MODULE 3

SYLLABUS:

CO3: Explain the working of Engine lubrication and cooling systems.

Properties of lubricating oil, Single and multi - grade oils. Oil additives,

Concept of lubrication, Working of engine lubrication system - Petroil, splash, pressure, dry sump and wet sump.

Types of oil pumps - construction and working of gear pump, vane pump and rotor pump, Layout and working of Full flow filtering system and By-pass flow filtering system, Functions of oil cooler, oil filter, pressure relief valve.

Cooling system, significance, Types - Air cooling & Water-cooling system, Types of coolant, Water pump - working, Radiator - necessity, Expansion tank - necessity, Construction and working of Thermostat valve, Anti-freeze solutions - purpose, Radiator Pressure Cap.

LUBRICATION SYSTEM:

- In engines, frictional losses are mainly due to sliding as well as rotating parts.
- A good engine design should not allow the total frictional losses to be more than 30% of the energy input in reciprocating engines. This is achieved by proper lubrication.
- So, lubrication is essential to reduce friction and wear between the components in an engine.

OBJECTIVES/FUNCTIONS OF LUBRICATION:

- The ***primary objectives*** of lubrication are:
  1. To reduce friction between moving parts to its minimum value so that power loss is minimized.
  2. To reduce wear of the moving parts as far as possible.
- The ***secondary objectives*** of lubrication are:
  1. **To provide cooling effect:** The lubricating oil takes heat from the hot moving parts during its circulation and delivers it to the surrounding air through the crank case.
  2. **To provide cushioning effect:** The lubricating oil serves also as a good cushion against the shocks present in the engine.
  3. **To provide cleaning action**: lubricating oil serves another useful purpose in providing a cleaning action. During its circulation it dissolves many impurities, e.g., carbon particles.
  4. **To provide a sealing action:** The lubricating oil also helps the piston rings to maintain an effective seal against the high-pressure gases in the cylinder from leaking out toward the crank case side.

REQUIREMENTS/PROPERTIES OF LUBRICATING OIL:

1. ***Viscosity:*** the viscosity may be considered as the resistance of the lubricating oil to flow. The viscosity of the lubricating oil should be just sufficient to ensure lubrication. A higher value than this would be of no use since it will involve higher power losses due to the increased oil resistance.

2. ***Physical Stability:*** The lubricating oil must be stable physically at the lowest and the highest temperatures. There should not be any solid formation at the lower temperatures and at higher temperatures it should not vapourise.
3. ***Chemical Stability:*** At higher temperatures the oil should remain chemically stable. There should not be any tendency for oxide formation; many of the oxidation products being sticky substances clog the lines and cause faulty piston rings and valve action. The oil should also not decompose at high temperatures to form carbon.
4. ***Resistance Against Corrosion:*** The oil should not have any tendency to corrode the pipe lines, crank case and other engine parts with which it comes into contact.
5. ***Flash Point:*** The flash point of the oil should be sufficiently high so as to avoid flashing of oil vapours at the temperatures.
6. ***Cleanliness:*** The oil should be sufficiently clean and stable itself so that the crank case and oil lines arc kept clean Further, il must contain agents, called detergents, which remove ihe impurities from the engine parts during oil circulation.
7. ***Resistance Against Extreme Pressure:*** In modern automobile engines, lubricating oil is subjected to very high pressures, particularly in bearings and the valve actuating mechanisms. This would cause the oil to be driven out. The lubricating oil should have sufficient resistance against this tendency.

SAE RATING OF LUBRICANTS:

- Selection of the lubricant for engine application is based on the temperature at which the engine is to be started and operated and the type of service to which the engine is to be subjected to.
- The SAE (Society of Automotive Engineers) has been the first organization that in June 1911 developed the standard that specifies Engine Oil Viscosity Classification.
- They have specified two grades for engine applications:
  1. ***Single grade***
  2. ***Multigrade***

1. SINGLE-GRADE OIL:

- A single-grade engine oil has eleven viscosity grades, of which six are considered Winter-grades and given a W designation.
- The eleven viscosity grades are 0W, 5W, 10W, 15W, 20W, 25W, 20, 30, 40, 50, and 60.
- For single winter grade oils, the dynamic viscosity is measured at different cold temperatures. Based on the coldest temperature at which the oil can flow, it is graded as 0W, 5W, 10W, 15W, 20W, or 25W.
- The lower is the viscosity grade, the lower will be the temperature at which the oil can flow.
- For single non-winter grade oils, the kinematic viscosity is measured at a temperature of 100 C.
- Based on the range of viscosity the oil falls in at that temperature, the oil is graded as SAE viscosity grade 20, 30, 40, 50, or 60. Higher the viscosity, the higher is the SAE grade.

2. MULTI-GRADE OIL:

- The temperature range the oil is exposed to in most automobiles can be wide. For example, it can range from cold temperatures in the winter before the vehicle is started up, to hot operating temperatures when the vehicle is fully warmed up in hot summer weather.
- A specific single-grade oil will have higher viscosity when cold and a lower viscosity at the engine’s operating temperature.
- The difference in viscosities for most single-grade oil is too large between the extremes of temperature.

- The multi viscosity oil is one that has a low viscosity when cold (for easier cranking) and a higher viscosity when hot (to provide adequate lubrication).
- Multi grade oils are rated at two different temperatures. The SAE designation for multi-grade oils includes two viscosity grades.
- Multi grade oils are specified as SAE10W 30, 20W 40 etc.

ADDITIVES FOR LUBRICANTS:

- The lubricating oil should possess all the above properties for the satisfactory engine performance.
- The modern lubricants for heavy duty engines are highly refined which otherwise may produce sludge or suffer a progressive increase in viscosity.
- Thus, oil soluble organic compounds added to the present-day lubricants to impart one or more of the following characteristics:
  1. ***anti-oxidant and anticorrosive agents***
  2. ***detergent-dispersant***
  3. ***extreme pressure additives***
  4. ***pour point depressors***
  5. ***viscosity index improvers***
  6. ***antifoam agent***
  7. ***oiliness and film-strength agents***

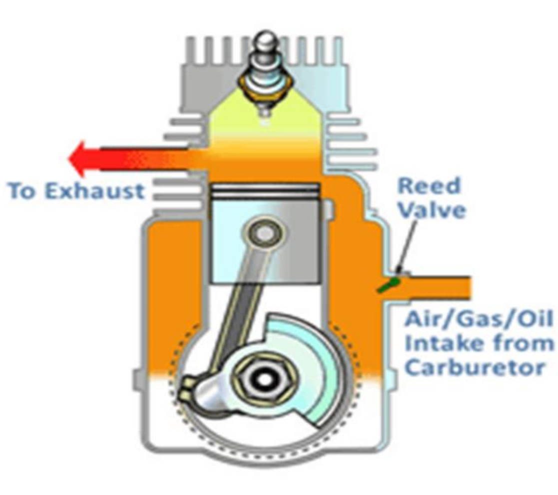
1. **Anti-oxidants and Anticorrosive Agents:** Oxidation of the lubricating oil is slow at temperatures below 90 ◦C but increase at an exponential rate when high temperatures are encountered. Oxidation is undesirable, not only because sludge and varnish are formed but also because of the formation of acids which may be corrosive. Thus, the additive has the dual purpose of preserving both the lubricant and the components of the engine. The additives may be alkaline to neutralize acids formed by oxidation.
2. **Detergent-Dispersant:** This type of additives improves the detergent action of the lubricating oil. These additives might be metallic salts or organic acids. Thus, the additives may chemically combine with the compounds in the oil that would otherwise form sludge and varnish.
3. **Extreme Pressure Additives:** At high loads and speeds with high surface temperatures, an extreme pressure additive is necessary. Such additives interact with the metal surface to form a complex inorganic film containing iron, oxygen, carbon and hydrogen.
4. **Pour Point Depressors:** In order to obtain flow of oil at low temperatures, pour point depressants is added to the lubricating oils to lower the pour point. An engine having a lubricant with higher pour point will not get adequate lubrication during starting at low ambient temperatures and excessive wear would result.
5. **Viscosity Index Improvers:** High molecule polymers are added to the lubricating oils to increase their viscosity index. An increase in the viscosity index increases the resistance of an oil to change its viscosity with a change in temperature.
6. **Oiliness and Film Strength Agents:** Oiliness and high film-strength can be improved by adding organic Sulphur, chlorine and phosphorus compounds.
7. **Antifoam Agents:** Foaming, to some extent is due to the violent agitation and aeration of the oil that occurs in an operating engine. The minute particles of air in a foaming oil increase oxidation and reduce the mass flow of oil to the bearings. In addition, foaming may cause abnormal loss of oil through the crankcase breather. Antifoam agents are used to reduce the foaming tendencies of the lubricant.

