# FUEL & FUEL SYSTEM

**PROPERTIES OF FUEL**

Fuel is a substance consumed by the engine to produce energy. The common fuels for internal combustion engines are:

1. Petrol
2. Power kerosene
3. High speed diesel oil
4. Light diesel oil.

The important properties of these fuels are given below:

| S.No | Name of fuel oil | A. P. I. degree | Specific Gravity | Calorific value | |
|---|---|---|---|---|---|
| | | | | kcal/kg | B.T.U./lb |
| (i) | Light diesel oil (L.D.O.) | 22 | 0.920 | 10300 | 18600 |
| (ii) | High speed diesel oil (HSD) | 31 | 0.820 | 10550 | 19000 |
| (iii) | Power kerosene | 40 | 0.827 | 10850 | 19500 |
| (iv) | Petrol | 63 | 0.730 | 11100 | 20000 |

**QUALITY OF FUEL**

The quality of the fuel mainly depends upon the following properties:

1. Volatility of the fuel
2. Calorific value of the fuel
3. Ignition quality of the fuel

**Volatility:** Volatility of fuel has considerable effect on the performance of the engine by affecting the following:

(i) Ease of starting the engine.
(ii) Degree of crankcase oil dilution,
(iii) Formation of vapour lock in the fuel system,
(iv) Accelerating characteristics of the engine,
(v) Distribution of fuel in multi-cylinder engine.

In I. C. engine, all the liquid fuel must be converted into vapour fuel before burning. High speed diesel oil is most difficult to vapourise. Vapourising temperature of high speed diesel oil is higher than that of the petrol, hence the petrol vapourises quicker than diesel oil in the engine cylinder. This helps in easy starting of petrol engines.

**Calorific value:** The heat liberated by combustion of a fuel is known as calorific value or heat value of the fuel. It is expressed in kcal /kg of the fuel. The heat value of a fuel is an important measure of its worth, since this is the heat which enables the engine to do the work.

**Ignition quality:** Ignition quality refers to ease of burning the oil in the combustion chamber. Octane number and cetane number are the measures of ignition quality of the fuel.

***(a) Octane number:*** It is a measure of knock characteristics of a fuel. The percentage of iso-octane ($C_8 H_{18}$) in the reference fuel consisting of a mixture of iso-octane and normal heptane ($C_7H_{16}$), when it produces the same knocking effect as the fuel under test, is called octane number of the fuel. Iso-octane has excellent antiknock qualities and is given a rating of 100. Normal heptane would knock excessively and hence it is assigned a value of zero.

***(b) Cetane number:*** The percentage of cetane in a mixture of cetane ($C_{16}$ $H_{34}$) and alphamethyl naphthelene ($C_{11}$ $H_{16}$) that produces the same knocking effect as the fuel under test is called cetane number of the fuel. Diesel fuels are rated according to cetane number which is the indication of ignition quality of the fuel. The higher the cetane number the better the ignition quality of the diesel fuel. The commercial diesel fuels have got cetane rating varying from 30 to 60.

***Detonation (Knocking):*** Detonation or engine knocking refers to violent noises, heard in an engine, giving a pinging sound during the process of combustion. It occurs during the process of combustion of the

mixture within the cylinder after the ignition has taken place. It is an undesirable combustion and results in sudden rise in pressure, a loss of power and overheating of the engine. It is caused by improper combustion chamber, high compression pressure, early ignition timing, improper fuel and inadequate cooling arrangement.

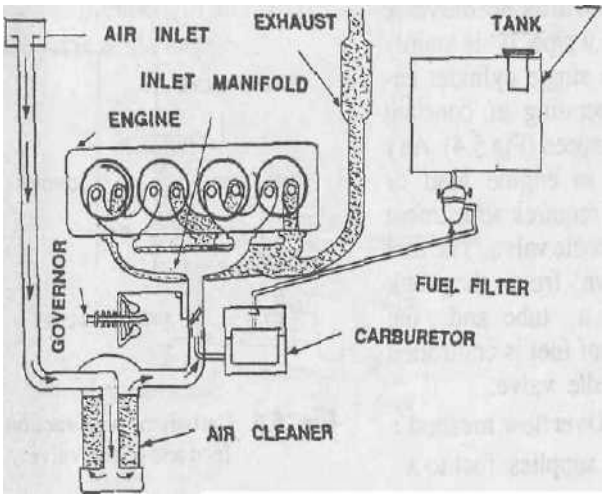
*Pre-ignition:* Burning of air-fuel mixture in the combustion chamber before the piston has reached the top dead centre is called pre-ignition. Pre-ignition occurs when the charge is fired too far ahead of the top dead centre of the piston due to excessive spark advance or excessive heat in the cylinder.

