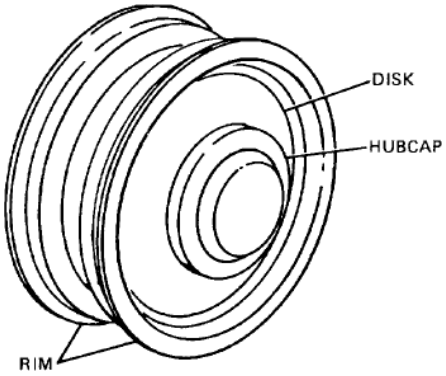

Figure 3.16. Split Wheel

A split wheel (rim) has a removable bead seat on one side of the rim The seat is split to allow for its removal so tires can be easily changed. Some bead seats also require the use of a lock ring to retain the seat. These wheels are used on large commercial and military vehicles.

Disk Wheels.

The center disk of a wheel may be a solid plate or of a slotted steel construction. In both cases, the disk is welded or riveted to the rim, and the wheels are demountable at the hub. The disk is dished to bring the point of ground contact under the large wheel bearing, and to permit the mounting of dual wheels. Modern passenger cars almost exclusively use the steel-disk type wheel.

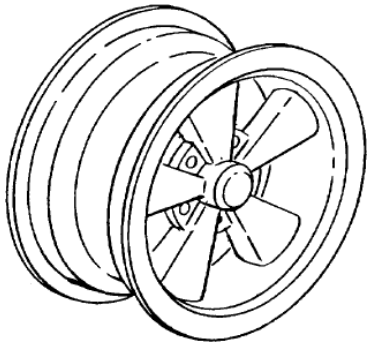

Figure 3.17. Disc Wheel

Pressed and Cast Spoked Wheels. On light vehicles, the wheel center section and rim are connected by spokes and the wheels are demountable at the hub. For heavier trucks, the spokes are integrated with the center section and a demountable rim is used. Another form of cast wheel , sometimes called a mag wheel, is a one-piece design made of lightweight alloys. These types of wheels are very popular on modern automobiles and are made in many sizes and styles. Great care must be taken when mounting and demounting tires on these rims, because the wheel assemblies are soft and brittle, which causes them to crack easily.

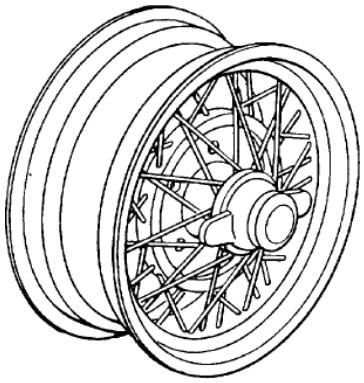

Figure 3.18. Spoked Wheel

Wire Wheels. This type of wheel consists of a pressed-steel hub and rim connected by welded spokes. This design allows greater amounts of air to flow past the brake assemblies, therefore keeping them cool and minimizing brake fade. Wire wheels, however, are hard to clean, require the use of full-circle antiskid chains only, and are not adapted for use with dual wheels.

Radial ply tyres

The radial ply tyre consists of two bead cores joined together radially via the carcass hence the name radial tyres. A belt of cords provides the necessary stiffness, whereas the external part of the tyre consists of the tread and sidewall and the interior of the inner lining, which ensures the tyre is hermetically sealed . In passenger car tyres, the carcass is made of rayon or nylon, the belt of steel cord or a combination of steel, rayon or nylon cord, and the core exclusively of steel.

Due to the predominance of steel as the material for the belt, these tyres are also known as 'steel radial tyres'. The materials used are indicated on the sidewall points and In commercial vehicle designs this is particularly important and the carcass may also consist of steel. The stiff belt causes longitudinal oscillation, which has to be kept away from the body by wheel suspensions with a defined longitudinal compliance, otherwise this would cause an unpleasant droning noise in the body, when on cobbles and poor road surfaces at speeds of less than 80 km/h. The only other disadvantage is the greater susceptibility of the thinner sidewalls of the tyres to damage compared with diagonal ply tyres. The advantages over cross-ply tyres, which are especially important for today's passenger cars and commercial vehicles, are:

• significantly higher mileage

• greater load capacity at lower component weight

Tubeless or tubed

In passenger cars, the tubeless tyre has almost completely ousted the tubed tyre. The main reasons are that the tubeless tyre is

• easier and faster to fit

• the inner lining is able to self-seal small incisions in the tyre.

In tubeless tyres the inner lining performs the function of the tube, i.e. it prevents air escaping from the tyre. As it forms a unit with the carcass and (unlike the tube) is not under tensional stress, if the tyre is damaged the incision does not increase in size, rapidly causing loss of pressure and failure of the tyre. The use of tubeless tyres is linked to two conditions:

• safety contour on the rim

• its air-tightness.

Because this is not yet guaranteed worldwide, tubed tyres continue to be fitted in some countries. When choosing the tube, attention should be paid to ensuring the correct type for the tyre. If the tube is too big it will crease, and if it is too small it will be overstretched, both of which reduce durability. In order to avoid confusion, the tyres carry the following marking on the sidewall.

Two types of tyres are used in vehicles :

(a) Tube tyres, and

(b) Tubeless tyres.

Both these tyres are called pneumatic tyres because air is filled in them.

Tube Tyres

Tube tyres encloses a tube which is wrapped on the wheel rim. Air is forced into tube which inflates the tube and tyre. The outer side of tyre which comes in contact of road is made from rubber. It is called tread. Tread provides resistance to slipping. It is very thick at the outer

periphery. Beads are made at the inner bide by reinforcing it with steel wires. Beads are very strong which have good resistance to wearing against the wheel rim. Rayon cords are also formed into a number of piles. Beads are cords provide good strength to tyres.

Tubeless Tyres

These tyres do not require any tube. The air at pressure is filled into the tyre itself. The construction of tyre is same as that of tube tyre. For filling the air, a non-return valve is filled in the tyre itself.

Advantages of Tubeless Tyres

(a) Tubeless tyres are lighter in weight.

(b) They remain cooler compared to tube tyres.

(c) The main advantage of tubeless tyre is that they remain inflated for long time even if these are punctured by a nail if the nail remains inside the tyre.

(d) Any hole in the tyre, due to puncture, can be repaired by rubber plugging.

(e) A simple puncture can be repaired without removing tyre from wheel.

Types of Front Axle

• Live front axle (used for front wheel drive and 4X4 type of drive).

• Dead front axle (used for 4X2 type of drive).

Types of Arrangement of Front Axle There are two types of Front Axle arrangements employed on automobiles which, are as follows:

1. Stub-axle with rigid axle beam type: This type was used earlier on all types of vehicles, but now it finds use on medium and heavy commercial vehicles only, such as trucks and buses.
2. Stub-axle without rigid axle beam type: It is widely used on cars and light commercial vehicles.

Rigid Axle Beam: The rigid axle beam is a stationary structural member used to sustain bending and torsional loads and to connect the stub axles. The bending is induced in its central region and due to the vehicle's weight the torsional loads are caused near its ends due to the wheel's braking. Since the I-section resists bending and the circular section can resists torsion more efficiently, the axle beam consists of a central region made of I-section and the ends of circular section. An elliptical section is also used sometimes.

Stub Axle: A stub axle is an inter-mediatory small shaft between the road wheel and the front (dead) axle. On one end it remains connected to the axle beam by means of a king pin or a ball joint, while the other end, the front wheel is mounted on it. The stub axles are available in different shapes and they are connected to the axle beam in different styles. Depending upon the shapes, and styles of connection, the stub axles can be one of the following types. 1. Elliot types

2. Reversed Elliot type as used on Eicher 10.90, Ashok Leyland Vicking, Tata 407 etc. 3. Lamoine type generally used on front axle of tractors. 4. Reversed lamoine type

Function of the Front Axle

• It carries the weight of the front of the vehicle.

• It carries stub axle king pin steering arm by which the vehicle can be steered.

• It works as cushion through its spring for a comfortable ride.

• It controls the ride through shock absorber fitted on it.

• It carries the brake system with which the moving vehicle can be stopped.

• In case of a four wheel drive, it also transmits power to road wheels. It carries hubs and wheels.

Front wheels of the vehicle are mounted on front axles. Functions of front axle are listed below : (a) It supports the weight of front part of the vehicle. (b) It facilitates steering. (c) It absorbs shocks which are transmitted due to road surface irregularities. (d) It absorbs torque applied on it due to braking of vehicle. There is two types of front axles : (a) Dead front axle, and (b) Line front axle. Dead Front Axle Dead axles are those axles, which donet rotate. These axles have sufficient rigidity and strength to take the weight. The ends of front axle are suitably designed to accommodate stub axles. Line Front Axle Line axles are used to transmit power from gear box to front wheels. Line front axles although, front wheels. Line front axles although resemble rear axles but they are different at the ends where wheels are mounted. Maruti-800 has line front axle.

Stub axles are connected to the front axle by king pins. Front wheels are mounted on stub axles arrangement for steering is connected to stub axles. Stub axle turns on kind pins. King pins is fitted in the front axle beam eye and is located and locked there by a taper cotter pin. Stub axles are of four types : (a) Elliot (b) Reversed elliot (c) Lamoine (d) Reversed lamoine All are differ from each other in the manner in which they are connected to the front axle. Elliot type stub axle is shown in Figure.

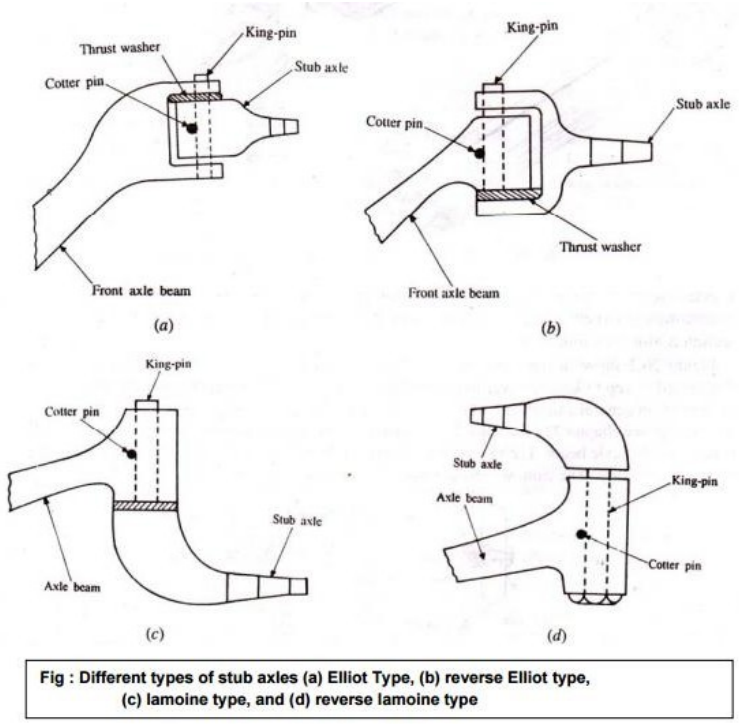

Fig : Different types of stub axles (a) Elliot Type, (b) reverse Elliot type, (c) lamoine type, and (d) reverse lamoine type

Figure 3.19. Stub Axles

Rear Axle

Rear axle transmits power from differential to the wheels so that vehicle may move. Rear axle is not a single piece but it is in two parts which are connected by the differential. This is shown in Figure 5.5. Each part of rear axle is called the half shaft. Outer end of the rear axle carries the wheel while inner end is connected to sun gear of the differential. In vehicles which employ rear wheel drive, rear wheels are driving wheels. However, in front wheel drive vehicles, front wheels are driving wheels. Rear axles and differential are completely enclosed in a housing to protect them from dust, dirt, water and any possible damage. Functions of Rear Axle (a) To transmit power from differential to the wheels. This is main function. (b) To carry weight of automobile.

Rear axles differ on the basis of method of supporting them and mounting of rear wheels. On this basis, these axles can be classified into three types :

(a) Half floating axle

(b) Three-quarter floating

(c) Fully floating

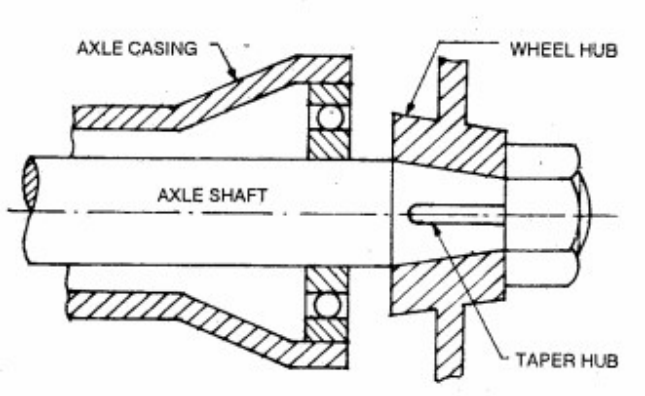

Figure 3.20. Half floating axle

Half Floating Axle In a half floating rear axle, the axle is at the centre of the axle casing and the bearings are inside the axle casing. The weight of vehicle is transmitted first to suspension spring, then to axle casing, then to axle and finally to ground.

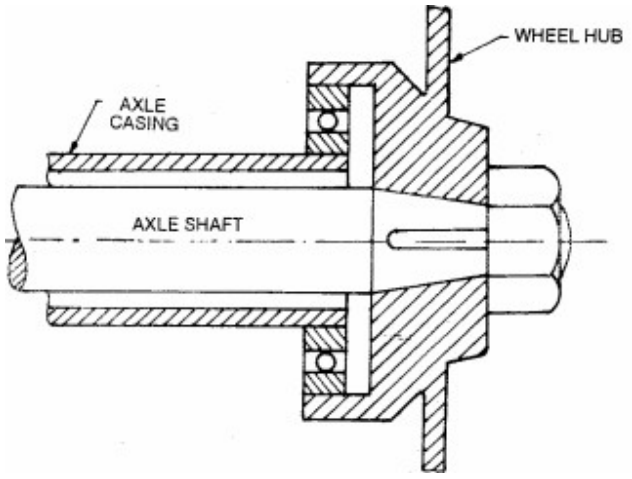

Figure 3.21. Three-quarter floating axle

Three-quarter Floating Axle: In three-quarter floating rear axle, bearings are on the outer side of axle casing, i.e. between casing and wheel. In this case, major part of vehicle weight is taken by axle casing and not by axle. This is the main advantage of three-quarter floating type over half floating type. Thus, axle breakdown is less in this case compared to the previous type.

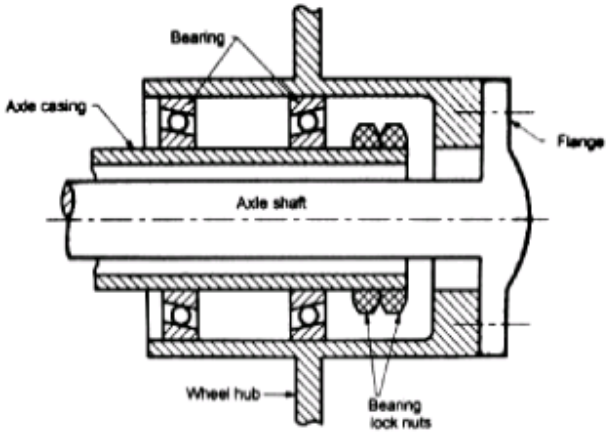

Figure 3.21. Full floating axle

A full-floating axle carries the vehicle's weight on the axle casing, not the halfshaft; they serve only to transmit torque from the differential to the wheels. They "float" inside an assembly that carries the vehicle's weight. Thus the only stress it must endure is torque (not lateral bending force).

