SHROFF S. R. ROTARY INSTITUTE OF CHEMICAL TECHNOLOGY (SRICT)
DEPARTMENT OF MECHANICAL ENGINEERING.

Chapter 8. Engine Lubrication and Cooling

Subject: Internal Combustion Engine

Outline

Chapter 8. Engine Lubrication & Cooling

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8.2 Lubricating Oil
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- 8.2.4 Classification based on rating

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8.5 Crankcase Ventilation

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8.1 Lubrication of engine components

Main component of IC engine to be lubricated

- Piston & cylinder
- Main crankshaft bearings
- Small and big end bearings of connection rod
- Cam, cam shaft and its bearing
- Valve and valve operating mechanism
- Timing gears

8.1 Lubrication of engine components

The method of reducing the friction by introducing the substance called lubricant between the mating parts is called **lubrication.**

Objectives

- Reduce friction thus increase efficiency
- Reduce wear and tear of moving parts
- Carry away heat
- Provides sealing action between cylinder and piston rings, thereby it reduce blow by.
- Provide protection against corrosion.
- Lubrication film acts as cushion and reduce vibration
- Carrying away the grit & other deposits and provide cleaning
- Reduce noise

Types of lubricants

- Solid (e.g. Graphite molybdenum, Mica)
- Semi-Solid (e.g. Heavy greases)
- Liquid (e.g. Mineral oils, Vegetable Oils, Animal Oils)

8.2 Lubricating Oil

Properties of lubricates

Viscosity

- It is measure of resistance to flow of an oil. It is measured in Saybolt Universal Seconds (SUS).

Viscosity Index

- The variation of viscosity of an oil with change in temperature is measured by viscosity index.
- Smaller the variation of viscosity, higher the VI.
- VI of *Paraffin oil* is 100 (small change) and VI of *Naphthenic oil* VI is 0.

Cloud Point

- The temperature at which the oil starts solidifying is called cloud point.

8.2 Lubricating Oil

Properties of lubricates

Pour Point

- It is the temperature just below which oil sample will not flow under certain prescribed conditions.
- Sample is cooled until no movement of the oil occurs for 5 sec after the tube is tilted from the vertical to the horizontal.

Flash Points

- The flash point is defined as the lowest temperature at which an oil will vaporize sufficiently to form a combustible mixture of oil vapour an air above the surface of the oil.
- It is found by heating a quantity of the oil in a special container while passing a flam above the liquid to ignite the vapour. A distinct flash of flame occurs when the flash point temperature is reached.

8.2 Lubricating Oil

Properties of lubricates

Fire Points

- Fire point is obtained if the oil is heated further after flash point. Fire point is the temperature at which the oil, it once lit with flame, will burnt steadily at least for 5 seconds.
- Fire point temperature is usually 10^0C higher than flash point temperature.

Oiliness

- The property of an oil to cling to the metal surface by molecular action and then to provide a very thin layer of lubricant under boundary lubrication condition is called the oiliness or lubricity or film strength. .

8.2 Lubricating Oil

Properties of lubricates

Carbon residue

- It is the quantity of carbon residue which remains after evaporation of a simple oil under specified conditions.

Detergency

- To prevent the formation of deposits, the engine oil has the property of detergency to clean the deposits.
- It has also the ability of dispersing the particles, preventing them from clotting and to keep then in a finally divided state.

Foaming

- Any violent agitation in the crankcase engine oil to foam. It is because of the presence of air bubbles in the oil. This action accelerates oxidation and reduces the mass flow of oil to the bearing and other moving parts causing insufficient lubrication.

8.2 Lubricating Oil

Additives

These are the compound added to lubricant oils to promote and improve their desired properties.

Major classes of engine oil additives and their primary function

- Detergent Dispersant (Metalic Salts, Organic acids)
- Anti-wear
- Anti-rust (Metal Sulphonates, Fatty acids, Amines)
- VI improver (Butylene Polymers, Polymerized Olefins, Iso-olefins)
- Pour point depressant (Phenols, Easters, Alkylated Naphthalene)
- Anti-foam (Silicone Polymers)
- Anti-oxidant (Zinc Dithiophosphate, Sulphur and Phosphorous compounds, Amine & Phenol Derivatives)

8.2 Lubricating Oil

Classification based on rating

SAE rating

- Society of Automotive Engineers assigned the number for gradation of oil based on their viscosity at -18^{0}C (5W, 10W, 15W) & 99^{0}C (20W, 30W, 40W, 50W).

API Service rating

- American Petroleum Institute classified the oil based on their property into three classes as Regular, Premium and Heavy Duty type based on quality & performance of oil.
- Petrol engine- SA, SB, SC, SD, SE
- Diesel engine- CA, CB, CC, CD, CE
- A,B stands for light duty and naturally aspirated while D,E stands for heavy duty and supercharged.

8.3 Type of lubrication system

Mist Lubrication system (Petrol)

- Employed in 2 Stroke Petrol engine
- In this system, the petrol and lubricating oil are previously mixed in fuel take from where it is supplied to the carburettor.
- Proportion 2 to 3 %
- It provide lubrication to cylinder, piston, piston rings and connecting rod bearing via the crankcase.
- Also the separate lubrication is provided to those parts of the engines where the mixture of oil and petrol cannot reach or in case it gives unsatisfactory lubrication

8.3 Type of lubrication system

Mist Lubrication system (Petrol)

Advantages

- Economical and cheap
- No oil pump, filter and oil carrying pipe needed
- Quantity of oil is automatically regulated with load and speed
- Probability of lubrication failure are the least

8.3 Type of lubrication system

Mist Lubrication system (Petrol)

Disadvantages

- Carbon deposits and burning of oil film
- Fouling of sparkplug, increases maintenance cost.
- Oil consumption is high, rather the engine is usually over oiled
- During long duration of no load due to almost closed throttle valve, engine mating parts may not get adequate lubricating oil.

