1
Lubricants and their Market

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1.1
Preface

The most important function of lubricants is the reduction of friction and wear and in some cases, the relative movement of two bearing surfaces is only possible if a lubricant is present. In times when saving energy and resources and cutting emission have become central environmental matters, lubricants are increasingly attracting public awareness. Scientific research has shown that 0.4 % of gross domestic product could be saved in terms of energy in Western industrialized countries if current tribological knowledge, i.e. the science of friction, wear and lubrication, was just applied to lubricated processes.

Apart from important applications in internal combustion engines, vehicle and industrial gearboxes, compressors, turbines or hydraulic systems, there are a vast number of other applications which mostly require specifically tailored lubricants. This is illustrated by the numerous types of greases or the different lubricants for chip-forming and chip-free metalworking operations which are available. Between 5000 and 10 000 different lubricant formulations are necessary to satisfy more than 90 % of all lubricant applications.

If one thinks of lubricants today, the first type to come to mind are mineral oil-based. Mineral oil components continue to form the quantitatively most important foundation of lubricants. Petrochemical components and increasingly derivatives of natural, harvestable raw materials from the oleo-chemical industry are finding increasing acceptance because of their environmental compatibility and some technical advantages.

On average, lubricating oils, which quantitatively account for about 90 % of lubricant consumption, consist of about 93 % base oils and 7 % chemical additives and other components (between 0.5 and 40 %).

The development of lubricants is closely linked to the specific applications and application methods. As a simple description of materials in this field makes little sense, the following sections will consider both lubricants and their application.

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1.2 Lubricant Sales

Lubricants today are classified into two major groups: automotive lubricants and industrial lubricants. Industrial lubricants can be sub-divided into industrial oils and industrial specialties. Specialties in this case are principally greases, metalworking lubricants and solid lubricant films.

Process oils are often included in lubricant statistics. These are oils which are included as raw materials in processes, but above all as plasticizers for the rubber industry. Process oil's only link with lubricants is that they are mineral oil products resulting from the refining of base oils but they often distort lubricant consumption figures. They will not be covered in this book. However, to provide a degree of comparison, they have been included in the following lubricant statistics.

In 2004, 37.4 million tons of lubricants were consumed worldwide (53 % automotive lubricants, 32 % industrial lubricants, including related specialties, 5 % marine oils, and 10 % process oils). Of total industrial lubricants, 37 % were hydraulic oils, 7 % industrial gear oils, 31 % other industrial oils, 16 % metalworking fluids (including temporary corrosion preventives whose multipurpose function often includes lubrication), and 9 % greases.

Tab. 1.1 Regional breakdown of world demand for lubricants (without marine lubricants).

Region	Amount (kT)	
	2004	2005[a]
North America	8,170	8,130
Latin America	3,215	3,295
Western Europe	4,705	4,635
Central/Eastern Europe	4,835	4,905
Near/Middle East	1,775	1,795
Africa	1,850	1,870
Asia-Pacific	11,580	11,870
World	36,130	36,500

a Estimated [1.4, 1.5]

Table 1.2 shows the 2004 per-capita consumption for various regions. North America and Western Europe make up 35.9 % of world lubricant consumption even though these regions only account for 9.4 % of the world's population [1.1, 1.4, 1.5].

Tab. 1.2 Per-capita consumption of lubricants in 2005 [1.4, 1.5].

Region	Amount (kg p.a.)
North America	24.9
Central/Eastern Europe	12.1
Western Europe	11.8
Near/Middle East	9.4
Latin America	5.7
Asia-Pacific	3.1
Africa	2.1
World	**5.6**

Global per-capita consumption decreased from 8.8 to 5.6 kg per year between 1970 and 2004, i.e. the increase in lubricant demand (+ 12.3 %) did not keep up with the worldwide growth in population (+ 72.5 %) during this period.

