Lecture No – 4 and 5 I.C. engine systems

Fuel supply system, cooling system, Air cleaner, lubrication of tractor

Ex. No.4 Study of Fuel supply systems for S. I. engines

Ex. No.5 Study of Fuel supply systems for C. I. engines

Ex. No.6 Study of Air Cleaning and Cooling systems of an engine

Ex. No.7 Study of Lubrication system

Ex. No.4 Study of Fuel supply systems for S. I. Engines

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.

PROPERTIES OF FUEL

SR. No.	Name of fuel oil	A. P. I. degree	Specific Gravity	Calorific value kcal/kg
1	Light diesel oil (L.D.O.)	22	0.920	10300
2	High speed diesel oil (HSD)	31	0.820	10550
3	Power kerosene	40	0.827	10850
4	Petrol	63	0.730	11100

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.

1. Volatility of the fuel: It is the vaporizing ability of a fuel at a given temperature.

2. 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. Calorific values (kcal/kg) of different fuels are as follows:

1) Petrol – 11,100 (highest)

2) Power kerosene – 10,850

3) High speed diesel oil (HSD oil)- 10,550

4) Light diesel oil (LDO oil) – 10,300

3. 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.

Octane number measures *knock characteristics of fuels.*

Cetane number is the relative measure of the interval between the beginning of injection and auto-ignition of the fuel.

Octane number: *It is a measure of knock characteristics of a fuel. The percentage of iso-octane (C8 H18)* in the reference fuel consisting of a mixture of iso-octane and normal heptane (C7H16), when it produces the same knocking effect as the fuel under test, is called octane number of the fuel.

Cetane number : Cetane number is the relative measure of the interval between the beginning of injection and auto-ignition of the fuel. The higher the cetane number, the shorter the delay interval and the greater its combustibility.

Fuels with low Cetane Numbers will result in difficult starting, noise and exhaust smoke.

Detonation: Detonation or engine knocking refers to violent noises heard in an engine during the process of combustion after the piston has passed over the TDC.

Pre-ignition: Burning of air-fuel mixture in the combustion chamber before the piston has reached the TDC is called pre-ignition.

Fuel supply systems in S. I engines:
The fuel supply system of spark ignition engine consists of

1. Fuel Tank
2. Sediment Bowl
3. Fuel Lift Pump
4. Carburetor and
5. Fuel pipes

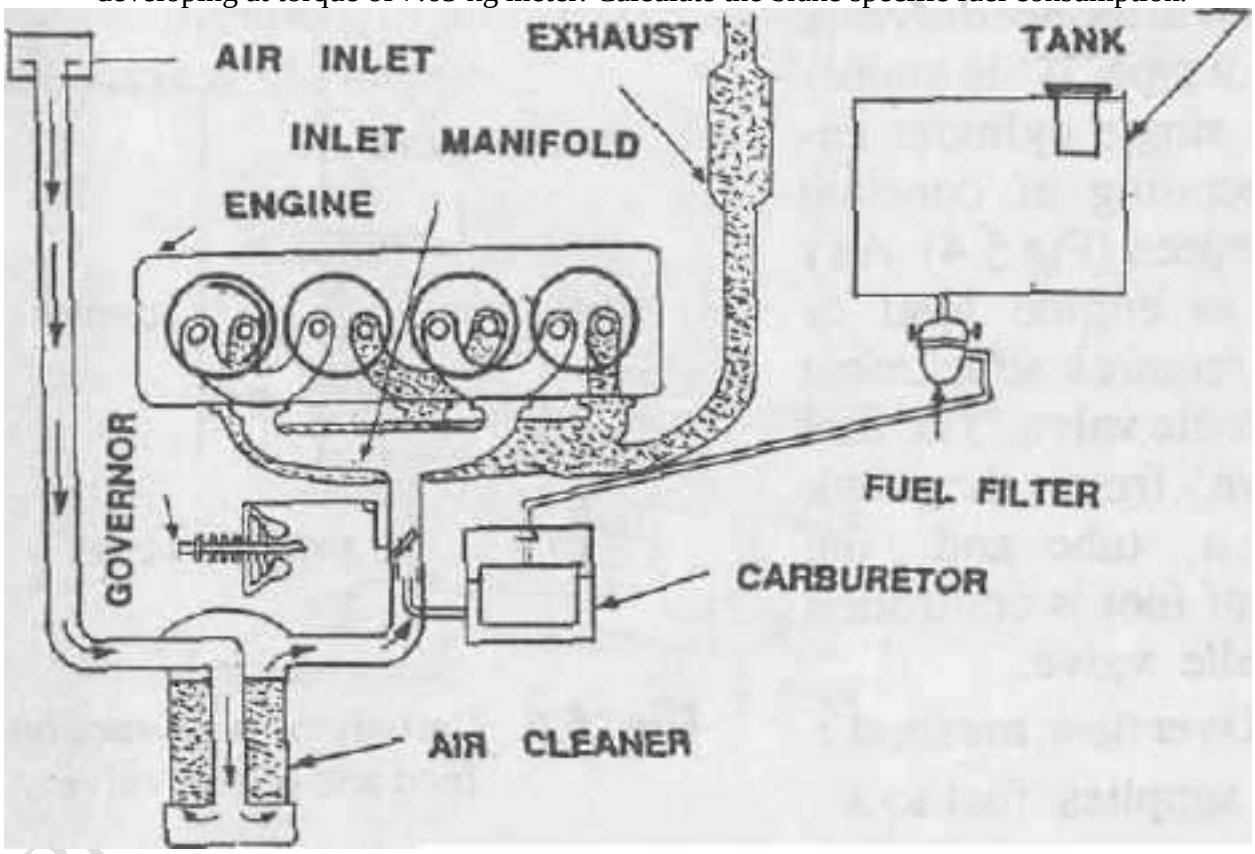
In some spark ignition engine, the fuel tank is placed above the level of the carburetor. The fuel flows from the fuel tank to the carburetor under the action of gravity. There are one or two filters between the fuel tank and the carburetor. A transparent sediment bowl is also

provided to the hold the dust and dirt of the fuel. If the tank is below the level of the carburetor, a lift pump is provided in between the tank and the carburetor for forcing fuel from the tank to the carburetor 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 carburetor through suitable pipe. From the carburetor, the fuel goes to the engine cylinder through the inlet manifold of the engine.

Carburetor: 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 takes place is called carburetor.

Problems

1. An internal combustion engine consumer high speed diesel oil at the rate of 0.5 kg per hour. Calculate the power in terms of kilo watt.
2. A four stroke diesel engine operating at 800 r.p.m. user 0.11 kg of fuel in 4 min. While developing at torque of 7.65 kg meter. Calculate the brake specific fuel consumption.