TEXT / REFERENCE BOOKS

1. Kirpal Singh, “Automobile Engineering Vol 1 and 2 ”12th edition Standard Publishers 2011

2. Banga T.R. &Nathu Singh, “Automobile Engineering”3rd edition Khanna Publications. 2012

3. Rajput R.K. “A Text–Book of Automobile Engineering”, Laxmi Publications Private Limited, 2008.

4. Heldt.P.M. Automotive Chassis, 3rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler “Advanced vehicle technology”2nd edition Edward Arnold publication 2002

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SCHOOL OF MECHANICAL ENGINEERING

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UNIT IV SUSPENSION SYSTEM AND BRAKES

4. SUSPENSION SYSTEM AND BRAKES

Objectives and principles of suspension system, types, rigid axle and independent suspension for front and rear ends, leaf spring, torsion bar, shock absorber Types of brake systems-drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, ABS.

SUSPENSION SYSTEM

The chassis of vehicle is connected to the front and rear wheels through the medium of springs, shock absorbers and axles. All parts perform the function of protecting parts from shocks are known as suspension system.

The automobile chassis is indirectly connected with axles by springs. It is done to prevent the vehicle body from road shocks due to bounce, pitch, roll or sway. These road shocks provide an uncomfortable ride and also additional stress to the automobile frame and body

Suspension system has a spring and damper. The energy of road shock produced by the spring oscillates. These oscillations are arrested by the damper known as shock absorber.

Components of Suspension System

1. Springs are used to neutralize the shocks from the road surface.

2. Dampers, called shock absorbers, are used to improve a riding comfort by limiting the free oscillation of springs.

3. Stabilizer, called sway bar or anti-roll bar, isto prevent lateral swinging of the car.

4. A linkage system holds above components to control the longitudinal and lateral movements of wheels.

Functions or Objectives of Suspension System

1. To eliminate road shocks from transmission to vehicle components.

2. To obtain good road holding while driving, cornering and braking.

3. To keep the proper steering geometry.

4. To obtain a particular height to body structure.

5. To resist the torque and braking reactions.

8. To maintain the stability of the vehicle while traveling over rough round or when turning in order to minimize the rolling, pitching or vertical movement tendency.

9. To safeguard the occupants against road shocks and provide a riding comfort.

10. To minimize the effects of stresses due to road shocks on the mechanism of the motor vehicle and provide a cushioning effect.

11. To keep the body perfectly in level while travelling over rough uneven ground. I.e. the up and down movements of wheels should be relative to the body.

12. To prevent the structure of the vehicle from shock loading and vibration due to irregularities of the road surface without impairing its stability.

13. To obtain the requisite height to body structure.

14. To support the body on the axles and keep the proper geometrical relationship between the body and wheels.

Requirements of Suspension System

1. There should be minimum deflection.

2. It should be of minimum weight.

3. It should have low maintenance and low operating cost.

4. It should have minimum tyre wear.

5. It should be of low initial cost.

Principles of Suspension System

The principles of the suspension system are due to springing action of motor vehicles.

I. Supporting the weight of vehicle.

2. Absorbing satisfactorily larger and smaller road impacts with the help of a single springing device.

3. The reduction of rolling or pitching of the body to a minimum design and attachment of springs.

Sprung Weight and Unsprung Weight

The body of vehicle is supported by springs. The weight of the body is supported by springs called sprung weight. Wheels, axles and other parts of the automobile which are not supported by springs, called the unsprung weight. Unsprung weight is the weight of everything between springs and road and a portion of weight of springs itself.

If greater is the sprung weight of an automobile, the better will be the riding comfort. This tendency of the body reduces the jolt. Sprung weight is the weight of vehicle minus unsprung weight

:. Sprung weight = Total weight of vehicle - unsprung weight.

Greater is the unsprung weight on a wheel, the greater will be the energy stored by the unsprung weight due to road bump and greater will be the disturbances. This greater unsprung weight increases tyre deflections but it reduces the vertical velocity on road bump. Lesser unsprung weight causes higher natural frequencies of the unsprung.

A lighter wheel moves on road irregularities without producing much reaction to the chassis frame, body and occupants. If the weight of wheel increases, its movement is highly noticeable to vehicle occupants. When the unsprung weight on the wheel becomes equal to thesprung weight above the wheel, the sprung weight will move as much as unsprung weight. So, the unsprung weight moves up and down over road irregularities. Therefore, the unsprungweight is kept as low as possible due to the reduced unsprung weight thereby resulting a better ride.

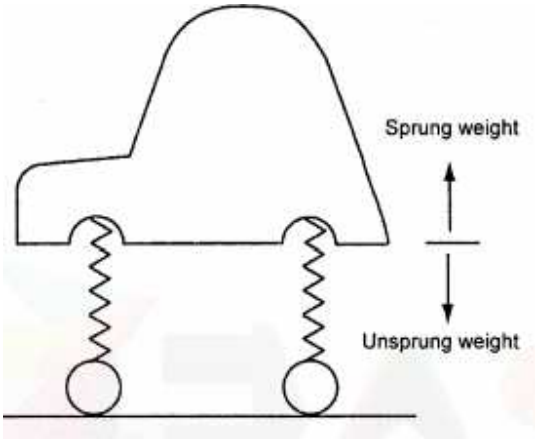

Figure.4.1. Sprung and Unsprung Mass

Effects of unsprung weight:

The unsprung weight of a wheel controls a trade-off between a wheel's bump and its vibration isolation. Bumps and surface imperfections in the road cause tyre compression which induces the force on the unsprung weight. Then, the unsprung weight responds to this force with movement of its own. The amount of movement for short bumps is inversely proportional to the weight. A lighter wheel which readily moves in response to road bumps will have more constant grip when tracking over an imperfect road. Therefore, lighter wheels are especially sought for high-performance applications. In contrast, a heavier wheel which moves less will not absorb as much vibration.

The irregularities of the road surface will transfer to the cabin through the geometry of the suspension and hence, ride quality and road noise are deteriorated. For longer bumps, the greater unsprung mass causes more energy to be absorbed by wheels and it makes the ride worse. Pneumatic or elastic tyres help by providing some springing action for most of the unsprung mass but the damping which can be included in tyres is limited due to fuel economy and overheating. The shock absorbers damp the wheel bounce if any spring motion must be less stiff than the optimum value. So, the wheels produce some vibrations after each bump before comingto rest.

High unsprung weight also exacerbates the wheel control issues under hard acceleration or braking. If the vehicle does not have adequate wheel location in the vertical plane, the vertical forces exerted by acceleration or hard braking combined with high unsprung mass can lead to severe the wheel hop, compromising traction and steering control. Similar to above case, there is a positive effect of unsprung mass. High frequency road irregularities such as gravels in an asphalt or concrete road surface are isolated from the body more completely because the tyres and springs act as separate filter stages with the unsprung weight tending to uncouple them. Similarly, sound and vibration isolation are improved in production automobiles by the use of rubber bushings between frame and suspension in theform of flexibility in the frame or body work and flexibility in seats.

Types of Suspension Springs

Springs are main important parts of any suspension system which are classified as follows.

1. Steel springs

a) Leaf springs

b) Tapered leaf springs

c) Coil springs

d) Torsion bar

2. Rubber springs

a) Compression springs

b) Compression-shear springs

c) Steel reinforced springs

d) Progressive spring

e) Face shear spring

3. Air springs

a) Bellow type springs

b) Piston type springs

4. Plastic springs.

Leaf Spring Suspension

Figure 2. Shows the construction of the laminated leaf spring suspension. It has a number of leaves of increasing lengths made of steel plates. The spring eye is mounted to the frame by a pin called shackle pin. The centre portion of the spring is attached to the front axle by a V-bolt. One

end of the spring is mounted on the frame with a simple pin. The other end is mounted by a shackle with the frame.

The stiffness or spring rate of the coil spring decides the capacity of the spring which is defined as the force required for unit deflection. It is governed by the following factors.

- The length of the spring: Shorter spring will have higher stiffness and vice versa.
- The width of the leaf: Wider spring will have higher stiffness and vice versa.
- The thickness of the leaf: Thicker leaf will have higher stiffness and vice versa.
- The number of leaves: Greater the number of leaves higher the stiffness is.

To obtain a smooth ride, a low-rate stiffness spring is required. The low rate spring will deflect a larger amount under a given load. Normal springs have a constant rate, and give a deflection which is proportional to the load applied.

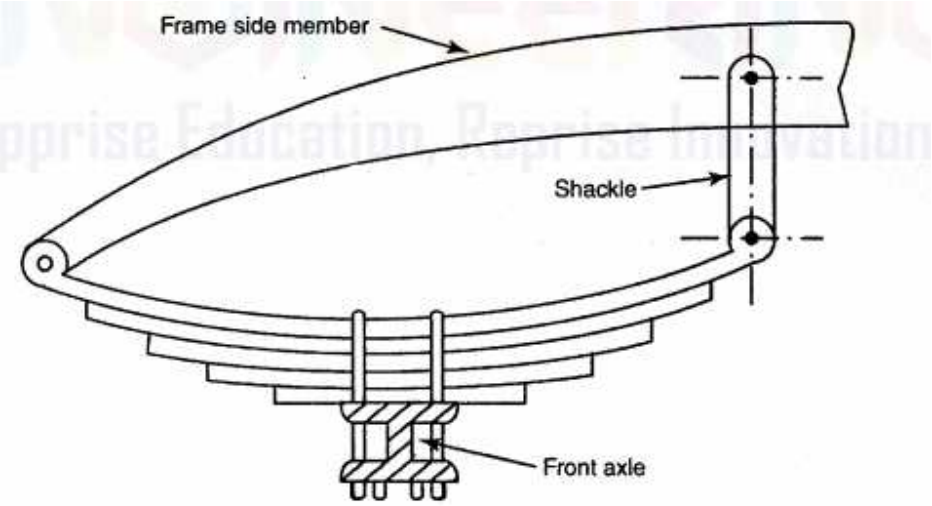

Figure 4.2. Leaf Spring

When a laminated leaf spring deflects, the leaves slide over each other and cause inter-plate friction. Although this has a beneficial damping effect, the hard ride, noise and wear occurs. Hence, it is necessary to reduce this friction as much as possible.

Older designs of spring had to be sprayed with penetrating oil, but the new designs have the following features to eliminate the need of periodic attention. Synthetic rubber buttons are provided at the ends of the leaves Inter-leaf plates of low friction materials are incorporated.

Types of leaf springs:

Differenttypes of leafspringsbased on its designare as follows.

1. Semi elliptical spring

2. Quarter elliptical spring

3. Three quarter elliptical spring

4. Full elliptical spring

5. Transverse spring

6. Platform type spring.

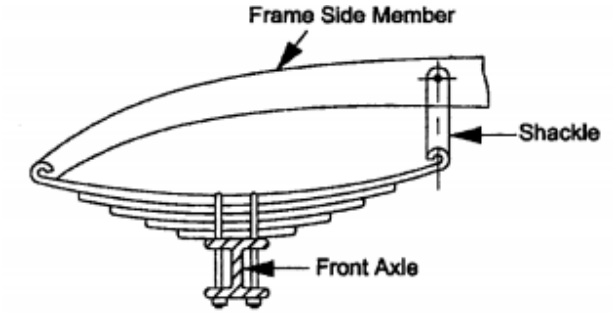

Figure 4.3. Semi Elliptical Spring

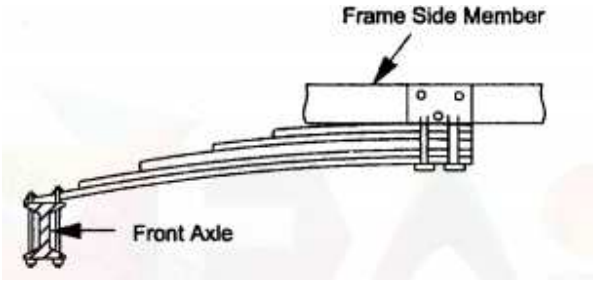

Figure 4.4. Quarter Elliptical Spring

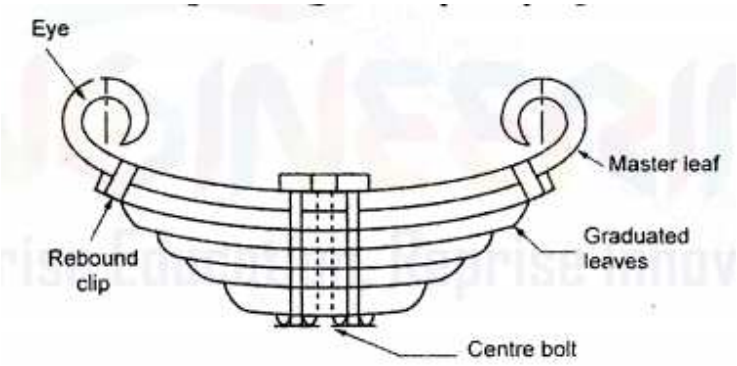

Figure 4.5. Full Elliptical Spring

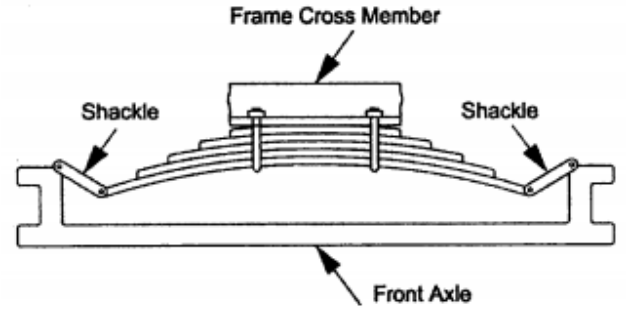

Figure.4.6. Transvers Spring

Helper Springs

Where there are fluctuations in the loads, helper springs are used in trucks and many other vehicles. It is mounted above the mainspring as shown in Figure.7. It is arranged in such a way that if the load is less, the main spring is operated. Both the main and helpersprings are operated if the load exceeds a certain value.

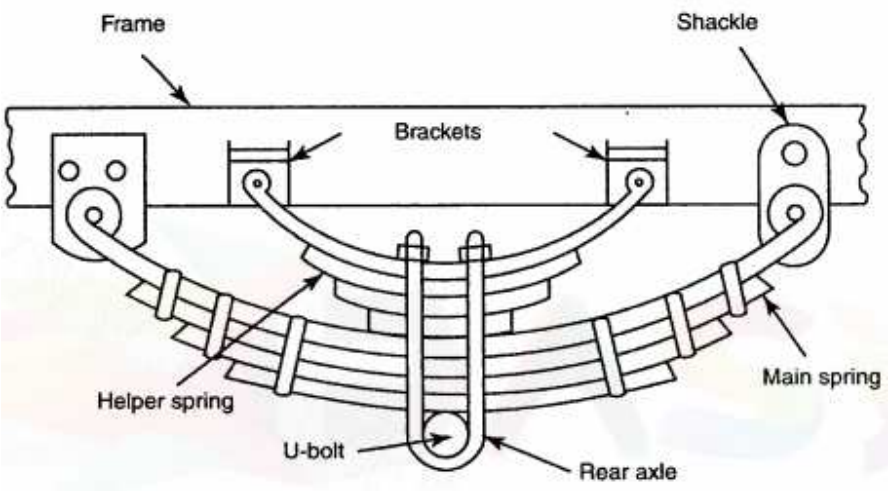

Figure 4.7. Helpers Spring

Helper springs are used along with the main leaf springs on many commercial vehicles. It is more suitable for a wide range of loading. Helper springs are mainly provided on rear suspension. When the load on the road wheel increases, ends of the helper spring is just made to touch the special brackets fitted to the side member thereby operating the helper spring.

Characteristics of helper springs:

1. Due to springs having enough rigidity to hold the axis in the proper position, they are required.

2. controlling of own oscillation through inter-leaf friction is performed.

3. These springs have durability in heavy-duty applications.

4. Due to inter-leaf friction, it is difficult to absorb minute vibrations from the road surface. So, leaf springs are more suitable for large commercial vehicles which can carry heavy loads.

