UNIT 6 LUBRICANTS

Structure

6.1 INTRODUCTION

It is very common that almost all the material surfaces – harder or softer – possess many irregularities in the form of peaks (or asperities) and valleys which are large in numbers when considered on molecular scale. Therefore, when two solid surfaces come in contact with each other, the real contact takes place at some points only between peaks of upper surface with the lower surface peaks. If we keep these surfaces under small load, the local pressure at the peaks may cause sufficient deformation in ductile metals. It is known as the weed junction which carries all the load between two surfaces. In this way, true contact area is very small fraction of the apparent contact area between the two surfaces.

As we know that the friction is the resistance towards the movement of two surfaces. Generally, two types of frictions occur : (a) Sliding Friction and (b) Rolling Friction.

(a) **Sliding Friction**

When two materials of different hardness slide over one another, the peaks of the softer metal get deformed or broken easily than the peaks of the harder metals (Figure 6.1). Besides this phenomenon, some more additional effects are also observed:

(i) Ploughing which is cutting out softer material by the peaks of the harder material.

(ii) The interlocking of surface irregularities.

Figure 6.1 : Surface Wearing during Sliding

(b) **Rolling Friction**

It occurs when a load sphere or cylinder rolls over a flat surface of the other body. The coefficient of rolling friction is very low as compared to sliding friction. Rolling friction is caused by elastic deformation of two surfaces as a result of the development of a contact area between a loaded area and flat surface. In this way, sliding friction is associated with much larger coefficient of friction in static condition than for the kinetic condition. In view of these facts, the lubricants play important role in sliding friction than rolling friction.

Due to friction, a considerable amount of heat is generated at the rubbing surfaces which is known as *frictional heat* which is more in case of sliding friction. It is non-uniformly distributed over the rubbing surfaces and is localized particularly at surface peaks. The magnitude of the frictional heat depends on the nature of material and sliding speed. When this frictional heat reaches the melting temperature of the material, welded junction may be formed.

Objectives

After studying this unit, you should be able to:

- define a lubricant,
- explain the need of a lubricant,
- state the types of lubrication,
- list the types of lubricants,
- explain the uses of solid, semisolid, liquid and gases as lubricants,
- discuss synthetic lubricants,
- explain lubricants properties like viscosity, viscosity index, flash and fire point, cloud and pour point, volatility, oxidation stability, corrosion resistance and carbon residue etc.,
- explain the determination of some properties, and

- give the criteria of selection of lubricants etc.

6.2 LUBRICANTS

In all type of machines, the surfaces of moving (sliding or rolling) parts rub each other. Due to this rubbing of one part against another, a resistance arises to their movement. This resistance is said to be **friction** which causes a lot of wear and tear of moving parts and a large amount of energy is dissipated in the form of heat. This dissipated heat decreases the efficiency of machines.

A substance which is introduced between these two moving surfaces to reduce the friction and wear and tear is said to be a **lubricant**. The process by virtue of which the frictional resistance and wear and tear is reduced is called **lubrication**. The lubricants exhibit the following functions :

6.2.1 Functions of a Lubricant

(i) It reduces the surface deformation and wear and tear.

(ii) It reduces the loss of energy in the form of heat. In this way, it acts as a coolant.

(iii) It increases the efficiency of machines.

(iv) It reduces the maintenance cost of machines.

(v) It helps in getting smooth motion of moving parts.

(vi) It reduces the expansion of metal by local heating and hence it avoids the seizure of moving parts.

(vii) In internal combustion (IC) engines, it acts as a seal by sealing the piston and cylinder wall at the compression rings. In this way, it avoids the leakage of gases at high pressure in IC engines.

SAQ 1

(a) Define a lubricant.

(b) A lubricant is used to prevent

(i) oxidation of metal

(ii) reduction of metal

(iii) wearing out of rubbing metal surfaces

(iv) corrosion of metals.

6.3 LUBRICATION

The lubricant does not permit the direct contact between the two rubbing surfaces. Therefore, the injuries to the surfaces due to seizure and wear are reduced.