8.3 Type of lubrication system

Wet Sump lubrication system

- Bottom of the crankcase contain an oil pan.
- Oil pump supply the oil to engine parts.
- Types :
  - Splash Lubrication system
  - Splash & Pressure feed system
  - Fully Pressure feed system

8.3 Type of lubrication system

Wet Sump lubrication system - Splash Lubrication system

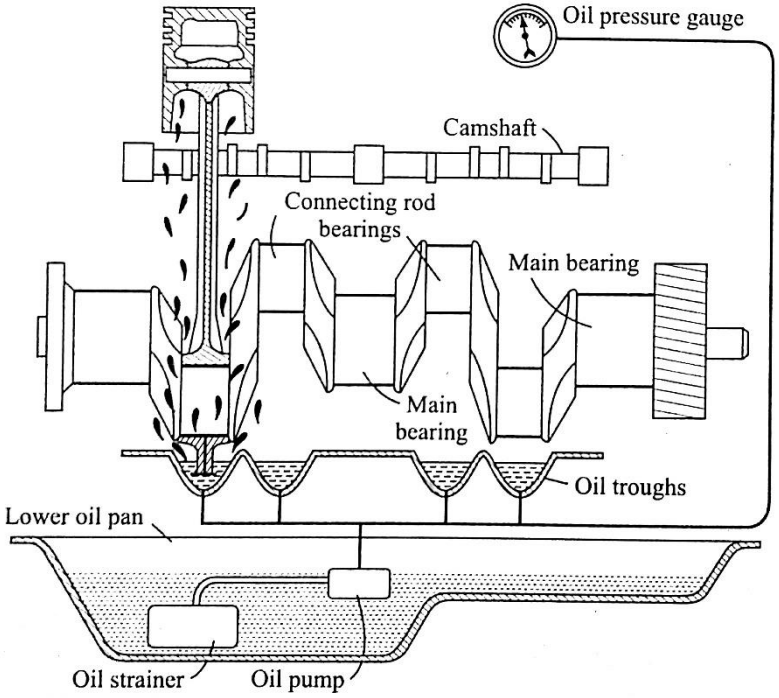

Figure Splash lubrication system.

- Suitable for small capacity 4 stroke engine with moderate speed and bearing loads.
- Big eye of connecting rod is facilitated with scoop dipping into trough to splash the oil.
- Oil pump is employed to maintain the level of oil in troughs.

8.3 Type of lubrication system

Wet Sump lubrication system - Splash & Pressure feed system

- Splash system is not sufficient in case of bearing loads are high.
- In that case splash and pressure feed system may be used.
- The oil pump also supplied oil under pressure to pipes which directs a stream of oil against the dippers on the connecting rod bearing cups.
- Other parts of the engine are lubricated by splash of oil thrown up by the dippers.

8.3 Type of lubrication system

Wet Sump lubrication system - Splash & Pressure feed system

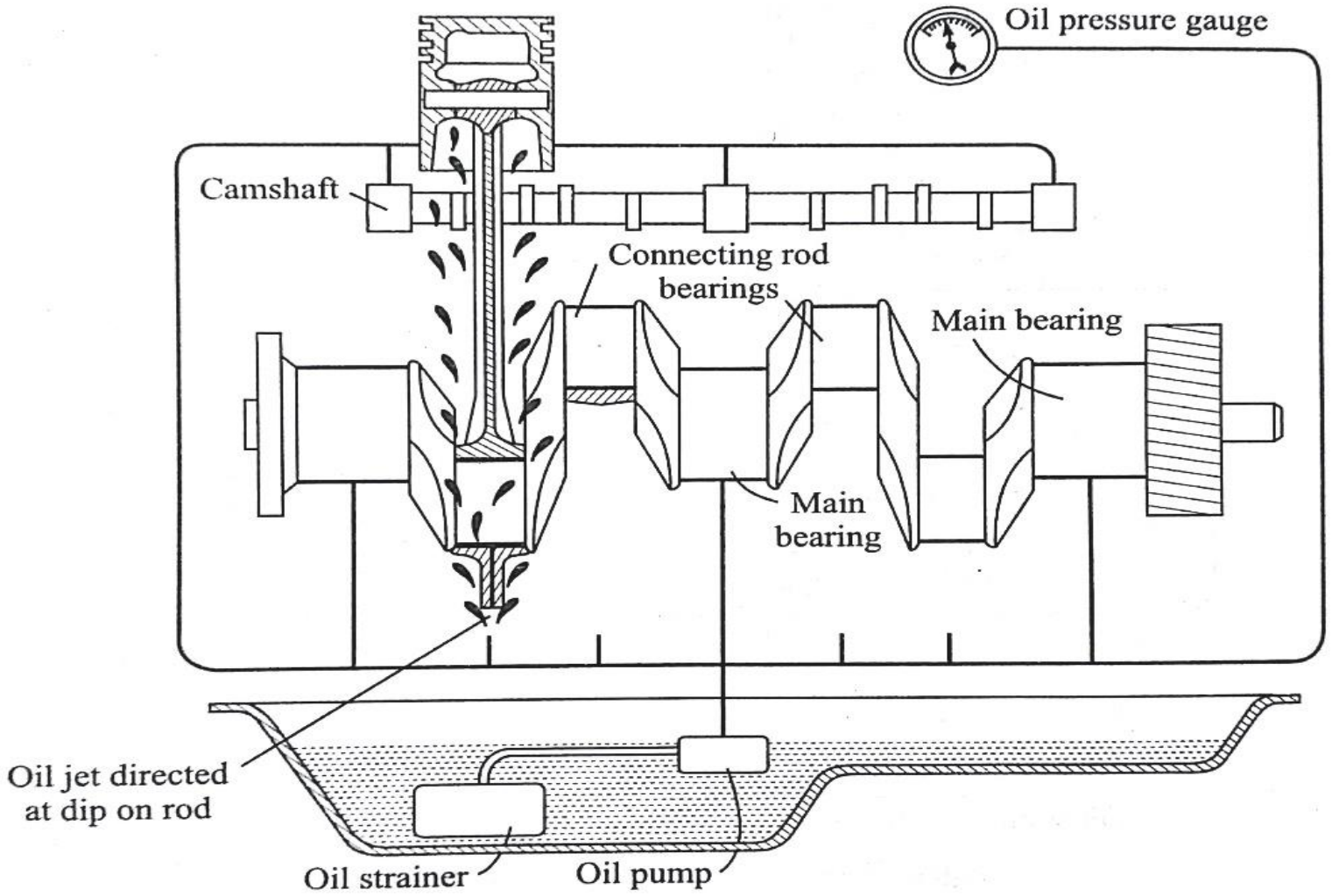

Figure The splash and pressure lubrication system.