Coil Spring

A coil spring is a steel wire. The required length is coiled throughout. The coil springs are used in both rear and front independent suspensions. The energy stored per unit volume is approximately twice in the coil spring when compared to leaf spring. The coil spring carries both shear and bending stresses but both torque reaction and side thrust cannot be carried out. So, some special arrangements are made to position the axles relative to the frame. Both driving reaction and braking torque reaction are also considered in arranging the coil spring. Ahelper spring is additionally used, as shown in Figure 8, to give progressive stiffness against the increasing load.

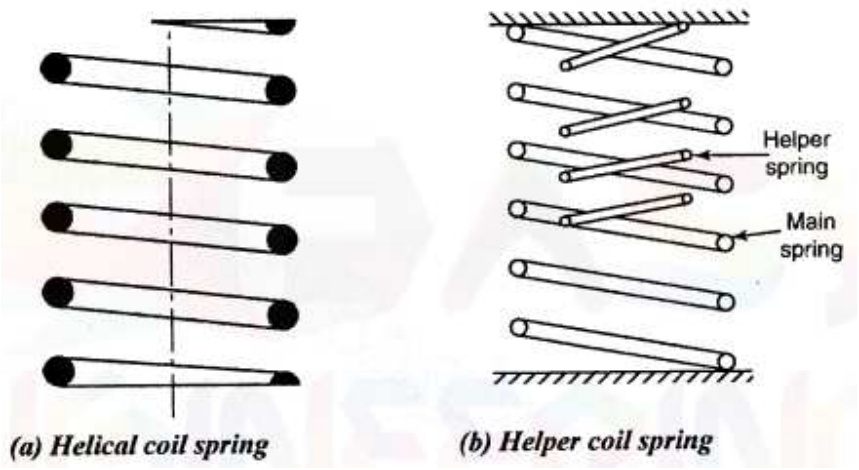

Figure 4.8. Coil Spring

Coil springs are again classified into two types.

l. Tension, and

2. Compression springs

Characteristics of coil spring:

1. The energy absorption rate per unit of weight is greater when compared to leaf springs.

2. Soft springs can be coiled.

3. Due to no inter-leaf friction with leaf springs, no control of oscillation is necessary by the spring itself but shock absorbers are needed.

4. Due to no resistance to lateral forces, linkage mechanisms to support the axle such as suspension arm, lateral control rod, etc. are required.

Torsion Bar

A torsion bar is a steel bar operated by both twisting and shear stress. Two long steel bars form springs. Torsion bar can be used with independent suspensions. It is a simple bar in which one end is fitted to the frame whereas the other end is fitted to the end of a wheel arm. The structure with a bearing supports the projection of the second end of the bar. The other end of the wheel arm is attached with the spindle of the wheel using kingpin.

When the wheel strikes a bump, it will start to vibrate up and down thereby producing a torque on the torsion bar called spring. Torsion bar spring is lighter in weight when compared to leaf springs. It also occupies less space. Torsion tubes replace torsion bars inmany cases. The main disadvantage of the torsion bar spring is that it does not carry thebraking or driving torque. Therefore. Additional linkages are needed. Due to the absence of friction force, the damping is required to absorb road shocks. The simple torsion bar is shown in Figure 9.

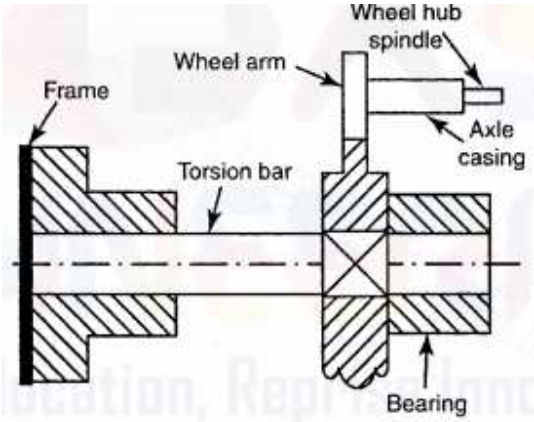

Figure 4.9. Torsion Bar

Advantages of torsion springs:

1. This spring needs less space.

2. It is lighter than leaf spring system.

3. This system provides very neat and compact design.

4. In some cases, torsion tubes are used instead of torsion bars.

Disadvantage of torsion springs:

It does not take the driving or braking torque. Therefore, inconvenient additional link mechanisms are provided for this purpose.

Rubber Springs

As rubber can store more energy per unit mass than any other type of spring material, considerable weight can be saved with rubber suspension. Rubber springs, if works on compression or shear, can be used as the main suspension spring, otherwise can be fitted along with metal springs to improve the suspension characteristics. Large rubber 'bump' stops used in many suspension layouts stiffens the suspension spring against maximum deflection:

Rubber springs absorb oscillations by the internal friction generation if they are stretched by an external force. The advantages of rubber springs are as follows.

I. Springs can be made into any desired shape.

2. Springs do not require to be lubricated.

The spring is installed between the frame and the top link of the suspension system.

When the spring is connected to a point near the link pivot, deflection of the spring reduces toa minimum, without affecting the total wheel movement. This arrangement of spring provides a rising-rate characteristic, which is 'soft' for small wheel movements but becomes harder as the spring deflects.

The energy released from the rubber spring after deflection is considerably less than that imparted to it. This internal loss of energy is called hysteresis, which is an advantage, because lower-duty dampers may be used. Some rubber suspension systems have a tendency to 'settle down' or 'creep' during the initial stages of service, therefore allowance for this must be provided.

Air Suspension System

Air springs are used in air suspension systems. The installation and configuration of air suspension systems varies for different makes and models but the underlying principle remains the same. The metal spring (coil or leaf) is removed, and an air bag, also referred to as an air spring, is inserted or fabricated to fit in the place of the factory spring. When air pressure is supplied to the air bag, the suspension can be adjusted either up or down (lifted or lowered).

Air spring is nothing but a flexible bellows, usually made from textile-reinforced rubber, containing compressed air which is used to carry load on vehicles. The air pressure inflates thebellows, and raises the chassis from the axle. Air springs have elasticity or "springiness" when it is compressed. It is used on many heavy-duty trucks, trailers and buses on the road today.

Characteristics of air springs:

1. They are soft if the vehicle is not loaded but the stiffness increases when the load is increased by increasing the air pressure inside the chamber. So, it gives the optimum riding comfort when the vehicle is lightly loaded and fully loaded conditions.

2. The height of the vehicle is kept constant by varying the air pressure whenever the load variation occurs.

3. Air springs increase vehicle stability by absorbing road shock.

4. Air spring systems are designed to maximize safe load carrying capacity, stability and overall ride quality.

Three basic types of air springs are available as follows.

- The double-convoluted,
- The tapered-sleeve, and
- The rolling-sleeve.

The double-convoluted design looks like a small tyres kept one over the other. These type of air springs generally has more load capacity, a shorter stroke, and a more progressive spring rate which is best suited for use on most front suspensions where the spring sits considerably inboard of the suspension's load point. This has the effect of multiplying loadcapacity requirements while dividing travel requirements.

Types of air suspension:

The following are different types of air suspension systems based on the design of air springs used.

a) Bellow type air suspension

b) Piston type air suspension

c) Elongated bellows air suspension.

(i) Bellow type air suspension (spring):

This type of spring consists of rubber bellows. The bellows are made into circular sections having two convolutions for proper functioning as shown in Figure 10. So, a bellow type air suspension replaces the coil spring.

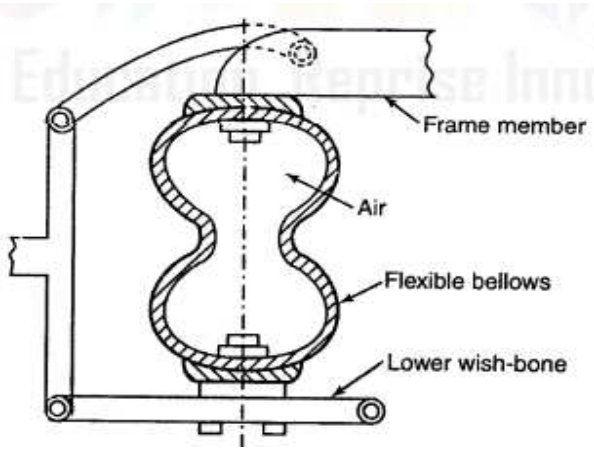

Figure 4.10. Bellow Type Air Spring

(ii) Piston type air suspension (Spring):

This spring has a metal air container in the form of an inverted drum. The drum is connected to the frame. A sliding piston is connected to the lower wishbone. A flexible diaphragm provides a seal. The diaphragm is tightly connected at its outer circumference to the lip of the drum and at the centre to the piston as shown in Figure 11.

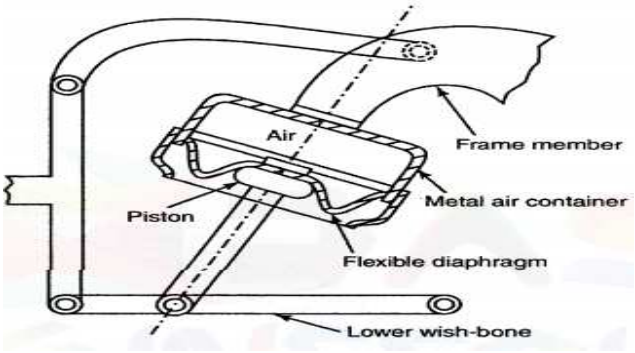

Figure 4.11. Piston Type Air Spring

Shock Absorber

Shock absorbers will not efficiently absorb road shocks if the suspension springs are highly rigid. They will be continuously vibrated for a longer time if springs are sufficiently flexible. To overcome this difficulty, a system having compromise between flexibility and stiffness should be used.

Shock absorbers are used as a part of the suspension system. They provide more resistance to the motion of the spring and road wheel in order to damp out vibrations.

Purpose of shock absorber:

(i) To control the vibrations on springs.

(ii) To provide comfortable ride.

(iii) To act flexible and to be rigid enough.

(iv) To resist the unnecessary motion of the spring.

Types of shock absorbers:

I. Mechanical shock absorber (friction type)

2. Hydraulic shock absorber.

Again the hydraulic shock absorbers are further divided into various types.

1. Van type

2. Piston type

a. Single acting

b. Double acting

3. Telescopic type

(i) Telescopic Shock Absorber:

Construction:

The upper eye of the telescopic shock absorber is attached to the axle and the lower eye is attached to the chassis frame as shown in Figure 12. A two way valve V1 is connected to a rod. Another one two-way valve V2 is connected to the lower end of the cylinder. The fluid occupies in the space between above and below the valve V1 and also the annular space between cylinder and tube. A gland is provided on the head. Fluid scrapped out by the rod is brought down into the annular space through the inclined passage.

Working:

When the vehicle comes across a bump, the lower eye will move up. So, the fluid follows from lower side of the valve VI to the upper side. Due to less volume of the space above valve VI than the volume of the rod, the pressure is exerted on valve V2 Thus, the damping force is produced by this pressure of the fluid. The fluid will flow from the upper side of the valve VI to lower side when the lower eye moves down and from lower side of the valve V2 to its upper side.

When a car absorbs shocks from the road surface, the suspension springs will compress and expand because the spring has the characteristic of continuing to oscillate for a long time of oscillation to stop. So, a riding comfort will be poor even the damp oscillation is supplied.

Shock absorbers provide better road-holding characteristics and improved steering stability to tyres. The stronger is the damping force, the more will be the oscillations of the body. But, the shock from the damping effect becomes greater than the strength of the stronger damping force. The damping force varies with the speed of the piston.

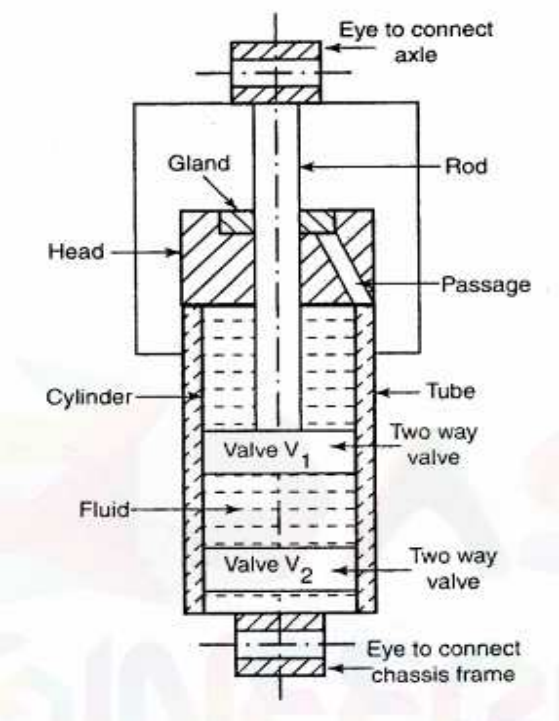

Figure 4.12. Telescopic Shock Absorber

Types of Suspension System

Generally, the following two basic types of suspension system are given below.

(i) Front end suspension

(a) Independent front suspension

(b) Rigid axle front suspension

(ii) Rear end suspension

(a) Longitudinal leaf spring rear suspension

(b) Transverse leaf spring rear suspension

(c) Coil spring rear end suspension.

Independent Front Suspension

The independent front suspension was developed in the 1930's to improve vehicle ride control and riding comfort. In this type of suspension, each front wheel is mounted on its own axle and independently supported by a coil or torsion bar or leaf spring. This allows the wheels to respond individually to road conditions. Now-a-days, all vehicles use this suspension system. Coil springs are commonly used in this suspension system. This suspension system completely prevents the wheel wobble. A greater wheel movement is utilized without affecting the steering

system. The steering conditions and qualities are improved by a wider spacing of the front springs.

Types of independent front suspensions:

1. Longitudinal suspension

2. Transverse suspension

3. Sliding suspension

4. Mac Pherson Strut and link type suspension

5. Parallelogram type suspension or Wishbone type

6. Trailing link type suspension

7. Vertical guide suspension.

1. Longitudinal independent front suspension:

Helical spring is connected between two wishbones (arms in U shape) with the support of frame member as shown in Figure. 13. The arms are in the shape of U. The upper wishbone is hinged at the inner end on a hydraulic damper. The outer end is hinged at stub axle carrier.

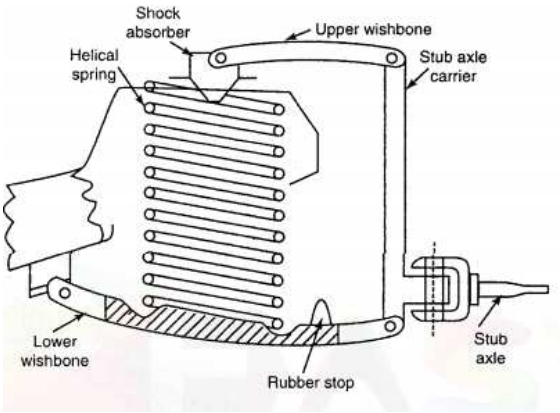

Figure 4.13. Longitudinal Independent Front Suspension System

2. Transverse independent front suspension:

In this type, two trailing arms are connected one above the other transversely at the front portion of the vehicle. The stub axle assembly is connected with ends of arms. Radius rods are of 45° to the centre line of the vehicle used to support it. Figure 14. Illustrates transverse independent front suspension system arrangement.

