LUBRICATION SYSTEM

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

In engine the frictional losses is attributed due to the following mechanical losses;

(i) Direct frictional losses:
-power absorbed due to the relative motion of different bearing surfaces such as piston rings, main bearings, cam shaft bearings etc.

(ii) Pumping loss:
-net power spent by the piston on the gas during intake and exhaust stroke
-more in case of four stroke engine compared to two stroke engine

(iii) Power loss to drive components to charge and scavenge:
-In four stroke supercharged engine, compressor used to provide high pressure air which is mechanically driven by the engine. This is counted as negative frictional loss.
-In two-stroke engine scavenging pump is used which is also driven by the engine

(iv) Power loss to drive the auxiliaries:
-Some power is used to drive auxiliaries such as water pump, lubricating oil pump, fuel pump, cooling fan, generator etc.

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

(a) Reducing frictional effect: The primary purpose of the lubrication is to reduce friction and wear between two rubbing surfaces. Two rubbing surfaces always produce friction. The continuous friction produce heat which causes wearing of parts and loss of power. In order to avoid friction, the contact of two sliding surfaces must be reduced as far as possible. This can be done by proper lubrication only. Lubrication forms an oil film between two moving surfaces. Lubrication also reduces noise produced by the movement of two metal surfaces over each other.
(b) Cooling effect: The heat, generated by piston, cylinder, and bearings is removed by lubrication to a great extent. Lubrication creates cooling effect on the engine parts.
(c) Sealing effect: The lubricant enters into the gap between the cylinder liner, piston and piston rings. Thus, it prevents leakage of gases from the engine cylinder.
(d) Cleaning effect: Lubrication keeps the engine clean by removing dirt or carbon from inside of the engine along with the oil.

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

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

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

Properties of Lubricant:

1. Viscosity: Viscosity is a measure of the resistance to flow or the internal friction of the lubricant.
-usually measured by Saybolt universal seconds (SUS) and Redwood viscometer. Also it is expressed with centistoke (unit of kinematic viscosity) and centipoise (unit of absolute viscosity)
-expressed in two temperature i.e. -18^{o}C (0^{o}F) and 99^{o}C (210^{o}F)

2. Viscosity Index: It is used to grade lubricants. Viscosity is inversely proportional to temp.
-If temp. increases, the viscosity of the lubricant decreases and if temp. decreases, the viscosity of the lubricant increases.
-The variation of viscosity of oil with changes in temperature is measured by viscosity index
-oil to measure is compared with 2 reference oil having same viscosity at 99^{o}C. one is paraffinic base oil index of zero and another naphthenic base oil index of 100
-high viscosity index number indicates relatively smaller change in viscosity of the oil with temperature.
-low viscos oil is recommended for automobile engines in winter than summer. The viscosity of a lubricant should be just sufficient to ensure lubrication. If it is more than this value, power loss will be higher due to increased oil resistance.
-VI improver are added to improve viscosity index

3. Oiliness: It is the property of a lubricating oil to spread & attach itself firmly to the bearing surfaces as well as provide lubricity. Generally, the oiliness of the lubricating oil should be high particularly when it is to be used for mating surfaces subjected to a high intensity of pressure and smaller clearance portion to avoid the squeezing out of the oil. Such a way that the metal is protected by a thin layer of the oil and the wear is also considerably reduced. It is measured by co-efficient of friction at extreme operating condition.

4. Flash Point: Flash point of oil is the min. temp. at which the vapours of lubricating oil will flash when a small flame is passed across its surface. It is of two type open flash point and closed flash point. The flash point of the lubricating oil must be higher than the temp. likely to be developed in the bearings in order to avoid the possibility of fire hazards.

5. Fire Point: If the lubricating oil is further heated after the flash point has been reached, the lowest temp. at which the oil will burn continuously for 5 seconds is called fire point.
-usually 11^{o}C higher than open flash point and varies from 190^{o}C to 290^{o}C for the lubricants used for IC engines
-The fire point of a lubricant also must be high so that the oil does not burn in service.

6. Cloud Point: It is the temp. at which the lubricating oil changes its state from liquid to solid. Its temp. must high for the low temp. operability of the lubricating oil during winter.