8.3 Type of lubrication system

Wet Sump lubrication system - Fully Pressure feed system

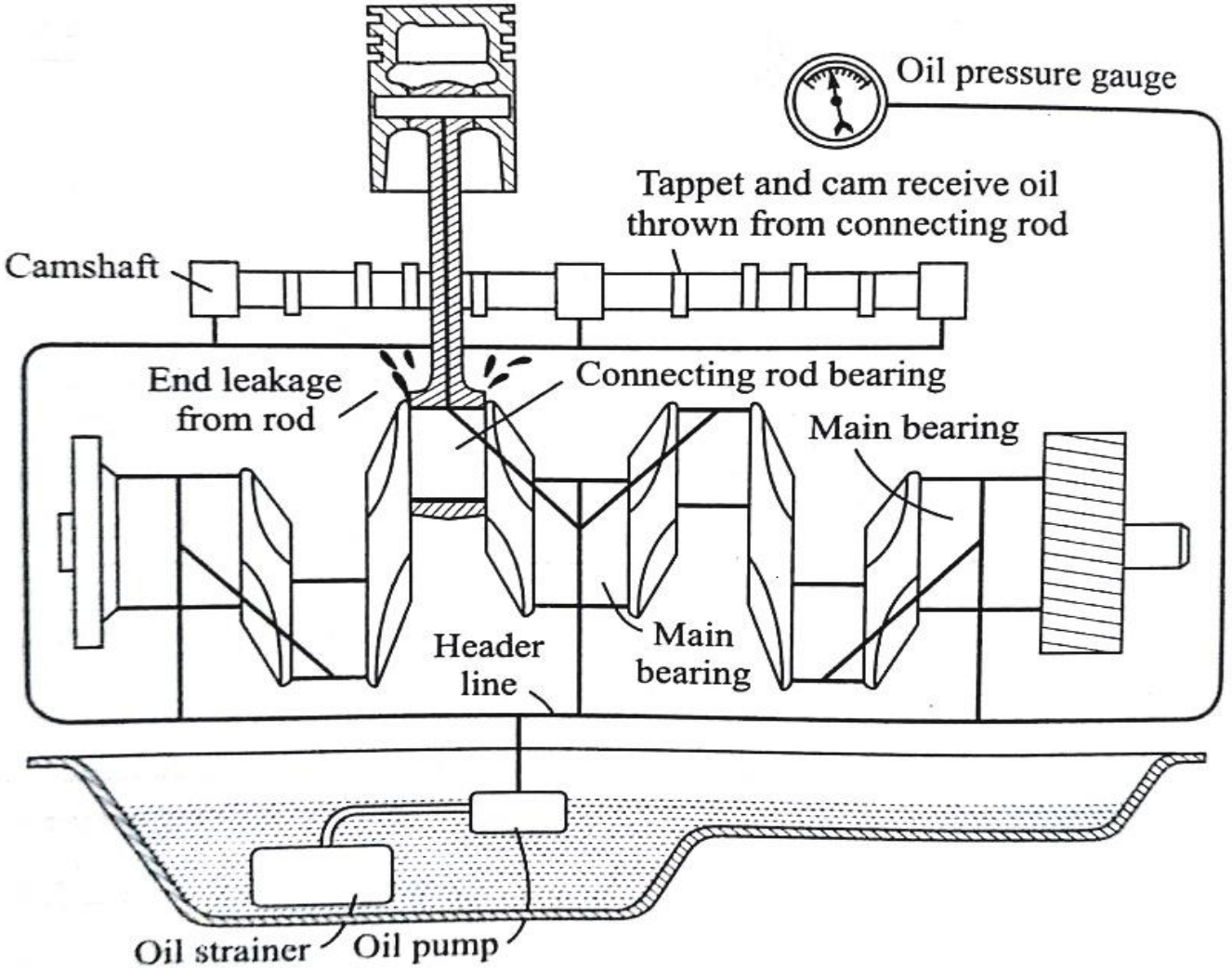

Figure Pressure-feed lubrication system.

8.3 Type of lubrication system

Wet Sump lubrication system - Fully Pressure feed system

- Suitable for heavy duty engines
- The oil from the sump is drawn by the pump through filter and it is forced to the main bearing through the branches of a distributor header.
- Drilled passages help to provide lubricating oil from the main bearing to the crank pin and it lubricates the big end bearing.
- The oil from the big end bearing is supplied to small end bearing through the drilled passage in the connecting rod.
- The lubrication of cylinder wall and the rocker arm is done by the oil sprays thrown by the crankshaft and the connecting rod.

8.3 Type of lubrication system

Dry sump lubrication system

- Lubricating oil is maintained in a separate tank kept behind the radiator.
- Oil is kept cool because of air blast thrown on the radiator.
- Due to less temperature, permits the use of thinner oil, which reduces the friction.