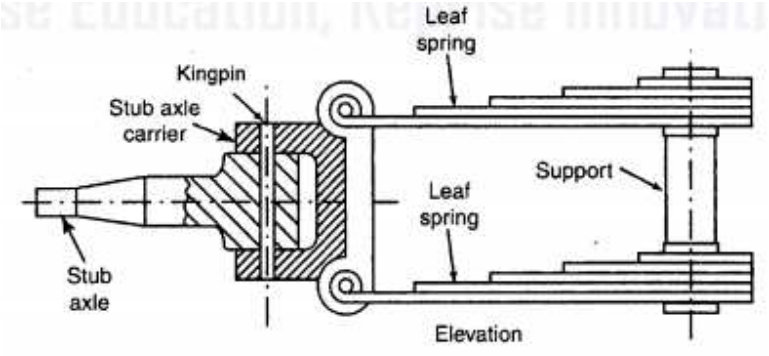

Figure 4.14. Transverse independent front suspension

3. Sliding type independent front suspension:

The stub axle moves up and down and it rotates in frame members. There is no change in track, wheel attitude and wheel base throughout the rise and fall of the wheel. The line diagram of the sliding type independent front suspension is shown in Figure 15.

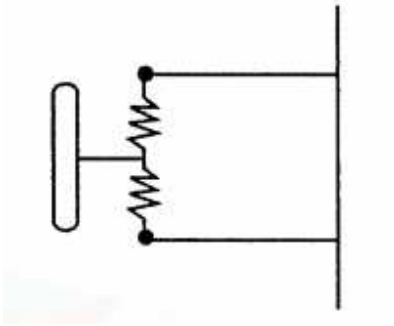

Figure 4.15. Sliding Suspension

4. Mac Pherson strut and link type independent front suspension:

It is used in an integral body construction due to wider spaced loading points. Instead of the normal top link, a flexible mounting and a telescopic damper are used. Both rolling action and shocks absorption are readily obtained as shown in Figure 16.

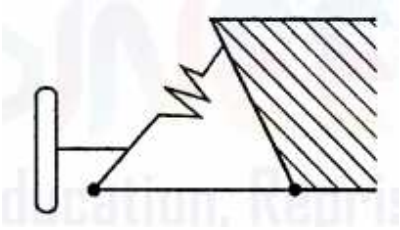

Figure 4.16. Mac Pherson strut and link type independent front suspension

5. Parallelogram independent front suspension or wishbone type:

The stub axle carrier connects an upper and lower link. The lower link is larger than the upper but it may not be parallel. It keeps the same the track width when the wheels rise andfall produced by the wheel scrubbing sideways. The various schematic arrangements ofparallelogram independent front suspension using coil, torsion and leaf springs are shown in Figure 17.

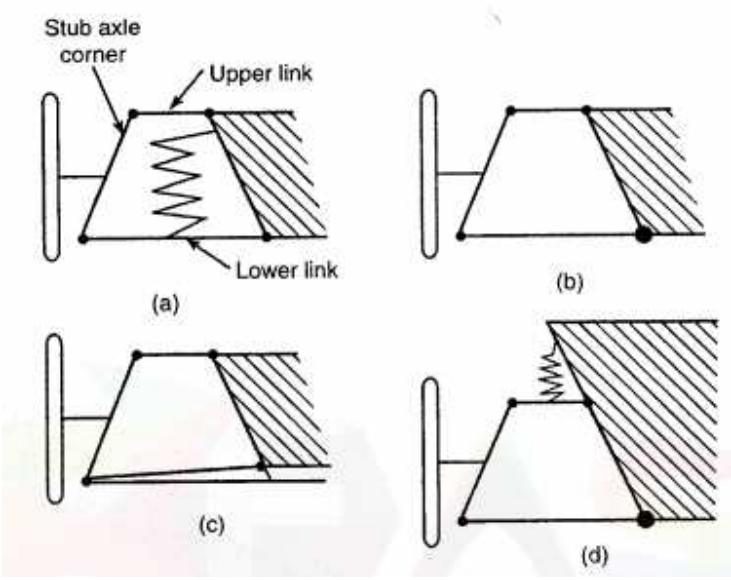

Figure 4.17. Parallelogram Independent Front Suspension

The use of coil springs in the front axle suspension of cars is universal. It consists of upper and lower wishbone arms pivoted to the frame member. The spring is placed between lower wishbone and underside of the cross-member. The vehicle weight is transmitted from body and cross-member to the coil spring through which it goes to the lower wishbone.

The wishbone arms are similar to a chicken wishbone or letter V in shape as shown in Figure .18. Due to V-shape, the wishbone not only positions wheels and it transmits the vehicle load to the springs but also they resist acceleration, braking and cornering (side) forces.

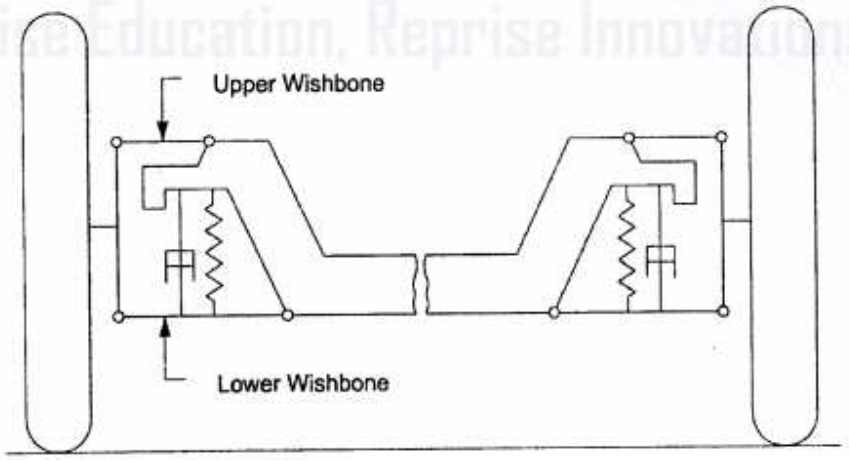

Figure 4.18. Wishbone Suspension

7. Vertical guide suspension:

In this type, the kingpin is directly connected to the cross member of the frame. It moves up and down thereby compressing and expanding the coil springs as shown in Figure 19.

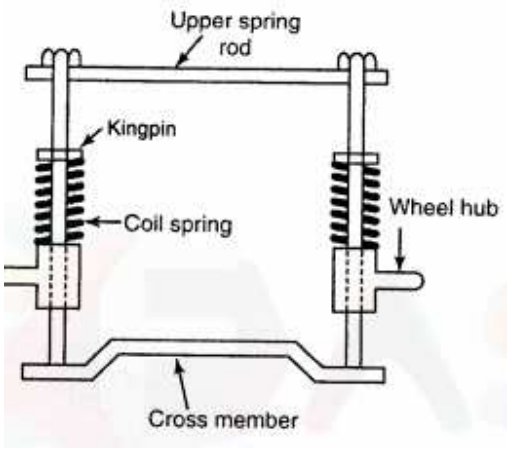

Figure 4.19. Vertical Guide Suspension

8. Swinging half axle suspension:

In this type of suspension system, wheels are mounted rigidly on half axles which are pivoted at their ends to the chassis member at the middle of the car as shown in Figure 20. The main disadvantage of this system is lip and down movements of the wheel causing the camber angle to vary.

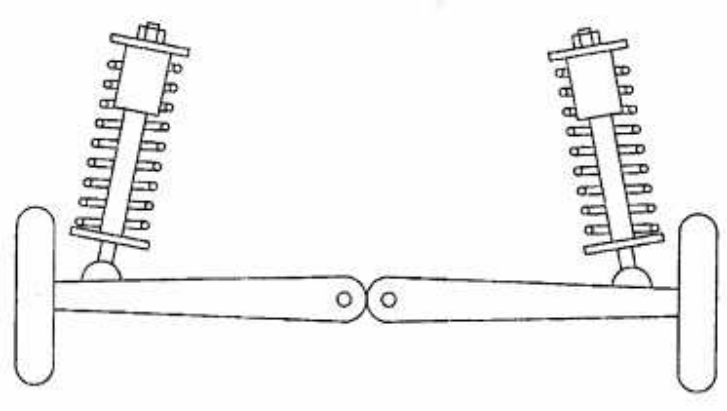

Figure 4.20. Swinging Arm Suspension System

Rigid Axle Front Suspension

Rigid axle front suspension is also called as dependent front suspension. This type of suspension uses a solid axle. This type of suspension has been universally used before drawing the independent front wheel suspension. This design consists of one steel or aluminium beam extending the width of the vehicle. This beam is held in place by leaf springs. This design also uses kingpins and bushings to attach the wheels outboard of the axle. Because of its load

carrying ability, the solid axle is only used on heavy trucks, and off-road vehicles. It is not suitable for use on modern passenger cars for three important reasons.

Transfer of Road Shock: There is transfer of road shock from one wheel to the other due to the way the wheels are connected to the axle. This causes a rough ride and could result in loss of traction.

Unsprung Weight. “Because the solid axle has a lot of unsprung weight, it needs more spring and shock control to keep the tyres in contact with the road.

Wheel Alignment: The solid axle design makes no provisions for alignment. Figure 21. illustrates a typical rigid axle front wheel suspension. It has either two longitudinal leaf springs or a transverse spring along with shock absorbers.

In this type of suspension, the front wheel hub rotates on anti-friction bearings and steering spindles already connected with steering knuckles. The steering spindle and steering knuckle assemblies are pinned at axle ends to permit the wheels turning. This pin is called kingpin or steering knuckle pin.

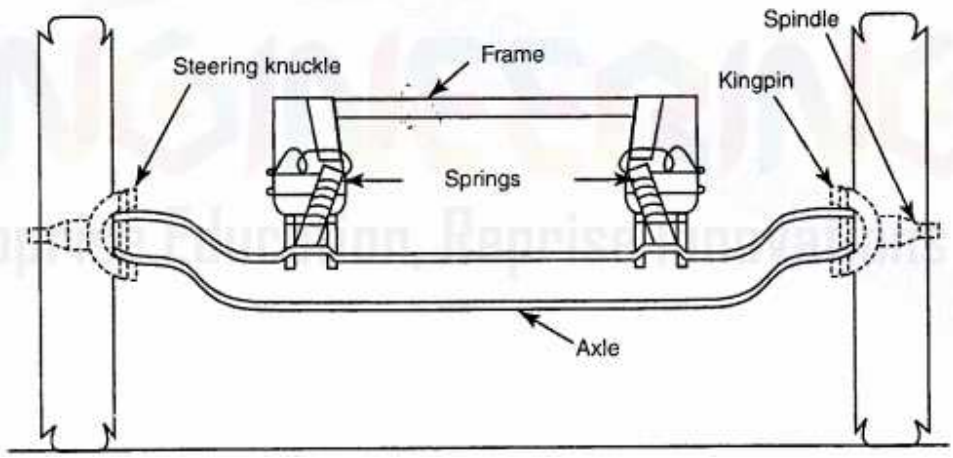

Figure 4.21. Rigid Axial Front Wheel Suspension System

Independent Rear Suspension

Any suspension that can be used on the front end of the ‘car can be used on the rear end. The versions of the independent' front systems described in the previous section can be found on the rear axles. But, in the rear end of the car, the steering Linkage is absent. Therefore, rear independent suspensions can be simplified versions of front ones, although the basic principles remain the same.

As explained in the independent front axle suspension, here also the wheels are mounted in separate axles and sprung independently. Figure 22. Illustrates a method of rear wheel

independent suspension. Universal couplings are used to keep the wheels vertical. Sliding coupling is necessary to keep the wheel track constant to avoid scrubbings of tyres.

Types of independent rear suspension:

1. Longitudinal leaf spring rear end suspension

2. Transverse leaf spring rear end suspension

3. Coil spring rear end suspension,

Both longitudinal leaf spring and coil spring suspensions are mainly used in vehicles but transverse leaf spring suspensions are rarely used. In addition to above types, there are some more types of such as

1. Parallel link system

2. Swinging arm type

3: Swinging half axles.

In parallel link system. Wheels are attached with a backbone-type frame using two wishbone shaped. Links.

In swinging arm type, a spring or a torsion bar is used at the pivot. These axles are usedin most of vehicles. It has two axle tubes joined to the final drive housing which allows the wheel to rise or fall. A universal joint is fixed to allow the change in drive axle at the centre of each axle joint.

1. Longitudinal leaf spring rear end suspensions:

Laminated leaf spring, as shown in Figure 23, is used as a suspension member in this type of system. The front end of the longest leaf is bending into a circle to form the spring eye. The spring eye is attached to the spring hanger by a bolt. The spring hanger is fixed to the vehicle

frame rubber bushings inserted in the spring hanger support the bolt as shown in Figure.

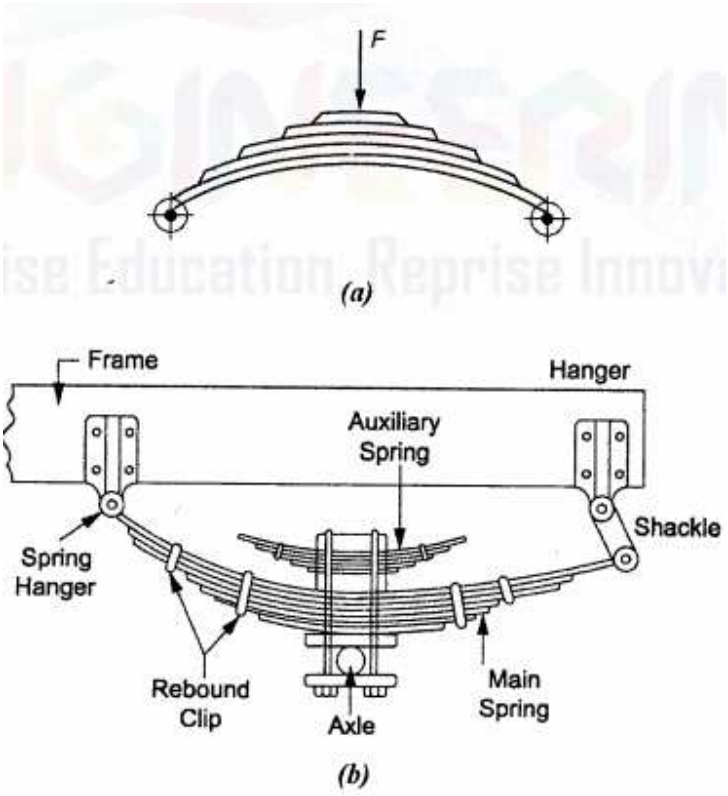

Figure 4.23. Longitudinal Leaf Spring Suspension

Transverse leaf spring rear end suspension:

This system is quite simple in which a single transverse spring is used. Such springs are mounted in inverted positions parallel and above the rear axle. Each end is shackled to the rear axle as shown in Figure.

The transverse rear springs are always used in combination with torque tube drive. Therefore, they do not carry the driving thrust and torque. Figure 24. Shows the another arrangement of this type of spring in which each rear wheel is independently suspended by one end of the transverse spring while the tubular cross member is attached to the high centre portion.

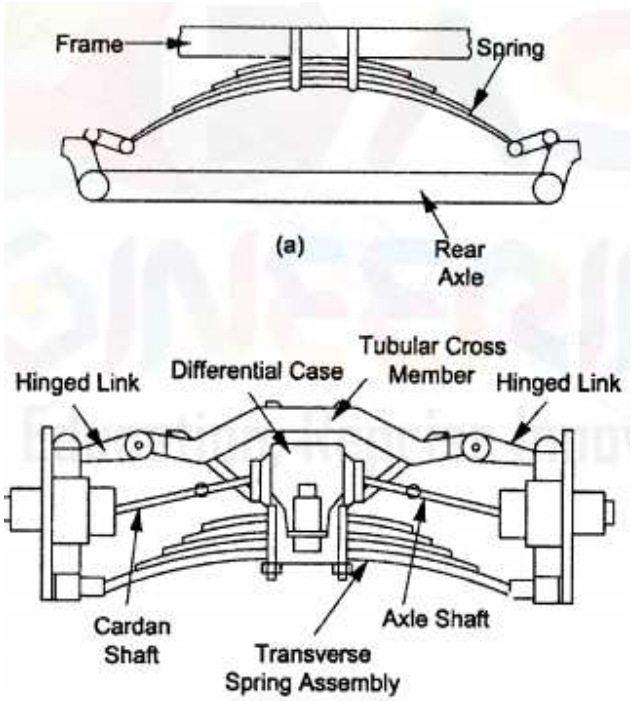

Figure 4.24. Transverse Leaf Spring

Coil spring rear end suspensions:

The coil springs, as shown in Figure 25, are seated in the pan shaped brackets attached to the rear axle and they are compressed against similar spring seats incorporated into the frame (or) body. There are two control arms (or) links attached between rear axle housing and car frame. They permit upward (or) downward movement of the axle housing regarding the car frame.

