Greases and Grease Thickener Systems

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Lubricating grease is one of the oldest lubricants used by man. Although the similarities and the technology of those days can barely match the current state of the art, yet the utilisation of animal fat-lime mixtures as a means of reducing friction, can be deemed as the ancient precursor of modern lubricating greases.

The market of lubricating greases is considered as "niche" when compared to the lubricating oils market, with the overall share representing 2-5% of all lubricants that are globally consumed.

This seemingly low market share by no means demonstrates the indispensable role that lubricating greases play and will continue to play in lubrication. In order to satisfy the increasingly challenging operating conditions a significant number of different chemistries have evolved since the first modern patent for calcium grease in 1835 - with the overwhelming majority of them still being active.

By all means the primary role of a grease is to reduce friction, but at the end of the day it has more functions than to lubricate.

Greases are utilised in various applications in the automotive and industrial sector – bearing, couplings, gears, ball-joints, cables etc - where liquid lubricants either cannot be employed or they are not able to give a sufficient level of performance. Compared to an equivalent liquid lubricant it can usually tolerate more extreme working conditions, within a wider temperature range offering better adhesion, lower noise and vibrations, while at the same time it will keep dirt and dust out, being more efficient when applied in humid environments.

Lubricating greases have a distinct physical form being a multi-phase system as a semi-solid, usually colloidal, non-Newtonian material. Grease is a thickened oil with a matrix equivalent to the so-called sponge-water system consisting of a thickener (5-25%) a lubricating-base oil (70-90%), plus additives that are components either oil soluble or solid to aid performance. A matrix of fibres or platelets with high surface area forming a dense 3D network of microstructures (voids) in which the oil is held in place until it is needed to lubricate.

Predominantly metal soaps are employed as thickening agents in greases that can be in the form of simple, "complex" or mixed-base matrix. Soaps based on calcium, lithium, aluminum, sodium are commonly employed and their "complexity" ranges from the simplest calcium (lime) chemistry up to calcium sulphonate complex. Non-soap thickeners (clay, polyuria, Polytetrafluoroethylene or PTFE) are utilised in greases intended for certain specialised application with specific requirements and therefore their use is about 10%.

With a more or less stable market share of more than 70%, lithium based greases constitute the lion's share of the total greases demand. However in terms of the grease thickener's trends, according to the latest Grease Production survey Report by National Lubricating Grease Institute (NLGI), Calcium Sulphonate greases show the most rapid increase compared to other thickeners with a Compound Annual Growth Rate (CAGR) of more than 12%.

Thickener type will affect grease selection in terms of fundamental properties such as, operating temperature, wet performance, pumbability and mechanical stability. Playing such a critical role the thickener system should be chosen based on the lubrication requirements, yet the proper combination of base-oil thickener can further boost the performance of a lubricating grease and/or can transfuse certain characteristics to the final formulation.

Still over 90% of all grease produced is based on mineral oil but other synthetic base stocks are increasingly used to improve service life and cope with harsh operating conditions. Moreover environmental esters can be used for high or low operating temperature applications depending on the ester chemistry or for environmentally sensitive applications as well.

Lubricating greases are often applied in loss lubrication systems where they inevitably leak onto the ground or water. Environmentally adapted biobased greases can be used either for general application or equipment working in areas where increased biodegradability, low toxicity is required such as in agriculture, forestry and marine. Although environmentally acceptable greases have been in commercial production for years, biobased production represents just over 0.6% of the total. The Vessel General Permit (VGP) programme has promoted the use of Environmentally Approved Lubricants (EAL) in certain marine applications in the US and similar frameworks could further increase the penetration of such products. Research activity is intense in the field of biogreases due to the need for increased renewability in view of the stricter environmental considerations as well as the incentives for circular-biobased economy.

Calcium sulphonate complex greases with novel base oils

As mentioned above the Calcium sulphonate greases appear to have the most distinct rising trend. These greases are preferred because of their ability to combine desirable fundamental characteristics in one soap-based thickening system such as high continuous operating temperature, outstanding load carrying properties, excellent resistance to water, very good wear preventive characteristics, good adhesiveness, while maintaining a very satisfactory level of mechanical stability. The fact that this type of special grease can be applied in a wide variety of applications makes it actually a premium multipurpose product that currently is almost exclusively formulated on mineral or synthetic base oils.

Within the context of biobased conceptual economy, the challenge is whether a more environmentally oriented Calcium sulphonate can be formulated but without diminishing the high performance character of these types of greases. In such a case esters can be utilised instead of mineral or synthetic base oils. In all greases in order to achieve a higher biobased content this automatically means that higher proportions of the renewable base oil should be used during cooking. Because of the special nature of Calcium sulphonate complex chemistry, the introduction of esters in the matrix is technically more challenging than in other soap-based grease chemistries.

Recent studies have focused on the evolution of Calcium sulphonate complex grease with increased renewability as a premium high performance multi-purpose biobased lubricant.

By developing a special manufacturing process to avoid side reactions with the esters and by employing novel tailor-made renewable and biodegradable polyol/complex biobased esters, Calcium sulphonate complex greases were formulated with an aggregate biobased content of over 50% in the final product. Although in theory this is not an EAL as per VGP - due to thickener type - yet biobased C is > 25% , so technically it can meet the renewable content requirements for biobased grease according to EN16807 standard for biolubricants.

The formulated ester-based Calcium sulphonate complex greases will demonstrate high dropping point, very good mechanical stability and equivocal wear preventive characteristics. Oxidation stability is comparable to the conventional counterparts, when determined per ASTM D8206 method (test method for oxidation stability of lubricating greases) unit. It is worth noticing here that for testing the oxidation stability of biobased greases, the relevant European Lubricating Grease Institute/NLGI Biobased Greases Working Group has found out that Rapid Small Scale Oxidation Test (RSSOT) and Pressure Differential Scanning Calorimetry (PDSC) could be used, yet the latter at less severe test conditions than the standard in order to give reliable and precise results.

The performance of the ester-based Calcium sulphonate complex grease in wet conditions testing implies that these type of renewable greases could be considered as high performance lubricants for marine applications. Additionally premium renewable products will become more and more essential for lubrication towards the materialisation of sustainable mobility/e-mobilty concepts.

Lubricating greases will continue to play a vital role in lubrication. With such a vast amount of available chemistries-formulations and thickening systems the industry can satisfy current and future needs as we move towards a low fossil carbon intensity society and economy,

The improved energy efficiency and the increasing utilisation of sustainable technologies and renewable feedstocks could be the key driving forces for the lubricating grease industry so as to target the low carbon footprint profile with less impact on the environment.

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