FUEL AND AIR FEED SYSTEM

PETROL FUEL SUPPLY SYSTEM

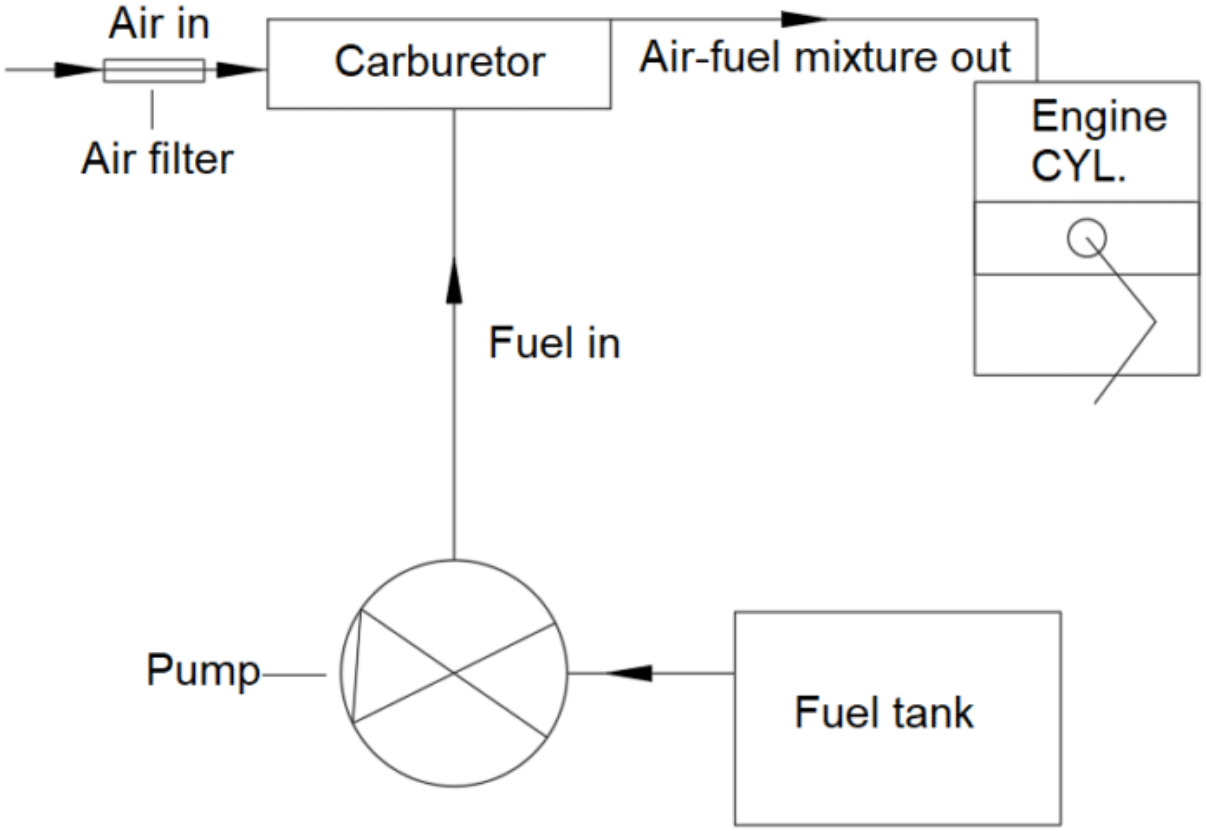
Types of Fuel Supply system in Petrol engines

In petrol engine fuel from the fuel tank can be supplied to the engine cylinder by following systems:

1. GRAVITY FUEL FEED SYSTEM
2. AIR PRESSURE FEED SYSTEM
3. VACUUM FEED SYSTEM (suction and gravity system)
4. PUMP FEED SYSTEM
5. FUEL INJECTION SYSTEM

Layout of Pump Feed Supply System:

In this system, a steel pipe carries petrol to the fuel pump which pumps it into the float chamber of the carburetor through the pipe.



Function /Location, Construction and working of Components:

1. **Fuel Tank:**

The fuel tank holds the fuel for the engine. This tank is placed in any suitable position of a vehicle. For front engine vehicle, the fuel tank is in the underside of

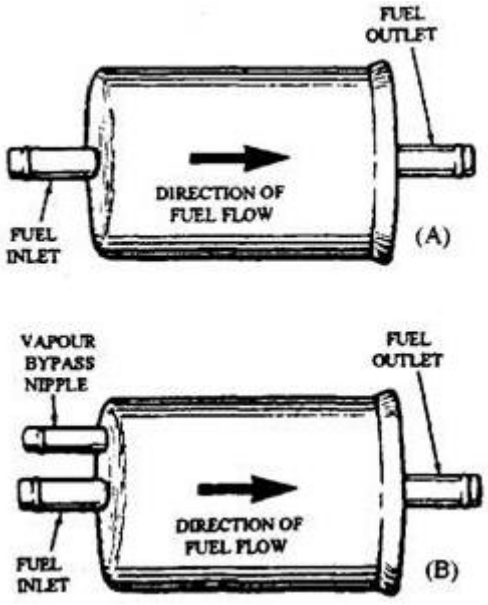
a luggage compartment at the rear end and for rear engines, the fuel tank is placed in the front.

It is made of sheet metal / steel or aluminum or synthetic rubber compounds and fiber reinforced plastics which are flame resistant. These tanks are coated with lead-tin alloy to protect from the corrosion effect.

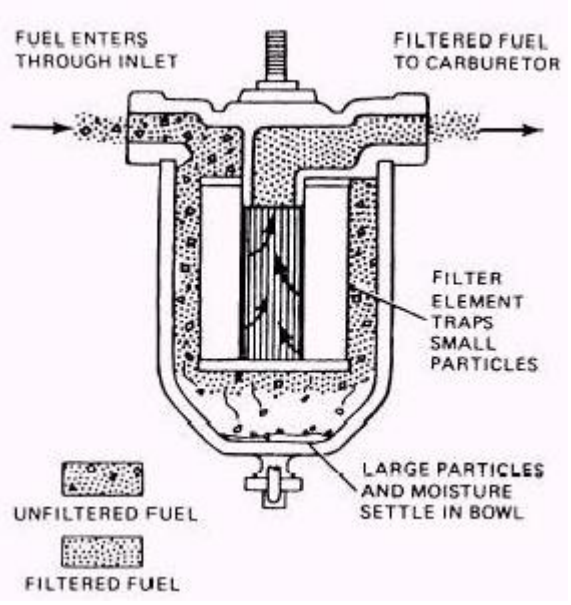
Petrol is filled by a small opening cap. Filler is placed at the tank end of the fuel line and a small hole is provided in the cap. A drain plug is fitted at the bottom of the tank to remove sediments and the fuel tank is also provided with a fuel gauge sensing unit for checking of fuel level inside the tank.

USE: It is used to store the fuel.

2. **Fuel Filter**: On carbureted engines fuel filters are mounted in the fuel lines between the fuel pump and the carburetor.



In-line fuel filter.
A. Without vapour bypass system. B. With vapour bypass system.



Functions of air filter:

1. Filters are used to remove foreign particles like dirt, dust and grit or filters are used to remove dust and particles out of the air.

2. It may also remove odors and gaseous pollutants.

3. It acts as a silencer for the carburetion system.

4. In case the engine backfires, the air filter also acts as a flame arrester.

3. Fuel Pump:

The fuel pump is used to deliver the fuel from the fuel tank to the carburetor.

There are generally two types of pumps used:

- A.C. Mechanical Fuel Pump
- S.U. Electrical Fuel Pump

Mechanical Fuel Pump

This pump is also called as A.C. mechanical pump. The construction features of this type of pump are as follows;

1) It is bolted to the engine block or the crankcase.

2) Drive is taken from the camshaft by means of an eccentric. The eccentric operates the rocker arm. Rocker arm operates the Diaphragm.

3) Diaphragm consists of high grade cotton; impregnated with the synthetic rubber.

4) The movement of the diaphragm sucks the fuel from fuel tank and pushes it to the carburetor.

5) Pressure in the petrol pipeline is between 20 to 35 kPa.

WORKING:

The mechanical fuel pump works in following manner;

1) As the cam shaft rotates, the eccentric on the camshaft operates the rocker arm; which in turn pushes the pull-push rod and the diaphragm upward.

2) The downward movement of the diaphragm sucks the fuel through strainer from the fuel tank.

