

Lubricating Grease Basics

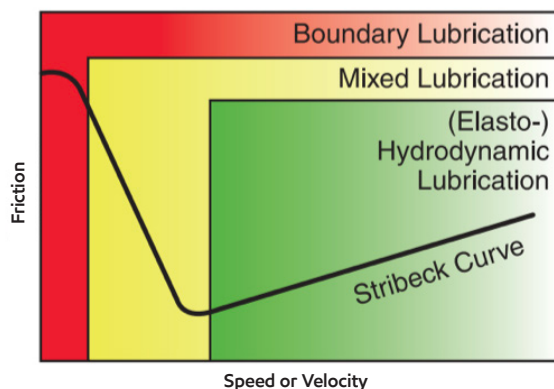
Technical Topic

Lubrication, whether with a lubricating oil or grease, focuses on the same key principle: building an oil film between two mating surfaces that move relative to each other, to separate the surfaces and prevent them from touching. Achieving this goal reduces friction and can help prevent wear caused by direct surface-to-surface contacts. Selecting the right viscosity oil is critical to preventing surface-to-surface contact: It's the oil that does the lubrication!

Optimum equipment performance and wear protection is achieved when the two surfaces are fully separated by the oil film. Under these conditions, friction is low and wear is minimized. The relationship between friction, fluid viscosity, and application conditions is described by the Stribeck Curve.

It's All About the Oil Film

- Under boundary- or mixed-lubrication conditions, the oil film is not sufficient to fully separate the mating surfaces. Contact of the surfaces can occur, causing friction and subsequently wear, which can lead to premature equipment failure. To prevent wear under these conditions where the oil film is not sufficient to separate the surfaces, lubricating grease formulators use additives to reduce friction and minimize wear.



- Under hydrodynamic lubrication conditions, oil film thickness is dependent on fluid viscosity, surface speed, surface finish, and load. Elasto-Hydrodynamic Lubrication (EHL) also factors in an oil's viscosity increase and elastic deformation of the surface geometries under conditions of the applied pressure.

While the lubrication principles for oils and greases are the same, the fundamental difference between the two is the method by which the oil is supplied to the contact zone. Lube oils of ten require complex ancillary support equipment to condition and deliver the oil to the contact zone, prevent leakage, and minimize contamination ingress. In contrast, lubricating grease delivers the oil via the thickener matrix. This matrix serves as a reservoir of lubricating oil for future use, as well as a method to keep the oil in place in application. A good way to think of grease is to consider it as a sponge (thickener matrix) soaked in oil. Under no-stress conditions, the sponge holds the oil within its matrix, ready to be released to provide lubrication. When stressed in application (e.g., rotation, churning, temperature, etc.) the sponge releases the oil to provide the necessary oil film. In addition to providing lubrication, grease also serves as a seal preventing environmental ingress that can lead to premature failure of the grease and the lubricated equipment.

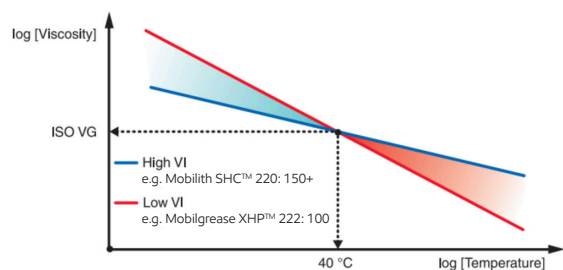
Benefits of Synthetics

Selecting the correct base oil viscosity of a grease is one of the most critical parameters considered when selecting a grease for an application. Various tools are available to help determine the proper oil viscosity under the specific conditions of the application and intended use.

Viscosity is temperature dependent; this relationship is described by the viscosity index (VI). High-VI base oils demonstrate a smaller change in viscosity over a wide temperature range compared with low-VI base oils, resulting in a thicker lubricant film over the full range of operating temperature when using synthetics. When effective lubrication over a wide temperature range is required, high-VI synthetic base oil provides the greatest benefit.

- Higher viscosity at high temperatures: Compared with conventional mineral oils, high-VI synthetic oils provide higher viscosity at elevated temperatures. Consequently, synthetics provide thicker lubricating films at high temperatures, providing increased friction reduction and wear prevention.
- Lower viscosity at low temperatures: Compared with mineral oils, synthetics also provide better fluidity at low temperatures, providing less resistance to movement of mechanical parts. Consequently, synthetic base oils enable starting up equipment at lower temperatures, while still providing sufficient fluidity to penetrate lubrication points.

High-VI synthetic base oils can also help mitigate some of the factors affecting controlled release of lubricating oil from the thickener matrix during service.