Basically there are three types of mechanisms of lubrications

(i) Fluid Film or Thick Film or Hydrodynamic Lubrication

(ii) Thin Film or Boundary Lubrication

(iii) Extreme Pressure Lubrication

Fluid Film or Thick Film or Hydrodynamic Lubrication

In this case, the moving or sliding surfaces are separated from each other by thick film of fluid. The thickness of the film is believed to be at least 1000 $\overset{o}{A}$. This fluid film does not allow surface to surface contact. The lubricant film covers the irregularities of the sliding/moving surfaces and forms a thick layer between them, so that there is no direct contact between the material surfaces (Figure 6.2).

Figure 6.2 : Fluid Film Lubrication

Thin Film or Boundary Lubrication

Thin film lubrication is done when a thick fluid film cannot be maintained between the two moving surfaces so that direct metal to metal contact is possible. This happens when

(i) the load is very high, or

(ii) a shaft starts from moving, or

(iii) the speed is very low, or

(iv) the viscosity of the oil is quite low.

Under such circumstances, the lubricant should be adsorbed physically or chemically on both the metallic surfaces. These adsorbed layers help in avoiding direct metal to metal contact. The load is carried by the layers of adsorbed lubricant on both the metal surfaces. The coefficient of friction in this case in usually low (Figure 6.3).

Figure 6.3 : Boundary Lubrication

Extreme Pressure Lubrication

When the moving surfaces/sliding surfaces are under very high pressure and speed, a high temperature gets generated locally. Under such circumstances, oil lubricants fail to stick, may decompose or even vaporize. To meet these extreme pressure conditions, some additives are required to be added to mineral oils. These additives are said to be *extreme pressure additives*.

These additives make more durable film on metal surfaces. These films are capable of withstanding very high loads as well as high temperatures.

6.4 SELECTION OF LUBRICANTS

The selection of lubricants is carried out on the basis of mechanism of lubrication.

Fluid film or Thick Film or Hydrodynamic Lubrication-Lubricants

To maintain suitable viscosity of oils, ordinary hydrocarbon lubricants are blended with long chain polymers. Hydrocarbon petroleum fractions which contain small quantities of unsaturated hydrocarbons get oxidized to form gummy products. To reduce the oxidation, antioxidants like amino phenols are added.

Thin Film or Boundary Lubrication-Lubricants

The lubricants used for thin film lubrication should possess following qualities :

(i) They should possess active groups to make chemical bond with metallic surfaces.

(ii) They should possess polar groups to facilitate spreading or orientation over the metallic surfaces at high pressure.

(iii) They should possess long hydrocarbon chains.

(iv) They should be capable of lateral attraction between the chains.

The vegetable and animal oils have all aforesaid qualities of lubricants. These get adsorbed physically or chemically on the metal surface easily with the active COOH-group. To increase the oiliness of the mineral oils, in general, a small quantity of fatty acids is added.

Extreme Pressure Lubrication-Lubricants

To meet extreme pressure lubricant conditions, some special additives or extreme pressure additives are added to oils to form more durable forms on the metal surfaces capable of withstanding very high loads and high temperatures. These special additives are organic compounds having active radicals or groups such as chlorine (as in chlorinated esters), phosphorus (as in tricresyl phosphate) or sulphur (as in sulphurized oils). These organic compounds react with metallic surfaces at prevailing high temperatures to form metallic chlorides phosphates or sulphides. These metallic compounds possess high meting points and have capability to serve as good lubricants under extreme pressure and extreme temperature conditions. If by the way in any instance, the low shear strength films get broken by the rubbing action of moving parts, they are easily replenished.

6.5 CLASSIFICATION OF LUBRICANTS

On the basis of their physical state, lubricants are classified as follow :

(i) Liquid Lubricants or Lubricating oils

(ii) Semi-solid lubricants or greases

(iii) Solid lubricants

6.5.1 Liquid Lubricants or Lubricating Oils

Lubricating oils decrease the friction and wear between two sliding and moving metallic surfaces. These oils also act as cooling medium, sealing agent and corrosion preventer. Lubricating oils must possess adequate viscosity, low freezing point, high boiling point, high oxidation resistance and non corrosive properties. These are further classified as follows :

- **Vegetable and Animal Oils**

  The oils of the vegetable and animal origin were used as lubricants. They possess good oiliness. They are such as rapeseed oil, castor oil, sperm oil, rosin oil, olive oil, coconut oil and palm oil etc.