This type of suspension is always used along with a torque tube drive. Therefore, the coil springs are not subjected to driving thrust. The excessive roll of side way while rounding a curve is prevented by a shock absorber mounted in rubber bushings. Energy stored in given weight of spring coil and torsion bar springs are superior to leaf springs.

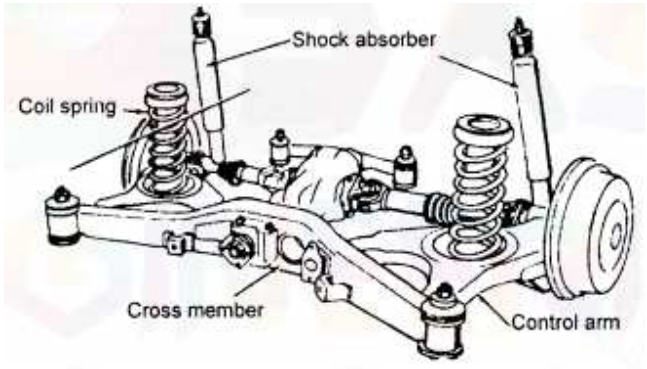

Figure 4.25. Coil Spring Rear End Suspension

BRAKING SYSTEM

The mechanism which is used to slow and stop the vehicle is known as braking system. It is an important component of a vehicle. In other words. The total system starting from brake pedal or lever to the brake shoe is known as braking system.

Principle of braking system:

In this system, the kinetic energy is converted into heat energy due to friction between two mating surfaces of brake lining and brake drum. Then the heat is dissipated into the atmosphere.

Need for brakes:

1. To stop or slow down the vehicle at the will of an operator.
2. To control the vehicle descending a hill.
3. To keep the vehicle in a desired position even at rest.
4. To park the vehicle and hold it in stationary position without the presence of driver.

Requirements of Braking System

1. It should have good anti-fade characteristics.
2. It should be consistent with safety.
3. It should not be skidding while applying brake.
4. It should have a better cooling system.
5. It should be strong enough to stop the vehicle within the minimum distance.

Types of Brakes

The automobile brakes are classified on the basis of following.

1. According to the applications:

i) Service or running or foot brake

(ii) Parking or emergency or hand brake.

2. According to the number of wheels:

(i) Two wheel brakes

(ii) Four wheel brakes.

3, According to the brake gear:

(i) Mechanical brake

(a) Hand brake

(b) Foot brake.

(ii) Power brake:

(a) With booster

(b) Without booster.

4. According to construction:

(i) Drum brake

(ii) Disc brake.

5. According to location

(i) Transmission brakes

(ii) Wheel brakes.

6. According to method of braking contact:

(i) Internal expanding brakes

(ii) External expanding brakes.

7. According to thepower unit:

(i) Cylinder brake

(ii) Diaphragm brake.

8. According to power transmission:

(i) Direct acting brake

(ii) Geared brake,

9. According to method of applying brake force:

(i) Single acting brake

(ii) Double acting brake.

10. According topower employed:

(i) Vacuum brakes

a, Atmospheric suspended

h. Vacuum suspended

(ii) Air or pneumatic brakes

(iii) Hydraulic brakes

(iv) Hydrostatic brakes

(v) Electric brakes.

Types of Drum Brakes

There are two types of drum brakes as follows.

(i) External contacting brakes

(ii) Internal expanding brakes

1. External contracting brake:

The main components of external contracting brakes are brake drum, bandwidth lining, operating lever, push ‘rod, return spring and adjusting lever.

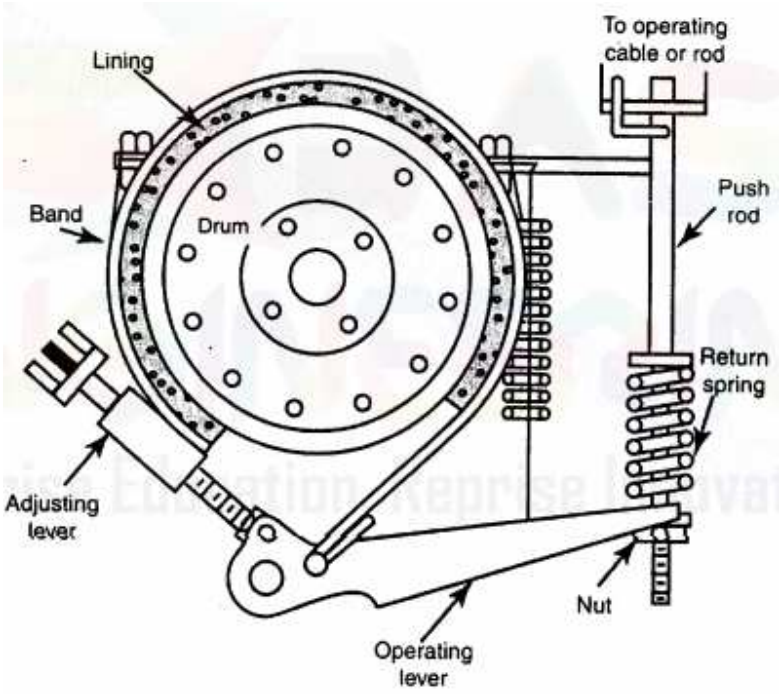

Figure 4.26. Drum Brake

Working:

When the push rod is started to function by the hand through operating, then the lined brake band fixed around the drum will be tightened in order to lock or slow down the rotating drum as shown in Figure 26. The return spring brings the band back to the off position when the brake is released. This system is pneumatically operated. The main disadvantages are greater wear and tear. To park the vehicle in position, this type of brake is mainly used.

Internal expanding brake:

These internal expanding brakes have the following parts such as brake drum, stationary plate, two brake shoes, anchor pins and retracting spring.

Working:

When the cam is turned, the shoes with brake linings will be moved beside the drum as shown in Figure 26. The brake linings create friction between rotating drum and expanding shoes. The force of the friction isjust opposite to the direction of drum rotation. Therefore, the vehicle is stopped or slowed down. When the brake releases, the retracting spring is brought shoes back to the off position. It is mainly used in modern vehicles. It is tightly connected to the steering knuckle in a front wheel brake.

Disc Brakes

A disc brake is a type of brake that uses calliper's to squeeze pairs of pads against a disc in order to create friction that retards the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The friction elements are shaped like pads and are squeezed inwards to clamp a rotating disc or wheel.

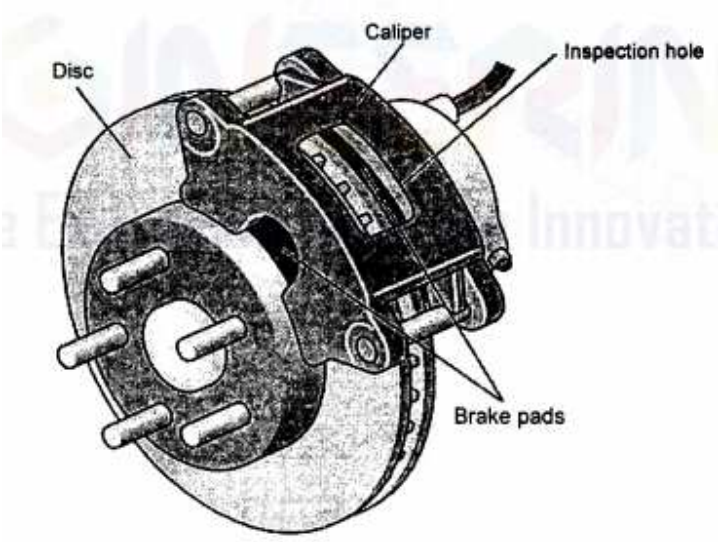

Figure 4.27. Components of Drum Brake

Components of Disc Brake

i) Brake Calliper

A disc brake assembly consists of a calliper, brake pads, and rotor as shown in Figure 27.

The calliper is the nonrotating unit in the system and it may be mounted to the spindle or splash shield to provide support. The brake calliper assembly includes the calliper housing, the piston(s), the dust boot(s), the brake pads or shoes, and the bleeder screw. The calliper is fitted

with one or more pistons that are hydraulically actuated by the fluid pressure developed in the system. When the brake pedal is applied, brake fluid flows into the calliper cylinder.

The piston is then forced outward by fluid pressure to apply the brake pads to the rotor. The piston boot keeps road dirt and water off the calliper piston and wall of the cylinder. The boot and seal fit into grooves cut in the calliper cylinder and piston. A bleeder screw allows air to be removed from the hydraulic system.

(ii)Disc brake pads:

Disc brake pads consist of steel shoes to which the lining is riveted or bonded. Brake pad linings are made of either asbestos (asbestos fiber filled) or semi-metallic (metal particle filled) friction material. Many new vehicles, especially those with front-wheel drive, use semi metallic linings. Semi-metallic linings withstand higher operating temperatures without losing their frictional properties. Anti-rattle clips are frequently used to keep the brake pads from vibrating and rattling.

(iii) Brake disc:

It is also called brake rotor. The brake disc uses friction from the brake pads to slow or stop the vehicle. Made of cast iron, the rotor may be an integral part of the wheel hub. However, on many front-wheel drive vehicles, the disc and hub are separate units. The brake disc may be a ventilated rib or solid type. The ventilated rib disc is hollow that allows cooling air to circulate inside the disc.

Types of Disc Brake

Disc brakes can be classified as follows.

1. Fixed calliper (or) swinging calliper type

2. Floating calliper type, and

3. Sliding calliper type.

Floating and sliding are the most common types. The fixed calliper may be found on older vehicles.

Fixed caliper disc brake:

The caliper is pivoted about a fulcrum pin but one of the friction pads is connected to the. caliper shown in Figure 28. The other pad is pressed by the fluid pressure against the disc to apply the brake. So, the caliper automatically makes to adjust its position by swinging about the pin.

In this design, the caliper usually is made in two pieces and has two or more pistons in use. The pistons accomplish the centering action of the fixed caliper, as they move in their bores. If the lining should wear unevenly on one side of the caliper. The piston would take up the excess clearance simply by moving further out of the bore. As the brakes are applied, fluid pressure enters the caliper on one side and isrouted to the other through an internal passage or by an

external tube connected to the opposite half of the caliper. As pressure is increased, the pistons force the brake pads against the rotor evenly, therefore maintaining an equal amount of pressure on both sides of the rotor.

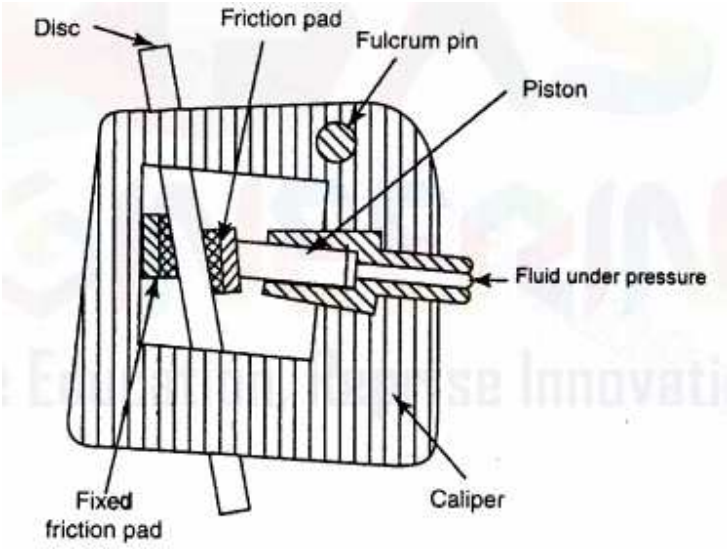

Figure 4.28. Fixed Caliper disc brake

Floating caliper disc brake:

The floating caliper type disc brake is designed to move laterally on its mount. This movement allows the caliper to maintain a centered position with respect to the rotor as shown in Figure 28. This design also permits the braking force to be applied equally to both sides of the rotor. The floating caliper usually is a one-piece solid construction and uses a single piston to develop the braking force.

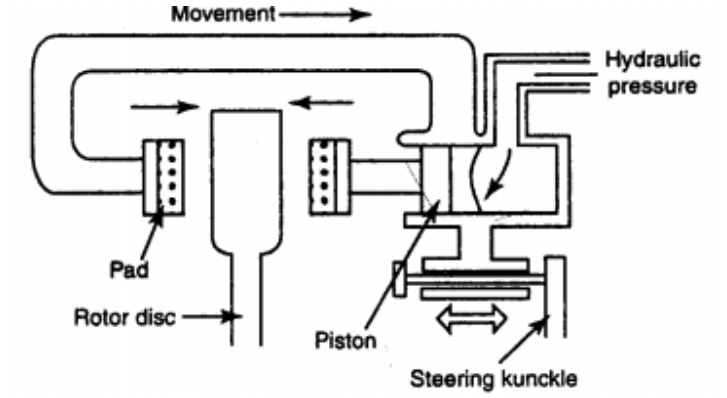

Figure 4.29. Floating Caliper Disc Brake

Sliding caliper disc brake:

The sliding caliper type disc brake, as shown in Figure 30, is mounted in a slot in the caliper adapter. It is a variation of the floating caliper, using a single piston and operating on the same principle, whereby the piston applies pressure to one brake pad and the movable caliper applies pressure to the other. This design has two major sections such as the sliding caliper and the caliper adapter (anchor plate). Each has two angular machined surfaces. Thisis where the sliding contacts

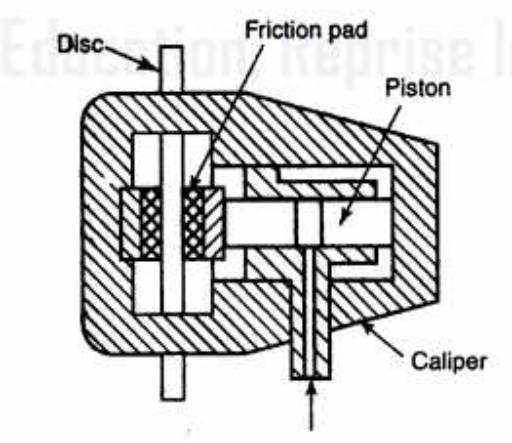

Figure 4.30. Sliding Caliper Disc Brake

come into play. The machined surfaces of the calliper housingslide on the mated surfaces of the caliper adapter when the brakes are applied.

Hydraulic Brakes

Today, most of the cars use hydraulic brake system on all wheels with additional hand brake to stop the rear wheel movement. The liquid pressure supplies hydraulic brakes. The pedal force is transmitted to the brake shoe by definite quantity of liquid passing through a force transmission system. Then the force applied to the pedal is multiplied and transmitted to brake shoes by a suitable transmission system based upon Pascal's principle. It states that the total pressure acting on the transmission system is equal to the sum of pressures acting in all directions without any losses.

Hydraulic braking system consists of two main components which are master cylinder and wheel cylinder. The master cylinder is attached to the wheel cylinder by tubes on each of four wheels. The system has light liquid pressure which acts as a brake fluid. This brake fluid is a mixture of glycerin and alcohol or castor oil, denatured alcohol and some additives.

Construction:

A wheel brake has a cylinder brake drum connected on the inner side of the wheel as shown in Figure 31. Two brake shoes are connected inside the brake drums. The shoes are fixed with heat and wear resisting brake lining on their surface. The brake pedal is fitted to the master cylinder piston by a piston rod.

