5. Cooling and Lubrication systems

5.1 Engine cooling system

- Need of cooling system.
- Limitations of cooling system.
- Types: Air, Water/ Liquid cooling system (Layout and Function of Components)
- Properties of coolants and coolant additives

5.2 Construction and working of cooling system

- Construction and working of: Thermostat valve, Water expansion tank, Temperature Indicators, Pressure cap, Water pump, Fan and fan belt.
- Electrically driven Fan circuit
- Radiator: Construction and type of radiator cores.

5.3 Introduction to Lubrication system

- Need of lubrication system.
- Properties of lubricating oil, additives of lubricating oil.
- Parts to be lubricated.

5.4 Types of Lubrication system

- Types of lubrication system: Splash, Pressure – wet sump and dry sump (Layout of lubrication system)
- Components: Oil filters, Pump and its drive, pressure regulators, oil pressure gauge.
- Positive crank case ventilation
- Classification of Lubricating Oils on the basis of Viscosity (SAE) and Load (API) Severity rating.

5.1 ENGINE COOLING SYSTEM

- **NEED/ PURPOSE OF COOLING:**

  The purpose of the cooling system is to keep the engine at most efficient working temperature at all the engine speeds and in all driving condition.

  **I.** All the heat generated by the combustion of fuel in engine cylinder is not converted into useful power at crankshaft.

  A typical distribution of the fuel energy is as given below;
  a) Useful work at crankshaft --- 25 %
  b) Loss to cylinder walls --- 30 %
  c) Loss in exhaust gas --- 35 %
  d) Loss of friction --- 10 %

  **II.** If the quantity of heat given to engine cylinder is considerable & if this heat is not removed from the cylinder, it will result in;
  a) Preignition of the charge.
  b) The lubricant would also burn away, thereby causing seizing of the piston.

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c) Excess heating will damage the cylinder material.
   Thus it is desired to maintain the engine temperature at desired level.

III. However, cooling beyond optimum limit is not desirable, because it decreases the overall efficiency due to following reasons:

   a) Thermal efficiency is decreased due to more loss of heat at the cylinder walls.
   b) The vaporization of the fuel is less; this results in fall of the combustion efficiency.
   c) Low temperature increases lubricant viscosity & hence more piston friction is encountered, thus decreased mechanical efficiency.

   Although more cooling improves volumetric efficiency, yet above factors result in decreased overall efficiency.

IV. Thus optimum temperature should be maintained & any deviation in this temperature will result in deterioration of the engine performance.

• **TYPES OF ENGINE COOLING SYSTEM:**

There are 2 methods for cooling of automobile engine; they are

A) **Air cooling system**

B) **Water Cooling system**

A) **AIR COOLING SYSTEM:**

The basic principles involved in this method are as below;

1. Current of air flows over the heated metal surface from where the heat is to be removed.
2. The heat dissipated depends upon following factors:
   a) Surface area of the metal into contact with air.
   b) Mass flow rate of the air.
   c) Temperature difference between the heated surface and air.
   d) Conductivity of the metal.
3. Thus for an effective cooling the surface area of the metal which is in contact with the air should be increased. This is done by using “fins” over the cylinder barrels.

- **Advantages of Air cooling system:**  
  1) It is lighter in weight due to the absence of the radiator, cooling jackets and coolant.  
  2) Maintenance is easier the problem of leakage does not exist.  
  3) Anti freeze is not required.  
  4) Engine warms up faster than water cooled design.  
  5) It can operate in cold climate where water may freeze.  
  6) It can be used in areas where there is scarcity of the cooling water.

- **Disadvantages of Air cooling system:**  
  1) Less efficient cooling, because the coefficient of the heat transfer for the air is less than that for water.  
  2) It is not easy to maintain even cooling all around that cylinder, distortion of the cylinder may take place.  
  3) Limited use in motor cycle and scooters where cylinders are exposed to air stream.  
  4) More Noisy Operation.

**B) Water Cooling system:**  

In water cooling system, the cooling medium used is water.

1) In this system engine cylinder are surrounded by the water jackets through which cooling water flows.  
2) Heat flows from the cylinder wall into water, which goes to radiator; water is cooled by air drawn through radiator.  
3) Usually antifreeze is added to cooling water, which it is often referred as “coolant”.