FUEL SUPPLY SYSTEM IN SPARK IGNITION ENGINE

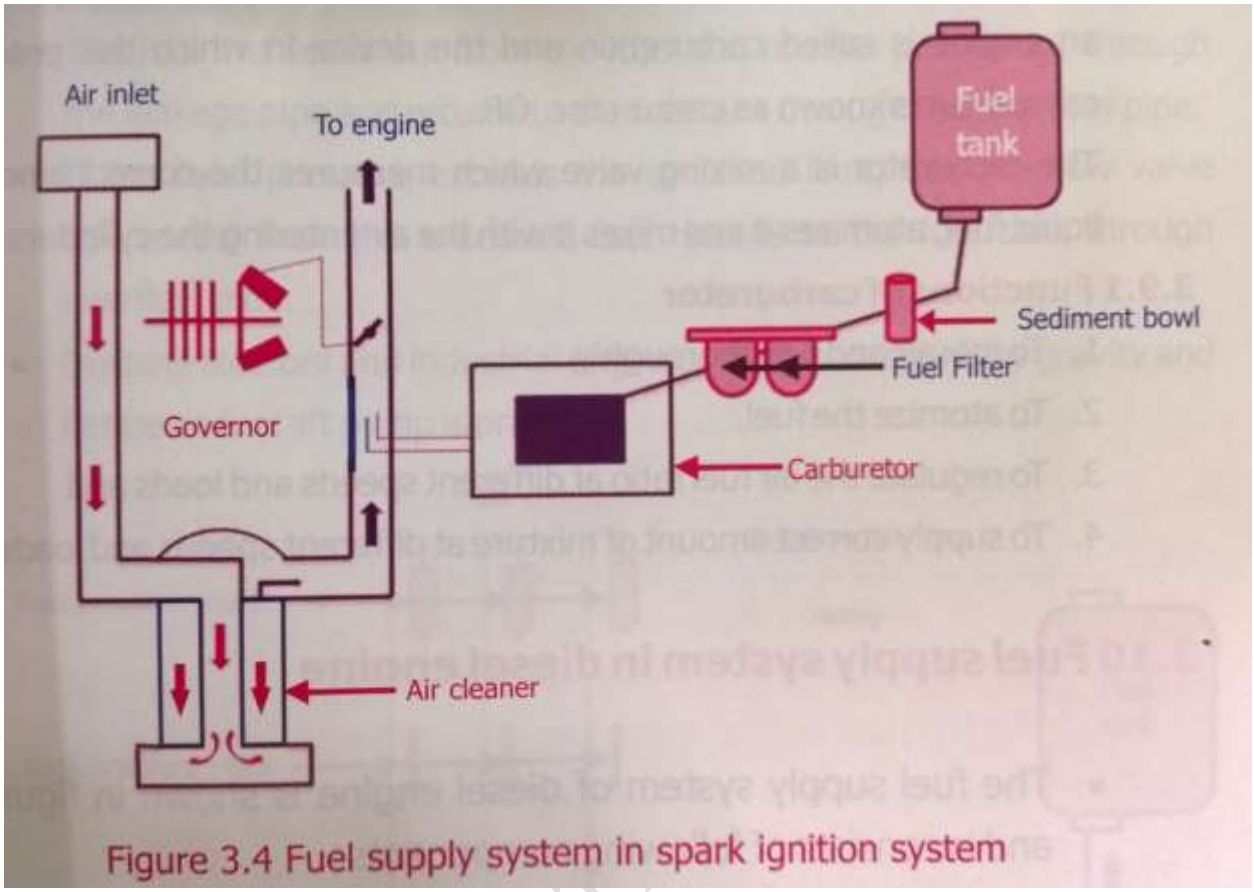


Figure 3.4 Fuel supply system in spark ignition system

Components of fuel supply system in spark ignition engine

1. Fuel tank :

- To store sufficient quantity of fuel.
- Made up of mild steel or galvanized steel.
- It has inlet & outlet.
- It is provided with vent.
- It is not air tight.

2. Sediment bowl :

- It is glass or aluminum cup used to remove heavier dust particles from fuel.

3. Fuel feed pump :

- To lift the fuel from the tank and supply to the carburetor, it is provided with plunger type hand primer to supply fuel to the filter before starting of engine or to bleed the air from the system.

3. Fuel feed pump :

Types : (i) Mechanical fuel feed pump :

(a) Plunger,

(b) Diaphragm type

(c) Gear type

(ii) Electrical fuel feed pump

4. Primary filter : To remove coarser particles of dust.

5. Secondary filter : To remove fine dust particles from fuel.

Combination of both is known as two stage filter.

Types of filter :

(a) Cloth & felt element filter

(b) Cartridge filter: Specially fitted cotton nodules or stock of filter papers.

(c) Metal filter : Porous metal as filtering element

***Carburetor*: The process of preparing air-fuel mixture away from the engine cylinder is called *carburetion*. and the device in which this process takes is called *carburetor*.**

Functions of carburetor:

1. To mix the air and fuel thoroughly.

2. To atomize the fuel

3. To regulate the air- fuel ratio at different speeds and loads on the engine.

4. To supply correct amount of mixture at different speeds and loads

Components of Carburetor:

1. Float chamber with float: It is the fuel reservoir which maintains the constant level of fuel in the carburetor with the help of float.

2. Venturi: It is provided to produce low pressure in the throat of the carburetor and high velocity of air flow. This affect suction of fuel through main jet, which is situated in the middle of the venturi, where velocity is maximum and pressure is minimum.

3. Throttle : It is a butter fly valve, fitted in between the mixing chamber of carburetor and inlet manifold of the engine to regulate the air fuel mixture at different speed and load. . It may be operated by hand lever, a foot lever or a governor.

4. Choke: A second butterfly valve called choke is used to provide a richer mixture for the engine to start in cold condition. It controls the volume of air entering into the venturi.

It is generally used at the time of starting to supply rich mixture, for easy start.

5. Main je : It discharges fuel, in the throat of the carburetor, in the form of spray. It receives the fuel directly from the float chamber.

6. Idling jet: It is placed on the manifold side of the throttle. It supplies fuel at idling speed or low speed only. Its level being higher than the main jet,in normal conditions.

7. Compensating jet: It supplies lean mixture at high speed when main jet tends to supply rich mixture. *This helps to maintain correct proportion of air-fuel at different loads and speeds.*

8. Economizer: *It is a device use for regulating supply in the main jet.*

Problems

1. An internal combustion engine consumes high speed diesel oil at the rate of 0.5 kg per hour. Calculate the power in terms of kilo watt.

Heat value = quantity (kg/h) x calorific value (kcal/kg)

(Take calorific value of HSD= 10550kcal/kg)

= 0.5 x 10550

= 5275 kcal/h

1 calorie = 4.2 joules

1 joules/ sec = 1 watt

5275 kcal/h = 5275 x 1000 cal/h = 5275 x 1000/(60 x60)

=1465.278 cal/ sec

=1465.278 x 4.2 = 6154.167 watts

=6154.167/1000 kW

Power of engine = 6.15 kW = 8.24HP

1 HP = 745.699872 watts = 0.745699872 kW

2. A four stroke diesel engine operating at 800 r.p.m. user 0.11 kg of fuel in 4 min. While developing at torque of 7.65 kg meter. Calculate the brake specific fuel consumption.