3) The upward movement of the diaphragm pushes the fuel up, which causes Suction valve to close and Pressure valve to open.

4) The fuel passing through outlet valve is supplied to the carburetor.

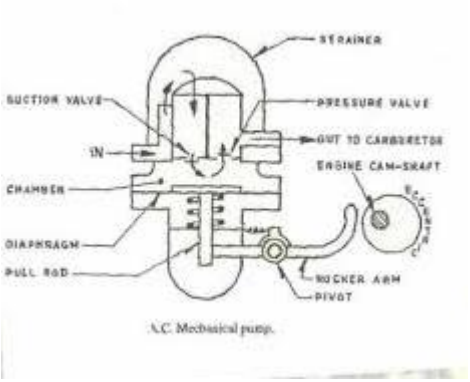
5) If the float chamber of the carburetor is completely filled up, then there is no need of pumping more fuel.

6) Diaphragm return spring restricts the supply of petrol. It remains compressed if the float chamber is full of fuel and due to the line pressure. Thus movement of the diaphragm is restricted.

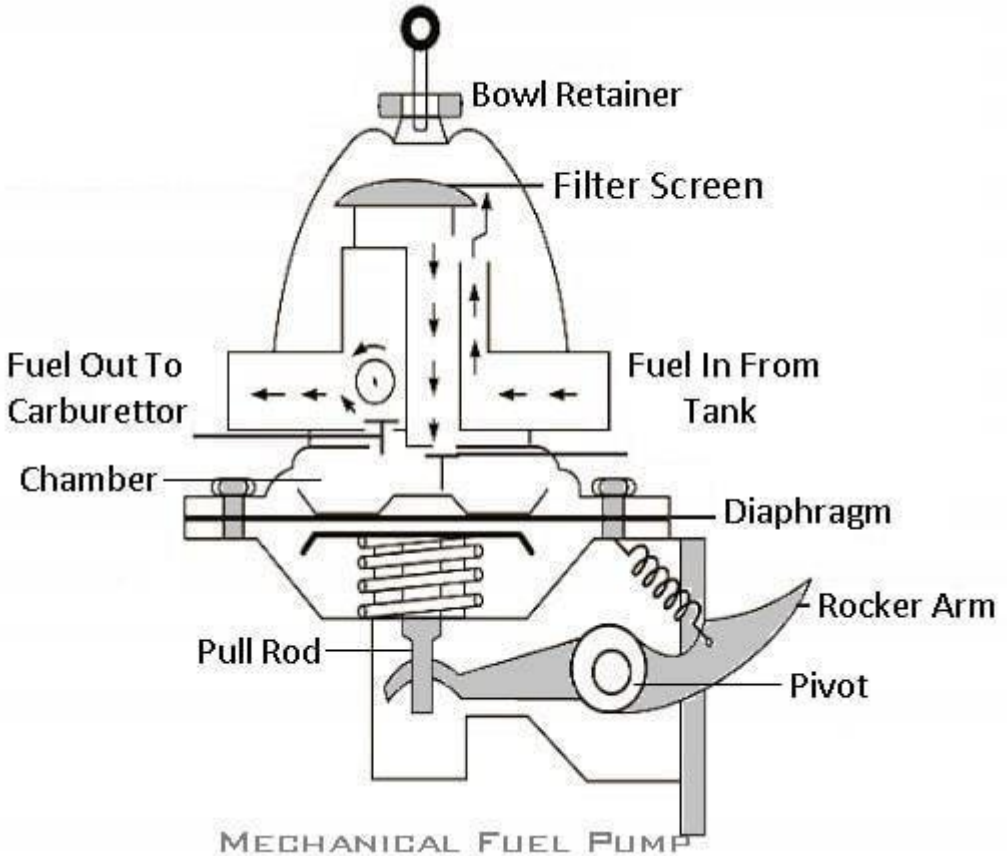
- Reliability is main advantage of the mechanical pump. However these pumps have some disadvantages;

1) They have to be situated close to the engine due to which they are exposed to engine heat, which may result in vapour lock in the fuel supply system.

2) They operate only after the engine has started.



A.C. Mechanical pump.



MECHANICAL FUEL PUMP

S.U. Electrical Fuel Pump:

It is also known as S.U. electric fuel pump. The construction & working features of this fuel pump are as follows;

1) It consists of a diaphragm, but it is operated electrically.

2) An ignition switch is turned on, thus the solenoid winding generates magnetic flux, which pulls the armature upward and the diaphragm moves up.

3) The upward movement of the diaphragm creates suction & thus the fuel is drawn into chamber through the inlet valve.

4) But as soon as armature moves up, the electric supply is disconnected at contact breaker point. The magnetic flux dies and the armature falls down, causing the diaphragm to move downward & creating pressure in the pump chamber.

5) This causes the outlet valve to open and inlet valve to close & the fuel goes to the carburetor via outlet valve.

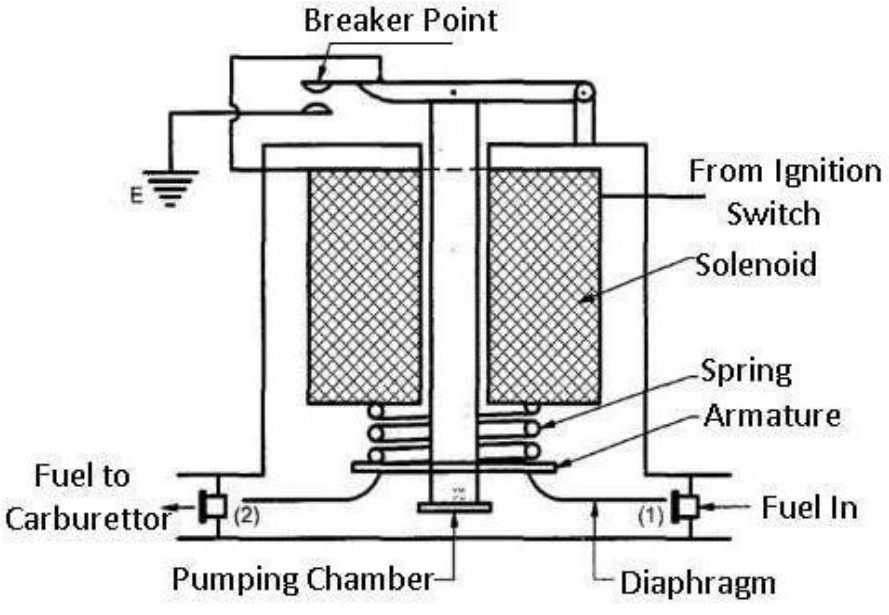
6) The downward movement of the armature again sets electric supply to the solenoid.

The process keeps on repeating, the pump continues to operate until the ignition switch is turned off.

The advantage of Electrical pump is that;

1) They need not need to be situated near the engine; mostly they are located near the fuel tank. So they are not subjected to the engine heat.

2) It starts operating as soon as the ignition is switched on; it does not wait for the engine to start.



ELECTRIC FUEL PUMP

AIR CLEANERS:

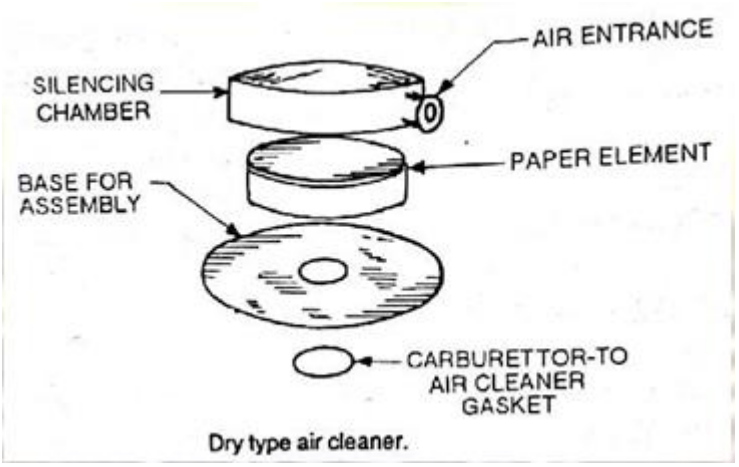
As hundreds of cubic meters of air per hour is used by the engine of an automobile, it is very important that this air should be very clean. Impurities like dust in the air cause a very rapid wear of the engine, particularly of the cylinders, pistons, rings, valves etc. Further if the dirty air enters the crankcase, it will contaminate the lubricating oil and ultimately damage the bearings and journals.