Working:

When the brake is applied, the driver depresses the pedal to force the piston into the master cylinder. It will increase the pressure of the fluid in the master cylinder. So, the entry hydraulic system pressure is increased. This pressure is transmitted equally to the wheel cylinder on each of four brakes. Then, it forces the wheel cylinder piston outwards. Due to this, the brake shoes are forced out against the brake drums. Hence, the brake is applied.

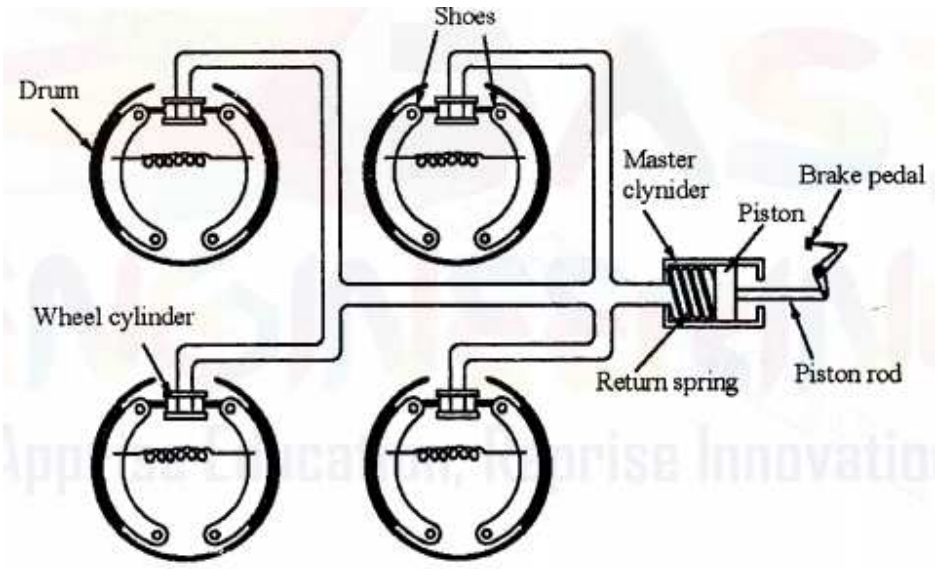

Figure 4.31. Hydraulic Brake System

When the driver releases the brake pedal, the master cylinder piston is returned to its original position by return spring. Thus, the fluid pressure in the entry system decreases to original value. It allows retracting springs on wheel brakes to pull the brake shoes out of contact along with brake drums. Therefore, the wheel cylinder pistons also come back to their original inward position. Thus, the brake is released.

Master Cylinder

The central unit in the hydraulic braking system is master cylinder. It produces the required hydraulic pressure to operate the system. The pressure of the driver's foot on brakes pedal is transmitted to the master cylinder piston through different linkage arrangements. So, the master cylinder is considered as the heart of the hydraulic braking system.
Purposes of a master cylinder:

1. The required hydraulic pressure is built up to operate the system.

2. It maintains a constant volume of fluid in the system.

3. To bleed or force air out of the brake line and wheel cylinder, a pump is used.

Construction of master cylinder:

Master cylinder is made of cast iron. It has brackets and holes for mounting. The two main types of chambers are as follows.

(i) Fluid reservoir

(ii) Compression chamber

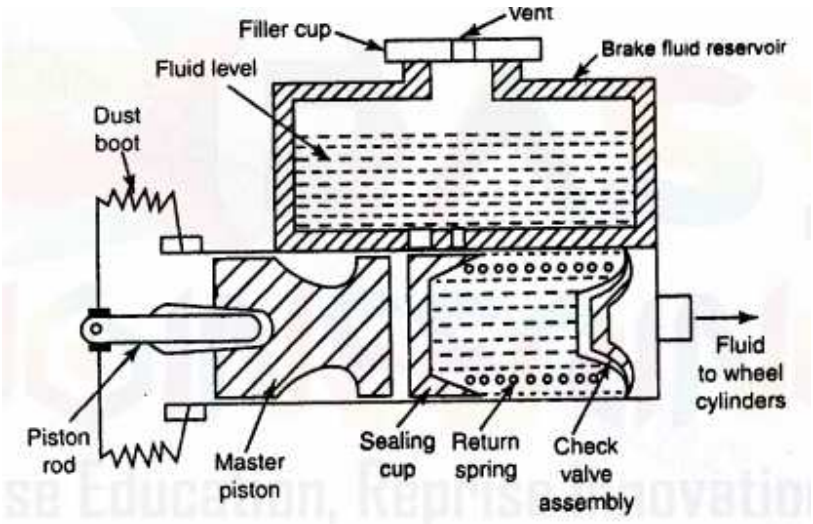

Figure 4.32. Construction of Master Cylinder

Working of master cylinder:

When the brake pedal is released, the master cylinder piston will be moved forward to force the liquid under pressure into the system. The relief port is arrested by sealing the system. The liquid pressure is transmitted by moving the wheel to wheel cylinders. The brake shoes are forced out by these pistons against brake drums.

When the brake pedal is depressed, the return spring quickly forces the master cylinder piston back against the piston stop. A vacuum is produced in the cylinder in front of the piston. So, the primary cup is collapsed to allow the liquid to flow from the reservoir through the filler port past the piston. When the pedal is in OFF condition, the liquid will flow from the reservoir to the relief port through the master cylinder, supply lines and wheel cylinder. A complete column of liquid is always same between master cylinder piston and wheel cylinder pistons.

Wheel Cylinder

The following are the functions of wheel cylinder.

1. It actuates the shoes outward to contact the brake drum.

2. It converts the hydraulic pressure of very low value into a significant value of mechanical force of higher value.

Construction of wheel cylinder:

The wheel cylinder, as shown in Figure 32, which is connected with the cast iron housing are fitted into the individual wheels. An expander unit activates the brake shoes, two pistons are connected with brake shoes through piston rods. Two-cup washers are connected at the inner side of the piston with a spring connected between them. Rubber boots and dust covers are used to keep the cylinder free from dust.

A bleeder valve is used for pumping out air and liquid during bleeding. The mechanism is sealed by the rubber cup to arrest any leakage of the brake fluid.

Working:

The brake fluid goes into the master cylinder when the brake effort is applied. The built-up pressure is sent to the space between two pistons in opposite direction to each other. Then, this outward movement is transmitted through links and piston rods by operating brake shoes.

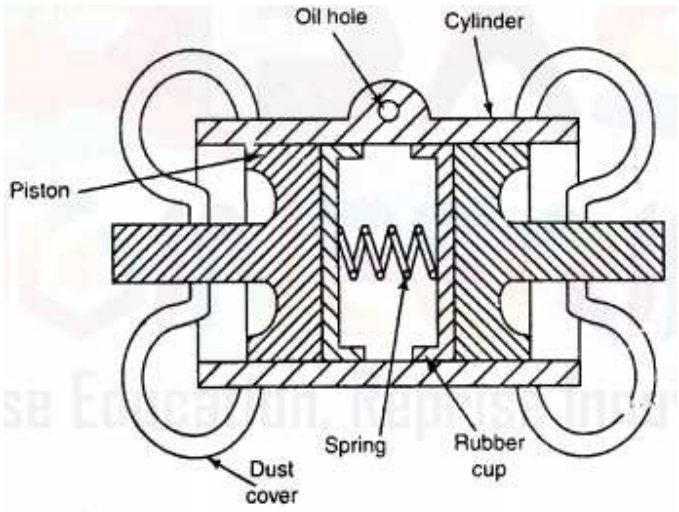

Figure 4.33. Wheel cylinder

Pneumatic Braking - System

The air is sucked by the compressor from atmosphere through the filter and it is compressed air as shown in Figure 33. During compression, both pressure and temperature increase. Then, the compressed air is passed to the reservoir through an unloaded valve by lifting at a pre-determined reservoir pressure. Due to this, the compressor load is released. Theair is allowed to flow to various accessories and diaphragm units at each wheel. It flows through the brake valve from the reservoir. The control of brake valve is effected the intensity of braking according to requirements

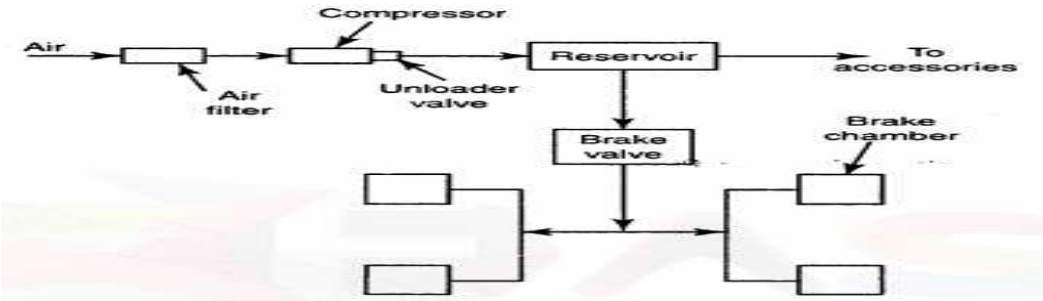

Figure 4.34. Layout of Pneumatic Braking System

Heavy vehicles of buses and trucks need a heavy effort at brakes thereby producing compressed. The main parts are air filter, unloaded valve, air tank, brake valve and brake chamber. The line pressure is regulated by the unloaded valve. This unloaded valve is connected to one side of the air tank.

When the line pressure attains the upper limit, this valve gets opened to allow air to the atmosphere. Brake valve is connected to the driver's pedal which controls the air pressure acting on four brake chambers. When the driver releases the brake pedal, force is exerted on the graduated spring and piston. The exhaust valve seat will also move downward when the piston moves downwards to contact the exhaust valve and seals the exhaust opening in the piston stem. By continuous downward movement of piston, the inlet valve is forced. At that time, air pressure from the air tank forces through the inlet valve and to brake chambers for applying the brake through delivery ports.

When the driver releases the pedal fully, the graduated spring is compressed and strike by the piston shoulder in the body. So, the inlet valve is fully opened and full air tank pressure is admitted to pass through brake valve into the brake chamber.

When the driver releases the pedal, the exhaust valve gets opened to allow full air pressure in brake chambers. So, the brake on the vehicle is fully released.

Advantages of pneumatic brakes:

1. It is more effective when compared to other brakes.

2. The air brake parts are easily located where the chassis design making is simple.

3. The compressed air can be used for tyre inflation wipers, horn and other accessories.

4. It employs only air as the working medium which is easily available.

5. It is easy to store air at high pressure.

6. It provides heavy braking effect used in heavy vehicles and trucks.

7. It provides better control.

8. It reduces the stopping distance.

9. It mainly allows less wear and tear of parts.

10. It has flexible hose connection.

Servo Brake Systems

The additional mechanism which is connected to reduce the driver's effort during applying brakes is known as servomechanism. When the weight of the vehicle increases, more braking effort is required to stop the vehicle. After reaching the desired limit, it is difficult to apply the effort required conveniently by an ordinary driver. This limit is almost three tones of the weight of the vehicle. The use of the servo action or self-energization of brakes isperformed beyond this limit.

Power-Assisted Braking System

Generally, a braking in automobiles magnifies a small force applied to the brake pedal into a proportionately larger force applied to slow or stop the vehicle called power brake. Most all modern vehicles use power assisted brakes. The power brake is a modern braking tool for cars to make braking safer and easier.

Power brakes are of two types as follows.

(i) Vacuum assisted hydraulic brakes

(ii) Pneumatic brakes.

Antilock Braking Systems (ABS)

Stopping safely is one of the most important functions a motor vehicle. Failure of the brake system will invariably lead to a property damage, personal injury or even death. Consequently, a great deal of consideration has been given to improve the brake system in trucks and passenger cars over last nine decades. One of the latest improvements is an antilock brake system which prevents a vehicle's brakes from locking up and skidding during hard stops on wet or icy roads.

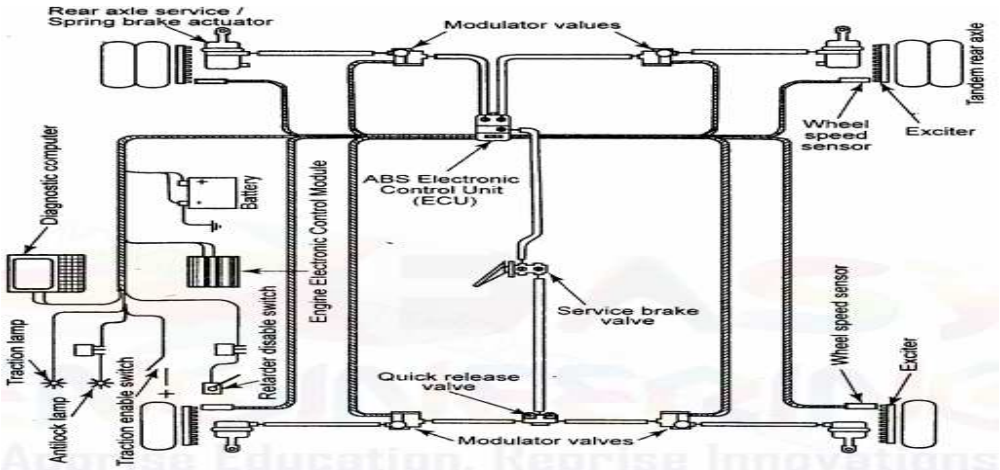

Figure 4.35. Components of ABS

The problem of skidding reveals the overwhelming weakness of all motor vehicle braking systems. They depend strongly on the coefficient of static friction between tyre and road. If the tyre momentarily loses its adhesion to the road while brakes are applied, the friction of brakes will be against drums or rotors which lock the wheel solidly and the tyre begins skidding across the road. In this condition, the braking force of the wheel is depend on the sliding friction between tyre and road which is much less than static friction. Under wet or icy conditions, the sliding friction is reduced even further thereby resulting significantly the longer stopping distance.

In addition, when the front wheels are in this condition, they cannot be used to steer the vehicle irrespective of the angle of front wheels and, the vehicle continues to skid whatever be the direction of its momentum until either the driver releases brakes or the vehicle collides with solid. Antilock Braking Systems (ABS) is a form of electronic braking which helps a driver to control the vehicle under heavy braking by preventing wheels from locking up.

Working Principle of ABS

Wheel speed sensors are placed on each wheel for controlling the speed. Each speed sensor has a toothed wheel such as a gear which rotates at the same speed as the vehicle wheel or axle. It is a permanent magnet wrapped with a coil of wire called pick-up coil. As each tooth rotates past the permanent magnet, it will cause the magnetic field to concentrate and increase slightly. Then, it induces a small pulse of current in the coil of wire.

The pulsed output from the wheel speed sensors goes to an ECU which monitors each wheel speed relative to the speed of other wheels. As long as the brakes are not being applied and all monitored wheels are rotating roughly at the same speed, the system takes no action.

However, the brakes are being applied and one or more of the monitored wheels suddenly begin to reduce the speed at high rate than other controllers and then they activate the antilock system.

In an automobile, brakes are actuated by hydraulic pressure. In ASS, electrically operated solenoid valves are used to hold, release and reapply the hydraulic pressure to brakes.

ASS controller operates solenoid valves built into high pressure side of the master brake cylinder. These valves are normally open and do not interfere with braking. When the controller senses a wheel locking up while braking, it .will first activate a solenoid to close a valve in the affected wheel brake line to prevent the pressure from increasing further. If the locked wheel continues to lose its speed, the controller activates a second solenoid which bleeds pressure off the affected brake line for effective releasing of the brake irrespective of the driver effort. As soon as the wheel regains traction and its speed increases, the solenoids are de-activated and normal braking resumes.

If conditions are that the wheel starts to skid again, the brake wilt promptly begin to lock up and ASS will take over. This cycle is repeated 12 to 15 times per second until either the road condition changes or the driver releases brakes. The driver will be able to detect this rapid cycling as a vibration felt through the brake pedal but it will not have to take any action.

