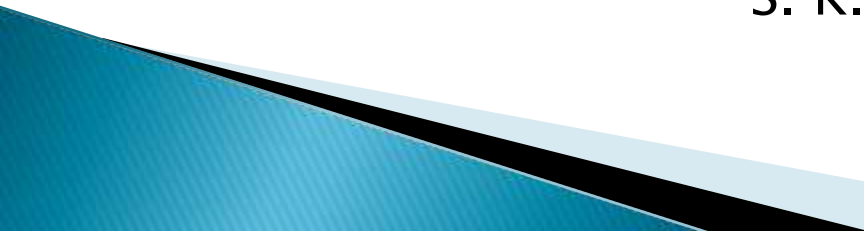


# **Lect.- 5**

## **Lubrication System – splash system and forced feed system; Cooling system – thermosiphon system and forced circulation system**

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# LUBRICATION

To supply lubricating oil between the moving parts is simply termed as “lubrication”.

- IC Engine is made of many moving parts.
- The moving components of IC engine operate at varying temperature, pressure, load and speed.
- 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.

Lubrication of IC engine is accomplished by circulating suitable grade of oil through passages drilled in the engine components at appropriate pressure with the help of a pump.



*Oil spurt holes in crankshaft*


## *Purpose of lubrication*

Lubrication of the moving parts of an IC Engine performs the following functions:

- (i) **Lubrication of moving parts:** It provides thin oil film between moving parts of engine and minimizes friction and their tear and wear. Also prevents seizure of rubbing surfaces.
- (ii) **Cooling of critical components:** The lubricating oil is largely responsible for cooling of piston by direct heat dissipation to cylinder walls and then to cooling system. It also removes heat from engine bearings, thus acts as cooling agent.

**(iii) Engine noise reduction:** The lubricating oil film acts as a cushion and absorbs shock between the bearings and other engine parts, thus reduces the noise and extends engine life.

**(iv) Sealing of compression pressure:** It forms a good seal between the piston rings and cylinder walls and prevents leakage of gases from combustion chamber.



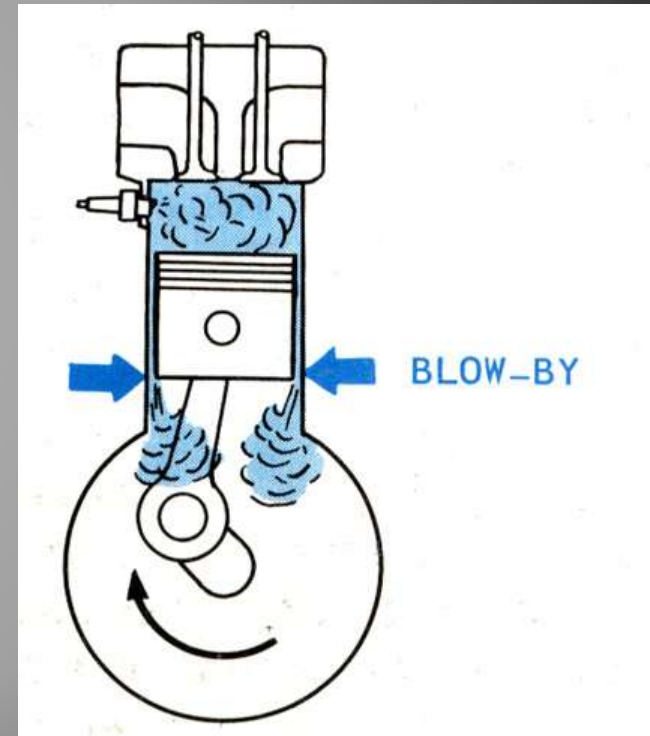
**(v) Cleaning of foreign materials:** It acts as a cleaning agent to carry away dirt, particles of carbon and other foreign matter to sump.

**(Vi) Frictional power reduction:** It reduces frictional resistance of moving parts thus reduces power required to overcome friction. It also prevents corrosion of bearings which offer resistance while moving.

# Purpose of Lubrication System

## Seals

The oil helps form a gastight seal between piston rings and cylinder walls  
(*Reduces Blow-By*)



## *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. Cotton seed 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 IC Engines.



Lubricating oils are marked by their SAE viscosity number recommended by the [Society of Automotive Engineers U.S.A.](#)

The low engine oil viscosity grades end with a “W” and are usually suited for winter use. For example: 20W. The high engine oil viscosity grades are not marked “W” and are suitable for summer use.

For ex. SAE 30 , SAE 40.

Higher viscosity grade is recommended for summer use.



## Oil classifications

The American Petroleum Institute (A.P.I.) had adopted in 1952 the following classification of engine oils.

The three classes for diesel engines are DG– diesel general service, DM– moderately severe service and DS– very severe service.

DG and MS oils have a high additive content which helps to keep the engine clean.

When the diesel fuel contains high sulphur content, it is best to use DS lubricating oils.

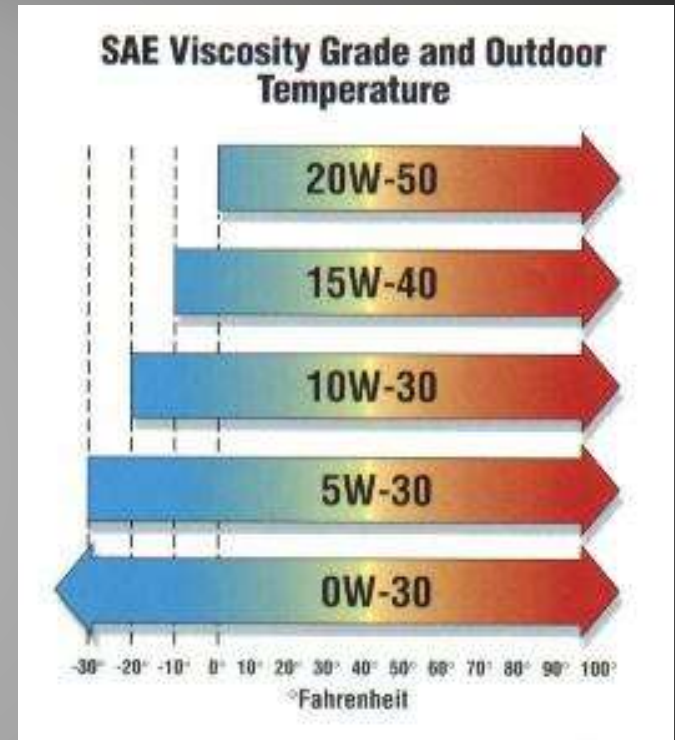
# VISCOSITY

Viscosity is a measure of oil's resistance to flow.

- A low viscosity oil is thin and flows easily
- A high viscosity oil is thick and flows slowly.
- As oil heats up it becomes more

viscous (*Becomes thin*)

- Single viscosity oils SAE 5W, SAE 10W (Winter) and SAE30 ... (Summer)



- Multiple viscosity oils SAE 10W-30. This means that the oil is same as SAE 10W when cold and SAE30 when hot.


