FUEL AND IGNITION SYSTEM

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Significance of air in IC engines:

The primary goal of an engine is to change heat energy into mechanical energy. The heat energy is obtained from combustion of fuel. The process of combustion within an engine involves of mixing fuel with air since fuel requires oxygen for burning. When fuel and air mixture is ignited, it releases heat energy, carbon dioxide and other substances. To obtain the maximum amount of efficiency while burning any fuel, we need to add a lot of air.

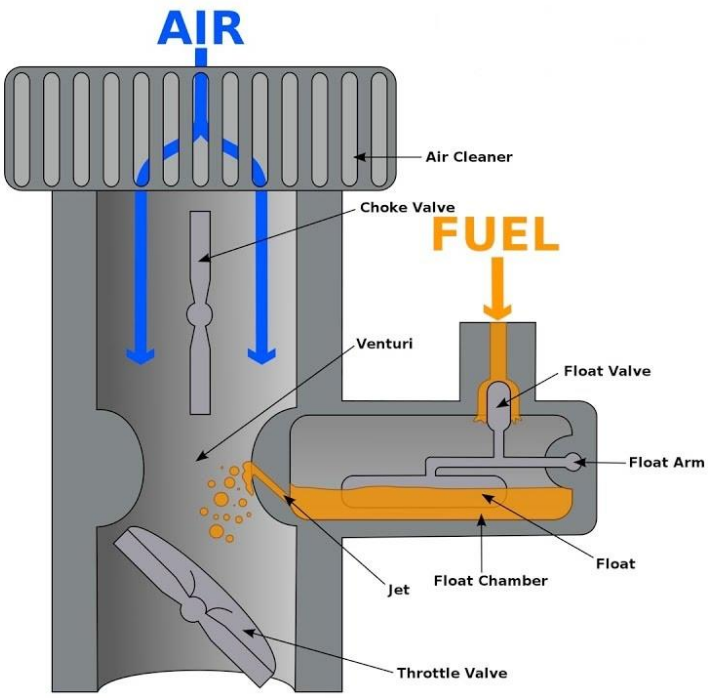
Stoichiometric mixture:

An ideal mixture in which both the fuel and the oxygen in the air are completely consumed while burning is called the stoichiometric mixture.

Carburetion:

It's a process of mixing air and fuel for the purpose of burning as air-fuel mixture inside the SI engines. The device used for preparing this mixture is called carburetor.

Working principle of Carburetor:



A carburetor works based on the Bernoulli's Theorem. The theorem states that "the total energy of an incompressible liquid flowing from one point to another remains constant throughout the displacement."

Above figure shows the construction of a carburetor. During suction stroke of engine air-fuel mixture is sucked into the engine cylinder. During this processes, the air flows down the vertical pipe after passing through the air filter. The contracted part shown in the figure is called the **Venturi**. The venturi significantly speeds up the air flow because of contraction in cross-sectional area. This increase in the speed of the air causes a fall in pressure, which creates a sucking effect and draws fuel from the float chamber. In the process a jet of fuel reaches the venturi. Then the fuel gets mixed with the air. This is how air-fuel mixture is prepared. Then the mixture goes to the engine. The quantity of air-fuel mixture enters into the engine cylinder is controlled by throttle valve which is operated by the accelerator. The orientation of choke valve shown in the figure is the default position. When engine fails to start because of cold temperature, the path of air is partially closed using this choke valve. As a result, a rich mixture is prepared and sucked into the engine. This rich mixture helps start the engine.

Air-fuel ratio:

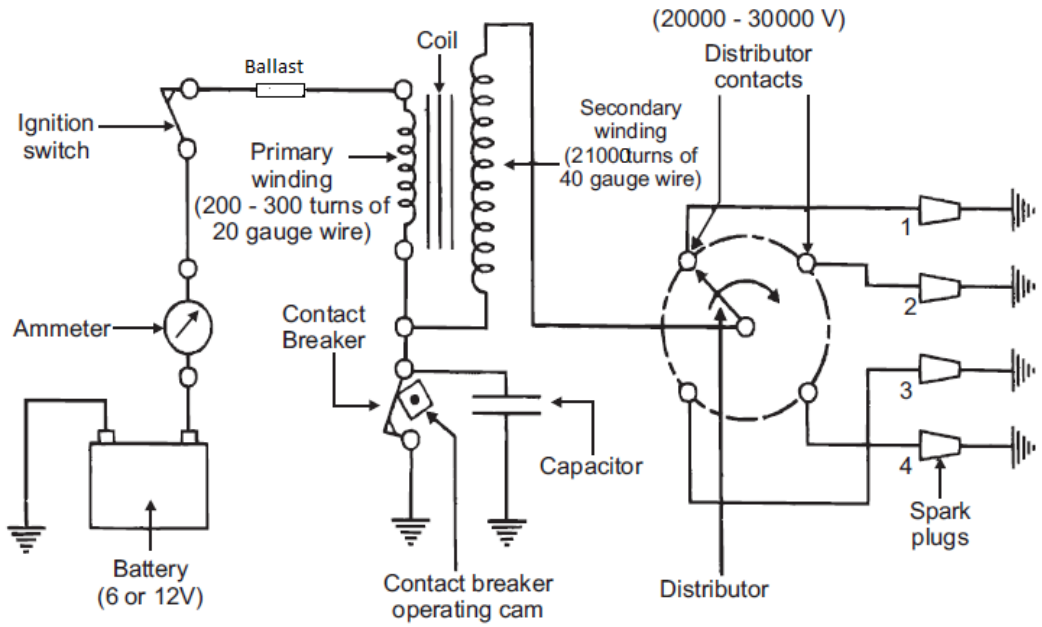
- It is the ratio of amount of air to that of fuel in an air-fuel mixture.
- The ideal (theoretical) air-fuel ratio, for a complete combustion, is called stoichiometric air-fuel ratio.
- For a gasoline (petrol) engine, the **stoichiometric air-fuel ratio** is around 14.7:1. This means that, in order to burn completely 1 kg of fuel, we need 14.7 kg of air.
- The combustion is possible even if the AFR is different than stoichiometric.
- For the combustion process to take place in a gasoline engine, the minimum AFR is around 6:1 and the maximum can go up to 20:1.
- When the air-fuel ratio is higher than the stoichiometric ratio, the air-fuel mixture is called **lean**.
- When the air-fuel ratio is lower than the stoichiometric ratio, the air-fuel mixture is called **rich**.
- For example, for a gasoline engine, an AFR of 16.5:1 is lean and 13.7:1 is rich.

Ignition system:

It's a system that is employed in SI engines for producing electric spark to ignite the air-fuel mixture. There are various types. Following two types are described in detail.

1. Battery ignition system.
2. Magneto ignition system.

Battery ignition system:

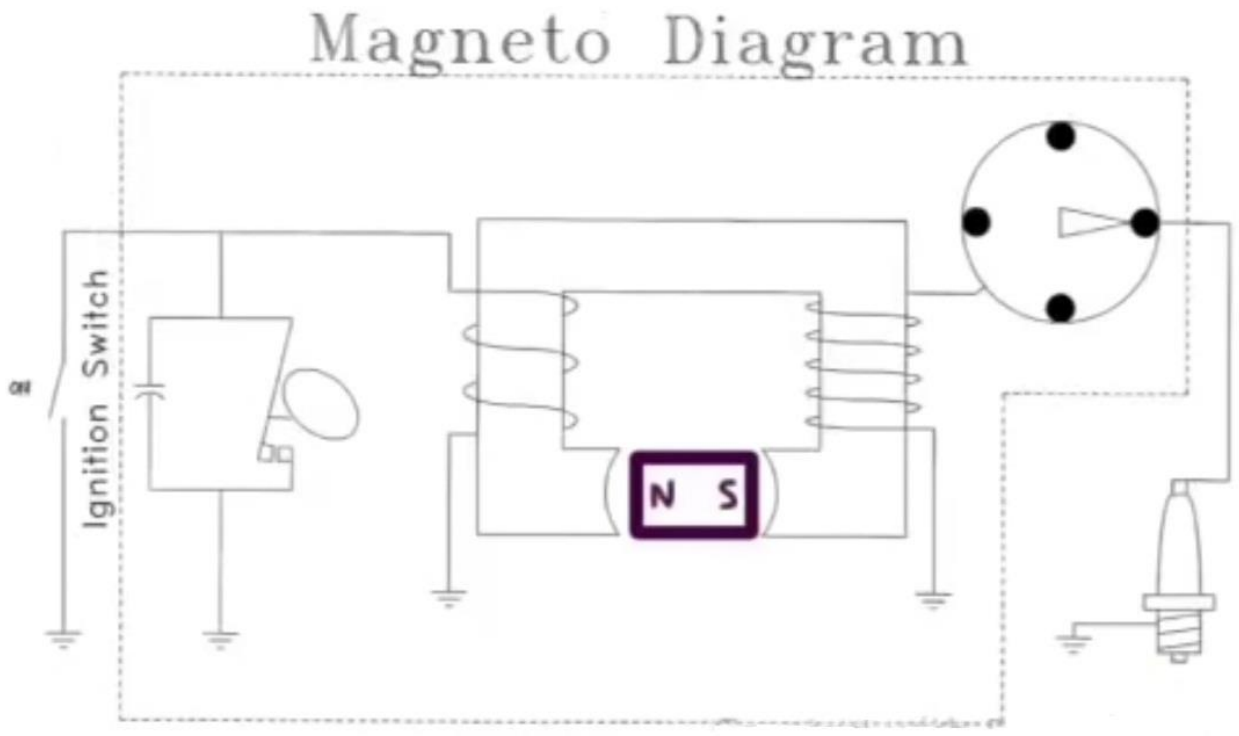


Above figure shows the circuit diagram. The battery ignition system consists of a battery, ignition switch, ballast, ignition coil, contact breaker, condenser (capacitor), distributor, spark plugs.

When the ignition switch is on, the current from battery starts flowing through the ballast, primary coil, contact breaker. The current in the primary winding induces a magnetic field around it. The more the current, the stronger the magnetic field. The contact breaker frequently closes and opens the primary circuit with the help of rotating cam. When the contact breaker is opens the circuit, the current in the primary winding collapses. This rapid collapse of current induces a voltage of about 300V in the primary winding. This induce voltage charges the capacitor to a voltage much greater than that of battery. As the

capacitor is charged, the current flow to the capacitor stops. Now the current flows from capacitor to the battery because of high potential of the capacitor. This is how the direction of current and magnetic field gets reversed. This rapid change in direction of magnetic field induces a very high voltage of about 15000V to 30000V in the secondary winding of the ignition coil. Because of this high potential of secondary winding, current flows from secondary winding to the distributor through high tension cable. The distributor has a rotor that rotates inside it. This rotor transmits current to the spark plugs as it rotates and makes contacts with the distributor contact points. This current produces spark in the spark plug.

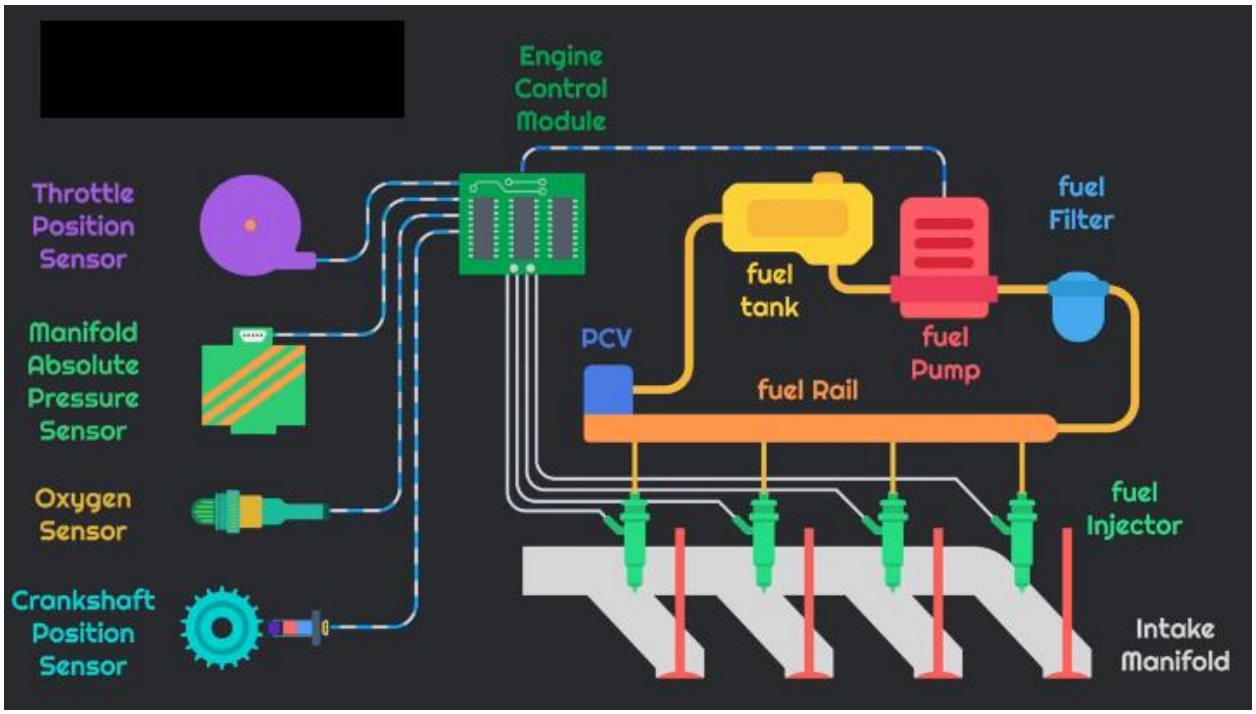
Magneto ignition system:



It consists of an ignition switch, contact breaker, a magneto, condenser (capacitor), permanent magnet, distributor, spark plug.

The permanent magnet is rotated by cranking. If the contact points are closed, current flows through primary circuit and magnetic field formed around it. When the contact points are opened, the current stops flowing through the contact points and the capacitor gets charged. This causes sudden collapse of magnetic field around the primary circuit. This sudden collapse of magnetic field induces a high voltage in the secondary circuit. Because of this high potential in the secondary circuit, spark jumps across the terminals of spark plug. As a result combustion occurs in the engine.

Multi point fuel injection (MPFI) system:



This system eliminates the carburetor. Its construction is shown in the above figure. It consists of a fuel tank, fuel pump, fuel filter, fuel rail, pressure control valve (PCV), fuel injectors for intake manifold. In addition to that it consists of throttle position sensor, manifold absolute pressure sensor, oxygen sensor, crankshaft position sensor. All the sensors, injectors and fuel pump are connected to an engine control module (ECM). The ECM receives/sends data from/to the above devices.

When accelerator is pressed, the throttle position sensor senses and send the signal to ECM. Manifold absolute pressure sensor senses the quantity of air goes

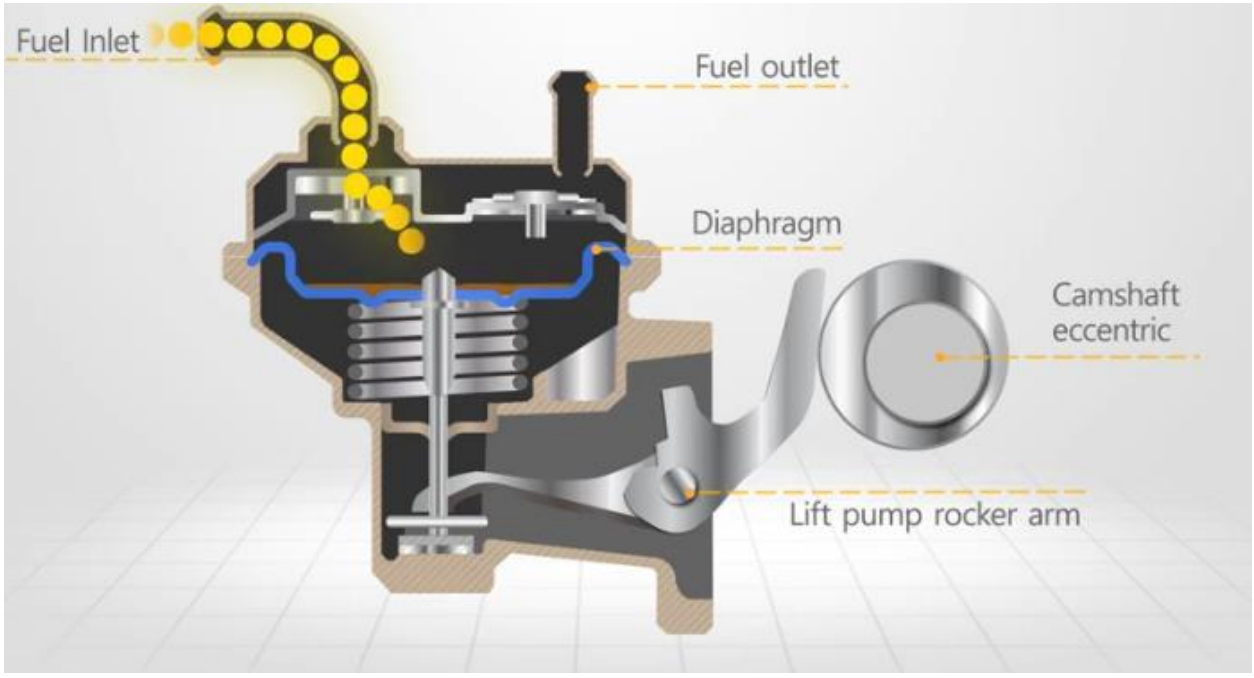
to the intake manifold and sends the signal to ECM. Oxygen sensor senses the quantity of oxygen in the engine exhaust and send the signal to the ECM. Crankshaft position sensor senses the position of crankshaft and sends the signal to the ECM. Using the signals from the four sensors, ECM calculates how much the accelerator is pressed, quality of air-fuel mixture to be injected, which injector should be operated. As per the calculation by ECM, it sends signal to the fuel pump and different injectors in order to inject fuel into the intake manifold. Then the fuel gets mixed with air in the manifold and enters the engine as air-fuel mixture. This system is used in SI engines.

