UNIT - 3

Fuel Supply System

3.0 Introduction:

The fuel system is made up of the fuel tank, pump, filter, and injectors or Carburetor, and is responsible for delivering fuel to the Engine as needed. Each component must perform flawlessly to achieve expected vehicle performance and reliability and To run a Diesel Engine, the fuel from the tank must reach by some means to the Engine cylinder at higher pressures for that purpose a fuel injector incorporated with nozzles and feed pumps will be provided.

Fuel Supply Systems in Petrol Engine:

There are many types of fuel supply system in Petrol Engine. The basic fuel supply system in an automobile Petrol Engine consists of a Fuel Tank, Fuel Lines, Fuel Pump, Fuel Filter, air Cleaner, Carburetor, intake manifold.

The components of fuel supply system:

1. Fuel tank:

The fuel tank holds the fuel for the Engine. It is made of steel or aluminum or synthetic rubber compounds and fiber reinforced plastics which are flame resistant. And these tanks are coated with lead-tin alloy to protect the tank from the corrosion effect.

2. Fuel pump:

The fuel pump is used to deliver the fuel from the fuel tank to the Carburetor. It supplies the high-pressure fuel from tank to the Carburetor.

3. Fuel lines:

These tubes are used to connect the fuel tank with the pump and pump to the Carburetor. Generally, these tubes are made of Copper or Steel.

The two joints of the tubes are made flexible because of the flexible joints help the fuel tank to moves back or front with the body, and also pump is moves according to the body. This joint prevents the loosening of fuel line by front-back movement of the body.

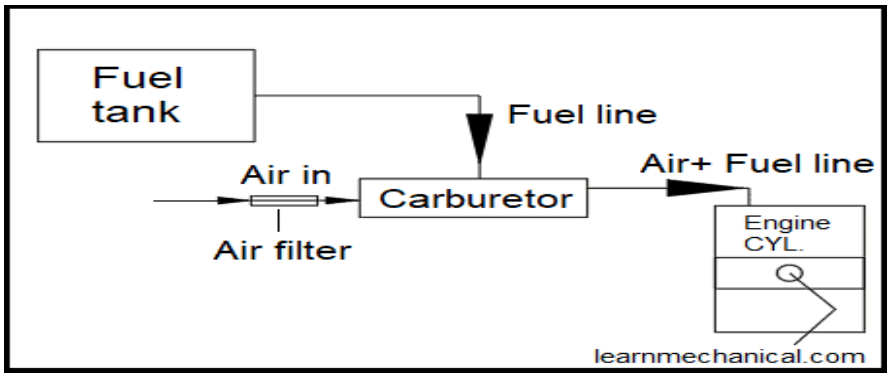

Fig 3.1 Components of Fuel System

4. Air Cleaner:

This is very necessary for an Engine to get fresh air, otherwise, the polluted air causes several damages to the Engine chamber. Particularly Piston, Piston chamber, Piston ring, and Valves. And if the polluted air enters the crankcase where we store Engine oil that can be damaged the lubrication parts like bearings. Therefore we need to install an air filter which purifies the air before entering the Engine cylinder.

Fuel Filters:

A fuel filter is necessary for a vehicle to clean the fuel. It screens off the dirt or foreign matter from the fuel and prevents entry to the pump.

There are 3 types of fuel filters. They are

1. Cartridge type
2. Edge type
3. Centrifugal type

1. Cartridge Type Oil Filter:

It consists of a filtering element placed in the metallic casing. The impure oil pass through the filtering element which takes all the impurities. The oil enters the filter at the top and passes through the filter element. The pure oil then goes to the porous metallic tube from where it goes to the out let for circulation and a drain plug is also provided.

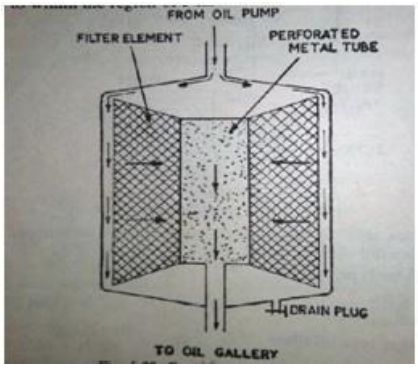

Fig 3.2 Cartridge Type Oil Filter

2. Stack or Edge Type Oil Filter:

In this the oil passes through a number of closely spaced discs. The alternate discs are mounted over a central spindle, while the discs in between these are attached to a separate spindle. The oil is made to flow through the spaces between the discs. The impurities are left on the peripheries. The impurities are removed by operating the central knob.

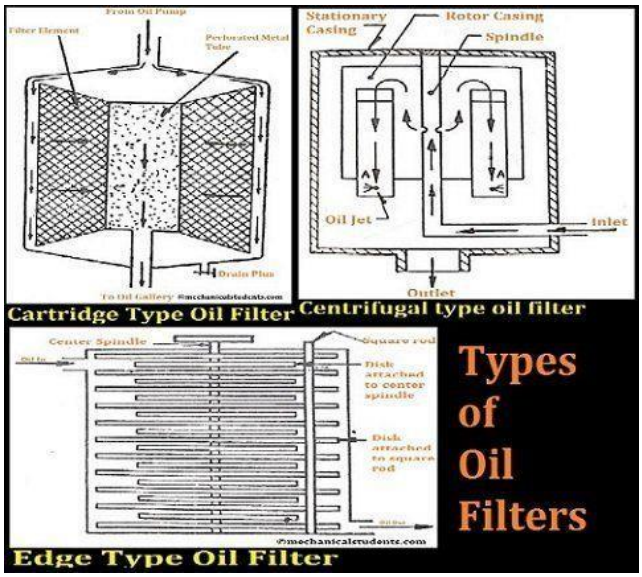

Fig 3.3 Types of Oil Filters

3. Centrifugal Type Oil Filter:

In this the impure oil enters the hollow central spindle having holes around its periphery. The dirty oil comes out of these holes and fills the rotor casing after oil passes down the tubes A at the ends which jets are attached. The oil under pressure passes through these jets, the reaction of which gives the motion to the rotor casing in the opposite direction

so that it starts rotating. The impurities are retained and clean oil falls below from where it is taken out.