- **Mineral or Petroleum Oils**

  These are obtained by distillation of petroleum. The number of carbon atoms in their chains varies from 12 to 50. The shorter number carbon atoms chain oils exhibit low viscosity than longer chain oils. These oils possess low oiliness.

  Sometimes minerals oils compounded with fatty oils have been used as lubricating oils. These are said to be blended oils.

6.5.2 Semi-solid Lubricants or Greases

The semi-solid lubricants are greases and Vaseline. These are obtained by the dispersion of soap along with some specific additives in lubricating oils.

The amount of mineral oil present in these semi solid lubricants determines the consistency. The added soaps act as gelling agents which interconnect the oils. Overall the greases behave like gels. To get more heat-resistant greases, some thickening agents like colloidal silica, clay or carbon black etc. are added. These greases have some merits as well as demerits also.

Merits

(i) Due to the presence of soap in oils, these stick well on the surfaces.

(ii) Grease can support heavier load at low speed.

(iii) Greases can be used in machinery parts i.e. bearing and gears that work at high temperatures.

(iv) Greases exhibit higher frictional resistance than oils.

(v) Greases can be used in situations where sealing is required against entry of dust, dirt or grit etc.

(vi) These require less attention than oils.

Demerits

(i) Due to gelling in nature, these are unable to dissipate heat from the bearings as oils.

(ii) Greases have tendency to get separate into oils and soaps.

(iii) On longer use, the oil may get evaporated from greases.

(iv) Greases have high coefficient of friction.

The greases are further classified on the basis of the soaps used in their preparations like sodium soap, lithium soap, calcium soap or aluminum soap greases.

6.5.3 Solid Lubricants

The two solid lubricants are usually in practice. These are graphite and molybdenum disulphide. These are used either in powdered form (dry state) or mixed with water or oil. These solid lubricants fill up the low spots in the surfaces of moving/sliding parts and form a solid film which exhibits low frictional resistance. The coefficient of friction between solid lubricants is between 0.005 and 0.01. The following are the merits of solid lubricants.

Merits of Solid Lubricants

(i) These can be used where operating temperature is high.

(ii) These can be used where load is high and even semi-solid lubricant cannot sustain.

(iii) These can be used where the contamination (by the entry of dust or grit or clay particles) of greases or lubricating oils is unacceptable, for example, in commutator bushes of electric generators and motors.

(iv) These can be used where the operating conditions are such that a lubricating film cannot be sustained with lubricating oils or greases.

(v) These can be used in a situation where combustible lubricants must be avoided.

Some more details of these lubricants are as follows :

Graphite

It consists of a multitude of flat plates, one atom thick which are held together by weak bonds. In graphite, the carbon atoms are arranged in hexagons in several flat layers which are held together by weak bond so that the force to shear the crystals parallel to the layers is low (Figure 6.4).

Figure 6.4 : Graphite Lubricant Structure

It is very soapy to touch, non inflammable and not oxidized in air upto 375^{o}C. It has its decency that in the absence of air, it can be used upto high temperatures. It is used either as dry powder or as suspension. The suspension of graphite in water or in oil is obtained with the use of emulsifying agent like tannin. When graphite is suspended in water, the suspension is known as aquadag while in oil it is known as oil dag. Oil dag is quite useful in internal combustion (IC) engines because it forms a film between the piston rings and cylinder and makes available a tight fit contact which helps in getting high compressions for the system. Aquadag is useful especially in food industries where a lubricant free from oil is required.

Graphite in fine powder form is also added to some greases to obtain Graphite greases which are used at high temperatures.

The graphite as lubricant is specially used in cast iron bearings, IC engines, air compressors, food industries, lathes, general machines work shops and in railway track joints etc.

Molybdenum Disulphide

It has a sandwitch like structure (Figure 6.5). It is clear from the figure that a layer of Mo atoms lies between two layers of S atoms. In case of molybdenum sulphide, the poor interlaminar attraction causes low shear strength in a direction parallel to the layers. It exhibits very low coefficient of friction. It is stable in the presence of air upto 400^oC temperature. Molybdenum sulphide in powder form is spread over the surfaces sliding at high velocities, when it fills low spots in metal surfaces forming its film. It is used as dry powder, aquadag, oildag or as greases. A recipe obtained from 70% molybdenum disulphide, 23% alkali/alkaline silicates and 7% graphite at very high temperature acts as a lubricant and hence it is used in space vehicles.

