

## COOLING SYSTEM

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

### NECESSITY OF COOLING SYSTEM

The cooling system is provided in the IC engine for the following reasons:

- The temperature of the burning gases in the engine cylinder reaches up to 1500 to 2000°C, which is above the melting point of the material of the cylinder body and head of the engine. (Platinum, a metal which has one of the highest melting points, melts at 1750 °C, iron at 1530°C and aluminium at 657°C.) Therefore, if the heat is not dissipated, it would result in the failure of the cylinder material.
- Due to very high temperatures, the film of the lubricating oil will get oxidized, thus producing carbon deposits on the surface. This will result in piston seizure.
- Due to overheating, large temperature differences may lead to a distortion of the engine components due to the thermal stresses set up. This makes it necessary for, the temperature variation to be kept to a minimum.
- Higher temperatures also lower the volumetric efficiency of the engine.

### REQUIREMENTS OF EFFICIENT COOLING SYSTEM

The two main requirements of an efficient cooling system are:

1. It must be capable of removing only about 30% of the heat generated in the combustion chamber. Too much removal of heat lowers the thermal efficiency of the engine.
2. It should remove heat at a fast rate when the engine is hot. During the starting of the engine, the cooling should be very slow so that the different working parts reach their operating temperatures in a short time.

### TYPES OF COOLING SYSTEM

There are two types of cooling systems:

- (i) Air cooling system and
- (ii) Water-cooling system.

### AIR COOLING SYSTEM

In this type of cooling system, the heat, which is conducted to the outer parts of the engine, is radiated and conducted away by the stream of air, which is obtained from the atmosphere. In order to have efficient cooling by means of air, providing fins around the cylinder and cylinder head increases the contact area. The fins are metallic ridges, which are formed during the casting of the cylinder and cylinder head

The amount of heat carried off by the air-cooling depends upon the following factors:

- (i) The total area of the fin surfaces,
- (ii) The velocity and amount of the cooling air and
- (iii) The temperature of the fins and of the cooling air.

Air-cooling is mostly tractors of less horsepower, motorcycles, scooters, small cars and small aircraft engines where the forward motion of the machine gives good velocity to cool the engine. Air-cooling is also provided in some small industrial engines. In this system, individual cylinders are generally employed to provide ample cooling area by providing fins. A blower is used to provide air.

### Advantages of Air Cooled Engines

Air cooled engines have the following advantages:

1. Its design of air-cooled engine is simple.
2. It is lighter in weight than water-cooled engines due to the absence of water jackets, radiator, circulating pump and the weight of the cooling water.
3. It is cheaper to manufacture.
4. It needs less care and maintenance.
5. This system of cooling is particularly advantageous where there are extreme climatic conditions in the arctic or where there is scarcity of water as in deserts.
6. No risk of damage from frost, such as cracking of cylinder jackets or radiator water tubes.

### WATER COOLING SYSTEM

It serves two purposes in the working of an engine:

- a) It takes away the excessive heat generated in the engine and saves it from over heating.
- b) It keeps the engine at working temperature for efficient and economical working.

This cooling system has four types of systems:

- (i) Direct or non-return system,
- (ii) Thermo-Syphone system,
- (iii) Hopper system and
- (iv) Pump/forced circulation system.

Though the present tractor has a forced circulation system, it is still worthwhile to get acquainted with the other three systems.

#### **Non-Return Water Cooling System**

This is suitable for large installations and where plenty of water is available. The water from a storage tank is directly supplied to the engine cylinder. The hot water is not cooled for reuse but simply discharges. The low H.P. engine, coupled with the irrigation pump is an example.

#### **Thermo-Syphone Water Cooling System**

This system works on the principle that hot water being lighter rises up and the cold water being heavier goes down. In this system the radiator is placed at a higher level than the engine for the easy flow of water towards the engine. Heat is conducted to the water jackets from where it is taken away due to convection by the circulating water. As the water jacket becomes hot, it rises to the top of the radiator. Cold water from the radiator takes the place of the rising hot water and in this way a circulation of water is set up in the system. This helps in keeping the engine at working temperature.