Requirements of Carburetion

A perfect air-fuel mixture is necessary for a Petrol Engine to run. So, therefore, the device which performs this operation is called Carburetor. It is the device which controls the air-fuel mixture and mixes with desired proportions. There are two chambers in Carburetor one is float chamber which is used to maintain the fuel level with the help of needle valve and another one is mixing chamber where the mixture of air-fuel takes place.

1. It atomize the fuel and mixed it with the air.
2. It maintains a small reserve of Petrol at a constant head.
3. It prepares a mixture of Petrol and air in correct proportions and makes homogenous mixture.
4. It supplies a fine spray of mixture

Carburetors used in S.I. Engines may be up draught, down draught and side draught. This is based on the direction of air flow in to the Carburetor and air-fuel mixture flow at the Carburetor out let to the inlet manifold.

In down draught Carburetor, the air enters top of the Carburetor and leaves at the bottom In side draught Carburetor, the air enters at the top and leaves at the side. In up draught Carburetor the air enters at the bottom or side of the Carburetor and leaves at the top.

Simple Carburetor:

The main components of simple Carburetor are

A) Float chamber
B) Float
C) Venturing,
D) Nozzle,
E) Choke Valve
F) Throttle Valve.

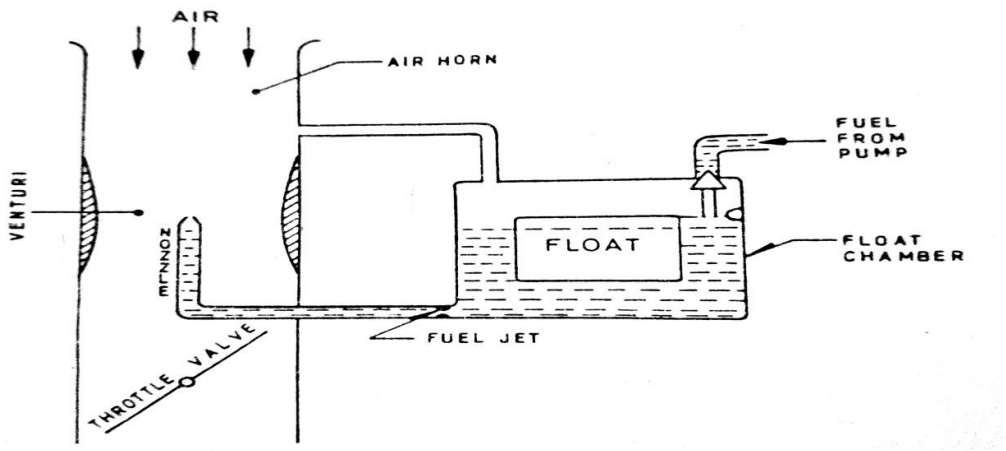

Fig 3.4 Construction of Simple Carburetor

Float Chamber:

In the float chamber, the float and a needle valve helps to maintain a constant level of Petrol. The float chamber is ventilated to atmosphere. This is used to maintain atmospheric pressure inside the chamber.

Float:

The float which is normally a metallic hollow cylinder rises and closes the inlet valve, as the fuel level in the float chamber increases to certain level.

Venturing:

The venture tube is fitted with the inlet manifold. The tube has a narrow opening called venturi.

Nozzle :

A nozzle is provided just below the center of the venture. The venture and the nozzle are kept in the mixing chamber. The mixing chamber has two butterfly valves. One is choke valve and the other is throttle valve.

Choke Valve:

It is a valve which allows air into the mixing chamber.

Throttle Valve:

It is a valve which allows air fuel mixture to the Engine cylinder.

Working:

Vacuum is created inside the cylinder during the suction stroke. Then exist a pressure difference between the cylinder and outside the Carburetor. Therefore the atmospheric air enters into the Carburetor. The air flow through venturi. It increases the velocity of air and reduces the pressure. This provides partial vacuum at the top of the nozzle. Because of this vacuum the fuel comes out from the nozzle in the form of a fine spray. The fuel particles mixed with the incoming air to form air-fuel mixture. Thus it gives homogenous mixture and goes to the Engine cylinder

Solex Carburetor:

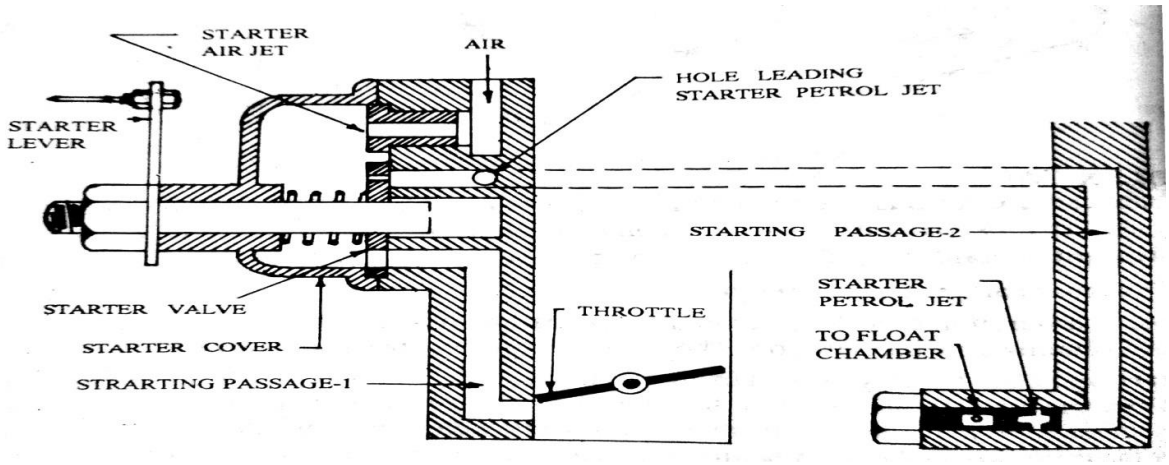

Fig 3.5 Construction of Solex Carburetor

Solex Carburetor is most commonly used down draught type of Carburetor. This Carburetor comes with an additional feature of Bi-starter. This Carburetor can work differently at different conditions known as

