UNIT- II: Fuels & Lubricants

Lubricants - Definition, theories of lubrication, characteristics of lubricants, viscosity, viscosity index, oiliness, pour point, cloud point, flash point, fire point, additives to lubricants, Solid lubricants.

Lubricants-Definition:

The moving parts of any machine rub against each other causing frictional force. This frictional force causes wear and tear of surfaces and loss of energy in the form of heat and thus affecting the efficiency of the machines. Hence lubricants are introduced to reduce frictional force between moving parts of a machine.

Any substance which reduces frictional force between surfaces is called lubricant and the phenomenon is called lubrication.

Functions of lubricants:

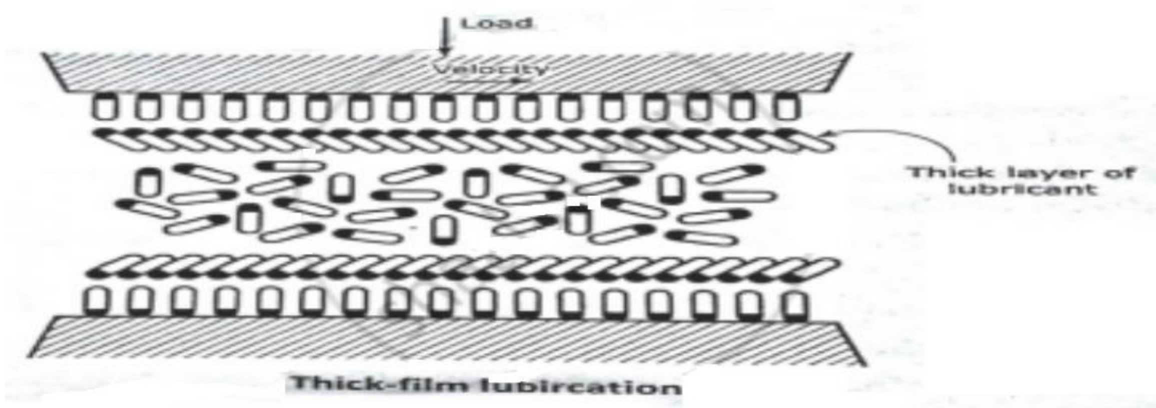
- It avoids direct contact between surfaces
- It reduces wear and tear of surfaces
- It absorbs heat produced and acts as coolant.
- It reduces maintenance costs of machines.

Theories of lubrication/ Mechanism of lubrication: There are mainly 3 types of lubricating mechanism:

(1) Thick film or Fluid film or Hydrodynamic lubrication:

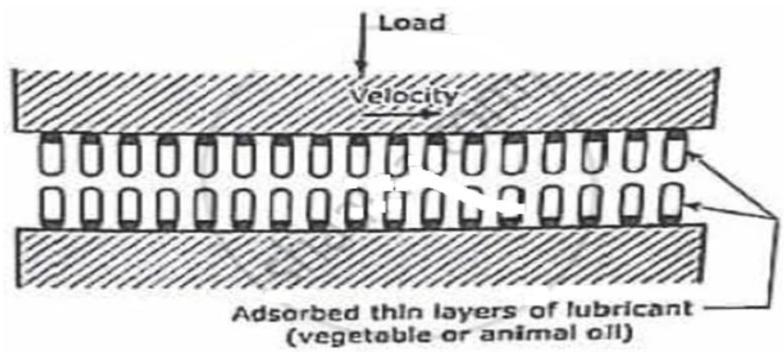
In this mechanism, the moving surfaces are separated by thick film of lubricant fluid which covers entire moving surfaces and fills irregularities. The thickness of liquid film is at least 7000 A^0. The liquid lubricants do not have any chemical affinity to the metal surface. When lubricant is introduced between the moving surfaces, some of the lubricant molecules are held up tightly at the surface due to adsorption. The remaining molecules are loosely arranged away from metal surfaces.