Water cooling systems are of 2 types:  
1) **Thermosyphon system**  
2) **Pump Circulation system**
I) **Thermosyphon system:**

The features of this water cooling system are as follows:

1) It is a simple system, it consist of radiator connected to the engine through flexible hoses.
2) The circulation of the water is activated due to the difference in density of the hot and cold water.
3) There is no pump to circulate the water.
4) Hot water from the engine water jackets being lighter, runs up in the hose pipe & enters the radiator from the top side in the header tank.
5) It is cooled in radiator & hence goes down to the collector tank of the radiator from where it goes again to engine jackets.
6) The advantages of the system are that; it is simple & has low initial cost.
7) But the system has certain disadvantages; to maintain the continuity of water flow, certain minimum level of coolant must be maintained or else continuity of flow would break & system fails.
11) **Pump Circulation system:**

The features of this water cooling system are as follows:

1) In this water cooling system, the circulation of the water is obtained by a pump.
2) Pump is driven by means of a V belt placed on a pulley which is mounted on the crankshaft.
3) This system is effective; water circulation becomes faster as engine speed increases. There is no need to maintain water at correct level.

- The system has following advantages over Thermosyphon system:

1) Circulation of the coolant is proportional to both the engine load and speed.
2) Radiator header tank is not necessary, unlike Thermosyphon system.
3) Circulation of coolant is positive, hence its more efficient due to which the smaller water jacket can be used, resulting in overall decrease of engine size.
4) Even radiator does not need to be placed in front. It can be placed in rear or side as per design conditions.
**PROPERTIES OF COOLANTS AND COOLANT ADDITIVES**

*(cooling water solution (anti freeze solution);)*

**Necessity:**

(S 12)

In cold climate, there is always a danger that water may get frozen. The volume of water when converted to ice increases, this may result in damage of entire system. This may result in bursting of radiator core & cylinder jackets.

To avoid this some additives are added in the cooling water.

- Some advantages of Anti Freeze solution are:
  (W 11/ S 12)
  1. The freezing point of the water is lowered when additives are added in the water.
  2. In hot climate, anti freeze increases the boiling point of the cooling water.

- The requirement or properties of the anti freeze material are:
  1) It should mix readily with water
  2) It should prevent freezing of the mixture at lowest temperature encountered.
  3) Is should circulate freely in the cooling system.
  4) It should not damage cooling system by corrosive action.
  5) It should not lose its anti freezing property after extended use.
  6) It should be reasonable cheap.
  7) It should not waste by evaporation.
  8) It should not deposit foreign matter on the water jackets or in the radiator.

The Commonly used additives are:

1) Wood alcohol (Methyl alcohol)  
2) Denatured alcohol (ethyl alcohol)  
3) Glycerine  
4) Ethylene glycol  
5) Propylene glycol  
6) Mixture of alcohol & glycerine

- The Alcohol is much volatile & evaporation losses are high. The mixture should be checked regularly with hydrometer to maintain adequate strength.
- Glycerine is less volatile but it is costly & it attacks rubber hose pipe.
- Ethyl glycol is permanent type anti freeze material because it remains liquid even at boiling point of the water.
➢ Glycerine & Glycol; although they are costly but they do not evaporate easily & hence prove cheaper in long run.

- **Comparison between Air cooled and water cooled system**: (W12/ S12)