1. Cold starting conditions
2. Idling conditions
3. Normal conditions
4. Acceleration conditions

1. Cold Starting Conditions:

It consists of a starter valve in the form of a flat disk having holes of different sizes. These holes connect the Petrol jet and starter jet ides to the passage which opens into the air horn just below the throttle valve. The starter lever is operated by the driver from the dash board. It adjusts the position of the starter valve so that either bigger or small holes come opposite to the passage. At the time of starting bigger holes connect

the passage so that more fuel go to the Engine. The throttle valve being closed, the hole of the Engine suction is applied to the starting passage1. So that the Petrol from the float chamber passes through the starter Petrol jet and rises into passage2. Some of the fuel comes out and mixes with air and entering through the air jet. After the Engine is started the starter lever is brought to the second position. The smaller holes connects to the passage reducing the amount of Petrol. The throttle valve is partly open then the Petrol coming from the main jet. When the Engine reaches the normal running temperature the starter is brought to off position.

2. Idling:

At idling or low speed the throttle valve is almost closed. The Engine suction is applied at the pilot Petrol jet which supplies Petrol. The jet itself draws Petrol from the main jet circuit. The air is drawn from the pilot air jet. The air and Petrol mix in the idle passage. The mixture comes out of the idle port which opens below the throttle valve.

3. Normal Running:

During Normal running the throttle valve is partly opened and the Engine suction is applied at the main jet which supplies the fuel. The air enters directly through the venture and mix with the fuel. The air fuel mixture is governed by the throttle valve.

4. Acceleration:

For acceleration extra fuel is required by the Engine, which is supplied by membrane pump. The pump lever is connected to the accelerator. When the accelerator peddle is depressed the pump lever presses the membrane forcing the fuel into the main jet. Then the peddle is returned the membrane moves back, sucking the fuel from the float chamber through the ball valve.

Carter Carburetor:

The Carter Carburetor is a down draught type of Carburetor which provides of fine air-fuel mixture for different conditions with the help of more number of venturi sections.

The carter Carburetor consists of following circuits

1. Float circuit
2. Starting circuit
3. Idle and low speed circuit
4. Part throttle circuit
5. Full throttle circuit
6. Acceleration pump circuit

Float Circuit:

The float chamber has a float. A needle valve closes the fuel inlet when the fuel in the float chamber attains a specific level. When the fuel level falls, the needle valve opens the inlet to admit more fuel.

Starting Circuit:

Choke is used for starting. It is mounted eccentrically which facilitates its automatic opening after the Engine has started. As the choke valve is closed the whole of the Engine suction is applied at the main nozzle the fuel delivers.

Idling & Low Speed Circuit:

For idling rich mixture is required in small quantity. The throttle valve is almost closed. The suction is now applied at the idle port, through which the air and fuel are drawn, giving rich mixture. While operating at low speed operation throttle valve is opened. The main nozzle also starts supplying the fuel. At this stage fuel is delivered both by the main venture and low speed port through idle passage.

Part Throttle Circuit:

When the throttle valve partly opened a small amount of air-fuel mixture is giving.

Full Throttle Circuits:

When the throttle is fully open, maximum amount of air is passing through the venture. Thus a higher rate of fuel is drawn.

Acceleration Pump Circuit:

When the acceleration is desired, acceleration pedal is pressed which actuate the pump giving an extra fuel for acceleration.

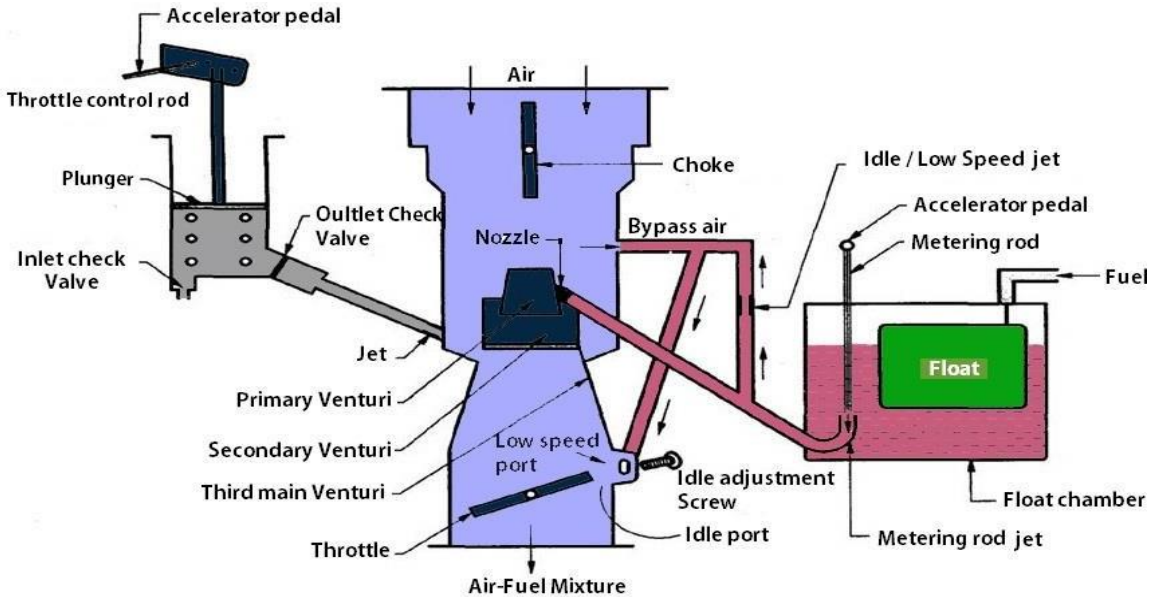

Fig 3.7 Construction of Carter Carburetor

Zenith Carburetor:

The standard model of Zenith Carburetor contains the old type of float chamber. The system is modified in recent years. There are three jets- main jet, compensating jet and idling jet in the Carburetor. This compensating jet is around the main jet. The choke valve is used for starting. For idling and slow speed running, the air enters through the holes A and B, mixes with the fuel in idling passage, and the mixture passes to the idling jet. A separate knob is provide for idle adjustment, which controls the opening B to supply the mixture.

