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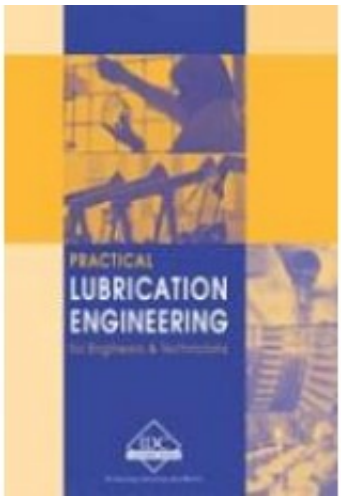
LB-E - Practical Lubrication Engineering for Engineers and Technicians



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Short Description

Basic knowledge of lubricants and their applications are very important for maintenance technicians and maintenance engineers. The variety of different lubricants increased considerably over the last 10 years and if the right lubricant is used at the right time and in the correct application, maintenance cost can be reduced and the life expectancy of equipment increased.

Description

Basic knowledge of lubricants and their applications are very important for maintenance technicians and maintenance engineers. The variety of different lubricants increased considerably over the last 10 years and if the right lubricant is used at the right time and in the correct application, maintenance cost can be reduced and the life expectancy of equipment increased.

This comprehensive manual focuses on lubricant management, design-applications, operations, maintenance and management issues and provides you with the most up-to-date information and best practice in dealing with the subject.

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Chapter 1: Introduction to Lubrication Engineering

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Introduction to Lubrication Engineering

1.1 Objectives

This first chapter of this manual is an introduction to Lubrication Engineering. When you have studied this chapter, you will have:

- Understood the term friction and the need for reducing and controlling friction in industrial environments,
- Understood the role lubricants play in industrial applications,
- Known about primary factors affecting choice of lubricants,
- Learnt about basic classification of lubricants according to their state,
- Learnt about basic properties of lubricating oils, greases, solids and gases, as lubricants, in context of speeds and loads
- Known the primary factors which decide whether to use an oil, or grease, or a gas as a lubricant,

- Known the main classes of applications for lubricants,
- Learnt about preliminary factors to be considered when selecting a lubricant for a new machine, or for a machine in use,
- Learnt how an initial suitability of a lubricant is assessed, and,
- Understood quality aspects to be considered after initial suitability is ascertained.

1.2 Introduction

Whenever two surfaces are in contact with each other, with relative movement between them, a resistance to this movement develops. This resistance to relative movement, between the surfaces in contact with each other, is known as Friction.

Friction, like gravity, is omnipresent; evident in all activities surrounding us. It is so essential for quite a few of our daily activities that we take it for granted and do not even notice it unless something unusual happens. Try walking on a slippery bathroom floor or driving a car on a slippery road, and then you realise how friction is necessary. Analogous examples in industrial context where friction is needed are those of flat and V-belt drives, clutches, brakes, etc. In all cases, friction is desirable and is used in a controlled manner to achieve the desired results.

In majority of industrial activities, however, friction is undesirable. Friction results in increased force to achieve relative movement, and results in wear and the consequent undesirable effects. Efforts have therefore to be made to reduce and control it. This is done by introducing a third substance between the two surfaces in contact, to reduce friction. This substance is called a Lubricant. This lubricant forms a layer between the two surfaces in contact. The lubricant layer has to withstand pressure between the two mating surfaces while allowing the two surfaces to slide with relative smoothness.

Introduction of a suitable lubricant between the two surfaces moving against each other greatly reduces and controls friction. The wear resulting from friction is reduced, and so are the harmful effects that follow.

Today the role of lubricants is so critical that its absence will grind our industrial world to a halt, both figuratively and literally.

This manual aims at providing a conceptual framework as well as practical information and knowledge in understanding, knowing, selecting, using, testing, and, disposing of lubricants in industry. Towards this end, this manual will discuss the role of friction and tribology, various properties of lubricants with their significance, different types of lubricants with their pluses and minuses, selection of lubricants for specific area of applications, maintenance and testing, and finally disposal, roughly in that order.

This introductory chapter will overview some topics to be covered later in detail, and lay down some general guidelines regarding factors affecting selection of lubricants.

1.3 The Role of Lubricants, or, ‘Why Use Lubricants?’

The main effects of friction are increased wear and increased magnitude of force

required to move one surface against the other.

Then the main role of lubricants will also, obviously be to reduce and control these two. Apart from these primary roles, lubricants are also called upon to perform the following roles/functions depending on the situation:

- Cooling or removal of heat (generated by friction) away from area of contact,
- Protection against rust and corrosion,
- Prevention of ingress of dust and moisture into contact area/bearings,
- Carrying away of contaminants and dirt (generated by friction) away from contact area,
- Transmission of force or torque,
- Reducing vibration,
- Reducing fuel consumption,
- Resisting fire.

