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Practitioner's Section

Emerging trends in the Industrial Greases Market

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Grease, as defined by the American Society for Testing and Materials (ASTM), is "a solid to semi-fluid product of a dispersion of a thickening agent in a liquid lubricant" (ASTM 1978). The production process as well as the overall technology used to produce industrial greases is quite advanced although the structure of industrial greases is very complex as they are composed of multiple semi-solid or solid substances whereas their final structure stays quite sticky.
The article identifies the emerging opportunities for industrial greases and existing drawbacks and challenges that the market participants are aiming to address. The key legislative and environmental factors affecting the industrial greases market are evaluated. The article further focusses on identifying the growth opportunities for bio-based materials in the industrial greases market.

1 Introduction

Industrial greases are one of the most important fluids extensively used by a large variety of industry branches. Their superior properties, durability as well as availability are highly appreciated by professionals. Since many years, different types of greases are employed to protect companies' equipment and machinery. Therefore, it is interesting to analyze the changes as well as future market opportunities for a market that is on the one side continuously developing and is on the other side at a mature stage. Market maturity is monitored especially in the well-developed regions such as North America and Europe. In both regions, it is observed that the average consumption level is persisted at a relatively constant level, with a tendency to decrease year-by-year due to shifting of manufacturing base to developing countries such as BRIC and ASEAN countries.

Industrial greases, not yet considered as a highly performing component, are showing a systematic growth. Especially environment compliant vegetable oils such as rapeseed and soybean oils are popular in the global market. Increasing popularity of bio-based materials is mainly driven by environment-oriented regulations. Additionally, it is supported by technological improvements, distinctive for industrial greases. Innovative solutions attract the interest of new industry sectors that look for the best performing products which are not harmful to the environment. Technologies used for greases are already advanced; nevertheless, biogreases are still not good enough to compete with mineral or synthetic products.

2 Industrial Greases

2.1 Composition of Industrial Greases

Grease typically consists of three main components that include base oil, thickener and additives (Fig. 1). Base oil is considered as a fundamental grease component. In most greases sold today, refined paraffinic and/or naphthenic petroleum oils are utilized. However, an extensive range of synthetic oils or synthetic fluids is also employed. Synthetic oils that are typically based on poly-alpha-olefins (PAOs), esters, poly-alkylene-glycols (PAG) and silicones are being chosen because of the specific properties they contribute to the industrial greases. For example, adding synthetic oils leads to a reduction or an increase of the operating temperature range. Additionally, these oils offer a good combination of performance characteristics and price. Moreover, the base oil used in grease production determines the type of industrial grease for end users. In general, three main groups of greas-

es exist in the worldwide market (Fig. 2), i.e. mineral oil-based greases, synthetic and semi-synthetic oil-based greases as well as environmentally-friendly greases.

Another crucial component used in greases is thickening agents, also called thickeners. Thickening agent can be a soap type or non-soap type. By adding it to a lubricating mixture, it increases its viscosity without substantially modifying its other properties such as lubricity. So, in general, thickener is a substance that, together with a fluid component, provides the solid or semi-fluid structure to grease. In total, there are many types of thickeners extensively used in the market of greases (Fig. 3). Additionally, from a technological perspective, grease can contain more than one thickening agent. Typically, such mixed and complex thickener-type greases are made of a combination of conventional lithium soap and a low molecular-weight organic acid used as complexing agent.

To sum up, one can observe that the most extensively used greases consists of salts of a fatty acid (soap) emulsified with mineral or synthetic base oil. As everybody who had the chance to work with greases knows that the most distinct feature of greases is their color and high initial viscosity, the type of thickener is normally the first decision making factor regarding the application. However, apart from base oil and thickener, the industrial grease has in its composition a third equally or even more important component. These are performance enhancing additives responsible for more individual and customized grease properties. These additives typically constitute up to 10% of the total grease weight, whereas the base oil can even account for 90% and thickening agents between 5% and 20%. Moreover, additives and the formulation behind additives are often kept confidential, protected by a number of patents. Additives play several critical roles in greases. They are able to enhance the existing desirable properties, suppress undesirable properties, and impart completely new ones. For instance, additives can improve the tolerance for extreme temperatures, pressure and even speed. So it is not surprising that these 10% of the grease weight distinguish one manufacturer from another and make one grease not compatible with other types.