There is no direct contact between surfaces which reduces the wear and tear. The liquid lubricant must have sufficient viscosity so as to maintain the fluid film in its place. This type of lubrication is used in watches, clocks, electric motors, turbines etc.



(2) Boundary or thin film lubrication:

In thin film lubrication, moving surfaces are separated by a thin layer of lubricant, which is absorbed by physical or chemical forces on metallic surfaces. The thickness of film is 10 A^0 and consists of one or two molecular layers. Vegetable oils, animal oils and their soaps possess the properties of adsorption on metal surfaces forming a thin film which acts as a good lubricant.



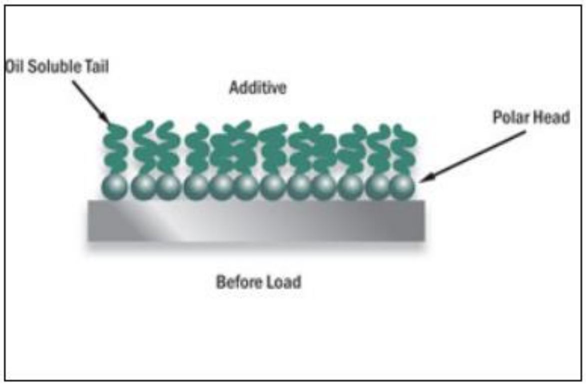
Fatty oils possess greater adhesion property than mineral oils, hence to improve the oiliness of mineral oils, a small amount of fatty oil is added to it. Gears, railway track joints, tractors, rollers etc are provided with this type of lubrication.

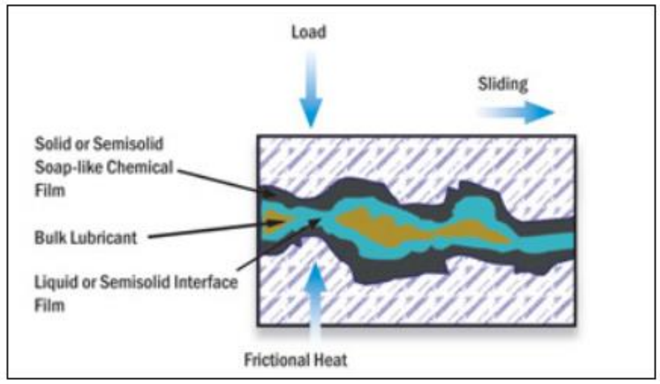
(3) Extreme pressure lubrication:

In this mechanism, the moving or sliding surfaces are under very high pressure or speed. Under such conditions, a high local temperature is attained wherein the liquid lubricants may decompose or vaporize. Special additives are added to mineral oils such as organic compounds having chlorine (chlorinated esters), sulfur (sulphurized oils) or phosphorous (tricresyl phosphate) to meet the extreme pressure conditions.

They are activated by reacting with the metal surface when the temperatures are elevated due to the extreme pressure. The chemical reaction between the additive and metal surface is driven by the heat produced from friction.

In reacting with the metal surface, these additive types form new compounds such as iron chlorides, iron phosphides and iron sulfides. The metal salts produce a chemical (soap like) film that acts as a barrier to reduce friction, wear and tear of surfaces, etc.





Characteristics of lubricants:

- It should have enough viscosity and oiliness.
- It should not come out of the surface under pressure.
- It should stick on the surface.
- The volatility of the lubricating oil should be low.
- It should possess a higher resistance towards oxidation and corrosion.
- It should have flash and fire points higher than the operating temperature of the machine.
- It should have cloud and pour points lower than the operating temperature of the machine.

Properties of Lubricants:

(i) Viscosity: Viscosity is the property of a fluid that determines its resistance to flow. The lower viscosity greater will be the flow ability. If temperature increases viscosity of the lubricating oil decreases and pressure increases viscosity of lubricating oil increases. A good lubricating oil is that whose viscosity does not change much more with temperature. The viscosity of a lubricant determines the thickness of the layer of oil between metallic surfaces. The most widely used unit of measurement of viscosity is the centistokes (cSt).