LUBRICATION SYSTEMS:

The various systems adopted for the lubrication of automobile engine are:

1. ***Petroil or mist System***
2. ***Splash System***
3. ***Pressure System***
4. ***Dry-Sump System***
5. ***Wet-sump system***

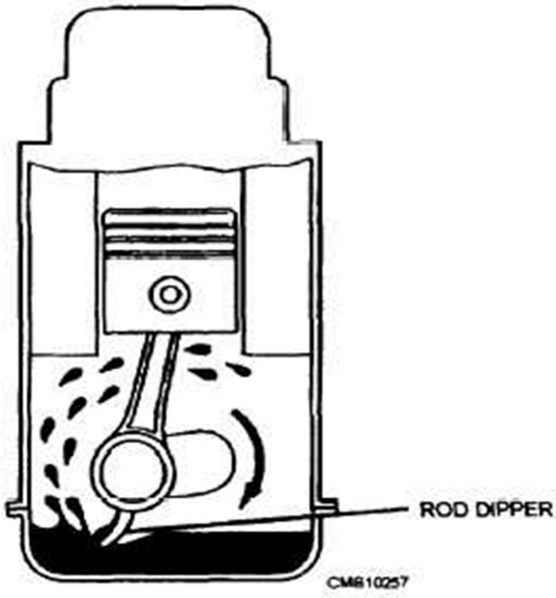
1. PETROIL / MIST LUBRICATION SYSTEM:



- This is used generally for small two-stroke engines.
- It is the simplest of all types of engine lubrication systems. Certain amount of the lubricating oil is mixed with the petrol itself, the usual ratio being 2% to 3% of oil.
- If it is less, there is danger of oil starvation or insufficient lubrication causing damage to the engine; however, if it is more, there will be excessive carbon deposits in the cylinder head and the engine will also give dark smoke.
- When the petrol mixture enters the crankcase, due to high temperatures there, the petrol vaporizes leaving a thin film of lubricating oil on the crankcase, cylinder walls, crankshaft and bearings.
- Thus, the common rail, serves as the high-pressure reservoir where the injection pressure is independent of the engine speed and load, due to which the injection parameters can be freely controlled.

2. SPLASH LUBRICATION SYSTEM:

- It is one of the cheapest methods of engine lubrication.
- A scoop is made in the lowest part of the connecting rod and the oil is stored in the oil trough; it being pumped there from the crankcase oil sump.
- When the engine runs, the scoop causes the oil to splash on the cylinder walls each time it passes through its BDC position.
- This affects the lubrication of engine walls, gudgeon pin, main crankshaft bearings, big end bearings etc.



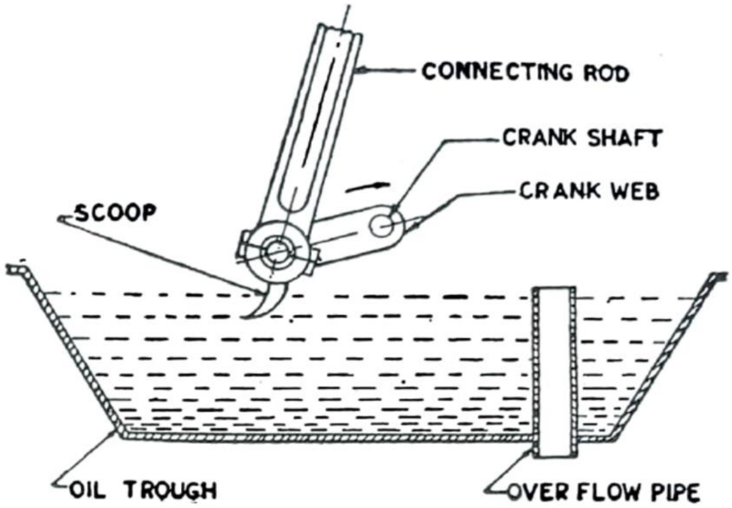


Fig. 6.8. Splash system lubrication.

3. PRESSURE LUBRICATION SYSTEM:

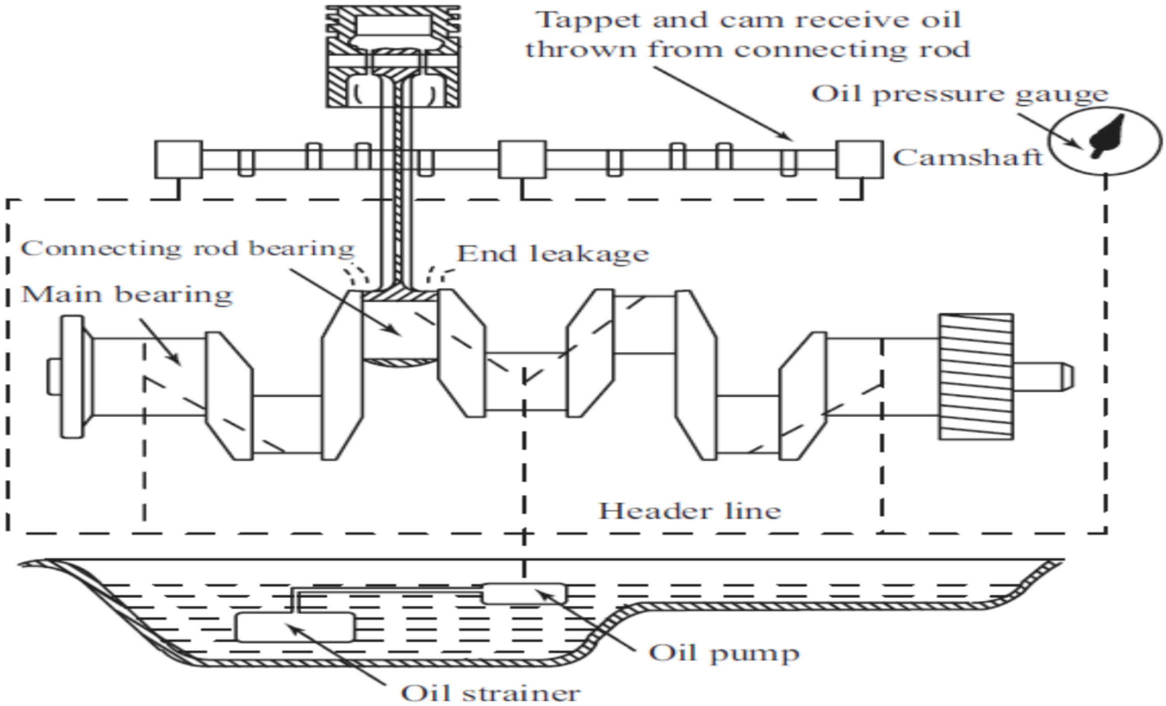


Fig. 12.11 Pressure feed lubrication system

- This system is used almost universally in modem car engines.
- In the pressure system, an oil pump takes the oil from the wet sump through a strainer and delivers it through a filter, to the main oil gallery at a pressure of 200 to 400 kPa.
- The oil pressure is controlled by means of a pressure-relief valve, situated in the filter unit or the pump housing.
- From the main gallery, the oil goes through the drilled passages to the main bearings from where some of the oil after lubricating the main bearings falls back to the sump, some is splashed to lubricate cylinder walls, while the rest goes through a hole to the crankpins.