## *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:

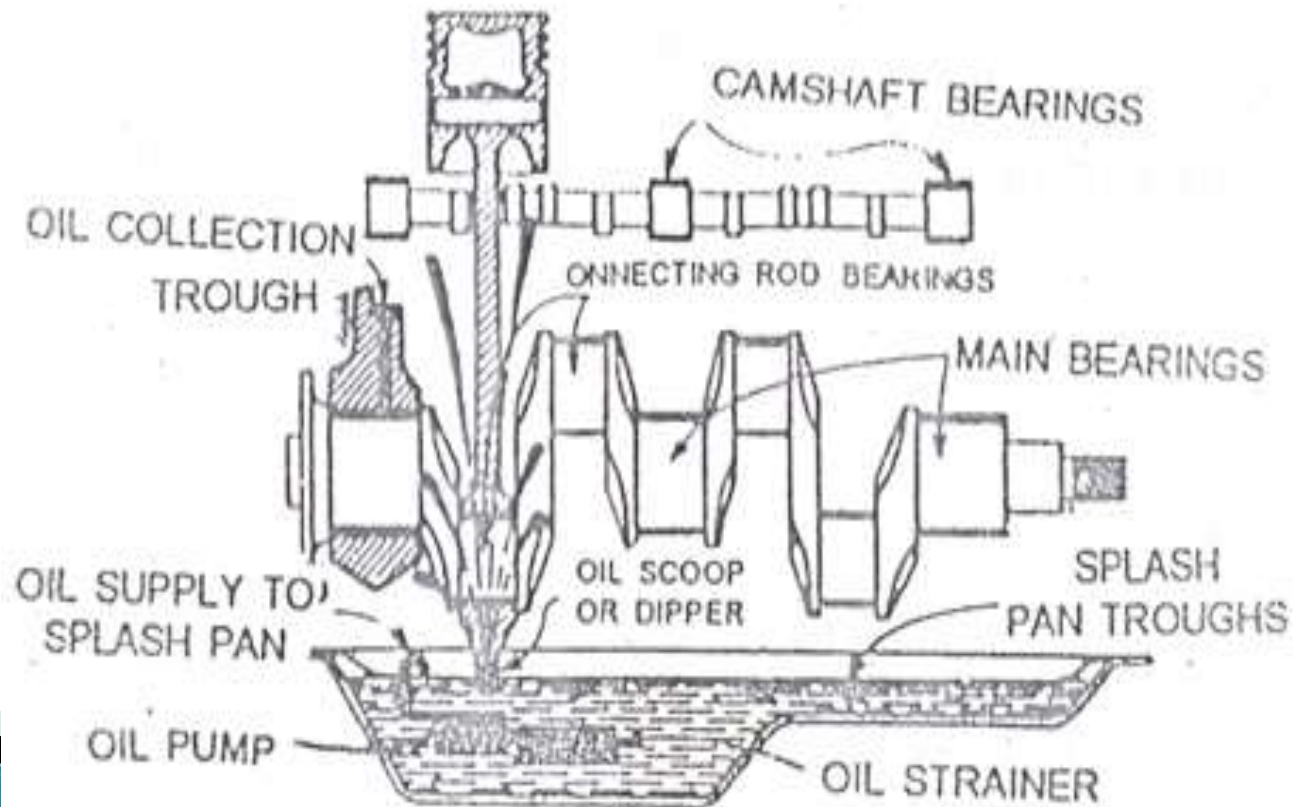
- (i) cylinder walls and piston,
- (ii) piston pin
- (iii) crankshaft and connecting rod bearings
- (iv) cam shaft bearings
- (v) valves and valve operating mechanism
- (vi) cooling fan
- (vii) water pump and
- (viii) ignition mechanism.

There are three common systems of lubrication used on stationery 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 type of lubricating system a dipper provided at the bottom end of connecting rod, scoops out of the pan placed below the crank shaft.



➤ This pan receives its oil supply from the crankcase, either by means of a pump or by gravity through equalizer holes drilled in the pan.


➤ The connecting rod scoops up oil as it passes over the BDC. **The splash is produced due to rotation of crankshaft in oil sump.**

➤ This splashed oil mist formed in crankcase housing lubricates :  
main bearing, crankshaft bearing,  
timing gear, push rod and cylinder liner walls etc.  
However, the valve mechanism is lubricated with the help of oil cans manually at regular intervals.

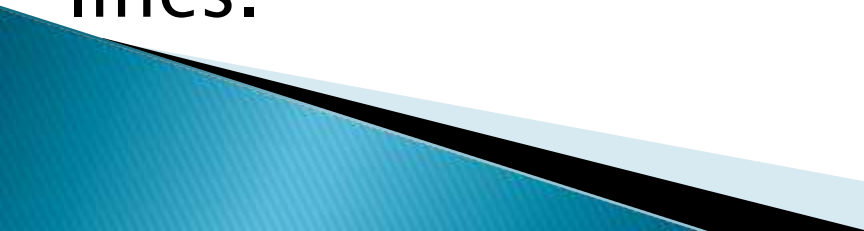
This type of lubricating system is **generally provided in single cylinder engine with closed crankcase.**


## Force feed system:

The system mainly consists of:

- oil sump
  - oil strainer
  - oil pump
  - oil pressure regulator (pressure relief valve)
  - oil filter
  - oil lines
  - drilled oil passages through moving parts and
  - oil pressure gauge.
- 



- The oil pump is driven by camshaft (through belt and pulley arrangement).
  - It draws oil from the sump through strainer and supplies to the oil filter with high pressure.
  - An oil pressure regulator ensures that oil pressure level is maintained properly.
  - The oil filter removes any dirt particle present in oil and supplies clean oil to the oil lines.
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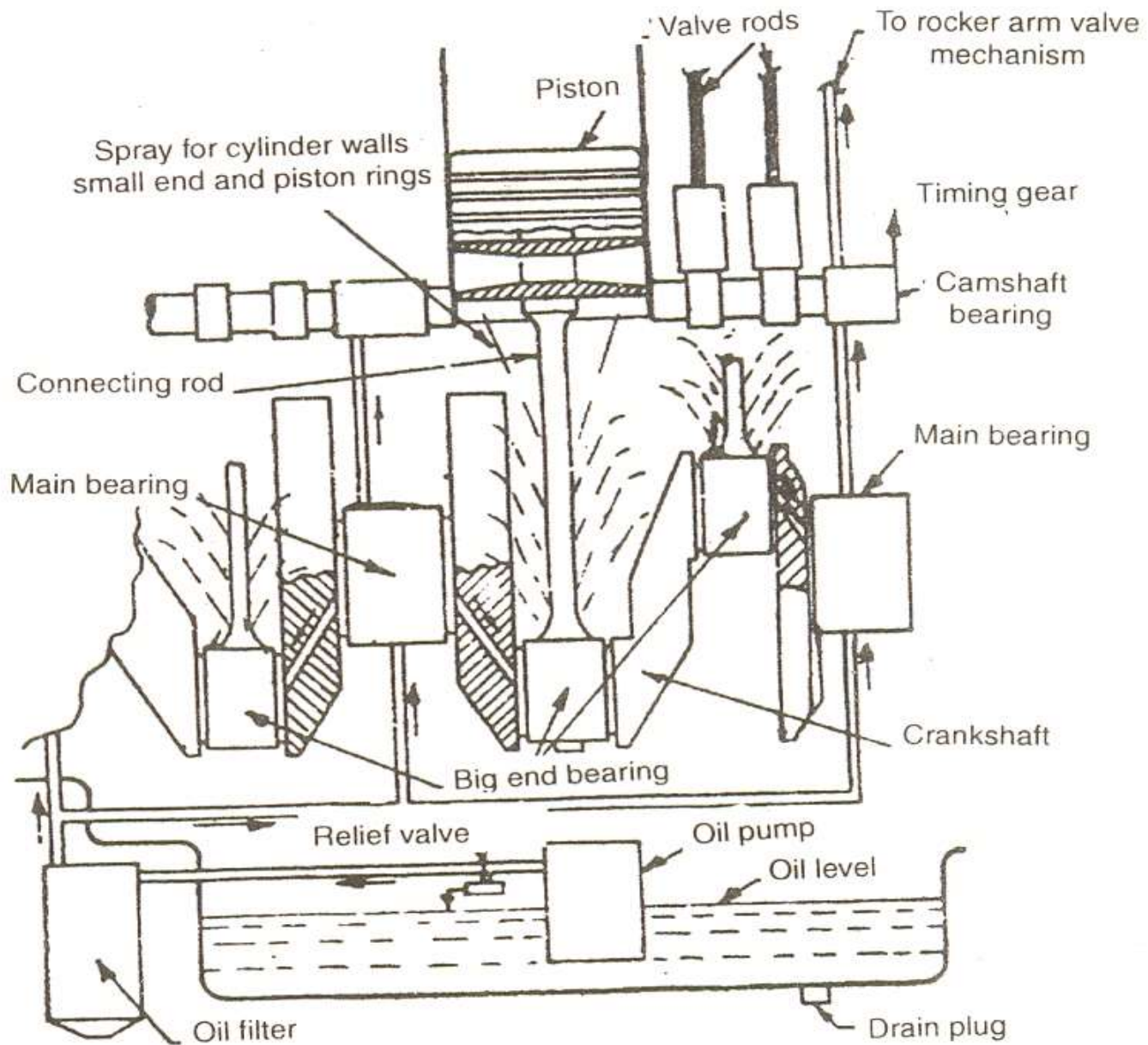
- The pump delivers oil to the main gallery from where it passes through holes drilled inside the crankshaft and main bearings, camshaft bearings and partially to connecting rod bearings to lubricate them.
  - Cylinder walls, piston pins and small end bearings of connecting rod are lubricated by the oil coming out from the big end bearing through holes drilled through connecting rod.
- 