<table>
<thead>
<tr>
<th>Sr. no</th>
<th><strong>Air Cooling system</strong></th>
<th><strong>Water Cooling system</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>In this system, cooling medium used is air.</td>
<td>In this system, cooling medium used is water.</td>
</tr>
<tr>
<td>2.</td>
<td>The engine design is simple.</td>
<td>The engine design is complex.</td>
</tr>
<tr>
<td>3.</td>
<td>The air cooled engine is less sensitive to climate condition. No antifreeze solution is needed. Due to greater temperature difference between cooling air and cylinder.</td>
<td>The engine performance becomes more sensitive to climate conditions. Cold water starting requires anti freeze solution which may deposit on cylinder wall on water side &amp; result in reduced heat transfer.</td>
</tr>
<tr>
<td>4.</td>
<td>Air cooling system has no maintenance.</td>
<td>It requires maintenance; slight leakage of radiator may result in engine breakdown.</td>
</tr>
<tr>
<td>5.</td>
<td>The warm up performance is better; this results in low cylinder wear.</td>
<td>Warm up performance is poor. The result in greater cylinder wear.</td>
</tr>
<tr>
<td>6.</td>
<td>Size of engine is small &amp; weight is less as there are no water jacket, radiator &amp; water pump.</td>
<td>Size &amp; weight of the engine is increased due to use of radiator, pump etc...</td>
</tr>
<tr>
<td>7.</td>
<td>Air cooled engine must be installed in front side of the vehicle.</td>
<td>Water cooling engine can be installed anywhere on the vehicle.</td>
</tr>
<tr>
<td>8.</td>
<td>Volumetric efficiency is lower due to high cylinder head temperature</td>
<td>Volumetric efficiency is higher than air cooled engine.</td>
</tr>
<tr>
<td>9.</td>
<td>Example: Bikes, Scooters etc...</td>
<td>Example: Cars, Bus, Trucks etc...</td>
</tr>
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</table>
5.2 CONSTRUCTION AND WORKING OF COOLING SYSTEM

(Parts of cooling system):

• THERMOSTAT:

A. Function: (W11)

The thermostat valve is used in the water cooling system to regulate the circulation of water in system & to maintain the normal working temperature of the engine parts during the different operating conditions.

B. Working principle: (W12)

It works automatically in the cooling system. When the engine is started from cold, the thermostat valve is closed & it prevents the flow of water from engine to radiator so that the engine readily reaches to normal working temperature.

After engine reaches to desired temperature the thermostat valve opens. Thermostat valves are most efficient over small temperature range of 80° to 100° C.

Location of the thermostat valve is as shown in the figure;

Two types of thermostat valve are used in Automobile;

1) Bellows type thermostat
2) Wax type thermostat.
1) **Bellows type Thermostat:**

- **Construction:**
  1) It consists of metallic bellow particularly filled with some volatile liquid like acetone, alcohol or ether which boils between 70 - 85°C.
  2) 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.
  3) The thermostat is fitted in to the coolant hose pipe at the engine outlet.

- **Working:** The working of bellow type thermostat is stated below;
  1) The engine is warming up, when it is started. It is desired that the cooling system should not operate so that engine warms up quickly.
  2) Thus during this temperature the thermostat valve remains closed, the liquid inside the valve has not changed its state and exerts no pressure on the valve.
  3) The thermostat valve is closed, while the coolant pump is running. Thus to avoid excessive pressure build up, a bypass is provided to circulate coolant back to the pump inlet.
  4) As the coolant temperature reaches a predetermined valve (about 80°C) the liquid inside thermostat is converted into vapour which exerts a pressure on the valve, thus the valve opens & the water circulation through the radiator starts.
  5) The valve is fully opened at about 90 - 95°C.

This is how the thermostat controls flow of water through the radiator according to the engine cooling requirement.
2) **Wax type Thermostat:**

The construction and working of wax type thermostat is as given below;

![Wax type thermostat](image)

1) As the coolant is heated, it transmits heat to the copper loaded wax having high coefficient of volumetric thermal expansion (0.28% per °C).
2) This copper loaded wax expands so that the rubber-plug contracts against the plunger and exerts force upward so that plunger moves vertically.
3) The movement of the plunger opens the valve in the thermostat, to allow coolant to flow through the radiator.

- **WATER EXPANSION TANK:**

The construction and working of Water Expansion Tank is as given below;
1) Instead of using overflow pipe, an expansion reservoir is provided in modern engines.
2) It is so connected with the radiator that, it receives the excess coolant as the engine temperature increases due to coolant expansion.
3) When the cooling water cools down, its volume decreases and the coolant in the reservoir returns to the radiator keeping the system full of coolant.
4) The reservoir is usually made of the translucent plastic so that it can indicate level of the coolant anytime.
5) This system is also called as “Coolant Recovery System”.

- The Expansion tank has following advantages:
  1) Loss of coolant is prevented as the coolant is recovered from the expansion tank.
  2) Air does not enter cooling system with this arrangement. Thus corrosion of cooling jacket is prevented & deterioration of antifreeze is reduced.
  3) Relatively smaller upper tank may be used with this type of radiator.