N= 800 rpm T= 7.65 kg meter

Power $PS = \frac{2\Pi \times 800 \times 7.65}{60 \times 75} = 8.55 =$ $PS = \frac{2\Pi \times N \times T}{60 \times 75} = 8.55$

$$BSFC = \frac{0.11 \times 60}{4 \times 8.55} = 0.193$$

$$BSFC = 0.193 Kg \ per \ bhp/hr$$

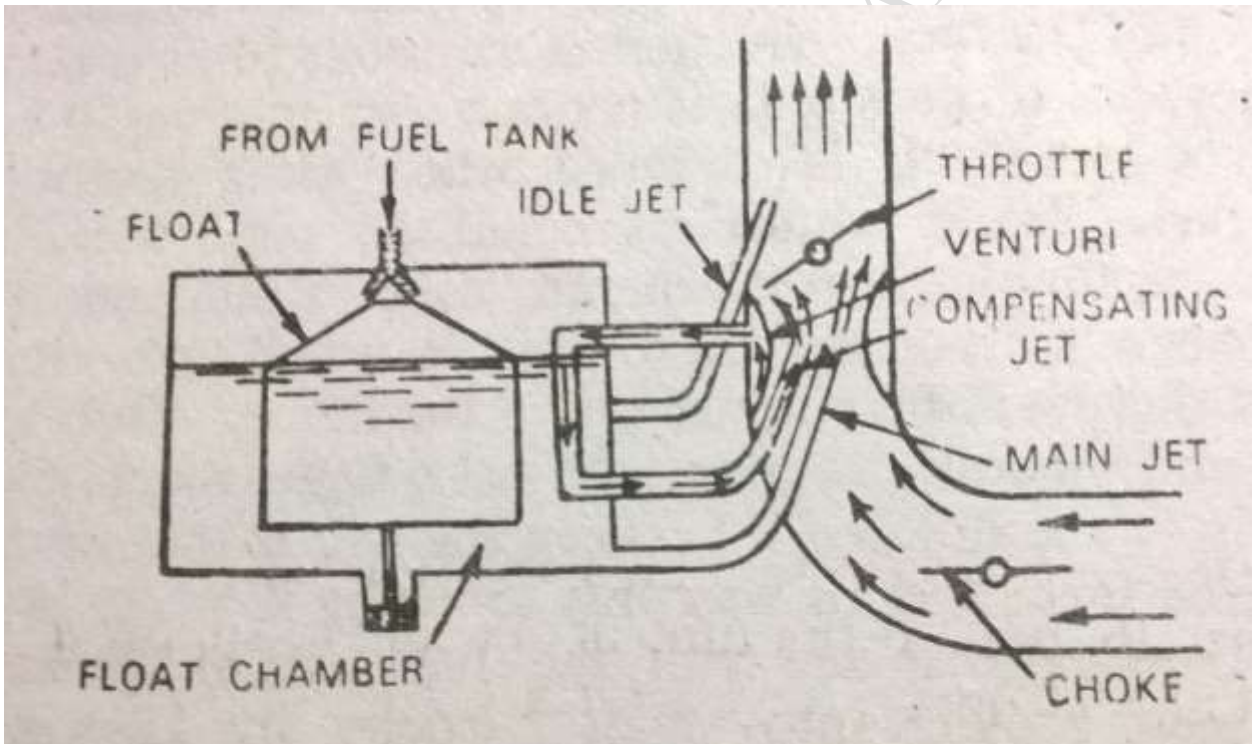


Fig. 4.2—Principles of Operation of a Carburetor.

Exercise No. 5 : Study of Fuel supply systems for C. I. Engines

Fuel supply system of C.I. 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 injection atomize 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. Atomizers and
5. High pressure pipe

The fuel lift pump lifts the fuel from the tank to the fuel injection pump. Usually the fuel goes from the fuel tank to the first filter, then to fuel lift pump, then to second filter, then to fuel injection pump and then to the atomizers. On some tractors and industrial engines, the fuel system is by gravity and hence no fuel lift pump is provided.

Two conditions are essential for efficiency 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 atomized 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.

Fuel Lift Pump (Feed Pump or Transfer Pump)

It is a pump which transfers fuel from the 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

1. Body
2. Piston
3. Inlet valve and
4. Pressure valve

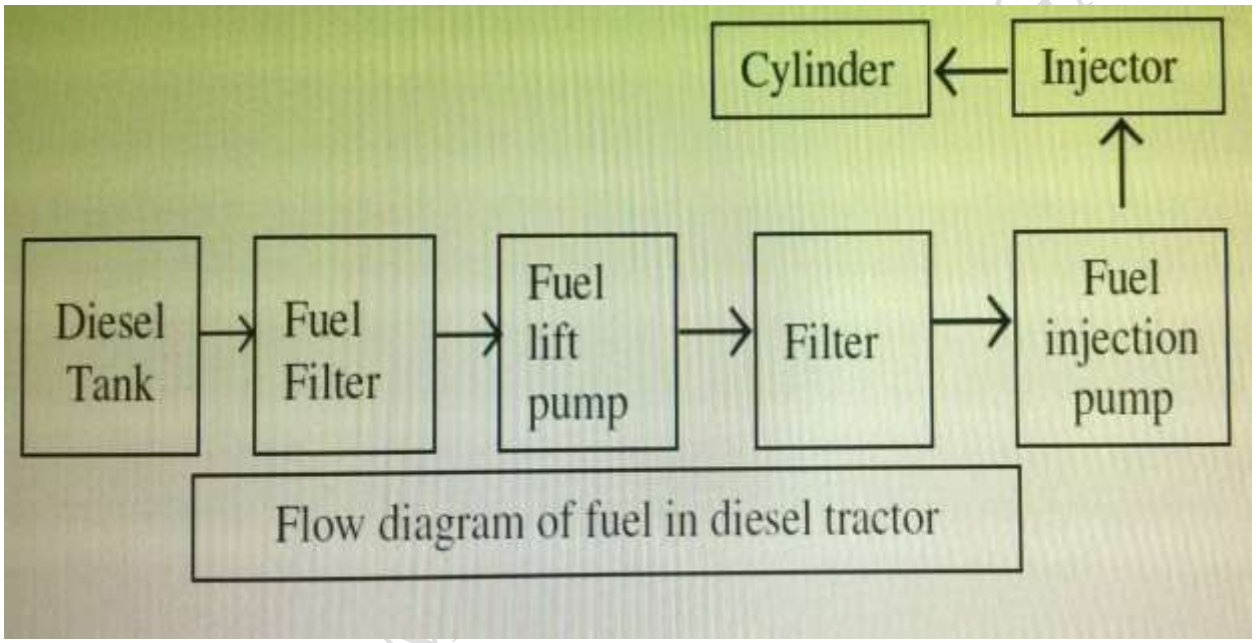
The valves are tightly pressed against their seats by springs. The piston is free to slide in the bore. The fuel contained in the space below the piston is forced to flow through secondary fuel

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 Injection 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.



Flow diagram of fuel in diesel tractor

Fuel supply system in diesel engine/SI engine :

The flow chart

Fuel tank

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Sediment bowl

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Primary filter

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Fuel feed pump

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Secondary filter

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Fuel Injection pump

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Injector (Air + Fuel mixture)