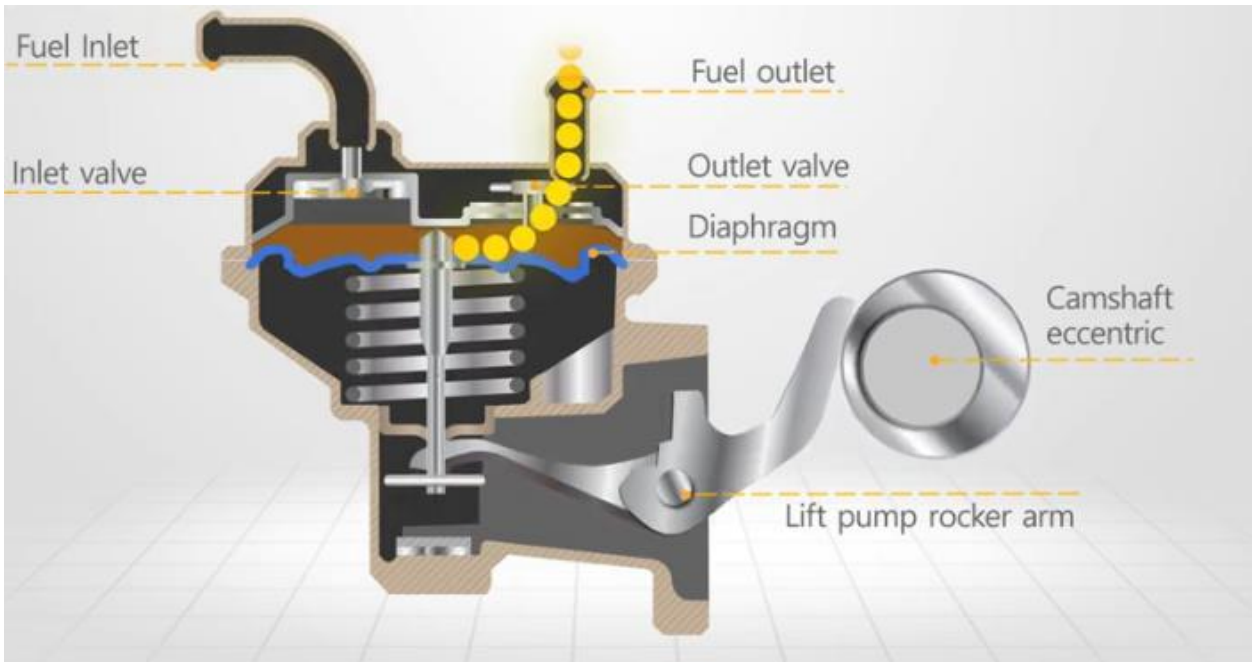
Supply of fuel:

The fuel which is stored in the fuel tank is taken to fuel injection system through fuel filter. This fuel is supplied by either gravity or fuel feed pump.