Figure 6.5 : Sandwitch Structure of Molybdenum Sulphide

The other substances like soap stone, talc, mica and teflon are also used as solid lubricants.

6.5.4 Synthetic Lubricants

Synthetic lubricants have been developed to meet the most drastic and sever conditions such as existing in aircraft engine where the same lubricant has to be used in the temperature range of -50^oC to 260^oC. These lubricants possess low freezing point, high viscosity index and non-inflammability. Synthetic lubricants show following characteristics also :

(i) High thermal stability

(ii) High chemical stability

(iii) High flash points

Some of the important synthetic lubricants are described below.

(i) **Silicones**

These are very good synthetic lubricants because these are not oxidized upto 200^{o}C. These possess high viscosity index also. Silicones undergo oxidation rapidly above 200^{o}C and start cracking onwards 230^{o}C. Therefore, these are not advised to be employed onwards 200^{o}C operating conditions

(ii) **Polyglycols**

Polyethylene glycol, polypropylene glycol, polyglycidal ethers and higher polyalkylene oxides etc. can be used as water soluble and water insoluble lubricants in rubber bearing and joints. They fulfill all the above mentioned characteristics.

(iii) **Chlorinated and Fluorinated Hydrocarbons**

These hydrocarbons show very good chemical resistance, thermal resistance as well as oxidation resistance.

(iv) **Polymer Hydrocarbons**

These are like polyethylene, polypropylene and polybutylene etc. (weight average molecular weight upto 50,000). Polymer hydrocarbons are residue free, chemically inert and thermally stable lubricants which do not possess non-carbon impurities therein.

(v) **Organic Amines and Imines**

These exhibit low pour points and high viscosity index. Organic amines and imines are good lubricants which can be used in the temperature range of 50^{o}C to 250^{o}C.

SAQ 2

(a) Enlist two solid lubricants.

(b) Give two merits of semisolid lubricants.

(c) What are two main classes of lubricating oils?

6.6 LUBRICATING EMULSIONS

As we know that a dispersion system consisting of two immiscible liquids is said to be an emulsion which is stabilized with the help of third agent called *emulsifying agent*. Emulsifying agents or emulsifiers are soap, detergents and sulfonic acids etc. Emulsifying agents contain polar as well as non-polar groups or in other words we can say they contain hydrophobic as well as hydrophobic groups. The hydrophobic end group (water hating) of emulsifying agent molecule is wetted by oil and hydrophilic end group (water loving) is wetted by water. In this way, emulsifier molecule gets adsorbed at the interface of two immiscible phases or liquids (water and oil) resulting in the formation of protective film around the dispersed droplets. These emulsions can be understood in better way with the help of well known example of sodium soap as an emulsifying agent a long chain fatty acid sodium soap, e.g. sodium palmitate hating group $C_{15}H_{31}COONa$. It possesses hydrophilic or water loving group - COONa and hydrophobic or water hating group $C_{15}H_{13}$.There are two types of emulsions, e.g. oil in water emulsions and water in oil emulsions.

(i) **Oil in Water Emulsions**

These are obtained by adding an oil to a required quantity of water in the presence of 3-20% water soluble emulsifying agent such as sodium soap, potassium soap or sodium/potassium salts of sulfonic acid. These emulsions are used as cooling and lubricating liquids for cutting tools, rust prohibitors as well as used as lubricants for heavy sliding components such as pistons in marine diesel engines.

(ii) **Water in Oil Emulsions**

These are obtained by adding water to a required quantity of oil in the presence of 1-10% water soluble emulsifier such as alkaline earth soap, e.g. calcium stearate to the oil. These emulsions are generally used as lubricants in compressors where they provide cooling effect because of evaporation of water.

6.7 GASES AS LUBRICANTS

With the result of recent developments, gases have also been used as lubricants in precious spindles, compressors, fans etc. The viscosity of a gas is not only low but also is independent of temperature and pressure. There is almost no contamination with the use of a gas as lubricant.

