Unit 9 Fuel Supply System

Contents

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Learning Objectives

- To learn the process of fuel filling in self-propelled vehicles.
- To learn about important components like carburettor, pump, etc.

9.0 INTRODUCTION

In this chapter we study about the Fuel injection system (types, parts)-Air fuel ratio-Carburettor- types (simple, solex) and Types of Diesel engines pump, Types of Governors, Advance mechanisms, Reasons for knocking (measures to control knocking), Injector and Different types of fuel supply system i.e DTSI, CCTI, VT, PGMFI, MPFI. Fig 9.0 shows the general layout of Fuel Supply System.

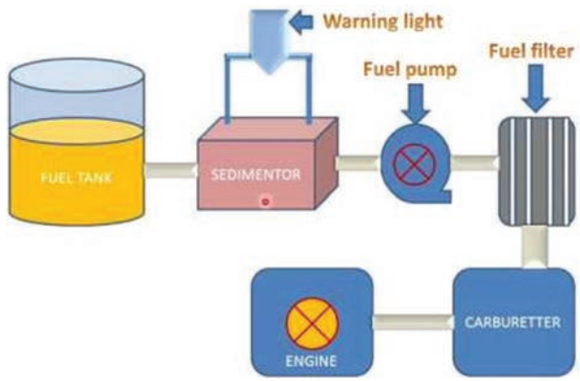


Figure 9.0 Fuel Supply System

9.1 FUEL SUPPLY SYSTEM IN PETROL ENGINE

The petrol from the petrol tank and the air from the air filter is mixed completely in correct ratio in order to make the fuel burn completely (stoichiometric air fuel ratio). The mixed fuel is sent in to the engine cylinder continuously according to the speed, load and torque of the engine in exact pressure. Fig 9.0 shows the general layout of Fuel Supply System in Petrol Engine.

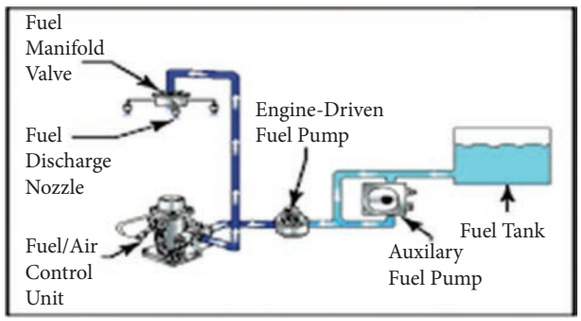


Figure 9.1 Fuel Supply System in Petrol Engine

9.2 TYPES OF FUEL SUPPLY SYSTEM

1. Gravity system
2. Vacuum feed system
3. Pump system
4. Injection system

9.2.1 Gravity System

In this method the petrol tank is kept just above the engine setup. So that the petrol in the tank reaches the Carburettor due to the gravity force. The air from the air filter and the petrol from the tank mixes and supplied in to the inlet manifold of the engine. This methods are commonly used in two wheelers like moped, scooter and motorcycles. This method can't be used in multi cylinder and heavy duty engines because as it has to be placed near the

fuel tank there is the possibility of catching fire. Fig 9.2.1 shows the Gravity System.

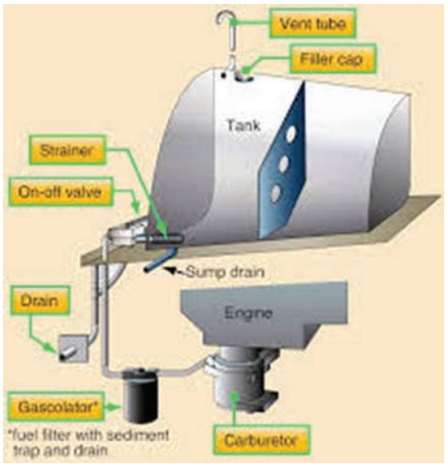


Figure 9.2.1 Gravity System

9.2.2 Vacuum Feed System

This method is actuated by the Vacuum in the engine. The vacuum created in the inlet manifold sucks the petrol from the tank and saved in the small substitute tank from there it is sent to the Carburettor by gravity method. But this method is not used in engine now a days.

9.2.3 Pump System

In this method the petrol from the tank is pumped by a pump. The pump may be mechanically or electrically actuated. In this method the tank can be fixed at any place in the engine and the pump can pump the fuel from the tank. So it is not necessary that the engine should be placed below the petrol tank as in the two former methods. The fuel can be supplied continuously even in any level. There is no chance of catching fire. So that all the vehicle now a days use this method only.

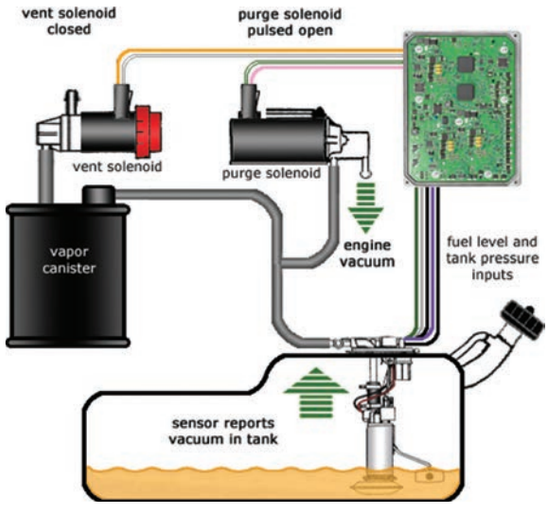
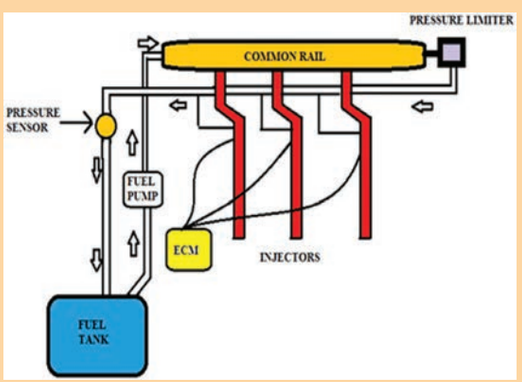


Figure 9.2.3 Pump system

What is Direct injection system?

- In a direct injection engine, the fuel skips the waiting period it would have to endure inside a standard engine and proceeds straight to the combustion chamber.
- It was used mainly during World War II in aero-engines such as the Junkers Jumo 210, the Daimler-Benz DB 601 and BMW 801.
- With gasoline engine it needs fuel, air (oxygen) and spark in order to operate.



9.2.4 Injection System

In this method the atomized fuel(petrol) is injected into the compressed air. So it is called as injection type. The diesel injectors are being done in this method only. Any how technology development in new vehicles as like diesel engine, the petrol is being injected in the petrol engine with the help of electronic circuits. Fig 9.2.4 shows the Injection System.

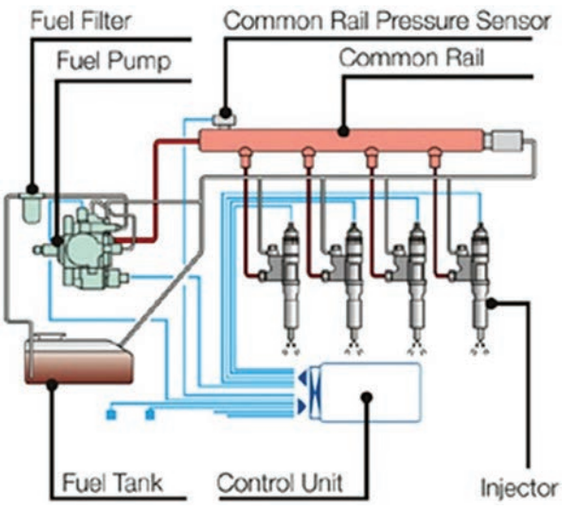


Figure 9.2.4 Injection system

9.3 FUEL SUPPLY SYSTEM COMPONENTS (PETROL ENGINE)

Now a days pump system only used in petrol engine. So the components used for that system can be clearly explained as follows,

1. Petrol Tank
2. Fuel Petrol Filter
3. Air Filter
4. Fuel Petrol Pump
5. Carburettor
6. Fuel Gauge
7. Inlet Manifold

Petrol Tank

Petrol Filter

Air Filter

A.C. Mechanical Fuel Pump

Carburettor

Fuel Gauge

Inlet Manifold

Figure 9.3 Components of Fuel Supply System

In the above said components petrol tank, petrol filter, air filter and inlet manifold are clearly explained in earlier chapter. So that petrol pump, Carburettor, fuel gauge can be seen clearly.

