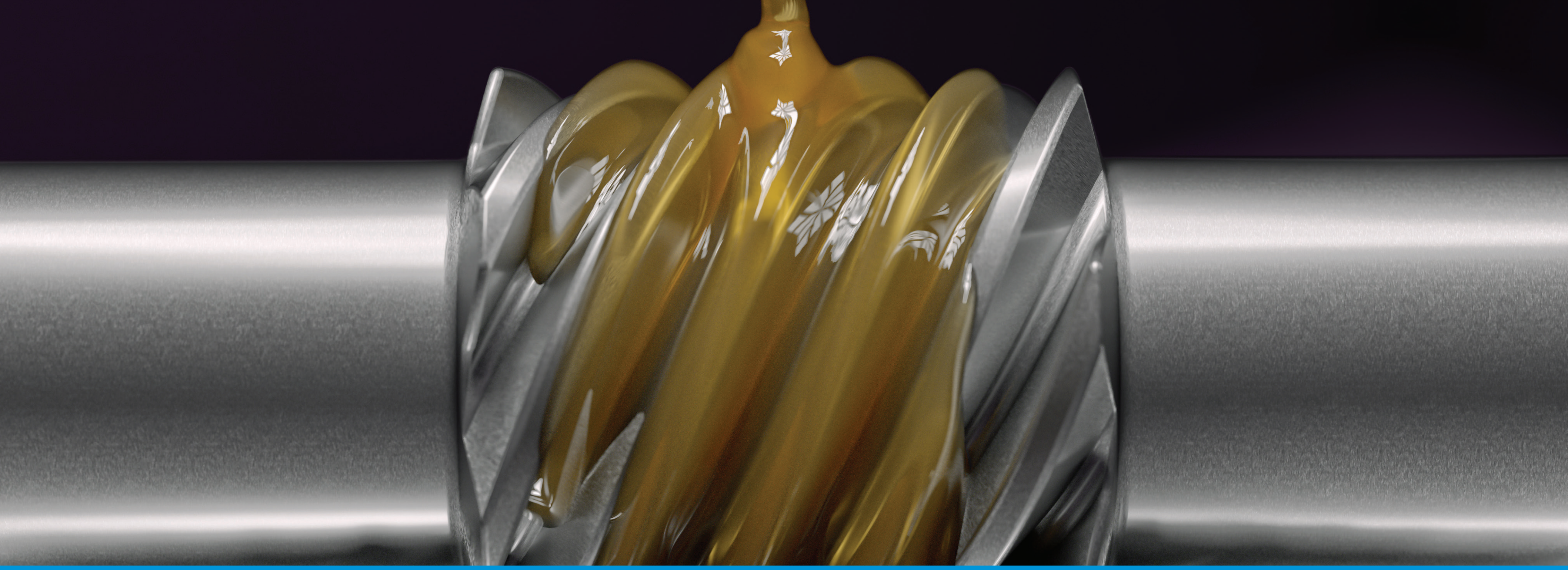

HOW ARE GREASES SELECTED IN REAL INDUSTRIAL APPLICATIONS?

Grease selection is always a very important topic to consider for industrial applications because ensuring use of the proper grease can increase equipment efficiency and lifetime and reduce wear. Not all greases are formulated the same and some are much better than others for certain specific applications. This article will explain the most important criteria for grease selection and will give insight into which major applications will require which type of grease or grease performance characteristics.

At first, it is relevant to look at which situations would warrant using a grease as opposed to a lubricating oil. Greases are preferred for machinery that operates remotely and is not easily accessible because the grease can provide lubrication for long periods of time and does not require frequent replenishment. Applications such as gearboxes which are sealed for life would also apply here and would be better served with greases. Greases are also preferred for machines that are in storage for lengthy periods of time or machines that run intermittently. Greases are a better option for applications in which wear is already present because of the more significant thickness of the lubricating film. Finally, extreme conditions with very high temperatures and also slow speeds with heavy loads are usually better treated with greases [1].