Surplus oil then flows back to crankcase (sump). This also washes extraneous impurities i.e. wear out products of bearings and clearance between mated parts to the sump by scrapping oil.

From cam shaft, the oil under pressure goes to the valve mechanism (rocker arm, shaft and tappet).

An oil pressure gauge is fitted with system to indicate the lubricating oil pressure in the system.

The forced feed type lubricating system is commonly used on high speed multi-cylinder tractor engines.



**Forced feed type lubricating system**

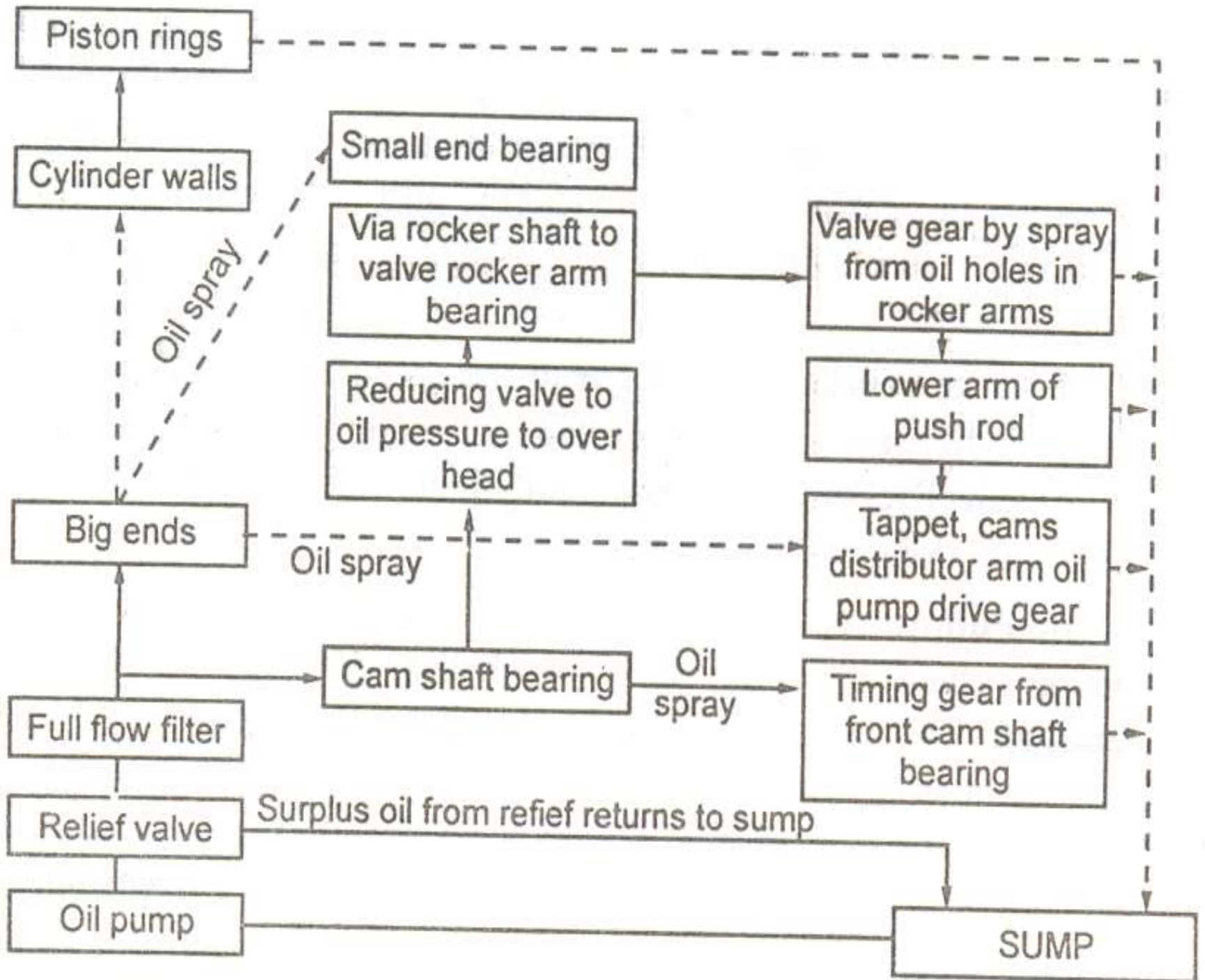
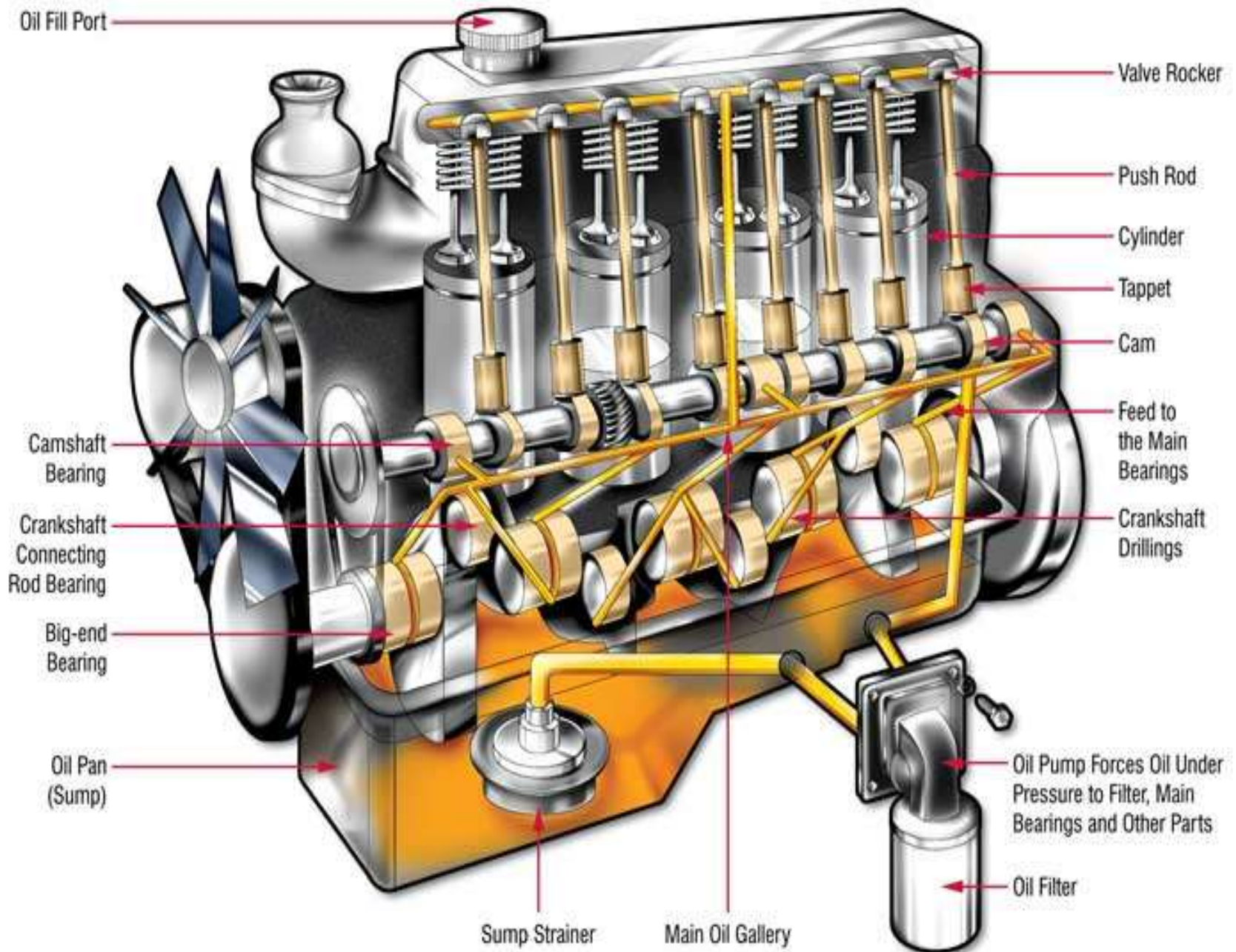