7. Pour Point: It is the lowest temp. at which the lubricating oil will not flow or totally form wax or solidify. This property must be considered because of its effect on starting an engine in cold weather. Oil derived from paraffinic crudes tends to have higher pour points than those derived from naphthenic crudes. The pour points can be lower by the addition of pour point depressant usually a polymerised phenol or ester. Pour point must be at least 15^{o}F lower than the operating temperature to ensure maximum circulation.

8. Corrosiveness: The present of acid (mineral acid, petroleum acid) is harmful to the metal surfaces. The lubrication oil should not attack chemically the materials of the engine. The lubricant should not be corrosive, but it should give protection against corrosion. New oil has low neutralisation number i.e. it maintains the alkaline and acid solution to make the oil neutral.

9. Oxidation stability: It is resistance to oxidation. Due to oxidation the oil will form deposits on the piston rings and lose its lubricating property. Low temperature operation avoiding the hot-area contact and crankcase ventilation can help in preserving the stability of oil over longer periods. Oxidation inhibitors are used to improve oxidation stability. These are complex compounds of sulphur and phosphorus or amine and phenol derivatives.

10. Cleanliness: Lubricating oil must be clean. It should not contain dust and dirt particles as well as water content which promote corrosion.

11. Carbon residue: after evaporation of a mass sample of lubricating oil under specific condition may remain as carbonaceous residue. It indicates the deposit characteristics of oil. Paraffinic oil has higher carbon residues than the naphthenic base oil.

Types of lubricants:
Lubricants are at following three types.
1. Solid: graphic, mica etc
2. Semi solid: grease
3. Liquid: Lubricants are obtained from animal fat, vegetables and minerals. Lubricants made of animal fat, does not stand much heat. It becomes waxy and gummy which is not very suitable for machines. Vegetable lubricants are obtained from seeds, fruits and plants. Cottonseed oil, olive oil, linseed oil and castor oil are used as lubricant in small machines. Mineral lubricants are most popular for engines and machines. It is obtained from crude petroleum found in nature. Petroleum lubricants are less expensive and suitable for internal combustion engines.

-Graphite is often mixed with oil to lubricate automobile spring. Graphite is also used as a cylinder lubricant.
-Grease is used for chassis lubrication.

Grade of lubricants: Generally lubricating oils are graded by SAE (society of automotive engineers) method by assign a number to oil whose viscosity at given temperatures falls in certain range.
-Two temperatures -18^{o}C (0^{o}F) and 99^{o}C (210^{o}F) are used to assign the number
ex-*Single grade type:* (a) SAE 5w,10w and 20w grades are viscosity at -18^{o}C (0^{o}F) and for

winter use.
(b) SAE 20, 30, 40 and 50 grades lubricating oil are viscosity at 99°C (210°F) and for summer use.
Multi-grade type: ex- SAE 20W/50 oil has viscosity equal to that at SAE 20W at -18°C and viscosity equal to that at SAE 50 at 99°C

SAE grades of oil are based on viscosity but not quality based. API (American petroleum institute) used regular, premium and heavy duty type oil which are based upon properties of oil and operating conditions. Generally regular type oil is straight mineral oil, premium type contained oxidation inhibitors and heavy type contained oxidation inhibitors plus detergent-dispersant additives.
According to API,
For gasoline engine 5 service ratings oil are used: SA, SB, SC, SD and SE
For diesel engines 4 service ratings are use: CA, CB, CC and CD
Where S and C stands for SI and CI engines
Rating A is for light-duty service, the severity of service increasing towards rating D and E which is severe duty.