When the throttle valve is widely opened, the main jet comes into action, along with the idling jet. On further opening the throttle valve, the whole suction is applied on the main and compensating jet. The idling jet is cut off. The compensating jet takes care to maintain correct air-fuel ratio at different speeds.

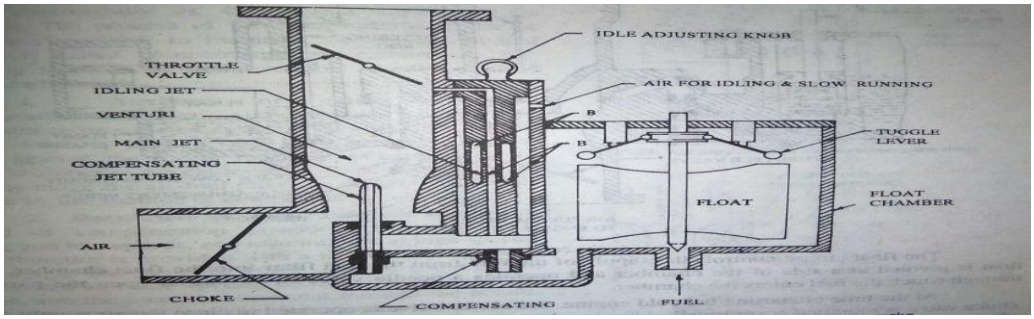

Fig 3.8 Zenith Carburetor

S.U. Carburetor:

It is constant vacuum type Carburetor. It consists of a single jet in which a tapered needle operates. The area of the throat is varied by means of piston which slides up and down. The tapered needle is connected to the accelerator. When the accelerator is operated the piston moves up and down in the throat, controlling the air. The needle moves up and down to the jet controlling the supply of fuel. When the piston moves down throat area decreases the annular area in the jet to pass less fuel. The piston and tapered needle are designed that they maintain correct air fuel mixture at different opening conditions.

The upper side of the piston is connected to the throttle passage through a slot cut in the piston. The lower side is covered to the atmospheric pressure. The piston at any instant depends up on the balance of its own weight against the vacuum force. As the weight of the piston is constant, the vacuum also constant. The jet can move broadly up and down with respect to the tapered needle by an adjusting screw fitted at the bottom of the screw. This is done for adjusting the mixture strength.

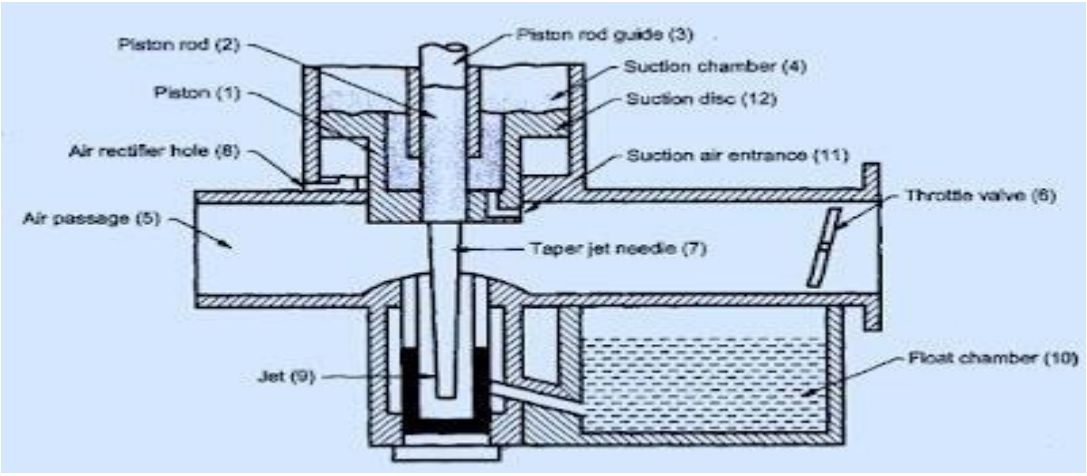

Fig 3.9 S.U Carburetor

3.5. Spark Plug:

Spark plug is a device for delivering electric current from an ignition system to the combustion chamber of a spark-ignition Engine to ignite the compressed fuel/air mixture by an electric spark, while containing combustion pressure within the Engine. A spark plug has a metal threaded shell, electrically isolated from a central electrode by a porcelain insulator. The central electrode, which may contain a resistor, is connected by a heavily insulated wire to the output terminal of an ignition coil or magneto. The spark plug's metal shell is screwed into the Engine's cylinder head and thus electrically grounded. The central electrode protrudes through the porcelain insulator into the

combustion chamber, forming one or more spark gaps between the inner end of the central electrode and usually one or more protuberances or structures attached to the inner end of the threaded shell and designated the side, earth, or ground electrode(s).