DO YOU KNOW? Carburettor?

- The first carburettor was invented by Samuel Morey in 1826.
- A carburettor meters out and mixes fuel with air for a proper combustible mixture.
- carburettors last longer than fuel injection systems and are favoured in motor sports.

9.3.1 Fuel Petrol Pump

The work of the petrol pump is to suck the petrol from the petrol tank with pressure and send it to Carburettor. Generally by the way of working it can be classified in to the types. They are,

1. AC mechanical petrol pump
2. SU Electrical petrol pump

9.3.1.1 AC mechanical petrol pump

The power required to drive the pump is taken from the eccentric in the cam shaft. So it is placed near cam shaft in cylinder block. When the engine starts the crank shaft starts to rotate. The cam shaft is actuated by the timing gear connected to it. The eccentric in the cam shaft operates the rocker arm in the pump. As the rocker arm moves upwards the diaphragm to it pushes the pull rod downwards. At that time the Vacuum is created in the pump chamber and the inlet value is being opened as a result. By which the petrol is being sucked in at this time the outlet valve is at clocked stage.

As the cam shaft further rotates the rocker arm is released from the eccentric pressure. So that with the help of the spring the pull rod moves the diaphragm to older stage. As a result the petrol in the pump chamber pressed out of the outlet valve and reaches floating chamber.

When the float chamber in the carburettor is filled with petrol, the needle valve closes the inlet path. So that the petrol can't come out of the outlet valve. So that the pressure is raised inside the pump chamber and the pressure makes the diaphragm and pull rod to stay down itself. At that time even the pull rod won't be actuated as a result the petrol won't come out of petrol chamber.

By this condition, the engine continuous to rotate the petrol is being supplied so that the petrol in the float chamber gets reduced and the needle valve is being opened, which makes the fuel to come out from the tank. So that the pressure in the pump gets reduced and starts to work as earlier. So that all operating conditions of engine the pump works smoothly

and supplies needed fuel. The petrol pressure exerted from the mechanical type is directly proportional to the spring in the diaphragm.

Usually in the mechanical petrol pump the pressure in the petrol depends on the tension in the spring of the diaphragm. Generally the pressure of the petrol coming out from the petrol will be in the range of 1 kg/cm^2. Fig 9.3.1.1 shows the diagram of A.C. Mechanical Fuel Pump.

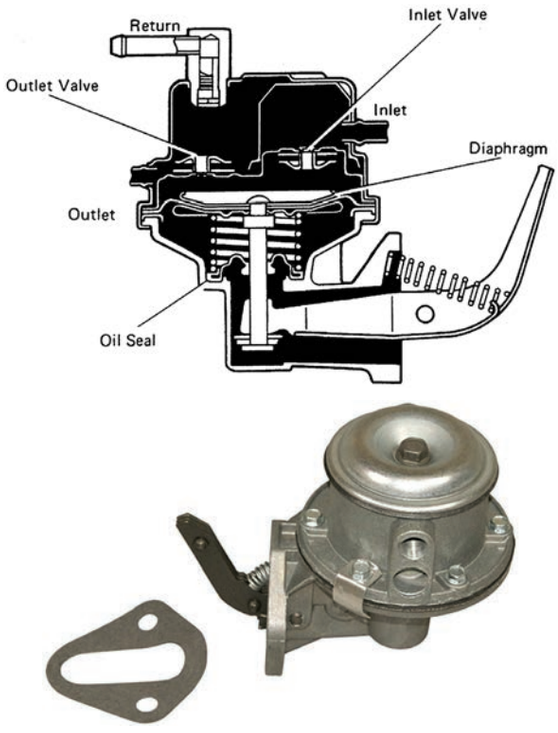


Figure 9.3.1.1 AC Mechanical Petrol Pump

9.3.1.2 SU Electrical fuel pump

As like the AC mechanical petrol pump SU electrical petrol pump also will be actuated by the diaphragm action. But in this pump, electricity is used to move the diaphragm up and down instead of eccentric. When the driver switch ON the ignition, the electricity is passed from the battery to the solenoid winding due to that the solenoid windings get demagnetised. Due to which the armature in the diaphragm moves upward. So that Vacuum is being created in pump chamber, by that time the suction valve gets opened and petrol sucked inside. At this stage, the armature moves upwards and the breaker point moves away and the electricity is disconnected. Then, by the spring action the diaphragm moves to the original position due to which the petrol in the pump chamber comes out by outlet valve and reaches float chamber in carburettor. If the fuel in the float chamber is full then the needle valve closes the inlet valve due to this the high pressure in pump chamber the spring restrict the action of diaphragm. When the level of fuel in the float chamber is reduced the needle valve gets opened and fuel (petrol) from the pump gets in as before. Fig 9.3.1.2 shows the diagram of S.U. Electrical Fuel Pump.

Figure 9.3.1.2 SU Electrical Fuel Pump

9.4 AIR FUEL RATIO (AFR)

For the various load and speed of the engine, the air and fuel should be mixed and supplied in the required manner with

the help of the carburettor and sent into the engine. The air-fuel ratio won't be same for all the time. It should be varied in different ratio according to the needs. For example (i)starting, (ii)slow speed, (iii)idling, (iv) ordinary speed, (v)high speed, (vi)cold or hot climate starting engine are the conditions at which the air-fuel ratio is to be varied and can be varied by three stages. Namely,

- Rich mixture
- Chemically correct (or) stoichiometric mixture
- Lean mixture

9.4.1 Rich Mixture

To burn 1 kg of fuel petrol completely, nearly 15 kg of air is being supplied. If the fuel in the air-fuel mixture is 1kg and air is 15kg it is said to be rich mixture.

Example, 10:1 (10 % air and 1 % fuel). Form the example, the mixture has high burning capacity. At the below given conditions the engine needs rich mixture.

- During starting (A:F = 5:1)
- Idling (A:F=10:1)
- While overtaking (A:F =12:1)

9.4.2 Chemically Correct (or) Stoichiometric Mixture

In the air-fuel mixture if the air is more and petrol is less, then it is called Chemically correct (or) stoichiometric mixture.

Example, 16:1 (16 % of air and 1% of fuel)

In normal and ordinary speed the engine is being operated at normal mixture.

9.4.3 Lean Mixture

If the fuel exceeds beyond the stoichiometric limit, then it is called lean mixture. Example: (18:1). The vehicle will operates at lean mixture in case of low load and high speed.

9.5 CARBURETTOR

The carburettor is the important component in the petrol engine. It makes the liquid form of petrol in to vapour form and mixes it with required amount of air and sends into the cylinder. It also atomises the fuel for easy mixing with air. This process is called carburetion.

9.5.1 Function of Carburettor

1. It stores the required amount of petrol in the float chamber
2. It vaporizes the fuel and mixes with air
3. Carburetion is done as per engine load and speed
4. Rich mixture is supplied to engine during starting and high speed conditions
5. When the engine is at idling stage it mixes less amount of fuel to the air and sends to the engine
6. According to the load and speed of the engine the air-fuel mixture is sent to the engine.

9.5.2 Requirements of Carburettor

1. For the required engine and load the air-fuel mixture should be mixed correctly and sent it to the engine cylinder.
2. During cooling and heating conditions, carburettor should able to start the engine easily.

3. It should not affect the fuel economy
4. Screw arrangement should be made properly for the various speed and load of the engine

9.5.3 Types of Carburettor

Carburettor can be classified as follows

9.5.3.1 Down draught carburettor

(I) In this type of carburettor the air would come from induction manifold to downward direction due to gravitational force. It will be placed above the induction manifold. Most of the vehicles use the down draught type carburettor. The fig 9.5.3 shows the down draught carburettor.

9.5.3.2 Up draught carburettor

In this type, air-fuel mixture goes from bottom to top of the induction manifold. The fig 9.5.3 shows the up draught carburettor.