Air cleaner are classified on the basis of principle of filtration. The air cleaners generally used are of the following types.

1. Dry type air cleaner
2. Oil wetted type air cleaner

Dry type air cleaner

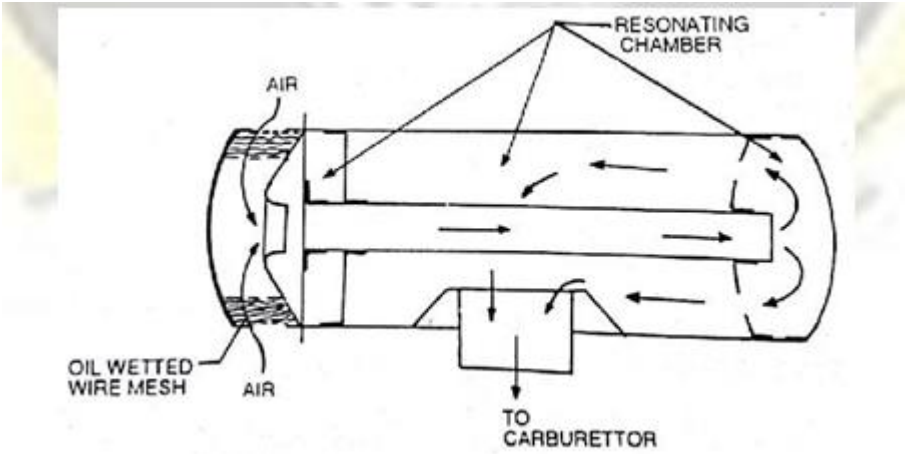
It is light duty air cleaner. It does not contain oil path. It consists of cleaning element only. Cleaning element is made up of paper which is enclosed in silencing chamber. The element is corrugated to increase the surface area exposed to the incoming air so that the resistance offered by the air cleaner is reduced to minimum.



Dry type air cleaner.

Oil wetted type air cleaner

It is heavy duty air cleaner. It consists of cleaning element made up of wire mesh coated with an oil film. When air from the atmosphere passes through this element, the dust particles collects on oil film.

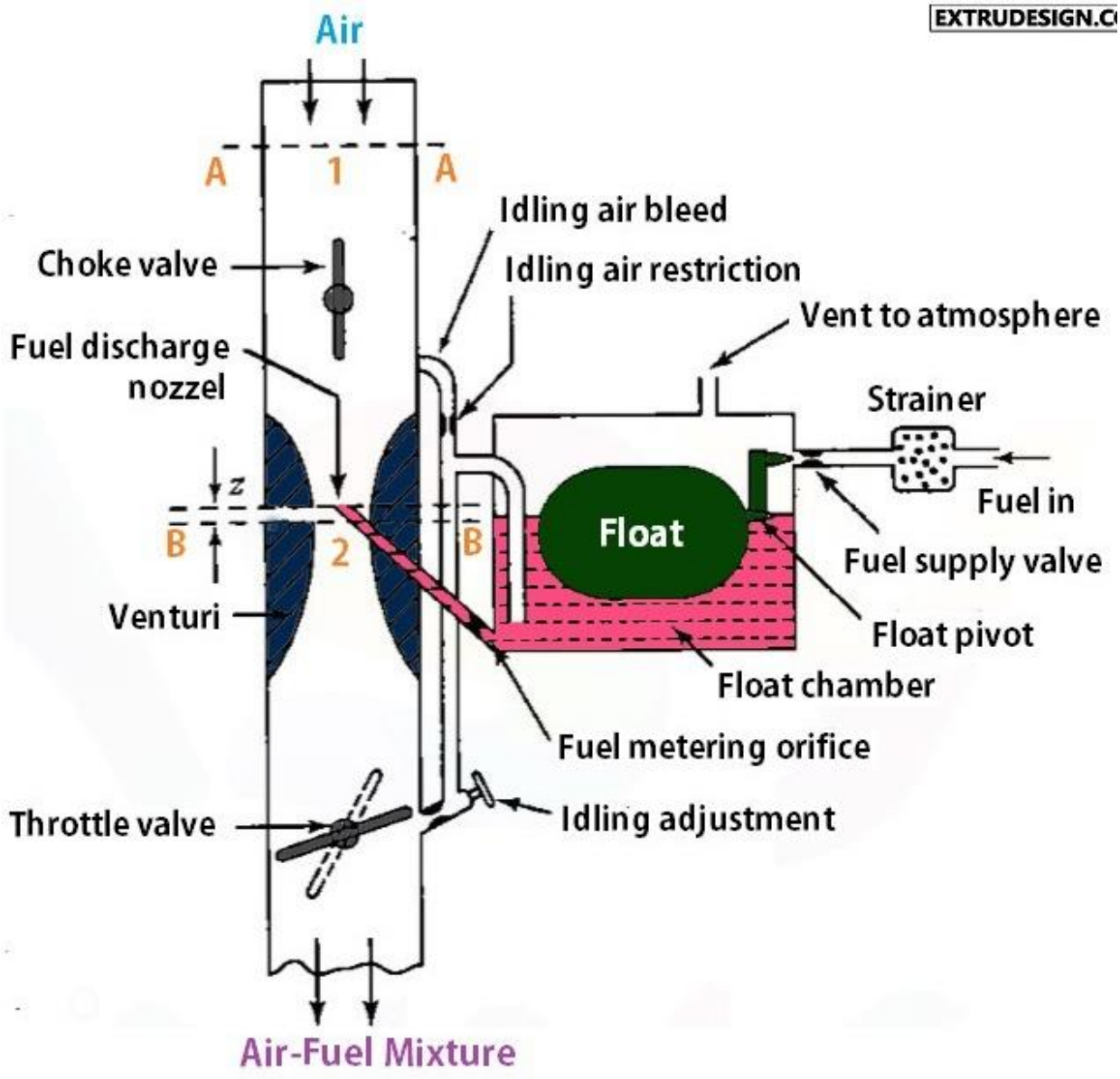


Simple Carburetor:

The process of preparation of a combustible air-fuel mixture by mixing the proper amount of fuel with the air before it goes into the cylinder is called Carburetion.

The simple Carburetor mainly consist of the following components

- Float Chamber
- Fuel discharge nozzle
- Metering orifice
- Venture throttle valve
- choke Valve



Construction

The float attached with a needle is located inside the float chamber and maintains a constant level of petrol inside the float chamber. There is a vent provided for the float chamber to atmosphere/upstream side of venturi to maintain pressure. Venturi tube is decreasing cross-section with a minimum area at the throat. This venturi tube is also known as the choke tube. This tube designed in such a way that it has very least resistance to the air flow. The choke valve is located in the air flow path and the fuel throttle valve is located after the venturi tube in the air flow path. Metering orifice and fuel discharge nozzle are connected to the float chamber to deliver the fuel at the venturi throat to prepare the mixture.

Working Principle of Simple Carburetor

- During the engine suction stroke, the air will be drawn through the venturi tube and the velocity will be gradually increased.
- The air velocity will be maximum at the venturi's throat and the pressure reaches a minimum value.
- The fuel discharge valve will inject the fuel at his position.
- Due to the differential pressure in the float chamber and the venturi throat, the fuel will be automatically discharged into the air stream.
- The air-fuel ratio will depend on the fuel discharge nozzle size.
- To control the fuel amount on to the throat the fuel level in float chamber is maintained slightly below than the fuel discharge nozzle tip height as shown in the above schematic diagram.
- The power output of the engine can be varied by discharging the amount of fuel mixture quantity into the cylinder governed by the throttle valve situated after the venturi tube.

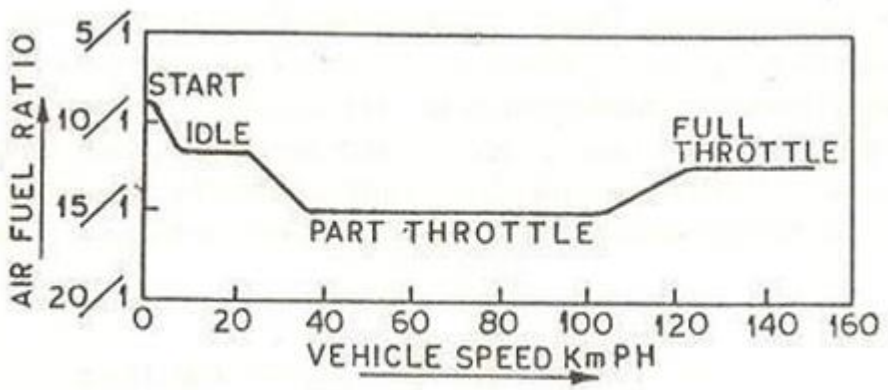
Drawbacks of simple Carburetor

The main functional drawback of the simple Carburetor is that it can only provide one air-fuel ratio at the one throttle position. The other throttle positions give either a lean mixture or richer mixtures.