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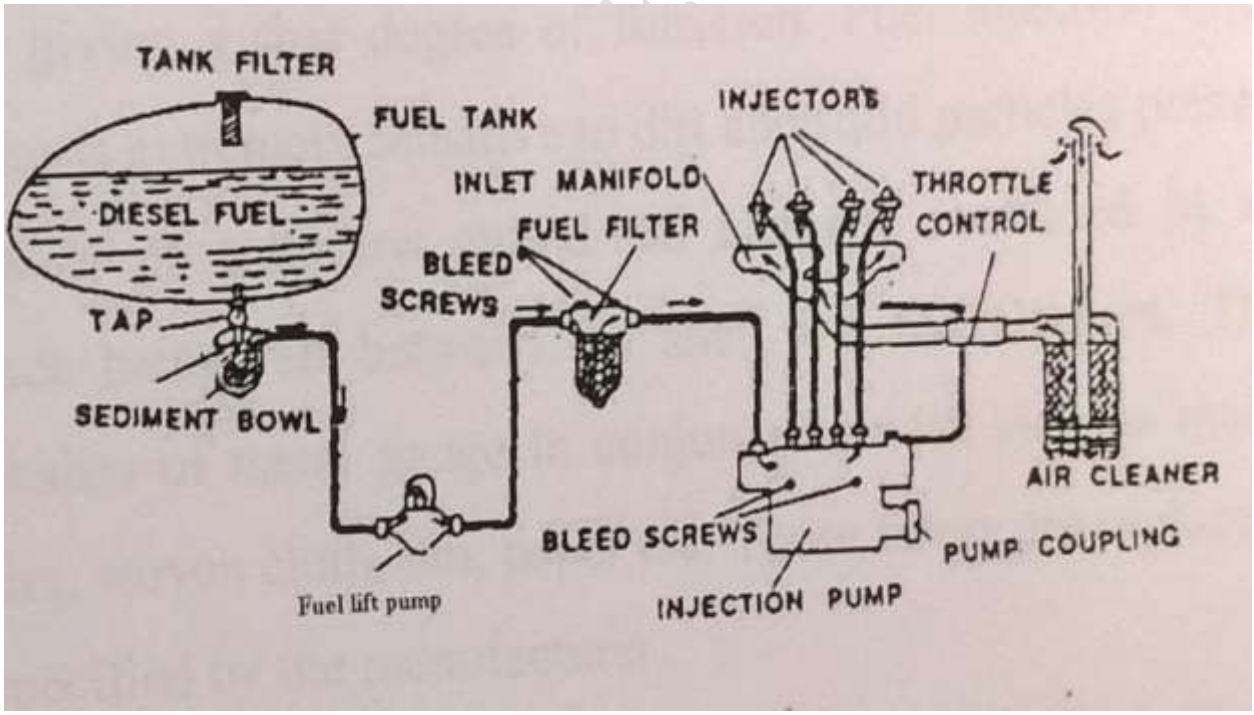
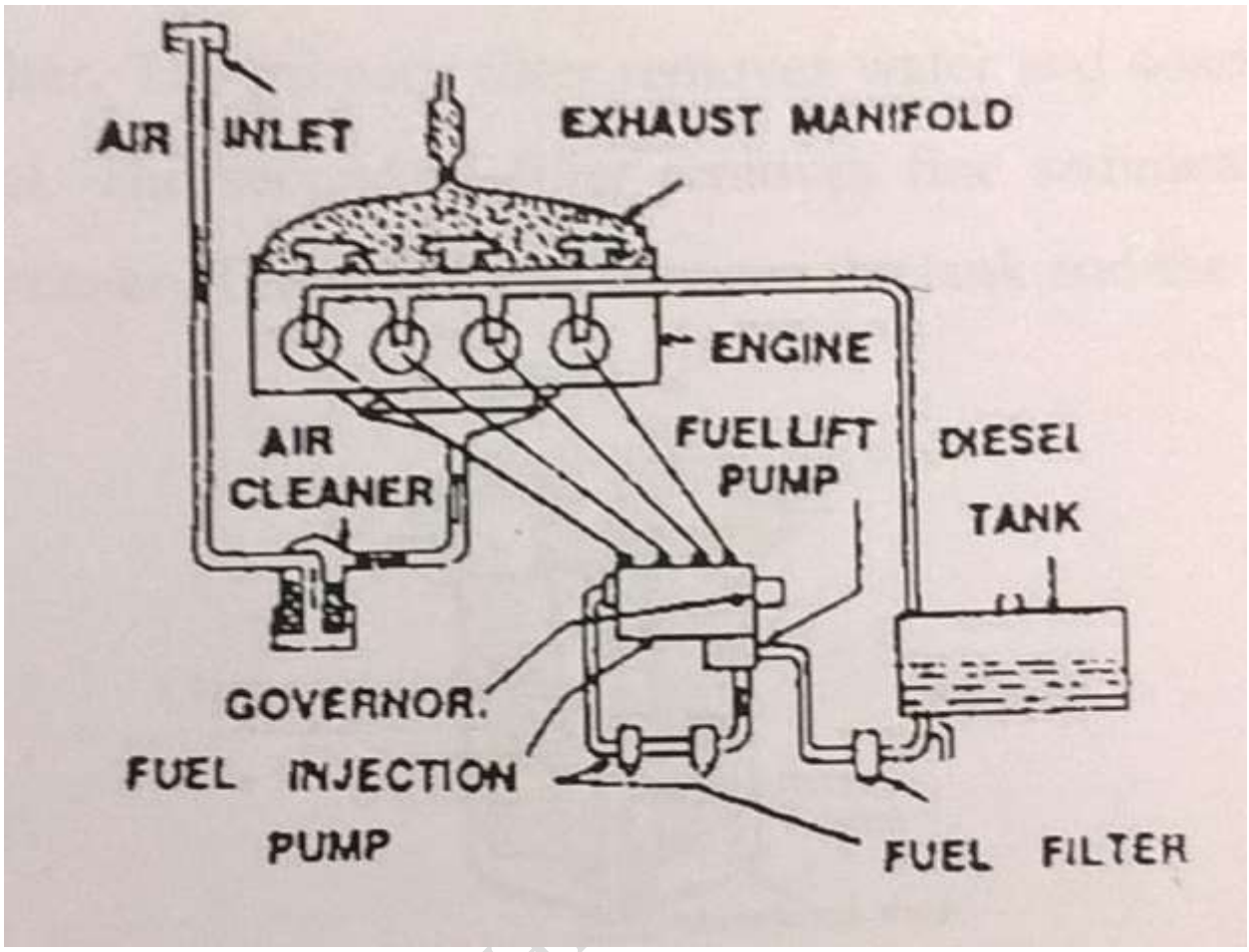
Inlet manifold



General Layout of Fuel Supply System of Compression Ignition Engine



Fuel Supply System in the Diesel Engine

Injector:It is the device which injects the fuel in to the combustion chamber. It is also called as atomizer or sprayer. Injector pump supply the fuel to the injector through valve and then pipe to the nozzle. The nozzle is provided at the end of injector. The nozzle sprays the fuel in the form of fine spray or mist by fuel pressure. It converts the pressure energy of fuel in to kinetic energy.

Fuel filter for diesel engine: 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 filtering 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.