- TEMPERATURE INDICATOR:

  A) Function/ Necessity: (W 12)

  It helps the driver to prevent serious damage to the engine due to overheating.

  For e.g.: If the thermostat gets stuck and does not open, the water circulation will stop and the engine temperature will go very high. However, if the temperature gauge is provided, the driver can stop the engine and take preventive action against engine overheating.

  Thus the temperature gauge is necessary.

  B) Type of Temperature gauge:

  There are 2 types of temperature gauges: 1) Bourdon tube type.

  2) Electrically operated type.

  1) Bourdon Tube type:
The working of this temperature gauge is explained below:

- A bourdon tube is placed inside the gauge, which is connected to the element.
- The element consists of some volatile liquid and is inserted in the cooling water circuit, generally this element is placed near the thermostat.
- As the temperature of cooling water increases, the liquid in the element evaporates and exerts its pressure in the capillary, which is later transmitted to Bourdon tube.
- Due to this pressure the bourdon tube tries to straighten out thus moves a pointer attached to it, to show the temperature on the scale.

2) **Electrically Operated type:**

![Electrically Operated Type Temperature Gauge](image)

The working of this temperature gauge is explained below:

- This gauge contains an element made of such a material that its electrical resistance decreases with increase of temperature.
- The element is connected to the coils inside the dash unit as shown in the figure. The gauge element is inserted into coolant at some appropriate place.
- As the cooling water temperature rises, the resistance of the element decreases, which causes more current to flow in the coil (2), thus increasing the e.m.f.
- The coil (2) pulls the armature which carries indicator pointer, therefore as temperature increases the pointer moves clockwise to show the higher temperature.
• **PRESSURE CAP:**

**A) Function:** The function of the pressure cap is as below;  

1) Pressure cap forms an air tight seal due to which the coolant is maintained at some pressure higher than the atmosphere.
2) High pressure causes rise in boiling point of the coolant. Approximately for 10 kPa increase in pressure, the B.P raises by 2.5°C.

**B) Construction:**

The construction features of pressure cap are discussed below;

1) Radiator filler neck is covered with a pressure cap.
2) It consist of two valves a) Pressure blow off valve (Relief valve)  
   b) Vacuum valve  
   a) In severe working condition, the coolant starts boiling & vaporizes, thus the pressure in the system exceeds a certain predetermined value (50 - 100 kPa), the pressure blow off valve (relief valve) opens & releases the excess pressure to the atmosphere through overflow pipe.

b) A vacuum valve is provided in the cap to admit air when pressure in the system falls bellow atmospheric pressure, due to condensation of the stem vapour. This valve operates when vacuum exceeds about 5 kPa.
C) **Advantages of using Pressure Cap are:**

1) The engine can operate at higher temperature without boiling the coolant. As the rate of the heat transfer from the cooling system to the atmosphere depends on the difference between coolant temperature and the atmospheric temperature, this will result in additional heat transfer to the atmosphere. This means that for the same engine, smaller radiator can be used.

2) The preparation of air – fuel mixture is improved at the higher operating temperature.

3) With seal cap, loss of coolant due to evaporation is prevented.

4) At high altitude, the atmospheric pressure is low, which causes the coolant to boil at lower temperature. With pressure cap, a higher pressure is maintained inside, irrespective of atmospheric pressure. Thus overheating of engine is avoided.

- **WATER**

![Coolant pump diagram](image)

The construction and the working of the water or coolant pump are discussed below;

1) A coolant pump is a necessity for the forced circulation type of engine cooling system.

2) 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 used for this purpose.

3) The coolant from the radiator enters the pump at the centre where the inlet is located.

4) The flow of the coolant depends on the pump speed which is proportional to the engine speed.
5) This is desirable since at the higher engine speed more heat will be developed which requires more cooling.

6) When the impeller rotates, the coolant between the vanes is thrown outward due to the centrifugal force, thus forcing the cooled coolant at periphery, with a force depending upon the speed of rotation of the pump spindle.

7) This coolant leaving the periphery of the impeller tangentially and having max kinetic energy then enters the involute or scroll.