Fuel feed pump:

It delivers fuel from the fuel tank to the injection pump continuously and at a reasonable pressure.



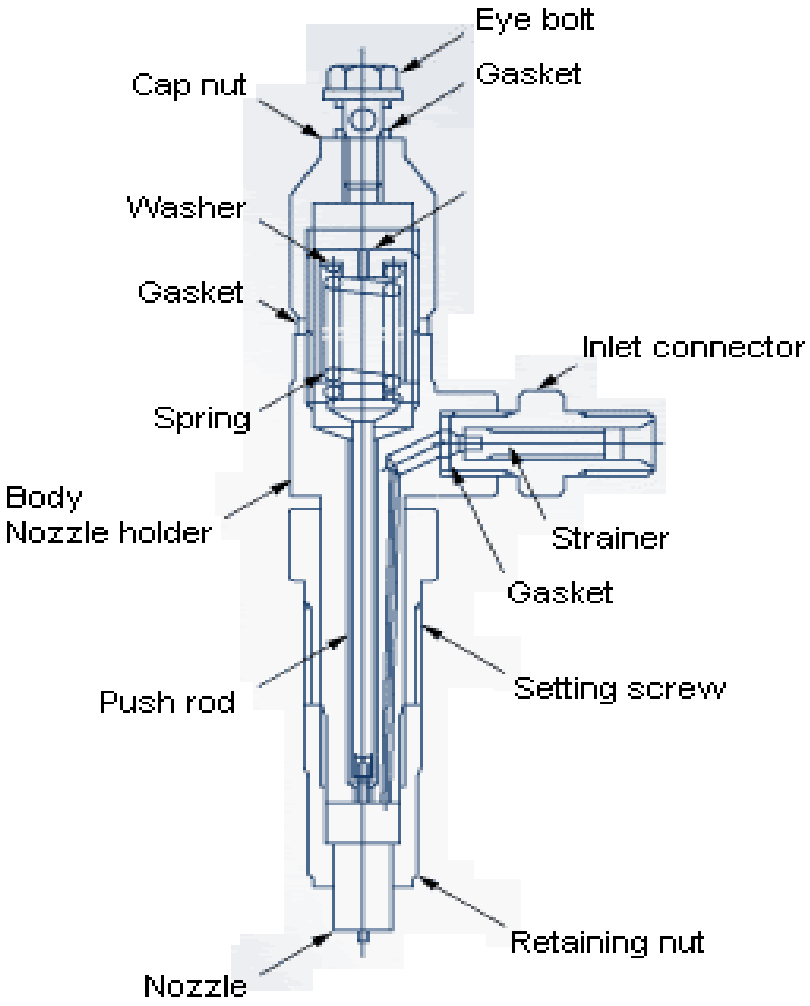


It consists of a diaphragm, diaphragm spring, inlet valve, outlet valve, lift pump rocker arm, camshaft, etc. The rocker arm is operated by camshaft. The rocker arm pulls down and pushes up the diaphragm depending upon the position and speed of the camshaft. When the diaphragm is pulled down, the fuel enters into the pressure chamber through inlet valve. When the diaphragm is pushed up, the fuel is pressurized and moves from the pressure chamber to the outlet manifold through outlet valve. The quantity of fuel it pumps depends upon the speed of the camshaft.

Injector:

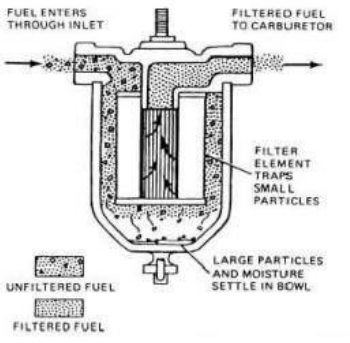
It is a device that atomises the fuel while injecting it into the combustion chamber. A typical fuel injector is shown in Figure. It has two basic parts, the nozzle and the nozzle holder or body. The high-pressure fuel enters and travels down a passage in the body and then into a passage in the nozzle, ending finally in a chamber surrounding the needle valve. The needle valve is held closed on a mitred seat by an intermediate spindle and a spring in the injector body. The spring pressure, and hence the injector opening pressure, can be set by a compression nut which acts on the spring. The needle valve will open when the fuel pressure acting on the needle tapered face of the needle exerts sufficient force to overcome the spring force. The fuel then flows into a lower chamber and is forced out through a series of tiny holes. The small holes are sized and arranged to atomise, or break into tiny drops, all of the fuel oil, which will then readily

burn. Once the injector pump or timing valve cuts off the high pressure fuel supply the needle valve will shut quickly under the spring compression force.



