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Lubricants & Lubrication

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New Scheme Based On AICTE Flexible Curricula

B.Tech. First Year

Branch- Common to All Disciplines

BT101	**Engineering Chemistry**	**3L-0T-2P**	**4 Credits**

(iii)Lubricants and Lubrication (4 Lectures)

Introduction, Mechanism of lubrication, Classification of lubricants, significance & determination of Viscosity and Viscosity Index, Flash & Fire Points, Cloud & Pour Points, Aniline Point, Acid Number, Saponification Number, Steam Emulsification Number and related numerical problems.

1. Introduction

Lubricants are substances used to reduce friction and wear between two surfaces in contact, allowing for smoother movement and better performance of mechanical systems. They help in minimizing heat buildup, protecting parts from corrosion, and extending the lifespan of machinery. Common types of lubricants include oils, greases, and waxes.

Lubrication refers to the process of applying a lubricant to reduce friction, heat, and wear between moving parts. It's used in various industries, from automotive (engine oils) to industrial machinery, to ensure smooth operation and prevent damage due to friction. The process of lubrication can be achieved through different methods, such as manual application, automatic systems, or by using lubrication devices.

2. Mechanism of Lubrication

a) Thick Film or Fluid Film or Hydrodynamic Lubrication

b) Thin Film or Boundary Lubrication

c) Extreme Pressure Lubrication

a) Thick Film Lubrication

- In this mechanism, two moving and sliding surfaces are separated by thick film of lubricant fluid of about 1000A°, applied to prevent direct surface to surface contact and consequently reduce wearing and tearing of metals.
- Therefore it is known as thick film or fluid film lubrication or hydrodynamic (hydro meaning liquid and dynamic meaning relative motion) lubrication.
- In this case fluid is formed by mixing of hydrocarbon oils and anti- oxidants with long chain polymer so as to maintain viscosity

Usage-

Engine Bearings: Oil forms a thick film between the crankshaft and bearings, preventing metal-to-metal contact.

Turbines: Thick lubricant film separates moving parts, reducing friction and wear.

Hydraulic Systems: High-speed pumps rely on thick film lubrication for smooth operation.

Fluid film lubrication is useful in delicated and light machines like watches, clocks, guns, scientific equipments etc.

Thin Film Lubrication

- It is carried out with semi-solid (grease) and solid (graphite and molybdenum disulphide) lubricants.
  - Boundary lubrication is a condition in which the lubricant film becomes too thin to provide total separation. And In this type of lubrication a thin film of lubricant is adsorbed on the surface by weak Vander Waals forces.
  - Thin film lubrication is operating at relatively low speed and heavy loading (pressure).

Usage- -

Gearboxes: Thin film under high load and moderate speed, with additives protecting surfaces.
Hydraulic Pumps: Thin lubricant film under low speed and high pressure.
Clutches: Protective thin film during engagement, with some surface contact.

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b) Extreme Pressure Lubrication

- surfaces are under high pressure and speed, therefore it is known as extreme pressure lubrication.
- In such a case high temperatures generated due to friction, under these condition liquid lubricants are fail to stick and decompose or vaporize.
- These problems are minimized by adding special additives to mineral oils. These additives form durable films on metal surfaces which can withstand high loads and high temperatures.
- Important additives are organic compound having group like chloride, sulphur, phosphorus etc.
- They react with metallic surface to form metallic compound (possess high melting points and serve as good lubricants under extreme temperatures and pressures) like metal chlorides, sulphides and phosphate as more durable film.

Usage-

Car Differentials: EP lubricants protect gears under high load and slow speed.
Industrial Gearboxes: EP lubricants prevent damage in heavy machinery.
Rolling Mills: EP lubricants protect surfaces under high compressive forces.

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3. Classifications of the lubricants

a) **Liquid Lubricants:**
b) **Semi solid Lubricants**
c) **Solid Lubricants:**

a) Liquid Lubricants:

- It includes animal oils, vegetable oils, petroleum oils, Animal oils, tallow oil, whale oil, lard oil etc.