Fig. 2.18. Oil lubrication system.



## Oil filters

- Lubricating oil in an engine becomes contaminated with various materials such as dirt, metal particles and carbon.
- An oil filter removes all 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 filters can be cleaned by washing, but in general old filters are replaced by new filters at specified interval of time.
- It is normally changed after about 120 hours of engine operation.
- Oil filters are of two types: (i) full-flow filter, and (ii) by-pass filter

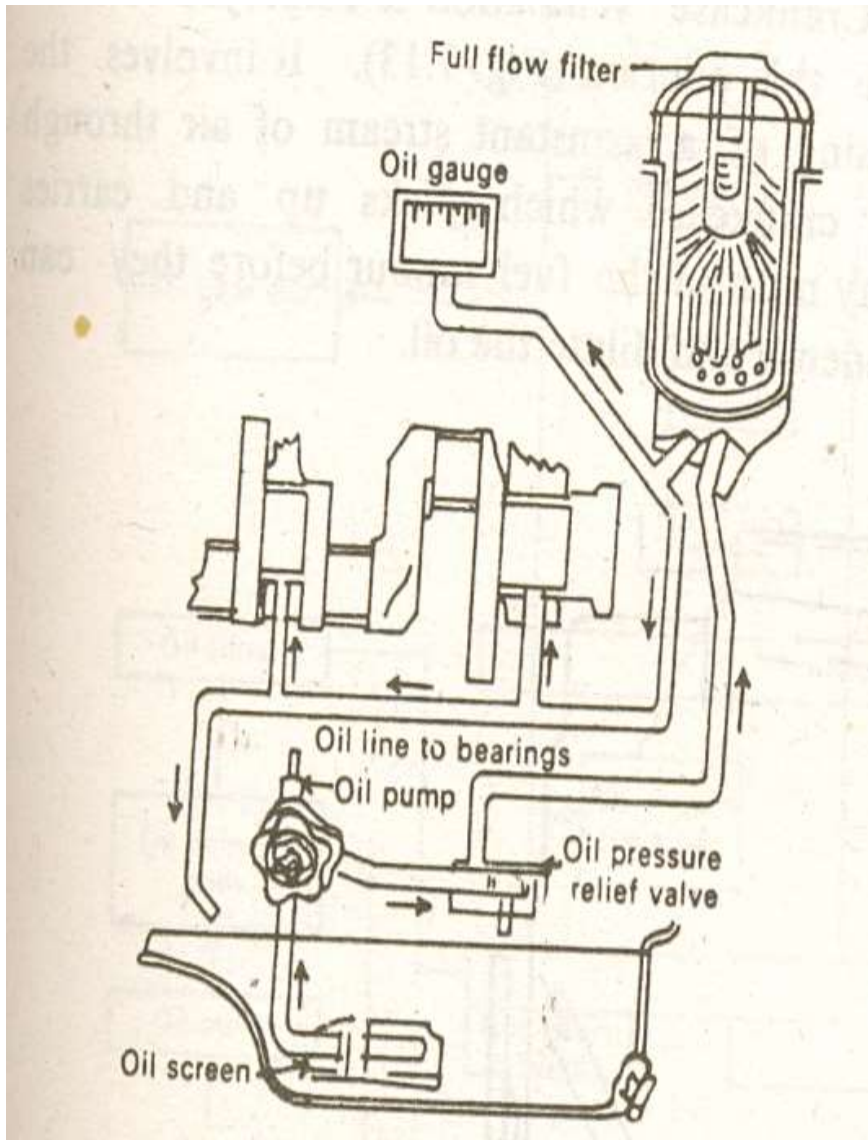
## **Full flow filter**

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.