6.8 PROPERTIES OF LUBRICANTS

One must be aware of the characteristics of a lubricant to assess its suitability for a particular use. The following are the important properties which help in the assessment.

6.8.1 Viscosity and Viscosity Index

Viscosity

It is the most important single property of any lubricating oil because it is the main dominating property related to the operating conditions.

Viscosity is the property of a fluid or liquid. It represents the resistance to its own flow or it is understood in terms of internal friction between layers of fluid as they pass over each other when moving with different velocities. When a liquid is flowing over a fixed horizontal surface, its layer in contact with surface is stationary and the with increase in the distance from horizontal surface to the centre of liquid flow, the velocity of liquid layers increases and it is maximum at the centre. Now consider two layers of liquid separated by a distance *d* and moving with a velocity difference υ, then the force per unit area (*F*) required to maintain this velocity difference is

$$F = \eta \frac{\upsilon}{d}$$

(The relation is applicable when the flow is laminar and steady only.)

where η (eta) is a constant characteristic of fluid/liquid and is called coefficient of viscosity. If υ = 1 cm/s (1 unit), *d* = 1 cm (1 unit) then *f* = η. In this way, coefficient of viscosity may be defined as the force per unit area required to maintain a unit velocity gradient (i.e. velocity difference of 1 unit between two fluid/liquid layers which are unit distance apart) between two parallel layers. When a force of 1 dyne is required to maintain a relative velocity difference 1 cm/s between two parallel layers 1 cm apart, the coefficient of viscosity is 1poise. Another smaller unit of viscosity is centipoise which is equal to 1/100 poise. If viscosity of the lubricating oil is quite low, the oil film cannot be maintained between the two moving/sliding surfaces because excessive wear will take place. On the other hand, if viscosity of lubricating oil is quite high, excessive friction will result.

Viscosity Index

It is very much common to all of us that the viscosity of liquids decreases with rise in temperature as a result the oil becomes thinner as the operating temperature increases but for good lubricating oil viscosity should not change much with rise in temperature so that it can be used within temperature variations. The viscosity change with temperature variation is measured by an arbitrary scale known as Viscosity Index (V.I). If viscosity of an oil decreases drastically as the temperature is raised, the oil possesses low Viscosity Index while on the other hand if viscosity of an oil decreases lightly with rise in temperature, the oil is of high viscosity index. The viscosity index of a lubricating oil can also be expressed with the average slope of viscosity temperature curve between 100°F (38°C) to 210°F (99°C). Hence, Viscosity Index is a measure of rate at which the viscosity of an oil changes with temperature (Figure 6.6).

Figure 6.6 : Viscosity Vs Temperature Curve

Measurement of Viscosity Index (VI)

To find out the Viscosity Index of an oil, the viscosity of an oil is measured between 100°F and 210°F. For this purpose, two types of standard oils are used.

(ii) Paraffinic base Pennsylvanian oils (V. I. = 100) and

(iii) Naphthanic base Gulf oils (V. I. = 0).

Paraffinic base oils exhibit small change in viscosity with rise in temperature while naphthanic base oils exhibit large change in viscosity with the rise in temperature. Paraffinic and napthanic base oils are known as H oils and L oils, respectively. The viscosity of the oil under test is represented by U.

The viscosity index of the oil under test is given

$$V.I. = \frac{L - U}{L - R} \times 100$$

where,

U = viscosity of the oil under test,

L = viscosity at 100^{o}F of Gulf oil (Naphthanic base oil), and

H = viscosity at 100^{o}F of Pennsylvanian oil (Paraffinic base oil).

Viscosity measurements are based on time in seconds for a given quantity of an oil to pass through a standard orifice under a given set of conditions. The viscosity of lubricating oil is determined by Redwood (UK) or Saybolt (USA). In UK, the time required for 50 ml of liquid to flow through an orifice of a Redwood viscometer (Figure 6.7) is expressed in Redwood seconds.

Figure 6.7 : Red Wood Viscometer

On the other hand in USA, the time required for 60 ml of the liquid to flow through an orifice in a Saybolt Viscometer is known as Saybolt universal seconds. Redwood viscometer is commonly used to determine the viscosity. It consists of an oil cup, a heating bath, Kohlarausch flask, levelling screws, spirit level and a stirrer.