**FUEL SUPPLY SYSTEM IN SPARK IGNITION ENGINE**

The fuel supply system of spark ignition engine consists of:

(i) Fuel tank
(ii) Fuel filter
(iii) Sediment bowl
(iv) Fuel lift pump
(v) Carburettor
(vi) Fuel pipes
(vii) Inlet manifold

In some spark ignition engine, the fuel tank is placed above the level of the carburettor. The fuel flows from the fuel tank to the carburettor under the action of gravity. There are one or two filters between the fuel tank and the carburettor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of the carburettor, a lift pump is provided in between the tank and the carburettor for forcing fuel from the tank to the carburettor of the engine. The fuel comes from the fuel tank to the sediment bowl and then to the lift pump. From there the fuel goes to the carburettor through suitable pipe. From the carburettor, the fuel goes to the engine cylinder, through the inlet manifold of the engine.

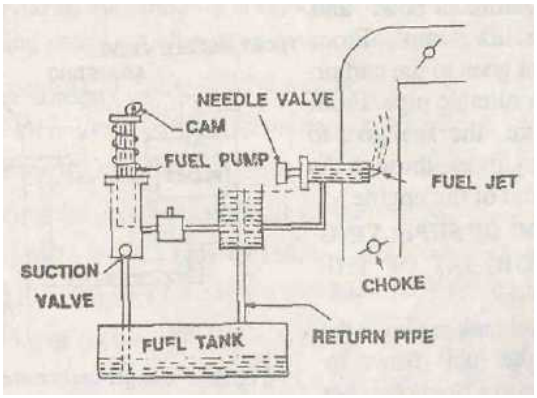



Fuel system of spark ignition engine.

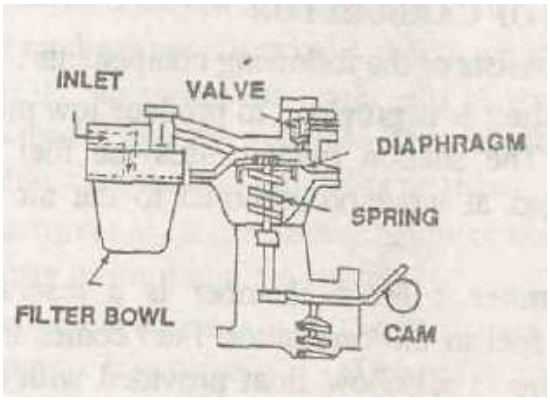
**CARBURETTOR:**

The process of preparing an air-fuel mixture away from the cylinders of an engine is called carburetion and the device in which this process take place is called carburettor.

**Principle of carburettor:** The basic principle of all carburettor design that when air flows over the end of a narrow tube or jet containing liquid, some liquid is drawn into the air stream. The quantity of liquid drawn into the air stream increases as the speed of air flow over the jet increases and also the quantity is greater if the jet is made larger.




Carburettor with pump feed to fuel reservoir




Diaphragm type fuel pump

In practice, the fuel level in the jet is maintained by a float chamber. The fuel levels in the jet and in the float chamber are always the same. As the fuel is consumed, the level in the float chamber goes down. The float in the float chamber also goes down and the needle valve comes off its seat allowing more fuel into the chamber from the fuel tank. When the fuel level rises to its correct level, the float presses the needle valve back to its seat and cuts off the fuel flow. The velocity of the air flowing over the jet is increased by a constriction in the induction pipe known as venturi. A throttle butterfly valve provides an adjustable obstruction in the induction pipe. It is used to control the flow of air-fuel mixture to the engine. As the butterfly valve is turned into the accelerate position, the airflow over the jet increases and more fuel is drawn out into the air stream, keeping the mixture strength constant.

A second butterfly valve called choke is used to provide a richer mixture for the engine to start in cold condition. The choke controls the volume of air entering into the venturi. A second jet is fitted near the throttle butterfly, which is used when the engine is idling.