8) The cross section area of this scroll gradually increases towards outlet port. Thus enlarging scroll converts kinetic energy of the coolant to pressure energy.

   In this way coolant pressure is created at the pump outlet that forces the coolant through the cooling system.

• **FAN AND FAN BELT:**

A) **Function/ Necessity:** The purpose of the fan is to suck the air through the radiator.

   • When vehicle is going at high speed, the natural flow of air passing through radiator is sufficient for cooling. So the fan that is always running will be consuming unnecessary energy & wasting the engine break power, which is not desired.

   • But, when vehicle is going at low speed the natural flow of air is insufficient to produce the desired cooling effect, here fan is required.

B) **Construction:** The construction features of the fan are as follows:

1. A fan is mounted behind the radiator on the same shaft on which water pump is mounted
2. It is driven by the same V belt that drives pump & the generator.
3. The fan has 4 to 7 blades.
4. It is made of moulded plastic material e.g. - Nylon or Polypropylene.

C) **Working:** The working principle of the fan is discussed as below:

1. For effective & economical running, it is required that fan must give sufficient air flow at all vehicle loads & speed.
2. Flow of the air must be optimum; it should not be excess or inadequate.
3. Thus the fan running at one constant speed is not desired; the fan must run at variable speeds.
4. The reason why fan should run at variable speed is discussed in above given function.
• **RADIATOR:**

A) **Function:** The function of the radiator is to ensure close contact of hot coolant coming out of the engine with outside air, so as to ensure high rate of the heat transfer from coolant to the air.

B) **Construction:**

The construction features of pressure cap are discussed below;

1) It consists of upper tank and lower tank. Between these tanks lies the Core.
2) The upper tank is connected to water outlet of the engine by the hose pipe.
3) The lower tank is connected to the water jacket inlet via a water pump.
4) Core is radiating element which cools the water.
5) An overflow pipe in header tank & drain pipe in lower tank are also provided.
6) There are 2 types of radiator core: a) Tubular type core
   b) Cellular type core
7) The size of radiator is proportional to heat energy developed in the engine & to displacement volume of engine.

a) **Tubular type core:**
   • In this type, coolant flows through tubes & air passes around them.
   • The air passings around the tubes absorb heat from the coolant.

b) **Cellular type core:**
   • In this type, the air passes through tubes & coolant flows in the space around them.
   • The core has large number of individual air cells which are surrounded by the water.
C) **Working:**

The working of the radiator is as stated below;

1. The hot coolant from the engine enters the radiator at the top.
2. The cross flow of air, cools down the coolant in the radiator core. When the coolant is cooled it flows downwards.
3. Thus the coolant is collected in the collector tank from where it is pumped to the engine for engine cooling purpose.

D) **Material:**

- Copper & yellow brass; are used due to high thermal conductivity & good resistance to corrosion.
- Aluminium is also used because it is light in weight and is economical.
5.3 INTRODUCTION TO LUBRICATION SYSTEM

- **NEED/PURPOSE OF LUBRICATION:**

  The purpose of the lubrication is as follows:

  1) To reduce friction between the moving parts.

  2) To reduce wear of the mating parts.

  3) To act as a cooling medium for removing heat.

  4) To keep the engine parts clean, especially piston ring & ring grooves, oil ways and filter. During the circulation, lubricant dissolves many impurities.

  5) It provides cushioning effect by absorbing shocks between bearing and the other engine parts thus reducing engine noise and extending engine life.

  6) To form a good seal between piston ring and cylinder wall.

  7) To prevent deposition of carbon.

  8) It prevents corrosion of the metallic components.

- **FUNCTION OF ENGINE LUBRICATION OIL:**

  The functions of the lubricating oil in an engine are as follows;

  1) To minimise friction and wear between mating parts.

  2) To cool the engine by carry the heat away.

  3) To seal the gap between piston ring and cylinder liner walls & thus prevent escape of gases from cylinder (i.e.: Minimise blow-by).

  4) To cushion the parts against vibration and impact.

  5) To clean the parts along with lubrication. Thus carry away the impurities.
• **PROPERTIES OF ENGINE LUBRICATION OIL:**  

Engine lubrication oil must have certain properties or characteristic for its satisfactory functioning. They are as follows;

1) **Viscosity:**  

   It is property of the lubricating oil that offers resistance to flow.