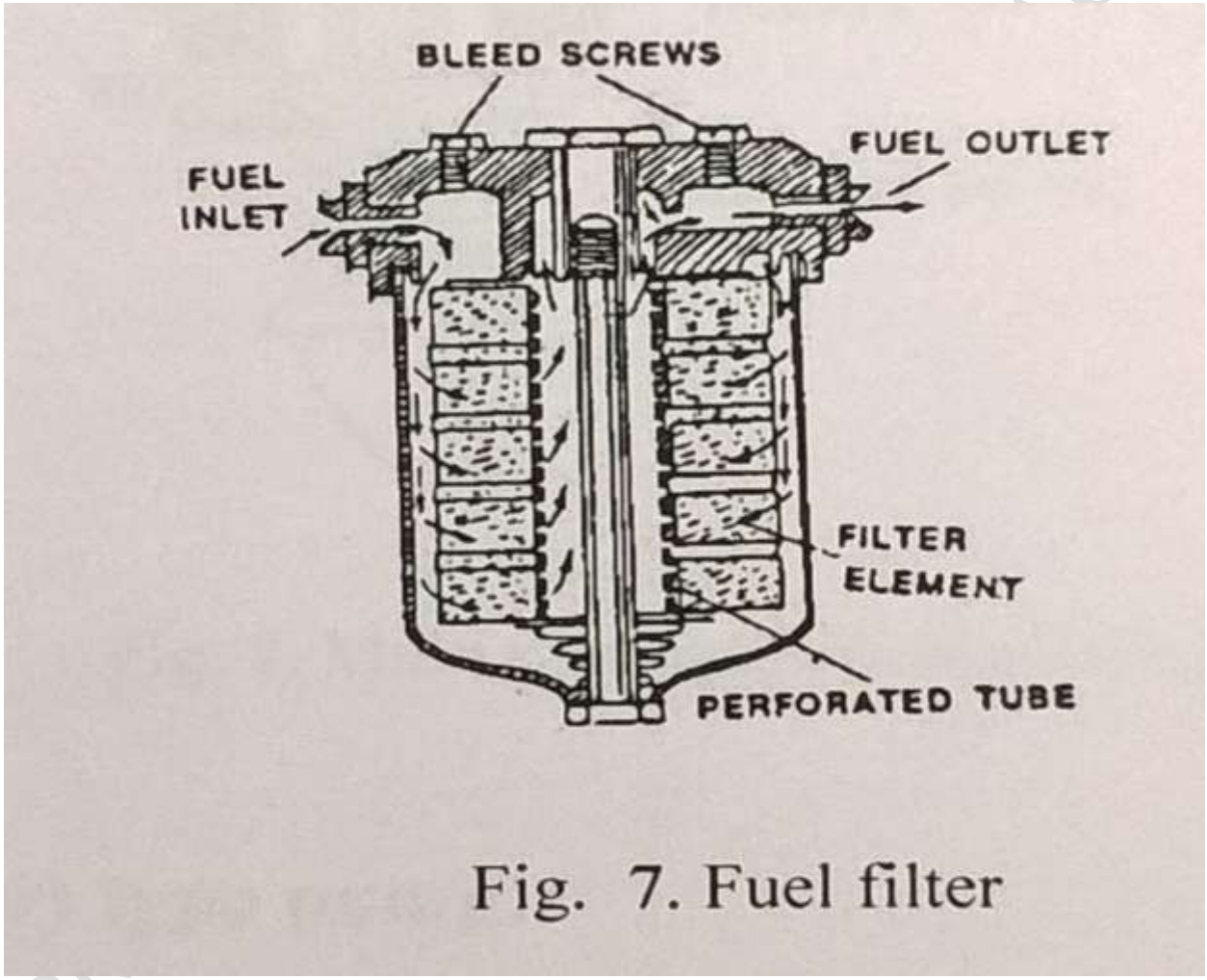


Fig. 7. Fuel filter

Exercise No. 6 Study of Air Cleaning and Cooling systems of an engine

Cooling System

A system which controls the engine temperature is known as cooling system.

Necessity of Cooling:

i. The temperature of the burning gases in the cylinder reaches upto 1500 to 2000 ^{O}C, which results in expansion, wear and tear of cylinder.
ii. Due to very high temperature the film of lubricating oil will get oxidized. This will result in piston deterioration.
iii. Large temperature difference may results in distortion of engine components.
iv. Higher temperature also lowers the volumetric efficiency of engine.

For satisfactory performance of engine, it should neither be overheated nor over cooled. Experiments have shown that petrol engine operates best at 180^{O}F, kerosene engine at 200^{O}F and diesel engine at 140^{O}F to 165^{O}F.

Purpose of cooling:

(i) To maintain optimum temperature of engine for efficient operation under all conditions.

(ii) To dissipate surplus heat for protection of engine components like cylinder, cylinder head, piston, piston rings and valves.

(iii) To maintain the lubricating property of the oil inside the engine cylinder for normal functioning of the engine.

Methods of Cooling

i. Air cooling
ii. Water Cooling

Air Cooling:

Air-cooled engines are those engines, in which heat is conducted from the working components of the engine to the atmosphere directly. In such engines, cylinders are generally not grouped in a block.

Principle of Air Cooling:

The cylinder of an air-cooled engine has fins to increase the area of contact of air for speedy cooling. The cylinder is normally enclosed in a sheet metal casing called cowling. The flywheel has blades projecting from its face, so that it acts like a fan drawing air through a hole in the cowling and directing a around the finned cylinder. For maintenance of air cooling system, passage of air is kept clean by removing grasses etc. This is done by removing the

cowling and cleaning out the dirt etc. by a stiff brush or compressed air. When separate fan is provided the belt tension is to be checked and adjusted if necessary.

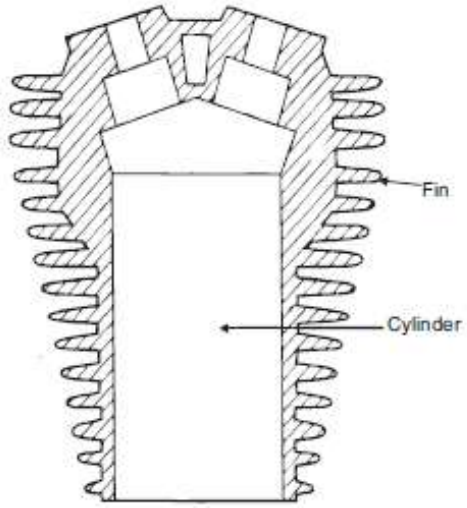
Advantages of Air Cooled Engine.

i. It is simpler in design and construction.
ii. Water jackets, radiators, water pump thermostat, pipes, houses etc. are not needed.
iii. It is more compact.
iv. It is comparatively lighter in weight.

Disadvantages:

i. There is uneven cooling of the engine parts.
ii. Engine temperature is generally high during working period.

Finned Engine Cylinder



Water Cooling: Engine, using water as cooling medium is called water-cooled engines. The liquid is circulated round the cylinders to absorb heat from the cylinder walls. In general, water is used as cooling liquid.

The heated water is conducted through a radiator which helps is cooling the water.

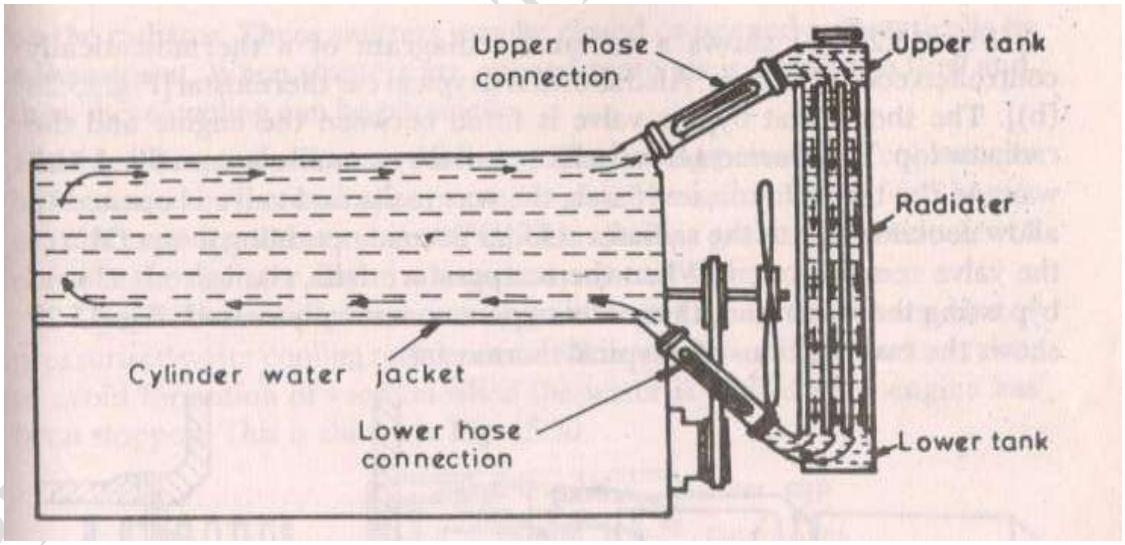
There are three common methods of water-cooling:

i. Open jacket or hopper method.
ii. Thermosiphon method.
iii. Forced circulation method.

i) Open jacket or hopper method: This also works on the same principle as the thermo-siphone system. In this there is a hopper on a jacket containing water, which surrounds the engine cylinder. In this system, as soon as water starts boiling, it is replaced by cold water. An engine fitted with this system cannot run for several hours without it being refilled with water.