AIR – FUEL RATIO REQUIREMENTS:

The carburetor must supply the air-fuel mixture of varying proportions to suit the different operating requirements. The mixture must be rich for starting, idling & must be relatively lean for general speed.

The figure shows air fuel ratio at different speeds of vehicle;



Mixture strength requirement.

1) For starting, Air-Fuel ratio is **9: 1**. It is rich mixture.

2) For idling the ratio is **12: 1**, it is comparatively leaner w. r. t. starting mixture.

3) For intermediate speed (35 to 80 km/h), the mixture is further leaner **15: 1**.

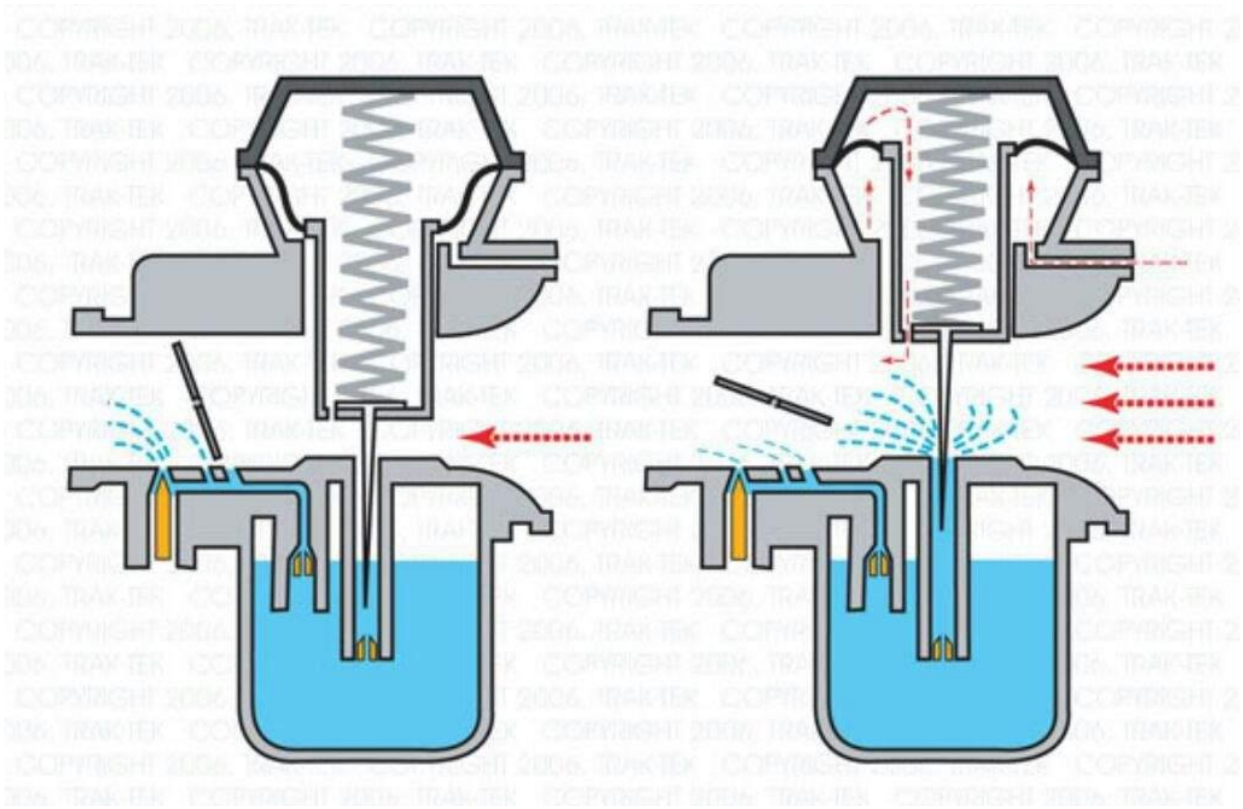
4) But at higher speed (80 to 150 km/h), the throttle valve is completely open, the mixture is enriched to about **13: 1**.

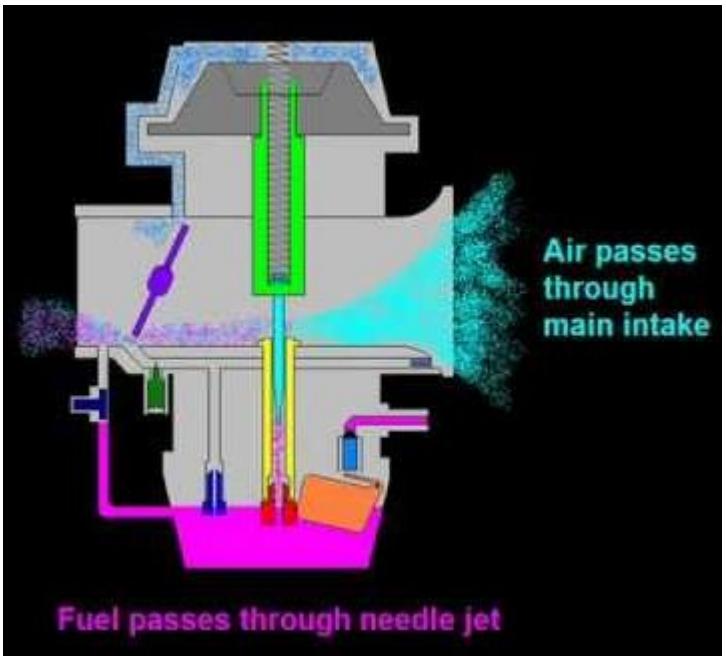
5) **Stoichiometric mixture**: At normal operation, **14.6: 1** i.e.: 14.6 parts of air & 1 part of gasoline (by mass) is the ratio, which would give chemically complete combustion of petrol under ideal condition.

At starting and at idle, the mixture must be rich for initial start, because the engine and the carburetor are cold, the fuel vaporizes very poorly. Thus extra amount of fuel is needed so that enough fuel will be available for vaporization.

At acceleration, sudden opening of the throttle valve occurs, air rushes suddenly. Hence extra fuel must come at the same time. Thus carburetor must be designed to supply correct air – fuel mixture for all the above operating conditions.

CIRCUITS IN TWO WHEELER CARBURETOR





CIRCUITS IN TWO WHEELER CARBURETOR:

STARTING CIRCUIT: An engine requires rich air-fuel mixture during cold starting. With the throttle slide in almost closed position, small amount of air passes through the air jet.

During this condition it is not possible to draw the fuel from the main jet, so during cold starting the driver pulls a choke plunger which uncovers the fuel passage for cold starting.

As the engine is started, engine vacuum is applied to the discharge passage of cold start and fuel is drawn in the mixing chamber to provide a rich air-fuel mixture (about 9:1) to the engine.

IDLING CIRCUIT: During idling conditions, the engine requires rich air-fuel mixture (about 12:1). The throttle slide is almost closed and the amount of air passing across the venturi is in small amount.

The engine vacuum is applied to the idle discharge port. Idle mixture screw controls the quantity of both air and fuel reaching the mixing chamber.

The throttle stop screw and idle mixture adjustment screw provide the required air-fuel mixture to the engine. It provides the necessary idling speed of the engine.

NORMAL SPEED/MAIN CIRCUIT: The normal running circuit of a two wheeler carburetor works in accordance to the opening position of the throttle valve. E.g: (0% open, ¼ open, ¾ open and full open).

During normal running, main jet supplies fuel to the discharge nozzle. Vacuum at the venturi increases with an increase in the throttle opening.

The emulsion tube receives air through the pilot air passage. It ensures that the charge sent to the engine is close to the chemically correct charge. As the engine speed increases more and more holes of the emulsion tube get exposed to air.

The main/normal circuit tends to provide slightly lean mixture at about 50% throttle opening. It results in better fuel economy.

Diesel fuel supply system

Need and requirements of Fuel Injection Systems:

If the engine is to develop full power and operate efficiently, its fuel system must fulfill the following;

1) **METERING:**

The quantity of fuel metered should vary to meet changing speed and load requirements.