Apart from these fundamental components, boundary lubricants such as molybdenum disulfide or graphite that reduces the friction can be suspended in the grease. These substances can suffer damages without adverse chemical reactions affecting metal surfaces during heavy loading and slow speeds.

Figure 1 Industrial Greases compositions (Source: Frost & Sullivan 2014).

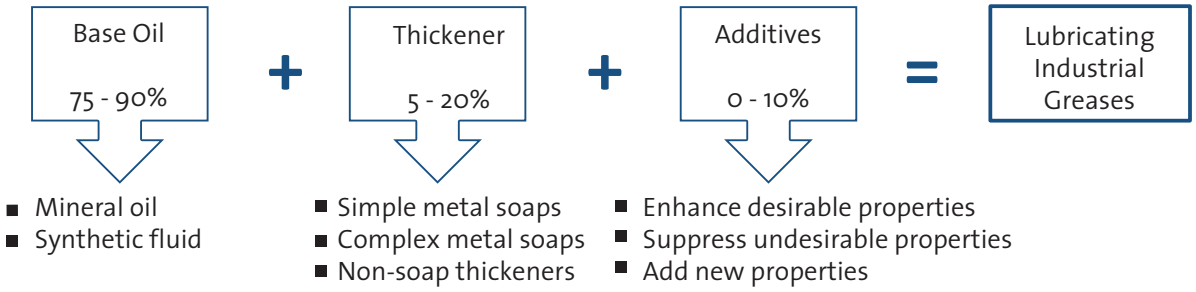
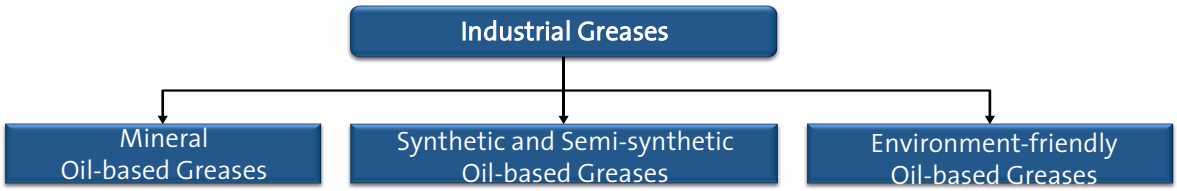


Figure 2 Industrial Greases types depend on the base oil used (Source: Frost & Sullivan, 2014).