The oil cup is a silver coated brass cylinder (90 mm height and 46.5 mm in diameter) with an open upper end. The bottom part of the cylinder is fitted with an agate jet of bore diameter 1.62 mm and length 10 mm. This jet is opened by a valve rod which is silver plated brass ball fixed to a stout wire. The level to which the cylinder is filled with the oil is shown by a pointer. The thermometer is there to measure the temperature of the oil, it is fitted with the lid of the cup. The oil cup is surrounded by a water bath made of copper. There is arrangement for siphoning off water as well as for heating the bath by gas burner. The stirrer is present outside the cylinder. It is provided with a circular shield at the tope to avoid the mixing of water into oil. The apparatus rests on three legs provided with levelling screws at the bottom. There is a 50 ml Kohlausch flask (special in shape) meant to get the oil from the jet outlet.

The levelling of oil cup is done and the valve rod is placed on the agate to close it. The oil under test must be free from all suspension and other impurities, is filled in the cup upto the mark. The Kohlausch flask (empty one) is placed below the jar. The water bath is heated gradually with constant stirring of the bath. When the oil attains the desired temperature, the ball valve is lifted and suspended from the thermometer bracket. In this way, the time required for 50 ml of the oil to collect in the flask is noted and the value is immediately replaced to prevent any overflow of the oil.

The result of this observation is expressed in Redwood No. 1 seconds at the particular temperature. In general, Redwood viscometer No. 1 is in common practice to determine the viscosity of thin lubricating oils while the viscosity of viscous oils is determined with the help of Redwood viscometer No. 2 which has the jet bore diameter 3.8 mm and length 15 mm.

6.8.2 Flash Point and Fire Point

These two points were considered to assess the volatile nature (volatility) of an oil which pertains to its consumption in Internal Combustion (IC) Engines.

The *flash point* of an oil is the lowest temperature at which sufficient vapours are given off by an oil to cause a momentary flash as the vapours come in contact with a test flame while the *fire point* is the lowest temperature at which the vapours of the oil burn continuously for at least five seconds when vapours come in contact with a test flame. In general, the fire points are higher than flash points by 4 to 50^o. Although these points have no direct relevance on the properties of lubricant but a good lubricant should have flash point at least above its working temperature. These two points act as safeguards against risk of fire during the use of lubricants. The flash and fire points are usually determined by using Penskey-Martan's apparatus (Figure 6.8).

Figure 6.8 : Penskey-Marten's Apparatus

The apparatus consists of an oil cup, shutter, flame exposure device, pilot burner and air bath. The oil under test is filled upto the mark in the oil cup and then heated by heating the air bath by a burner. The heat is provided so as to raise the oil temperature by about 5^oC per minute. At every 1^oC rise of temperature, the test flame is introduced for a moment with the help of shutter. The temperature at which a distinct (visible) flash appears inside the cup is noted as the flash point of the oil. The heating is continued thereafter. The test flame is introduced as before when the oil ignites and continues to burn for at least 5 seconds, the temperature is noted as fire point of the oil.

6.8.3 Cloud and Pour Points

These two points also help in the assessment of an oil for lubricating purpose. When an oil is allowed to cool slowly the temperature at which it appears cloudy is called its *cloud point* while the temperature at which it ceases to flow is called its *pour point*. Cloud and pour points indicate its suitability in cold conditions because the machines working in cold conditions need lubricant of low pour point so that the jamming of machines could be avoided.

The pour point of lubricating oil is determined with the help of apparatus shown in Figure 6.9. It consists of a flat bottomed tube enclosed in an air jacket which is surrounded a freezing mixture. The tube is nearly half filled with the oil. A thermometer is placed in oil. Due to the cooling of oil, the temperature decreases slowly. With every degree fall of temperature of the oil, the tube is taken out from the air jacket for a moment (about 2-3 seconds) and oil condition is observed. It is placed therein immediately. The temperature at which cloudiness is observed is noted as cloud point. Onwards this observation, cooling is continued and the test tube is taken out after every $3^{o}C$ fall temperature and it tilted to observe the flow or pour of oil. The temperature at which oil ceases to flow in test tube, even on keeping test tube in horizontal position for 5 sec, is noted as the pour point of the oil.