8.3 Type of lubrication system

Dry sump lubrication system

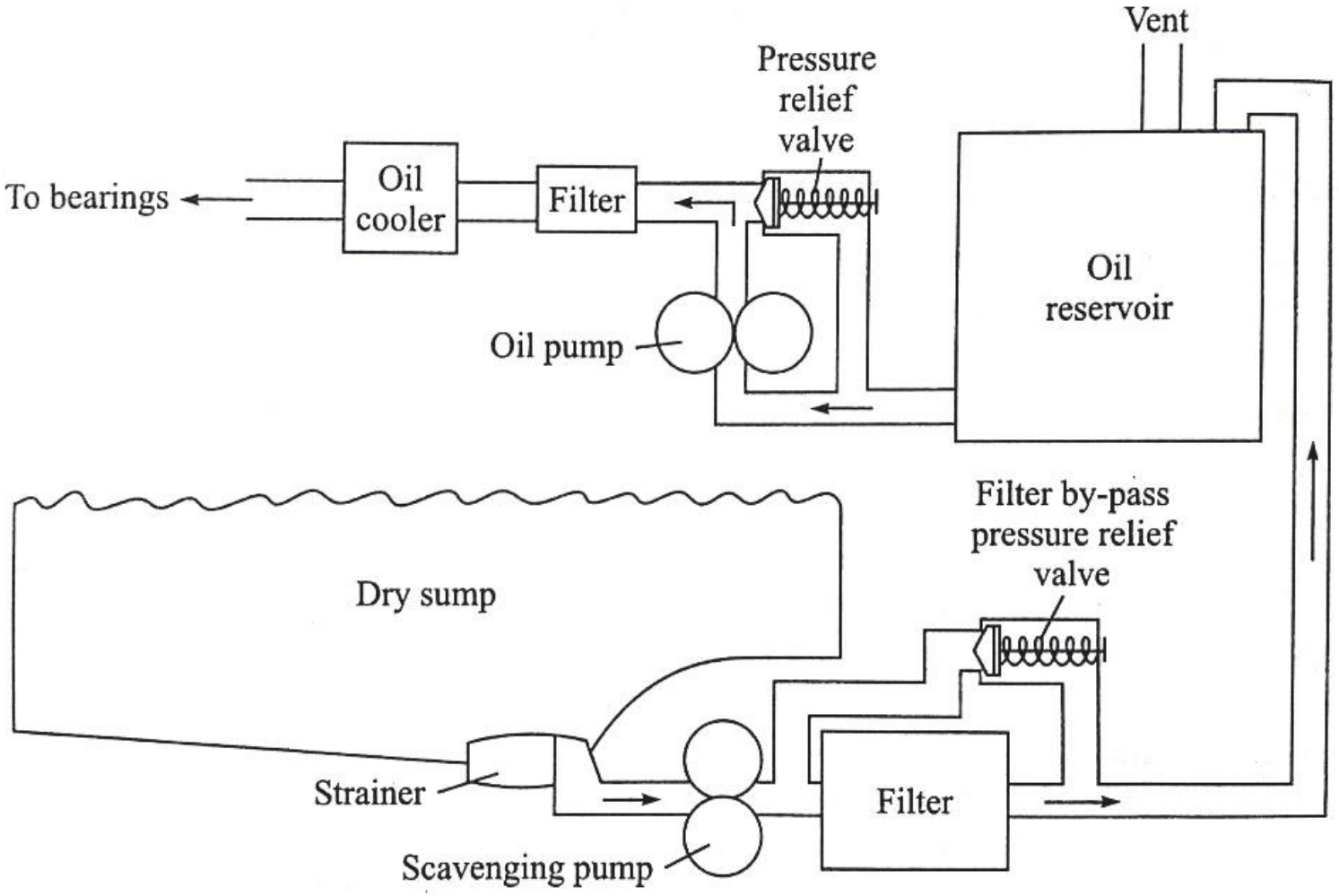

Figure Schematic diagram of a dry-sump lubrication system.

8.4 Oil pump

- Circulate the lubricant under pressure to various part of the engine. Driven by gear mounted on the cam shaft.
- Gear type pump, which consist two meshing spur gears of equal size in housing is commonly used.
- Pressure depends on speed
- Overcome excessive pressure, pressure relief valve is provided, which bypass the oil into the pump inlet.

8.4 Oil pump

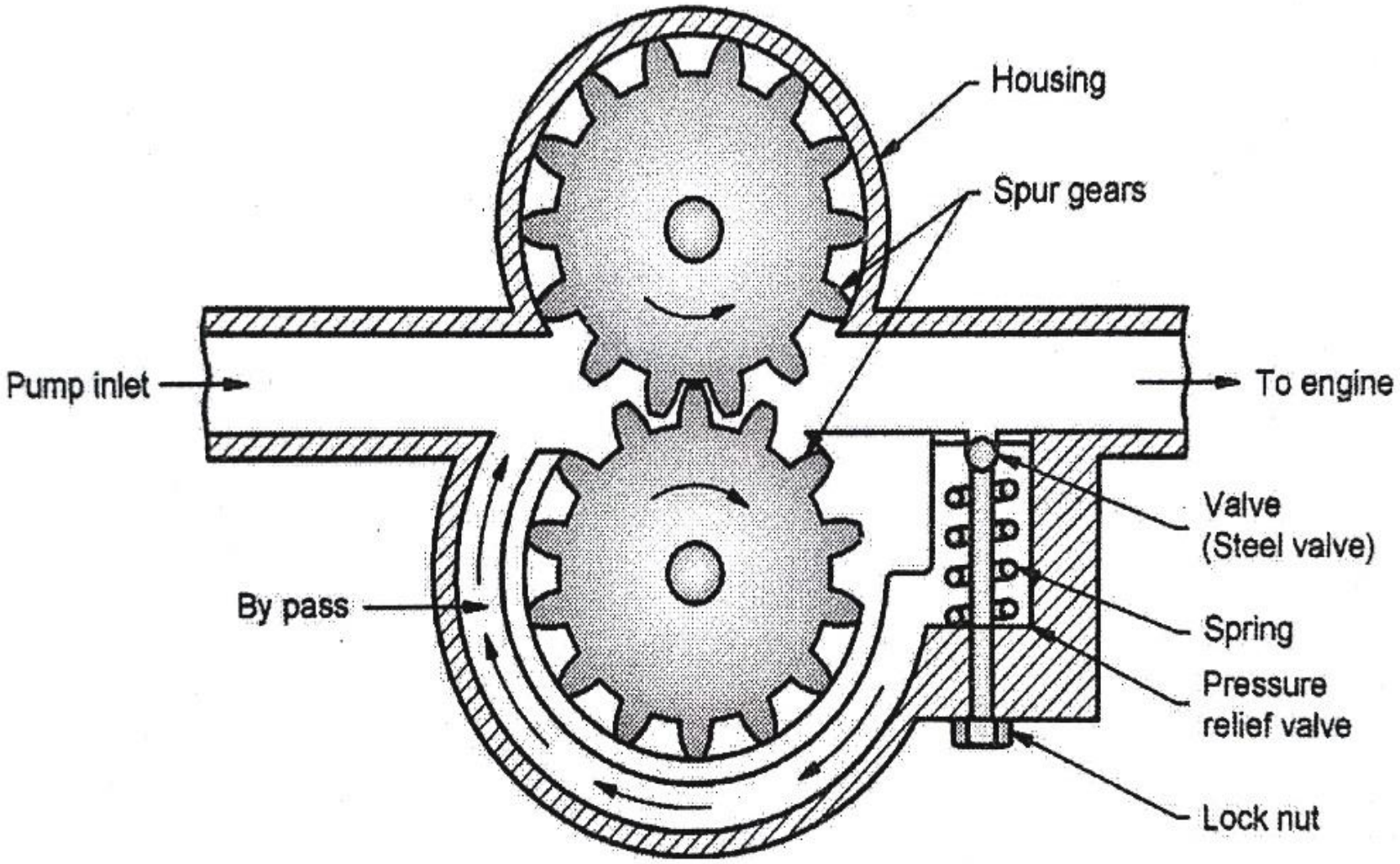

Fig. Gear type lubricating pump

8.5 Crankcase Ventilation

- The pressure inside the combustion chamber is high, so small amount of gases escapes through gap between piston ring and cylinder and enter into the crankcase.
- These gases can dilute and contaminate the engine oil, caused corrosion to critical parts and contribute to sludge built up.
- At high speed, blowing gases increase crankcase pressure that cause oil leakage from sealed engine surfaces and consume some expansion work.
- The crankcase ventilation system removes these blow by gases from crankcase and reduces the pressure of crankcase.