2) **TIME:**

The timing of fuel injected into cylinder is very important so that maximum power is obtained ensuring fuel economy and clean burning.

3) **PRESSURE:**

The fuel system must pressurize the fuel to open the injection nozzle i.e.: it must develop sufficient pressure to open the nozzle.

4) **ATOMIZE** (The Breaking- up of fuel into Small particles)**:**

The fuel must be atomized when it is injected into the combustion chamber since atomized fuel will burn easily.

Good spray pattern for rapid mixing of fuel and air.

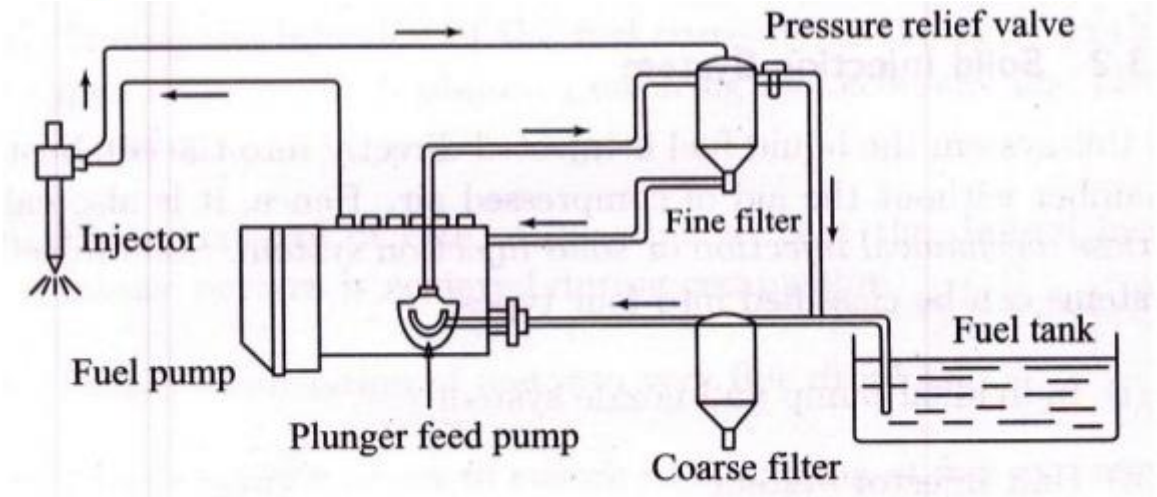
5) **DISTRIBUTE:**

It is closely related to the timing, the distribution of fuel must be accurate & according to the engine firing order.

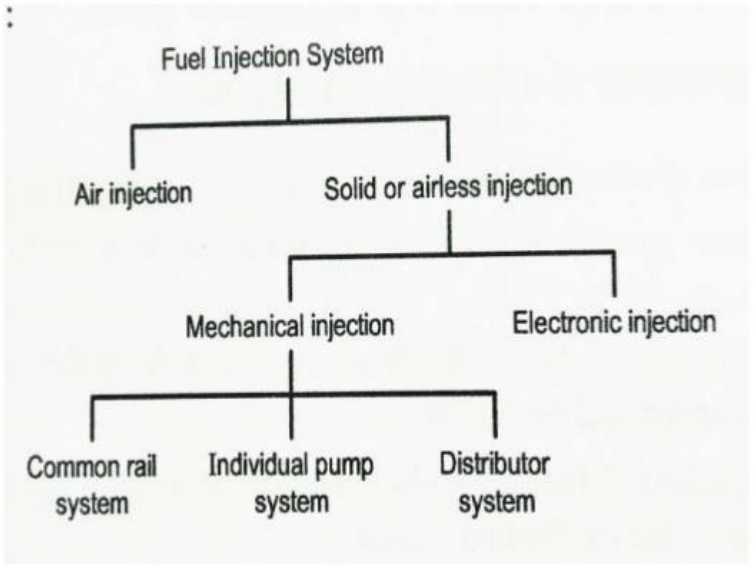
6) **CONTROL, START & STOP INJECTION:**

- Injection of fuel must start quickly & end quickly.
- No lag during beginning and end of injection i.e., to eliminate dribbling of fuel droplets into the cylinder.

A typical arrangement of various components for CI engine is shown

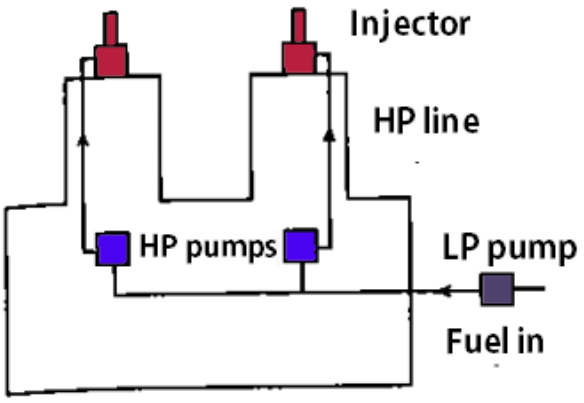


Fuel injection system for diesel engine

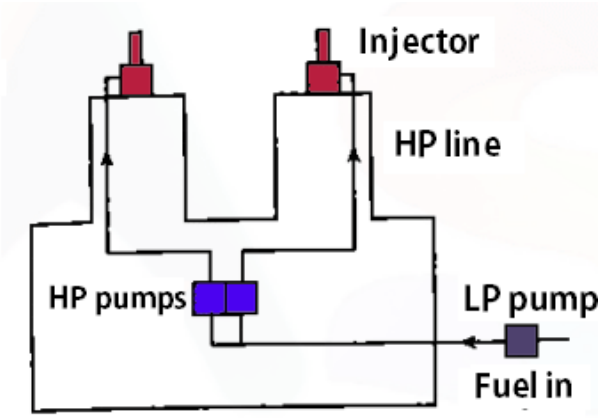


Individual Pump and Nozzle System

- In this system, each cylinder is provided with one pump and one injector.
- This type differs from the unit injector in that the pump and injector are separated from each other, i.e., the injector is located on the cylinder, while the pump is placed on the side of the engine.
- Each pump may be placed close to the cylinder, or may be arranged in a cluster.
- The high-pressure pump plunger is actuated by a cam, and produces the fuel pressure necessary to open the injector valve at the correct time.
- The quantity of fuel injected is again controlled by the effective stroke of the plunger

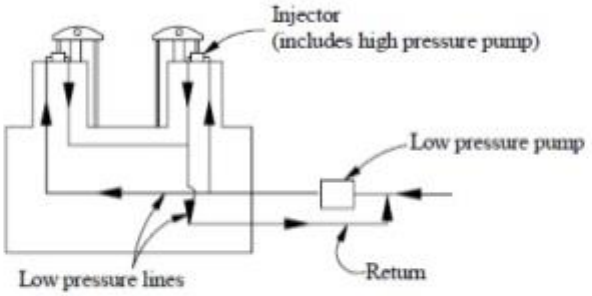


(a)



(b)

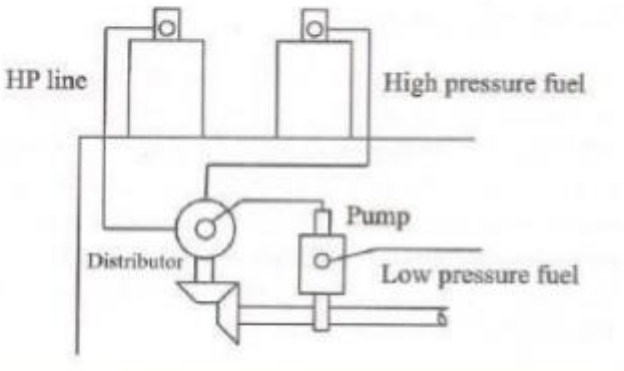
Unit Injection System



(b)

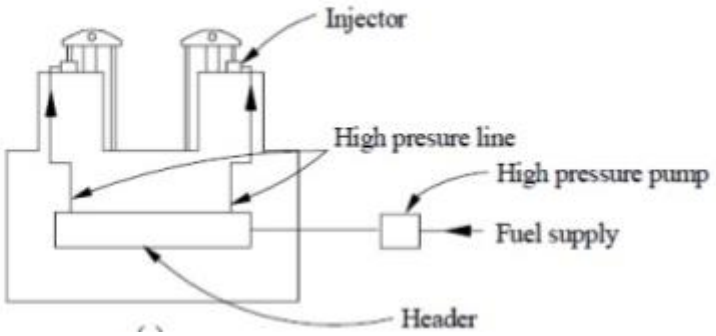
Here, the pump and nozzle are combined in one housing. Each cylinder is provided with one of these unit injectors. Fuel is brought up to the injector by a low-pressure pump, where at the proper time, a rocker arm activates the plunger and thus injects the fuel into the cylinder. The quantity of fuel injected is controlled by the effective stroke of the plunger.