Thermosiphon Method:

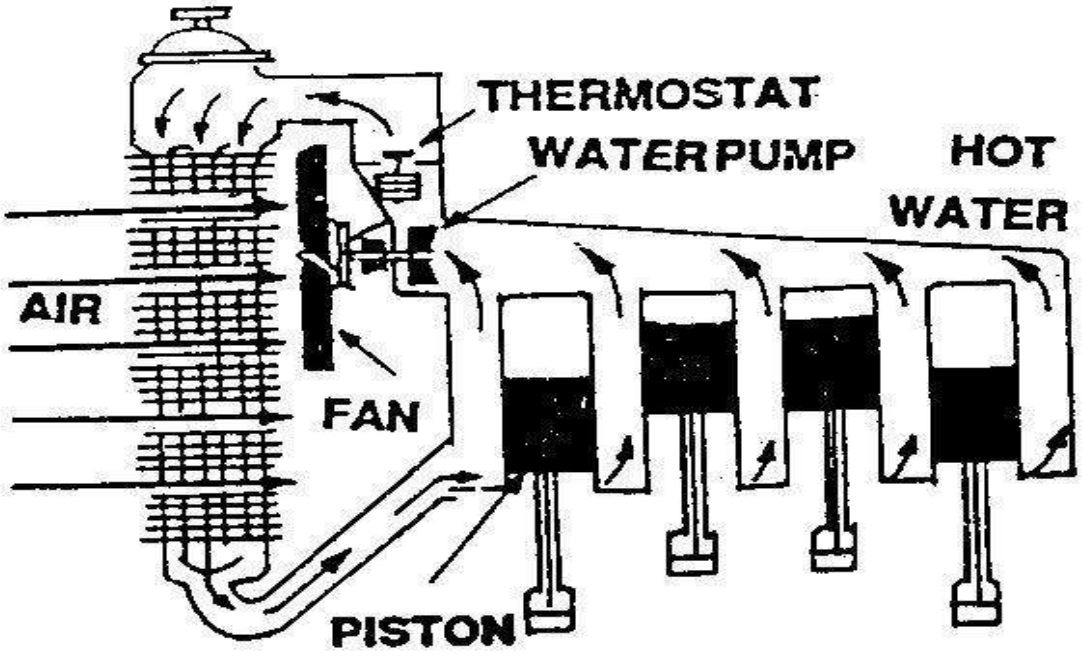
It consists of radiator, water jacket, fan, and temperature gauge and hose connections. The system is based on the principle that heated water which surrounds the cylinder becomes lighter in weight and it rises upwards in liquid column. Hot water goes to the radiator, where it passes through tubes surrounded by air. Circulation of water takes place due to the reason that water jacket and the radiator are connected at both sides i.e. at the top and the bottom. A fan is driven with the help of a v-belt to suck air through tubes of the radiator unit, cooling radiator water. The disadvantage of the system is that circulation of water is greatly reduced by accumulation of scale or foreign matter in the passage and consequently it causes overheating of the engine.



Forced Circulation Method:

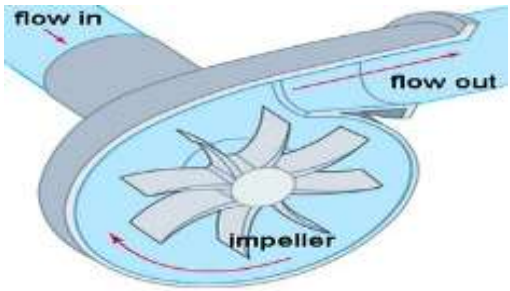
In the method, a water pump is used to ford water from the radiator to the Water jacket of the engine. After circulating the entire run of water jacket, water comes back to the radiator where it loses its heat by the process of radiation. To maintain the correct engine temperature, a thermostat valve is place at the outer end of cylinder head. Cooling liquid is by-passed through

the water jacket of the engine until the engine attains the desired temperature. Then thermostat valve opens and the by-pass is closed, allowing the water to go to the radiator. The system consists of: (1) Water pump (2) Radiator (3) Fan (4) Fan-belt (5) Thermostat valve (7) Temperature gauge (8) Hosepipe.



Water Pump:

It is a centrifugal type pump. It has a casing and an impeller, mounted on a shaft. The casing is usually made of cast iron. Pump shaft is made of some non-corrosive material. At the end of the shaft, a small pulley is fitted which is driven by a V-belt. Water pump is mounted at the end of the cylinder block between block and the radiator. When the impeller rotates, the water between the impeller blades is thrown outward by centrifugal force and thus water goes to the cylinder under pressure. The pump outlet is connected by a hosepipe to the bottom of the radiator. The impeller shaft is supported on one or more bearings. There is a seal, which prevents leakage of water.



Radiator:

Radiator is a device for cooling the circulating water in the engine. It holds a large volume of water in close contact with a large volume of air, so that heat is transferred from the water to the air easily.

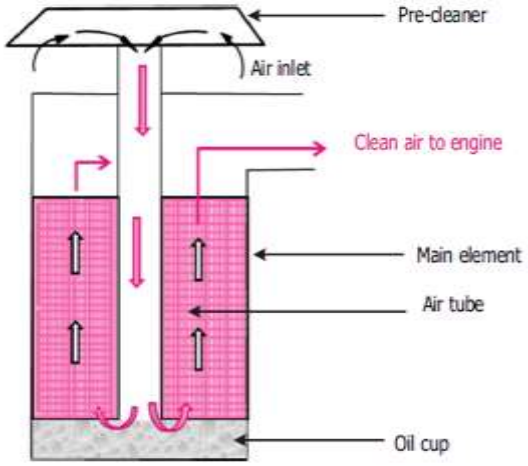
Hot water flows into the radiator at the top and cold water flows out from the bottom. Tubes or passages carry the water from the top of the radiator to the bottom, passing it over a large metal surface. Air flows between the tubes or through the cells at right angles to the downward flowing water. This helps in transferring the heat from the water to the atmosphere. On the basis of fabrication, the radiator is of two types: (a) Tubular type and (b) Cellular type.

Air cleaner: It is a device which filters and removers dust, moisture and other foreign matter from the air before it reaches the engine cylinder.

Air cleaner is usually of two types: 1Dry type air cleaner and 2. Oil bath type air cleaner

1. Dry type air cleaner: The filtering element in this case is a type of felt. The air passes through the element. The element has got larger surface area so the air speed becomes relatively low and consequently particle or dirt in the air is deposited on or stopped by its surface.