- From the crankpin it reaches piston pin bearing through a hole drilled in the connecting rod.
- The cylinder walls, piston and piston rings are lubricated by oil spray from around the piston pins and the main and connecting rod bearings.

4. DRY SUMP LUBRICATION SYSTEM:

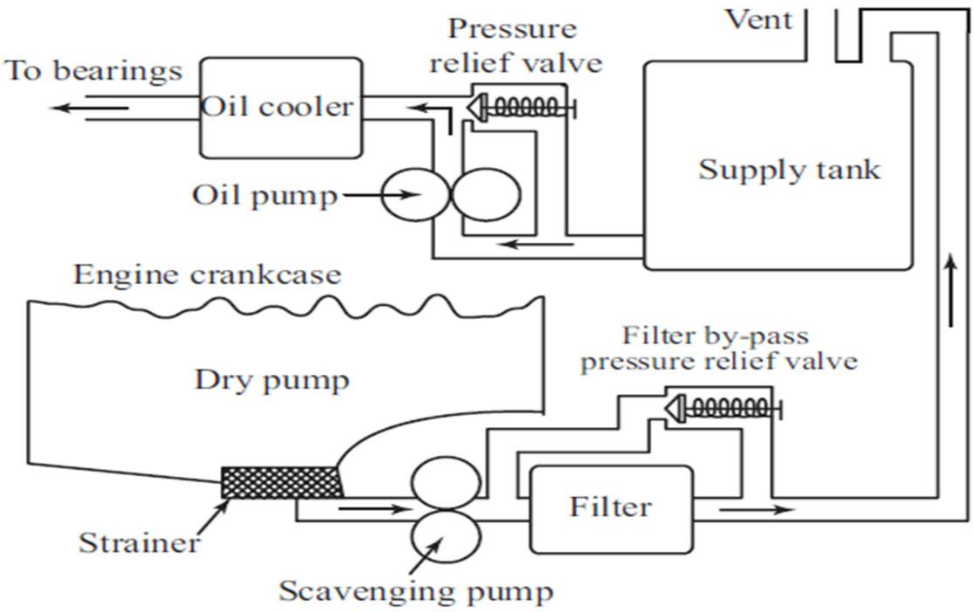


Fig. 12.14 Dry sump lubrication system

- In this, the supply of oil is carried in an external tank. An oil pump draws oil from the supply tank and circulates it under pressure to the various bearings of the engine.
- Oil dripping from the cylinders and bearings into the sump is removed by a scavenging pump which in turn the oil is passed through a filter, and is fed back to the supply tank.
- Thus, oil is prevented from accumulating in the base of the engine.
- In this system a filter with a bypass valve is placed in between the scavenge pump and the supply tank.
- If the filter is clogged, the pressure relief valve opens permitting oil to by-pass the filter and reaches the supply tank.

5. WET SUMP LUBRICATION SYSTEM:

- Oil is drawn from the sump by a gear or rotor type of oil pump through an oil strainer.
- The strainer is a fine mesh screen which prevents foreign particles from entering the oil circulating systems.
- A pressure relief valve is provided which automatically keeps the delivery pressure constant.
- When the oil pressure exceeds that for which the valve is set, the valve opens and allows some of the oil to return to the sump thereby relieving the oil pressure in the systems.
- Most of the oil from the pump goes directly to the engine bearings and a portion of the oil passes through a cartridge filter which removes the solid particles from the oil.
- This reduces the amount of contamination from carbon dust and other impurities present in the oil.
- All the oil will pass through the filter over a period of operation.
- The advantage of this system is that a clogged filter will not restrict the flow of oil to the engine.

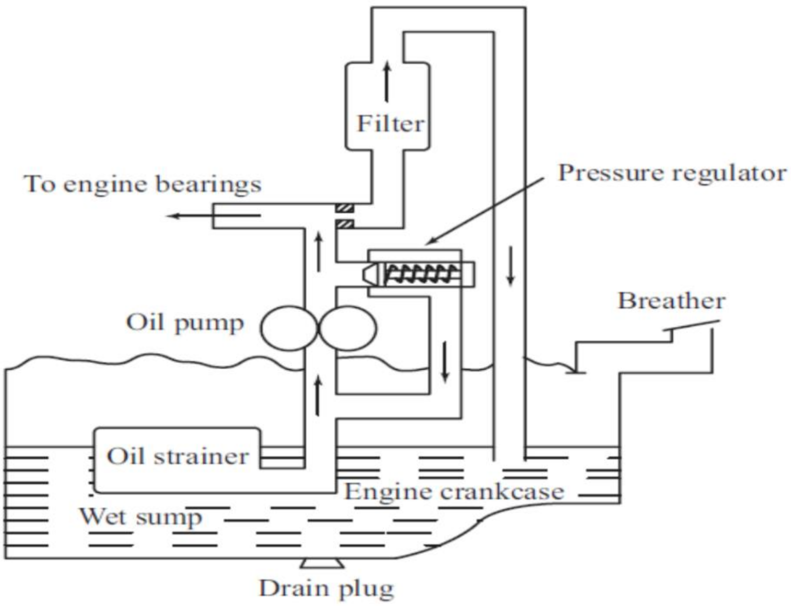


Fig. 12.12 Basic components of wet sump lubrication system

OIL PUMPS:

- Its function is to supply oil under pressure to the various engine parts.
- The oil pump is generally located inside the crank case below the oil level. However, instances exist where it has been mounted outside the crank case above the oil level.
- In some automobile engines mounted transversely, the oil pump is driven directly from the camshaft end through a coupling. Since no separate shaft is required, this is a compact arrangement.
- The oil pressure in the engine increases with the increase in engine speed which would increase the pump speed.
- The maximum pressure is limited by means of a pressure relief valve.
- Minimum oil pressure required is almost 100 kPa. Usually, 15 to 30 litres per minute oil circulation is enough for engine lubrication.
- The different types of pumps used for engine lubrication are:
  1. ***Gear pump***
  2. ***Rotor pump***
  3. ***Vane pump***

1. GEAR PUMP:

- This is the type once almost universally used in the automotive engines.
- Its construction is very simple in that it consists of two spur, or for quieter running, helical gears are in mesh with each other.
- One gear is the driving gear, and is driven directly by the cam shaft whereas the other gear is mounted on a stub shaft and is driven only through the driving gear.
- The oil is transported from the inlet to the outlet side in gear spaces between the gear teeth as shown in figure and is discharged through the outlet port.
- The pump is always submerged in oil in the crankcase and, therefore no priming is necessary.
- The pump delivers oil at about 300-400 kPa.

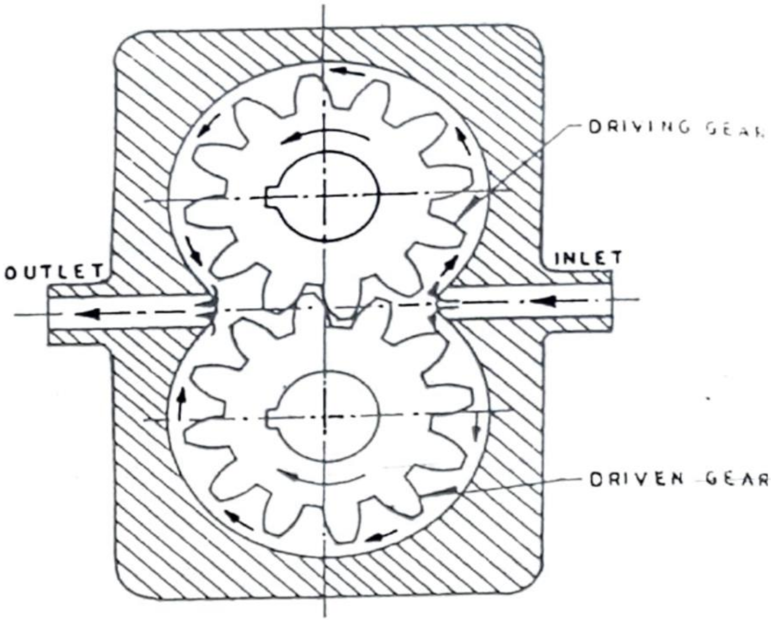


Fig. 6.16. Gear pump.