Distributor System

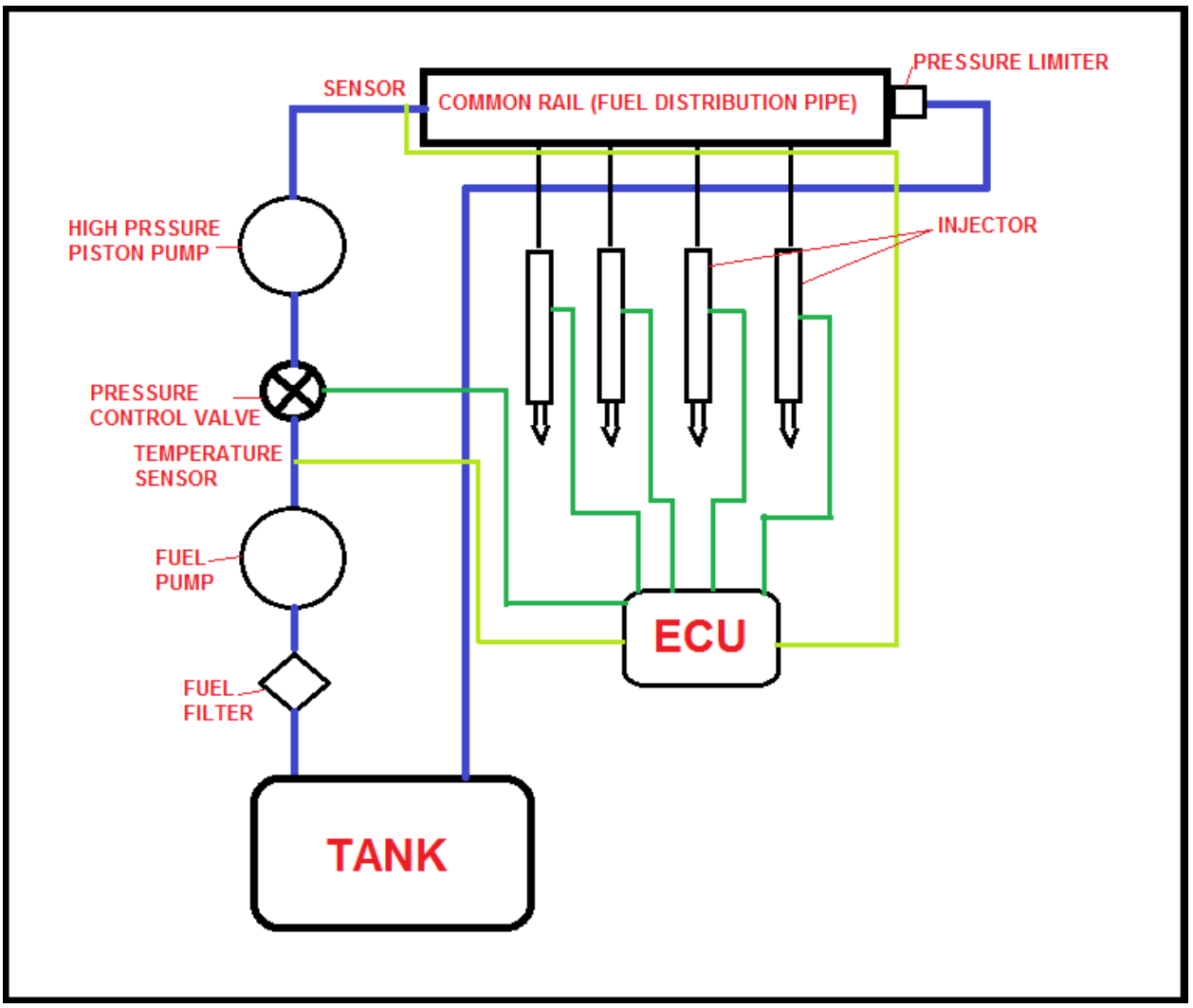


Here, the pump which pressurizes the fuel also meters and times it. The fuel pump after metering the required quantity of fuel supplies it to a rotating distributor at the correct time for supply to each cylinder. Since there is one metering element in each pump, a uniform distribution is ensured.

Common Rail System



In this system, a high-pressure pump supplies fuel to a fuel header as shown. The high-pressure in the header forces the fuel to each of the nozzles located in the cylinders. At the proper time, a mechanically operated (by means of push rod and rocker arm) valve allows the fuel to enter the cylinder through nozzle.



Fuel Injector and types of nozzles.

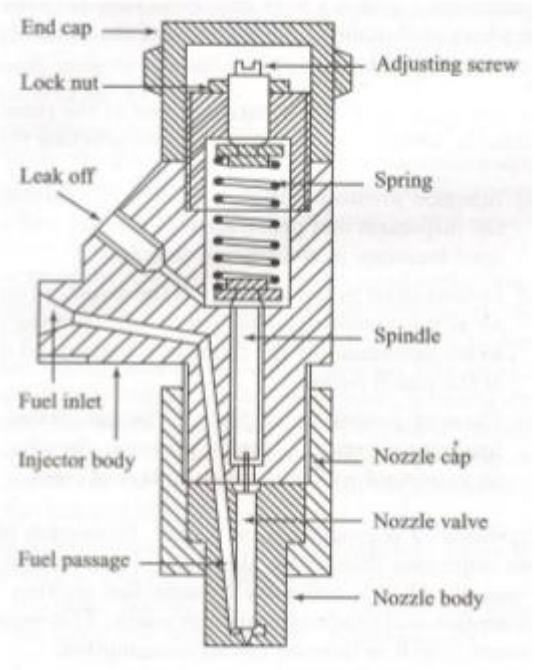
Function: Its function is to inject fuel in the cylinder, in properly atomized form & in proper quantity.

Construction & Working:

The construction & working features of fuel injector are as follows;

The injector assembly consists of:

i) A nozzle/needle valve
ii) A compression spring
iii) A nozzle
iv) An injector body



1) A spring loaded spindle in the nozzle holder keeps the nozzle valve pressed against its seat in the nozzle body, till the fuel supplied by FIP through inlet passage exerts sufficient pressure, so as to lift the nozzle valve against the spring force. Thus a spray of atomized fuel is fed into the combustion chamber.

2) The fuel spray continuous till the delivery from injection pump is exhausted. Later the spring pressure again suddenly closes the nozzle back on its seat.

3) A small quantity of fuel is purposely allowed to leak between nozzle valve & its guide for lubrication purpose.

4) The fuel accumulated around spindle is drained back to the fuel tank through the leak off connection.

5) An adjusting screw provided at the top serves to adjust the tension in the spring. With the help of this adjusting screw we can set the pressure at which the nozzle valve opens.

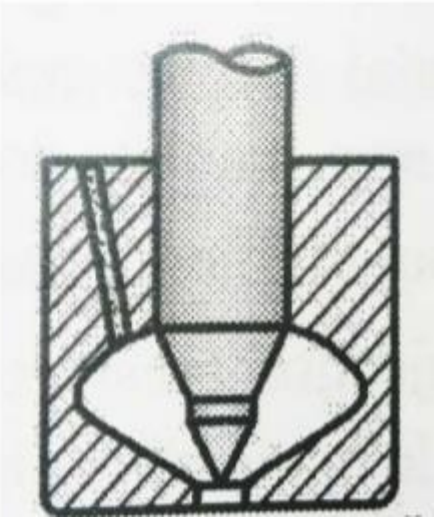
Nozzle

- The nozzle sprays the liquid fuel. The functions of the nozzle are: (a) atomization, (b) distribution of fuel to the required area, (c) non-impingement on the walls, and (d) no dribbling.

Single hole nozzle

Specifications

I. A single hole is bored at bottom tip of nozzle.
II. Hole diameter is of 0.2 mm.
III. Spray cone angle obtained ranges from 5-20 degrees.