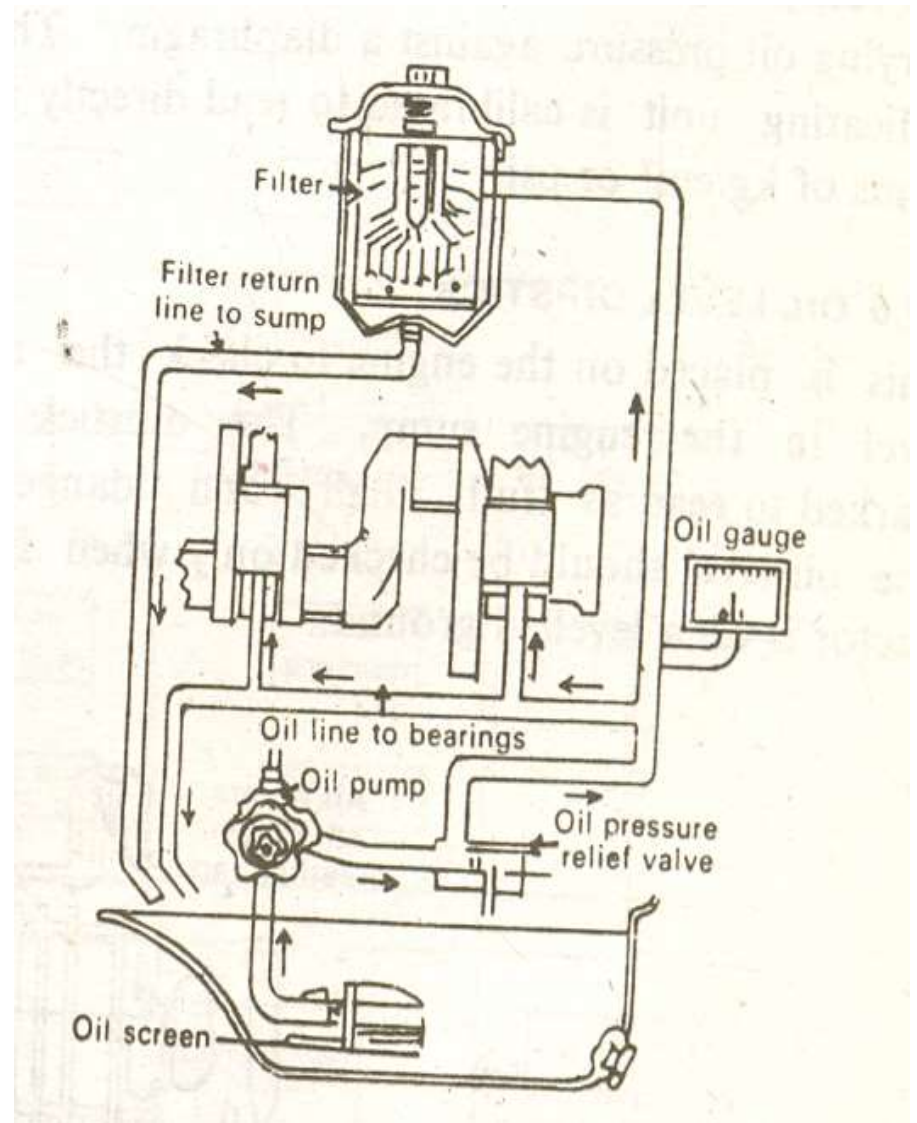
## **By pass filter**

By pass filters take a small portion of oil from the pump and return the filtered oil into the sump. Over a period of operation, all the oil in the crankcase passes through the filter. Through the filter, the balance oil reaches directly to the engine parts.





*Full flow type oil filter system*



*By pass type oil filter system*

# Oil Pump

Lubricating oil pump is a positive displacement pump, usually **gear or vane type**.

The gear pump (external meshing) consists of a set of two helical gears to develop about  $3 \text{ kg/cm}^2$  pressure.

**The pump is driven by the camshaft of the engine.**

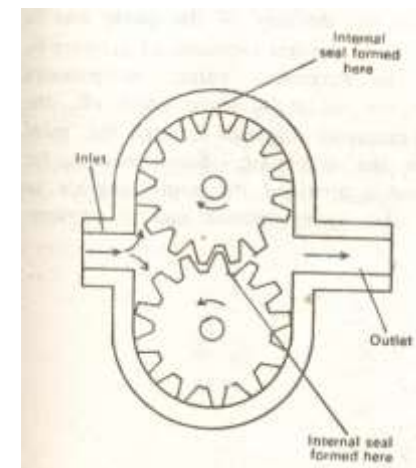
The lower end of the pump extends down into the crankcase, which is covered with a screen to check foreign particles.

An oil pressure gauge fitted in the line, indicates the oil pressure in the lubricating system.

About  $3 \text{ kg/cm}^2$  pressure is developed in the lubrication system of a tractor engine.



Star shaped rotor pump



*Gear type oil pump*

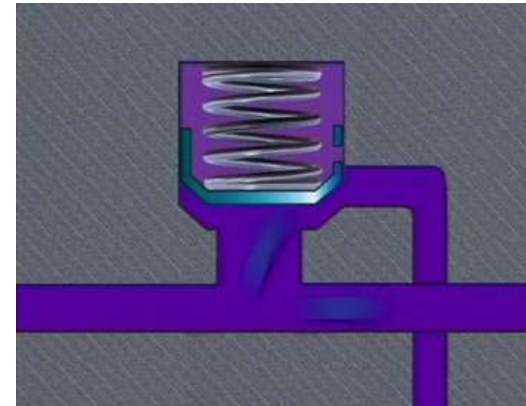
# Oil pressure relief valve

A normal pump is capable of delivering more oil than an engine needs. It's a safety measure to ensure the engine is never starved for oil.

As the pump rotates, and engine speed increases, the volume of oil delivered also increases.

The fixed clearances between the moving parts of the engine prevent oil escaping back to the sump, and pressure builds up in the system.

An oil pressure relief valve **stops excess pressure developing**. It's like a controlled leak, releasing just enough oil back to the sump to regulate the pressure of the whole system.



# Oil Pressure Indicator

The light turns on or gauge reads low when the pressure drops.

- Light or a Gauge



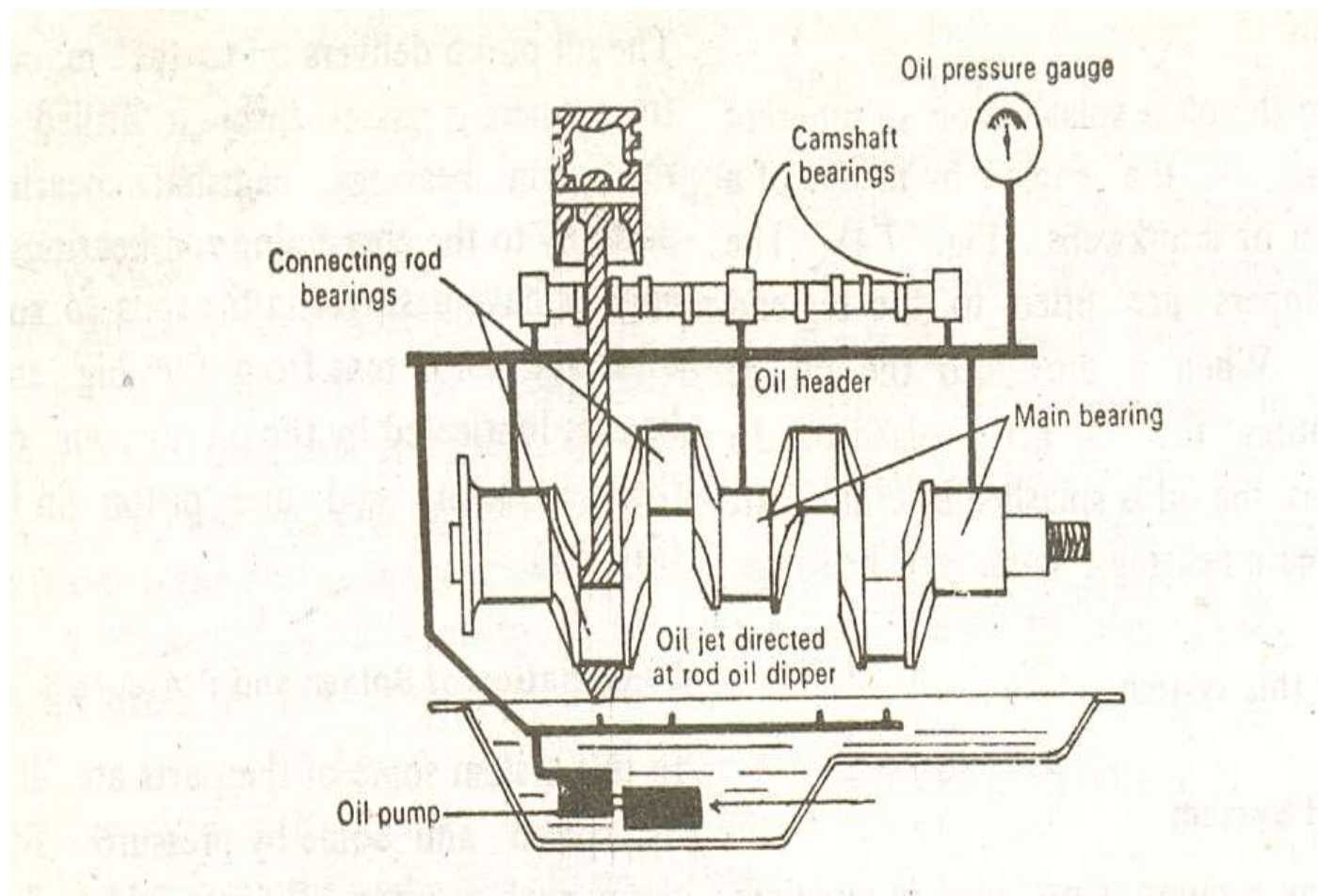
Common causes of low oil pressure are:

- Low oil level
- Worn out pump



# Combination of Splash and pressure system

In this system some of the parts are lubricated by splash and some by pressure.



