

CHAPTER 6

FUEL SYSTEM

The purpose of the fuel system is to supply the engine a clean and correct form of diesel or gasoline mixture. The components of the fuel system may vary according to the type of fuel used by the engine i.e. petrol or diesel.

6.1 FUEL SYSTEM OF PETROL ENGINE

The main components of this system include fuel tank, fuel lines, fuel delivery pump, fuel filter, air cleaner and carburetor. The function of each component is discussed below.

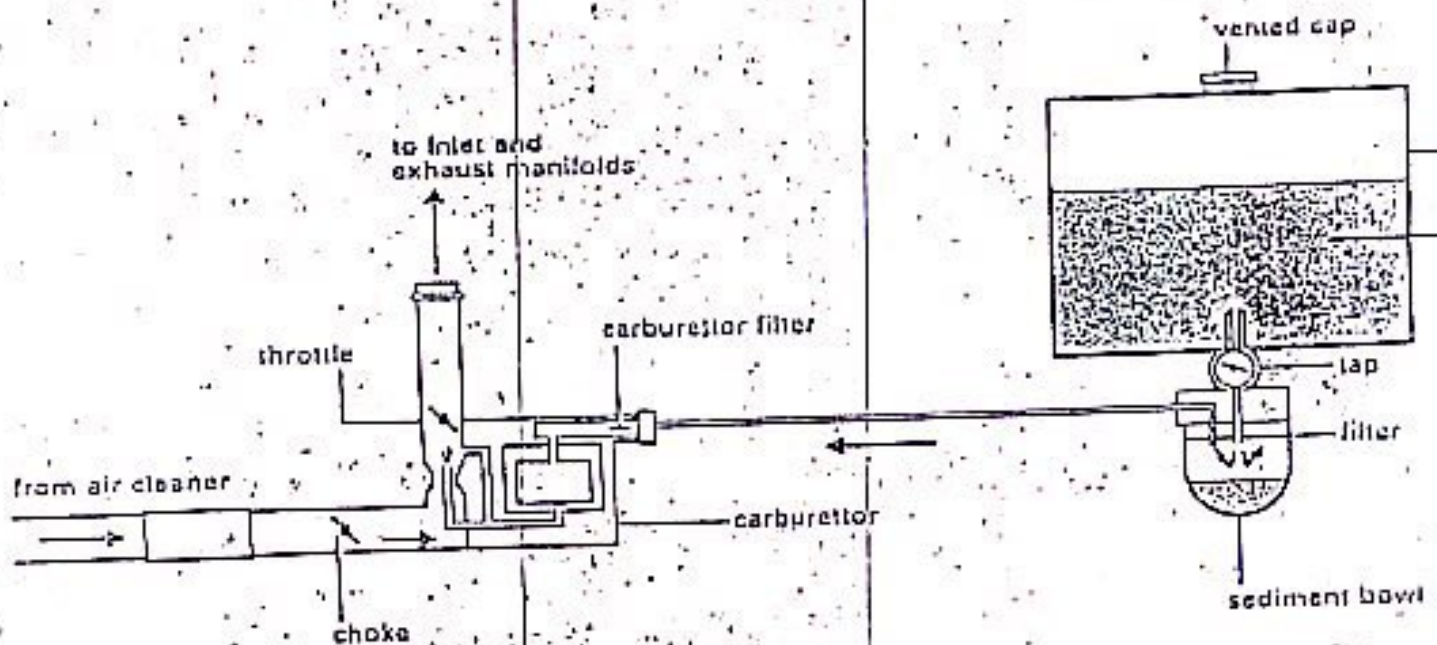


Figure 6.1 A schematic diagram of fuel system of petrol engine

6.1.1 Fuel Tank

It is used to store fuel for extended hours of engine operation. Regardless whether the tank is used to store petrol or diesel commonly it has following four outlets.

- Outlet to fill the tank at the top covered with a vented cap. This cap prevents dirt and rain water from entering into the tank, while allows air to enter to replace the quantity of fuel used.

- Outlet for the fuel to go out from the tank, which is controlled by the fuel shut-off valve at the bottom.

- Outlet for the drain of fuel tank, covered by drain plug.

- Fuel return line, if the engine has a fuel injection pump as in diesel engine.

