Lubricants

In all types of machines, the surfaces of moving or sliding or rolling parts rub against each other. Due to mutual rubbing of one part against another, a resistance is offered to their movement. This resistance is known as friction.

Any substance used between two moving/sliding surfaces to reduce the frictional resistance between them is known as a lubricant. The phenomenon of reducing frictional resistance between moving/sliding surfaces by using lubricants is called lubrication. Good lubricants possess the following characteristics:

i. High boiling point
ii. Low freezing point
iii. High viscosity index
iv. Stability to heat at working condition
v. Corrosion preventive
vi. High resistance to oxidation

Functions of Lubricants

Some important functions of lubricants are as follows:

1. It acts as coolant and reduces the loss of energy in the form of heat.
2. It reduces expansion of metal by local frictional heat.
3. It increases efficiency of machine.
4. It reduces unsmooth relative motion of the moving/sliding parts and avoids seizure of moving surfaces.
5. It reduces wearing, tearing and surface deformation.
6. It reduces the maintenance and running cost and increases durability of the machine.
7. It sometimes acts as a seal.

Classification of Lubricants

On the basis of physical state, lubricants can be classified as:

i. Liquid Lubricants or Lubricating Oil
ii. Semi-solid Lubricants or Greases
iii. Solid Lubricants
iv. Emulsions
v. Synthetic Lubricants

Lubricating Oils

It reduces friction and wear between two surfaces by providing a continuous fluid film in between them. Lubricating oils are further classified as:

a. Animal or Vegetable Oils

The oils of vegetable origin such as castor oil, mustard oil, olive oil, palm oil, cotton seed oil and that of animal origin such as whale oil, mutton oil are the most commonly used lubricants. They possess good oiliness due to which surfaces of the machine parts stick together even under high temperatures and heavy loads. However, they are costly, easily oxidized (i.e. get thickened) and hydrolyzed on coming in contact with air. Hence, these lubricants are less in use nowadays.

b. Mineral or Petroleum Oils

Mineral oils are obtained by fractional distillation of crude petroleum oil. The length of the hydrocarbon chains in petroleum oils varies between about 12-50 carbon atoms. The viscosity of petroleum oils depends upon the length of hydrocarbon chains. These are the most widely used lubricants because they are cheap, easily available and quite stable under service conditions. However, crude petroleum oils contain lot of impurities. Therefore, petroleum oils should be well refined before use. Further, they possess poor oiliness as compared to that of animal and vegetable oil. The oiliness properties of petroleum oils can be enhanced by adding vegetable and/or animal oils.

c. Blended or Compound Oils

The characteristics of lubricating oils are improved by adding small quantities of various specific additives. The oils thus prepared are known as blended oils or compounded oils. The blended oils give desired lubricating properties required for machines. The commonly employed special additives are:

Vegetable and animal oils: to increase oiliness characters

Aromatic or amino compounds: to control oxidation

Organic phosphorus compounds: to prevent corrosion

Organic S, Cl and P: to resist extreme pressure

Glycerol: to reduce foam formation

High molecular weight compounds (Hexanol): to improve viscosity index

Semi-solid Lubricants or Greases

Greases are semi-solid lubricants. Greases are prepared by saponification of fat with alkali, followed by adding hot lubricating oil with continuous agitation. Greases have higher shear or frictional resistance than oils and therefore, can support much heavier loads at lower speeds. The main function of soap is thickening of lubricating oil so that grease sticks firmly to the metal surfaces. According to the types of alkali used during saponification, different types of soaps are formed. The nature of soap determines the properties of greases like temperature resistance, oxidation resistance.

USES OF GREASES

i. When a machine is working at slow speed and high pressure
ii. Where oil cannot remain in place due to heavy load, intermittent operation and low speed
iii. In bearing and gears that work at high temperatures
iv. Where bearing needs to be sealed and prevent contamination due to entry of dust, grit or moisture
v. Where dripping or spurting of oil is undesirable

Important greases are:

a. *Calcium based greases*: These greases are prepared by saponification of fatty acids with calcium hydroxide. These greases are cheapest and most commonly used below temperature 80^0C.
b. *Soda based greases*: These greases are prepared by saponification of fatty acids with sodium hydroxide. They are used in ball bearing up to temperature 175^0C. However, they are not water resistant.
c. *Lithium based greases*: They are water resistant and prepared by mixing lubricating oils with lithium soap. These greases are suitable for low temperatures (up to 15^0C).
d. *Axle greases*: They are prepared by adding heavy metal hydroxide into resin and fatty oils. They are water resistant and suitable for less delicate equipments and working under high load at low speeds.