2. Oil bath type air cleaner: In this type of air cleaner, this incoming air impinges upon the surface of the oil, kept in a container in the lower part of the casing. The foreign particles of the air are trapped in the oil and then the air passes through a wire element before reaching the inlet manifold of the engine. The wire element also arrests the remaining dirt particles of the air.



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Exercise No. 7: Study of Lubrication system

I.C. engine is made up of many moving parts. The continuous movement of two metallic surfaces over each other, there is wearing of parts, generation of heat and loss of power in engine and hence lubrication is must to prevent all these harmful effects.

Types of Lubricants

i) Animal Lubricants

These are obtained from animal fat. Animal fat does not stand much heat, it becomes waxy and gummy which is not suitable for machines. Also it freeze at lower temperature hence not used.

ii) Vegetable oils

Source of these are oil seed, fruits and plants. They get oxidized very easily. Castor oil has some application on slow moving parts of farm machine.

iii) Mineral lubricants

These are obtained from crude petroleum. This group of lubricants is available in the form of oils and greases. They are the major source to meet the lubrication requirements of the engines and farm machines.

Qualities of good lubricants

i) It should have sufficient viscosity to keep rubbing surface a-part.

ii) It should remain stable under changing temperature

iii) It should keep lubricated parts clean

iv) Its should not erode metallic surfaces

Purpose of Lubrication

a) Reducing friction effect

The primary purpose of the lubrication is to reduce friction and wear between tow rubbing surfaces. It also reduces noise produced by the movement of two metal surface over each other.

b) Cooling effect

The heat generated by piston, cylinder and bearings is removed by lubrication. Lubrication creates cooling effect on the engine parts.

c) Sealing effect

The lubricant enters into the gap between cylinder liner, piston and piston rings. Thus it prevents leakage of gases from the engine cylinder.

d) Cleaning effect

Lubrication keeps the engine clean by removing dirt or carbon from inside of the engine.

Engine Lubricating System

The lubricating system of an engine is an arrangement of mechanism and devices which maintains supply of lubricating oil to the rubbing surface of an engine at correct pressure and temperature.

The parts, which require lubrication, are:

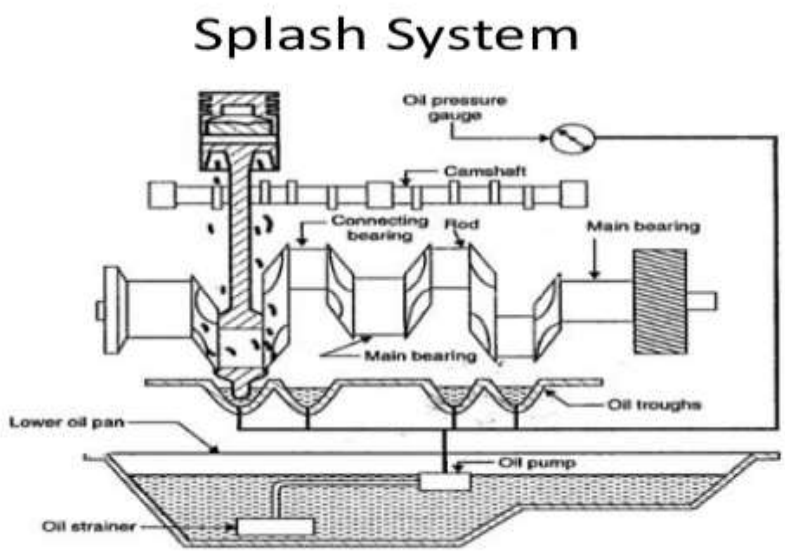
(i) Cylinder walls and piston.
(ii) Piston pin.
(iii) Crankshaft and connecting rod bearings.
(iv) Camshaft bearing.
(v) Valves and valve operating mechanism.
(vi) Cooling.
(vii) Water pump and.
(viii) Ignition mechanism.

There are three common systems of lubrication used on stationary engines, tractor engines and automobiles:

Splash system (ii) forced feed system and (iii) Combination of splash and forced feed system.

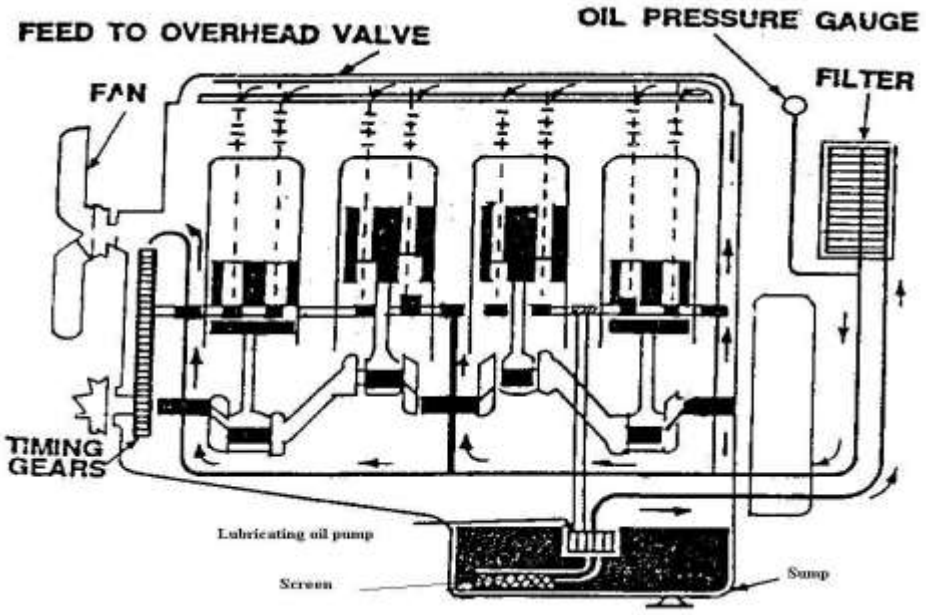
1. Splash System

In this system there is an oil trough, provided below the connecting rod. Oil is maintained at a uniform level in the oil trough. This is obtained by maintaining a continuous flow of oil from the oil sump or reservoir into a splash pan. This pan receives its oil supply from the oil sump either by means of a gear pump or by gravity. The dipper is provided at the lower end of the connecting rod which splashes oil out of the pan. The splashing action of oil maintains a fog or mist of oil providing lubrication to inner parts of engine. This system is usually used on single cylinder engine with closed crankcase.