A typical industrial lubricant may have to perform some or all of the above roles, and will also have to perform these roles in adverse operating conditions of load, speed, operating/ambient temperatures, presence of water/moisture, oxidizing conditions and so on.

Lubricants are used to perform all of the above-mentioned primary and secondary functions. While performing these diverse roles, the lubricants also have to be compatible with their environment. For example, the lubricant must have compatibility with seal materials if there are seals around it; compatibility with refrigerants if used in refrigerating machinery; non-toxicity with food if used in food processing machinery; and they must be safe to handle and store.

These enlightened and environmentally aware times also rightly demand that the lubricants must also be as renewable/recyclable and biodegradable as possible; and of course be easy to dispose off.

1.4 Primary Factors Affecting Selection of Lubricants

Choice of a lubricant is affected by some basic factors. These are:

- Load or pressure with which the surfaces in contact press against each other,
- Speed of relative motion between the two,
- Material of construction of the two contacting surfaces,
- Roughness and degree of roughness of the contacting surface,

- Geometry of contact area, and,
- Temperature range within which, the lubricant is expected to give satisfactory service.

1.4.1 Lubricant Types Based On State

Major lubricant types based on their state are:

- Solid Lubricants,
- Liquid Lubricants,
- Emulsions,
- Semi-liquid lubricants, and,
- Gaseous lubricants.

Of these, liquid and semi-liquid form the bulk of lubricants used, and are more important and versatile in their usability.

Liquid lubricants can flow. They are therefore amenable to pouring, pumping, dripping, splashing, and or, draining. Because they can flow, they have the ability to carry heat away from a bearing. They can also flush out debris produced by wear. On the other hand, they are prone to leakage. They also cannot seal against dirt or moisture.

Liquid lubricants comprise lubricants based on vegetable oils, mineral oils, and synthetic oils.

Semi-liquid lubricants or greases, as they are commonly known, are like oils in many of their properties. Technically, they are oils containing thickening agents to make them semi liquid. These are preferred where circulation of lubricant is not necessary and sealing against ingress of dirt is required. They are however difficult to apply to or feed into a bearing. They also cannot carry away heat because they cannot flow.

Solid lubricants or dry lubricants as they are also called, do not flow. They therefore cannot have properties which flow-ability endows. These may be bulky solids, dry powders, or paint-like coatings.

Gases flow most freely. These include air itself, apart from other gases.

Gases and solids however are used only in special cases.

Liquid lubricants are usually the lubricants of first choice.

1.4.2 Basic Properties of Oils, Greases, Solids, and Gases as Lubricants.

Basic properties of the four lubricant types are shown in Table 1-1. An examination of the table will indicate the preliminary and tentative range of state wise or form wise selection of a lubricant.

Table 1-1

Basic Properties of Four Types of Lubricants Based on Their State

(Source: Landsdown, A.R., “Lubrication and Lubricant Selection A Practical Guide”, Mechanical Engineering Publications, London, 1996)

1.4.3 Effect of Speed and Load on Choice of State of Lubricant.

The speed at which two rubbing surfaces move against each other, and the contact pressure (or load), are the two critical factors that are to be first considered when selecting a lubricant.

Viscosity (an indication of ability to flow) is the most important property of liquid and semi-liquid lubricants. Generally speaking, when increasing speed, lower viscosity is required. On the other hand, increasing loads require increasingly viscous lubricants.

Figure 1.1 indicates increasing/decreasing suitability of state of a lubricant vis-à-vis load and speed.

Figure 1.1: *Suitability of Lubricants of Different States with respect to Speed and*

Load

Figure1.2 on the next page depicts load and speed limits for oils, greases, and solids. The limits shown should be taken as broad and general guidelines. Actual specific limits will depend on the nature of contact, the type of lubricant additives used, etc. Limits for gases are not depicted in Fig.1-2 for simplicity. As a rule, gases are used at very high speeds and low loads.

Figure 1.2*: Speed/Load Limitations for different types of Lubricants. (Source: Landsdown, A.R., "Lubrication and Lubricant Selection A Practical Guide", Mechanical Engineering Publications, London, 1996)*

1.5 Main Areas of Application

Industrial applications where lubricants are used are countless and diverse. The main areas can, however, be broadly classified as under:

- Journal bearings;
- Slide ways, guide ways, and other sliding contact situations;
- Antifriction bearings such as ball, roller, needle bearings;
- Power/ torque transmission through enclosed gears;
- Power/torque/force transmission through open gears, chains, ropes etc.;
- Metal forming operation such as wire drawing, extrusion, rolling, deep drawing and forming etc.;
- Force/torque transmission in hydraulic actuators, hydraulic motors etc.;
- Metal cutting/machining operations such as turning, milling, grinding etc.;
- Steam/Gas/hydro turbines;
- Internal combustion engines/Auto engines;
- Air/Gas compressors;
- Military applications;
- Applications in Space Industry;
- Instruments, watches etc.;
- Simple mechanisms like latches, hinges, locks, etc.