Advantages

I. Suitable for open combustion chamber

Disadvantages

I. Gives small spray cone angle.
II. Have a tendency to dribble.

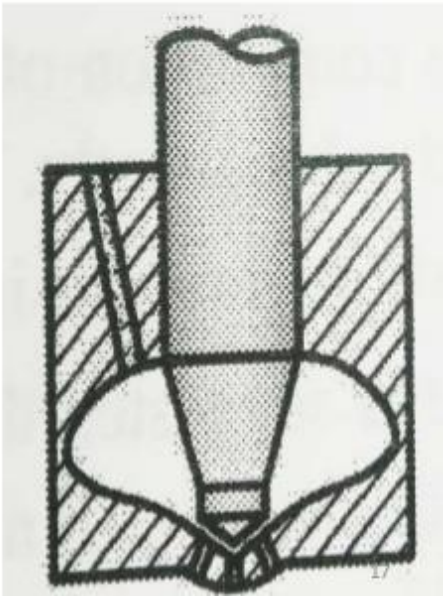
Multiple hole Nozzle

Specifications

I. Have multiple holes bored at the tip of the nozzle.

II. Number of holes vary from 4 to 8.

III. Diameter vary from 0.2 mm to 0.35 mm.



Advantages

I. It ensures proper mixing of fuel in the chamber.

Disadvantages

I. It requires high injection pressures in the range of 180 to 200 bar.

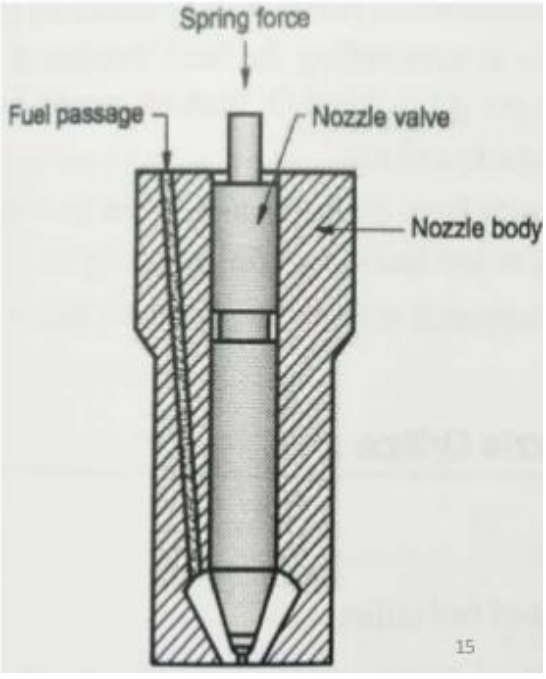
Pintle Nozzle

Specifications:

I. Have thin ends in the form of pin.

II. Shape of the pin can be varied.

III. Hollow cylindrical jet or a wide angle spray can be obtained.



Advantages

I. It avoids dribbling of fuel in the combustion chamber

Pintaux Nozzle

Specifications

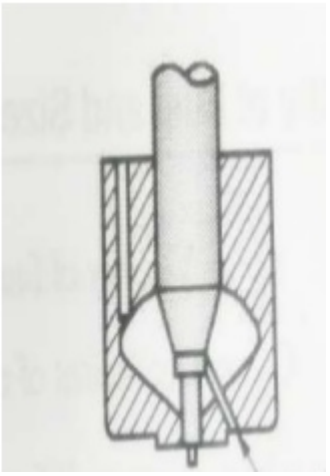
I. Pintle type of nozzle with an auxiliary hole drilled in it.

II. Auxiliary hole injects fuel in a direction upstream the direction of air before the main injection starts.

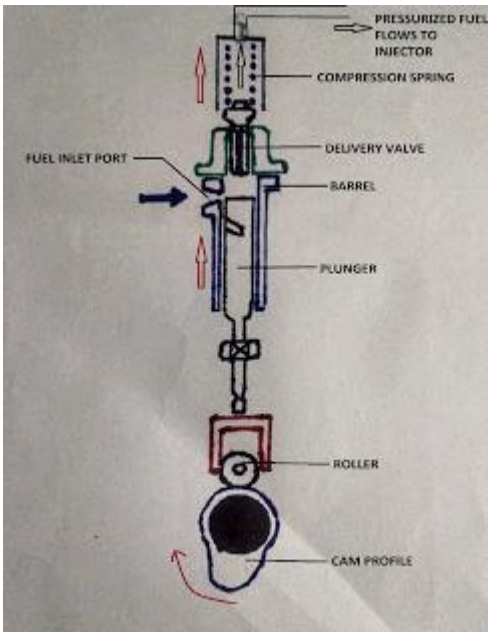
Advantages

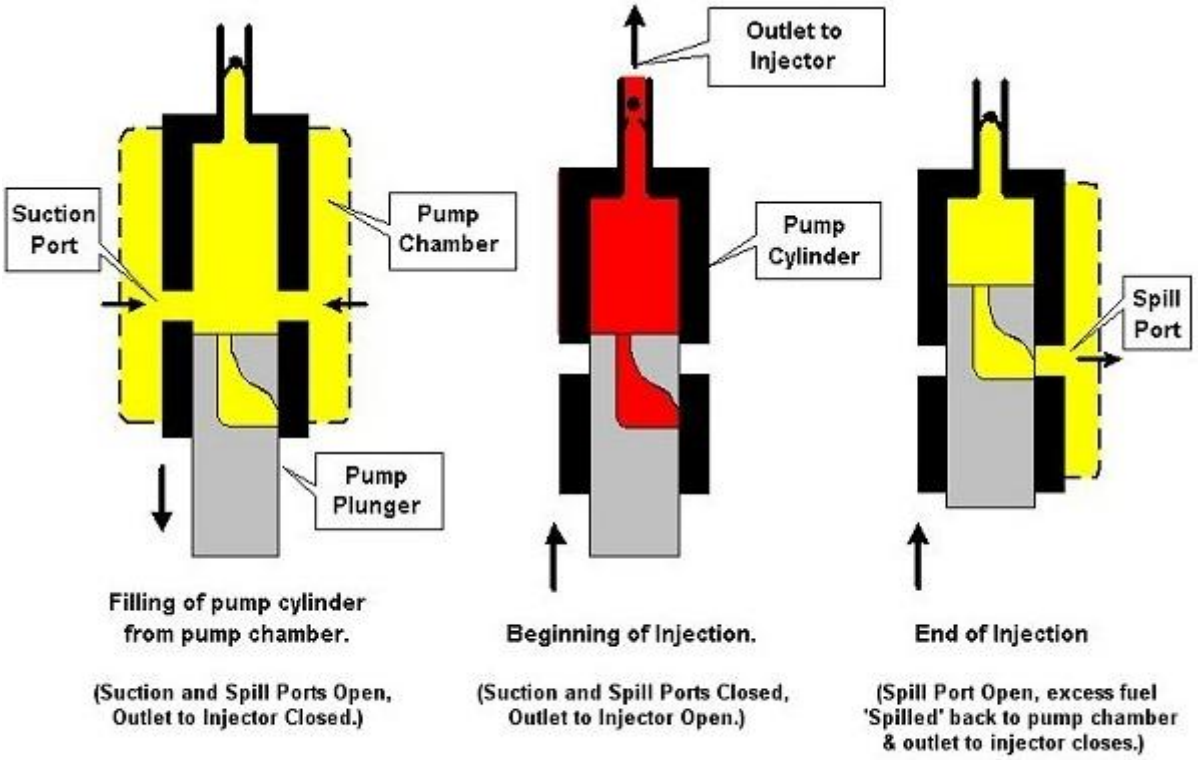
I. It reduces the delay period due to better heat transfer between fuel & air.

II. It results into better cold starting performance.



FUEL INJECTION PUMPS: (IN-LINE OR JERK TYPE PUMP)





Operation of a plunger pump showing the spill method of delivery volume control.

- It is an aluminum housing which has an internal camshaft. The camshaft is driven via a timing device or directly by the engine. The in-line pump camshaft rotates at the same speed as that of the engine camshaft (i.e) speed of camshaft is half the speed of the crankshaft.
- Roller tappets sit over the cam lobes. The number of roller tappets equals the number of cylinders. Above each roller tappet, plunger return springs are placed to assist the plungers in returning to the bottom dead centre (BDC) after each stroke. The plunger is guided inside a barrel where the fuel is pressurized. Plunger has a vertical groove and a helical groove that assist in varying the fuel quantity. The plunger and barrel together are called plunger and barrel assembly.
- Delivery valves are seated between the barrel-and-plunger assembly and the delivery valve holder. In the event of delivery stroke, delivery valve cone is lifted from the valve seat due to the high pressure created in the barrel. The delivery valve cone is pressed against the spring provided in the delivery valve holder. The fuel escapes through the holder to the nozzle via a fuel delivery line.