TEXT / REFERENCE BOOKS

1. Kirpal Singh, “Automobile Engineering Vol 1 and 2 ”12th edition Standard Publishers 2011

2. Banga T.R. & Nathu Singh, “Automobile Engineering”3rd edition Khanna Publications. 2012

3. Rajput R.K. “A Text–Book of Automobile Engineering”, Laxmi Publications Private Limited, 2008.

4. Heldt.P.M. Automotive Chassis, 3rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler “Advanced vehicle technology”2nd edition Edward Arnold publication 2002

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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SAU1401 AUTOMOBILE ENGINEERING

UNIT V ELECTRICAL SYSTEM

5. ELECTRICAL SYSTEM

Classification of batteries, battery construction, maintenance, testing and charging, cutout, lighting circuit, horn, indicators, sprays, wipers, starting system, instruments, sensors and actuators, electric control unit, electric stability program, traction control devices, electrical car layout

BATTERY

Battery is an electrochemical device which converts chemical energy to electrical energy when discharging and electrical energy to chemical energy while charging. The main purposes of battery are to store electrical energy andto provide a supply of current for cranking the starting motor and for other electrical units.

Different types of Battery

1. Lead acid battery
2. Alkaline battery
3. Zinc - air battery
4. Nickel - Metal hydride battery
5. Lithium - ion battery

LEAD ACID BATTERY

CONSTRUCTION

The major components of the battery are:

1. Container
2. Plates
3. Separators
4. Cell
5. Electrolyte

Container

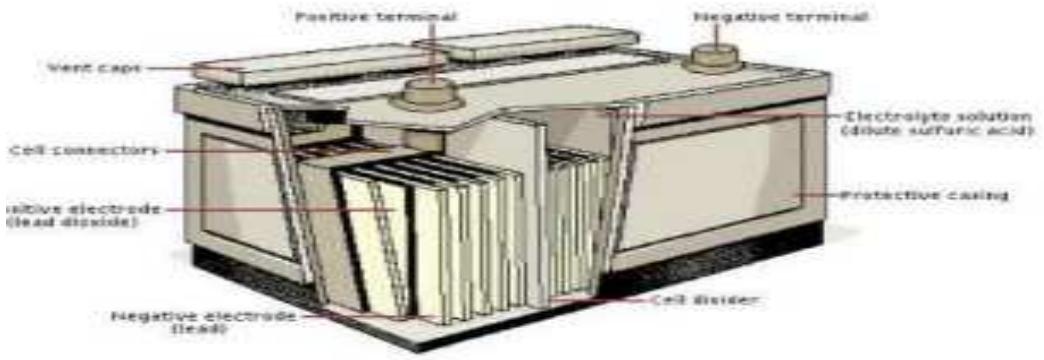

Figure 5.1. Battery

They are of single piece construction made of polypropylene which is very strong and light weight plastic. There are partitions inside the container for different cells. To avoid the short of positive and negative plates, bridges are formed at the bottom of the container.

Plates

There are two types of battery plates

1. Positive plate

2. Negative plate

For each plate there is supporting grid made of alloy of lead and antimony. The function of grid is to hold the active material and to carry current in the plates.

The active material in the positive plate grid is lead peroxide (PbO_2) in chocolate colour and negative plate is spongy lead (Pb) in grey colour. These plates are immersed in dilute sulphuric acid. There are separators to keep the positive and negative plates apart. These separators are made of non - conducting porous materials and prevent short circuits.

A number of positive plates are lead burnt to a post strap to form a positive plate group; while the negative plate group contains one plate more than positive group so that both side of positive plates can be utilized as greater electro chemical activity takes place. The positive plate post is usually larger in diameter than the negative plates.

Cells

One positive and one negative group of plates are slide over each other with separators in between, to form cell. Each cell supplies a current of 2V. i.e, a12 volt battery consists of 6 cells. The size of the plates and their number per cell determines the capacity of the battery. Cells are connected in series.

Electrolyte

After assembling completely, the battery is filled with electrolyte. It is a solution of water and sulphuric acid. It contains approximately one part of sulphuric acid and two parts of water by volume. In fully charged condition, the gravity is 1.290 at 15 degree where; the specific gravity of fully discharged battery is about 1.110.

Working of lead acid battery

Chemical equation of a battery while discharging and charging is given below:

$PbO_2 + 2H_2SO_4 + Pb$ ------> discharging $PbSO_4 + 2H_2O + PbSO_4$

<-------- charging

(+ve plate electrolyte -ve plate) (+ve plate electrolyte -ve plate)

On discharging both PbO_2 and Pb are converted to lead sulphate, ($PbSO_4$) and water is produced, which dilutes the electrolyte solution. During recharging, lead sulphate on positive plates is converted into lead peroxide (PbO_2), while on negative plates lead sulphate is converted to spongy lead. Water is split up into oxygen and hydrogen gases during charging process. The hydrogen combines with the sulphateions to reform sulphuric acid. In this way the specific gravity of electrolyte is increased during the charging process.

CHARACTERISTICS OF BATTARY

CELL VOLTAGE

The open circuit voltage of a fully charged battery cell is 2.1V. A six volt battery would, therefore, be made of 3 cells, while a 12 volt battery would contain 6 cells connected in series. It may be noted that cell voltage is not affected by the cell sizeand the number of plates.

BATTERY CAPACITY

The capacity of a battery is defined as the amount of current it can deliver. It depends upon the number and area of plates in the cell and the quality of the electrolyte. It also depends upon the temperature of electrolyte.

BATTERY RATINGS

It is determined by the current it can produce and the time for which it can sustain this current. Some types of ratings are:

1. 20 hour rate - it indicates the lasting power of battery on small load. That is the rate of current a battery can deliver continuously for 20 hours after which the cell voltage should not drop below 1.75 volts.

2. Reserve capacity - This is the length of time that a fully charged battery at 27 degree Celsius can deliver 25 Amperes. A typical rating is 125 minutes in which a battery can be discharged at 25 amperes for 125 minutes if the alternator is not working.

BATTERY TESTING

The following are the important tests conducted to determine the conditions of a battery.

1. Specific Gravity Test

2. Open Volt Test

3. High Discharge Test

Specific Gravity Test

This is conducted with the help of a hydrometer. Immerse the sampler tube in the cell electrolyte, squeeze the rubber bulb and release the same which would cause a sample of the electrolyte to be drawn inside the glass body. Let the float inside rise and then read the scale at the surface level of the sample drawn in. Note down the reading of the float. If the specific gravity is 1.290, the battery is in full charged condition. If the reading is 1.20 the battery is in half charged condition. If it is 1.110 the battery is fully discharged. If the temperature is above 320 C; the specific gravity may decrease.

Open Volt Test

The vehicle fitted with maintenance free battery is sealed and hence, that cannot be checked by hydrometer. In such case, that can be checked by open volt test.

The open circuit voltage of the battery cell is measured with the help of ordinary voltmeter. The open circuit voltage of a fully charged battery cell is about 2.1 volts. Connect the voltmeter to battery terminals by shutting off all the other accessories. In case of a 12 volt battery, if the voltmeter reads 12.6 volts, it is fully charged. If it reads 12.2 volts it is half charged. If the reading is below 11.9 volts, it is fully discharged.

High Discharge Test

Open voltage test is not representative of the cell voltage under actual operating conditions. The cranking motor at the time of starting draws very heavy current which causes the cell voltage to fall. To stimulate this condition a high discharge test is made with the help of a cell voltage tester. A cell voltage tester consists of a voltmeter connected to 2 legs with a high resistance placed across this. Pressing the 2 legs of the cell tester on the cell terminals causes heavy current (say 150 to 200 amperes) to flow. The test is made for 5 to 10 seconds at the end of which the voltage should not fall below 1.5 volts and the difference of cell voltages ofvarious cells should not exceed 0.2 volts, otherwise the battery is defective. If the cell tester is not available, this test may also be made with help of cranking motor. The voltage readings are taken with the help of a good voltmeter.

BATTERY CHARGING

If the battery charge has got down to a lower value, the run of vehicle is not sufficient to charge the battery. In this condition the battery is to be charged from other external sources. There are different methods of battery charging. They are:

1. Slow Rate Charging

i) Constant voltage charging

ii) Constant current charging

2. Quick Rate Charging or Booster Charging

3. Trickle Charging

1. Slow rate charging

Ordinarily batteries are charged by slow rate charging method. It takes about 12 to 20 hours for charging a battery using this method. It is the safest method of charging as it increases the life of a battery. There are 2 types of slow rate charging. They are

i) Constant voltage charging

This type of charger is a motor generator set. The generator is rated 15 volts for 12 volt batteries. When the battery in a discharged condition is connected to the generator, current will flow into the battery. As the battery nears its charge, its terminal voltage will increase with increase in opposition to charging current. Thatis the charging current tapers off as the battery approaches the charged condition.The battery should be removed from the charger if the temperature increases beyond the limit.

ii) Constant current charging

This type of charger is a rectifier. The charging current of this rectifier can be adjusted with the help of a rheostat. The battery may be charged at 5A rate. The charging may be continued till all the cells of the battery are gassing freely and no further rise in the specific gravity of the electrolyte takes place for another 2 hours.

2. Quick Rate Charging or Booster Charging

Boosters are devices which supply high charging currents of 40 to 100A, depending upon the size of the battery. It is possible to recharge a battery to almost the full charge condition in an hour using this process. Some precautionsshould be taken before attempting booster charging. They are:

1. The battery must be in good condition.

2. A badly overcharged battery which has been allowed to stand idle for long period should not be charged this way.

3. A badly sulphated battery should not be quick charged.

4. The electrolyte temperature should not be allowed to rise above 500 C.

CARE AND MAINTENANCE OF BATTERY

The vehicle batteries must be inspected periodically, say, every week. The following points may be taken care of.

1. The battery terminals should be clean and tight.

2. Remove vent plugs while charging.

3. Never bring flame near vent holes while charging as it may cause explosion.

4. In case the electrolyte level in the battery is not sufficient, top up with distilled water.

5. Never let the battery remain in discharged condition, otherwise the plates will become sulphated.

6. Do not put weight on battery as it may bend the plates.

7. Do not hammer the battery terminals.

8. Put petroleum jelly on battery terminals to avoid sulphation.

9. To avoid accidental arching, always remove the negative cable first while disconnecting and connecting the battery.

10. Avoid the contact of electrolyte with eyes, skin or cloths

Starting system

Starting system uses battery power and an electric DC motor to turn engine crankshaft for engine starting. It changes electrical energy to mechanical energy. It provides gear reduction/torque multiplication (16:1 to 20:1). When the ignition key is turned on the current flows through the solenoid coil, this closes the contacts, connecting battery to the starter motor.

STARTING CIRCUIT

The starting system includes the battery, starter motor, solenoid, ignition switch and in some cases, a starter relay. An inhibitor (neutral safety) switch is included in the starting system circuit to prevent the vehicle from being started while in gear.

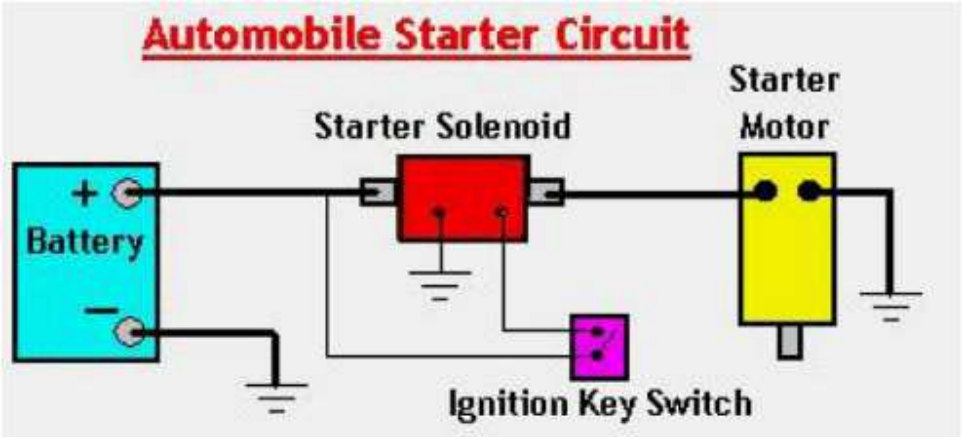

Figure 5.2. Starting Circuit

When the ignition key is turned to the start position, current flows and energizes the starter's solenoid coil. The energized coil becomes an electromagnet which pulls the plunger into the coil; the plunger closes a set of contacts which allow high current to reach the starter motor. On models where the solenoid is mounted on the starter, the plunger also serves to push the starter pinion to mesh with the teeth on the flywheel.

LIGHTING CIRCUIT

The purpose of the lighting system is to provide illumination for the driver to operate the vehicle safely at night, to convey information to the other driver and people on the road about the vehicle's presence, position, size, direction oftravel, illuminating instruments on the dash board etc. The automobile lighting system consists of the following circuits:

1. Head lamp circuit 2. Tail lamp circuit

3. Stop light circuit 4. Parking light circuit

5. Number plate light circuit 6. Instrument panel light circuit

7. Interior light circuit

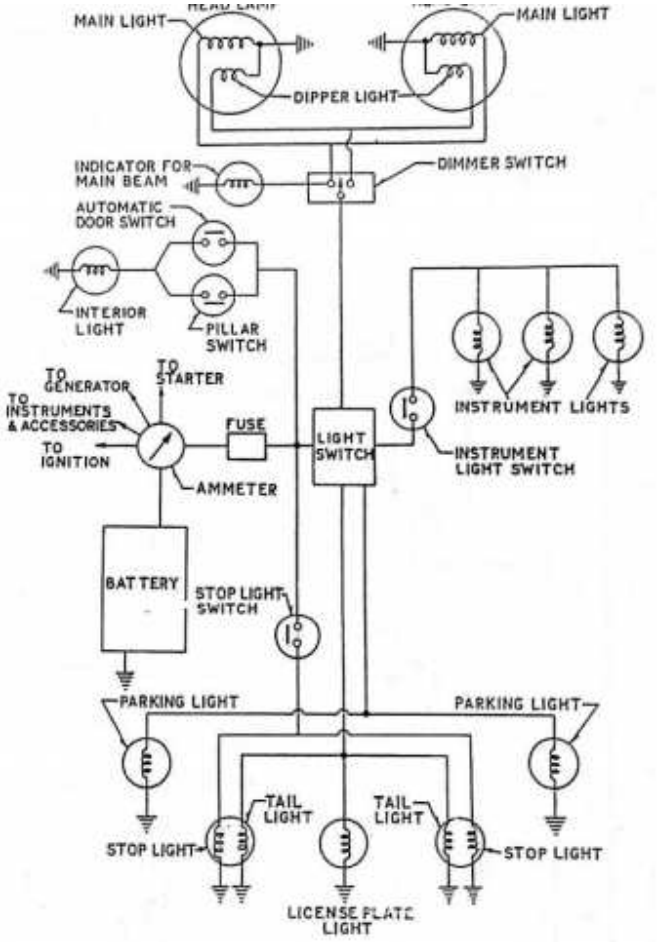

Figure 5.3. Lighting Circuit

HEAD LAMP

A head lamp is a lamp attached to the front of a vehicle to light the road ahead with a reasonable distance with sufficient intensity. For this purpose a reflector is used. The following are the important types of head lamps.

1. Incandescent lamp

2. Halogen lamp

3. High intensity discharge (HID) lamp

4. LED lamp

LIGHTING SWITCHES

Switches used in lighting circuit of an automobile are of different types depending upon their requirements. The important switches are

a) Light switch: - This may be of push-pull type and is mounted on the board.It has three positions (i) off position, (ii) side lamps, tail lamps, number plate light and instrument lamps (iii) head lights. This switch is also mounted on a stick on the steering column.

b) Dimmer switch: - This switch is mounted on the stick on the steering column.