Modern carburetors are quite sophisticated in that they are fitted with several auxiliary valves or jets to accomplish the air fuel ratio in accordance with the load and speed of engine. These include compensating jets, idling jet, a pilot jet and so on. On modern engines, electronic fuel injection discussed later in this book, has replaced the use of carburetors. Instead, fuel injection nozzles are used to inject petrol directly into the intake manifold before the intake valve. This has increased the fuel use efficiency.

6.2 AIR CLEANER

It is arranged before the carburetor to remove dust particles from the air as it passes to the engine cylinder. These particles, if not filtered would enter the engine with the air fuel mixture and cause rapid wear and tear of bearings, rings, cylinder walls and other engine parts. There are two types of air cleaners generally in use i.e. **dry air cleaner** and **oil bath air cleaner**.

6.2.1 Dry Type Air Cleaner

This type of air cleaner consists of a filtering element made of paper. This paper is arranged in the pleated form to obtain maximum filtering surface. The filter traps all incoming dirt in its folds and allows clean air to pass to the engine. The disposable filtering element should always be replaced at stated intervals, and the dirt element discarded. This type of air cleaner is mostly used for light duty engines working in cleaner environment. The advantages of dry air cleaner are that it is lighter, compact and cheaper than oil bath type air cleaner.

6.2.2 Oil Bath Type Air Cleaner

This type of air cleaner consists of a filter element made of mesh of metal wool. The filter element is enclosed in a sheet metal shell (Fig. 6.4). An oil pan/sump is provided at the bottom of shell. A pre-air cleaner is provided at the top of air entering duct to trap heavier items such as straw, leaves and so on. After passing through pre-air cleaner, air moves towards oil pan where it is deflected upward. Most of the dust and sand is rejected to the oil sump at this point. The air then passes through wire mesh where finer dust particles are attached to oil wetted surfaces and drained back into the oil sump. The cleaned air passes through a passage way to the carburetor or intake manifold.

Servicing for this type of air cleaner involves cleaning the pre-cleaner, air duct and washing wire mesh with paraffin. In addition, the oil pan is refilled with fresh oil of specified grade to the level marked on the pan. The pre-air cleaner pipe of tractor is extended on top of engine quite higher to attract air with less dust concentration.

6.3 MANIFOLDS

Two types of manifolds, the intake manifold and exhaust manifold are used. The intake manifold is a series of pipes or passages through which the fuel-air mixture from the carburetor is directed to the engine cylinders on the intake stroke. After the mixture is burned and the piston is moving up in the cylinder on the exhaust stroke (exhaust valve open), the burned gases are discharged into the exhaust manifold. From there, they pass through the muffler (silencer) and through the tail pipe into the open air.

6.1.2 Fuel Lines

Fuel line is simply **metallic tube** through which fuel is sucked from the fuel tank by the fuel pump and delivered to the carburetor.

6.1.3 Fuel Gauge

As a **signaling system** it indicates to the driver the **amount** of fuel present in the fuel tank.

6.1.4 Fuel Filter

The filter removes from the liquid gasoline, dirt or particles that might otherwise get into other components of the fuel system or into the engine. Such particles could clog fuel passages in the carburetor and prevent normal action of fuel system.

6.1.5 Fuel Feed/Lift Pump

It is a mechanically (or electrically) operated device, which pumps gasoline from the fuel tank and delivers it through the fuel lines to the carburetor. Mostly, it is mounted on the side of the cylinder block at the front end of engine. Fuel pump develops pressure to facilitate fuel flow through filters. The pump found on tractor engines is diaphragm type operated by camshaft or battery. So it may be mechanical or electrical. It is also used for hand priming to remove air lock in diesel engines.

6.1.6 Carburetor

It is a device, which breaks down the petrol into tiny particles and then mixes it with air (Figure 6.3). The main functions of the carburetor are stated as under:

- Break the fuel into tiny particles.
- Mix the air and gasoline vapors in correct proportions for various engine speeds and torque. This is done with the help of a **choke**, which controls the quantity of air entering into the carburetor.
- Control the speed of the engine by regulating the amount of mixture entering into the cylinder. This is done with the help of foot/hand accelerator, which opens or closes the **throttle valve**.

6.1.7 Working Principle of Carburetor

During suction stroke, vacuum is developed through out the intake manifold, which causes air to rush through venturi of the carburetor. The venturi helps to increase the velocity of air and consequently decrease the pressure of air. This decrease in pressure at the venturi helps the fuel to get out from the jet in the form of tiny particles and mix with air stream entering the combustion chamber. To start a cold engine and to obtain quick acceleration, a rich mixture with air to fuel ratio of 12:1 (by weight) is required which is attained by closing the choke valve. This decreases the quantity of air going to engine cylinder. After engine has warmed up, air to fuel ratio is changed to about 16:1 for better fuel economy. This is done by opening the choke valve. The main parts of a simple carburetor are shown in Figure 6.3.

