Defination :

A substance which is capable of reducing friction between two surfaces which are moving/ sliding over each other is called Lubricant.

The process of prevention of metal to metal contact by means of an intervening layer of fluid or fluid like material is termed as **Lubrication.**

Functions of Lubricants

1. It reduces wear and tear and surface deformation, by avoiding direct contact between the rubbing surfaces.
2. It reduces the loss of energy in the form of heat by acting as a coolant.
3. It reduces the efficiency of the machine by reducing the waste of energy.
4. It reduces expansion of metal by local frictional heat.
5. It minimizes the liberation of frictional heat and hence avoids seizure of moving surfaces.
6. It prevents unsmooth motion relative motion of the moving or sliding parts.
7. It reduces the maintenances as well as running cost of the machine to a large extent.
8. As seen above it also acts as a seal in IC engines.
9. It acts as an anti corrosive agents.

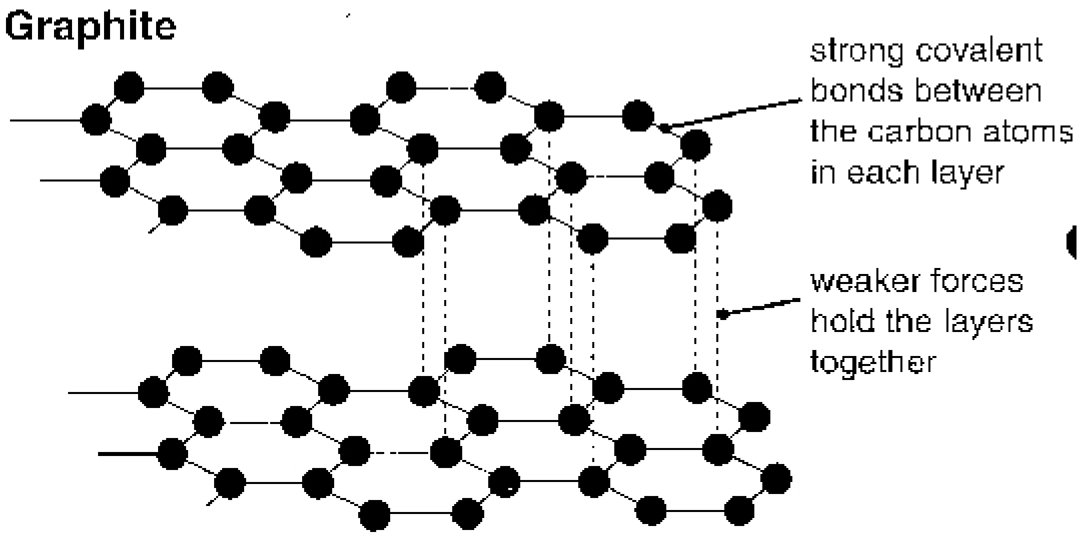
Classification of lubricants:

Lubricants can be broadly classified, on the basis of their physical state, as follows:

1. Solid lubricants
2. Semi-solid lubricants or greases
3. Liquid lubricants or lubricating oils

Solid lubricants: The two most usual solid lubricants employed are graphite and molybdenum disulphide.

Graphite : Graphite is the allotrope of carbon. It has four unpaired electron in the excited state of electronic configuration, in which one s and two p electrons are participate in SP2 hybridization and remaining p electron form a weaker bond with another carbon atom, hence it consists of a multitude of flat plates, one atom thick, which are held together by only weak bonds, so that the force to shear the crystals parallel to the layers is low. Consequently, the parallel layers slide over one another easily. Usually, some organic substances are mixed solid lubricants so that they may stick firmly to the metal surface.



Properties: Graphite is the most widely used of all solid lubricants.

1. It is very soapy to touch.
2. Non-inflammable and not oxidized in air below 375oC.
3. In the absence of air, it can be used upto very much higher temperatures.

Graphite is used either in powdered form or as suspension. Suspension of graphite in oil or water is brought about with the help of an emulsifying agent like tannin.

When graphite is dispersed in oil, it is called 'oildag' and when it is dispersed in water; it is called 'aquadag'. Oildag is found particularly useful in internal combustion engines, because it forms a film between the piston rings and the cylinder and gives a tight-fit contact, thereby increasing compression. On the other hand, oildag is useful where a lubricant free from oil is needed. e.g., foodstuffs industry. Graphite is also mixed with greases to form graphite-greases, which are used at still higher temperatures.

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

Molybdnem disulphide : molybdenum disulphide has a sandwich like structure in which a layer of a Mo atoms lies between two layers of S atoms. Poor interlaminar attraction is responsible for low shear strength in a direction parallel to the layers.