9.5.3.3 Side draught carburettor

In this type, air-fuel mixture goes from one side to another side way. This is placed side of the induction manifold. Figure 9.5.3 shows various types of Carburettor.

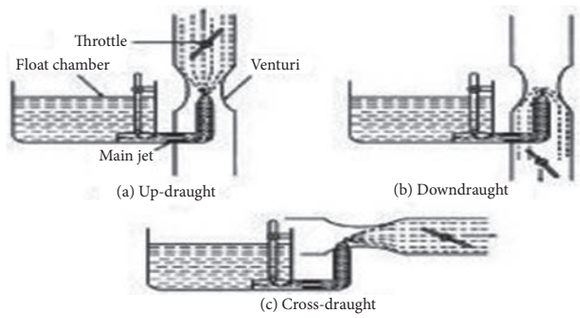


Figure 9.5.3 Various Types of Carburettor

Semi down draught carburettor:

This type of carburettor is the combination of down draught and side draught carburettor .in this type petrol-air mixture will be slightly slanting position.

(II) According to working of carburettor,

a) Constant choke carburettor:

In this type by keeping the area of the orifice constant and changing the pressure using venturi, carter, solex and zenith are the types coming under constant choke carburettor

b) Constant Vacuum carburettor:

By changing the area of orifice and keeping pressure as constant. This type of carburettor is called constant Vacuum carburettor comes under this type.

(III) According to number of barrel,

1. Single barrel carburettor:

Generally in four cylinder engines single barrel carburettor is being used. it contains only one barrel along with fuel jet, venturi, choke valve and the throttle valve.

2. Dual or multi barrel carburettor:

In this each barrel has the separate parts that are associated with the system. For each barrels there will be a separate connection to inlet manifold. This type of carburettor mixes the air fuel ratio uniformly.

9.5.4 Simple Carburettor

Without any of the advanced technologies in the system supplies the air

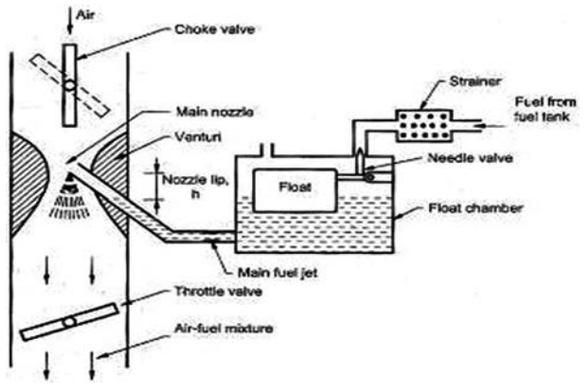


Figure 9.5.4 Simple Carburettor

fuel (petrol) ratio correctly according to the load and speed of the engine in a carburettor works it can be called as simple carburettor. Figure 9.5.4 shows the Simple Carburettor.

The parts of simple carburettor

1) Float chamber
2) venture (or) choke tube
3) main jet
4) choke valve
5) throttle valve

Working:

In float chamber there be a float and a needle valve, usually the float will be thin copper plate or plastic material of less weight and it will be made such that there will be Vacuum inside.

The inlet petrol from the fuel pump will be attached to the top position of the float chamber. So that when the petrol comes into the float chamber when it reaches the certain level the float moves upwards. When the float chamber is full the need valve in the float block the petrol line. Like the same way when the petrol level reaches down the float comes down and allows petrol to come in. so that the level is maintained inside the chamber always.

The level of the petrol in the float chamber will be 5mm less than needle height. So that when the engine at rest and while climbing hills it won't allow petrol to over flow in the mixing chamber.

To control the amount of air fuel mixture from the carburettor to the engine, there will be throttle valve in the carburettor. This valve will be connected to the accelerator cable with suitable arrangements. So that when the driver presses the accelerator pedal the amount of air fuel mixture goes inside the engine accordingly.

During the suction stroke of the engine more air will be sucked inside via air filter. In the air flow passage there will be venture with convergent type. When the air crosses the venture the pressure reduces and speed is increased around the main nozzle. So that when the petrol enters the nozzle with less pressure it can be vaporized easily and mixes with the air. It crosses the throttle valve inlet manifold and inlet valve and reaches the engine cylinder.

In cold climate when engine is started the choke valve is being closed using the choke cable. So that the air flow passage is closed for some time at that time the petrol and less amount of air in the mixing chamber and enters the nozzle as rich mixture. So that it will be easy to start engine as petrol high and less air (rich mixture).

Drawbacks of simple carburettor:

1. Starting difficulty:

To start the engine rich mixture is needed to the engine, but simple carburettor will supply only the lean mixture.

To supply rich mixture we need to use any of the following setup adjustable area jet (or) separate air passage.

2. Idling difficulty:

After the engine starts without the movement of the vehicle the engine alone working is a stage called "idling stage". To maintain the engine at idling stage the suction in the venturi is very less so that it can't take required amount of fuel from the main nozzle. So that there is difficulty to run engine in slow speed.

3. Running difficulty:

When the engine speed is high (or) getting slow, the simple carburettor won't work properly. So to avoid the running difficulty we need to adopt any one of the following methods.

1) Extra air compensation valve
2) Restrict air fuel compensation valve
3) Jet compensation valve
4) Main jet compensation valve.

4. Acceleration difficulty:

When the throttle valve opens suddenly more amount of air is sucked inside, so that there is a delay in petrol supply. So that the lean mixture will be supplied to the engine so the engine struggles at load. To compensate this acceleration pump is being used.

5. Weather difficulty:

If a carburettor is set in hot climate it will give lean mixture during cold climate. In the same way if it is set at cold climate it will give rich mixture during hot climate. To overcome this problem a climatic control device is being installed in advanced carburettors.

6. Icing difficulty:

The venturi part in the carburettor is the place where the petrol gets vaporized. So at that place the cold region is formed by removing hot region. So that at the cold climates and in hill regions the petrol in the carburettor gets freezes. To avoid this idling port and throttle regions of carburettor is heated using exhaust gas, also the hot water from the radiator is poured on to the carburetor which avoids petrol freezing.

7. Altitude difficulty:

At higher altitude regions the pressure will be less which makes air concentration very less. So that will give rich mixture to the engine. Some additional arrangements are made to supply lean mixture to the engine.

9.5.5 Solex Carburettor

To meet the fuel requirments of the different operating conditions of the engine in most of the transportation vehicles like petrol cars the solexcarburator is used. This is one of the down draft type carburetors. With respect to the engines speed and torque the fuel air mixture is prepared by this carburettor and sent through the intake manifold to the

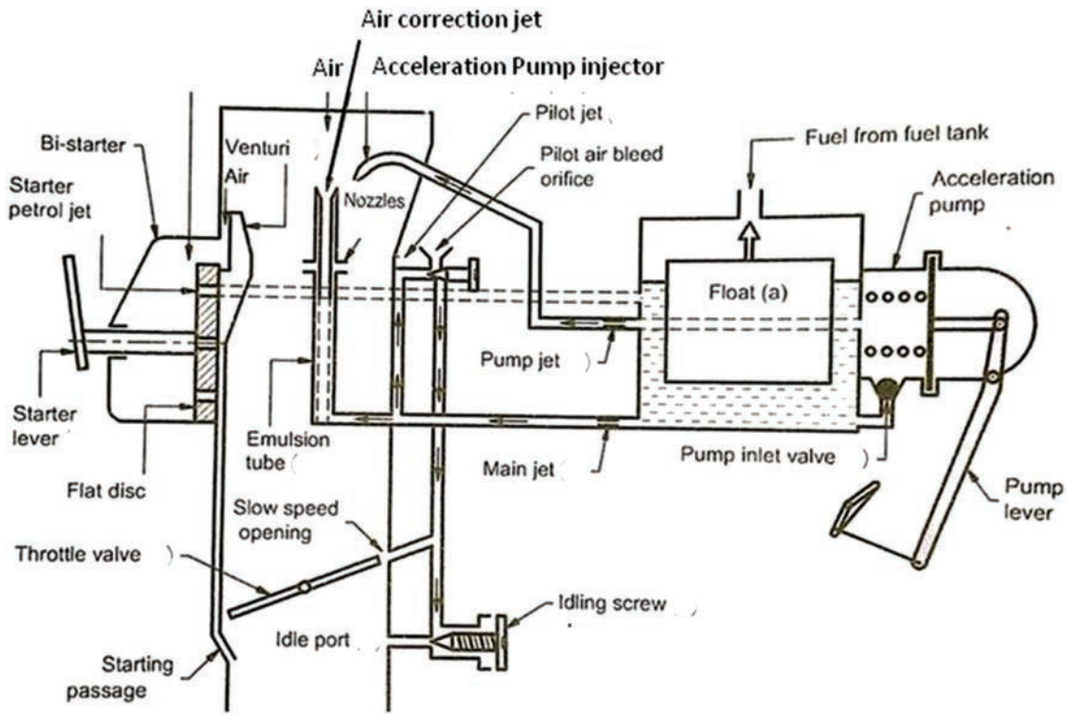


Figure 9.5.5 Schematic view of the Solex Carburettor

engine combustion chamber. The schematic view of the Solex carburettor can be seen in Fig. 9.5.5.