6.5 FUEL SYSTEM OF DIESEL ENGINE

This system is composed of fuel tank, lift pump, filters, fuel injection pump and injector. In diesel engine, only air is drawn into the cylinder during suction stroke, which is then compressed to a volume ratio of usually 16:1 while raising air pressure 20 to 40 kg/cm² and temperature 500 to 600 °C. Now diesel fuel with a pressure of 105 to 175 kg/cm² is injected into the compressed air in the form of mist by means of a fuel injection pump and injector. Soon after the diesel is injected it starts burning due to high temperature of compressed air. The temperature of the combustion is raised to about 2000 to 2700 °C but pressure does not rise appreciably above compression pressure as in the case of a petrol engine.

6.5.1 Fuel Tank

The fuel tank for diesel engine is similar to that used for petrol engine but it usually has a fuel return line from the injector.

6.5.2 Filters

In diesel engines, multiple filters are provided in the system to ensure that absolutely clean fuel enters the fuel injection pump and injector. Any dust or dirt would cause abrasion and damage to the highly polished and delicate parts of the injection pump and the injector. The filter used in diesel system is almost the same as in petrol system. However, air-bleeding screws are provided at the top of filter for the removal of air lock.

6.5.3 Fuel Feed Pump or Lift Pump

The fuel lift pump is the same as used in petrol fuel system. A lever present on one side of lift pump for hand priming helps in the removal of air lock.

6.5.4 Fuel Injection Pump

- This is one of the most sophisticated parts of the diesel fuel system. It is used;
- (i) To develop high fuel pressure of over 2600 psi in the injection system and
 - (ii) To regulate the amount of fuel discharged into the cylinder in order to control engine speed

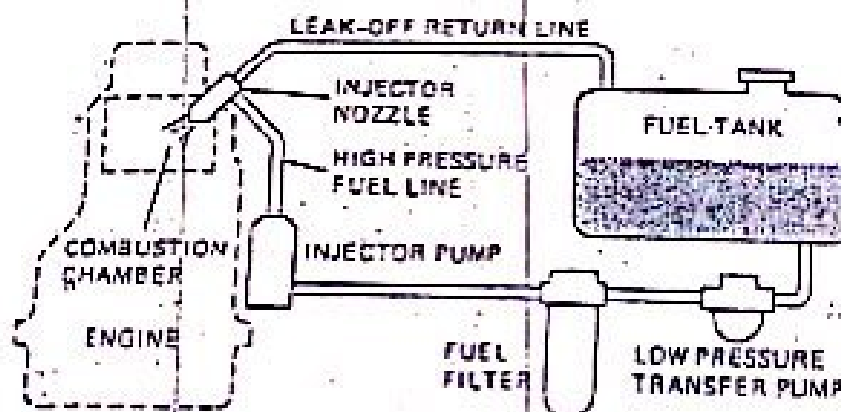


Figure 6.5 Schematic diagram of diesel engine fuel system.