# Cooling system

- In internal combustion engines, combustion of air and fuel takes place inside the engine cylinder and hot gases are generated.
- The temperature of gases will be around 2300–2500°C. This is a very high temperature and may result into burning of oil film between the moving parts and may result into seizing.
- Too much cooling is also not desirable since it reduces the thermal efficiency.
- So, the object of cooling system is to keep the engine running at its most efficient operating temperature.
- **Correct operating temperature range**  
For petrol engine: 71°C to 82°C  
For heavier fuel: 88°C to 90°C

## Need / purpose of cooling:

- To maintain correct engine operating temperature.
- To dissipate surplus heat resulting from the combustion of the fuel in the cylinders.
- Properly cooling also results in maintaining proper lubrication between engine parts.
- Cooling reduces the possibility of loss of power due to pre-ignition and valve burning.
- Cooling also ensures proper fuel combustion and prevents dilution of the crankcase oil.

Based on cooling media, engines are classified as **air cooled and water cooled engines.**

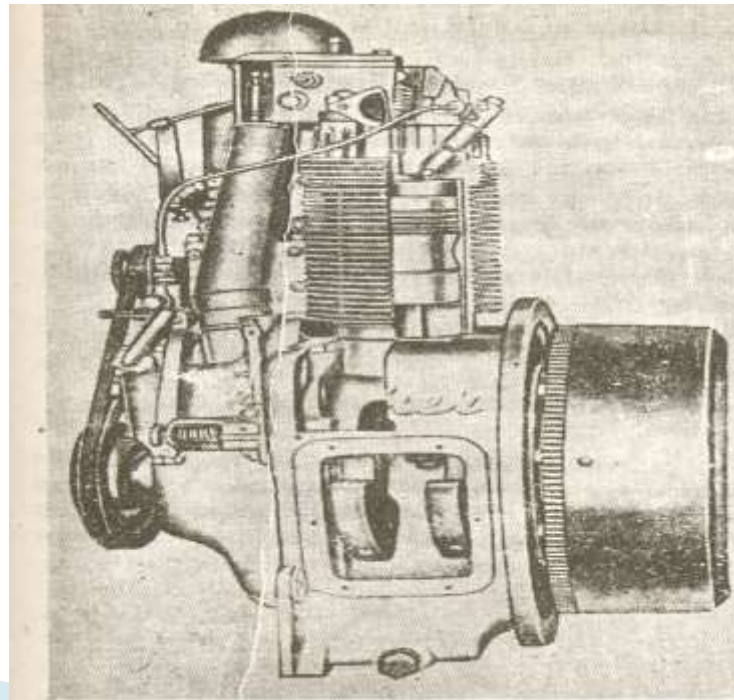
Engines are also cooled by a combination of air and water.

## Air cooling:

- ▶ This method is used on small size stationary engines and garden tractors.
- ▶ In this method of cooling, a strong blast of air is forced all around cylinder walls and cylinder head which are **provided with fins to increase the surface area**. Heat generated due to combustion in the engine cylinder will be conducted to the fins and when the air flows over the fins, heat will be dissipated to air.
- ▶ The amount of heat dissipated to air depends upon:
  - (a) Amount of air flowing through the fins.
  - (b) Fin surface area.
  - (c) Thermal conductivity of metal used for fins.



- ▶ The fly wheel of the air cooled engines is generally equipped with fan blades to create the air blast.
- ▶ Air cooled engines run hotter than water cooled engines and heavier lubricating oil is recommended.



## Advantages of air cooled system:

- (a) Radiator/pump is absent hence the system is light.
- (b) In case of water cooling system there are leakages, but in this case there are no leakages.
- (c) Coolant and antifreeze solutions are not required.
- (d) This system can be used in cold climates, where if water is used it may freeze.

## Disadvantages of air cooled system

- (a) Comparatively it is less efficient.
- (b) It is used in aero planes and motorcycle engines where the engines are exposed to air directly.

## Water cooling:

There are three types of water cooling systems for engines

- ▶ Hopper system
- ▶ Thermo siphon system
- ▶ Forced circulation system

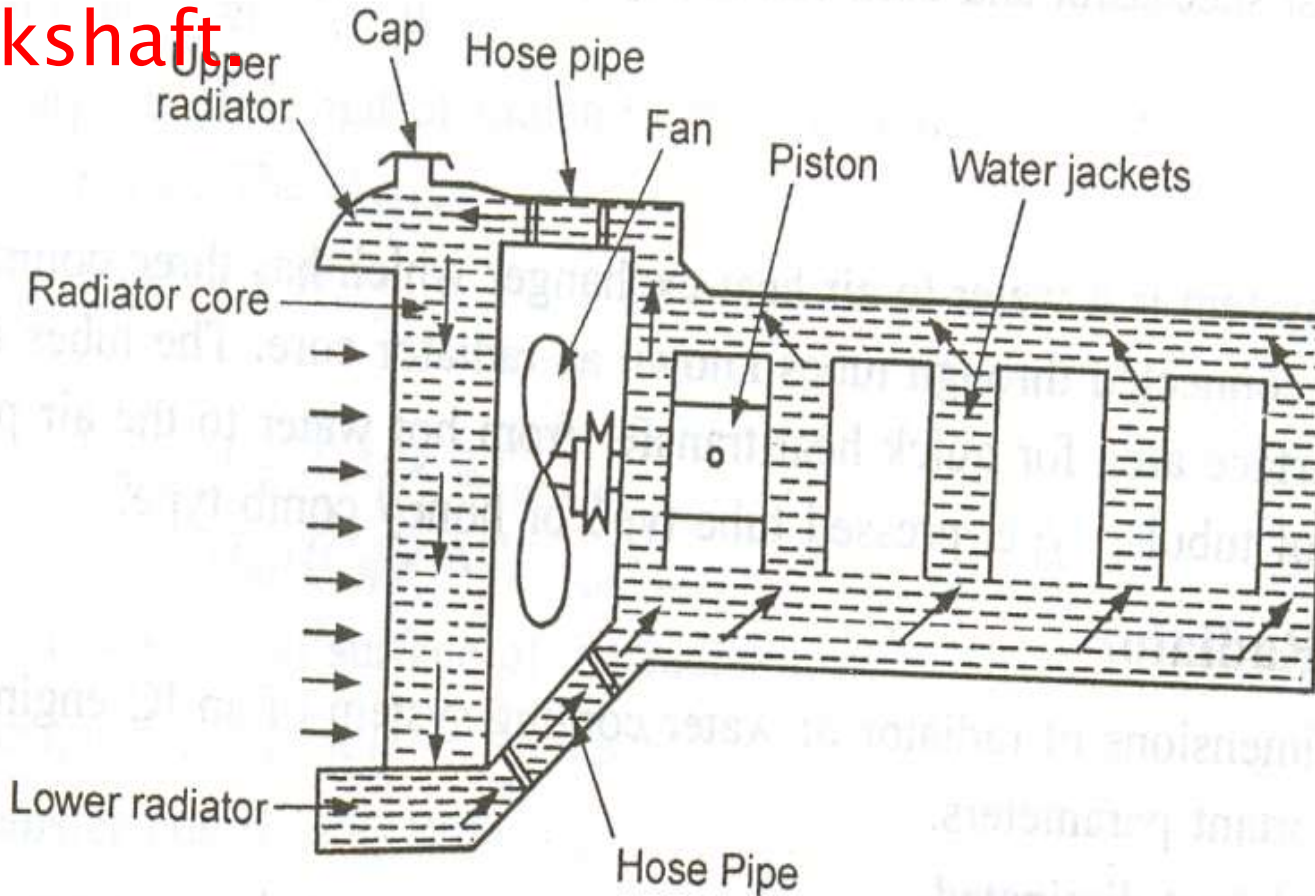
**In hopper system** a small water reservoir is placed just above the water jacket as their integral part. It was in use in old stationary engines and now completely replaced by the other two systems.