Vegetable oils: castor oil, palm oil etc

Petroleum oils: petroleum fractions, mineral oil

Synthetic lubricants: polyglycol, silicones etc.

b) Semi-solid Lubricants (Grease):

Semi-solid Lubricants are formed by emulsifying oil and fat with thickening agents like soap of sodium, calcium, lithium, aluminum at higher temperature.

Classification of Grease:

1.Soda based grease:

- In this case sodium soaps are used as a thickening agent in mineral or petroleum oil. They are slightly soluble in water. They can be used up to 175^0C.

2. Lithium based:

- In this case lithium soaps are emulsifying with petroleum oil. They are water resistance and used up to 15^0C.

3.Calcium based:

- In this case calcium soaps are emulsifying with petroleum oil. They are also water resistant and used up to 80^0C. At higher temperature soap and petroleum oil are separate from each other.

b) Solid Lubricants:

Graphite, molybdenum disulphide (MoS_2), boron nitride (BN)x are predominantly used as a solid lubricants. They are used under high temperature and high load (pressure).

i) 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, non-

inflammable. It is used at higher temperature (around 4500C) condition. They are either used as powder form or mixed with oil(oildag) or water(aquadag).

ii) Molybdenum disulphide (MoS2):

- 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°C
- It is differ from graphite because it is used in high vacuum unlike graphite.
- It adheres even more strongly to the metal or other surface.

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4. Properties of the Lubricants

1. **Cloud & Pour Point:**
2. **Flash & Fire Point:**
3. **Visocity & Viscosity index:**
4. **Aniline Number**
5. **Acid Value**
6. **Saponification Number:**
7. **Steam Emulsification Number:**

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1. Cloud & Pour Point:

- **Cloud Point**: The temperature at which lubricating oil becomes cloudy in appearance is called cloud point.
- **Pour Point:** The lowest temperature at which the lubricant oil become semi-solid and ceases to flow is called pour point. It indicates the suitability of lubricants used in cold condition. Good lubricant should possess low pour point.

Significance: Cloud & Pour point

- determines the suitability of a lubricant for low temperature.

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1. Flash and Fire Point:

i) 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 reasonably above its working temperature.

ii) Fire point: The fire point of a fuel is the lowest temperature at which the vapors of that fuel will continue to burn for at least 5 seconds when an ignition source brought near to it. Fire point is around 100C higher than flash point.

Significance: The flash point and fire points are used to indicate the fire hazards of petroleum products.

Apparatus for Flash & Fire Point

- **There are three types of Apparatus**

1.Cleveland open cup Apparatus:

- By this apparatus we can determine flash & fire point of all petroleum products except fuel oils and those having an open cup flash below 175°F.

Limitation: The flash & fire point of lubricating oil generally obtained above 170°C.

2.Penskey Marten's closed cup Apparatus

- By this apparatus we can determine flash & fire point of lubricating oils, fuel oils, solvents and suspension of solids.

Limitation: The flash & fire point of lubricating oil generally obtained below 120°C.

3. Abel's closed cup Apparatus

- By this apparatus we can determine flash & fire point of volatile inflamemable oils and lubricating oils.

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3. Viscosity & Viscosity Index:

i) Viscosity:

- Viscosity is the property of a fluid that determines its resistance to flow.
- It is an indicator of flow ability of lubricating oil. 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.

- **Unit of Viscosity is **poise or centipoise**

Significance:

- A good lubricating oil should have viscosity which does not change rapidly with temperature.

ii) Viscosity Index:

- The rate at which the viscosity of a liquid changes 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.

Significance:

- A good lubricating oil should posses high viscosity-index.