Disadvantages of Thermo-Syphone System

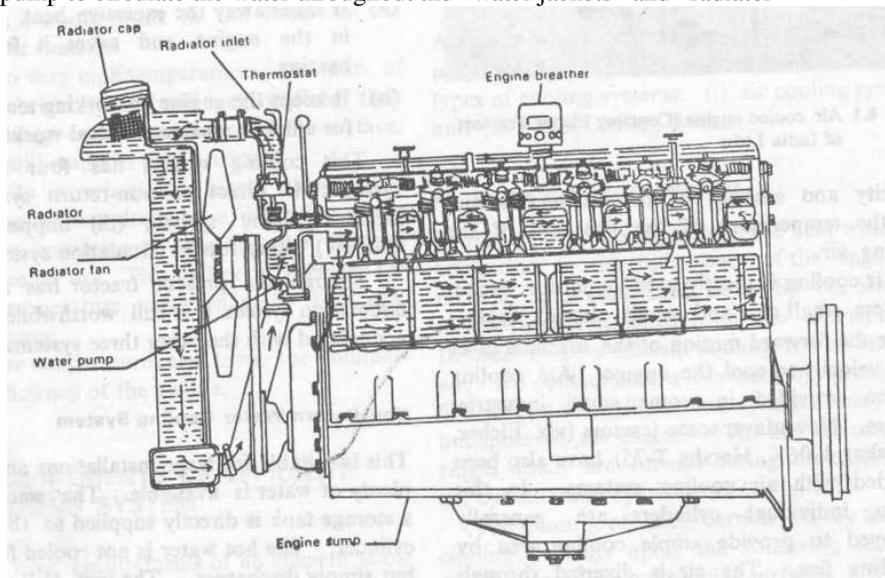
1. Rate of circulation is too slow.
2. Circulation commences only when there is a marked difference in temperature.
3. Circulation stops as the level of water falls below the top of the delivery pipe of the radiator. For these reasons this system has become obsolete and is no more in use.

#### **Hopper Water Cooling System**

This also works on the same principle as the thermo-syphone 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.

#### **Force Circulation Water Cooling System**

This system is similar in construction to the thermo-syphone system except that it makes use of a centrifugal pump to circulate the water throughout the water jackets and radiator



The water flows from the lower portion of the radiator to the water jacket of the engine through the centrifugal pump. After the circulation water comes back to the radiator, it loses its heat by the process of radiation. This system is employed in cars, trucks, tractors, etc.

### Parts of Liquid Cooling System

The main parts in the water-cooling system are: (i) water pump, (ii) fan, (iii) radiator and pressure cap, (iv) fan belt (v) water jacket, (vi) thermostat valve, (vii) temperature gauge and (viii) hose pipes.

#### Water Pump

This is a centrifugal type pump. It is centrally mounted at the front of the cylinder block and is usually driven by means of a belt. This type of pump consists of the following parts: (i) body or casing, (ii) impeller (rotor), (iii) shaft, (iv) bearings, or bush, (v) water pump seal and (vi) pulley.

The bottom of the radiator is connected to the suction side of the pump. The power is transmitted to the pump spindle from a pulley mounted at the end of the crankshaft.

Seals of various designs are incorporated in the pump to prevent loss of coolant from the system.

#### Fan

The fan is generally mounted on the water pump pulley, although on some engines it is attached directly to the crankshaft. It serves two purposes in the cooling system of an engine.

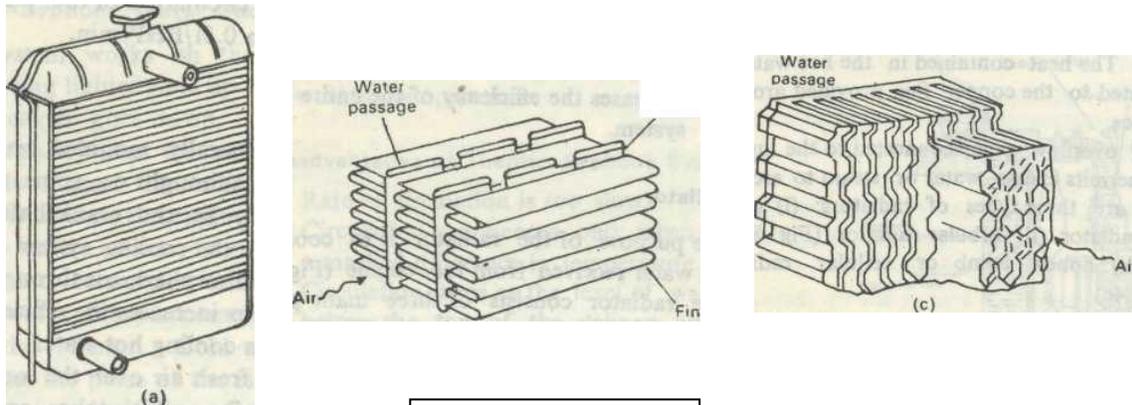
- (a) It draws atmospheric air through the radiator and thus increases the efficiency of the radiator in cooling hot water.
- (b) It throws fresh air over the outer surface of the engine, which takes away the heat conducted by the engine parts and thus increases the efficiency of the entire cooling system.