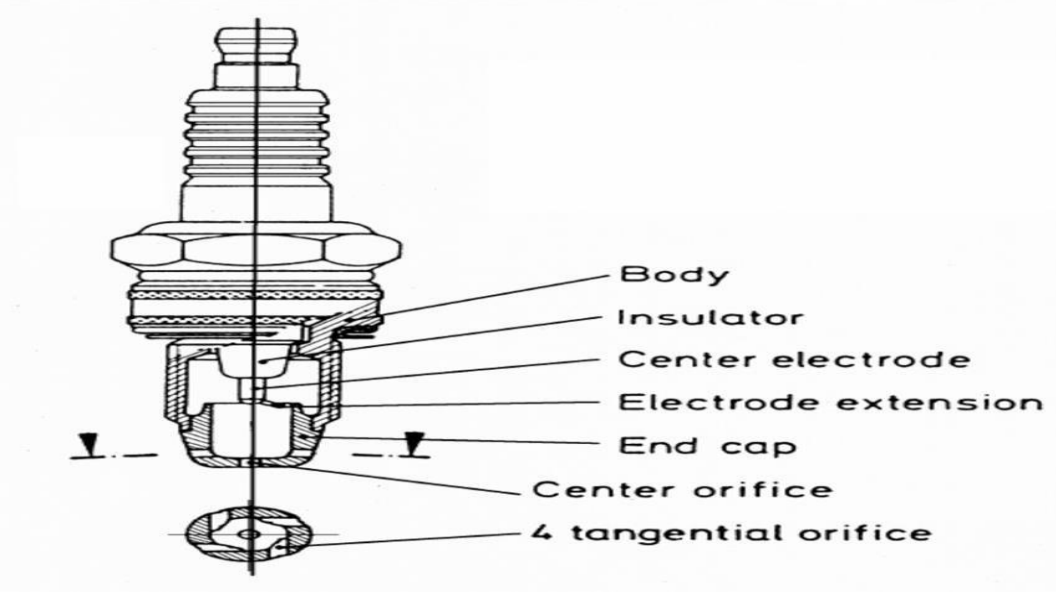

Fig 3.10 Spark Plug Construction

Super Charging:

The process of supplying the air fuel mixture to the Engine above the atmospheric pressure is called super charging. A super charger is used to increase the pressure of air fuel mixture from the Carburetor before it enters the Engine.

Types of Super Chargers:

1. Centrifugal type Super Charger.
2. Vane type Super Charger.
3. Roots Blower type Super Charger.

Scavenging:

The process of driving exhaust gases out of the cylinder and replacing it with fresh air is called scavenging. The methods of scavenging are A) Loop scavenging, B) Uni- flow scavenging.

3.8. Petrol Injection System in Modern vehicles:

This system is used in modern cars where a single Carburetor is used to deliver air fuel mixture into multi cylinder Engine. Some of the cylinders may not get regular supply of the mixture. It ensures unrestricted fuel supply and controls it at all times of

the Engine operation. Petrol injection gives both higher power and low specific fuel consumption.

3.9 Line diagram of a Diesel Engine Fuel System:

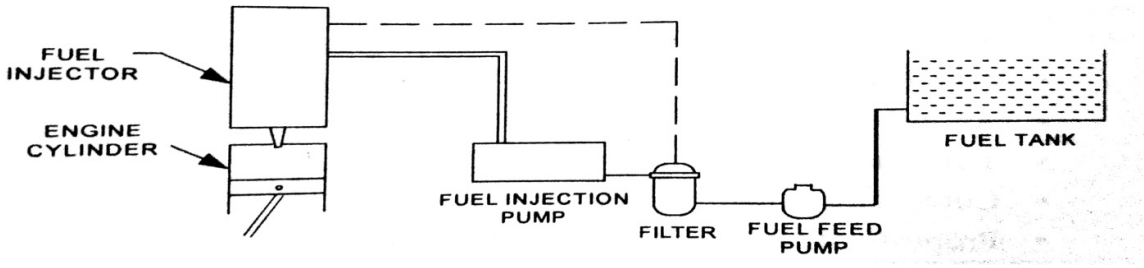

Fig 3.11Line Diagram of Diesel Engine Fuel System

Requirements of Fuel Injection System:

1. To meter or measure the correct quantity of fuel to be injected.
2. Atomized the fuel into fine particles.
3. The timing of fuel injected into the cylinder during Engine starting, full load and high speed.
4. Control the rate of fuel injection.
5. Properly distribute the fuel to the combustion chambers.

Fuel Feed Pump

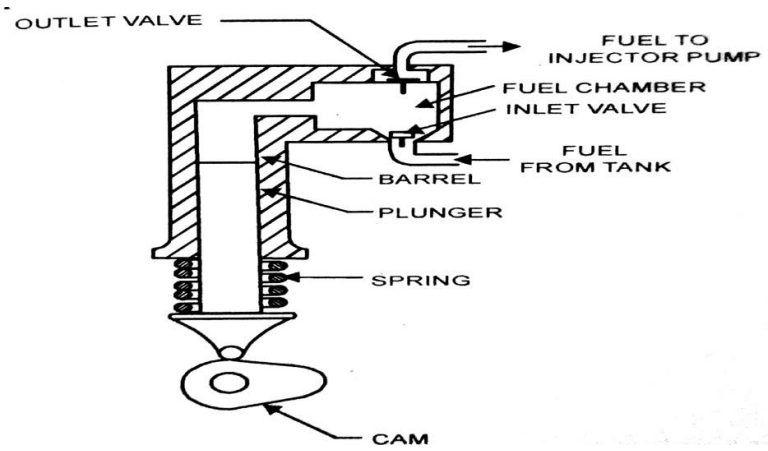

Fig 3.12 Fuel Feed Pump in Diesel Engine

Fuel Feed Pump serves to deliver fuel to the fuel injection pump. The fuel field pump deliver adequate amount of fuel to the fuel injection pump at a pressure of 1.2 bar.

The fuel feed pump consists a barrel, plunger and two valves. The plunger is activated by a spring and a cam. Plunger requires two strokes to deliver fuel to the injection pump. Due to rotation of the cam, the plunger moves upwards against the spring action. At the same time its inlet valve is closed and fuel is forced through outlet valve. At the initial lift position of the cam, the spring forces the plunger to move downwards. The downward movement of the piston creates low pressure above the plunger and fuel enters into pump. As the cam continues to rotate, the plunger moves upwards and the pressure above the plunger increases. This pressure causes the inlet valve close and outlet valve to open and fuel comes out from the pump.

