

## Unit-5

### Lubrication and Lubricants

#### Lubrication:

*Definition:* Lubrication can be defined as the application of some materials between two objects moving relative to each other to allow smooth operation as much as necessary. Either oil or grease is used for rolling bearings to prevent noise, wear and tear, and heat from being generated from their rolling and sliding movements, and in some special cases, solid lubricants are occasionally used.

The amounts and kinds of lubricants for rolling bearings are determined depending on operation speed, temperature, and surrounding condition, and so on. Because lubricants have spent their service-life or polluted with foreign materials, they cannot serve their function well hence they have to be periodically replaced or oiled.

#### Purpose of Lubrication:

The main purposes of lubrication are as follows:

1. To prevent wear and premature fatigue by forming the lubrication film on the surface of load transferring parts to prevent contacts between metals.
2. To enhance the favourable driving characteristics, such as low noise or friction.
3. To prevent overheating of bearings and to prevent lubricants deterioration by radiating the generated heat to outside. It works particularly well if the circulation lubrication method is adopted.
4. To prevent foreign material penetration, rust, and corrosion.

#### Lubricants:

*Definition:* In all types of machines, the surfaces of moving or sliding or rolling parts rub against each other. Due to the mutual rubbing of one part against another, a resistance is offered to their movement. This resistance is known as friction. It causes a lot of wear and tear of surfaces of moving parts. Any substance introduced between two moving/sliding surfaces with a view to reduce the friction (or frictional resistance)

between them, is known as a lubricant. The main purpose of a lubricant is to keep the moving/sliding surfaces apart, so that friction and consequent destruction of material is minimized.

### **Classification of Lubricants:**

Lubricants are classified on the basis of their physical state, as follows;

- (a) Liquid lubricants or Lubricating Oils,
- (b) Semi-solid lubricants or Greases and
- (c) Solid lubricants.

#### **(a) Liquid lubricants or Lubricating oils:**

Lubricating oils also known as liquid lubricants and further classified into three categories;

- (i) Animal and Vegetables oils,
- (ii) Mineral or Petroleum oils and
- (iii) Blended oils.

##### **(i) Animal and Vegetables oils:**

Animal oils are extracted from the crude fat and vegetables oils such as cotton seed oil and castor oils. These oils possess good oiliness and hence they can stick on metal surfaces effectively even under elevated temperatures and heavy loads. But they suffer from the disadvantages that they are costly, undergo easy oxidation to give gummy products and hydrolyze easily on contact with moist air or water. Hence they are only rarely used these days for lubrication. But they are still used as blending agents in petroleum based lubricants to get improved oiliness.

##### **(ii) Mineral or Petroleum oils:**

These are basically lower molecular weight hydrocarbons with about 12 to 50 carbon atoms. As they are cheap, available in abundance and stable under service conditions, hence they are widely used. But the oiliness of mineral oils is less, so the addition of higher molecular weight compounds like oleic acid and stearic acid increases the oiliness of mineral oil.

(iii) Blended oils:

No single oil possesses all the properties required for a good lubricant and hence addition of proper additives is essential to make them perform well. Such additives added lubricating oils are called blended oils. Examples: The addition of higher molecular weight compounds like oleic acid, stearic acid, palmitic acid, etc or vegetable oil like coconut oil, castor oil, etc increases the oiliness of mineral oil.

**(b) Semi-solid Lubricants or Grease:**

A semi-solid lubricant obtained by combining lubricating oil with thickening agents is termed as grease. Lubricating oil is the principal component and it can be either petroleum oil or a synthetic hydrocarbon of low to high viscosity. The thickeners consist primarily of special soaps of Li, Na, Ca, Ba, Al, etc. Non-soap thickeners include carbon black, silica gel, polyureas and other synthetic polymers, clays, etc. Grease can support much heavier load at lower speed. Internal resistance of grease is much higher than that of lubricating oils; therefore, it is better to use oil instead of grease. Compared to lubricating oils, grease cannot effectively dissipate heat from the bearings, so work at relatively lower temperature.

**(c) Solid lubricants:**

They are preferred where

- (1) The operating conditions are such that a lubricating film cannot be secured by the use of lubricating oils or grease
- (2) Contamination (by the entry of dust particles) of lubricating oils or grease is unacceptable
- (3) The operating temperature or load is too high, even for grease to remain in position and
- (4) Combustible lubricants must be avoided. They are used either in the dry powder form or with binders to make them stick firmly to the metal surfaces while in use. They are available as dispersions in non-volatile carriers like soaps, fats, waxes etc and as soft metal films. The most common solid lubricants are graphite, molybdenum disulphide, tungsten disulphide and zinc oxide. They can withstand temperature up to 650° C and can be applied in continuously operating situations. They are also

used as additives to mineral oils and greases in order to increase the load carrying capacity of the lubricant. Other solid lubricants in use are soapstone (talc) and mica.

### **Graphite:**

It is the most widely used of all the solid lubricants and can be used either in the powdered form or in suspension. It is soapy to touch; non-inflammable and stable up to a temperature of 375° C. Graphite has a flat plate like structure and the layers of graphite sheets are arranged one above the other and held together by weak Vander Waal's forces. These parallel layers which can easily slide one over other make graphite an effective lubricant. Also the layer of graphite has a tendency to absorb oil and to be wetted of it. Molybdenum Disulphide: It has a sandwich- like structure with a layer of molybdenum atoms in between two layers of sulphur atoms. Poor inter-laminar attraction helps these layers to slide over one another easily. It is stable up to a temperature of 400° C.