2. ROTOR PUMP:

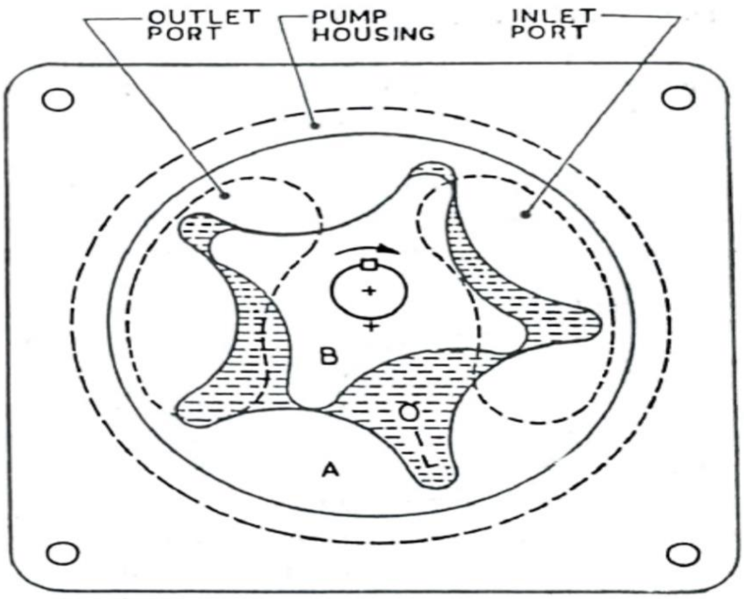


Fig. 6.20. Rotor pump.

- This type of oil pump is now widely used in automobiles. It is similar to the gear pump except that in this two gears mesh internally.
- A is the external rotor having the number of lobes one more than on the internal rotor B. The axes of rotation of the two rotors are different which causes the size of the spaces between them to vary.
- Rotor B gets its drive from the engine and causes rotor A to rotate along with it.
- The oil enters the pump through inlet port, as the rotor lobes are moving out of mesh. The oil is then transported from inlet to the outlet of the pump in the spaces between rotor lobes.
- The rotation reduces the clearance between the lobes and the oil is discharged under pressure as the lobes of the rotors.
- This type of pump is about 25% more efficient and compact than the gear type pump. This is also quieter running since there are comparatively lesser teeth in mesh for each revolution. Because of these advantages, its use is on increase in the automobile engines.

3. VANE PUMP:

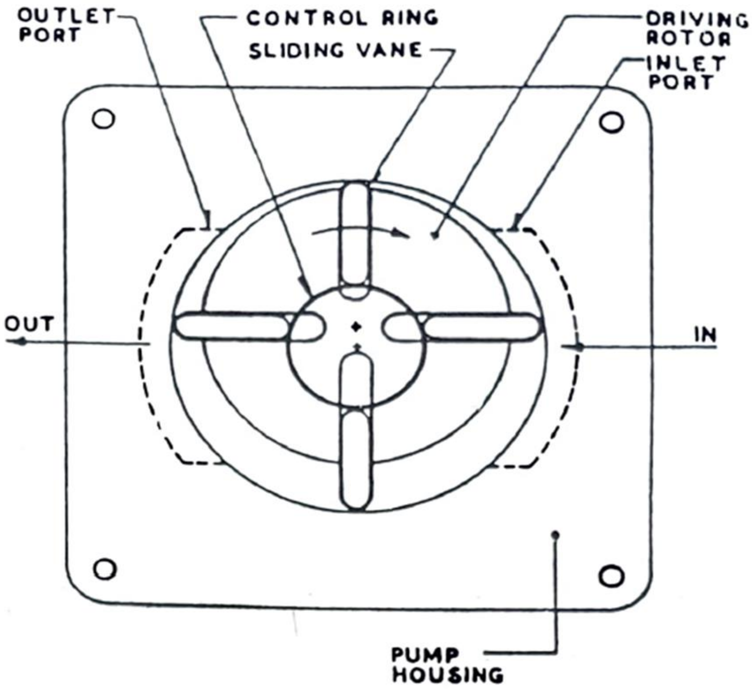


Fig. 6.22. Vane pump

- This type consists of a cylindrical housing, within which is eccentrically mounted a driven rotor.
- The rotor contains a number of vanes in the rotor slots equally spaced around its periphery.
- These vanes can slide back and forth into these slots. The movement of sliding vanes is guided by means of a control ring as shown.
- When the pump is operating, the vanes are pressed outwards against the housing by their centrifugal force.
- The oil enters the inlet port and is swept by the vanes to the outlet port. This type of pump has an advantage of a continuous oil flow compared to the pulsating oil flow in case of gear pump.

OIL COOLER:

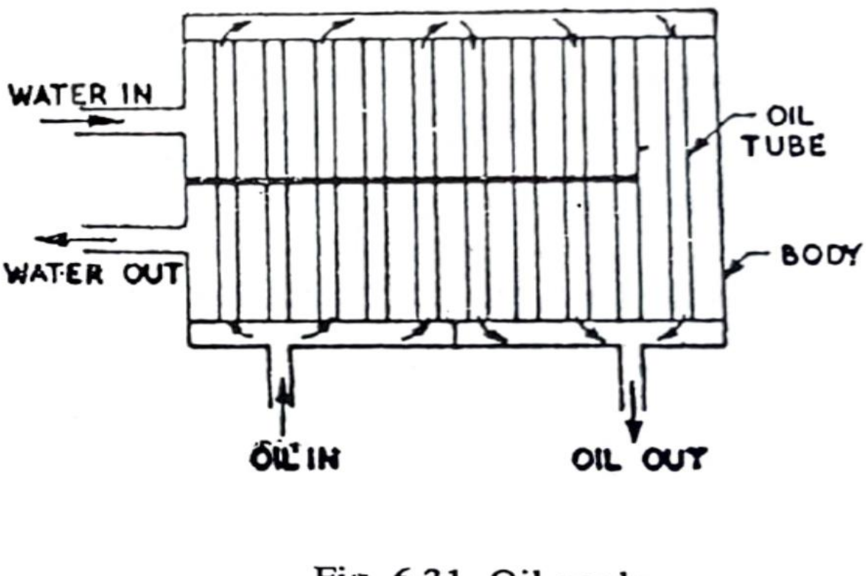


Fig. 6.31. Oil cooler.

- In all heavy-duty engines, the engine temperature and hence the temperature of oil becomes quite high.
- As the viscosity of lubricating oil decreases with temperature rise, at higher temperatures the oil film in the bearings might break.
- To avoid such thing from happening, the heavy engines are provided with oil coolers. Oil coolers are nothing but simple heat exchangers.
- Either the cold water from the radiator or the air stream is used to cool the oil.
- The water type coolers are, however, more common because they can be used as reversible coolers, i.e., at the start when it is desirable that the oil should be heated to provide complete circulation in the lubrication system as fast as possible.
- The water being hotter than the oil, will initially heat the oil and when higher temperatures are reached, the reverse will happen, i.e., the water will cool the oil.
- One such oil cooler is shown in Fig. The water enters the cooler and then cools the oil tubes which are placed in a direction perpendicular to the flow of water, after which it comes out.