# Thermo siphon system:

Thermo siphon (a property of physics) refers to a method of **passive heat exchange based on natural convection**, which circulates a substance (liquid, or gas such as air) without the necessity of a mechanical pump.

- Thermo siphon system is used on tractors and on stationary engines.
- It consists of a radiator, water jacket, fan, temperature gauge and hose connections.
- It works on the principle that heated water surrounding the cylinder gets lighter in weight and rises. Hot water goes to the radiator where it passes through tubes surrounding by air. Water is circulated because of density difference only.

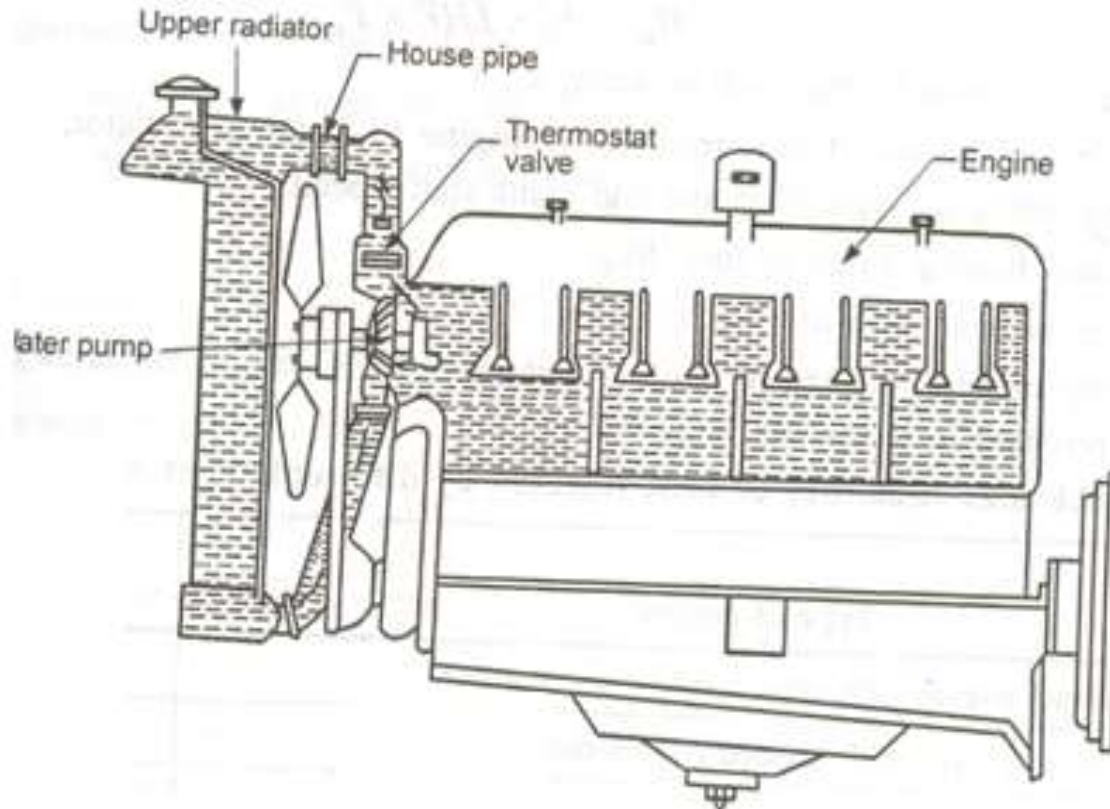
➤ A fan located between the radiator and engine sucks air through the radiator tubes thus cooling the radiator water. The fan is driven by a pulley mounted on the crankshaft.



*Thermo siphon type cooling system*

## Forced circulating system:

It consists of a radiator, water pump, water jacket, thermostat valve, fan, fan belt, temperature gauge and sufficient hose to complete the cooling system.



# Radiator

It mainly consists of an upper tank and a lower tank and between them is a core.

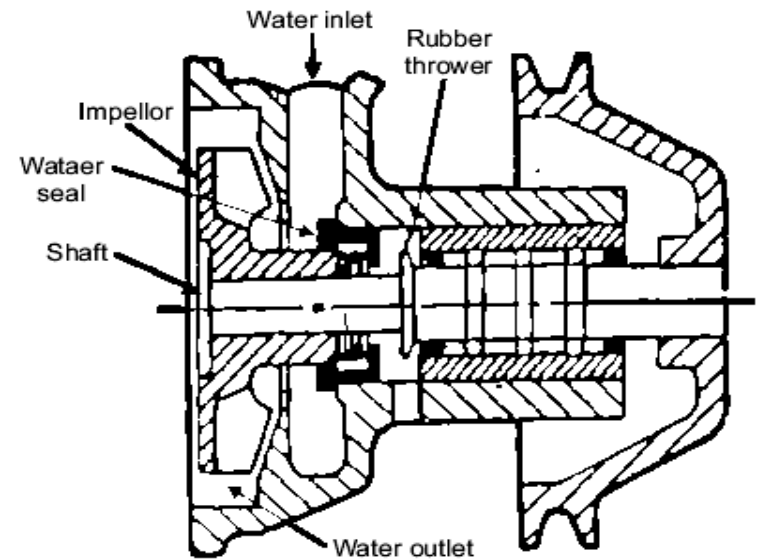
The upper tank is connected to the water outlets from the engines jackets by a hose pipe and the lower tank is connect to the jacket inlet through water pump by means of hose pipes.

A spring loaded sealed radiator cap is provided to create 0.34 to 0.4 kg/cm<sup>2</sup> pressure and thereby boiling temperature of water in the radiator is raised to about 110°C.




## Water pump

- ▶ In this system a pump is used to lift the water from the bottom of radiator and force it through the water jackets provided around the cylinders and in the cylinder head.
- ▶ The pump consists of an impeller mounted on a shaft and enclosed in the pump casing.
- ▶ The pump casing has inlet and outlet openings.
- ▶ The pump gets drive from the engine crank shaft through V- belt.





## Water jackets

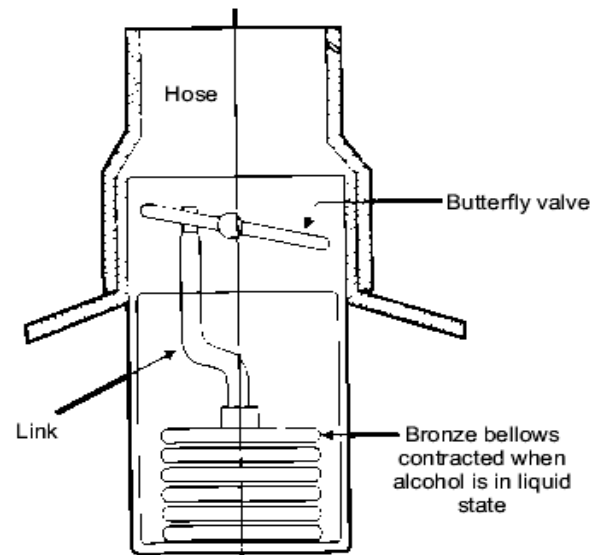
- ▶ Cooling water jackets are provided around the cylinder, cylinder head, valve seats and any hot parts which are to be cooled.
  - ▶ Heat generated in the engine cylinder, conducted through the cylinder walls to the jackets.
  - ▶ The water flowing through the jackets absorbs this heat and gets hot.
  - ▶ This hot water will then be cooled in the radiator.
- 

# Thermostat valve

- ▶ A thermostat valve is placed at the forward end of the cylinder head to maintain the correct engine operating temperature.
- ▶ It restricts the flow of water through the radiator and bypasses it till it gets warmed up after cold start of engine.
- ▶ The thermostat then opens, closing the bypass and allowing the water to circulate through the radiator.
- ▶ Generally the **bellows** type thermostat is used on the tractors.
- ▶ Generally the thermostat begins to open at about  $74^{\circ}\text{C}$  and opens widely at about  $80^{\circ}\text{C}$ .