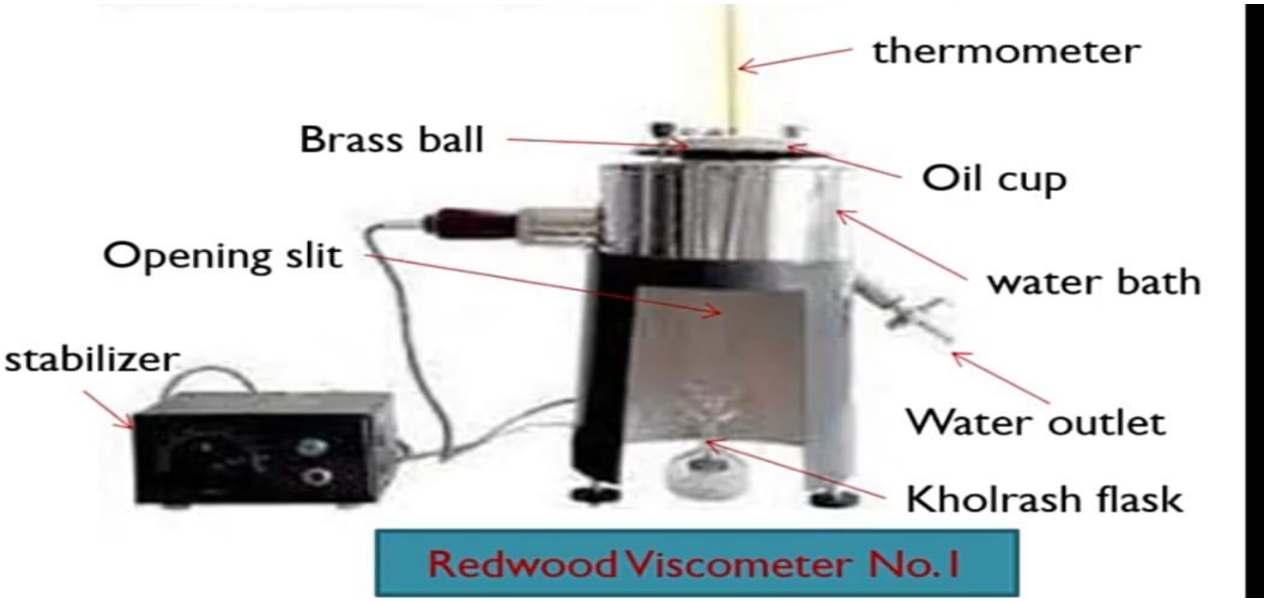
Types of instruments:

***Viscosity & Viscosity Index can be determine by various apparatus i.e.

i) kinematic Saybolt universal viscometer used in -USA

ii) Engler's viscometer used in Europe

iii) Redwood viscometer used in Commonwelth countries like India



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2. Aniline point:

- It is defined as "*the minimum equilibrium solution temperature for equalvolume of aniline and oil sample*" it is determined by mixing equal volume of oil sample and aniline in a test tube and heating the mixture until a homogenous solution is obtained. After cooling the temperature at which oil and aniline phase separate out is recorded as aniline point.

Significance:

- Higher aniline point is desirable for a good lubricant.

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3. Acid value:

- "The number of milligrams of potassium hydroxide (KOH) needed to neutralize any acid present in one gram of oil is known as Total Acid Number(TBN)".

Significance:

A good lubricating oil should possess acid value less than 0.1, exceeding value lead to corrosion and sludge formation.

6.Saponification Number:

- It is defined as "the number of milligrams of potassium hydroxide required to saponify the fatty material present in one gram of the oil"

Significance:

- This test gives an indication of the amount of animal and vegetable oil added to mineral oil to improve oiliness, it helps also in identifying whether the oil is animal/ vegetable or mineral oil or blended oil.

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8. Steam Emulsification Number:

- The tendency of lubricant water emulsion to break is determined by this test; steam at 100°C is bubbled through a test tube containing 20 ml of oil, till the temperature increases to 90°C and "the time is noted when the oil and water separate out in distinct layers as Steam Emulsification Number (SEN)"

Significance:

- SEN is needed to avoid corrosion of polished steel surfaces like roll necks and ensure proper lubrication.