1.6 General Guidelines on Selection of Lubricants

Selection of lubricants is a vast subject requiring study of the application concerned as well as examination of a large number of lubricant alternatives that are sometimes available. Very few application situations are exactly like each other. This makes it necessary that each situation be studied thoroughly with nothing taken for granted. Lowest overall long-term costs should be the objective when choosing a lubricant. This does not necessarily mean that the cheapest available lubricant is the only choice. Many times very good lubricants of very high initial cost prove to be cheaper in the long run.

1.6.1 Lubricants for New Machinery

Lubricant selection and its method of application should be addressed early in the design of a machine. If this has been done, it can be assumed that the manufacturer of a machine knows his machine the best. The manufacturer's recommendations should therefore not only be followed in regard to the use of a particular lubricant, but also in regard to the manner of use of the machine, so that it is not abused.

1.6.2 Lubricants for Machinery Already in Use

In many cases where a lubricant appears to be performing satisfactorily, a detailed analysis of lubrication costs, replacement of worn out components costs, downtime costs, power/fuel costs and the like will reveal whether a better lubricant could have been used, and can still replace the old one so as to improve performance.

Condition of the machinery already in use also needs to be examined at appropriate intervals, especially with regard to clearances and alignments. It is likely that original clearances have increased due to wear, and that some of the alignments have gone bad.

Increased clearances should be restored to their original values. If this is not possible, then consideration should be given to the use of more viscous lubricants.

When original alignments go awry, what was once a uniformly distributed load now becomes a highly concentrated load over a smaller surface area, or sometimes, even becomes a point load. Here again the first resort should be the correction of misalignments, for, apart from affecting the lubricant, misalignments can lead to the concerned components becoming highly stressed.

If it is not possible to correct misalignments, then a study of contact geometry should be carried out and an appropriate lubricant with Excess Pressure (EP) property, or a lubricant with pressure withstanding additives, should be considered.

On the spot examination as well as laboratory analysis of a sample of lubricant, drained from the machine, will also give good pointers to degradation of lubricant, wear, and some other useful diagnostic information.

1.6.3 Selection Process-Starting from basics-Study of Initial Suitability and Quality

Whether one is selecting lubricants for a new machine, reassessing existing lubrication practices or trouble shooting a sticky situation, it makes good sense to view the available information in a structured fashion and proceed from the basics of this discipline.

Generally, choice of a lubricant should be made in two steps:

- Conduct a basic ‘Initial Suitability Exercise’,
- Superimpose ‘quality’ on the Initial Suitable choice.

Initial Suitability

An initial suitability exercise involves:

- Considering the type of part to be lubricated (bearing, gear, sliding contact etc.),
- Considering the size of part, type of motion, clearances, and the like;
- Considering speed and load;
- Considering normal operating temperature range (At low starting temperatures a lubricant must be fluid enough to prevent oil starvation at

start-up, and also provide satisfactory lubrication at operating temperatures. At high temperatures, the lubricant must not be so thin and fluid that it does not have enough body to support loads.);

- Considering viscosity related requirements such as basic viscosity requirements, viscosity index (important if temperature range is wide), pour point (low pour point is needed if the starting or operating temperatures are low), etc. Viscosity is the most fundamental property of a liquid lubricant and operating variables may change basic viscosity requirements. Viscosity requirements vary:
- Inversely with speed,
- Directly with load,
- Directly with clearances,
- Inversely with temperature, and,
- Directly with pressure.
- Considering the lubrication regime involved (for example, in boundary conditions, film strength or EP property becomes critical);
- Considering the condition of equipment with respect to clearances, misalignment etc.;
- Considering compatibility requirements of proposed lubricant with surroundings such as seals, metals, other co-existing lubricants if any, paints etc.;
- Considering surrounding atmosphere (if atmosphere is humid, rust protection is needed, if there are acid vapours around, corrosion prevention is called for); and finally;
- Considering fire hazards and radiation hazards, if any.

Quality

Once an Initial Suitability exercise is carried out and a tentative selection made, based on the outcome of this study and examination of alternative lubricants available, ‘Quality’ is considered and its needs superimposed on the initial selection made, and additives selected if necessary.

‘Quality’ of a lubricant, refers to properties such as oxidation resistance, wear protection, extreme pressure (EP) property, detergency, dispersive ability, rust protection, corrosion protection, demulsibility, resistance to foaming, etc.