Solid Lubricants

Solid lubricants are used in situations such as:

i. When a liquid or semi-solid lubricant film cannot be help or their presence is undesirable
ii. Contamination of lubricant oil or grease in unacceptable
iii. The operating temperature or load is too high
iv. Combustible lubrication must be avoided

The most commonly employed two solid lubricants are graphite and molybdenum disulphide.

a. GRAPHITE: It is the most widely used solid lubricant. The structure of graphite is responsible for lubricating effect. The carbon atoms in graphite are arranged in regular hexagons in flat parallel layers, and each atom is linked by covalent bonds to three other atoms but its distance from the fourth one is more than the double. This fourth valency bond is not fixed but moves about and hence there is no strong bonding between different layers. Therefore, a sheet of carbon in graphite can slide over another.

The graphite lubricant is very soapy to touch, non-inflammable and not oxidized in air below 375^0C. It is used either in powdered form or as suspension. When graphite is dispersed in water, it is called ***aquadag***. It is useful when a lubricant free from oil is needed e.g. foodstuffs. When the graphite is dispersed in oil, it is called ***oildag***. It is useful in internal combustion engines, because it forms a film between the piston rings and the cylinder and gives tight fit contact, thereby increasing compression.

Uses: As lubricant in air-compressors, general machine-shop works, foodstuffs industry, railway track-joints, internal combustion engines, open gears, chains, etc.

b. MOLYBDENUM DISULPHIDE: This compound has a sandwich like structure, where a layer of Mo atoms lies between two surfaces of Sulphur atoms. The weak force of attraction between the Molybdenum and sulphur layers is responsible for its lubricating effect.

Uses: It possesses very low coefficient of friction and is stable in air up to 400^0C. Its fine powder may be sprinkled on surfaces sliding at high velocities, when it fills low spots in metal surfaces, forming its film. It is also used along with solvents and in greases.

Lubricating Emulsions

During various operations such as milling, threading, boring, the tools get heated to a very high temperature at the cutting edge. This may lead to oxidation and rusting of the metal under work. In order to prevent overheating, emulsion oil droplets in water are employed, which are called cutting emulsions. Oil has good lubricating properties and water is an excellent cooling medium because of its high specific heat and a high heat of vaporization. Hence, combination of two provides both lubricating and cooling effects. There are two types of lubricating emulsions:

a. OIL IN WATER TYPE EMULSIONS (CUTTING EMULSIONS): It is prepared by mixing oil containing about 3-20% of water soluble emulsifying agent (e.g. water soluble soap, alkyl sulfonate and alkyl sulphates) and a suitable quantity of water. These types of emulsions are used as coolant and as lubricant for cutting tools, diesel mortar pistons and large internal combustion engines.
b. WATER IN OIL TYPE EMULSIONS (COOLING EMULSIONS): It is prepared by mixing together water and oil containing 1-10% of water insoluble emulsifiers (e.g. alkaline earth metal soaps).

Synthetic Lubricants

They are oily petroleum based liquids which can be used under abnormal conditions. These lubricants are not found naturally or not produced directly during normal manufacturing and refining process of the petroleum industry. They are designed in such a way which alone can meet the drastic and sever conditions mostly existing in aircraft engines such as chemically reactive atmosphere, high and low temperatures. Modern synthetic lubricants possess the following distinct characteristics:

i. Non-inflammable
ii. High flash points
iii. High thermal stability at high operating temperature
iv. High viscosity index
v. Low freezing point
vi. Chemical stability, etc.

Some examples of synthetic lubricants are:

Polymerized hydrocarbons (polyethylene, polypropylene, etc.) : They are chemically non-reactive and can resist high temperature.

Polyglycols: They have high viscosity index and are used in roller bearing of glass manufacturing machine.

Silicones: They have high viscosity index and high oxidation resistant.

Fluorocarbons: Chemically inert and stable to heat.

Organic amines and amides: They have high viscosity index and can be used in the temperature range of -50^0C to 250^0C.