Lubricating greases consist of a base oil (70-95%), additives (0-10%), and a thickener (3-30%). In this regard, they are essentially a lubricating oil but are separated from this by the addition of a thickener, which turns the oil into a grease [1]. The most important criterion in grease selection is the viscosity of the base oil as most of the grease is composed of the oil. The choice of correct viscosity of the base oil will mainly depend on the speed and the operating temperature of the application. Finding the operating speed is usually done using either the DN method or the NDm method, with the latter being generally more accurate because it incorporates the pitch diameter instead of bore diameter of a bearing element. There are charts that will determine the minimum viscosity grade once the speed factor and operating temperature are known. Beyond the base oil viscosity, the type of base oil in the formulation can also play a large role in the appropriate application of the grease. The API Group I and II mineral oil base stocks are usually used because they function well in most scenarios. Group I mineral oils contain greater than 0.03 wt% sulfur and Group II contains less than or equal to 0.03 wt% sulfur. Synthetic base oils would serve better in applications with extreme temperatures, either very high or very low, and applications with a wide temperature range. Traditional synthetic base stocks are polyalpha-olefins (PAOs) but also include esters derived from vegetable oils [2,3]. Several additives can also be included to enhance the performance of a grease in certain applications. Some of the additives available include extreme pressure, anti-wear, or rust and oxidation inhibitors. The additives used depend on the nature of the application. Usually high-load situations will require extreme pressure additives as well as anti-wear, while a more high-speed and low-load situation would not need the extreme pressure additive [4].

Consistency is another important characteristic of grease and which consistency is chosen will depend on the application. The consistency is defined by NLGI as "the degree of deformation of the grease under the application of a force." [5] The consistency is categorized based on grades set forth by the National Lubricating Grease Institute (NLGI) and these grades are numbers ranging from 000 up to 6, with 000 being a semifluid and 6 being akin to a block. Both Tables 1 and 2 below give a general overview of how to address consistency for different applications. Although these rules might be applied generally, certain applications may require a very specific type of grease.

Grease consistency is largely affected by the thickener type and there have been different thickeners developed with different properties and characteristics. The most common types of thickeners are the simple lithium soaps and lithium complex, which is a simple lithium soap with an added complexing agent [2]. Lithium soap greases are very cost effective, have dropping points above 180°C, good structural and shear stabilities, and good water resistance. Other properties such as oxidation stability and antiwear performance are not as good in lithium soaps but these can be improved through additives. The lithium complex greases perform in a similar way to simple lithium soaps but the dropping point can go up to 50°C higher than simple lithium. The maximum operating temperature for lithium complex is around 175°C while it is usually only 140°C for simple lithium soap. In addition to the lithium soap/complex thickeners, there are aluminum soap, barium soap, and calcium soap greases, all of which can also be combined with a complexing agent. Aluminum soaps have good water resistance but have poor shear stability, low dropping point, and become rubbery after being exposed to temperatures above 170°C. Because of these disadvantages, lithium soaps are preferred. The aluminum complex greases have better mechanical stability than simple aluminum, good water tolerance, and dropping points of 250°C and higher, but they are less cost-effective than the lithium soaps. Barium soaps were widely used in the past because of their good water and shear stabilities and high dropping points around 177°C. Disadvantages such as instability in low temperatures and high speeds and also environmental concerns led to their phasing out. Barium

complexes are good for their high dropping points but also lack in environmental and toxicological safety. Calcium soaps have good mechanical properties such as good water resistance and adhesion, are good for low-temperature applications, and resist washout from bearings. They are fairly cheap to produce as well. Their disadvantages include instability in high-speed applications, low dropping points around 95°C, and low maximum working temperature of around 80°C. Their usual applications are in water pumps, wet machinery, and equipment exposed to weather due to their excellent water resistance. Calcium complex greases are actually the second most used after lithium soaps because of high dropping points of 260-300°C, good water resistance, good shear stability, and low tendency to bleed excessively. The downside is poor low-temperature performance and they are not always compatible with other greases. All of these greases mentioned previously are soap greases but about 17% of the market share is made up of non-soap greases, which mainly consist of those

NLGI number applications based on speed factor (DN) and operating temperature	
1	Good for: DN 0-75,000 & -34 to 37°C
2	Good for: DN 0-150,000 & -17 to 65.5°C
3	Good for: DN 75,000-300,000 & 37.7 to 135°C

Table 1. NLGI grades (left column) and corresponding speed factor and temperature [2].