   • It is property due to which 2 bearing surface are kept apart.
   • The viscosity of lubricant should be sufficient to ensure hydrodynamic lubrication. If it is more than required value, it will cause higher power loss due to increased oil resistance.
   • Viscosity is inversely proportional to temperature. Viscosity decreases with rise in temperature & increases with fall of temperature.
   • **Viscosity Index (VI)** is an indication of change of viscosity with respect to temperature. Higher viscosity index means less change of oil viscosity with respect to rise in temperature.
   • Most lubrication oils are selected on the basis of the viscosity and viscosity index.

2) **Flash point:**

   Flash point is defined as the lowest temperature at which the lubricating oil will flash when a small flame is passed across its surface.

   Flash point of oil should be sufficiently high so as to avoid flashing of oil vapors at the temperature occurring in common use.

3) **Resistance to corrosion:**

   The oil should not have tendency to corrode the pipe lines, crankcase and other engine parts with which it comes in contact.

4) **Physical stability:**

   The lubricating oil must be stable physically at the lowest and the highest temperature encountered. It should not vaporize at high temperature and there should not be separation of solids at lower temperature.

5) **Pour Point:**

   The lowest temperature at which lubricating oil will pour. It is ability of lubricating oil to flow at lowest temperature.

6) **Adhesiveness:**

   It is property of lubricating oil due to which the oil particles stick with the metal surface.

7) **Chemical stability:**
Lubricating oil should be chemically stable. It should not have tendency of oxide formation. The oil should not decompose at high temperature to form carbon.

8) **Cleanliness:**

The oil should be sufficiently clean and stable, so that the crank oil holes and oil lines are kept clean.

It contains agents, called detergents. These detergents remove the impurities from engine parts during oil circulation. These impurities may either be filtered out or removed with change of oil at periodic intervals.

9) **Resistance against extreme pressure:**

In modern engines, lubricating oil are subjected to extreme pressure, particularly in bearings and the valve actuating mechanisms.

The oil must stick to metal surface even under high pressure to reduce the friction between mating parts.

- **ADDITIVES FOR LUBRICANTS:**

  Additives are chemical substances which are added to the lubricating oil either to reinforce some of its natural properties or to provide it certain new properties which it does not possesses originally.

  Oil additives are classifies as follows;

  1. Viscosity index improvers
  2. Oxidation Inhibitors
  3. Corrosion inhibitors
  4. Detergents and Dispersants
  5. Anti scuffing additives
  6. Anti foaming additives
  7. Extreme Pressure additives
  8. Pour point depressants
  9. Rust inhibitors

1. **Viscosity index improver:**

   These are the additives which minimise or resist the decrease of oil viscosity with the increase in temperature.

   The additives are usually polymers such as acriloid plastics. These are long chain molecules, on heating the molecule unwind and prevent movement of the hydrocarbon molecules. Thus oil viscosity does not decrease with temperature.

2. **Oxidation Inhibitors:**
At high temperature oil in the crankcase reacts with air, the oil oxidation takes place. This oxidized oil forms various harmful substances. These are extremely sticky tar like substances. They may clog oil channels and restrict the action of piston ring and valve. Oxidation inhibitors prevent formation of such harmful substances.

3. **Corrosion inhibitors:**
   Corrosion inhibitors prevent the formation of acids which could cause bearing corrosion.

4. **Detergents and Dispersants:**
   Additives which handle high temperature deposits are called “detergents” & additives which deal with low temperature deposits are called “dispersants”.
   Dispersants prevent clotting of oil. Without dispersant, the small particles will form large particles which might block the oil filter and oil passages.

5. **Anti scuffing additives:**
   This additives help to polish mating parts such as piston, cylinder wall, cams etc. and there by prevent their tendency of scuffing.

6. **Anti foaming additives:**
   The engine oil may have tendency to form foam due to engine vibration, which causes churning of oil in the sump. Heat and churning mixture produce foam. This foam decreases lubricating properties of the oil.
   Thus anti foaming additives are added which suppress the foaming tendency of lubricating oil.