This carburetor has different additional circuits to be present for the complete operation of the engine. The important circuits are

1. Float circuit
2. Starting circuit
3. Idling and low speed circuit
4. Normal running circuit
5. Accelerating pump circuit

1) **Float circuit:** Float circuit is used for balancing or maintaining the fuel level uniformly in the carburetor with the help of needle valve placed above on the float. When the float moves down, the fuel (petrol) from the fuel tank automatically enters into the float chamber. If the petrol fuel level is increased inside the chamber then the float moves upward and the needle valve closes the fuel flow inlet path. By this way the float circuit maintains the petrol fuel level uniformly. Fig 9.5.5(a) shows the float circuit.

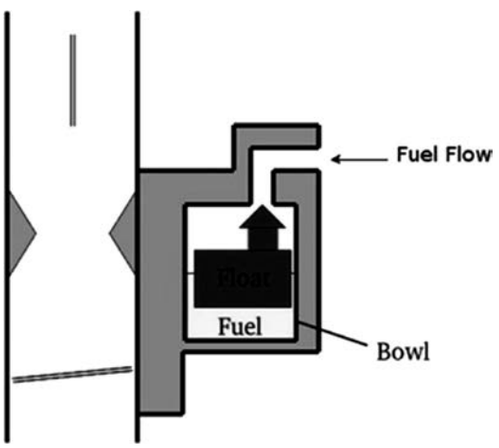


Fig.9.5.5(a) Float Circuit

2) **Starting circuit:** The bi-starter valve adapted in this circuit is actuated by using starter lever. It consists of two different sized holes.

The required amount of rich mixture for starting the engine is given by the starting petrol jet. In the two holes presented in the starter valve one is connected with starter petrol jet and another hole is connected with the starting passage. While starting the engine, for sending rich mixture the bigger size hole in the starter valve is connected to the starting passage. Hence the amount of petrol fuel mixed with the air gets increased and results in formation of rich mixture and enters into the mixing chamber. After the engine is started the starter lever must come to the balanced state. Hence a small hole in the starter valve coupled with the petrol jet is closed and hence the level of petrol fuel is reduced. When the engine comes to its normal operation the startor lever is brought to its off position.

3) **Idling and low speed circuit:** During idling stage the engine will not be accelerated. So the venturi is completely closed by the throttle valve. Hence the vacuum created inside the intake manifold is passed to the idle port located below the throttle valve. Hence the petrol fuel from the idlejet is mixed with air which coming from air jet and finally the mixture is sent to the engine through idle port. Idling and low speed circuit can be seen in Fig 9.5.5(c) Idling and Low Speed Circuit.

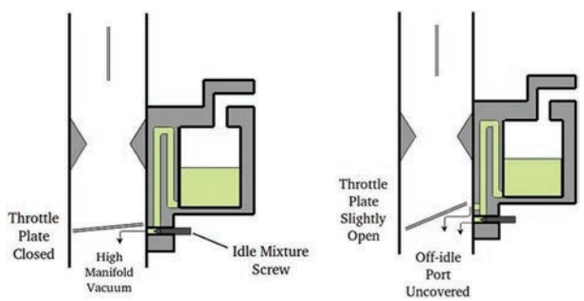


Fig.9.5.5(c) Idling and Low Speed Circuit

When driver accelerates the engine for moving the vehicle, the throttle valve gets opened slightly. Because of the above phenomenon vacuum inside the intake manifold is spreaded in to the idle port and slow speed opening. Hence the fuel coming from the petrol jet and air coming from the air jet are inducted to the engine through slow speed opening and idle port.

4) **Normal running circuit:** For increasing the engine speed driver presses the accelerator, at the time throttle valve gets opened further. Hence the required amount of petrol fuel needed for the engine is comes through the main jet and at the same time maximum amount of air is supplied to the venturi. The air is mixed with the petrol fuel and sent to the engine through the throttle valve.

5) **Acceleration circuit:** If the vehicle is to be accelerated the more fuel must be supplied with rich mixture condition for the engine operation. Acceleration pump in the acceleration circuit is used to perform the above process. Acceleration pump is connected to the accelerator pedal with linkages. The acceleration pump which consists of diaphragm coupled with a spring at one side and linkages on other side which is connected to the accelerator pedal. Petrol fuel is supplied from the float chamber to pump chamber with the help of ordinary pump connected in between the both chambers with pump valve.

By giving sudden acceleration to the accelerator pedal the diaphragm inside the pump will acts against its spring tension.

When the diaphragm is stressed,the more amount of petrol fuel from the tank is injected to the engine through the venturi. When the driver released the accelerator pedal, diaphragm get relived from the stress and comes to its original position. Because of this a vacuum created inside the pump chamber will sucks petrol fuel and sent to the float chamber with help of pump valve. By this way pump get actuated automatically for the next process. Fig 9.5.5(e) shows the Acceleration Circuit

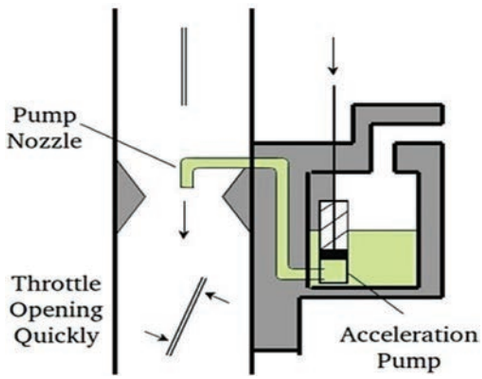


Fig.9.5.5(e) Acceleration Circuit

9.6 PETROL INJECTION

There are some disadvantages faced by sending air fuel mixture with carburation technique in petrol engines. For example, in multi cylinder engines the amount of air fuel mixture was varied from cylinder to cylinder. So at the slow speed engine could not attain steady state condition. Furthermore the energy produced from the each and every cylinder is getting varied. Hence engine vibrates more. So now days in petrol engines also direct injection of petrol is practiced.

Robert Bosch is a German engineer who introduced first time the concept of direct injection of petrol in the Mercedes racing cars. Comparably Petrol injection technique is completely varied from diesel injection. Petrol injection was made near to the intake manifold with minimum pressure in the injector whereas diesel injector operates with high pressure for injection.

9.6.1 Advantages of Petrol Injection technique

1. We can inject uniformly the air-fuel mixture with required amount to the each cylinder in the multi cylinder engine.
2. Increases in volumetric efficiency.
3. It reduces air-fuel mixture escapes from the exhaust during scavenging process.
4. Reduces knocking.
5. For all the speed and torque conditions, uniform amount of air fuel mixture can be supplied.

The following four parts are mainly used in petrol injection technique:

1) Pumping element – used for pumping petrol from tank
2) Metering element – it measures the petrol fuel quantity
3) Mixing element – it atomize the petrol fuel and tend to fine mix with air.
4) Distributing element – supplies petrol fuel to all the cylinders uniformly.

Electronic fuel injection system was established for the proper functioning of the engine. In this technique mechanical injector was replaced with electronic fuel injector with control valve.

The layout of electronic fuel injection system was shown in the fig. 9.6.