OIL FILTERS:

- The lubricating oil with use, is deteriorated resulting in the formation of sludge, lacquer and carbon. Further, it is contaminated by various by-products of combustion of fuel, water, acids and unburnt fuel.
- In addition to these the fine particles of metal due to wear, especially during the running-in period and particles of rust formed in the engine are the other impurities presents in the oil.
- It is therefore, absolutely necessary to remove these impurities to avoid permanent damage to any or more running parts of the engine.
- Oil filters are basically of two types: the primary and the secondary. A primary filter is also known as surface filter since the impurities are retained on the outer surface of the filter. The secondary filter is installed on the outlet side of the oil pump and since the impurities in this are retained progressively along the depth of the filter material, it is also called depth filter.
- Primary filter is more commonly known as strainer and is formed from wire gauze. The secondary filters used in the automobile engines are of various kinds, the important ones out of them being:
    1. ***Cartridge type.***
    2. ***Centrifugal type.***

1. CARTRIDGE TYPE OIL FILTER:

- This type is used on most automobile engines and it consists of a filtering element placed in the metallic casing.
- The impure lubricating oil is made to pass through the filtering element, which takes up all the impurities.
- Currently filler elements with fine pores have been employed which has made it practicable to arrest particles of size down to within the region of 5 microns.
- In the filter shown in Fig. the oil enters the filter at the top and passes through the filler elements as shown by arrows. The pure oil then goes to the porous metallic tube from where it goes to the outlet for circulation. A drain plug is also provided as shown.

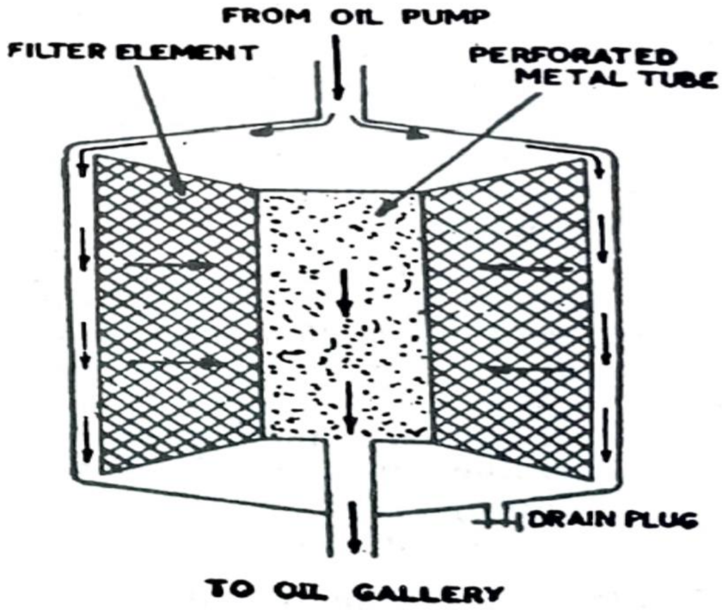


Fig. 6.26. Cartridge type oil filter

2. CENTRIFUGAL TYPE OIL FILTER:

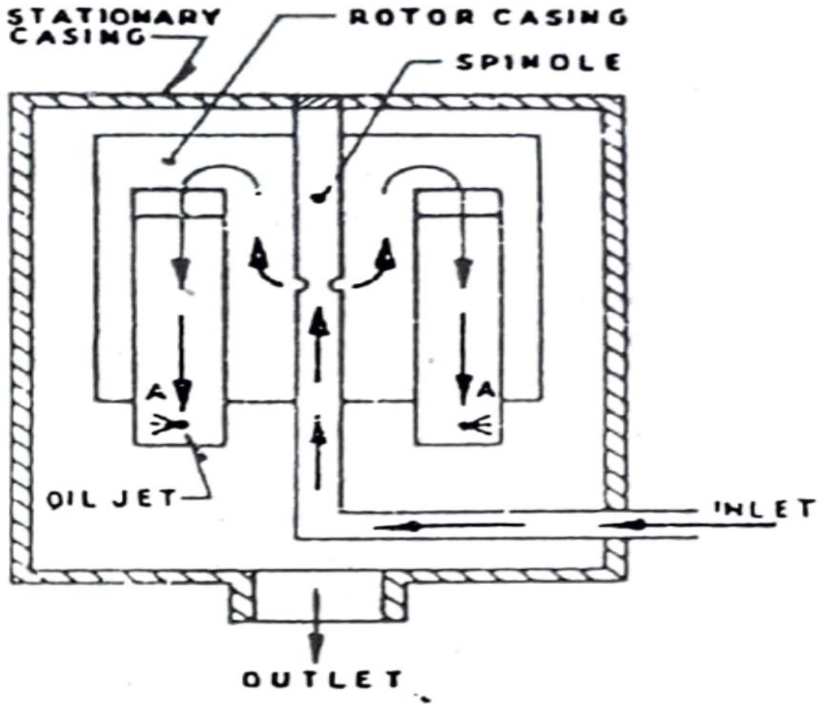


Fig. 6.28. Centrifugal type oil filter

- In this the impure or dirty oil from the engine enters the hollow central spindle having holes around its periphery as shown in Fig.
- The dirty oil comes out of these holes and fills the rotor casing after which it passes down the tubes A at the ends of which jets are attached.
- The oil under pressure passes through these jets, the reaction of which gives the motion to the rotor casing in the opposite direction so that it starts rotating.
- The oil impinges on the outer stationary casing under heavy pressures, where the impurities are retained and clean oil falls below from where it is taken out.

- The working speed of the rotor is usually between 2000 and 7000 rpm, depending upon the oil pressure circulating the oil.

COOLING SYSTEM:

NECESSITY:

- All the heat produced by the combustion of fuel in the engine cylinders is not converted into useful power at the crankshaft.
- A typical distribution for the fuel energy is given below:
  - Useful work at the crank shaft = 25 percent
  - Loss to the cylinder walls = 30 percent
  - Loss in exhaust gases = 35 percent
  - Loss in friction = 10 percent
- It is seen that the quantity of heat given to the cylinder walls is considerable and if this heat is not removed from the cylinders it would result in the preignition of the charge.
- In addition, the lubricant would also burn away, thereby causing the seizing of the piston. Excess heating will also damage the cylinder material.
- Keeping the above factors in view, it is observed/that suitable means must be provided to dissipate the excess heat from the cylinder walls, so as to maintain the temperature below certain limits.

COOLING SYSTEM:

1. ***Air cooling***
2. ***Water cooling***

1. **AIR COOLING:**

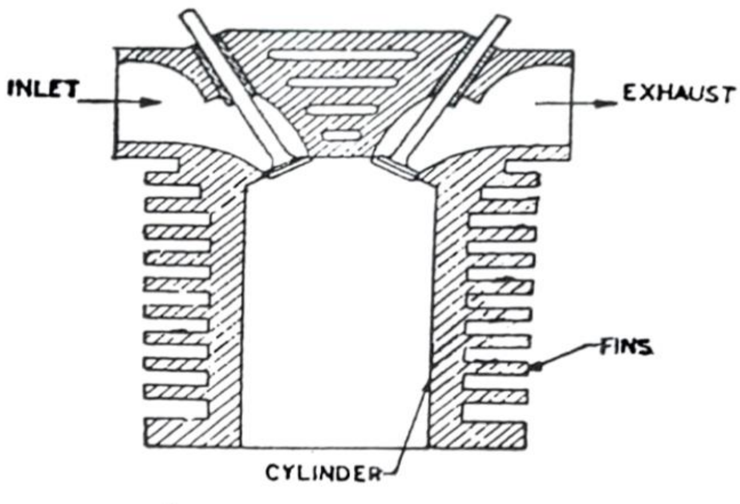


Fig. 5.1. Cylinder with cast fins.

- The basic principle involved in this method is to have current of air flowing continuously over the heated metal surface from where the heat is to be removed.
- The heat dissipated depends upon following factors:
  - Surface area of metal into contact with air.
  - Mass flow rate of air.

- ➢ Temperature difference surface and air between the heated
- ➢ Conductivity of metal.

2. Thus, for an effective cooling the surface area of the metal which is in contact with the air should be increased.
3. This is done by using fins over the cylinder barrels. These fins are either cast as an integral part of the cylinder or separate finned barrels are inserted over the cylinder barrel.