Since 1975, quantitative lubricant demand has significantly detached itself from gross national product and also from the number of registered vehicles. This quantitative view, which at first glance shows a continuous decline in lubricant volumes, gives an inadequate impression of the significance of the lubricants business today. In almost all areas, products now have a longer life and offer greater performance, i.e. specific lubricant consumption has declined but specific revenues have increased noticeably. This is also confirmed by the volumetrically very important group of engine oils: the doubling of requirements with extended oil change intervals in recent years have quadrupled the cost of such oils. The efforts to increase the life of lubricants are not based on the wish to reduce lubricant costs. Much more important is the reduction of service and maintenance costs which result from periodic oil changing or regreasing.

As about 50 % of the lubricants sold worldwide end in and thus pollute the environment, every effort is made to minimize spillages and evaporation. An example is diesel engine particulate emissions, about a third of which are caused by engine oil evaporation. These high lubricant losses into the environment were behind the development of environmentally friendly lubricants which are thoroughly covered in this book.

A further incentive to reduce specific consumption is the ever-increasing cost of disposal or recycling of used lubricants. But this again creates new demands on lubricants because reduced leakage losses means less topping-up and less refreshing of the used oil. The new oils must therefore display good aging stability.

Bearing in mind the growth potential in Asia where per-capita consumption in some areas is extremely low (2004: India 1.1 kg, China 2.9 kg) and a continuing reduction in volumes or stagnation in Western industrialized countries, overall a modest global growth is forecast. This has been estimated to be 0.5 % p.a. between 2005 and 2010 [1.2, 1.4, 1.5]. The growth in value will be more pronounced because the rapid globalization of technologies will promote high-value products even in the new lubricant markets such as China, India or Indonesia and the machines and plant used in these countries will be similar or identical to those used in the developed industrialized countries.

1.3 The Lubricants Industry

Worldwide, there are 1380 lubricant manufacturers ranging from large to small. On one hand there are vertically-integrated petroleum companies whose main business objective is the discovery, extraction and refining of crude oil. Lubricants account for only a very small part of their oil business. At present, there are about 180 such national and multinational oil companies engaged in manufacturing lubricants. The 1200 independent lubricant companies mainly concentrate on the manufactur-

ing and marketing of lubricants and view lubricants as their core business. While the large, integrated companies focus on high-volume lubricants such as engine, gear and hydraulic oils, many independent lube companies concentrate on specialties and niche business, where apart from some tailor-made lubricants, comprehensive and expert customer service is part of the package.

The top 1 % of the world's manufacturers of finished lubricants (of which there are more than 1380) account for more than 60 % of global sales; the other 99 % share less than 40 %. The world's largest manufacturers of finished lubricants are listed in Tables 1.3 and 1.4.

Tab. 1.3 World ranking of the largest manufacturers of lubricants (2005) [1.3, 1.4, 1.5].

1	Shell	Great Britain/The Netherlands
2	Exxon Mobil	USA
3	BP	UK
4	Petrochina/Sinopec	China
5	Chevron	USA
6	Lukoil	Russia
7	Fuchs	Germany
8	Nippon Oil	Japan
9	Valvoline	USA
10	Idemitsu	Japan
11	Conoco Phillips	USA
12	CPC	Taiwan
13	PDVSA	Venezuela
14	Repsol	Spain
15	Indian Oil	India
16	Agip	Italy
17	Yukos	Russia

Tab. 1.4 World ranking of the largest manufacturers of industrial lubricants (2005) [1.3, 1.4, 1.5].

1	Exxon Mobil	USA
2	Shell	Great Britain/Netherlands
2	Petrochina/Sinopec	China
4	Chevron	USA
5	BP	UK
6	Fuchs	Germany
7	Nippon Oil	Japan
8	Idemitsu	Japan
9	Total	France
10	Lukoil	Russia
11	PDVSA	Venezuela
12	Yukos	Russia
13	Repsol	Spain
14	Agip	Italy
15	Valvoline	USA
16	Conoco Phillips	USA

The independent lubricant manufacturers also generally purchase raw materials on the open market and they rarely operate base oil refineries. They buy their raw materials from the chemical and oleo-chemical industry and their mineral base oils from the large petroleum companies.