### **Characteristic of good lubricating oils:**

- (1) High boiling point
- (2) Low freezing point
- (3) Adequate viscosity for proper functioning in service
- (4) High resistance to oxidation and heat
- (5) Non-corrosive properties and
- (6) Stability to decomposition at the operating temperatures.

### **Function of Lubricants:**

- (1) It reduces wear and tear of the surfaces by avoiding direct metal to metal contact between the rubbing surfaces, i.e. by introducing lubricants between the two surfaces.
- (2) It reduces expansion of metal due to frictional heat and destruction of material.
- (3) It acts as coolant of metal due to heat transfer media.
- (4) It avoids unsmooth relative motion.
- (5) It reduces maintenance cost.
- (6) It also reduces power loss in internal combustion engines.

### **Mechanism of Lubrication:**

The phenomenon of lubrication can be explained with the help of the following mechanism;

- (a) Thick-Film lubrication (Fluid-Film or hydrodynamic lubrication)
- (b) Thin Film lubrication (Boundary lubrication) and
- (c) Extreme Pressure lubrication

#### **(a) Thick-Film lubrication:**

In this, moving/sliding surfaces are separated from each other by a thick film of fluid, so that direct surface to surface contact and welding of junctions rarely occurs. The lubricant film covers/fills the irregularities of moving/sliding surfaces and forms a thick layer between them, so that there is no direct contact between the material surfaces. This consequently reduces friction. The lubricant chosen should have the minimum viscosity (to reduce the internal resistance between the particles of the lubricant) under working conditions and at the same time, it should remain in place and separate the surfaces. Hydrocarbon oils are considered to be satisfactory lubricants for thick-film lubrication. In order to maintain the viscosity of the oil in all seasons of year, ordinary hydrocarbon lubricants are blended with selected long chain polymers.

#### **(b) Thin Film lubrication:**

This type of lubrication is preferred where a continuous film of lubricant cannot persist. In such cases, the clearance space between the moving/sliding surfaces is lubricated by such a material which can get adsorbed on both the metallic surfaces by either physical or chemical forces. This adsorbed film helps to keep the metal surfaces away from each other at least up to the height of the peaks present on the surface. Vegetable and animal oils and their soaps can be used in this type of lubrication because they can get either physically adsorbed or chemically react in to the metal surface to form a thin film of metallic soap which can act as lubricant. Although these oils have good oiliness, they suffer from the disadvantage that they will break down at high temperatures. On

the other hand, mineral oils are thermally stable and the addition of vegetable/animal oils to mineral oils, their oiliness can also be brought up. Graphite and molybdenum disulphide are also suitable for thin film lubrication.

**(c) Extreme Pressure lubrication:**

When the moving/sliding surfaces are under very high pressure and speed, a high local temperature is attained under such conditions, liquid lubricants fail to stick and may decompose and even vaporize. To meet these extreme pressure conditions, special additives are added to mineral oils. These are called extreme pressure additives. These additives form more durable films (capable of withstanding very high loads and high temperatures) on metal surfaces. Important additives are organic compounds having active radicals or groups such as chlorine (as in chlorinated esters), sulphur (as in sulphurized oils) or phosphorus (as in tricresylphosphate). These compounds react with metallic surfaces, at existing high temperatures, to form metallic chlorides, sulphides or phosphides.

**What is lubricating emulsion?**

An emulsion is a two phase system which consists of two immiscible liquid (such as oil and water), the one being dispersed in other. Out of two liquids, one which is broken into droplet is called as dispersed phase whereas the other liquid-liquid surrounding the internal phase is called dispersion medium or external phase, such a system of two immiscible liquids is very unstable and separates out into a different phase.

So to increase the stability, the emulsifier is added. The emulsifier molecules like sodium palmitate shown polar character. It consists of hydrophilic and hydrophobic ends which are preferably wetted by water and oil respectively. Thus emulsifier molecule is absorbed and places itself at the interface of two phases namely oil and water forming an intermediate layer in between two phases.

**Conditions where lubricating emulsions are used:**

These are used in various jobs like milling, threading etc. The tool at the cutting edge experiences very high pressure and temperature. They

may result in oxidation and deformation of metal under work. Hence to prevent overheating of metal and tools proper lubricating and cooling as done by lubricating emulsion. Oils are coolant but lubricant whereas water is good coolant but a poor lubricant.

### **Advantages of Emulsion**

- It increases the life of machining tools.
- It reduces power requirement
- It maintains higher machining speed.
- It increases the accuracy of machining of metals and reduces its cost.

**The Emulsion is further classified as:**

#### **Oil-in water:**

Oil is the dispersed phase and water is dispersing medium. It is prepared by mixing oil and water along with 3% to 20% of water-soluble emulsifiers like water soluble soaps alkyl etc. E.g. cutting fluids.

#### **Water-in oil:**

Water is dispersed by mixing water and oil along with 1% to 10% of water insoluble emulsifiers like alkaline earth metal soaps etc. cooling liquids.