8.5 Crankcase Ventilation

Closed PCV system

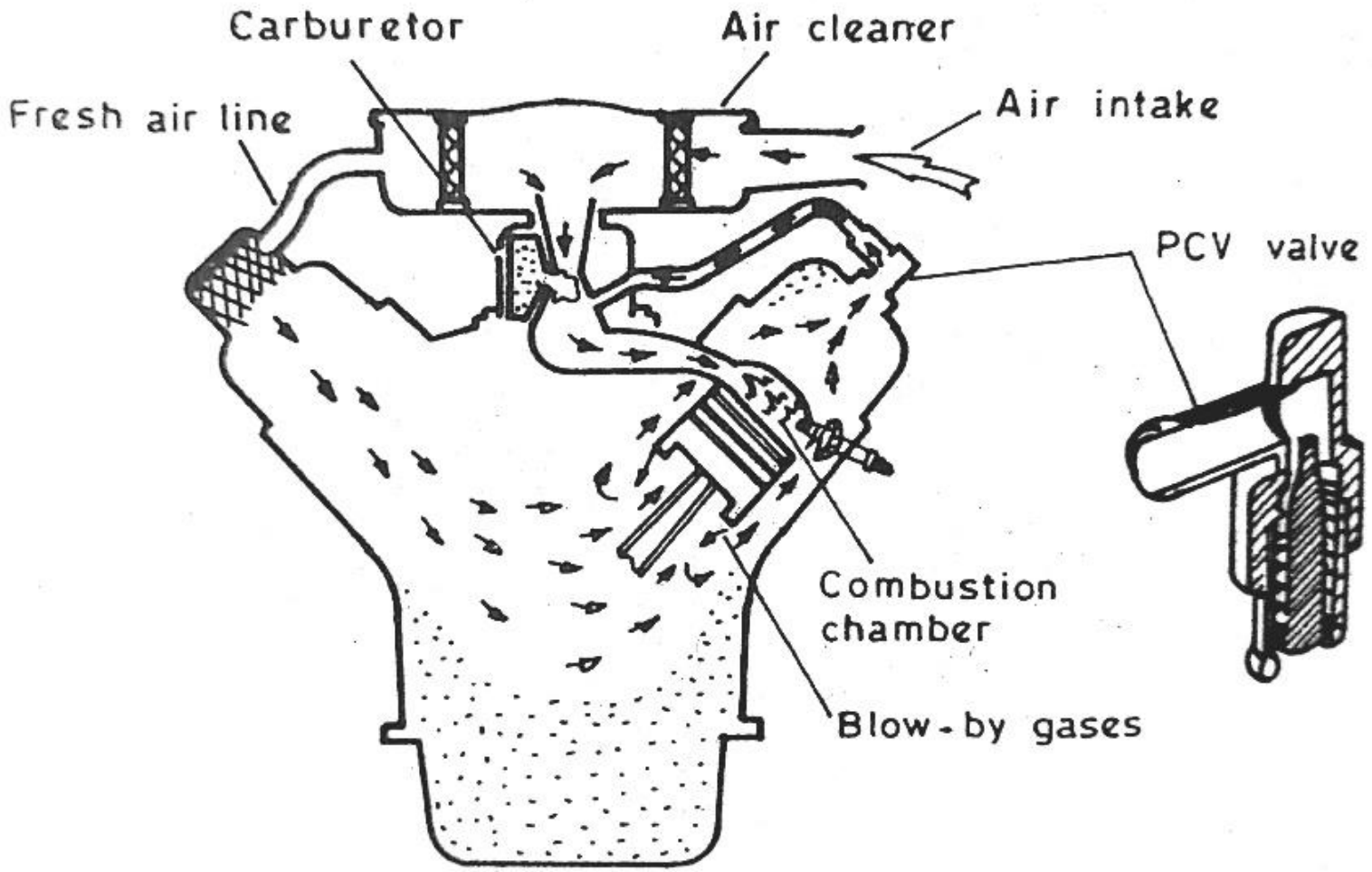

Fig. Closed crankcase ventilation system.

8.5 Crankcase Ventilation

- The breather inlet was relocated inside the air cleaner housing, so if pressure backed up, it would overflow into the air cleaner and get sucked down the carburettor.
- No vapour would escape into the atmosphere.
- PCV valve is used to regulate blow by flow back into the intake manifold.
- During idle, blow by is low so PCV valve pintle provide small vacuum passage and allow low blow by flow to the combustion chamber.
- During high speed, blow by is high so PCV valve pintle allows maximum flow to the combustion chamber.
- When engine is shut off, spring tension closed the valve completely and provide safety against accidental fire.

8.6 Engine Cooling

Engine Cooling

- 30% of heat is carried by cooling water, includes combustion and friction heat.
- Outlet temperature of water from engine varies from 50^0C to 80^0C in water cooled.
- It has been observed that the gasoline engine requires much more air than diesel engine and the turbo-charged diesel engine require less cooling than naturally aspirated diesel engine.

8.6 Engine Cooling

Need

- Maintain temperature of lubricating oil (below 200^0C) and different components.
- Reduce thermal stresses and cracking.
- Reduce abnormal combustion (detonation)
- Increase volumetric efficiency.

8.6 Engine Cooling

Disadvantage of overcooling

- Engine must be sufficiently hot to assure smooth combustion.
- At low temperature problem in starting and low temperature corrosion.
- At low temperature, the sulphurous and sulphuric acids resulting from combustion of fuel attack the cylinder barrel.
- To avoid condensation of acids the coolant temperature should be greater than 70^0C.

8.6 Engine Cooling

Type of cooling system

- Air cooling (small engine, air-craft(low weight), Industrial and Agricultural (strong objection))
- Water cooling (large engine)
- Oil cooling (Racing etc.)