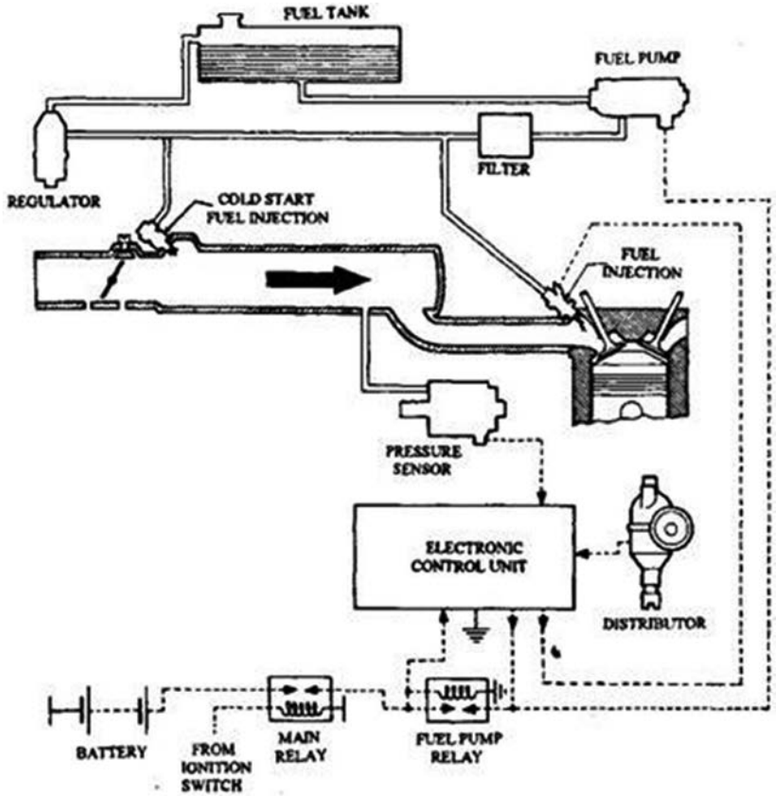


Figure 9.6 Layout of Electronic Fuel Injection System

In this fuel injection system electrically operated control valve with injection pump is introduced. This injection system receives petrol fuel from the fuel tank and injects at high pressure to the engine through metering distributor.

Inside the injector there is a solenoid which is operated under electrical supply with the help of electron control unit. ECU is a preprogrammed control unit with computer.

The injection of petrol fuel timing was given to the injector through the ECU with help of signals from the sensors. Meter valve receives the signal from the sensor and controls the solenoid for injecting petrol fuel in proper ratio in the each cylinder.

The signal quality received from the ECU shows need of some other purpose of the engines behaviour. To determine such behaviours so many sensors are introduced in to the engine. The behaviours are finally converted and send to the ECU. The required sources are air intake temperature, engine load, engine pressure, engine performance, air flow rate, engine coolant temperature, oxygen sensor, etc.,

9.6.2 Types of Petrol Injection

1) Direct injection
2) Single point or throttle body injection
3) Multi point or port injection
4) Timed and continuous fuel injection.

a) Combustion chamber injection (or) direct injection:

It will looks like diesel engine. In this type of injection, it was designed to inject petrol fuel directly to the engine cylinder.

Here petrol fuel air mixture is not sent in to the cylinder through intake manifold and inlet valve. In case of that only air is inducted to cylinder through the intake manifold, whereas petrol fuel was directly injected in to the cylinder. Because of this engine consumes less fuel and produces higher performance. But presently this type of injection system was not in practice, because of some uncontrollable parameters such as exhaust smoke and petrol fuel consumption.

b) Single point or throttle body injection:

In this system injectors are placed at each and every throat in the throttle body. This injector injects and sprays the petrol fuel before the throttle valve in the air. This developed spray of fuel was sent to the intake manifold and mixed with the air. By this way air fuel mixture is sent to the intake port through the inlet manifold. Non-uniform rate of air fuel mixture, vaporization of petrol fuel in the intake manifold, pressure difference inside the manifold are some of the problems involved in this system.

c) Multi –point or port injection:

In this system a separate injector was mounted in to the each and every cylinders intake manifold line. This injector injects and sprays petrol fuel in to the air passage in the intake manifold. This process denotes multi point fuel injection system.

d) Timed and continuous fuel injection:

Injection was depends on timed control it denotes this timed fuel injection. Fuel injection occurs from the injector by fixed timing mode in this system. In continuous injection system fuel injection occurs continuously in to the manifold. The cost and handling in continuous injection system is low and easy compared to timed injection system. In this system more amount of fuel injects in to the intake manifold with low pressure. The injected fuel mixed with the air in the manifold and mixed to form flammable mixture before entering in to the intake port. Now this mixture is ready to inject in to each cylinder. These mixtures get in to the engine by the opening of each and every inlet valve respectively. Inside the cylinder these mixture get mixed more fine for attaining its ignition point. In timed injection system fuel get injected in to the manifold at particular duration given from the timed control unit. In this system by controlling the fuel supply, the consumption of petrol fuel gets controlled. This system looks like diesel injection system used in the diesel engine.

9.7 COMPARISON BETWEEN MPFI AND CARBURETTOR

The working principle of MPFI and Carburettor are mostly same. However, there are several methods are used to identify the amount of air required when sending fuel in to the engine

Carburettor:

When engine is running under idle or slow speed the throttle valve is in closed position, hence the amount of air inducted in to the engine was measured using the pressure difference occurred in the manifold surroundings. During normal running condition the Vacuum created inside the venturi is used to measure the amount of air supplied in to the engine

MPFI:

In this system for injecting fuel we need to measure the amount of air inside the system. Electronic injection system consists of various devices. Air flow meter (sensor) is placed in the system for measuring the amount of air inducted and the signal is sent to the ECU. Then this ECU sends one signal to the injectors. By the method injectors injects fuel in uniform manner with the help of pump in to the each cylinder separately respective to the signal from the ECU.

Types of MPFI System:

Based on the amount of air inducted in to system MPFI classified in to two types

1. D-MPFI (manifold pressure control type)
2. L-MPFI (air flow control type)

D-MPFI

D-MPFI also called as a D-Jetronic. D-Jetronic is a german word comes from a word 'Druck' (pressure). In the type of system air flow rate is measure based on the Vacuum created inside the manifold. D-MPFI is mainly used in the engine which was controlled by the computer control system.

L-MPFI

L-MPPFI also called as L-Jetronics. The word L in the L-Jetronics is comes from the german word called 'Luft'. The meaning for 'Luft' is air. This L-MPFI system is mainly used in the electronic fuel injection (EFI) and Computer controlled system (CCS) adopted engines. In this type of system the air flow rate inside the manifold is measured using sensor called Air flow meter.

Basic parts of MPFI:

The MPFI are consists of three different parts:

1) Electronic Control System
2) Fuel System
3) Air Induction System

(i) MPFI – Electronic Control System

It consists various sensors like Air flow meters, Water temperature sensor, throttle position sensor, Intake Air Temperature sensors etc. The ECU system controls the injection duration of the injectors based on the signals received from the above sensors.

(ii) MPFI – Fuel System

It consists of Fuel Pump, fuel cold start injector, Timing and Injection signal control (ECU). The ECU system controls and defines the amount of fuel to be injected in to the manifold with the help of injector by receiving signals from the sensors.

(iii) MPFI – Air Induction System

It consists of Air cleaner, Air flow meter, Throttle body, Air valve, Air intake chamber, Intake manifold and cylinder. All this devices are used in the system is for supplying exact amount of air required for the complete combustion.

9.8 METHOD OF FUEL SUPPLY (DIESEL ENGINE)

In the present economic condition spending more money for buying fuel for the vehicles becomes a difficult one for the

common people. Hence people prefer low cost fuel for the vehicles. Diesel is a low cost fuel than petrol and it has high thermal energy and pulling power. In this way when diesel is used as fuel the method of supplying the fuel and combusting it becomes different from using petrol in Otto cycle. In the diesel cycle based engines a separate fuel supply system is used for introducing fuel inside the combustion chamber of the engine. The fuel supply system of the diesel engine has the following components.

1. Fuel Tank
2. Primary (course) Fuel Filter
3. Fuel feed pump
4. Secondary (fine) fuel filter
5. Fuel Injection Pump
6. Fuel Injector or Nozzle

In the above components of the fuel supply system the fuel tank, fuel filter, fuel feed pump were already discussed in detail. Hence here the details of types of fuel injection pumps and their arrangements can be seen in detail.