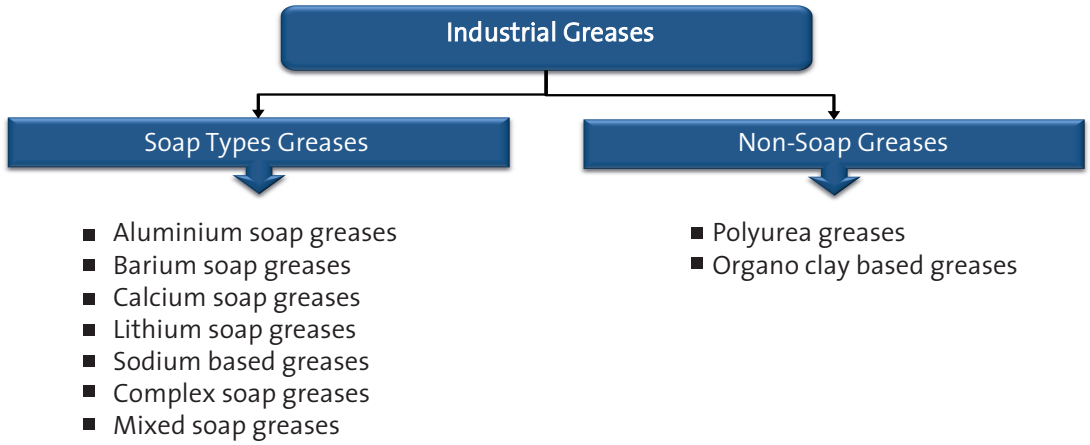


2.2 Functions of Industrial Greases

So, what is the main role of greases? Why is grease so important for machinery? To answers this, one should understand the purpose behind designing industrial greases. In general, industrial greases' main purpose is to minimize friction and wear between moving surfaces. A large number of greases currently available in the market are used in various rolling element bearings. Lower quantities are used in plain bearings, gearboxes and on open gears. Normally, grease for a given industrial application is expected to provide adequate lubrication to reduce friction and to prevent harmful wear of bearing components. Simultaneously, it protects surfaces in machinery against corrosion and acts as a seal that prevents access of dirt, moisture and water. Additionally, grease resists leakage, dripping or undesirable lose from the lubricated surfaces as well as intolerable change in structure or consistency in the bearing especially during prolonged service. Nowadays, industrial greases have suitable physical characteristics adjusted to their application area. They are compatible with seals and other types of materials of construction in the lubricated portion of the mechanism to maximize the comfort of working and the overall performance. Advanced industrial grease tolerates even certain degree of contamination, for instance moisture, without loss of its characteristics. Unfortunately or fortunately, depending on the point of view, there is no all-purpose grease. However, this increases the product variety and improves the competition between manufacturers. Otherwise there would be only one type of grease applicable everywhere. Isn't it a too idealistic perspective? Maybe, but despite large investments to design the most innovative and the best performing multipurpose grease, modern premium quality multipurpose grease are able to meet between 70% and 75% of all applications where grease lubrication is required. For the remaining 25% to 30%, many different and often highly specialized types of grease are necessary. Does it mean that key manufactures were not able to develop grease applicable for 100% of all applications? As it was mentioned at the beginning of this article, industrial greases are technologically quite interesting and at the same time quite challenging. Moreover, requirements of different industries vary quite significantly.

When industrial grease is used, the base oils, whether it is mineral, synthetic or vegetable oil, the grease is gradually degraded by temperature and pressure in the work piece that is being lubricated. This degrade process will continue until the oil becomes carbonized, unless fresh lubricating grease is applied periodically. As the base oil oxidizes in service, it becomes a contaminant and mixes with the collapsing and degrading base to become so-called "used grease". Typically it is extruded regularly as fresh industrial grease is added to the bearing or work piece. However, sometimes synthetic greases made of synthetic fluid rather than petroleum re required. Even though synthetic greases are affected in service in a similar way, they are characterized by high and/or low temperature capabilities and significantly longer service life. The extent of these capabilities strongly depends on the type of synthetic base oil, thickener type and enhancing performance additive formulation.

Figure 3 Industrial greases types depend on the thickening agent (Source: Frost & Sullivan 2014).



2.3 Market Overview

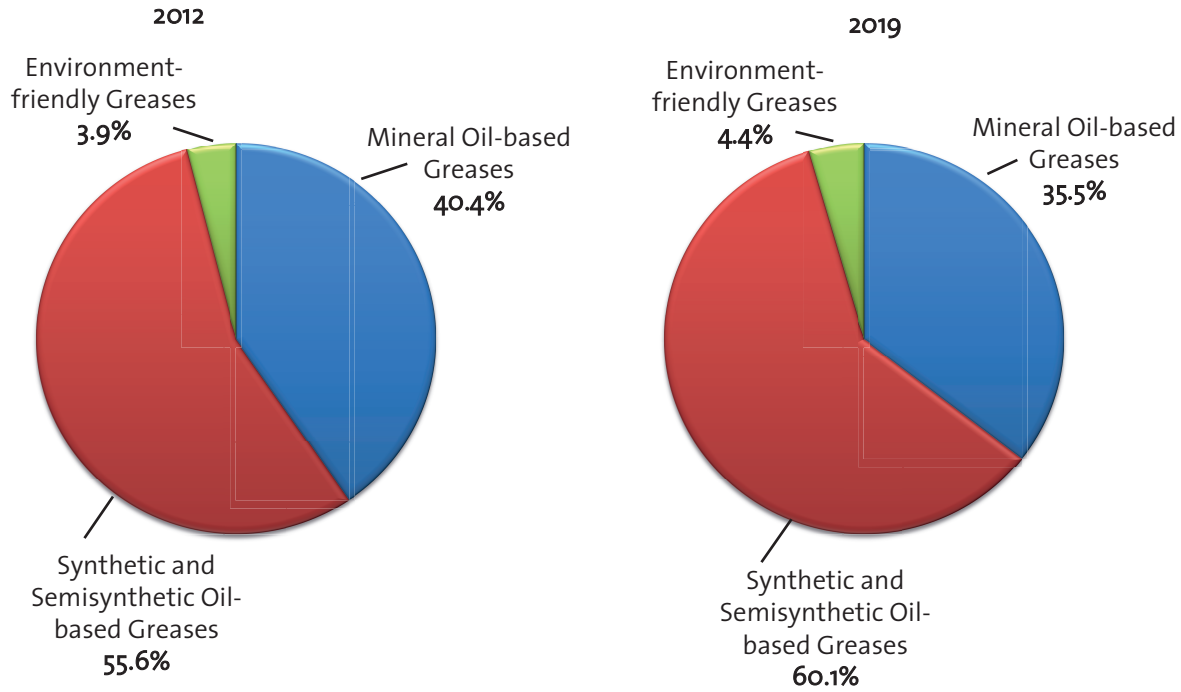
As greases are available in the market since 19th century, the market for industrial greases is quite old and mature. However, technological innovations and improvements are expected to boost market growth. For instance, Europe and North America are characterized by long-term experience and an extensive knowledge in this field. However, the most rapid growth at the moment is observed in emerging countries such as India, China and Brazil. It is crucial to mention that from the global perspective, the industrial grease market is highly competitive and dominated by key multinational corporations typically related to crude oil production.