8.7 Air Cooling

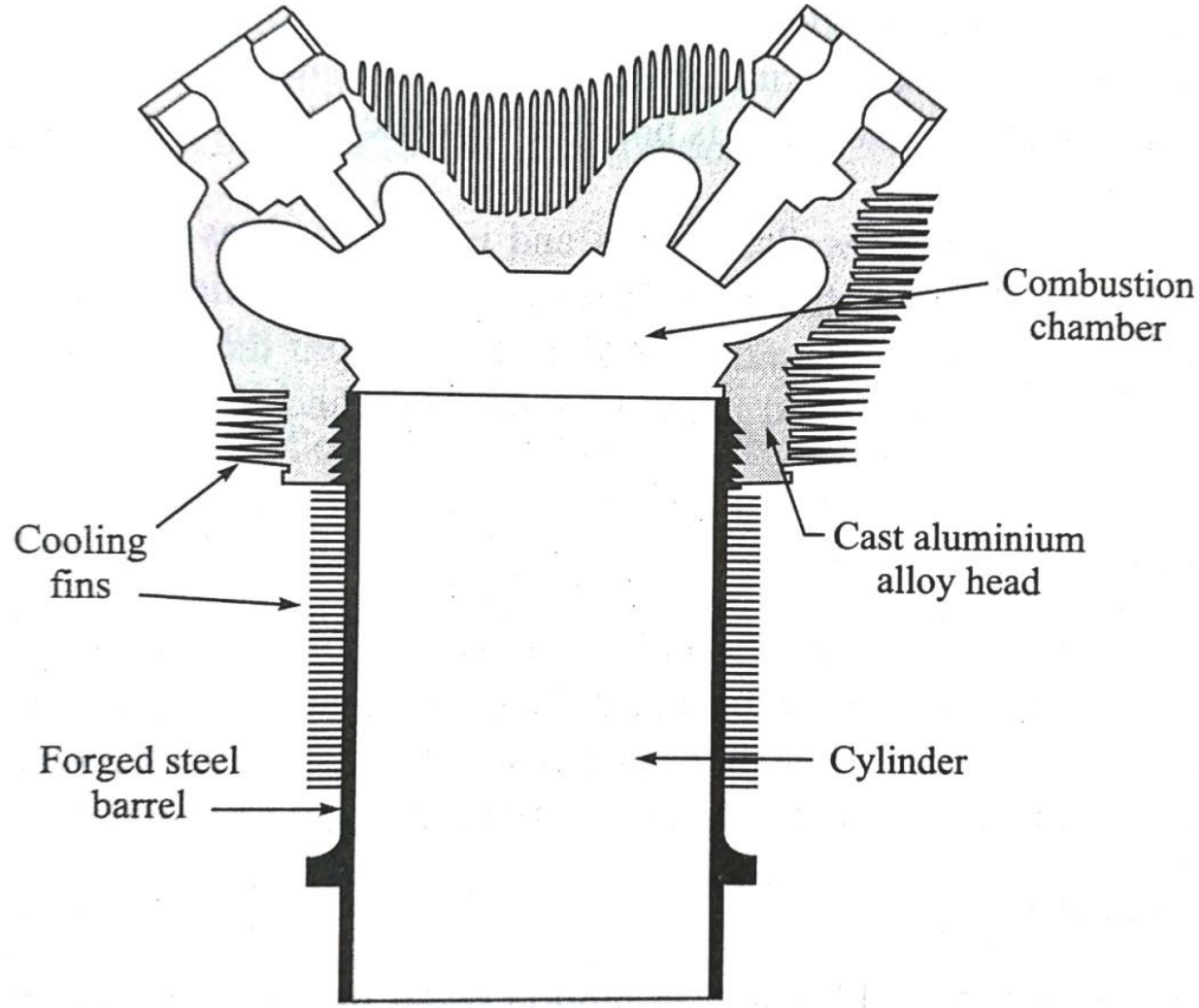

Figure Cylinder and cylinder head of an air-cooled aircraft engine.

8.7 Air Cooling

- Length and spacing of fin is important for efficient cooling
- Larger inter-spacing offers large area for cooling air but less surface area, while small interspacing provide less area for cooling air and large pressure drop.
- If the distance between two fins is quite small the laminar layers of the opposite area come in contact with each other and the efficiency of the fins is reduced very much.
- Therefore a spacing less than 2.5 mm is not used.
- Fins height varies from 15 to 25 mm

8.8 Water cooled engine

- Cylinder are closed in a water jacket
- The flow path as well as the local velocity should be carefully planned to cool highly thermally stressed areas.
- Local velocities greater than 3 to 4 m/s are used to provide a reasonable heat transfer
- The cast surfaces are usually machined to improve heat transfer co-efficient. Sometimes drilled coolant passages are provided to cool highly stressed parts.
- Anti freeze materials: Kerosene, Glycerine, Ethylene glycol and propylene glycol

8.8 Water cooled engine

- Some anti-freeze solution from sticky deposits on the cylinder and reduce the heat transfer co-efficient. Chromates are used as additives to cooling water to prevent deposits.
- Various methods are used for circulating the water around cylinder

1. Thermosiphon cooling
2. Forced or pump cooling
3. Cooling with thermostatic regulator
4. Pressurised water cooling
5. Evaporative cooling