ROTARY OR DISTRIBUTOR TYPE PUMP:

The construction & working feature of Rotary type pump is discussed below;

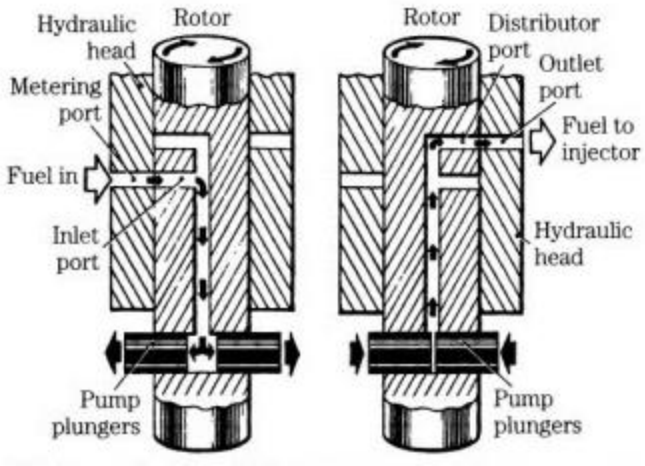
The **construction features** of rotary pump are discussed below;

1) It consists of a single pumping element. In this pump fuel is distributed to each cylinder by means of a rotor.
2) The rotor has a central longitudinal passage & a set of radial holes, called ports.
3) **Suction ports** are equal to the number of engine cylinders; they are at the level A inside the rotor.
4) Similarly outer sleeve has equal number of holes (**Delivery ports**), at a different level B.
5) Delivery port is connected to the high pressure delivery lines leading to injectors.
6) There is a **Metering port** in the sleeve for fuel intake at level A.
7) A **Distributor port** is in the rotor at level B, it is connected to central passage in the rotor.

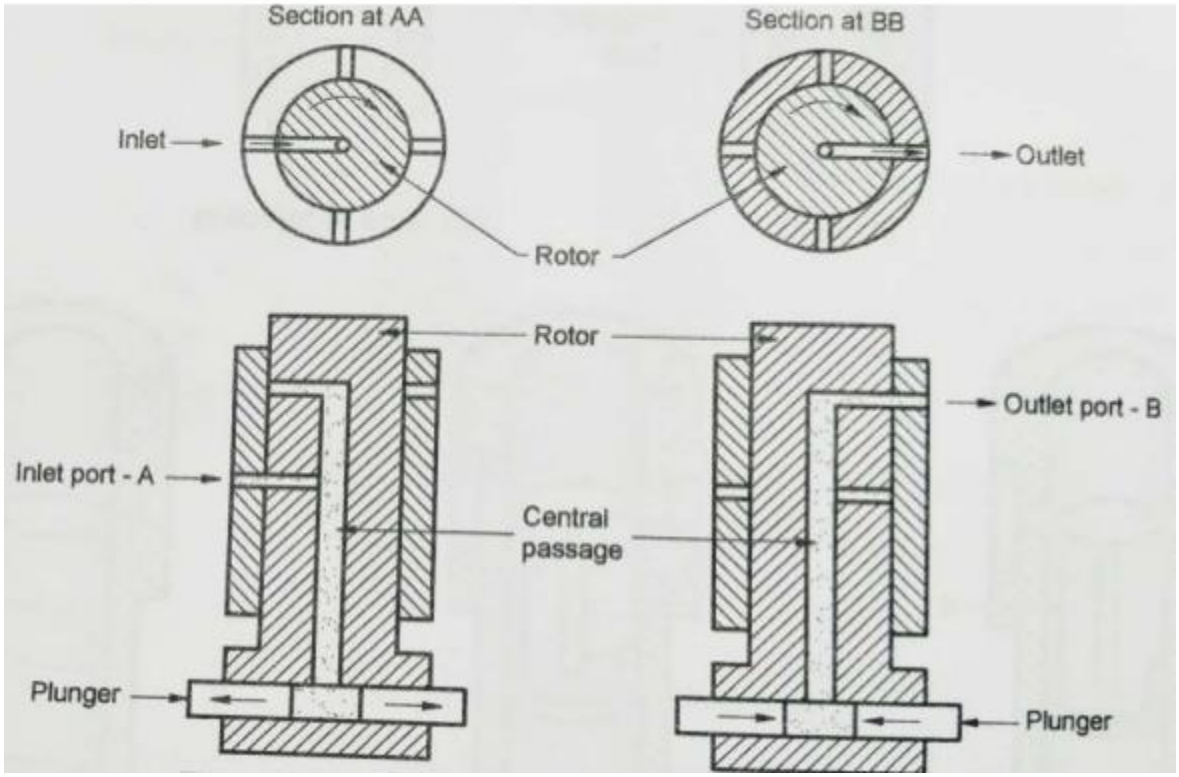
The **working** of Rotary type FIP is discussed below

1) As the rotor rotates, the Suction ports align with the intake Metering port & the Fuel is sucked in the rotor.
2) Later the Distribution port aligns with the delivery ports, to deliver the fuel.
3) At the lower end of the rotor, there are 2 opposed plungers.
4) As the rotor rotates inside a stationary ring with internal cams. These cams operate the plunger & the plungers push the fuel to Delivery port.
5) As the plungers move away from each other, the fuel is drawn into central rotor passage through Suction ports.

This process keeps on repeating itself. The fuel is delivered to each cylinder at high pressure.



Distributor Type Fuel Pump



GOVERNORS IN FUEL INJECTION PUMPS:

Necessity:

In petrol engines, the carburetor controls both air and fuel delivery at various speed and load conditions. However, in diesel engines, governor is the device used to control the engine speed. Governor regulates the engine speed by varying the fuel flow as per the load conditions.

Engine speed tends to overshoot to hazardous values on reduction of load and also to very low speed (almost on the stage of engine halt) on increase in sudden and unexpected load application.

To avoid such conditions, the engine speed is controlled by regulating the fuel supply by using engine governor.

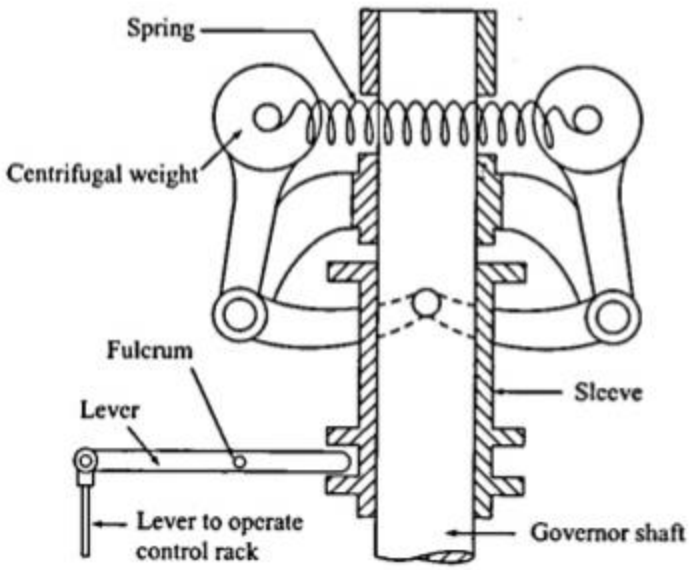
All injection pumps operate in conjunction with the governor. Generally, when the engine speed increases, the air intake decreases and hence results in more injection of fuel. On the other hand, at idling speed (no load conditions) or when the engine speed is relatively low, the fuel supply is also minimum. A governor is, therefore, a necessity to control the fuel injected to ensure optimum conditions at all speeds and loads within the range specified. A governor capable of holding any speed between idling and maximum speed is called variable speed governor.

Governors are generally of two types:

1. Mechanical Governor
2. Pneumatic Governor

Mechanical Governor:

The working principle of mechanical governor is illustrated in figure. When the engine speed tends to exceed the limit the weights fly apart. This causes the bell crank levers to raise the sleeve and operate the control lever in downward direction. This actuates the control rack on the fuel-injection pump in a direction which reduces the amount of fuel delivered. Lesser fuel causes the engine speed to decrease. The reverse happens when engine speed tends to decrease.


Spring
Centrifugal weight
Fulcrum
Lever
Sleeve
Lever to operate
control rack
Governor shaft