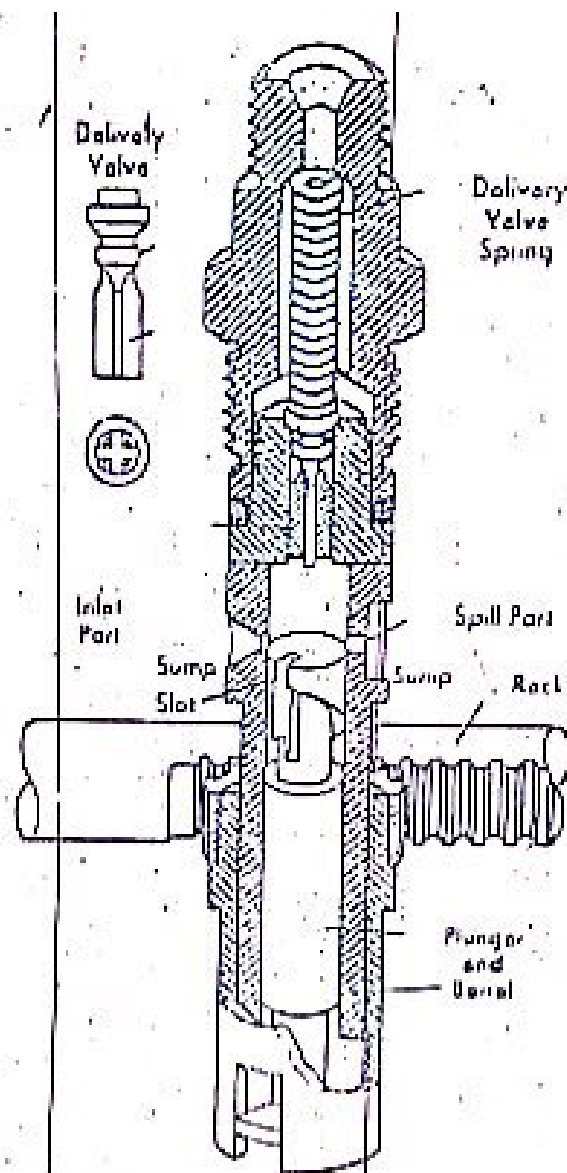


Figure 6.6 Cross-sectional view of a plunger type fuel injection pump

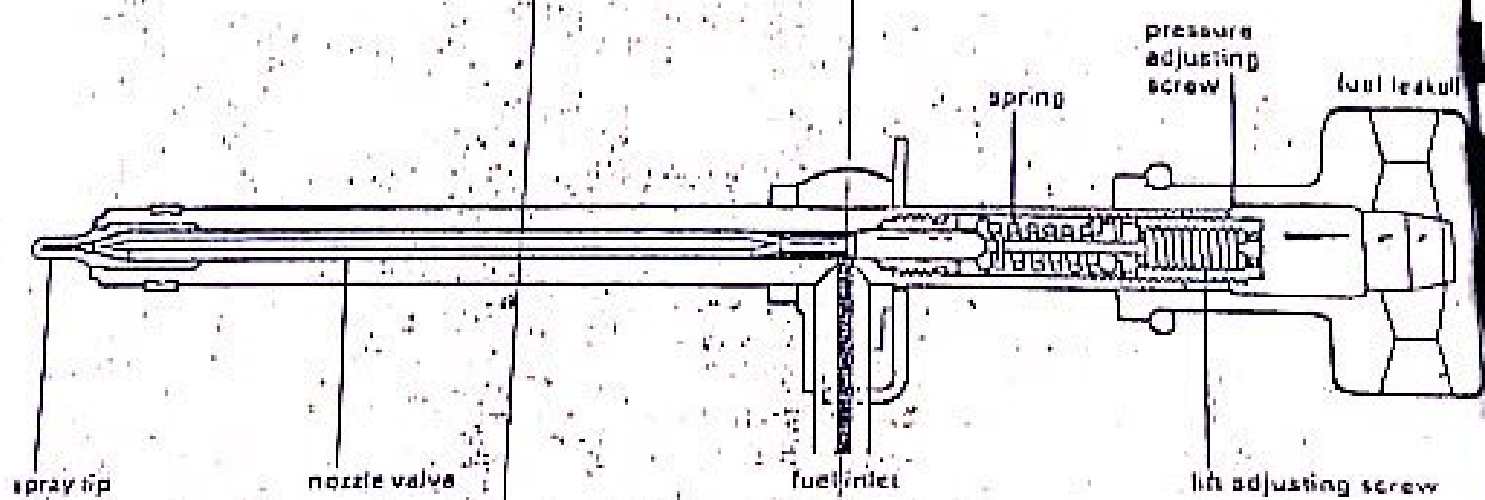


Figure 6.7 Cross-sectional view of a diesel fuel injection nozzle

- ❖ Change oil and oil filter, air filter, and fuel filter
- ❖ Check battery fluid level and clean the battery posts and clamps
- ❖ Check PCV valve, vacuum hoses, and electric connections
- ❖ Check for loose, cracked, or hardened spark plug wires. Replace the whole set of spark plug wires every three years.
- ❖ Replace spark plugs
- ❖ Replace distributor cap and rotor.
- ❖ Adjust idle speed
- ❖ Adjust ignition timing

Two types of pumps are in common use for small and heavy-duty engines. These are; (i) plunger type and (ii) rotary type. Single cylinder engines usually use plunger type pump, which is operated by camshaft. This pump consists of a plunger working in a barrel or cylinder. The barrel has inlet and outlet ports controlled by spring valves. The surface of the plunger has a cut or groove called helix which controls the quantity of fuel being metered. A rack attached to the accelerator controls the position of the helix. If more of the helix is exposed to outlet port, lesser is the fuel supplied to the injector while slipping more of the fuel back to inlet port.