8.8 Water cooled engine

Thermosiphon cooling

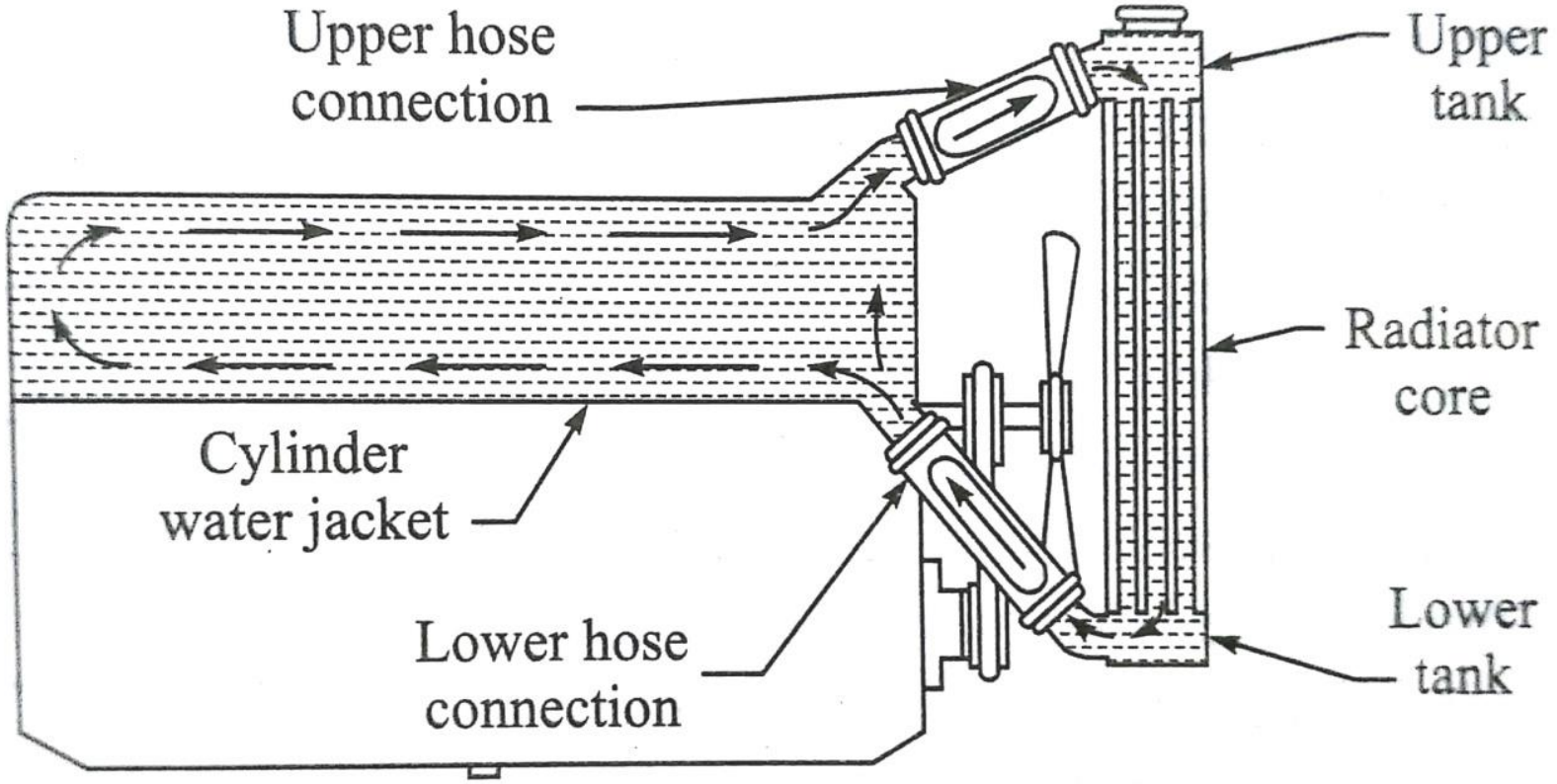

Figure Thermosyphon or natural circulation cooling system.

8.8 Water cooled engine

Thermosiphon cooling

- Water circulation occurs due to temperature and density difference and independent on engine speed
- Rate of circulation is slow and insufficient
- The circulation of water starts only after the engine has become hot enough to cause thermosiphon action
- Radiator should be above the engine for gravity flow of water to engine.

8.8 Water cooled engine

Forced or pump system

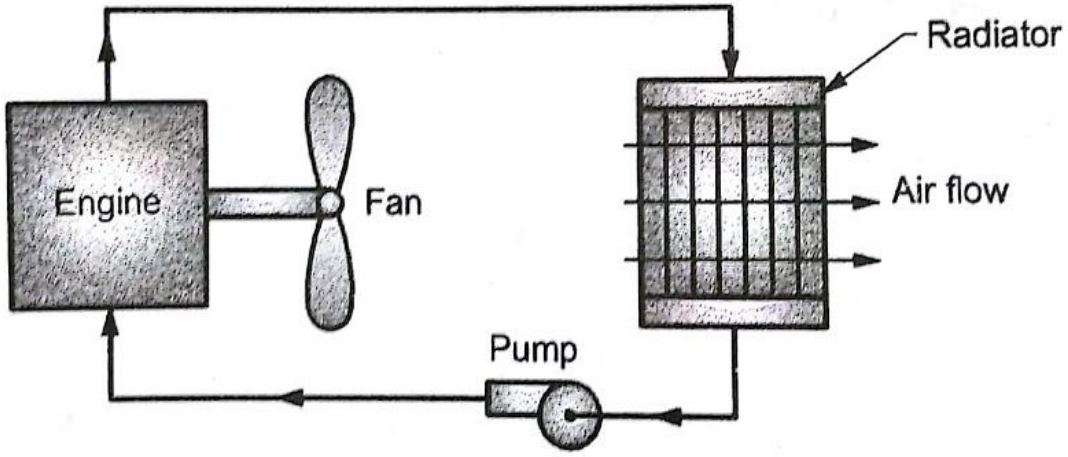

Fig. : Forced circulation method

- Pump driven from engine through belt is used to cause positive circulation of water in water jacket
- The advantages of forced system are that the cooling is ensured under all conditions of operation

8.8 Water cooled engine

Forced or pump system

Drawbacks

- The cooling is independent of temperature. This may under certain circumstances, result in overcooling the engine.
- While moving uphill the cooling requirement is increased because more fuel is burned. However, the coolant circulation is reduced while may result in overheating the engine.
- As soon as the engine is stopped the cooling also ceases. This is undesirable because cooling must continue till the temperature is reduced to normal values.