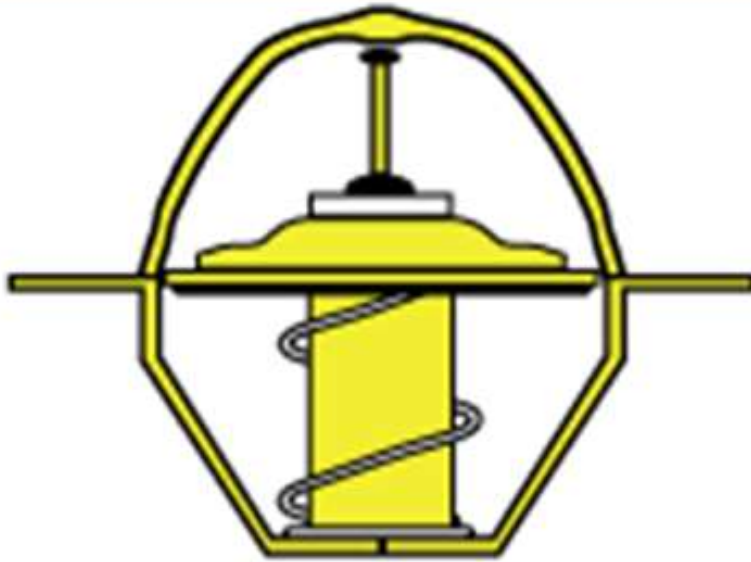
It contains a bronze bellow containing liquid alcohol which has a narrow boiling range.

When the temperature of water increases, the liquid alcohol evaporates and the bellow expands and in turn opens the butterfly valve, and allows hot water to the radiator, where it is cooled.

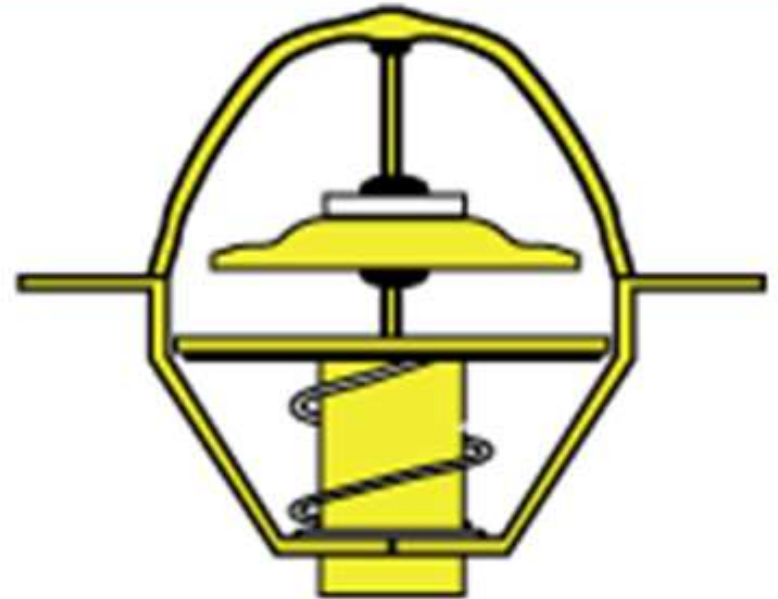


*Thermostat valve*

# Thermostat



**CLOSED POSITION**



**OPEN POSITION**

## Fan

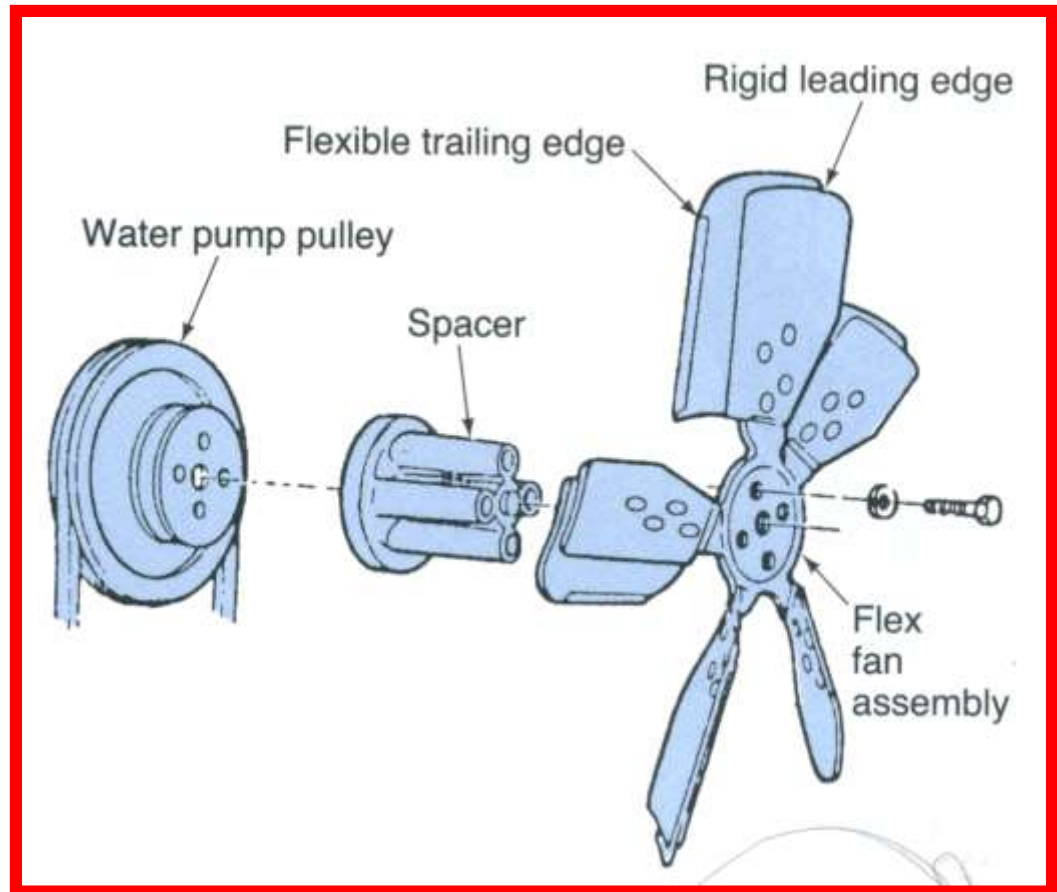
It is driven by the engine output shaft through same belt that drives the pump.

It is provided behind the radiator and it blows air over the radiator for cooling purpose.




# Flex Blade Fan

- ▶ Fan blades flatten out at high speeds, reducing noise, increasing horse power



## Advantages of Water Cooling System:

- (a) Uniform cooling of cylinder, cylinder head and valves.
  - (b) Specific fuel consumption of engine improves by using water cooling system.
  - (c) If we employ water cooling system, then engine need not to be provided at the front end of moving vehicle.
  - (d) Engine is less noisy as compared with air cooled engines, as it has water for damping noise.
- 

## Disadvantages:

- (a) It depends upon the supply of water.
  - (b) The water pump which circulates water absorbs considerable power.
  - (c) If the water cooling system fails then it will result in severe damage of engine.
  - (d) The water cooling system is costlier as it has more number of parts. Also it requires more maintenance and care for its parts.
- 