6.5.5 Fuel Injector

This is also a high precision component. The injector is also called atomizer as it creates a fine mist (atoms) of diesel fuel when passes through needle valve. The injector is arranged in the cylinder head of the engine. The functions of the injector are;

- i. To start the injection of fuel into the cylinder when the fuel pressure of about 2600 psi is reached.
- ii. To atomize the fuel directly into the combustion chamber and
- iii. To stop the spray when pressure of the fuel drops below the injection pressure.

An injector consists of a nozzle body, needle valve, pressure adjusting screw and spray tip. The tension of the spring can be increased or decreased to adjust the desired pressure as recommended by the manufacturer. According the shape of nozzle and needle valves, the nozzles may be called as

- i. Pintle type: with one hole at the tip of nozzle or
- ii. Pointed cone nozzle: with multiple holes around the tip.

6.6 AIR LOCK

Diesel engines are usually get air locked when air makes it way into the fuel system. Air being compressible changes its volume in the fuel injection pump and does not move ahead thereby blocks the injection of fuel into the cylinder. Air lock is mostly developed when (i) the fuel tank gets empty (ii) the nuts of fuel feed pump or filter are loose or (iii) dust particles block the fuel filter/lines. Air from low-pressure line can be removed by opening the air bleeding valves of the filter and pump while operating the fuel lift pump by hand priming. Air from high-pressure lines (after the fuel injection pump) can be removed by opening the air bleeding screw at the injector while cranking the engine by self-starter or human push. Once a stream of diesel starts coming out of air bleeding valves without air bubbles, the engine will start. At this point the air bleeding screws should be tightened again.

Clearance Volume (CV): The volume or space between the top of piston and the cylinder head when the piston is at TDC. This is also called as combustion chamber.

Total Cylinder Volume (TCV): The volume designated by the sum of piston displacement and clearance volume (PD + CV).

Compression Ratio (CR): It is the ratio of total cylinder volume to clearance volume (TCV/CV).

Engine Size: This is given by the bore and stroke of the engine. For example, a 100 mm x 124 mm engine has a bore of 100 mm and a 124 mm stroke.

Example

Given the above engine size, it is possible to calculate: the piston displacement, the total cylinder volume and the compression ratio given that $CV = PD/6$.

i) Piston Displacement = volume swept in one stroke

$$PD = (\pi d^2/4) \times L = (3.14 \times 100^2)/4 \times 124 = 973400 \text{ mm}^3$$

Where D = bore diameter and L = stroke length

ii) Total cylinder volume (TCV) = PD + CV

$$\text{Where } CV = PD/6 = 973400/6 = 162233.3 \text{ mm}^3$$

$$TCV = 973400 + 162233.3 = 1135633.3 \text{ mm}^3$$

iii) Compression Ratio (CR) = $TCV/CV = 1135633.3/162233.3 = 7.0$

EXERCISE PROBLEMS

Q1. A 47 HP three cylinder Massey Ferguson tractor (MF-135) engine has a bore of 91.44 mm and stroke of 127 mm. If total capacity of the engine is 2.5 liters, find Clearance Volume (CV) when the Compression Ratio (CR) is 18.5:1.
Hint: Piston Displacement (PD) = Engine Capacity/No. of Cylinders

$$(\text{Ans. } 47.62 \text{ cm}^3)$$

Q2. A three cylinder MF-240 tractor engine has a CV = 53.763 cm³, CR = 16.5:1 and a stroke length of 127 mm. Calculate (i) Piston Displacement (ii) Engine Capacity (EC) and (iii) Bore.

$$(\text{Ans } PD = 833.33 \text{ cm}^3, EC = 2.5 \text{ L, Bore} = 91.44 \text{ mm}).$$

Q3. Calculate CV, CR and Engine Capacity of a 4-cylinder MF-375 tractor engine when Total Volume of one cylinder (TCV) is 1029.33 cm³ and Bore and Stroke are 98.4 and 127 mm, respectively.

$$(\text{Ans } CV = 64.33 \text{ cm}^3, CR = 16:1, EC = 3.86 \text{ L}).$$