Modern technologies, advanced equipment, environmental legislations as well as the application of new materials and systems are continuously demanding improvements equally in mature and emerging regions. Apart from innovation and advancement, the grease market struggles for solutions that are professionally adjusted to applications and specific customer needs. Due to inadequate recommendations, many customers still use grease incorrectly, especially at the wrong place, and thus destroying the overall performance of the grease and the equipment. Even if a grease supplier or distributor has a very wide range of greases, the selection is hardly ever a straight forward matter. The process of choosing the grease with the right physical and chemical properties for the application is quite complex.

The majority of industrial greases manufactured today predominantly uses mineral oil as fluid component. Mineral oil-based greases provide a satisfactory performance in many industrial applications and are less expensive in comparison to synthetic and semi-synthetic oil-based greases. Moreover, it is proven that in case of extreme temperatures, these greases provide better stability; however, they are less durable in comparison to other two types. While the mineral oil-base greases ac counted for 40.4% of the global industrial grease market revenue (in 2012) and are still dominant with regard to the volume consumed, synthetic oil-base greases are preferably employed in more severe or even quite exotic applications. In 2012, revenues for semi-synthetic and synthetic oil-based greases amounted to 55.6% of the global industrial grease market mainly due to higher prices (Fig. 4).

The most popular thickeners are metallic, mixed and complex-metallic soaps, which yielded 92% of the revenues generated by the global industri-

Figure 4 Percent sales breakdown in global industrial greases market market in 2012 and 2019 (Source: Frost & Sullivan 2014).



al grease market in 2012. Metallic soap thickener may include lithium, aluminum, barium, clay, polyurea, sodium, and calcium soaps. At present, lithium soap greases are the most dominating products in a global market that generated 52% of the global market revenues in 2012. Apart from the metallic soap greases, the complex thickener-type greases are rapidly gaining market popularity. These complex products often combine the conventional metallic soap with a complexing agent. One of the main reasons why these products are more and more appreciated by end users is related to their high dropping point and excellent load-carrying abilities.

Regarding the overall grease production cost, a significant proportion consists of the amount of soap that is required to achieve a certain National Lubricating Grease Institute (NLGI) grade as its solvating power affects the amount of soap needed. Besides soap type greases, also non-soap thickeners such as bentonite and silica aerogel are systematically gaining attention from the key industry participants such as Klueber, Petrofer and Quaker. These products are typically required by end applications that use greases in equipment or machinery operating in an extremely high-temperature environment.

Additives decide about the product competitiveness in the market. Therefore, there is a large variety of highly innovative products that are added to industrial greases. At present, the most extensively used additives are oxidation and rust inhibitors, extreme pressure, anti-wear, and friction-reducing agents.