Fuel is delivered to the float chamber through fuel pipe either by gravity or by a pump. The float chamber is connected with the mixing chamber (venturi) via fuel nozzle equipped with fuel jet.

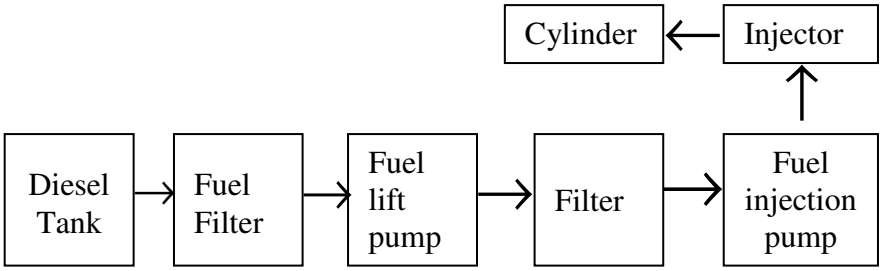
**Function of Carburettor:** The main functions of the carburettor are:

(i) To mix the air and fuel thoroughly
(ii) To atomise the fuel
(iii) To regulate the air-fuel ratio at different speeds and loads and
(iv) To supply correct amount of mixture at different speeds and loads.

**FUEL SYSTEM OF DIESEL ENGINE**

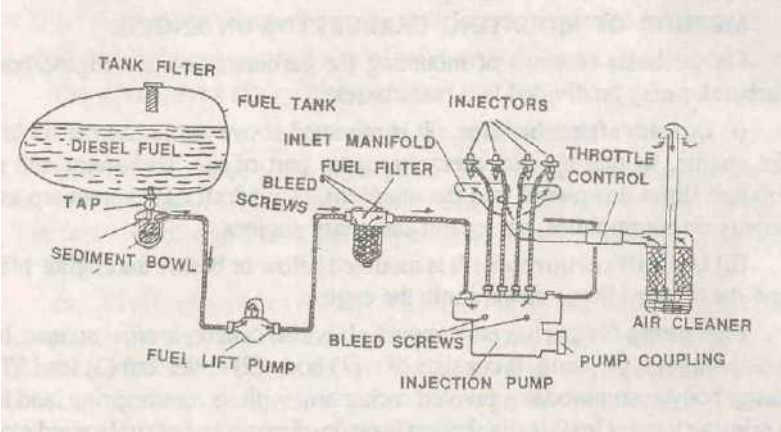
During engine operation, the fuel is supplied by gravity from fuel tank to the primary filter where coarse impurities are removed. From the primary filter, the fuel is drawn by fuel transfer pump and is delivered to fuel injection pump through second fuel filter. The fuel injection pump supplies fuel under high pressure to the injectors through high pressure pipes. The injectors atomise the fuel and inject it into the combustion chamber of the engine. The fuel injection pump is fed with fuel in abundance. The excess fuel is by-passed to the intake side of the fuel transfer pump through a relief valve.

The main components of the fuel system in diesel engine are: (1) fuel filter (2) fuel lift pump (3) fuel injection pump (4) atomisers and (5) high pressure pipe.




Flow diagram of fuel in diesel tractor

Two conditions are essential for efficient operation of fuel system: (i) The fuel oil should be clean, free from water, suspended dirt, sand or other foreign matter, (ii) The fuel injection pump should create proper pressure, so that diesel fuel may be perfectly atomised by injectors and be injected in proper time and in proper quantity in the engine cylinder. Fuel should be filtered before filling the tank also. If these precautions are followed, ninety per cent of diesel engine troubles are eliminated.




Layout of fuel supply in diesel engine

**FUEL LIFT PUMP (FEED PUMP OR TRANSFER PUMP)**

It is a pump, which transfers fuel from the fuel line to the fuel injection pump. It is mounted on the body of fuel injection pump. It delivers adequate amount of fuel to the injection pump. The pump consists of: (I) body (2) piston (3) inlet valve and (4) pressure valve. The valves are tightly pressed against their seats by springs. The piston is free to slide in the bore. The fuel contained in the space below the piston is forced to flow through secondary fuel filter to the injection pump. At the same time downward movement of the piston creates a depression in the space above the piston which, causes the fuel to be drawn in the transfer pump from the fuel tank through the inlet valve and the primary filter.