(ii) Viscosity Index (VI): The variation of viscosity of a liquid with temperature is called viscosity index. A relatively small change in viscosity with temperature is indicated by high viscosity index whereas, a low viscosity index shows, a relatively large change in viscosity with temperature.

(iii) Cloud point: The temperature at which the crystallization of solids in the form of a cloud first becomes noticeable when cooled in a standard apparatus is called cloud point

(iv) Pour point: The lowest temperature at which the lubricant oil become semi-solid and ceases to flow when cooled at a standard rate in standard apparatus is called pour point. Good lubricant should possess low pour point.

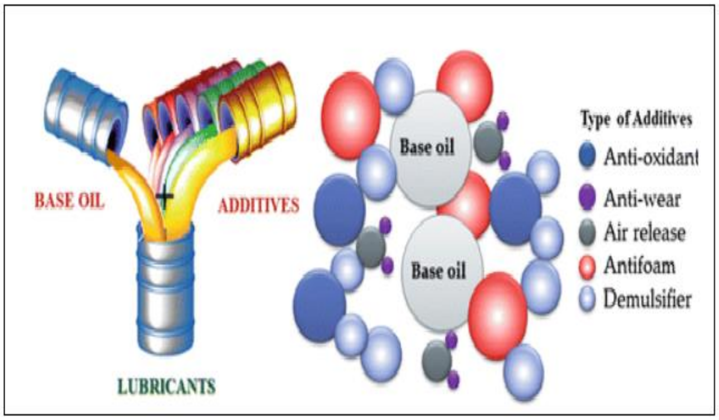
(v) Flash point: The flash point of a volatile material is the lowest temperature at which vapors of the material will ignite for a moment when an ignition source brought near to it. The lubricating oil should have flash point above its working temperature.

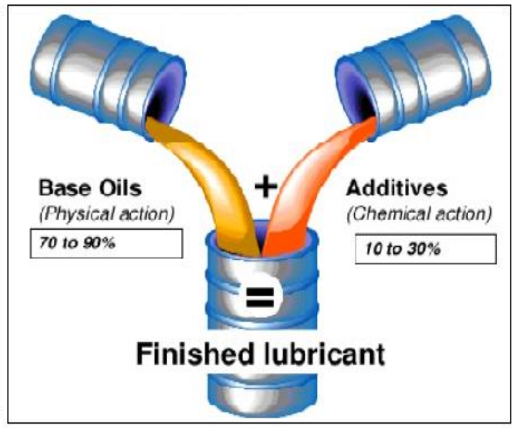
(vi) Fire point: The fire point of a fuel is the lowest temperature at which the vapor of that fuel will continue to burn for at least 5 seconds when an ignition source brought near to it.
A good lubricant should have flash point above the operating temperature while the fire point is 5-40^{0}C higher than flash point.

(vii) Oiliness: It is an important properties of a lubricant, it shows the capacity of a lubricants to stick on the surface of machine parts. If the oil has good oiliness it can remain in place and can give lubrication even under pressure. Mineral oil has very poor oiliness whereas vegetable oil possess good oiliness.

Additives to lubricants:

- Lubricants are not just oils they contains chemical compounds as well.
- Lubricants comprises of base oil and additives.
- Additives are chemical compounds that improve the lubricant performance of base oil.
- Additives are organic or inorganic compounds dissolved in oil.
- Additives range between 0.1-30 % of the oil volume, depending on the application of lubricant.
- The additives are used to enhance the performance characteristics of the lubricating oil.