9.9 FUEL INJECTION PUMPS

In any diesel engine for producing required power, specified amount of fuel at the specified pressure and at the specified time must be introduced inside the combustion chamber. The device used for achieving such operation is called as the fuel injection pump. If the fuel is injected in such high pressure inside combustion chamber which has the compressed air at very high temperature then the fuel will get auto ignited and the engine power will increase. The pumps used for such operation are classified into the following types.

1. In line or jerk type Pumps
2. Distributor pumps

9.9.1 Inline (Jerk type) Pump

When the fuel is supplied through the intake manifold by induction like carburetion due to wall wetting effect appropriate fuel will not be supplied to the individual cylinders. Due to this improper distribution of the fuel supply, individual cylinders produce varying power outputs in multi cylinder engines. This distribution of the fuel could be avoided by injecting the fuel by using separate injectors fitted at the individual cylinders of the engine. In multi cylinder engines when the appropriate amount of fuel is injected at the appropriate timings as per the firing order then the power variations can be eliminated. In multi cylinder engines the injectors are mounted at each cylinder of the engine and arranged in line and operated by individual injection pumps which are operated by a common cam shaft. These types of pumps are called as in line pumps. The injection pressure in such pumps can be increased from 7 Mpa (mega pascal) to 30 Mpa. In a diesel engine operating at 6000 rpm with 150 mm^3 quantity of the fuel will be injected 20 times. The In line pumps can be also called as jerk pumps.

Construction:

In an in line diesel pump plunger, barrel and delivery unit are the important components present. The plunger is kept inside the barrel in correct fit and allowed to move inside the plunger barrel up and down. Tooth quadrant provided on the barrel

unit helps to operate the accelerator rod front and back. This arrangement is made in the fuel injection pump by using a spring arrangement. The cam shaft is present at the bottom of the fuel injection pump. When the cam shaft rotates the cam present in the shaft lifts the plunger unit of the pump. There are provisions made in the barrel to admit fuel and deliver the fuel. The helix present in the plunger in connection with the spil port is designed to suck the fuel and pressurise it. The delivery unit present in the pump at the top has the spring loaded delivery valve and the spring as a single unit. The schematic view of the in line pump can be seen in Fig 9.9.1 and the plunger control rack arrangement can be seen in Fig 9.9.1(a).

Operation:

The in line injection pump of the engine is operated by the timing gear. When the engine is started, the crank shaft is rotated and the power is transferred to the engine cam shaft. From the cam shaft the power goes to the fuel injection pump cam shaft through the timing chain. The plunger present in the fuel injection pump moves up and down due to the cam's rotation. When the plunger is moved down the fuel is sucked inside the barrel of the pump through the inlet port. This happens when the vertical slot is in connection with the spill port and the fuel enters into the pump barrel. To control the amount of fuel delivered to the injector the

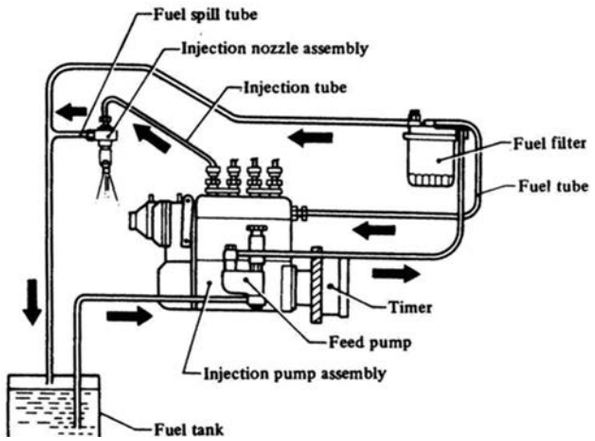


Figure 9.9.1 Schematic View of the In line Pump

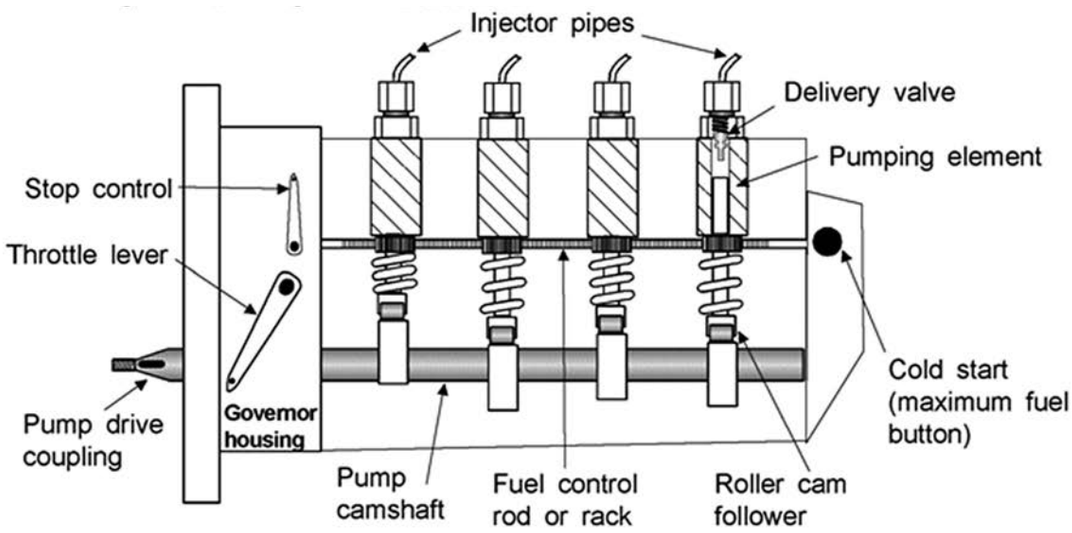


Figure 9.9.1(a) Control Rack and Plunger Arrangement

Control rack in connection with the tooth quadrant present in barrel unit is used. By moving the control rack front or back the helix position in the plunger meeting the spill port is varied. When the plunger is moved up, the inlet and spill port are cut and hence the fuel is compressed inside the barrel and high pressure is developed in the pump. When sufficient pressure is attained the delivery valve opens and the pressurised fuel present in the pump is supplied to the respective injector as per the firing order and injected inside the combustion chamber.

9.9.2 Distributor Pumps

Use of individual pump and injector in individual cylinders of a multi cylinder engines leads to energy loss (due to the operation of the individual plungers in the pump) and more maintenance in diesel engines. Hence instead of the in line pump, a single unit arrangement can be used which could pressurise the fuel and supply it to the appropriate cylinders at the appropriate time. Such pump is called as the distributor pump. The power for the distributor pump is obtained from the gear present in the cam shaft.

Construction: The distributor pump has a sleeve, rotor, plunger and a delivery unit. Rotor is placed inside the sleeve to rotate and move up and down. For the diesel fuel to enter and leave ports are made in the sleeve. The port is called as the metering ports. The plunger unit is placed inside the rotor unit to operate. There is a gear placed at the bottom of the rotor. The delivery unit of the pump is kept at the top of the rotor. The view of the distributor pump can be seen in Fig 9.9.2.

Operation: Unlike the in line pump, the distributor pump is designed as a single unit in such a way to distribute the diesel fuel to all cylinders. In the rotor a long path is present to pass the fuel. This path is provided to supply the fuel to the individual cylinders depending on the rotation of the suction port. When the engine is started due to the rotors rotation and up and down movement the fuel entering inside the pump is compressed and hence the pressure of the fuel is raised. The pressurised fuel then reaches the delivery valve. From the delivery valve through the high pressure line fuel is supplied to the injectors as per the firing order and sprayed at high pressure. The fuel delivered from the pump is controlled by using a metering rod and the governor unit for controlling the engine's speed. To control and meter the fuel the metering rod and the governor unit are used. The governor unit is connected with the accelerator pedal of the vehicle.

