# Mechanical Equipment - Course 430.1

## LUBRICATION

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There are many reasons for lubrication of metal surfaces such as control of friction, reduced wear, reduced errosion, limiting temperature, cleaning, dampening shock, or forming a seal. Most of these requirements are interrelated, for example, a lubricant doing a relatively poor job of controlling friction must be able to assume the added burden of removing more heat. This additional heat may thin out the lubricant which results in a poor lubricant for the job at hand.

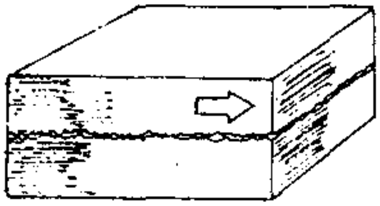
Of all the reasons for lubrication the two major ones are firstly to reduce friction and wear between surfaces and secondly to carry away heat generated by friction resulting from the metal surfaces or internally from the lube oil itself.

To understand the need for lubrication we should first look at friction and what causes it. Basically friction is the force that resists sliding motion. The term coefficient of Friction relates this friction force to the load, ie, the friction force divided by load. The thing which causes friction is the fact that surfaces are made up of peaks and depressions irregardless of how smooth they appear. When two such surfaces come together, these peaks and depressions interfere and cause resistance to slipping. Even rollers or balls suffer from this problem. When rollers or balls are placed between flat surfaces the materials deform and rolling elements slip under load giving rise to sliding friction.

We can divide the problem of friction into three main types Figure 1, sliding friction, rolling friction and fluid friction. The first is as we have mentioned, two metal surfaces being moved across each other. Examples here are a shaft turning in a bearing or pistons in a cylinder.

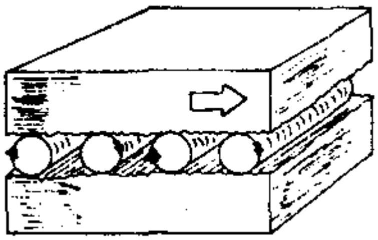
The second of these is rolling friction which, as we have said, is due to the deformation of the roller or ball material and the flat surfaces, and the tendency for rolling elements to slip under load.

The third type is fluid friction which is the resistance to movement within a fluid of one molecule relative to another molecule.



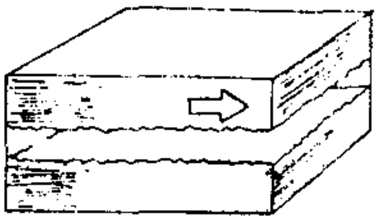
Sliding

This is most basic type of friction-one solid body pulled or pushed across the surface of another with adhesion, shearing and plowing coming directly into play. Examples are piston moving in a cylinder or shaft revolving in a bearing with no lubricant separating the surfaces.



Rolling

Any system of rolling elements reduces friction considerably. If balls or rollers and flat surfaces were smooth and inelastic, friction would be almost zero. But materials deform, rolling elements slip under load. However starting and running friction are about the same.



Fluid

When a film of liquid lubricant separates the surfaces, the only friction is from the motion within the fluid. The fluid splits into "layers". The top layer sticks to the top surface, the bottom layer to the lower surface. Each successive layer travels at lower speed, shearing the layers on either side.

Types of Friction

Figure 1

In order to reduce sliding friction we must at.empt to keep the two surfaces apart. This can be done by rollers giving rise to rolling friction or by introducing a fluid which gives rise to fluid friction. If we use rollers of some sort we still get some sliding friction and the addition of a lubricant will reduce this. In these two cases we get back to fluid friction to some degree.

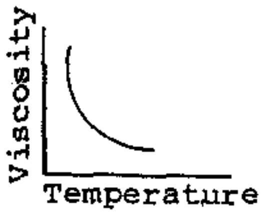
Taking a look at the properties of a lubricant which must exist for it to fulfil these functions, we find four major properties-viscosity, oiliness, flash point and temperature stability.

Oiliness is the ability of a lube-oil to cling to or be absorbed to the surface of a material. It is this characteristic which is used to aid in overcoming boundary friction. It is normally achieved today by means of additives to the oil which improve their natural adsorptive qualities.

Flash point of a lube-oil is the temperature at which vapour will be given off in enough quantities and ignite. This value should be high so that the oil does not break down during operation.

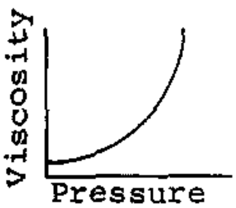
Temperature stability is the ability of a lube-oil to maintain its load carrying capacity over a range of temperature variation under which it is likely to be used.