Figure 6.9 : Cloud and Pour Point Apparatus

6.8.4 Carbon Residue

It is useful for IC engines. To determine the carbon residue, a definite amount of an oil sample is allowed to evaporate and pyrolyse under prescribed set of conditions. After pyrolysis, the carbonaceous residue left behind is expressed as % by weight of the sample. A good lubricant should deposit least carbon residue.

6.8.5 Aniline Point

The miscibility of an oil with aniline is the *aniline point*. It indicates the aromatic content. It is defined as the lowest temperature at which oil is totally miscible with an equal volume of freshly distilled aniline. The aniline point is inversely related to the aromatic content of the oil. As we are aware that aromatic hydrocarbons have tendency to dissolve natural as well as some synthetic rubbers, therefore, the oil with low aromatic content is good for lubrication.

It is determined by mixing equal volume of an oil sample and aniline in a test tube which is heated until homogeneous solution is formed. The test tube is allowed to cool at a controlled rate. The temperature at which the two phases get separated distinctly is noted as the aniline point.

6.8.6 Volatility

It is very much required in case of heavy machinery working at high temperature. Due to high temperature, a portion of the lubricating oil gets vapourised and residual portion of oil exhibits different lubricating properties. Hence, for a good lubricant, low volatility is desirable.

6.8.7 Oiliness

The oiliness is an important property of the oil specially for extreme pressure lubrication. The oils of vegetable origin have greater oiliness than oils of mineral origin.

6.8.8 Emulsification

The tendency (ability) of an oil to form emulsion with water immediately is known as *emulsification*. These water-oil emulsions are capable of gathering dirt, dust and other impurities, thus causing an abrasion and wearing out of lubricated parts of the machinery. Easily emulsion forming oil is considered a good lubricant. The tendency of an oil-water emulsion to break off is known as "Steam-Emulsion Number" (SEN). An oil possessing low SEN is a good lubricant.

6.8.9 Decomposition Stability

The lubricants must be stable towards decomposition which may occur due to oxidation, pyrolysis and hydrolysis. To prevent oxidation, some anti-oxidant additives are added. The harmful effects of oxidation may also be avoided by filtration or by changing the oil at regular intervals.

6.8.10 Corrosion Stability

A good lubricant exhibits corrosion stability which can be determined with a corrosion test. To perform this test, a polished copper strip is dipped in the lubricating oil for a definite time at particular temperature. If there is any change in polish or tarnishing of copper strip, it is guessed that oil contains some chemically active substance. A good lubricant has no effect on the strip. To inhibit this effect, organic compounds of Pb, Sb, Bi, As or P can be added.

SAQ 3

(a) The most important property of lubricating oil is its

- (i) oiliness
- (ii) oxidation stability
- (iii) viscosity Index
- (iv) cloud point

(b) The oiliness is least in case of a

- (i) vegetable oil
- (ii) mineral oil
- (iii) palm oil
- (iv) grease

6.9 SUMMARY

Lubricants are important as they play very good role in the functioning as well as maintenance of machines which are associated with sliding friction or rolling friction. One has to select the lubricant after assessing the operating conditions and knowing the characteristics parameters of lubricants. The property of lubricants can be improved by the addition of special additives, i.e. corrosion inhibitors, and antioxidants etc. Finally, one has to be vigilant on the conditions of lubricants which gather dirt, impurities and attain gummy condition either on account of oxidation, hydrolysis or decomposition etc. In such a situation, the periodically change of lubricant with fresh lubricant is suggested.

6.10 ANSWERS TO SAQs

SAQ 1

(a) A substance introduced between moving surfaces to reduce friction and wear and tear.

(b) (iii) Wearing out of rubbing metal surfaces.

SAQ 2

(a) Graphite and molybdenum disulphide.

(b) Refer to Sub-section 6.5.2.

(c) (i) Vegetable and Animal oils.

(ii) Mineral or Petroleum oils.

SAQ 3

(a) (iii) Viscosity Index.

(b) (ii) Mineral oil.