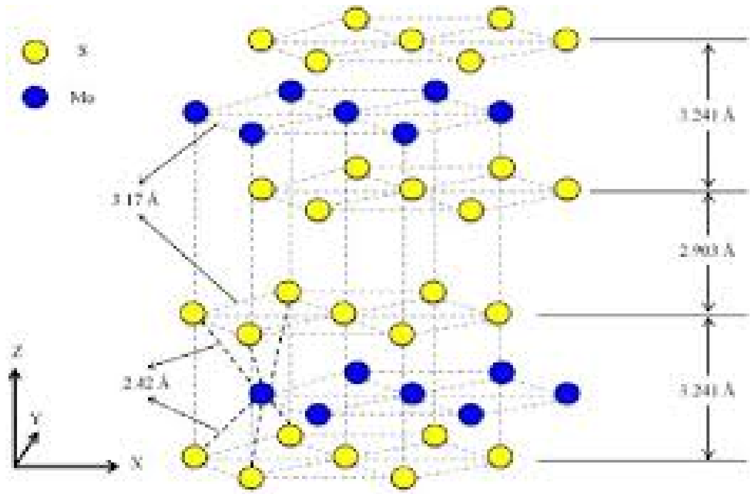


Figure 1. Crystal Structure of MoS_2. [1]

Properties: Solids lubricants are used either in the dry powder or mixed with water or oil. The solids fill up the low spots in the surfaces of moving parts and form solid films, which have low frictional resistance. The usual coefficient of friction between solid lubricants is between 0.005 and 0.01.Molybdenum disulphide possesses very low coefficient of friction and is stable in air up to 400oC.

Uses: 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. Besides the more important graphite and molybdenum disulphide, other substances like soapstone, talc, mica, etc., are also used as solid lubricants

Semi-solid lubricants or greases: grease is a semi - solid, consisting of a soap dispersed throughout liquid lubricating oil. The liquid lubricant may be petroleum oil or even synthetic oil and it may contain any of the additives for specific requirements. Greases are prepared by saponification of fat (such as tallow or fatty acid) with alkali (like lime, caustic soda, etc.), followed by adding hot lubricating oil while under agitation. The total amount of oil added determines the consistency of the finished grease. The structure of lubricating greases is that of a gel. Soaps are gelling agents, which give an interconnected structure (held together by intermolecular forces) containing the added oil.

Drawback of grease: At high temperatures, the soap dissolves in the oil, whereupon the interconnected structures cease to exist and the grease liquefies. Consistency of greases may vary from a heavy viscous liquid to that of a stiff solid mass. To improve the heat-resistance of grease, inorganic solid thickening agents (like finely divided clay, bentonite, colloidal silica, carbon black, etc.) are added.

Greases have higher shear or frictional resistance than oils and, therefore, can support much heavier loads at lower speeds. They also do not require as much attention unlike the lubricating liquids. But greases have a tendency to separate into oils and soaps.

Uses :

1. Greases are used in situations where oil cannot remain in place, due to high load, low speed, intermittent operation, sudden jerks, etc. e.g. rail axle boxes,
2. Greases are used in bearing and gears that work at high temperatures
3. Greases are used in situations where bearing needs to be sealed against entry of dust, dirt, grit or moisture, because greases are less liable to contamination by these
4. Greases are used in situations where dripping or spurting of oil is undesirable, because unlike oils, greases if used do not splash or drip over articles being prepared by the machine. For example, in machines preparing paper, textiles, edible articles, etc.

Types of Grease:

The main function of soap is thickening agent so that grease sticks firmly to the metal surfaces. However, the nature of the soap decides:

a) The temperature up to which the grease can be used

b) Its consistency

c) Its water and oxidation resistance.

So, greases are classified after the soap used in their manufacture. Important greases are:

Calcium-based greases or cup-greases: These are emulsions of petroleum oils with calcium soaps. They are, generally, prepared by adding requisite amount of calcium hydroxide to hot oil (like tallow) while under agitation. These greases are the cheapest and most commonly used. They are insoluble in water, so water resistant. However, they are satisfactory for use at low temperatures, because above 80oC, oil and soap begins to separate out.

Soda-base greases: These are petroleum oils, thickened by mixing sodium soaps. They are not water resistant, because the sodium soap content is soluble in water. However, they can be used up to 175oC. They are suitable for use in ball bearings, where the lubricant gets heated due to friction.

Lithium-based greases: are petroleum oils, thickened by mixing lithium soaps. They are water-resistant and suitable for use at low temperatures up to 15oC only.

Axle greases: These are very cheap resin greases, prepared by adding lime (or any heavy metal hydroxide) to resin and fatty oils. The mixture is thoroughly mixed and allowed to stand, when grease floats as stiff mass. Filters (like talc and mica) are also added to them. They are water-resistant and suitable for less delicate equipments working under high loads and at low speeds. Besides the above, there are greases prepared by dispersing solids (like graphite, soapstone) in mineral oil. These are mostly used in rail axle boxes, machine bearings, tractors rollers, wires ropes etc.