8.8 Water cooled engine

Thermostat Cooling

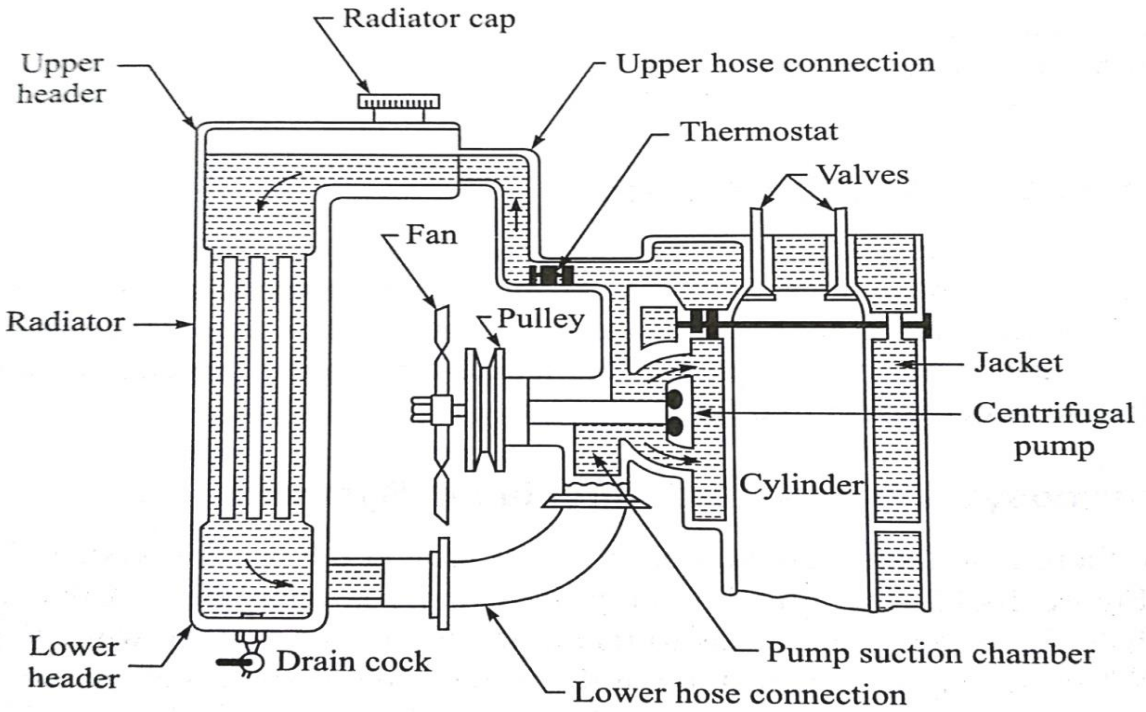

Figure Layout of a pump circulating cooling system.

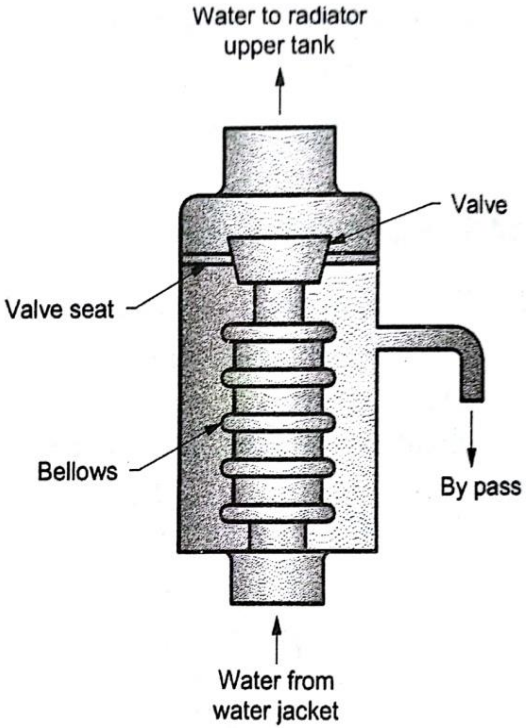

Fig. Thermostat

- Too low a cylinder barrel temperature, may result in corrosion damage
- Thermostat is used to stop flow of coolant below a pre-set cylinder barrel temperature.

8.8 Water cooled engine

Thermostat Cooling

- Thermostat prevents the water from circulating through the radiator until its temperature has reached to a suitable value.
- The thermostat bypass valve is fitted between the engine and the radiator top. The thermostat valve is operated by a small element filled with wax. As the temperature increases, the wax melts and valve is opened to allow coolant to go to the radiator.

8.8 Water cooled engine

Pressurized water cooling

- The boiling point of the coolant can be increased by increasing its pressure. (2 bar, 121^0C ; 10 bar, 180^0C)
- This allows a greater heat transfer to occur in the radiator due to a large temperature difference.
- Usually the water pressure is kept between 1.5 to 2 bars.

8.8 Water cooled engine

Pressurized water cooling

- Use of pressurised water cooling required an additional valve called vacuum valve, to avoid formation of vacuum when the water is cooled after engine has been stopped.
- A safety valve in the form of pressure relief valve is provided so that whenever the filler cap is opened the pressure is immediately relieved.

8.8 Water cooled engine

Evaporative cooling

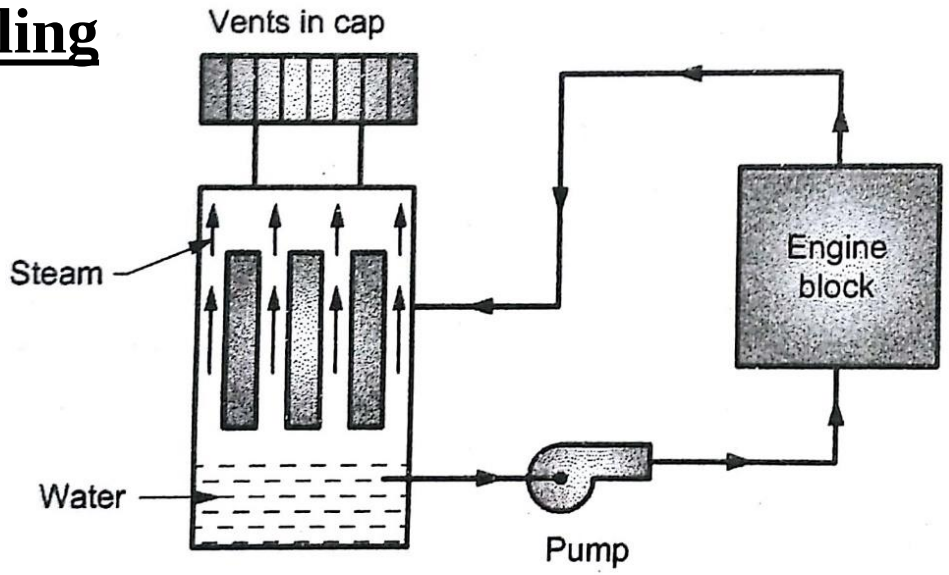

Fig.: Evaporative cooling

- This method of cooling utilizes the high latent heat of vaporisation of water to obtain cooling with minimum of water
- The cooing circuit is such that the coolant is always liquid but the steam formed is flashed off in a separate vessel.
- The makeup water so formed is sent back for cooling

8.9 Comparison between air and water cooling

Sr. No.	Air cooling	Water cooling
1.	No danger of water freezing at low temperature.	There is a danger of water freezing at low temperatures.
2.	Maintenance is low and design is simple.	Maintenance is high due to radiator and design of engine is move complicated.
3.	Engine warms up quickly.	Engine warm up takes comparatively more time.
4.	Specific fuel consumption is lower.	Specific fuel consumption is higher.
5.	Weight to power ratio is low.	Weight to power ratio is high
6.	Suitable for low capacity engines.	Suitable for high capacity engines.
7.	Regulation of cylinder temperature is not possible	Regulation of cylinder temperatures is possible.
8.	Volumetric efficiency is low.	Volumetric efficiency is high
9.	Cooling is not even	More even cooling is achieved.


Thank You !