7. **Extreme Pressure additives:**
   At high pressure and temperature, the oil film between moving parts is likely to break down and allow metal to metal contact. Thus causing wear of the mating parts.
   These additives provide extra film strength by forming a chemical film and reduce the wear of mating parts.

8. **Pour point depressants:**
   These serve to lower the pour point of the oil by coating the wax crystals in the oil so that they would not stick together and facilitate the oil flow.

9. **Rust inhibitors:**
   Rust inhibitors are added which displaces water from metal surface so that oil coats them.
• **PARTS TO BE LUBRICATED:**

The engine parts which need to be lubricated are as follows:

1. Main crankshaft bearings
2. Big end bearings
3. Small end bearings
4. Camshaft bearings
5. Piston rings and cylinder walls
6. Timing gear
7. Valve mechanism

**5.4 TYPES OF LUBRICATION SYSTEM**

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

1. Petroil System
2. Splash System
3. Pressure System
4. Dry - Sump System

1. **PETROIL SYSTEM:**

The features of this Petroil system are as follows;

• This system is used for small 2 stroke engines e.g. in scooter & motor cycle engines. It is the simplest type of engine lubrication systems.

• Certain amount of lubricating oil is mixed with the petrol itself, the usual ratio being 2 - 3%.

• If the lubricating oil is less, there is danger of oil starvation. The insufficient lubrication casing damage to the engine.

• If the lubrication oil is more, there will be excessive carbon deposits in the cylinder head & the engine will also emit black smoke.

• When the petrol mixture enters the crankcase, due to high temperature there, the petrol component vaporizes leaving thin film of lubricating oil on the crankcase, cylinder walls, crankshaft & bearings.

• The main requirement of the lubricating oil for 2 stroke engine is; it should mix with petrol & burn without leaving residue.
2. **Splash System:**

   The features of this Splash system are as follows;
   - This system is employed in the engines of the motor cycles. It’s the cheapest method of engine lubrication.
   - The lubricating oil is stored in an oil trough or sump.
   - A scoop or a dipper is made in the lowest part of the connecting rod.
   - When the engine runs, the scoop causes the oil to splash on the cylinder walls each time it passes through its B.D.C. position.
   - This affects the lubrication of engine walls, gudgeon pin, main crankshaft bearings, big end bearings etc.

3. **Pressure System:**

   The features of this Pressure system are as follows;
   - This system is most widely used system in modern cars.
   - In this system, the engine parts are lubricated under pressure feed. The oil pump takes the oil from the wet sump through a filter to main oil gallery at a pressure of 200 – 400 kPa.
   - The oil from main gallery goes to the main bearing, some lubricant fall backs to the sump & some is splashed to lubricate cylinder walls.
   - From crank pin it goes to the piston pin through a hole in the connecting rod.
• Lubrication of camshaft and timing gear is gone through separate oil lines from the oil gallery.
• Sometimes rocker arms are mounted on the hollow shaft, which carry oil under pressure. The hollow shaft feeds oil for the lubrication of the rocker arm.
• During oils circulation, the oil gains heat from various engine parts, which is given out to the sump wall. In some heavy duty engines separate oil cooler is also employed.

4. **Dry Sump System:**

![Dry Sump System Diagram]

(W - 11)
The features of this Dry Sump system are as follows:

- In this system the lubricating oil is not stored in the oil sump.
- This system is employed in some racing car engines for situations where the vehicle has to be operated at very steep angles.
- If ordinary pressure system of lubrication is used in such a case, the situation may arise when there is no oil at the place where oil pump is installed. To avoid such situation dry sump system is used.
- Two pumps are used instead of single oil pump
- The scavenge pump A is installed in the crankcase portion which is the lowest.
- It pumps oil to a separate reservoir B, from where the pressure pump C pimps the oil through filter D, to the cylinder bearings.
- The oil pressure is maintained at 400 - 500 kPa for main & big end bearings.

- **COMPONENTS OF LUBRICATION SYSTEM**

  **Oil filter:**
  Oil filter used in the engine lubricating system of most of the motor vehicles to filter out the dirt or grit particles from the oil.

  The oil filter systems are of the two types.