Fuel Injection Pump:

The fuel injection pump serves the supply of metered quantity of fuel into Engine cylinder. It has plunger reciprocating in a barrel. Barrel is a cylindrical one with two opposite ports, one is inlet port and other is spill port. Inlet port serves to fill the barrel space above the plunger with fuel. The upper portion of plunger is provided with by a vertical groove. Fuel injection pump is connected to its fuel injector through delivery valve.

As the plunger moves up, it closes the inlet port and pill port of the barrel. The fuel pressure increases causes delivery valve to open and allow the fuel to enter into the fuel injector at high pressure. With further rise of the plunger, At a certain movement, the spill port is connected to the edge of helical groove. As soon as spill port uncovers the fuel passes through the vertical groove. The delivery valve is closed by spring action.

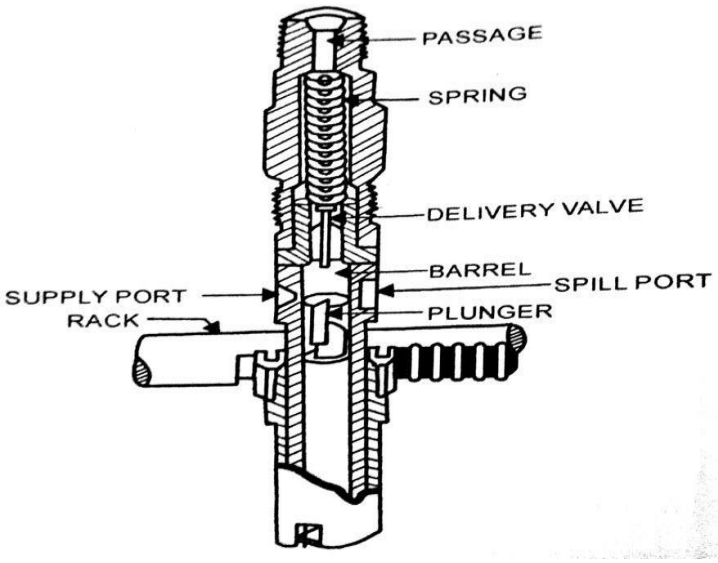

Fig 3.13 Fuel Injection Pump

Fuel Injector (Atomizer):

The friction of an injector is to spray the high pressure fuel into the Engine cylinder. It is basically, a spring loaded valve which opens by oil pressure. The fuel from injector pump enters through fuel inlet and is directed down to a space below the nozzle valve. Due to high pressure of fuel, the valve is lifted against the spring pressure. The fuel is then sprayed through nozzle into the Engine cylinder. Any leakage of excess fuel is taken off through the leak of pipe. The valve is again closed by spring pressure.

Fuel Injection Types:

The function of a fuel injection system is to inject proper quantity of fuel into the Engine cylinder at the correct time and at a predetermined rate.

There are two types of fuel injection systems.

Common Rail Fuel Injection System:

In this a single injection pump with injector is employed on each cylinder. The unit injectors are operated by rocker arms and springs. The fuel is taken from the fuel tank by the feed pump. It is supplied at low pressure through a filter to all the unit injectors. Any excess fuel from the relief valve is returned to the fuel tank.

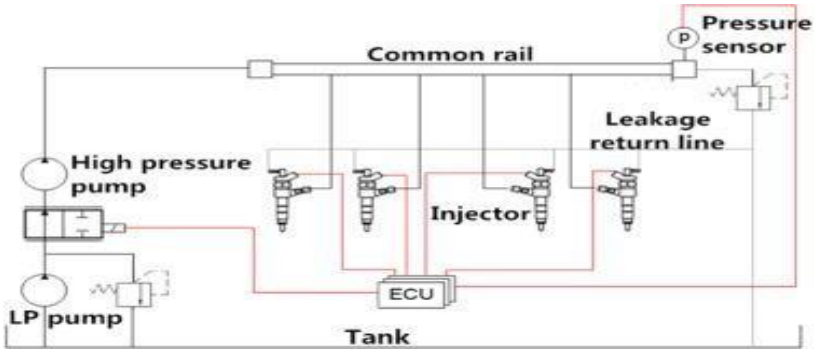

Fig 3.14 Common Rail Fuel Injection System

Individual Pump Fuel Injection System:

This system using in-line injection pump. The plunger type or the diaphragm type of fuel feed pumps are used. The pump I provided with hand pumping lever o that Diesel oil can be forced into the system. The fuel is then passed through a filter and to the fuel injection pump. The fuel injection pump, inject definite quantity of fuel into individual cylinder according to firing order.

Governors:

A typical governor regulates an Engine's speed according to its load by varying the rate at which fuel is furnished to it.

There are three types of governors.

1. Mechanical or Centrifugal Governors
2. Pneumatic Governor
3. Hydraulic Governor

1. Mechanical Governor:

Mechanical governors are fitted to large Engines on an extension of the pump cam shaft. When the Engine starts, the weights take up a position to maintain a stable idling speed, as the accelerator pedal is depressed against the spring, the weights move inwards. The weights are linked to the control rod. Then the fuel delivery is increased so the Engine speed increases. The increased Engine speed causes the pump cam shaft to rotate faster, then the weights are moves outwards. Then fuel delivery decreases. Thus the accelerator does not increase delivery directly but delays the action of governor.