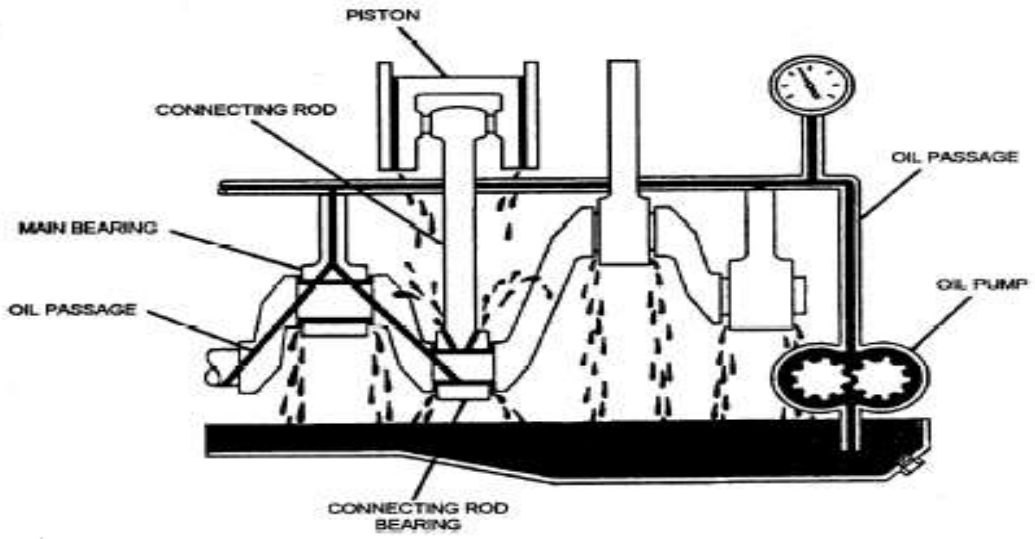
2. Forced feed system

In this system the oil is pumped directly to the crankshaft, connecting rod, piston pin, timing gears and camshaft through suitable paths of oil. Usually the oil first enters the pipes in the crankcase through a positive displacement pump. From this pipe it goes to big end bearing of connecting rod. From there it goes to lubricate the walls, piston and rings. From separate pipe to lubricate timing gears. The excess oil comes back from the cylinder head to the crankcase. The system is commonly used on high speed multi-cylinder engine in tractors, trucks and automobiles.



Combination of Splash and Forced Feed System:

In this system, the engine component, which are subjected to very heavy load are lubricated under forced pressure, such as main bearing, connecting rod bearing and camshaft bearing. The rest of the parts like cylinder liners, cams, tappets etc. are lubricated by splashed oil.

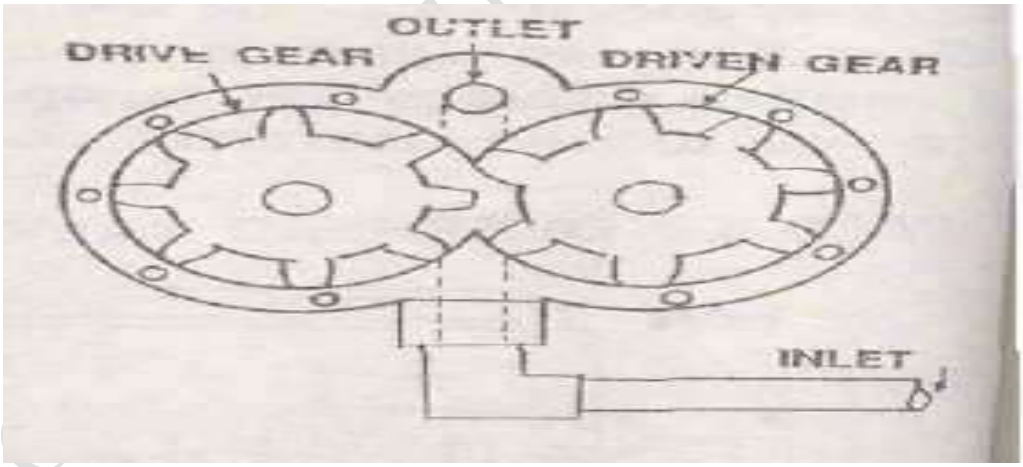


Care and Maintenance of Lubrication System

The following are few suggestions for good lubrication system

1. A good design of oil circulation system should be chosen
2. Correct grade of lubricant ensures long and trouble free service.
3. Oil should be maintained at desired level in the oil chamber
4. Oil should be cleaned regularly and after specified period of use, old filters should be replaced by new filters.
5. Connections, pippins, valves and pressure gauge should be checked regularly.
6. Oil should be changed regularly after specified interval of time. Before putting the new oil, the crankcase should be cleaned and flushed well with flushing oil.
7. Precautions should be taken to keep the oil free from dust and water.

Oil pump: Oil pump is usually a gear type pump, used to force oil into the oil pipe. The pump is driven by the camshaft of the engine. The lower end of the pump extends down into the crankcase which is covered with a screen to check foreign particles. A portion of the oil forced to the oil filter and the remaining oil goes to lubricate various part of the engine. An oil pressure gauge fitted in the line, indicates the oil pressure in the lubricating system. About 3 kg/sq cm (45 psi) pressure is developed in the lubrication system of a tractor engine, If the oil pressure gauge indicates no pressure in the line, there is some defect in the system which must be checked immediately. Lubricating oil pump is a positive displacement pump.

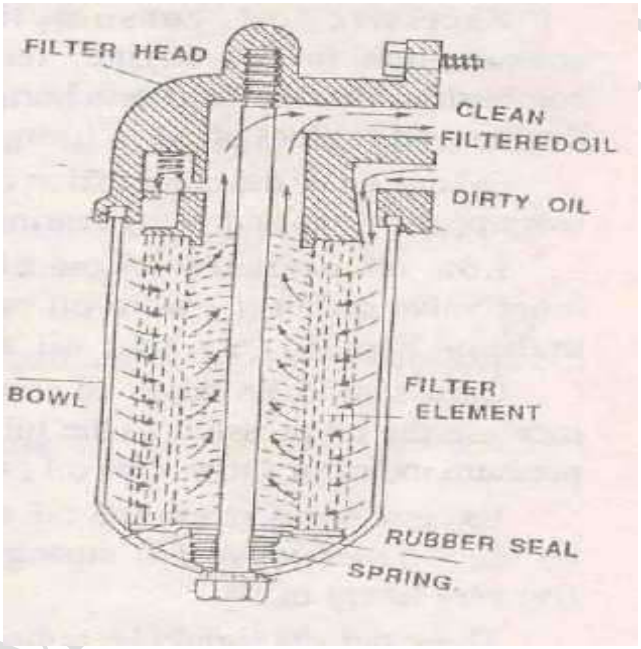


OIL FILTER: Lubricating oil in an engine becomes contaminated with various materials such as dirt,metal particles and carbon. Oil filler removes the dirty elements of the oil in an effective way. It is a type of strainer using cloth, paper, felt, wire screen or similar elements .Some oil filter can be cleaned by washing, but in general old filters are replaced by new filters at specified interval of time prescribed by manufacturers. Wearing of parts, oil consumption and operating

cost of an engine can be considerably reduced by proper maintenance of oil filters. Oil filters are of two types: (i) Full-flow filter and (ii) By-pass filler.

(i) Full flow filter: In this filter the entire quantity of oil is forced to circulate through it before it enters the engine. A spring loaded valve is usually fitted in the filter as a protection device against oil starvation in case of filter getting clogged. Filter element consists of felt, cloth, paper and plastic. All these elements are replaceable and should be changed after the recommended period.

(ii) By pass filter: In this type of filter, the supply lines are from the pump and are connected to permit only a part of the oil. Through the filter the balance oil reaches directly to the engine parts. Over a period of operation, all the oil in the crankcase passes through the filter.



Oil pressure gauge: Oil pressure gauge is used to indicate the oil pressure in the oil lines. It serves to warn the operator of any irregularity in the system.

Grease: - Grease is a semi fluid lubricant, used for slow moving parts. It is useful for those parts, which are connected and are not easily accessible, such as universal joints, water pumps, wheel and axle bearings. Grease consists of a mixture of mineral oil and metallic soap along with a few other chemicals. Soap works as a thickening agent for a lubricant at a certain temperature. Grease is classified according to consistency of the fluid as No.O,No.1,No.2,No.3 and No.4 specifying the condition as fluid, very soft, soft, medium and hard respectively**.**

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