#### Radiator

The purpose of the radiator is to cool down the water received from the engine. The radiator consists of three main parts: (i) upper tank, (ii) lower tank and (iii) tubes.

Hot water from the upper tank, which comes from the engine, flows downwards through the tubes. The heat contained in the hot water is conducted to the copper fins provided around the tubes.

An overflow pipe, connected to the upper<sup>1</sup> tank, permits excess water or steam to escape. There are three types of radiators: (i) gilled tube radiator, (ii) tubular radiator (Fig. b) and (iii) honey comb or cellular radiator (Fig. c)



Type of radiators

#### *Gilled tube radiator:*

This is perhaps the oldest type of radiator, although it is still in use. In this, water flows inside the tubes. Each tube has a large number of annular rings or fins pressed firmly over its outside surface.

***Tubular radiator:*** The only difference between a gilled tubes radiator and a tubular one is that in this case there are no separate fins for individual tubes. The radiator vertical tubes pass through thin fine copper sheets which run horizontally.

***Honey comb or cellular radiator:*** The cellular radiator consists of a large number of individual air cells which are surrounded by water. In this, the clogging of any passage affects only a small parts of the cooling surface. However, in the tubular radiator, if one tube becomes clogged, the cooling effect of the entire tube is lost.

#### Thermostat Valve

It is a kind of check valve which opens and closes with the effect of temperature. It is fitted in the water outlet of the engine. During the warm-up period, the thermostat is closed and the water pump circulates the water only throughout the cylinder block and cylinder head. When the normal operating temperature is

reached, the thermostat valve opens and allows hot water to flow towards the radiator (Fig. 8.5a). Standard thermostats are designed to start opening at 70 to 75°C and they fully open at 82°C. High temperature thermostats, with permanent anti-freeze solutions (Prestine, Zerex, etc.), start opening at 80 to 90°C and fully open at 92°C.



Types of thermostat

There are three types of thermostats: (i) bellow type, (ii) bimetallic type and (iii) pellet type.

**Bellow type valve:** Flexible bellows are filled with alcohol or ether. When the bellows is heated, the liquid vaporises, creating enough pressure to expand the bellows. When the unit is cooled, the gas condenses. The pressure reduces and the bellows collapse to close the valve.

**Bimetallic type valve:** This consists of a bimetallic strip. The unequal expansion of two metallic strips causes the valve to open and allows the water to flow in the radiator.

**Pellet type valve:** A copper impregnated wax pellet expands when heated and contracts when cooled. The pellet is connected to the valve through a piston, such that on expansion of the pellet, it opens the valve. A coil spring closes the valve when the pellet contracts.

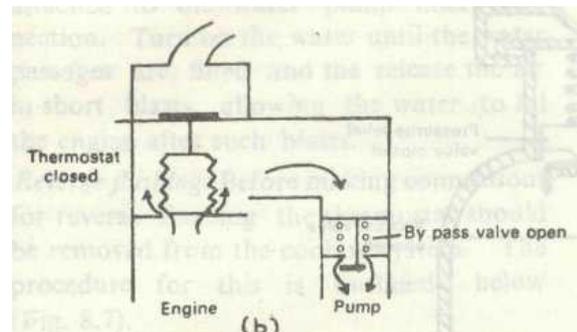
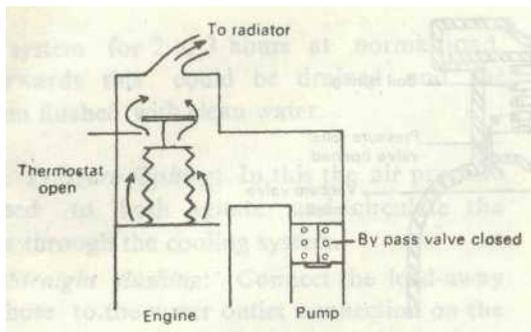
### PRESSURE COOLING SYSTEM

In the case of the ordinary water-cooling system where the cooling water is subjected to atmospheric pressure, the water boils at 212°F. But when water is boiled in a closed radiator under high pressure, the boiling temperature of water increases. The higher water temperature gives more efficient engine performance and affords additional protection under high altitude and tropical conditions for long hard driving periods. Therefore, a pressure-type radiator cap is used with the forced circulation cooling system (Fig. 8.6a). The cap is fitted on the radiator neck with an air tight seal. The pressure-release valve is set to open at a pressure between 4 and 13 psi. With this increase in pressure, the boiling temperature of water increases to 243°F (at 4 psi boiling tap 225°F and 13 psi boiling temperature 243°F). Any increase in pressure is released by the pressure release valve to the atmosphere. On cooling, the vapours will condense and a partial vacuum will be created which will result in the collapse of the hoses and tubes. To overcome this problem the pressure release valve is associated with a vacuum valve which opens the radiator to the atmosphere.