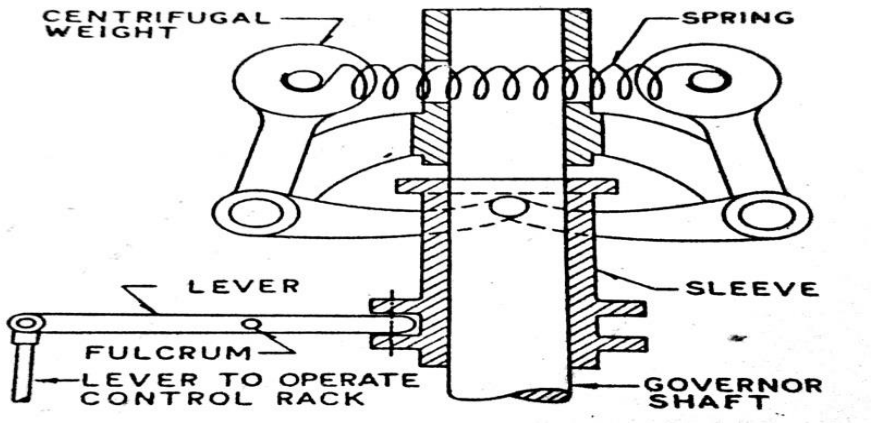

Fig 3.14 Centrifugal Governor

2. Pneumatic Governor:

A Pneumatic Governor consist two main parts, The Venturi unit and the Diaphragm unit. The Venturi unit is connected to the Engine inlet manifold and the diaphragm unit is fitted on the fuel injection pump. The two units are connected by a vacuum pipe.

Accelerator pedal controls the position of the butterfly valve in the Venturi unit. Hence vacuum from the manifold is applied to the diaphragm via vacuum pipe. The diaphragm is connected to the fuel pump control rack. The rack is operated left or right depending upon the amount of vacuum applied. Thus the position of the accelerator pedal determines the position of the pump control rack. Hence the amount of fuel injected. These Governors are used in small and medium sized Engines.

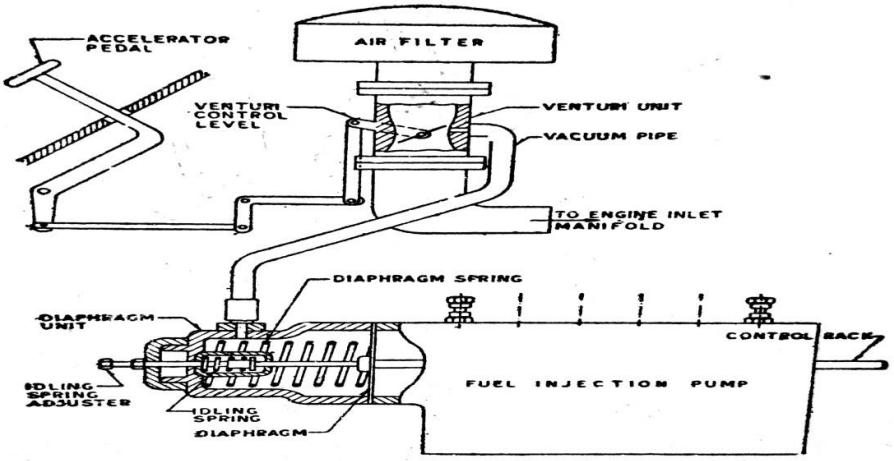

Fig 3.14 Pneumatic governer

3. Hydraulic Governor:

Hydraulic governors have more moving parts and are generally more expensive than mechanical governors, they are used in many applications because they are more sensitive, have greater power to move the fuel control mechanism of the Engine, and can be timed for identical speed for all loads.

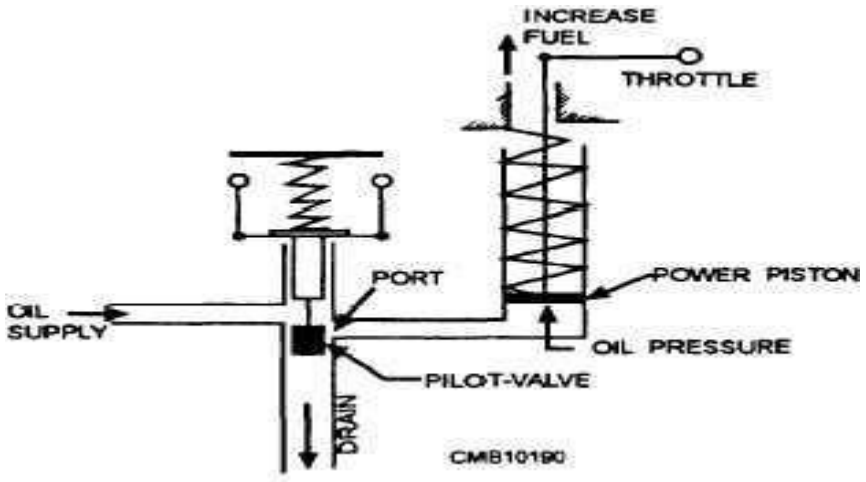

Fig 3.15 Hydraulic Governor

When the governor speed rises due to a decrease of Engine load, the flyweights move out and the pilot valve moves up. This opens the port from the power piston to the drain into the sump. The spring above the power piston forces the power piston down, thus decreasing the speed.

The simple hydraulic governor has a serious defect, which prevents its practical use. It is inherently unstable. It keeps moving continually, making unnecessary corrective actions. In other words it hunts. The cause of this hunting is the unavoidable time lag between the moment the governor acts and the moment the Engine responds. The Engine cannot come back to the speed called for by the governor.

Most hydraulic governors use a speed droop to obtain stability. Speed droop gives stability because the Engine throttle can take only one position for any speed. Therefore, when a load change causes a speed change, the resulting governor action ceases at a particular point that gives the amount of fuel needed for a new load. In this way speed droop prevents unnecessary governor movement and overcorrection (hunting).

Fuel Injection Nozzles:

The modern high speed oil Engines depends on the proper functioning of its fuel injection system. A nozzle is held in position in its cylinder head by the nozzle holder. A complete nozzle consists two parts. The nozzle value and nozzle body. The inner end of the nozzle valve is reduced in diameter to produce a stem upon which value face is formed. The out end is provided with a stalk. Fuel is fed to the mouth of the nozzle through small holes drilled vertically in the nozzle body. The nozzle value is raised from its seating in the nozzle body. Thus the fuel is forced through the hole or holes in the nozzle. In the form of spray the fuel is injected in the Engine combustion chamber.