**FUEL INJECTING PUMP**

It is a pump, which delivers metered quantity of fuel to each cylinder at appropriate time under high pressure. Tractor engines may use two types of fuel injection pump:
(i) Multi-element pump and (ii) Distributor (Rotary) type pump.

**Fuel Injector**: It is the component, which delivers finely atomised fuel under high pressure to the combustion chamber of the engine. Modern tractor engines use fuel injectors, which have multiple holes. Main parts of injector are: nozzle body and needle valve. The nozzle body and needle valve are fabricated from alloy steel. The needle valve is pressed against a conical seat in the nozzle body by a spring. The injection pressure is adjusted by adjusting the screw.

**FUEL INJECTION SYSTEM**

Diesel fuel is injected in diesel engine through injectors with the help of fuel injection pump. The system using injectors, fuel injection pump, fuel filter, and fuel lines is called fuel injection system. The main functions of fuel injection system are:

(i) To measure the correct amount of fuel required by engine speed and load,
(ii) To maintain correct timing for beginning and end of injection,
(iii) To inject the fuel into the combustion space against high compression pressure.
(iv) To atomise the fuel for quick ignition.

Process of fuel injection in diesel engine is of two types: (i) Air injection (ii) Solid injection.

**Air injection:** In this process, the engine uses compressed air to force the fuel into the cylinder. It is a bulky system and hence it is not considered very suitable for vehicles and tractors. It is mostly used on heavy-duty stationary engines.

**Solid injection:** A high-pressure pump is used for forcing the fuel into the combustion chamber.

**COMBUSTION CHAMBER**

A combustion chamber is a space inside the engine, where the combustion of fuel takes place. In diesel engine, the fuel is atomised, vapourised and burnt inside combustion chamber, whereas in spark ignition engine, atomisation of fuel takes place in the carburettor and vaporisation occurs in carburettor as well as the inlet manifold. Combustion chamber is classified as:

(a) Direct injection chamber
(b) Indirect injection chamber

**TURBOCHARGER**

It is a turbo-compressor driven by the exhaust gases of the engine to supply air under pressure to the cylinders of the engine.

Turbocharger is useful because the power output of a diesel engine can be increased by supplying compressed air to the engine cylinders. If more air is delivered to the cylinders the fuel charge can also be increased and will release more energy.

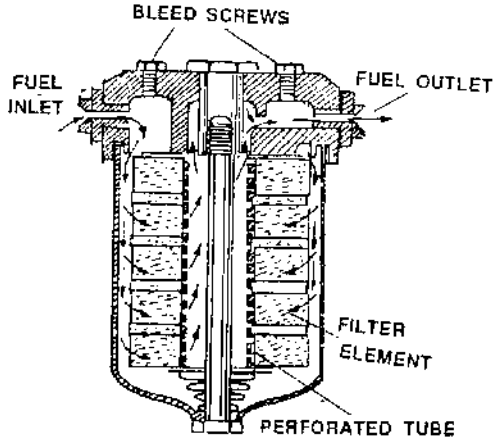
The turbocharger consists of a centrifugal compressor with impellers and a gas turbine unit. The compressor impeller and the turbine wheel are rigidly fixed on a common shaft. Compressor impeller draws air from the atmosphere and delivers it to the intake manifold and from there it goes to the engine cylinders thus improving the volumetric efficiency of the engine.

**FUEL FILTER**

It is a device to remove dirt from fuel oil. Solid particles and dust in diesel fuel are very harmful for giving a fine degree of filtration. Fuel injection equipment in diesel engines is extremely sensitive to dirt and solid particles present in fuel. A filter is used to remove the dirt and solid particles from the fuel to ensure trouble free fuel supply. It consists of a hollow cylindrical element contained in a shell, an annular space being left between the shell and the element. The filtering element consists of metal gauge in conjunction with various media such as packed fibres, woven cloth, felt, paper etc. These filters are replaced at certain intervals, specified by the manufacturer.

Usually there are two filters in diesel engine: (1) Primary filter and (2) Secondary filter.

The primary filter removes water and coarse particle of dirt from the fuel. The secondary filter removes fine sediments from the fuel.