Viscosity is by far the most important single factor when dealing with lube-oils. It can determine the friction loss, heat generation, load carrying capacity, film thickness, ability to flow and in many cases wear. The simplest definition of viscosity is the oil's internal resistance to motion. Oil with a high viscosity won't flow as easily as an oil with a low viscosity. Some of the characteristics of oil viscosity are shown in Figure 2. It is obvious that a combination of all these factors must be considered when selecting lubrication for any one problem. The use of lube-oil additives increases the scope of lube-oils for any given condition.



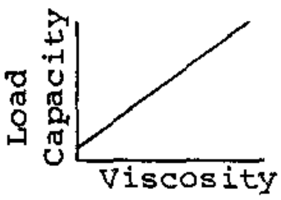

Temperature

Increasing temperature lowers oil viscosity. A high-viscosity oil can support a heavy load, especially at low temperatures. High-viscosity oils also have more internal friction.



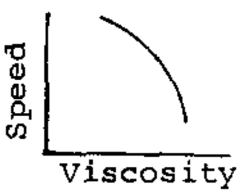

Pressure

Increasing pressure increases oil viscosity. However, this only becomes important when pressures are in the neighborhood of several thousand psi.




Load Capacity

Viscosity of an oil must be matched to the application. The oil must have enough viscosity to handle the load, yet increasing the viscosity causes an increase in fluid friction, which heats the oil and lowers the viscosity.



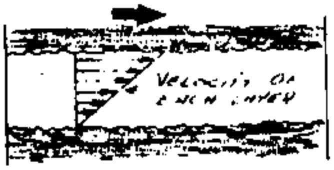

Shaft Speed

High speed means faster shearing of oil layers, and more fluid friction. As temperature goes up, viscosity goes down to decrease load capacity. However, a high speed helps to form a hydrodynamic wedge in bearings.

Oil Viscosity Characteristics

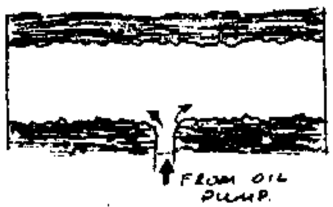
Figure 2

We have mentioned the three types of friction and we attempt to reduce them to fluid friction by means of lubricating materials. Now we should mention the types of lubrication. These are boundary or thin film, hydrodynamic and hydrostatic. (See Figure 3 on following page.)



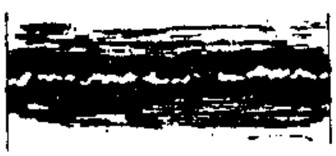
Hydrodynamic

Full film of oil, exaggerated above, is normally about 0.01 to 0.001 in. for 1-in. bearing-or lower.




Hydrostatic

Oil pressure from outside pump keeps surfaces apart. For slow, heavy loads or to cut down starting friction.



Thin-Film

Many bearings will operate with only 0.0001 in. or less oil film between surfaces; some metal-to-metal contact.

Types of Lubrication

Figure 3

Boundary lubrication is a very thin film of oil which adheres to the surface of the metals. There will be some metal to metal contact depending upon the oiliness characteristics of the lubricant.

Hydrodynamic lubrication is achieved by a relatively thick film of oil. Pressure, which is the key to separating surfaces, is built up within the bearing. This is accomplished either by temperature rise or by an oil wedge which will be explained later.

Hydrostatic lubrication is achieved by supplying a lubricant to a bearing area. In other words the pressure separating the two surfaces comes from an external source and physically lifts the two surfaces apart.

So far our discussion has dealt with fluid lubricants. However lubricants can be broadly classified as gas, liquid, semi-solid or solid and they may be grouped roughly into three general types - fluids, greases and solid-film lubricants.

The term oil covers a broad class of fluid lubricants and some of the general types are as follows:

1. Mineral oils - produced from crude or petrolium oil distillation. They are still the largest single type in general use.

2. Fixed Oils - produced from animals and plants. These are not generally used alone but are combined with mineral oils usually serving as oiliness agents.

3. Synthetic oils - these are man-made lubricants which have a wider range than petrolium oils. They can be carefully designed and additives can be more easily tailored for them.

Greases are essentially a mixture of a lubricating oil and a metallic soap which keeps the oil in suspension. The most common soaps in use are calcium, sodium, and lithium. Rather than using viscosity for the classification of greases the term consistency is used which is a measure of how easily the grease may be squeezed out from between the two parts being lubricated. Like oils greases may have special additives to enhance their lubricating qualities.

A solid lubricant is simply a solid material placed between two moving surfaces to prevent metal-to-metal contact. Therefore the application of solid lubricants is generally in the boundary area. They may be applied as dry powders, mixtures with grease and oil or mixtures with binders which form dry films when cured. Some of the solid lubricants found in use to-day are graphite powder, molybdenum disulfide, tungsten disulfide, teflon powder and other plastics.

## ASSIGNMENT

1. What is friction?

2. What are the four major properties of lube oil?

3. Define viscosity.

4. What are the three main types of lubrication?

5. What is a grease?

G.S. Armstrong