Advantages:

- Air cooled engines are lighter because of the absence of the radiator, the cooling jackets and the coolant.
- They can be operated in extreme climates, where the water may freeze.
- In certain areas where there is scarcity of cooling water, the air-cooled engine is an advantage.
- Maintenance is easier because the problem of leakage is not there
- Air cooled engines get warmed up earlier than the water-cooled engines.

Disadvantages:

- It is not easy to maintain even cooling all around the cylinder, so that the distortion of the cylinders takes place.
- As the coefficient of heat transfer for air is less than that for water, which results in less efficient cooling.
- The fan used is very bulky and absorbs a considerable portion of the engine power (about 5%) to drive it.
- Air cooled engines are nosier, because of the absence of cooling water which acts as sound insulator.
- The cooling fins around the cylinders may vibrate under certain conditions due to which noise level would be considerably enhanced.

2. WATER COOLING:

- water cooling system, the cooling medium used is water.
- In this, the engine cylinders are surrounded by water Jackets through which the cooling water flows.
- Heat flows from the cylinder walls into water which goes to the radiator where it loses its heat to the air. Usually, some antifreeze is added to the cooling water, due to which it is often referred to as coolant.
- Water cooling systems are of two types:
  - ***a) Thermosyphon system***
  - ***b) Pump circulation system***

a) THERMOSYPHON SYSTEM:

- It consists of a radiator connected to the engine through flexible hoses.
- In this system, circulation of water is obtained from the difference in densities of the hot and the cold regions of cooling water.
- The circulating water gets heat from the engine cylinders, thereby cooling the same.
- The same heat in the water is then dissipated into the atmosphere, through the radiator, by mainly conduction and convention.
- Therefore, the circulating water becomes cold by the time it reaches the collector tank of the radiator.
- The same water is then circulated through the engine to collect heat from the cylinders.

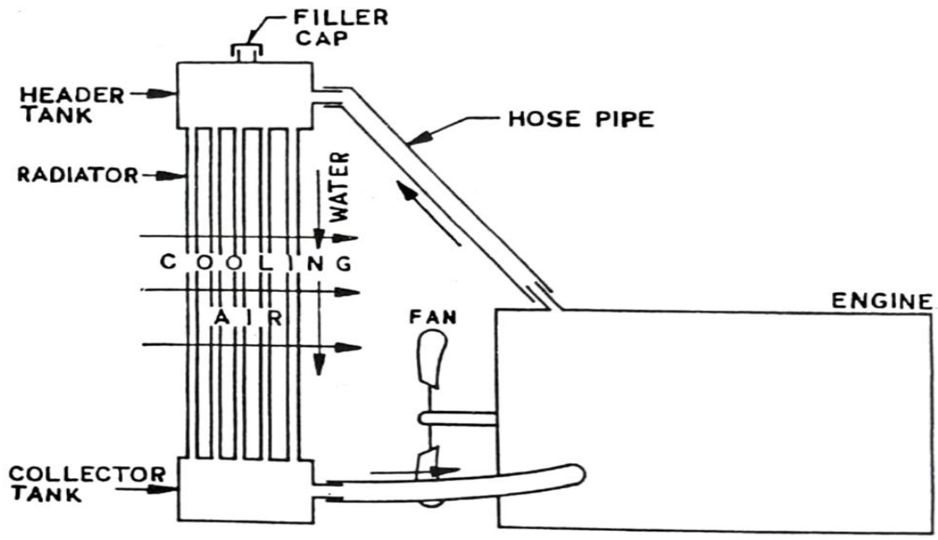


Fig. 5.4. Thermosyphon system of cooling

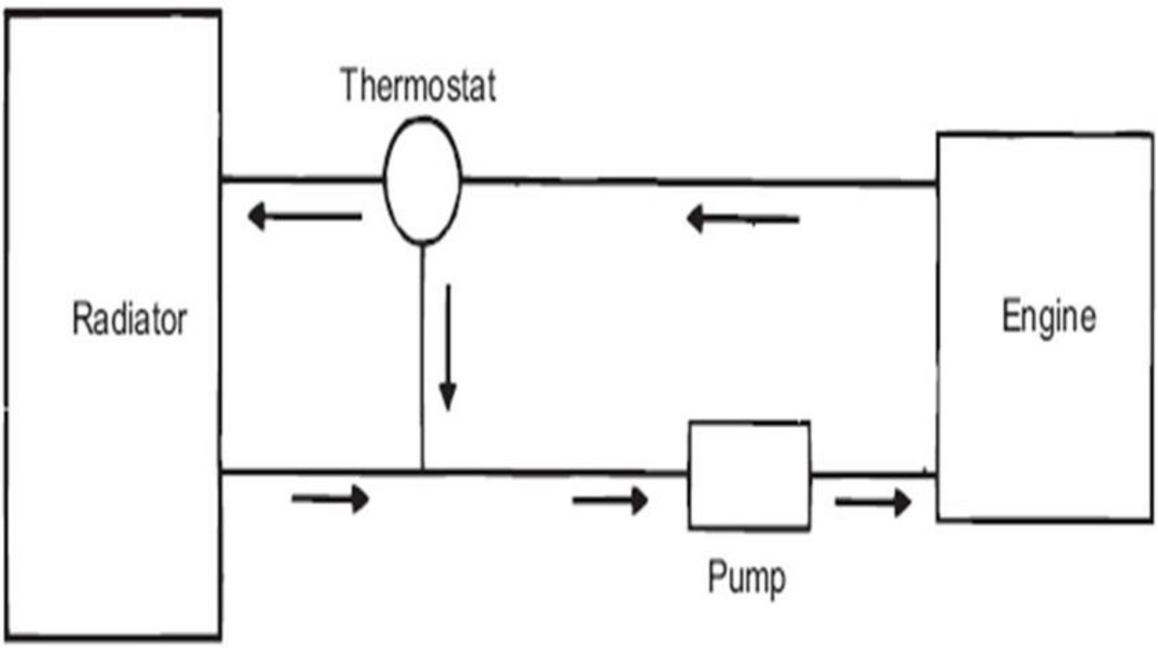
Advantages:

- Simplicity and low cost

Disadvantages:

- As the circulation of coolant is maintained by natural conventional only, the cooling is rather slow.
- Due to the quantity of coolant being large, it takes, more time for the engine to reach the operating temperature.
- Radiator header tank must be located higher than the top of the cylinder coolant jackets, which is no more possible with the modern body styles.
- Certain minimum level of coolant must be maintained in the system. If the coolant falls below that level, continuity of flow would break and the system would consequently fail.

b) PUMP CIRCULATION SYSTEM:



- Here a pump is used for the circulation of coolant and a thermostat is employed to control the flow of coolant.
- The pump is driven by means of a belt from the engine crankshaft.
- The drive for the fan is also obtained from the same belt that drives the pump and the generator.
- The thermostat valve will not allow the water to enter the radiator below the operating temperature of the engine. When the water temperature rises above a particular temperature, the valve opens and allow the hot water to enter the radiator to cool down.
- This will help the engine to reach its operating temperature quickly.