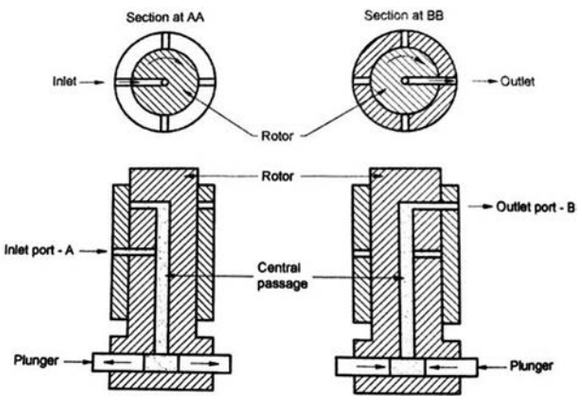


Fig.9.9.2 A view of the Distributor pump

9.10 GOVERNOR

Normally in petrol engines the carburettor unit mixes the air and fuel at correct proportions and supplies to the engine depending upon the engine's requirement. However, in diesel engine air and fuel are

separately introduced inside the engine combustion chamber and then ignited. Hence for supplying the required amount of fuel (in diesel engine) or fuel air mixture (in petrol engines) depending upon the engine's speed and load governor unit is used. At all speeds and loads to operate the engine safely the governor has the following operation stages of operation,

1. Governor cut in speed
2. Governor cut out speed
3. Governor over run

Note:

Governor Cut in Speed: Governor cut in speed represents controlling the speed of the engine by using the control rack by moving the rack out and supplying the required amount of fuel to the engine.

Governor cut out speed: When the control rod is operated beyond the control speed the fuel supply is cut by the governor this is called as cut out speed.

Governor Over run: The difference between the governor cut in and cut out speeds is called as governor over run.

9.10.1 Governor Terminologies

Based on the working principle governors can be classified into three types. They are

1. Mechanical Governors
2. Pneumatic Governors
3. Hydraulic Governors

1. **Mechanical Governor:** To control the engine's speed and load and reduce wastage of fuel governor is used in engines. The mechanical governor is operated mechanically. This governor is generally used in diesel engines. The construction and working principle of the mechanical governor are as follows,

   Construction: In this governor spring loaded weights, control rack, sleeve and bell crank lever are present and linked together properly. The sleeve is placed on the governor shaft and allowed to move freely. The two centrifugal masses are connected with the plunger sleeve through the bell crank lever. The governor shaft gets the power from the engine. The layout of the mechanical governor can be seen in Fig 9.10.

1. ***Height of a governor.*** *It is the vertical* distance from the centre of the ball to a point where the axes of the arms (or arms produced) intersect on the spindle axis. It is usually denoted by *h*.
2. ***Equilibrium speed.*** *It is the speed at* which the governor balls, arms etc., are in complete equilibrium and the sleeve does not tend to move upwards or downwards.
3. ***Mean equilibrium speed.*** *It is the speed* at the mean position of the balls or the sleeve.
4. ***Maximum and minimum equilibrium speeds.*** *The speeds at the maximum and minimum* radius of rotation of the balls, without tending to move either way are known as maximum and minimum equilibrium speeds respectively.
5. ***Sleeve lift.*** *It is the vertical distance which* the sleeve travels due to change in equilibrium speed.

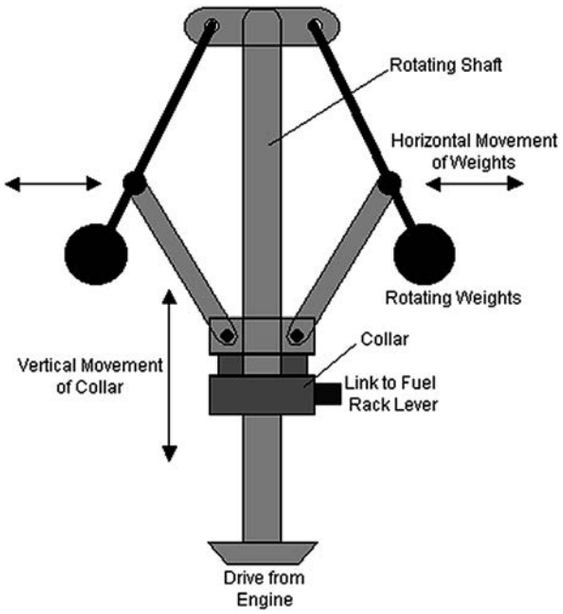


Fig 9.10.1.1 Layout of a Mechanical Gover**nor**

Working Principle: When the engine is started the governor shaft gets the power and rotates. As the governor shaft rotates the masses connected with the spring also rotate and hence the masses are forced to rotate outside due to the centrifugal force. Hence the sleeve placed in the governor shaft is moved upwards. The one end of the lever connected with the control rack is moved up along with the sleeve. This causes the other end of the lever to move down and operates the control rack. Due to this the diesel supplied to the engine is reduced and hence the engine speed is reduced. Similarly when the accelerator pedal of the driver is pressed the control rack is operated and the speed of the engine is varied. In the same way the engine speed can also be increased by moving the centrifugal mass. The governors of this type are of two types. 1. All speed governor and 2. Maximum speed governor. The governor operated by the driver's engine speed control is called as the maximum speed governor and the governor operated by the spring force without the accelerator is called as all speed governor.

2. **Pneumatic Governor :** The governor operated by using only the engine Vacuum without any bolts is called as the pneumatic governor.

Construction: This type of governor has two main parts such as 1. Venturi unit and 2. Diaphragm unit. The venturi unit is connected with the intake manifold and the diaphragm unit is connected with the fuel pump. The venturi unit and diaphragm unit are connected by the Vacuum pipe. The diaphragm is connected to the control rack. The construction of the pneumatic governor is shown in Fig 9.10.1.2.

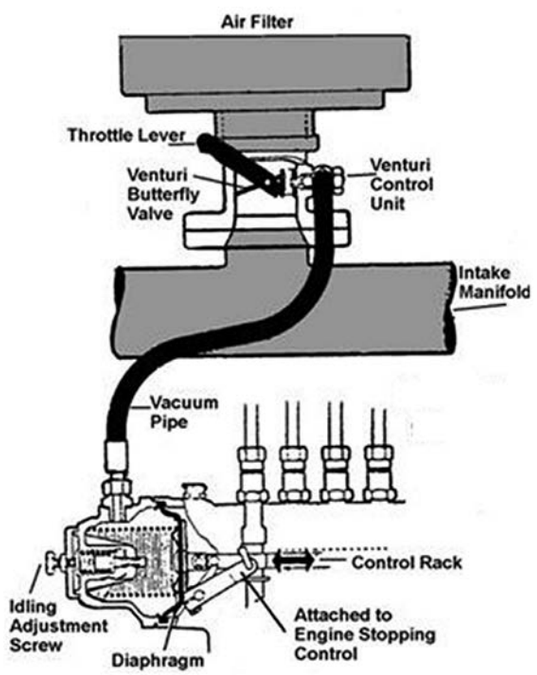


Fig 9.10.1.2 Pneumatic Governor

Working Principle: When the accelerator pedal is pressed the butterfly valve in the venturi opens. Hence the Vacuum in the inlet manifold reaches the diaphragm unit

through the Vacuum pipe. The control rack connected with the diaphragm is operated and the diesel supply is controlled. By this way the engine speed is controlled in the pneumatic governor.

3. **Hydraulic Governor :** This type of governor is operated by the cam shaft of the engine. The control plunger in this governor is connected with the control rack of the fuel injection pump by a spring. This type of governors are operated by the liquid present in the control plunger. When engine is started due to the rotation of the cam shaft the control plunger is operated and the control plunger operates the control rack of the fuel injection pump. The control rack of the fuel injection pump is operated by the hydraulic liquid in the control plunger. The schematic view of the hydraulic governor shown in Fig 9.10.1.3.

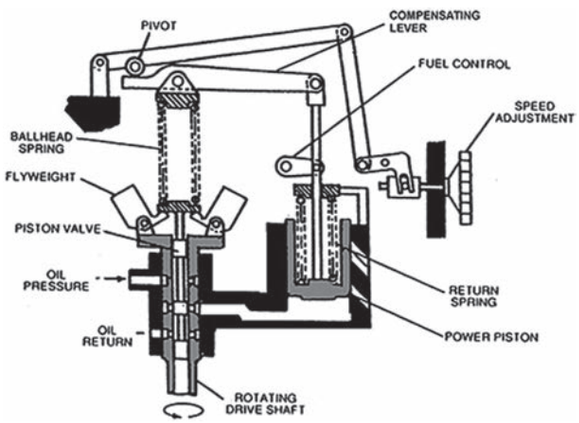


Fig 9.10.1.3 Schematic View of the Hydraulic Governor

9.11 DIESEL KNOCK

Knock in diesel engine is an unwanted effect caused due to the increased ignition delay of the engine. During the ignition delay period fuel is injected continuously. When the accumulation of the fuel is more due to the increased ignition delay, when ignited the accumulated fuel suddenly gets combusted and results in severe fluctuation in cylinder pressure and rate of pressure rise. This cause violent sound called as diesel knock.