### ANTI-FREEZE SOLUTIONS

In order to prevent the water in the cooling system from freezing, some chemical solutions which are known as anti-freeze solutions are mixed with water. In cold areas, if the engine is kept without this solution for some time, the water may freeze and expand leading to fractures in the cylinder block, cylinder head, pipes and/or radiators.

The boiling point of the anti-freeze solution should be as high as that of water. An ideal mixture should easily dissolve in water, be reasonably cheap and should not deposit any foreign matter in the jacket pipes and radiator.



No single anti-freeze solution satisfies all these requirements. The materials commonly used are wood

alcohol, denatured alcohol, glycerine, ethylene, glycol, propylene glycol, mixtures of alcohol and glycerine and various mixtures of other chemicals.

### **SERVICING & CLEANING OF COOLING SYSTEM**

For smooth and trouble-free service, the cooling system should be cleaned at periodic intervals to prevent the accumulation of excessive rust and scale. The commercial cleaning compounds available must be carefully used in accordance with the manufacturers' instructions.

A general cleaning procedure is outlined below. If a considerable amount of scale and rust has accumulated, it may not be possible that cleaning alone will remove it. In that case, the radiator and engine water jackets must be flushed out with special air pressure guns.

#### **Cooling System Cleaning Procedure**

It involves the following steps.

1. Drain the system by opening the drain cocks. Prepare a solution of washing soda and water, with a ratio of 1 kg soda to 10 litres of water. Fill up this solution in the radiator and engine block and run the engine on idle load for 8 to 10 hours. Drain this solution and flush the system with clean water.
2. In case the scale formulation is hard and cannot be completely removed with washing soda, another cleaning agent can be prepared with 40 parts of water, 5 parts of commercial hydrochloric acid and 1 part of formaldehyde. This solution is allowed to remain in the system for 2 to 3 hours at normal load. Afterwards this could be drained and the system flushed with clean water.
3. *Pressure flushing*: In this the air pressure is used to both agitate and circulate the water through the cooling system.
  - (a) *Straight flushing*: Connect the lead-away hose to the water outlet connection on the engine. Insert the flushing gun in the hose attached to the water pump inlet connection. Turn on the water until the water passages are filled and then release the air in short blasts, allowing the water to fill the engine after such blasts.
  - (b) *Reverse flushing*: Before making connections for reverse flushing the thermostat should be removed from the cooling system. The procedure for this is outlined below:
    - (i) *Radiator*: Disconnect the top hose of the radiator from the engine and attach a lead-away hose to the radiator. Disconnect the bottom of the radiator from water pump and attach the flushing gun. Connect water and air hoses to the gun. Turn on the water and fill the radiator to the top. Release the air in short blasts and allow the water to fill the radiator between each blast. Continue the operation until the water from the lead-away hose is clear, (ii) *Engine*: Connect the lead-away hose to the inlet of the water pump and the flushing gun to the water outlet of the pump on the cylinder head. Follow the same procedure.

## **LUBRICATION SYSTEM**

I. C. engine is made of many moving parts. Due to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in the engine. Lubrication of moving parts is essential to prevent all these harmful effects.

### **PURPOSE OF LUBRICATION**

Lubrication produces the following effects: (a) Reducing friction effect (b) Cooling effect (c) Sealing effect and (d) Cleaning effect.

(a) **Reducing frictional effect**: The primary purpose of the lubrication is to reduce friction and wear between two rubbing surfaces. Two rubbing surfaces always produce friction. The continuous friction produces heat which causes wearing of parts and loss of power. In order to avoid friction, the contact of two sliding surfaces must be reduced as far as possible. This can be done by proper lubrication only. Lubrication forms an oil film between two moving surfaces. Lubrication also reduces noise produced by the movement of two metal surfaces over each other.

(b) **Cooling effect**: The heat, generated by piston, cylinder, and bearings is removed by lubrication to a great extent. Lubrication creates a cooling effect on the engine parts.