Type of nozzles:

1. Single hole Nozzle
2. Multi hole Nozzle
3. Long stem Nozzle
4. Pintle Nozzle
5. Delay Nozzle
6. Pintaux Nozzle.

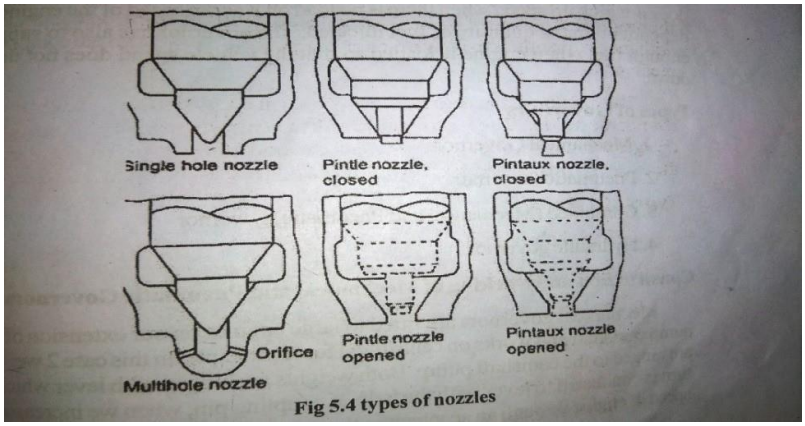

Fig 3.16 Types of Nozzles

1. Single Hole Nozzle:

It has one hole drilled centrally through its body which is closed by the nozzle valve. The hole can be of any diameter from 0.2mm onwards. The single hole is bored at an angle to the vertical center line of the valve as required.

2. Multi Hole Nozzle:

This nozzle can have a varying number of holes drilled in the bulbous end under the valve seating. Their actual number, size and disposition being dependent upon the requirements of the Engine.

3. Long Stem Nozzle:

For direct injection Engines where owing to limited space between the valves in the cylinder head . It is not possible to provide adequate cooling for the standard short stem nozzle. An alternate form of nozzle with a small diameter extension has been developed.

4. Pintle Nozzle:

It is used in the Engine combustion chambers of the cell, swirl or pre combustion type chambers. The valve stem is extended to a pin or pintle which produces through the mouth of the nozzle body.

5. Pintaux Nozzle:

A pintle-type Diesel fuel injector nozzle with a hole in the side through which a very small amount of fuel is sprayed when the needle valve is partly opened at low pressure, before the main hole comes into use.

6. Delay Nozzle:

It has an auxiliary spray hole to assist easy starting under cold condition. At Engine starting speeds the nozzle valve is not lifted sufficiently to clear the pin hole and the fuel is discharged through auxiliary hole.

Turbocharger:

Turbochargers are used to increase Engine power by compressing the unit that goes into the Engine combustion chambers. The Turbocharger is located to one side of the Engine close to the exhaust manifold. When exhaust pipe runs between the Engine exhaust manifold and the turbine housing to carry the exhaust flow to the turbine wheel. Another pipe connects the compressor housing intake to an injector throttle body or Carburetor.

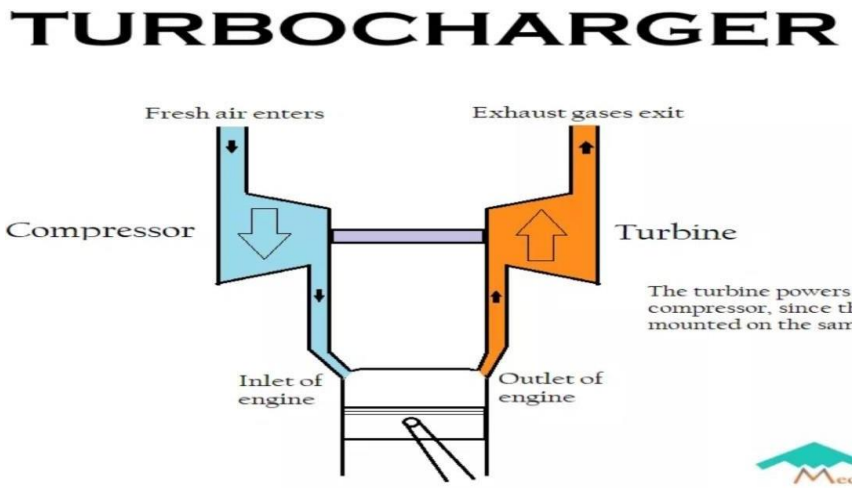

Fig 3.17 Turbocharger

Working:

The turbo charger is bolted to the exhaust manifold of the Engine. The exhaust from the cylinders spins the turbine. The turbine is connected by a shaft to the compressor, which is located between the air filter and the intake manifold. The compressor pressurizes the air going into the piston. The exhaust from the cylinders passes through the turbine blades causing the turbine to spin. The more the exhaust that goes through the blades the faster the spin. On the other end of the shaft the turbine is attached, the compressor pumps air into the cylinders. It draws air into the center of its blades and flings it outward as it spins. In order to handle speeds up to 150,000rpm the turbine shaft has to be made of costlier metals like duraluminum.

Short Answer Questions

1. Write the additional features of solex carburetor.
2. Write about the special circuit features of carter carburetor.
3. Write the parts of spark plug.
4. Draw the line diagram of diesel engine fuel supply system.
5. Explain the functions of turbo charger.

Long Answer Questions

1. Draw the line diagram of fuel supply system and give brief explanation on its components.
2. Explain any two types of filters with neat sketch.
3. Explain the construction and the working of simple carburetor.
4. With a neat sketch, explain the working of fuel injection system.
5. Write a note on governors and explain any two of them with neat diagram.