Types of lubricant additives

- Performance enhancing additives - Improves overall properties of lubricants
  - Viscosity Index improvers
  - Anti-foaming additives
  - Detergent additive
  - Pour point depressant
  - Acid neutralizer additives
- Surface protecting additives – protects the interacting surfaces in metal to metal contact from chemically active lubricants.
  - Extreme pressure additives
  - Anti-rust additives
  - Anti-wear additives
- Lubricant protecting additives – protects the lubricity of base oil.
  - Anti-oxidant additives

Additive Type	Compounds Used	Function
Extreme Pressure (EP)	Sulfur-Phosphorous compounds.	Increase load carrying ability.
Antioxidant	phenols. Amines.	Prolong oil life by slowing oxidation.
Antifoam	Silicones.	Control foaming in forcefeed systems.
Anticorrosion	Zinc dithiophosphates. (ZDDP)	Form anticorrosion film.
Detergent	Calcium sulfonates.	Prevent deposition of carbon.
Alkalinity (TBN)	Calcium carbonates. Magnesium Sulfonates.	Neutralize acidic engine byproducts.
Antiwear	Zinc dithiophosphates. (ZDDP)	Reduce wear.
Pour Point Depressant	Methacrylate polymers.	Lower pour point.
VI Improvers	Organic polymers.	Improve VI.

Solid lubricants:

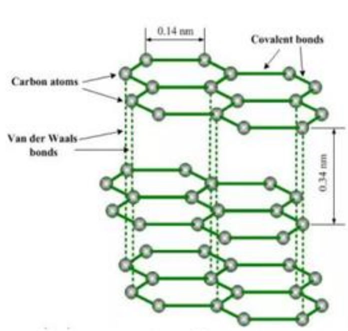
A solid lubricant is a material used as powder which reduces friction and wear of contacting surfaces and provides protection from damage.
Ex: Graphite, molybdenum disulphide (MoS_2), boron nitride (BN)x

Graphite: It is most widely used as a solid lubricant. Graphite has layer structure; layers are held together with the help of weak Vander Waals' forces which facilitate the easy sliding of one layer on the other layer. It is very soapy to touch. It is stable up to 450^{o}C. It is either used as powder or mixed with oil or water.

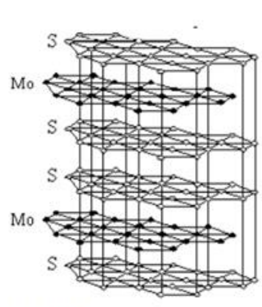
Molybdenum disulphide (MoS_2): It is sandwich like structure in which hexagonal layer of molybdenum (Mo) lies between two hexagonal layers of sulfur (S) atom. Like graphite each layers are held together with weak Vander Waals' forces. It is stable up to 400^{o}C. It adheres even more strongly to the metal or other surface.

Boron nitride: Hexagonal boron nitride (HBN) is a solid lubricant. The crystal lattice of hexagonal boron nitride consists of hexagonal rings forming thin parallel planes. The planes are bonded to each other by weak Van der Waals forces.

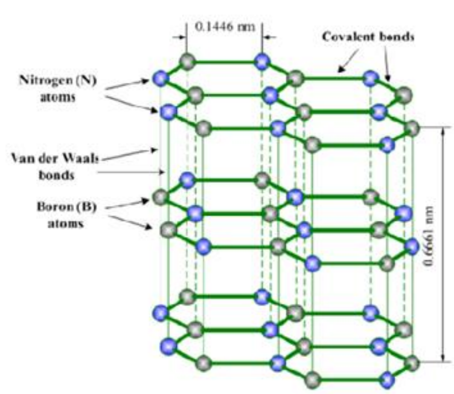
Boron nitride forms a lubrication film strongly adhered to the metal surface. The lubrication film provides good wear resistance. Boron nitride is chemically inert substance. The main advantage of boron nitride as compared to graphite and molybdenum disulfide is its thermal stability. Hexagonal boron nitride retains its lubrication properties up to 5000°F (2760°C) in inert and up to 1600°F (870°C) in oxidizing atmosphere.



Graphite structure



Molybdenum disulphide structure



Hexagonal boron nitride structure