The production of simple lubricants normally involves blending processes but specialties often require the use of chemical processes such as saponification (in the case of greases), esterification (when manufacturing ester base oils or additives) or amidation (when manufacturing components for metalworking lubricants). Further manufacturing processes include drying, filtration, homogenizing, dispersion or distillation.

Depending on their field of activity, lubricant manufacturers invest between 1 and 5 % of their sales in research and development.

Towards the end of the nineties, the petroleum industry was affected by a wave of mergers which will continue. These created new and larger lubricant structures at the merged companies. The principal reasons for these mergers were economic factors in crude oil extraction and refining which resulted in lower refining margins.

Independent lube companies also experienced a continuing concentration with technological, safety-at-work and ecological considerations along with the globalization of lubricant consumers playing an important role. Critical mass is becoming increasingly important in company strategies.

1.4 Lubricant Systems

Apart from the most common lube oils, the many thousands of lubricant applications necessitate a diverse number of systems which is seldom equaled in other product groups.

The group next to oils are emulsions, which as oil-in-water emulsions are central to water-miscible cutting fluids (Chapter 14), rolling emulsions and fire-resistant HFA hydraulic fluids (Chapter 11). In these cases, the lubricant manufacturer normally supplies a concentrate which is mixed with water locally to form an emulsion. The concentration of these emulsions with water are generally between 1 and 10 %. The annual consumption of such emulsions in industrialized countries is about the same as all other lubricants together. From this point of view, the volumetric proportion of these products (as concentrates) is significantly under-rated in lubricant statistics with regard to the application engineering problems they create and their economic significance.

The next group of lubricant systems are water-in-oil emulsions. Their most important application is in metal forming. These product are supplied ready-to-use or as dilutable concentrates. Fire resistant HFB fluids are designed as water-in-oil emulsions too (invert emulsions).

In some special cases, oil-in-oil emulsions are developed as lubricants and these are primarily used in the field of metalworking.

Water-based solutions in the form of non-dispersed systems are sometimes used in chip-forming metalworking operations.

Greases (Chapter 16) are complex systems consisting of base oils and thickeners based on soaps or other organic or inorganic substances. They are available in semi-liquid form (semifluid greases) through to solid blocks (block greases). Special equipment is required for their production (grease-making plants). A group of products closely related to greases are pastes.

Solid lubricant suspensions normally contain solid lubricants in stable suspension in a fluid such as water or oil. These products are often used in forging and extrusion as well as other metalworking processes. Solid lubricant films can also be applied as suspensions in a carrier fluid which evaporates before the lubricant has to function.

Solid lubricant powders can be applied directly to specially-prepared surfaces.

In the case of dry-film lubricants (Chapter 17), solid lubricants are dispersed in resin matrices. Dry-film lubricants are formed when the solvent (principally water or hydrocarbons) evaporates.

Molten salts or glass powder are used for hot forming processes such as extrusion. These are normally supplied as dry powders and develop lubricity when they melt on the hot surface of the metal.

Polymer films are used when special surface protection is required in addition to lubricity (e.g. the pressing of stainless steel panels). Together with greases, these products are also used to some extent in the construction industry.

An intermediary field between materials and lubrication technology is the wide area of surface treatment to reduce friction and wear. While the previously mentioned dry-film lubricants are an accepted activity of the lubricants industry, chemical coatings are somewhat controversial. These coatings are chemically bonded to the surface of the metal. They include oxalation and phosphating (zinc, iron and manganese). In cases when such coatings adopt the carrier function of an organic lubricant, the entire system could be supplied by the lubricant manufacturer. If the chemical coating is not designed to be supplemented with an additional lubricant coating (e.g. dry film on phosphatized gear), it will probably be supplied by a company which specializes in surface degreasing and cleaning.

Even more different from traditional lubricants are metallic or ceramic coatings which are applied with CVD (chemical vapor deposition) or PVD (physical vapor deposition) processes. They also sometimes replace the EP functions of the lubricants (Chapter 6). Such coatings are increasingly being used together with lubricants to guarantee improved wear protection in extreme conditions and over long periods of time.