Applications for higher NLGI (NLGI 1-4)	Applications for lower NLGI (NLGI 000-1)
-Journal bearings	-Low-speed rolling element bearings
-High-speed rolling element bearings	-Low operating temperatures
-Applications with concern for bleeding and water washout	-Good pumpability required
-Dusty conditions	-Filled-for-life (e.g., gearboxes)
-High operating temperatures	
-Applications prone to leakage	

Table 2. Different applications for high and low-consistency greases [6].

derived from polyurea and organo-clay. Some of their general advantages compared to soap greases are higher dropping points, better cold flow properties, better water stability, better oxidative stability, and better stability in consistency. Some of their general disadvantages include no compatibility with other greases and they have more difficult production processes [7].

The art of grease selection is going to be completely dependent on the lubrication requirements of the specific application, and there is very rarely a grease which is a "one size fits all." Sometimes, a certain grease will be very good for a specific characteristic while also being not so good in another important characteristic. In this case, the importance of each specific characteristic and property must be weighed in terms of the specific application to find the best grease. Finally, it is important to remember that in the applications where greases are most appropriate, they will need to serve some basic functions: reduce frequency of relubrication, prevent wear, act as a sealant, protect against rust, corrosion, and oxidation, protect elastomer seals, minimize leakage, and reduce noise or vibration, among other requirements [7].

The authors would like to thank Ms. Melissa Quinn of BP international for her review and useful comments

References

[1] Wright, J. "Grease Basics." Machinery Lubrication, May 2008. https://www.machinerylubrication.com/Read/1352/grease-basics

[2] Noria Corporation. "Step-by-Step Grease Selection." Machinery Lubrication, September 2005. https://www.machinerylubrication.com/Read/798/grease-selection#:~:text=%20Step-by-Step%20Grease%20Selection%20%201%20Base%20Oil,step%3A%20The%20consistency%20of%20grease%20is...%20More%20

[3] Brown, S. F. "Base Oil Groups: Manufacture, Properties, and Performance." Tribology & Lubrication Technology, April 2015.

[4] Sumerlin, S. "The Rights and Wrongs of Greasing: From Selection to Application." Machinery Lubrication, March 2010.

[5] Moon, M., Turner, D., and Tuszynski, B. "NLGI Grease Glossary." https://www.nlgi.org/grease-glossary/

[6] Noria Corporation. "Consider Consistency When Selecting Grease." Machinery Lubrication, December 2012.

[7] Rizvi, S. Q. A. "A comprehensive review of lubricant chemistry, technology, selection, and design." ASTM International, West Conshohocken, PA, 2009.

About the Authors

Dr. Raj Shah is a Director at Koehler Instrument Company in New York, where he has worked for the last 25 years. He is an elected Fellow by his peers at IChemE, CMI, STLE, AIC, NLGI, INSTMC, The Energy Institute and The Royal Society of Chemistry An ASTM Eagle award recipient, Dr. Shah recently coedited the bestseller, "Fuels and Lubricants handbook", details of which are available at

https://www.astm.org/DIGITAL_LIBRARY/MNL/SOURCE_PAGES/MNL37-2ND_foreword.pdf

A Ph.D in Chemical Engineering from The Penn State University and a Fellow from The Chartered Management Institute, London, Dr. Shah is also a Chartered Scientist with the Science Council, a Chartered Petroleum Engineer with the Energy Institute and a Chartered Engineer with the Engineering council, UK. An adjunct professor at the Dept. of Material Science and Chemical Engineering at State University of New York, Stony Brook, Raj has over 400 publications and has been active in the petroleum field for 3 decades. More information on Raj can be found at

https://www.petro-online.com/news/fuel-for-thought/13/koehlerinstrument-company/dr-raj-shah-director-at-koehler-instrumentcompany-conferred-with-multifarious-accolades/53404

Mr. Nathan Aragon studied Chemical engineering at SUNY, Stony Brook University, and currently works at Koehler Instrument Company, in Long Island, NY.

Nathan Aragon

Author Contact Details

Dr. Raj Shah, Koehler Instrument Company • Holtsvile, NY 11742 USA • Email: rshah@koehlerinstrument.com • **Web: www.koehlerinstrument.com**