Lubrication system: various lubrication system used for IC engines are,
(a) Mist lubrication system
(b) Wet sump lubrication system
(c) Dry sump lubrication system

(a) Mist lubrication system:
-Used where crankcase lubrication is not suitable
- Generally adopted in two stroke petrol engine line scooter and motor cycle. It is the simplest form of lubricating system.
- It is the simplest form of lubricating system. It does not consist of any separate part like oil pump for the purpose of lubrication.
- In this system the lubricating oil is mixed into the fuel (petrol) while filling in the petrol tank of the vehicle in a specified ratio (ratio of fuel and lubricating oil is from 12:1 to 50:10 as per manufacturers specifications or recommendations.
- When the fuel goes into the crank chamber during the engine operation, the oil particles go deep into the bearing surfaces due to gravity and lubricate then. The piston rings, cylinder walls, piston pin etc. are lubricated in the same way.
-If the engine is allowed to remain unused for a considerable time, the lubricating oil separates oil from petrol & leads to clogging (blocking) of passages in the carburettor, results in the engine starting trouble. This is the main disadvantage of this system.
-It causes heavy exhaust smoke due to burning of lubricating oil partially or fully
-Increase deposits on piston crown and exhaust ports which affect engine efficiency
-Corrosion of bearing surfaces due to acids formation
-thorough mixing can fetch effective lubrication
-Engine suffers insufficient lubrication during closed throttle i.e. vehicle moving down the hill.

(b) Wet sump lubrication system:
Bottom of the crankcase contains oil pan or sump from which the lubricating oil is pumped to various engine components by a pump. After lubrication, oil flows back to the sump by gravity. Three types of wet sump lubrication system,

(i) Splash system
(ii) Splash and pressure system
(iii) Pressure feed system

(i) Splash system:

-In this system of lubrication the lubricating oil is stored in an oil sump. A scoop or dipper is made in the lower part of the connecting rod. When the engine runs, the dipper dips in the oil once in every revolution of the crank shaft, the oil is splashed on the cylinder wall. Due to this action engine walls, piston ring, crank shaft bearings are lubricated.

-It is used for light duty engine

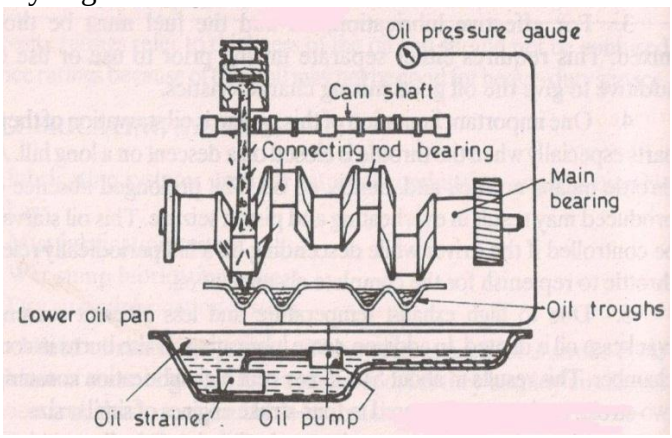

Fig. 40. Splash lubricating system

(ii) Splash and pressure system:

Lubricating oil is supplied under pressure to main, camshaft bearings and pipes which direct a stream of oil against the dippers on the big end of connecting rod bearing cup and thus crankpin bearings are lubricated by the splash or spray of oil thrown up by the dipper.

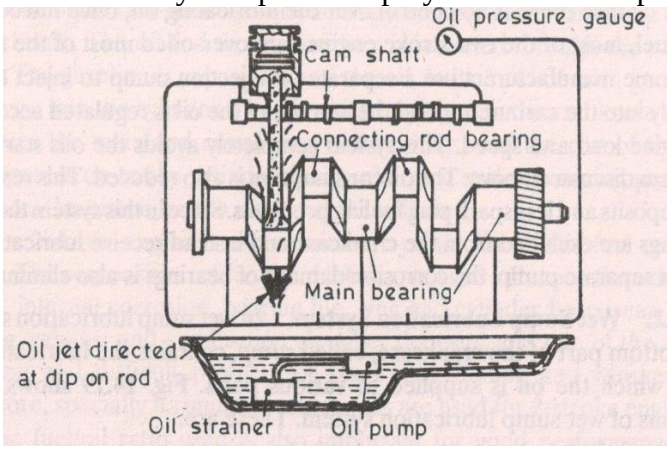

Fig. 41. Splash and pressure lubricating system

(iii) Pressure feed system:

In this system of lubrication, the engine parts are lubricated under pressure feed. The lubricating oil is stored in a separate tank (in case of dry sump system) or in the sump (in case of wet sump system), from where an oil pump (gear pump) delivers the oil to the main oil gallery at a pressure of 2-4 kg/cm^2 through an oil filter. The oil from the main gallery goes to main bearing, from where some of it falls back to the sump after lubricating the main bearing and some is splashed to lubricate the cylinder walls and remaining goes through a hole to the

crank pin. From the crank pin the lubricating oil goes to the piston pin through a hole in the connecting rod, where it lubricates the piston rings. For lubricating cam shaft and gears the oil is led through a separate oil line from the oil gallery. The oil pressure gauge used in the system indicates the oil pressure in the system. Oil filter & strainer in the system clear off the oil from dust, metal particles and other harmful particles.

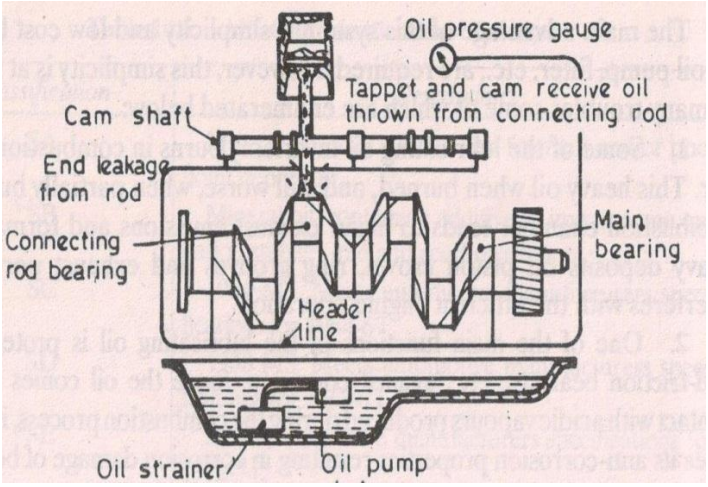

Fig. 42. Pressure lubricating system

Gear system:
-Used for a medium sized diesel engine
-It is a forced-feed system of lubrication and uses the oil contained in the bed plate as a reservoir. A gear type oil pump is driven from the crankshaft.
-The oil enters the pump and is carried around the pump casing by the gear teeth. It is then discharged. The oil is prevented from returning to the inlet by the meshing of the gear teeth. Oil is pumped from the bed plate through an oil filter and cooler into the lubricating oil manifold. A separate pipe supplies oil to the turbocharger. A supply of cooled oil is critical for the turbocharger to lubricate the high-speed bearings and to carry heat away from the rotor.

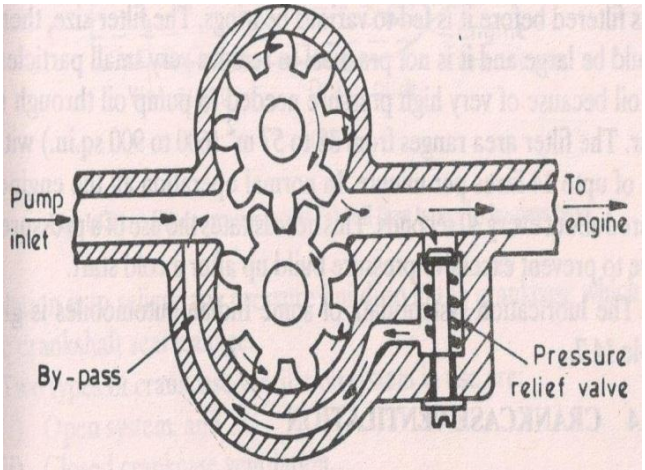

Fig. 43. Gear type lubrication system

(c) Dry sump lubrication system:
-Supply of oil is carried in external tank
-Oil pump draws oil from the supply tank and circulates it under pressure to various bearings of the engine

- Oil dripping from the cylinders and bearings into the sump is removed by a scavenging pump and again return to supply tank through the filter
-The capacity of scavenging pump is greater than the oil pump
-Separate oil cooler to remove heat from oil is used which is either cooled by air or water