Fuel filter for diesel engine

**IGNITION SYSTEM**

There are four different systems of igniting fuel: (a) Ignition by electric spark i.e. spark ignition (b) Ignition by heat of compression i.e. compression ignition (c) Ignition by hot tube or hot bulb and (d) Ignition by open flame. Only the first two are important methods for modern engines.

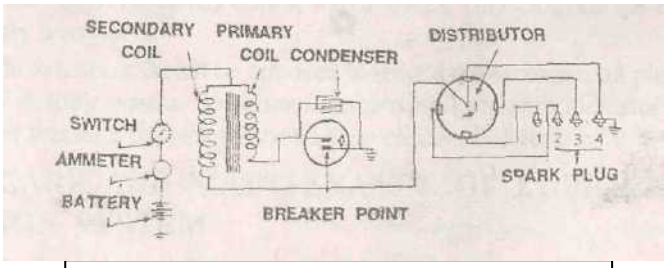
**SPARK IGNITION**

The purpose of spark ignition is to deliver a perfectly timed surge of electricity across an open spark plug gap in each cylinder at the exact moment so that the charge may start burning with maximum efficiency. There are two methods in spark ignition: (a) Battery ignition and (b) Magneto ignition.

**BATTERY IGNITION**

**Principle of working**: Battery ignition system includes two circuits: (i) Low voltage (primary circuit) and (ii) high voltage (secondary circuit). The low-voltage circuit consists of: (i) battery (ii) ignition switch (iii) a series register (iv) primary winding and (v) contact breaker. All are connected in series. The high voltage circuit consists of: (i) secondary winding (ii) distributor rotor (iii) high voltage wiring and (iv) spark plugs.

When the ignition switch is closed, current flows from the battery through the primary winding of the ignition coil, provided contact breaker points arc closed. They produce magnetic field around the winding. When the piston is at the end of compression stroke, the contact breaker point opens. Thus the flow of current in primary winding causes the magnetic field to collapse. As the field collapses, its lines of force cut the wire turnings of the secondary winding. This increases the voltage across the secondary winding terminals to a value of 20 to 24 thousand volts. The high-voltage surge is delivered to the centre terminal of the distributor cap where it is picked up by the rotor and directed to the proper spark plug. A spark jumps the plug gap and ignites the compressed air-fuel mixture.




Battery Ignition System

Ignition circuit: Ignition circuit gets electric current from the battery. When the distributor points are closed, low voltage current flows through the primary winding of the ignition coil to the distributor terminal and through the breaker points to the ground. A strong magnetic field is built up during this period of operation. When the distributor points are opened, the magnetic field in the coil starts collapsing. Thus a current is induced in the primary winding of the coil, which tends to prevent break down of the magnetic field A very high voltage is produced in the secondary winding due to sudden collapsing of the magnetic field. This high voltage makes the spark to jump across the gap of the spark plug.

**STORAGE BATTERY**

Storage battery is a device for converting chemical energy into electrical energy. There are several types of battery, but lead-acid battery is most common for I. C. engines, used for tractors and automobiles.

A battery consists of: (i) Plates (ii) Separators (iii) Electrolyte (iv) Container and (v) Terminal wire.

**GOVERNOR**

Governor is a mechanical device designed to control the speed of an engine within specified limit used on tractor or stationary engines for:

(i) Maintaining a nearly constant speed of engine under different load conditions
(ii) Protecting the engine and the attached equipments against high speeds, when the load is reduced or removed.

Tractor engines are always fitted with governor. There is an important difference in principle between the controls of a tractor engine and that of a motor car. In case of motor car, the fuel supply is under direct control of the accelerator pedal, but in tractor engine, the fuel supply is controlled by the governor. The operator changes the engine speed by moving the governor control lever.

A governor is essential on a tractor engine for the reason *that* load on the tractor engine is subjected to rapid variation in the field and the operator cannot control the rapid change of the engine speed without any automatic device. For example, if the load on the tractor is reduced, the engine would tend to race suddenly. If the load is increased, the engine would tend to slow down abruptly. Under these circumstances, it becomes difficult for the operator to regulate always the throttle lever to meet the temporary changes in the engine load. A governor automatically regulates the engine speed on varying load condition and thus the operator is relieved of the duty of constant regulating the throttle lever to suit different load conditions.