COMPONENTS OF WATER-COOLING SYSTEM:

- The main components that will be discussed are:
  1. ***Radiator and Pressure cap***
  2. ***Expansion reservoir***
  3. ***Thermostat***
  4. ***Pump***
  5. ***Fan***

1. RADIATOR:

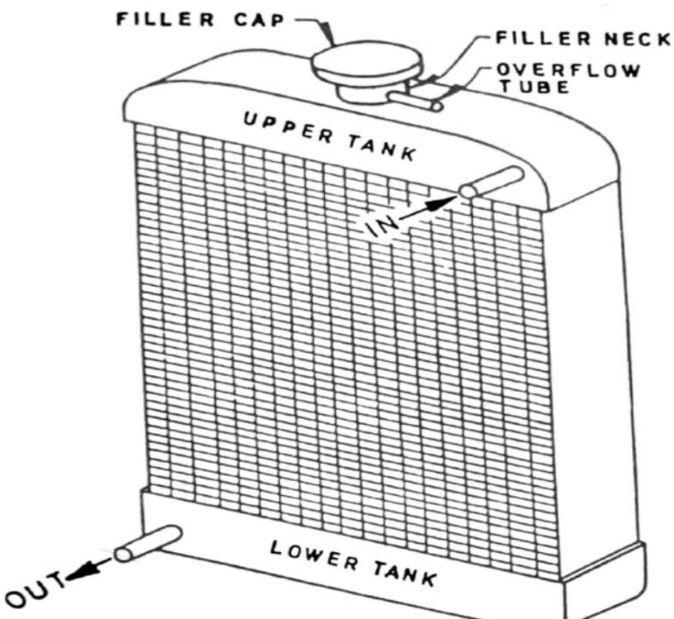
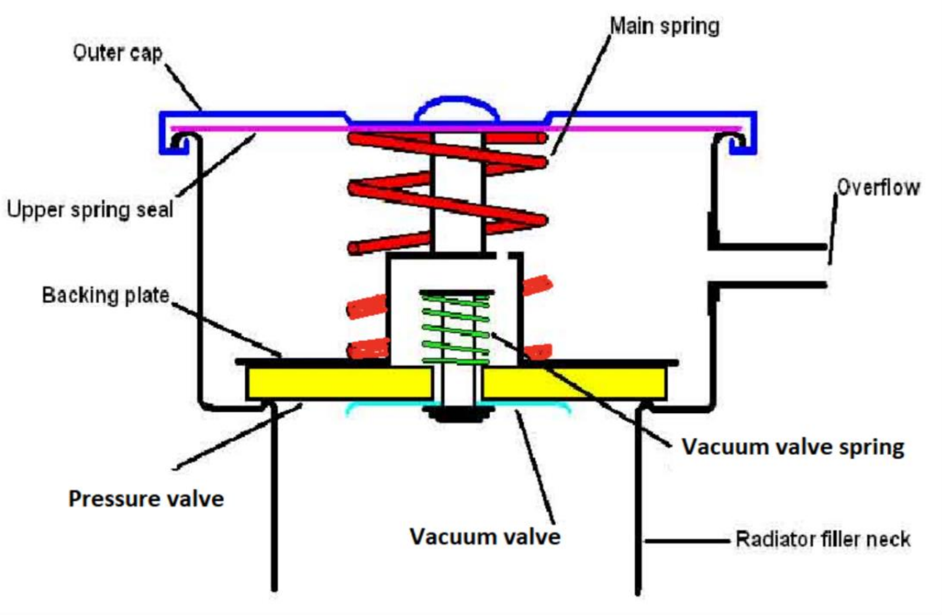


Fig. 5.7. Radiator.

- The function of the radiator is to ensure close contact of the hot coolant coming out of the engine with outside air, so as to ensure high rates of heat transfer from the coolant to air.
- A radiator consists of an upper (or header) tank, core and the lower (or collector) tank. Besides, an overflow pipe in the header tank and drain pipe in the lower tank are provided.
- Hot coolant from the engine enters the radiator at the top and is cooled by the cross-flow of air, while flowing down the radiator.
- The coolant collects in the collector tank from where it is pumped to the engine for cooling.

2. PRESSURE CAP:



- Radiator filler neck in modern use is covered with a pressure cap, which forms an air tight joint due to which the coolant is maintained at some pressure higher than the atmosphere.
- Due to this higher pressure, the boiling point of coolant is raised.
- A pressure cap is shown in Fig. It contains a pressure valve and a vacuum valve.
- When due to severe working conditions, the coolant starts boiling and vaporizes, the pressure in-the system exceeds a certain predetermined value (50-100 kPa), the pressure valve opens releasing the excess pressure to the atmosphere through the overflow pipe.
- On the other hand, if due to any reason (e.g., sudden cooling of the hot radiator), a vacuum is created inside, the vacuum valve operates to avoid collapse of the radiator.
- The following advantages thus result from the use of pressure cap:
  - The engine can operate at higher temperature without boiling the coolant.
  - The preparation of air-fuel mixture is improved at the higher operating temperatures.
  - With sealed cap, loss of coolant due to evaporation is prevented, which makes the system particularly useful in deserts.
  - At high altitudes, the atmospheric pressure is low which causes the coolant to boil at a lower temperature. With pressure cap, a higher pressure is maintained inside, irrespective of any change in the atmospheric pressure.

3. EXPANSION RESERVOIR/TANK:

- In modern engines, instead of overflow pipe, an expansion reservoir is provided.
- This is so connected with the radiator that it the receives the excess coolant as the engine temperature increases.
- When cooling water cools down, its volume decreases and the coolant in the reservoir returns to the radiator keeping the system full of coolant.
- The reservoir is usually made of plastic so that it can indicate the level of the coolant anytime.
- Such a system is also known as coolant recovery system and it has the following advantages:
  - There is no loss of coolant due to overflow on account of expansion.
  - As air does not enter the cooling system with this arrangement, corrosion of the cooling jackets and passages and deterioration of antifreeze is reduced appreciably.

- Relatively smaller upper tank may be used with the radiator

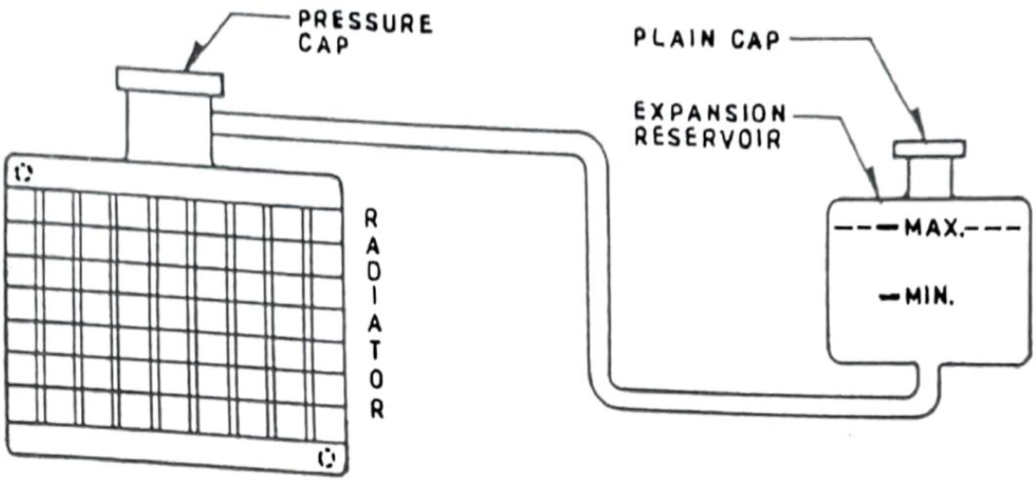


Fig. 5.11. Expansion reservoir.