2.4 Market Growth Direction

In 2013, the total industrial grease market generated $1,169.3 million and it is expected to grow at a compound annual growth rate (CAGR) of 6.6% between 2012 and 2019 (Frost & Sullivan 2014). This growth is relatively high despite of the increasing number of challenges, competition and legislative changes. The increasing need especially in emerging countries such as Brazil, Russia, India, China, and South Africa (BRICS) for improved performance and reliability as well as the sheer speed at which technology is moving drives the growth of this highly attractive market. Despite the fact that the industrial grease market is rapidly developing and changing, the dominant end user sector is not changing much. For many years, typically machinery and heavy industry as well as the infrastructure sector constitute the largest segment in terms of applications of mineral greases and less often application of synthetic industrial greases. Other equally important, however smaller end-user segments include pulp and paper, aerospace, mining, food processing, and power generation. With regard to bio-based greases, they receive impressively increased attention for marine and food-grade applications.

Interestingly, there are a group of customers in the automotive, aviation and mining segments as well as machine designers or builders that require suitable lubricating greases regardless of whether such products are feasible, costly, and widely available or require special development and improved manufacture technology. These customers are strongly influencing the research and development and hence the innovativeness of industrial greases.

2.5 Stimulating Factors Affecting Industrial Grease Markets

Year-by-year the industry grease manufacturers are facing an increasing number of challenges, drivers and constraints. It is well-known that the industrial grease market is not a simple market. It is impacted by different factors that often vary depending on the situation and economy. The most influencing challenges are related to environmentally-oriented legislations, regulations and certificates. High environmental concerns drive the need for more advanced, effective, and safe industrial greases. Legislative requirements affect the grease composition as it is controlled how and where the greases are stored, especially the "used greases". In this case legislative pressure accelerates the market growth; however, often significant legislative changes are problematic to small and medium-sized companies that do not hold a strong share in the market and are not strong enough to compete with larger manufacturers. Any change in composition extorted by legislation requires additional finances and delay in commercialization in the case when the product is registered. This legislative pressure, especially constantly tightening rules, restrains the immediate use of certain, innovative greases by end users. Other forces that accelerate the market growth combine the extensive range of industrial applications supported by technological improvements that introduce more sophisticated and efficient greases as well as awareness campaigns supporting bio-based products. The purpose is to increase the end users' knowledge about the performance benefits of bio-greases. Most of them still consider environmentally friendly greases as detrimental in terms of performance.

There is one factor that in general accelerates the revenue market growth and at the same time restrains the volume consumed. This factor is the improved industrial grease quality. On the one side,

higher quality products are attractive and appreciated in the market especially due to the extended durability and shelf life. So it became an advantage for higher quality industrial greases to last longer and be more effective. Because of this, end users do not need to replace these greases as often as is in the case of more conventional products. This clearly reduces the need for frequent grease replacement and parallel saves time, money and reduces the amount of used greases. Regarding restraining factors, the most meaningful one is the unstable economic situation. It influences the financial fluency of each of the industry sectors that apply greases. This often leads to reduced interest in more innovative and advanced industrial greases as manufacturers are skeptical and not willing to financially support research and development (R&D), especially at the time when everybody is looking for savings. Another restraint as it was mentioned earlier is caused by the fact that grease markets depend on the industrial customers and their overall market situation. The economic situation impacts the demand for different types of industrial greases as well as the need for certain equipment and grease replacement. Also high switching costs caused by typically low industrial grease compatibility lead to minimal willingness to switch to new products as well as to products offered by other manufacturers. It is quite comfortable to use the grease originally applied. However, when the whole equipment (and associated process chains) is immobilized, it is highly recommended to choose another grease.

At the end of the restraining factors list, there is competition. Competition not only results from multinational companies but also from cheaper and often lower quality products typically from Asia. Although the competition provides high entry barriers for new market entrants, it can be possible for the manufacturers of lower quality greases or customized products with limited availability to challenge these barriers. In the global grease market, often price is still the first decisive factor during decision making. The second one considers technology performance and innovativeness.

To conclude, it is still highly reasonable to expect a continued systematic growth of the global industrial grease market in the near. The same estimate is realistic for bio-based materials used to manufacture industrial greases.