By moving the lever up and down, we can select the dim and bright position of the head lamp.

c) Stop light switch: - This is attached to the master cylinder in the brake system. When the brake pedal is applied, the fluid pressure developed in the compression chamber is communicated to a metallic diaphragm which deflects to close the two terminals for the stop light switch.

INSTRUMENT PANEL INDICATING LIGHTS

These lights are used to indicate the driver about the position and situations of different systems.

a) Main beam warning light:-This light glows when the main beam of the head lights are on. This reminds the driver to dip the lights for the oncoming vehicles.

b) Ignition warning light: - The red light lights up when the ignition switch is on. It goes off when the engine speed increases. This lamp serves as a warning against leaving the ignition switched on when the engine is not running.

DIRECTION INDICATOR CIRCUIT

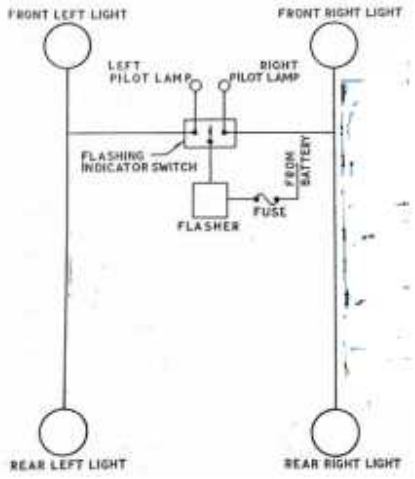

Figure 5.4. Direction Indicator Circuit

One light on each side is fitted both at the front as well as on the rear side of the vehicle. The wiring diagram for the same is shown in the figure. The current is taken from the battery through a fuse and a flasher unit. The flashing indicator switch is usually in the form of a horizontal lever mounted on the steering column so that when its outboard end is actuated upward, the light side indicator lights are operated and the downwards movement of the switch arm operates the right side indicator lights. Flasher unit consists of a thermostatic bimetallic blade. The blade expands due to flowing of the current through it, warms and opens a pair of contacts, thus opening the

circuit. But as the current stop flowing, the blade cools and straightens to close the circuit again. In this way the lights are made to flash.

HORN CIRCUIT

The horn employed on present-day automobiles is electrically operated. The construction of such a horn is shown in figure. It consist of a diaphragm and an armature inside a field coil. In the figure, the contacts are shown closed,

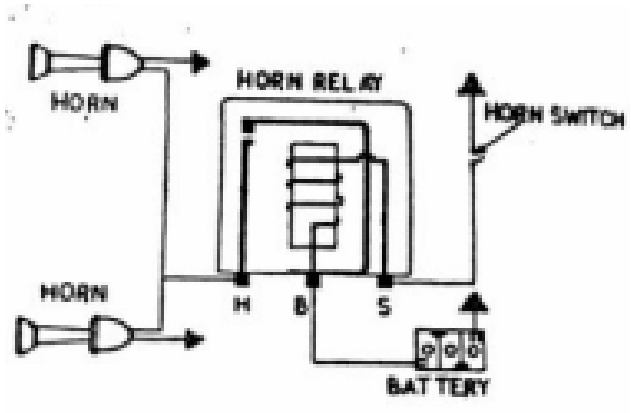

Figure 5.5. Horn Circuit

which is the position when the horn switch is in the off position. When the driver pushes the horn switch, the circuit is completed and the field coil produces an e.m.f. which causes the armature and along with it the diaphragm, to move down. But the moment the armature moves down, the contacts separate opening the electrical circuit. The field coil is then de-energised and the armature again moves up on account of the force of a mechanical spring (not shown) which keeps it into the uppermost position. This upward movement of the armature causes the contacts to close again, thereby pulling the armature and the diaphragm down. In this way, the diaphragm starts vibrating up and down causing the vibrations of the air column below it. These vibrations of the air column subsequently produce the horn sound, which depends upon the frequency of diaphragm vibration. A relay is usually inserted in the horn circuit.

It protects the contacts at the horn button and provides a more direct connection between the horn and the battery. The reason for this becomes clear when we consider that the current required for the horn operation is quite large. Therefore the least length of the current carrying cable is necessary. With the relay in the circuit, the heavy load required is only from the battery to the relay and then to the horns, which may be placed near one another thus requiring shorter leads only. The relay itself can be operated with a light current only and therefore the cable from the relay to the horn push button may be of a smaller cross-section.

WIND SCREEN WIPER

These are employed to keep the wind screen clean during rain, snow etc., to ensure good visibility. Wind screen wipers are operated by means of a small motor. The figure shows the

layout of a wind screen wiper. The motor drives the worm A which rotate the wheel B, link D connects the wheel

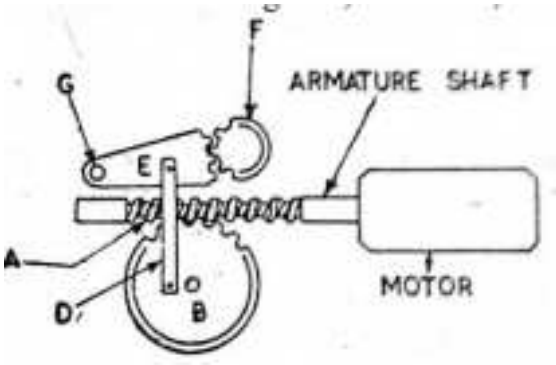

Figure 5.6. Wind Screen Wiper

with the toothed sector E. As wheel B rotates, the sector E reciprocates about fulcrumG. This motion is then imparted to a similar sector F on the spindle on which is mounted the wiper arm. Wiper blade is attached to the wiper arm by means of a spring lock. A rubber wiping element is held in place in the wiper blade. Wiper arms pivot against the windscreen under spring pressure to ensure adequate wiper blade pressure against the glass.

Working of Electric Vehicles

Electric vehicles (EVs) do not burn gasoline in an engine. They use electricity stored on the car in batteries. Sometimes, 12 or 24 batteries or more are needed to power the car such as a remote-controlled and model electric car. EVs have an electric motor which turns wheels and a battery to run.

Electricity, the same energy that lights lamps and runs TV isstored in batteries on an EV. In an EV, batteries and other energy storage devices are used to store the electricity that powers the electric motor in the vehicle. Figure 5.24 shows the typical arrangement of batteries and electric motor in an electric car. The batteries can be lead acid batteries or Ni-cad (nickel-cadmium). EV batteries must be replenished by plugging in the vehicle to a power source.

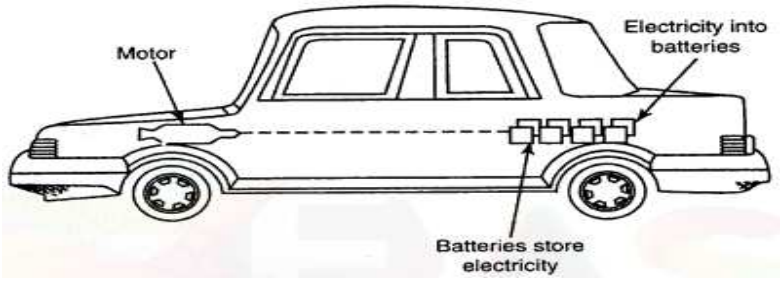

Figure 5.7. Electrical Vehicle

Better batteries which hold more energy and last longer are being developed. In 2001, by 'the time today's fifth graders are ready to drive, electric vehicles are able to go 150 to 200 miles before recharging.

Some EVs have on-board chargers whereas others plug into a charger located outside the vehicle but both must use electricity which comes from the power grid to replenish the battery. Although electricity production may contribute to air pollution, an EV is a zero emission vehicle and its motor produces no exhaust 01 emissions.

Electric Vehicles

Electric Vehicles (EVs) come in a variety of shapes and sizes. They can be light-duty delivery vehicles or heavy-duty trams and buses because the range of an EV (approximately 80 miles) is limited by weight, design and type of battery used. EVs are particularly well suited to short-distance and high-use applications. One of the first modem EVs was the General Motors Impact. GM changed its name and started selling GM "EV1" in 1997. This sleek looking car even sets a World Record of more than 180 miles per hour. EVI is very aerodynamic. It means that air slides around the body ofthe car very easily. Less air resistance or drag is required less energy to power the car at freeway speeds. EVI is as aerodynamic as somejet fighter aircraft.

Some EVs such as Toyota RAV-4 EV are made by major auto companies. Other electric vehicles built today are made by small car companies or by people who build them in their own garages as a hobby. Some people build cars from kits and make them look such as gasoline roadsters or such as sports cars. Other people convert regular cars into electric vehicles.

They pull out the motor and gas tank and put an electric motor and batteries into the car. Beginning in 1999, nearly all of the major auto companies such as Ford, General Motors, Toyota, Chrysler and Honda offered at least one model electric car. The numbers has dropped in 2002 with many auto companies working on hybrid vehicles which are the combination of small internal combustion engine and an electric motor. There are other types of electric vehicles. Many cities use electric-powered buses, trolleys, subways or light-rail. Even most trains are electric. Other places will use electric buses with batteries because they do not want wires over roads. Other people are using electric-powered bicycles. The motor is mounted above the rear wheel and under the seat.

The bag which is hanging from the middle holds the battery. The bike can go 20 miles per hour and it can travel 20 miles before needing a recharge. For people who have disabilities, an electric-powered bike might allow them to be free to act as outdoors.

Benefits of Electric Vehicles EVs are zero emission vehicles.

It means, they produce no tailpipe or evaporative emissions that contribute to air pollution and global warming (although electricity production is not pollution-free). The cost of electricity per kilowatt-hour usually compares favourably to gasoline but it varies depending on location. More than 95% of the electricity used to charge EVs originates from domestic resources. So, driving an EV reduces the nation's dependence on imported oil. As mentioned previously, EV s require less service because they do not need oil and they have no timing belts, water pumps, radiators, fuel injectors or tailpipes. Advantages of electric vehicles are summarised below:

1. There is no pollution due to emission. i.e., zero emission.

2. It ensures smooth operation. i.e., vibration and noise is less.

3. Cost of operation is less.

4. Less maintenance is required.

5. It is easy to start the vehicle.

6. It takes up less space on the road. So, they help to reduce traffic congestion.

HYBRID VEHICLES

The word hybrid means, something is mixed together from two things. Usually, it refers to plants 0" animals that are breed from different dissimilar parents. Hybrid electric vehicles (HEVs) typically combine the internal combustion engine of a conventional vehicle with the battery and electric motor of an electric vehicle.

The combination offers low emissions, power, range and convenient fueling of conventional (gasoline and diesel) vehicles and they never need to be plugged in. The inherent flexibility ofHEVs makes them well suited for fleet and personal transportation.

Electronic Stability control programme

Electronic Stability Control (ESC) is an active safety system that reduces the risk of a driver losing control of the vehicle when it skids, swerves suddenly or when road conditions change. ESC builds upon features such as Anti-lock Braking Systems (ABS) and traction control to stabilise the vehicle when it deviates from the driver's steered direction. ESC considerably reduces the risk of single vehicle crashes by:

• Correcting impending over steering or under steering

• Stabilising the vehicle during sudden evasive maneuvers e.g. swerving

• Improving handling on gravel roads e.g. road shoulders

• Improving traction on slippery or icy roads. Different manufacturers call ESC by different names, some include:

• Electronic Stability Program (ESP)

• Dynamic Stability Control (DSC)

• Vehicle Dynamic Control (VDC)

• Vehicle Stability Control (VSC)

• Dynamic Stability & Traction Control (DSTC)

• Active Stability & Traction Control (ASTC)

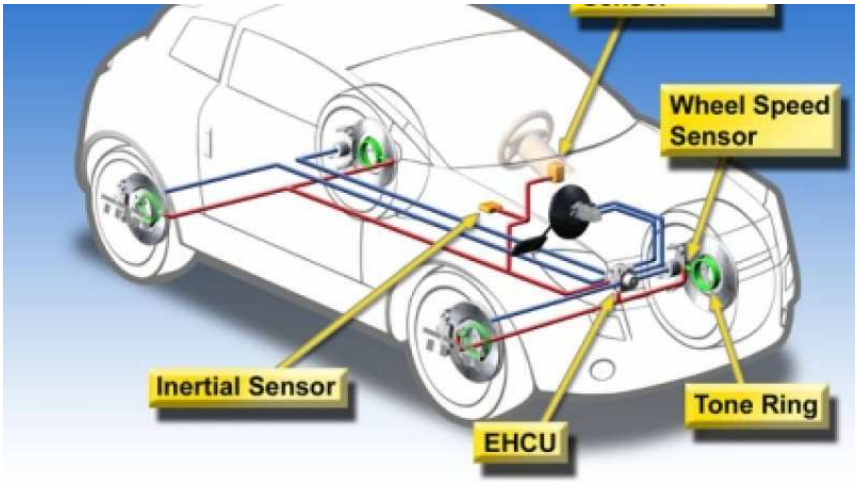

Figure 5.8. Electronic Stability Control layout

Using a number of intelligent sensors, ESC immediately identifies when a car has deviated from the driver's steered direction and the driver has lost control of the vehicle. As soon as impending instability, over steering or under steering are registered, ESC stabilises the vehicle by selectively braking individual wheels and reducing engine torque to bring it back on course. ESC uses components of ABS and traction control to stabilise the vehicle, but unlike ABS and traction control which only operate in the driving direction, ESC also helps the driver control sideways movements which create instability. This makes ESC a total, holistic system that controls a car's entire movements.

TRACTION CONTROL SYSTEM

Traction Control (TCS) is an option that is often found on vehicles equipped with antilock brake systems (ABS). Traction control is essentially an "addon" feature to ABS that improves traction when the vehicle is accelerating on a wet or slick surface, or is accelerating too quickly for the tires to maintain their grip. Traction control prevents wheel spin by applying the brakes on the drive wheel that is losing traction, and/or momentarily reducing engine torque by various methods. The main difference between ABS and TCS, therefore, is that ABS only comes into play when braking while TCS only comes into play while accelerating.

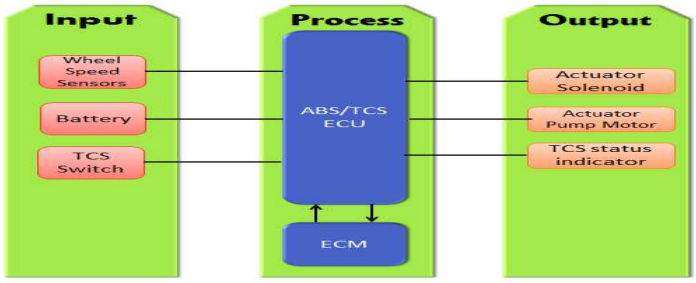

Figure 5.8. Traction Control System

TRACTION CONTROL SYSTEM COMPONENTS

Traction control shares many of the same components and sensor inputs with the ABS system:

A common control module is often used with additional software and control circuits for TCS. In some vehicles, a separate TCS control module may be used.

The same wheel speed sensors are used to monitor wheel speeds.

The same pump and high pressure accumulator are used to generate and store hydraulic pressure for TCS braking.

The same modulator (with a couple of extra solenoid valves) is used to control braking.

TEXT / REFERENCE BOOKS

1. Kirpal Singh, "Automobile Engineering Vol 1 and 2 "12th edition Standard Publishers 2011

2. Banga T.R. &Nathu Singh, "Automobile Engineering"3rd edition Khanna Publications. 2012

3. Rajput R.K. "A Text–Book of Automobile Engineering", Laxmi Publications Private Limited, 2008.

4. Heldt.P.M. Automotive Chassis, 3rd edition Chilton Co. Publications, New York, 1990.

5. Heinz heisler "Advanced vehicle technology"2nd edition Edward Arnold publication 2002