4. **THERMOSTAT:**

- Only optimum cooling of the engine is desirable and overcooling results in deterioration of engine efficiency.
- To keep a rigid control over the cooling, therefore, a thermostat is used which automatically keeps the cooling water temperature at predetermined value.
- Moreover, it also helps the engine to reach the operating temperature as soon as possible after starting as the engines are designed to operate most efficiently over a small temperature range of 80° to 100°C.
- Two types of thermostats are used in automobiles:
    - ***a) Bellows or aneroid type***
    - ***b) Wax or hydrostatic type***

1. **BELLOWS TYPE THERMOSTAT:**

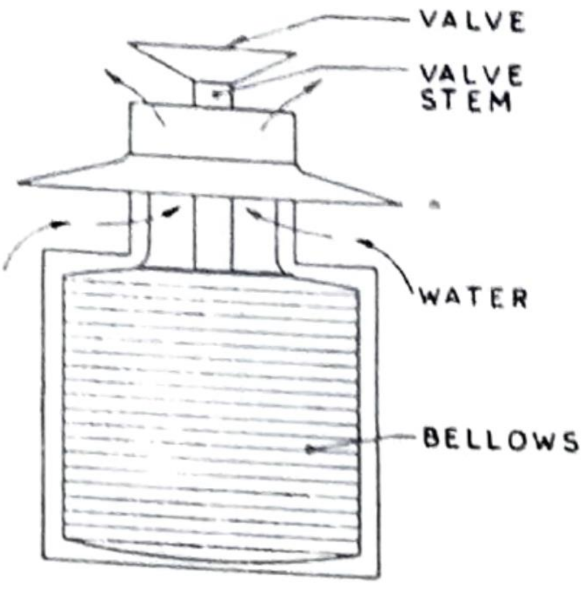
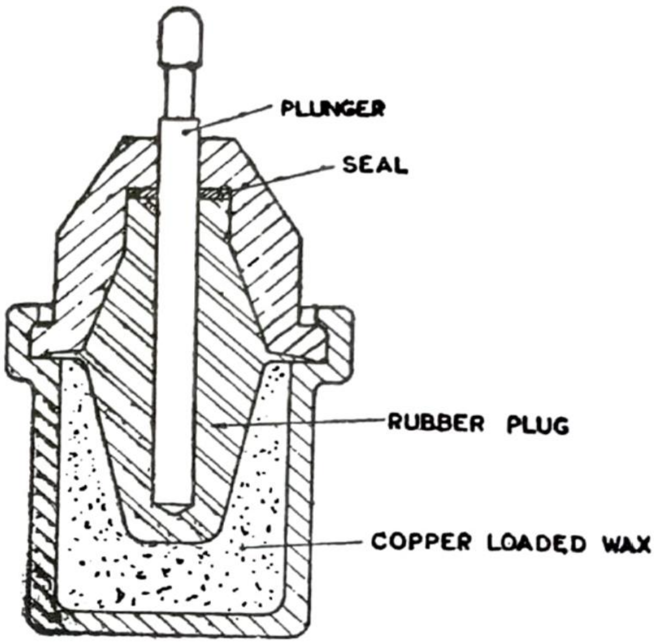


Fig. 5.12. Bellows type Thermostat

- It consists of metallic bellows particularly filled with some volatile liquid like acetone, alcohol or ether which boils between 70-85°C.
- A valve is attached to one end of the bellows, while to the other end is attached a frame which fits into the cooling passage.
- The thermostat is fitted in the coolant hose pipe at the engine outlet. When the engine after start is warming up, it is desired that the cooling system should not operate so that the engine warms up early.
- During this period, the thermostat valve remains closed, because the liquid inside as yet has not changed its state and, therefore, does not exert any pressure on the valve.
- But as the coolant temperature reaches a predetermined value, (about 80°C) the liquid inside the thermostat is converted into vapour which exerts a pressure on the valve, which begins to open, so that the water circulation through the radiator starts.
- The valve then opens gradually further as the water temperature rises, until it is fully open at about 99-95°C. Thus, the thermostat controls the flow of water through the radiator according to the engine cooling requirements.

b) <u>WAX THERMOSTAT:</u>



- As the coolant is heated, it transmits its heat to the copper-loaded wax having high coefficient of thermal expansion (0.28% per °C) which expands so that the rubber plug contracts against the plunger and exerts a force on it upwards so that it moves vertically.
- This movement of the plunger opens a valve in the thermostat to allow coolant to flow through the radiator.
- This type of thermostat, in contrast to the bellows type, is not sensitive to the pressure variations.
- Thus, it is more reliable to operate within the specified temperature range, due to which reason, it is being increasingly used.

5. <u>COOLANT PUMP:</u>

- A coolant pump is a necessity for the forced circulation type of engine cooling system.
- The pump is mounted at the front end of the engine and is driven from the crankshaft by means of a V-belt.

- Centrifugal type pump is the one which is used for this purpose.
- The coolant from the radiator enters the pump at the centre where inlet is located.
- The flow of the coolant depends upon the pump speed which is proportional to engine speed. This is desirable since at higher engine speeds in which more heat is developed which requires more cooling.
- The main parts of the pump are a casing and a shaft-mounted impeller having a number of vanes.
- When the impeller rotates, the coolant between the vanes is thrown outward due to the centrifugal force, enters the involute or the scroll, which is a curved passage in the casing, whose cross-sectional area gradually increases towards the outlet port.
- Thus, the enlarging scroll converts the kinetic energy of coolant to pressure energy. In this way a coolant pressure is created at the pump outlet that forces the coolant through the cooling system.

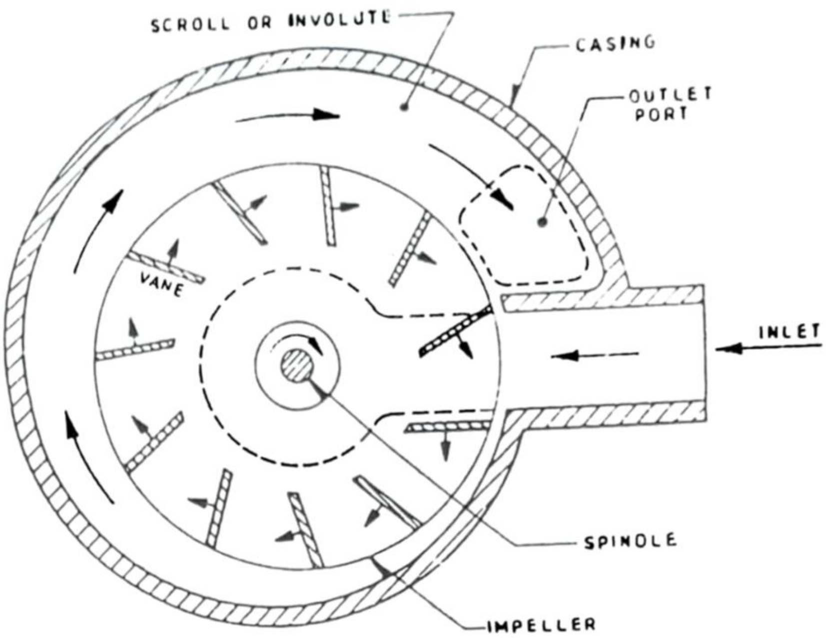


Fig. 5.15. Coolant pump

ANTI-FREEZE SOLUTIONS:

- In cold climates, there is always a danger that the water in the cooling system may get frozen.
- As the volume of water when converted into ice decreases by about 10%, this may result in the damage of the entire system including in extreme cases the bursting of the radiator core and the cylinder jackets.
- To avoid this some additives are used, which when mixed with water in suitable proportions, lower the freezing point of water. Such additives are called antifreeze.

REQUIREMENTS:

- The requirements of an anti-freeze are:
  - It should be thoroughly mixable with water and should prevent the freezing of the coolant.
  - It should not have any corrosive action on system components, especially the radiator hose pipes.
  - Its boiling point should be high so that there is minimum loss due to evaporation and the coolant can operate at higher temperatures.
  - It should not deposit any foreign matter in the jackets, hose pipes or radiator core.
  - It should have high specific heat capacity so as to be comparable to the specific heat capacity of the coolant.
  - It should not be inflammable

- Its viscosity should not be excessive so that the circulation is not affected.
- It should be readily mixable with corrosion inhibitor and anti- scaling compounds.

TYPES:

- The anti-freezes most commonly used are wood alcohol (methyl alcohol), denatured alcohol (ethyl alcohol), glycerin, ethylene glycol etc. Each of these has its own advantages and disadvantages.
- Alcohol is quite effective, but it is very much volatile and due to this reason evaporation losses are high.
- Ethylene glycol corrodes copper, aluminium and tin-lead solder alloys. The glycerin is less volatile (boiling point 195°C). but it is comparatively costly and also it attacks rubber hose pipes.
- Calcium chloride is another good antifreeze. Moreover, with chromates like sodium chromate added to it, the corrosion of most metals is drastically reduced.
- Antifreeze solutions usually spoil the finish of the paint work. Therefore. adequate precaution should be taken while topping up the cooling system with antifreeze solution.