  1. By pass system
  2. Full flow system

  **By pass system:**
  In by pass system some oil goes to the engine bearing bypassing (without going through) filter. In this system if filter is clogged due to any reason, the engine will not halt and gradually whole oil gets filtered in running of engine.
Full flow system:
In full flow system whole oil passes through the filter and then goes to bearing.
In this system if filter is clogged due to any reason, the engine will halt due to absence of oil.
Oil Pump: Oil pump is generally located inside the crankcase below the oil level. The function of oil pump is to supply oil under pressure to the various engine parts to be lubricated.

The different types of the oil pumps used for engine lubrication are as follows
1. Gear pump
2. Rotor pump
3. Plunger pump
4. Vane pump
(See details of above types of oil pump in R.B. Gupta)

Oil pressure Regulator: A pressure regulator is a valve that automatically cuts off the flow of oil at a certain pressure. Regulators are used to allow high-pressure fluid supply lines to be reduced to safe and usable pressures.
**Oil pressure gauge:** An oil pressure gauge is mounted on the instrument panel of all cars equipped with pressure lubricating system to tell the driver what the oil pressure is in the engine. The oil pressure gauges are of the following types.

1. Pressure expansion type.
2. Electric type.

(See details of above types of oil pressure gauge in R.B. Gupta)

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**Positive Crankcase Ventilation:**

**Blowby:** During the combustion the gases inside the combustion chamber gets past (leak) through piston rings and enters the crankcase which is called blowby.

As blowby contains vapors and sulphur, they might cause corrosion of parts and sludge formation in lubricating oil. Hence it is important to remove blowby from crankcase.

Removal of blowby can be achieved by passing a constant stream of fresh air through the crankcase which is known as **crankcase ventilation.**

In **positive crankcase ventilation**, the blowby is returned to the engine through the intake manifold, instead of being exhausted into the atmosphere.(Air out shown in fig is connected to intake manifold)
• **CLASSIFICATION OF LUBRICATION OIL:** (W - 11)

  The classification of the lubricating oil is based on their origin; there are 3 types of lubricating oil.

  A. Liquid - mineral oil, Vegetable oil animal oil etc...
  B. Semi solid - greases.
  C. Synthetic Lubricants.

  A. **LIQUID LUBRICATION OIL:**

  i. **Mineral Oil:**

      These oils are derived from petroleum & are most widely used in automobiles.
      The advantages are;
      a. Greater chemical stability at higher temperature.
      b. Lesser tendency to form emulsions with water.
      c. These are economical.

  ii. **Vegetable oil:**

      These are produced from seeds, fruits of plants, trees etc... They get oxidized easily and become gummy.
      Caster oil, once found extensive use in automobile industry because of its high viscosity & high film strength.

  iii. **Animal oil:**

      These are obtained from the animal fat. These are not at all suitable for automotive engine lubrication, because they are oxidized easily & become gummy after some use.

  B. **SEMI SOLID - Grease:**

      These are suspension of metallic soaps (calcium or sodium soaps) dispersed in a lubricating oil. Grease finds use in automobiles at place where retention of liquid lubricants is difficult and where high temperature is encountered e.g. - Axles.

      Grease is classified according to its purpose, like water pump grease, chassis grease, and multipurpose grease or on the basis of type of soap base.

  i. **Calcium - based greases:**

      This grease is fairly water proof & useful in water pumps, chassis & wheel bearings.

  ii. **Sodium - based grease:**

      This grease is able to withstand moderately high temperature & tend to absorb water, which reduces rusting problem.
iii. **Aluminium - based grease:**
   This grease has are not suitable for high temperature & are useful on chassis, transmission & chains.

iv. **Lithium - based grease:**
   They can withstand high temperature & are used on wheel bearing, universal joints, brake cable etc., they are also referred as multipurpose greases.

C. **SYNTHETIC LUBRICANTS:**
   The examples of synthetic lubricant are silicon fluid, polyglycol ethers & aliphatic diester oils.
   Following are advantages of synthetic oil:
   i. Higher viscosity index.
   ii. Reduced lacquer formation.
   iii. Reduce loss due to evaporation.
   iv. Considerably less oil consumption.
   v. Less frequency of changing lubricating oil.
   vi. Less engine deposits.
   vii. Increased fuel economy.