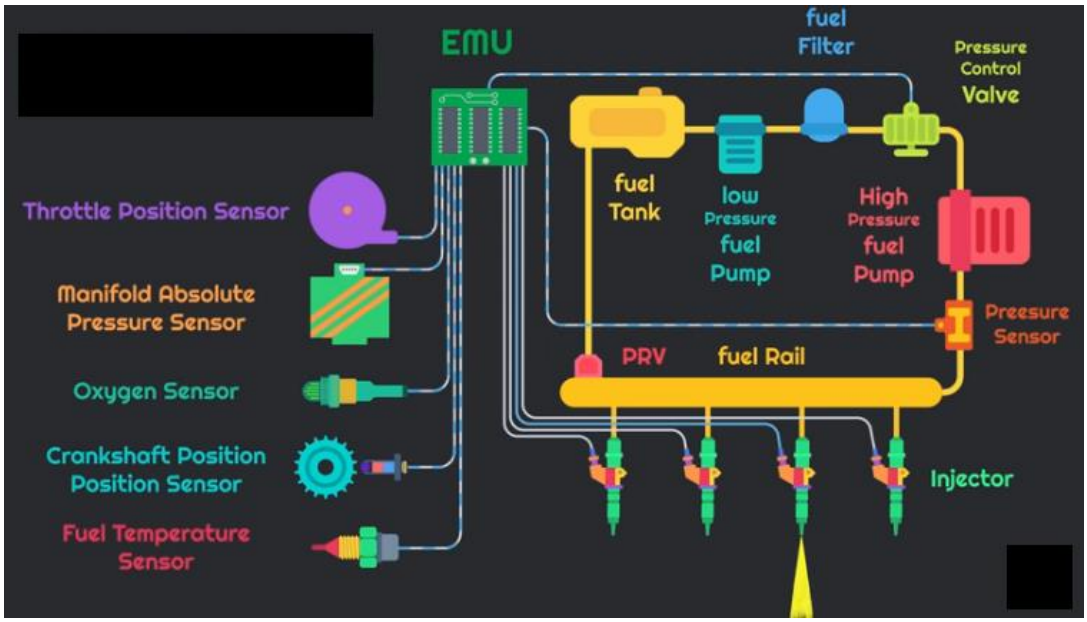
Injector figure

Fuel filter:



Filter consists of a single bowl, in which a perforated tube is fitted centrally. The perforated centre tube is surrounded annularly by a filter element. A gasket is placed on top of the bowl, to check for any leakage of fuel. When fuel feed pump sucks the fuel, it passes through the filter element. It will drop the impurities and enter into the central perforated tube, where it is drawn out by the feed pump. The dirt and other impurities left by the fuel at filter element are collected at the bottom of the bowl. These are removed frequently, through drain plug fitted at the bottom of the bowl.

Fuel injection system for multi cylinder diesel engine (CRDI):



Above figure shows various components used in this system. The low pressure fuel pump delivers fuel from the fuel tank to the pressure control valve (PCV) through the fuel filter. The high pressure fuel pump delivers the fuel from the PCV to the fuel rail through pressure sensor. The pressure sensor continuously sends signal of pressure of the system to the engine management unit (EMU). A pressure regulating valve (PRV) is used to regulate the pressure inside the fuel rail. Injectors are connected to the fuel rail. Throttle position sensor sends signal of position of throttle to the EMU. Manifold absolute pressure sensor sends signal of quantity of air in the intake manifold to the EMU. The oxygen sensor sends signal of quantity of oxygen in the engine exhaust to the EMU. Crankshaft position sensor sends the signal of crankshaft position to the EMU. The fuel temperature sensor sends the signal of fuel temperature in the tank to the EMU. After

gathering all the data from different sensors, the EMU sends signal to the PCV for maintaining required pressure in the system. The EMU sends the signal to the different injectors for injecting fuel into the combustion chamber depending upon the valve timing. The above injection system is called common rail direct injection(CRDI).