(c) **Sealing effect**: The lubricant enters into the gap between the 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 along with the oil.

**Lubrication theory**: There are two theories in existence regarding the application of lubricants on a surface: (i) Fluid film theory and (ii) Boundary layer theory.

**(i) Fluid film theory:** According to this theory, the lubricant is, supposed to act like mass of globules, rolling in between two surfaces. It produces a rolling effect, which reduces friction.

**(ii) Boundary layer theory:** According to this theory, the lubricant is soaked in rubbing surfaces and forms oily surface over it. Thus the sliding surfaces are kept apart from each other, thereby reducing friction.

### TYPES OF LUBRICANTS

Lubricants are obtained from animal fat, vegetables and minerals. Lubricants made of animal fat, does not stand much heat. It becomes waxy and gummy which is not very suitable for machines.

Vegetable lubricants are obtained from seeds, fruits and plants. Cottonseed oil, olive oil, linseed oil and castor oil are used as lubricant in small Simple machines.

Mineral lubricants are most popular for engines and machines. It is obtained from crude petroleum found in nature. Petroleum lubricants are less expensive and suitable for internal combustion engines. A good lubricant should have the following qualities:

1. It should have sufficient viscosity to keep the rubbing surfaces apart
2. It should remain stable under changing temperatures.
3. It should keep lubricated parts clean.
4. It should not corrode metallic surfaces.

### 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.

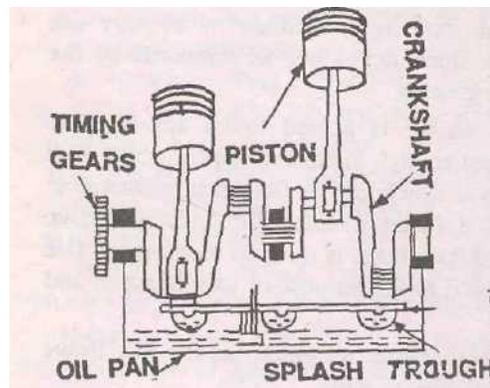
The parts which require lubrication are: (i) cylinder walls and piston (ii) piston pin (iii) crankshaft and connecting rod bearings (iv) camshaft bearings (v) valves and valve operating mechanism (vi) cooling fan (vii) water pump and (viii) ignition mechanism.

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

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

### 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, which has a depression or a trough like arrangement under each connecting rod. This pan receives its oil supply from the oil sump either by means of a gear pump or by gravity. A dipper is provided at the lower end of the connecting rod. This dipper dips into to oil trough and splashes oil out of the pan. The splashing action of oil maintains a fog or mist of oil that drenches the inner parts of the engine such as bearings, cylinder walls, pistons, piston pins, timing gears etc.



Splash lubrication system

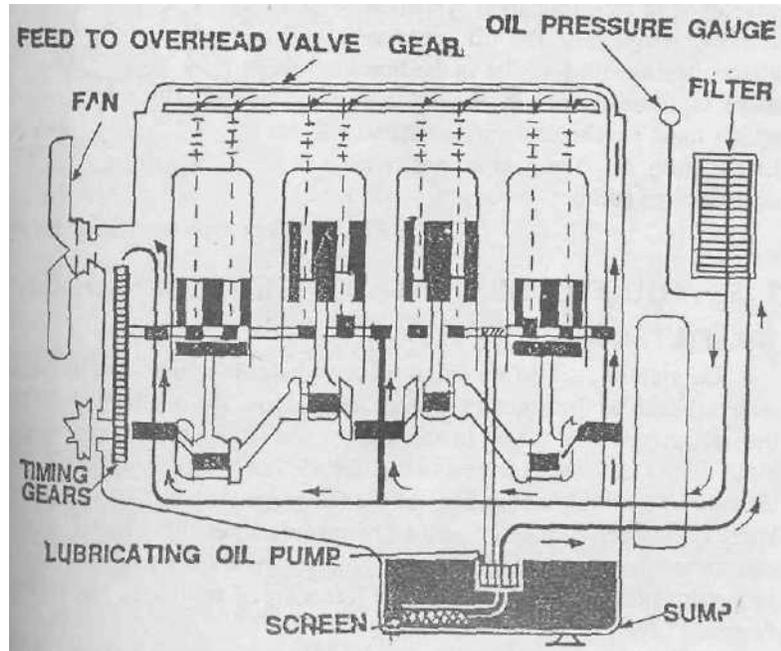
This system is usually used on single cylinder engine with closes crankcase. For effective functioning of the engine, proper level of oil maintained in the oil pan.