2.6 Industrial Greases Market Trends

At the moment the most significant market trend is related to the fact that industrial greases are under a very strong pressure as they need to be developed for modern and often extremely demanding applications where high pressure, temperature and speed are the main requirements. Because of this, the manufacturers are continuously investing in new products and lubrication solutions by improving thickeners, additives and even based oils. This might be a potential opportunity for bio-based materials. Moreover, grease manufacturers are anticipating future demands and trends by following the direction of market development. High quality and innovative greases are significantly driving down maintenance costs and increasing the equipment as well as the whole production plant productivity. There is a general trend towards continuously improving the quality and performance of industrial greases as end users are more demanding. Simultaneously, advanced greases protect the equipment and machines better, enhance the reliability of working parts and improve the profitability. Therefore, major trends and developments are related to the fact that often the choice and adaptation of greases for the right application can be a huge challenge which needs to be addressed by manufacturers to meet the customers' needs.

At the same time it is critical to guarantee the consistent product performance with in-depth support knowledge. A long life under high-temperature conditions and considerable low-temperature fluidity is required for industrial greases used in bearings of engine electrical components. Normally, semi-fluid greases offer a prolonged protection. Another product trend is related to increasing the number of plastic elements. As an increasing amount of plastic material instead of metals is used, especially for the purpose of weight-saving, synthetic hydrocarbon greases are used to avoid any adverse effects on plastics.

Further trends are caused by other new, often niche applications that require special greases fulfilling specific requirements, such as conductivity and vacuum conditions. The trend typical in most industries is to maintain their machines for longer periods without re-greasing, and thus, especially synthetic greases are considered to be the best solution. One can also find some grease that addresses multiple applications. Multi-purpose industrial greases are highly popular between manufacturers as these products cover a wide range of applications, simplifying maintenance and reducing customers' stock levels. The high-temperature greases for the most severe conditions exhibit an increased popularity especially when we consider the well-established European and North American market.

2.7 Market Opportunities for Bio-based Materials

It can be monitored that there is a market opportunity for bio-based materials in the global market of grease production, especially for greases applicable in the marine sector and other environmentally sensitive areas. An increased availability and number of greases that are based on vegetable oils such as rapeseed and soybean oil can be observed. In 2012, oils based on rapeseed oil accounted for 26.5% and those based on soybean oil for 32% of the bio-based greases market. However, from the other side it seems that end users are not yet ready for such a drastic change, especially as the performance and durability require some additional developing effort. In addition, bio-based greases require the usage of comparably expensive raw materials which increases the overall price. As industrial grease end users quite price sensitive, they are not willing to pay for premium bio-based solution. To help to increase bio-based materials' popularity in industrial grease markets, governmental and legislative rules are required. Additionally, reduced prices and improved performance will also support the market opportunities for bio-materials in greases. It is also critical to provide industrial greases that do not contain lead or heavy metals which are considered to be harmful to human health and the environment. Additionally, it almost became a rule to offer products that are biodegradable, non-toxic and hence not harmful to the environment. Non-biodegradable greases of any kind should always be handled with great care, particularly by avoiding any contact with the skin.

3 Conclusions

There is a constant drive in the industry to create machines that are smaller, more sophisticated, and compact. At the same time, the machinery industry are building parts to serve multiple purposes. Hence, when working parts and moving components are brought closer to one another, the heat released will be higher than it would be under normal circumstances. Therefore, more customized, innovative, and advanced industrial greases are expected to drive the market economy whereby high quality, environmentally suitable, and more durable, multi-functional and efficient industrial greases are the most important end user needs at the moment. Biodegradability is also an important characteristic but to be made of bio-based material is not so critical for greases at present. Some bio-greases are present in key industry participants' product portfolios but they are often established for marketing purposes to demonstrate the manufacturer's willingness to be flexible and sustainable. Realistically saying, the industry seems to have no room for less effective products; therefore, industrial customers have to wait a few years before bio-based greases can offer equally attractive properties to those that currently dominate the global market. However, new regulations and requirements, environmentally suitable or acceptable standards, engine hardware changes, and the extension of oil drain intervals will put additional pressure on industrial grease manufacturers to increase the performance, durability, and robustness of greases as mechanical equipment operating conditions are becoming harsher as well.

There is an overall large potential for bio-greases; however, improving their performance will largely depend on manufacturers' promotions backed up by the necessary government policies that can enforce the usage of bio-lubricants in key areas such as hydropower plants.

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