9.11.1 *Reasons for Diesel Knock*

1. Lower compression ratio of the engine
2. Lower fuel injection pressure
3. Faulty injector
4. Blockage in the nozzle
5. Earlier injection of the diesel fuel

9.12 COMMON RAIL DIRECT INJECTION

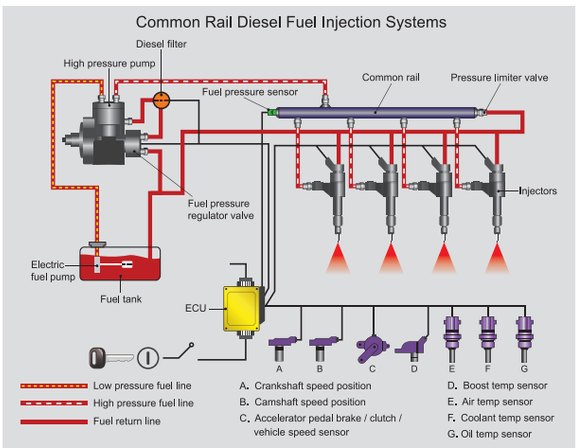


Fig.9.12 Common Rail Direct Injection

Common Rail direct injection of diesel fuel is the recent technology followed in modern diesel engines in introducing diesel fuel inside the engine combustion chamber. To improve the vaporization behaviour of the diesel fuel, the fuel is supplied to a common rail at very high pressure from the fuel pump. This method is called as the common rail direct injection. In this method with a small amount of diesel fuel more power is obtained. In addition the emission levels are reduced

significantly. Hence in modern diesel engines this system is used for good fuel economy and lower emission levels. In this common rail direct injection system the fuel pressure is maintained at 1350 – 2000 bar in the common rail by using a fuel pump. The fuel is supplied to all the injectors from the common rail and injected into the combustion chamber according to the firing order. The pressure maintained in the common rail is not depending on the engine's operation. Hence the CRDI system shows as better method as compared to the conventional engine systems. In the CRDI system the common rail and the high pressure lines connected with the injectors are designed to withstand very high fuel pressures. The electronic control unit (called as ECU) present in the system determines the amount of diesel fuel injected, the fuel pressure, injection timing and the injection duration. The ECU receives the input signals from different sensors, calculates the amount of fuel required, time for injection duration and other details for injection of the fuel and delivers required output signals to the solenoid operated injectors. By this way the fuel injection pressure, time and duration of injection and the amount of fuel injected are controlled.

Construction of CRDI system: The CRDI system consists of a fuel lift pump, a high pressure diesel pump, a common rail for storing diesel at high pressure and solenoid operated diesel injectors. In addition the system has different sensors, actuators and an electronic control unit (ECU). The lift pump is used to pump the diesel fuel through the filter to the high pressure diesel pump. The diesel from the high pressure pump transfers the fuel to the common rail. The injectors mounted on the cylinder head of the engine receive the high pressure fuel from the common rail through the high pressure lines. The solenoid operated injectors open the injector holes according to the signals received from the ECU. 16 bit or 32 bit microprocessor acts as the brain of the ECU used in the CRDI system. The temperature of the engine, temperature of the air and fuel, the rail pressure, engine booster pressure, accelerator pedal position, vehicle speed and intake air amount etc. are monitored continuously by the ECU using different sensors located at different parts of the engine by input signals. Figure 9.12(a) presents the construction of the CRDI system

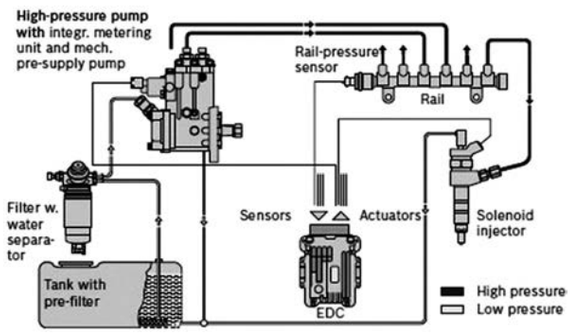


Fig 9.12(a) Construction of the CRDI system

Operation: Diesel fuel from the fuel tank is lifted by the fuel lift pump and supplied to the fuel filter. The fuel lift pump is operated electrically without the support of the engine power. The high pressure pump operated by the engine develops very high pressure and forces the high pressure fuel to the common rail. The fuel from the common rail is supplied to the individual injectors through the high pressure lines and the fuel is sprayed in the cylinder at very high pressure. The electronic control unit receives the

signals from the sensors and calculates the diesel injection pressure, injection timing, amount of fuel injected and the duration of injection etc. and gives output signals to the injectors. The electrical signals from the ECU operates the solenoid switch. Depending on the electrical signals received from the ECU the solenoid will open and close the injector hole and sprays the fuel. The limit switch and the non return valve in the common rail control the diesel pressure and the excess diesel is returned to the fuel tank.

9.12.1 Advantage of CRDI System

1. Improves the engine's performance
2. Reduces the diesel supplied
3. Reduces the emissions
4. Improve the power output
5. Starts the engine quickly
6. Smooth engine operation

Student Activity

1. Students should prepare a report on the rich mixture, lean mixture and normal mixture used in two-wheeler engines.
2. Students should visit the nearby workshops to study the process fuel combustion in an IC engine and should submit a report with the sketch of float chamber, carburettor and AC mechanical pump.

Glossary

Convergent	-	தரமாற்றிக் கொள்ளுதல்
Ventury	-	குறுகிய
Vaporized	-	ஆவியாதல்
Intel Mani Fold	-	உட்செல்லும் வழி
Vacuum	-	வெற்றிடம்
Multi Point Fuel Injection	-	பல துளைகள் கொண்ட எரி பொருள் உமிழ்ப்பான்
Electronic Control Unit	-	மின்னணு கட்டுப்பாட்டுக் கருவி
OTTO Cycle	-	ஆட்டோ சுழற்சி
Centrifugal	-	மைய விலக்கு
Governor	-	செயல் கட்டுப்பாட்டுக் கருவி

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SAMPLE QUESTIONS

1. How many types of Fuel Supply System are used in IC Engines?
   a) Two
   b) Three
   c) Four
2. How many Kilogram of air is needed for complete compression of 1 kg of Petrol?
   a) 4 kg
   b) 10 kg
   c) 15 kg
3. Based on air inlet how many types of Carburettor are there?
   a) Two
   b) Three
   c) Four
4. How the Throttle Value in Carburettor is operated?
   a) By Vacuum
   b) By accelerator pedal
   c) By petrol pump
5. Who initially introduced petrol injection system?
   a) Robert Bosch
   b) Nicholas Otto
   c) Rudolph Diesel

Answer the following questions

1. What are the types of Fuel Supply system?
2. What are the important parts in the fuel supply system?
3. How many types Petrol Pump? Mention the names.
4. What is meant by Air fuel ratio?
5. What is meant by Rich mixture?
6. What is meant by Normal mixture?
7. What is meant by lean mixture?
8. What are the functions of the carburettor?
9. What are the requirements of the carburettor?
10. What are the types of the carburettor?
11. Explain with a neat sketch of a simple carburettor.
12. What are the troubles in the simple carburettor?
13. Draw and explain the starting circuit.
14. What are the advantages in the Petrol Injection system?
15. What is meant by ECU?
16. What is meant by MPFI? And name the types.
17. What are the types MPFI? Explain any one type.
18. What are the important parts of the Fuel supply system in Diesel Engine?
19. What is meant by Governor?
20. What are the types Governor?
21. Name the types of a Governor? Explain any one type with sketch.
22. What is meant by Diesel Knocking?
23. What are the reasons for Diesel Knocking?
24. What is common rail diesel injection system? And explain.
25. What are the advantages of CRDI?