Lubricating oils: Lubricating oils reduce friction and wear between two moving/sliding metallic surfaces by providing a continuous fluid film in-between them. They also act as:

(a) cooling medium

(b) sealing agent

(c) corrosion preventer.

Good lubricating oil must possess:

(a) low pressure (or high boiling point)

(b) adequate viscosity for particular service conditions

(c) low freezing point

(d) high oxidation resistance.

(e) Heat stability

(f) non-corrosive properties

(g) stability to decomposition at the operating temperatures.

Classification of Lubricating oils: These are further classified as:

Animal and vegetable oils: Before the advent of the petroleum industry, oils of the vegetable and animal origins were the most commonly used lubricants. They posses good oiliness (a property by virtue of which the oil sticks to the surface of machine parts, even under high temperatures and heavy loads). However, they are: costly, Undergo oxidation easily forming gummy and acidic products and get thickened on coming in contact with air.

They have some tendency to hydrolyze, when allowed to remain in contact with moist-air or aqueous medium. So at present, they are rarely used as such. Actually, they are used as "blending agent" with other ' lubricating oils (like mineral oils) to produce desired effects in the latter.

Mineral or petroleum oils: These are obtained by distillation of petroleum. The length of the hydrocarbon chain in petroleum oils varies between about 12 to 50 carbon atoms. The shorter-chain oils have lower viscosity than the longer-chain hydrocarbons. These are the most widely used lubricants, because they are cheap, available in abundance, and quite stable under service conditions. However, they possess poor oiliness as compared to that of animal and vegetable oils. Tile oiliness of petroleum oils can be increased by the addition of high molecular weight compounds like oleic acid, stearic acid, etc.

Purification : Crude liquid petroleum oils contain lot of impurities (like wax, asphalt,etc.) and consequently, they have to be thoroughly purified before being put to use.

The wax, if not removed, raises the pour-point and renders the lubricating oil unfit for use at low temperatures.

Certain constituents get easily oxidized under working conditions and cause sludge formation.

Some constituents mainly asphalt, undergo decomposition at higher temperatures, causing carbon deposition and sludge formation. A number of processes are used for removing these unwanted impurities by using Dewaxing or acid refining or by solvent refining.

Blended oils: No single oil saves as the most satisfactory lubricant for many of the machineries. Typical properties of petroleum oils are improved by incorporating specific additives. These so-called 'blended oils' give desired lubricating properties, required for particular machinery. The following additives are employed:

(i) Oiliness-carriers: Oiliness of a lubricant can be increased by addition of an oiliness-carrier like vegetable oils (e.g., coconut oil, castor oil) and fatty acids (like palmitic acid, stearic acid, oleic acid. etc.).

(ii) Extreme-pressure additives: Under extreme-pressure, a thick film of oil is difficult to maintain, and the oil need to have a high oiliness. Besides improving oiliness directly, high-pressure additives are used. .these additives contain certain materials which are absorbed on the metal surface or react chemically with metal, producing a surface a layer of low shear-strength on the metal surface, thereby preventing the tearing up of the metal. Another property of high-pressure additives is that they react, at high temperature on metal surfaces, forming surface alloys so as to prevent the welding together of the rubbing parts under severe operating conditions.

The main substances added for high-pressure lubrication are :(a) fatty ester, acids, etc., which form oxide film with the metal surface ; (i) organic materials, which contain sulphur ; (c) organic chlorine compounds ; (d) organic phosphorus compounds. High-pressure lubricants also contain some lead in order to produce thin film of lead sulphide and other lead compounds on the surfaces of machines like gear teeth.

(iii) Pour-point depressing additives used are phenol and certain condensation products of chlorinated wax with naphthalene. These prevent the separation of wax from the oil.

(iv) Viscosity-index improvers are certain high molecular weight compounds like hexanol.

(v) Thickeners such as polystyrene are materials usually of molecular weight between 300 and 3,000. They are added in order to give the lubricating oil a higher viscosity.

(vi) Antioxidants or inhibitors, when added to oil, retard oxidation of oil by getting them- selves preferentially oxidized. They are particularly added in lubricants used in internal combustion engines, turbines, etc., where oxidation of oil is a serious problem. The antioxidants are aromatic, phenolic or amino compounds.

(vii) Corrosion preventers are organic compounds of phosphorus or antimony. They protect the metal from corrosion by preventing contact between the metal surfaces and the corrosive substances.

(viii) Abrasion inhibitors like tricresyl phosphate.

(ix) Antifoaming agents (like glycols and glycerol) help in decreasing foam formation.

(x) Emulsifiers such as sodium salts of sulphonic acid.

(xi) Deposit inhibitors are detergents such as the salts of phenol and carboxylic acids. Deposits are formed in internal combustion engine, due to imperfect combustion. Such additive disperses and cleans the deposits.