Lubrication depends largely upon the size of oil holes and clearances. This system is very effective if the oil is clean and undiluted. Its disadvantages are that lubrication is not very uniform and when the rings are worn, the oil passes the piston into combustion chamber, causing carbon deposition, blue smoke and spoiling the plugs. There is every possibility that oil may become very thin through crankcase dilution. The

worn metal, dust and carbon may be collected in the oil chamber and be carried to different parts of the engine, causing wear and tear.

### FORCED FEED SYSTEM

In this system, the oil is pumped directly to the crankshaft, connecting rod, piston pin, timing gears and camshaft of the engine through suitable paths of oil. Usually the oil first enters the main gallery, which may be a pipe or a channel in the crankcase casting. From this pipe, it goes to each of the main bearings through holes. From main bearings, it goes to big end bearings of connecting rod through drilled holes in the crankshaft. From there, it goes to lubricate the walls, pistons and rings. There is separate oil gallery to lubricate timing gears. Lubricating oil pump is a positive displacement pump, usually gear type or vane type. The oil also goes to valve stem and rocker arm shaft under pressure through an oil gallery.

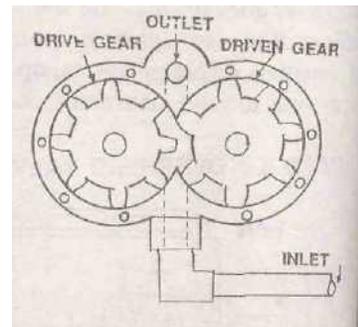


Forced feed lubrication system

The excess oil comes back from the cylinder head to the crankcase. The pump discharges oil into oil pipes, oil galleries or ducts, leading different parts of the engine. This 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.

**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 parts 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, [f 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.

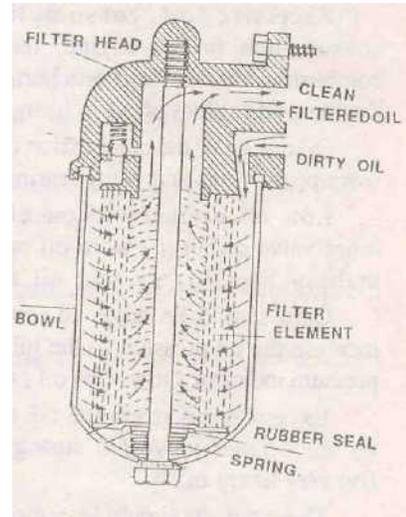


**OIL FILTER:** Lubricating oil in an engine becomes contaminated with various materials such as dirt, metal particles and carbon. Oil filter removes the dirty elements of the oil in an effective way. It is a type of

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 filter.

(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.

**Crankcase breather:** The engine crankcase is always fitted with some kind of breather, connecting the space above the oil level with the outside atmosphere. The purpose of the breather is to prevent building up pressure in the crankcase.

**Relief valve:** Relief valve is provided to control the quantity of oil circulation and to maintain correct pressure in the lubricating system.

#### **TROUBLES IN LUBRICATION SYSTEM**

There are a few common troubles in lubrication system such as: (1) Excessive oil consumption (2) Low oil pressure and (3) Excessive oil pressure-

**Excessive oil consumption:** When there is excessive oil consumption in the engine, the reasons are: (a) more oil goes to combustion chamber and gets burnt (b) some leakage occurs in some part of the line and (c) loss of oil in form of vapour through ventilating system. Oil can enter the combustion chamber through rings and cylinder walls, worn piston rings and worn bearings.

**Low oil pressure:** Low oil pressure can result due to: (i) weak relief valve spring (ii) worn oil pump (iii) cracked oil line (iv) obstruction in the oil lines (v) very thin oil and (vi) worn out bearings.

Care should be taken to remove these defects as far as possible to increase the oil pressure in the lubricating system. Sometimes defective oil pressure indicator shows low oil pressure. This should be checked.

**Excessive oil pressure:** Excessive oil pressure may result due to: (i) stuck relief valve (ii) strong valve spring (iii) clogged oil line and (iv) very heavy oil.

These defects should be removed to reduce the excessive oil pressure in the lubricating system. Sometimes defective oil pressure indicator records high oil pressure. Care should be taken to check this defect.

#### **CARE AND MAINTENANCE OF LUBRICATION SYSTEM**

The following are few suggestions for good lubrication system:

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