Grease Performance Retention

After selecting the correct base oil type and viscosity, the next challenge is to ensure the controlled release of the lubricating oil to the critical contact zones. Even the best oil will not provide good lubrication and trouble-free operation of grease-lubricated equipment if it is not available at the right time, in the right amount. Too much oil release will cause the grease to “dry out,” causing wear and premature failure. Too little oil release will provide insufficient oil film, again resulting in wear and premature failure.

In operation, lubricating greases as lube oils will undergo property changes, e.g., through thermo-oxidative degradation. However, due to their very nature, performance retention of lubricating greases in service depends on additional lubricant parameters, most importantly, consistency and mechanical stability.

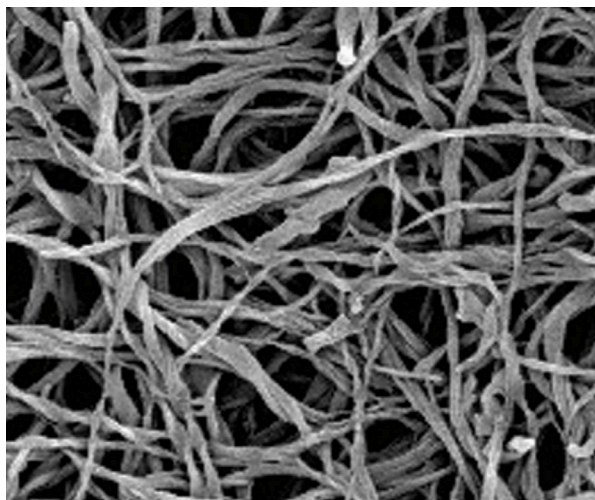
Consistency

Under the mechanical stresses of an application, some lubricating oil is “squeezed” out of the grease thickener matrix and delivered to the lubrication points, providing the lubrication, film formation, and wear prevention that is required to ensure optimum equipment performance.

Controlling this oil release requires the formulator’s skills to carefully balance the cohesive forces between lubricating oil and thickener matrix.

When properly formulated and manufactured, a well-balanced grease can even reabsorb some of the released oil, providing a reserve of lubricant to be released in the future when needed to provide lubrication. As noted previously, to effectively release oil to lubricate, the grease thickener matrix must be subjected to an external stress, such as shear. If the lubricating grease is too “stiff” to migrate into the zone of mechanical work, release of lubricating oil may not be sufficient to support effective lubrication (channeling effect) and equipment protection.

Low temperatures can significantly reduce the oil-release characteristics of grease, leading to insufficient lubrication and, potentially, to wear and, finally, equipment failure. High-VI synthetic base oils can



Grease contains a thickener like the soap fibers pictured above, which hold a lubricating oil in suspension.

help ensure sufficient flow of lubricating oil under these low-temperature conditions. This is particularly important at start-up, when speeds are too low to build up an EHL film.

Conversely, excessive oil separation can lead to starvation of the lubrication points when the grease has “dried out” (excessive oil separation during storage is usually a sign of improper storage conditions and/or poor manufacturing practices; see Technical Topic: Grease Oil Bleed).

Consistency is related to thickener type and content. In general, simple soap-based greases present higher oil release than complex soap greases, all other variables being held consistent (additives, base oil type, etc.). Softer greases with low thickener contents tend to release oil more readily and, thus, are often preferred at lower operating temperatures to facilitate sufficient release of lubricating oil.

Mechanical Stability

While some shear is necessary to enable release of the lubricating oil from the grease matrix, excessive shear can irreversibly destroy the thickener matrix and, thus, can cause excessive softening. Once the thickener structure is destroyed, the grease will not stay put and oil leakage can occur.

Water and other environmental contaminants can also affect the thickener matrix, causing severe hardening or softening. In the extreme, water can displace the oil phase causing oil loss. Selecting the right thickener type is key to avoiding such failures. In general, complex soaps are more shear-stable than simple soaps, while polymer additives can be used to enhance structural stability under shear and improve water resistance.

Thermal-Oxidative Stability

High temperatures can trigger many different grease failure mechanisms, directly affecting the effective useful grease performance life. Under high temperatures, two mechanisms can occur that can cause grease failure.

The first mechanism is oil oxidation, which can lead to increased oil viscosity, deposits, and the loss of the ability to form a protective lubricant film. The second, unique to grease, is the loss of the ability of the thickener to retain to the oil phase. This temperature-driven tendency will, in the extreme, lead to the permanent loss of lubricating oil.

As a general rule of thumb, the rate of chemical reactions (which would include oxidative and thermal degradation) changes by a factor of 2 for every 10°C (18°F) change in temperature, e.g., increasing temperature by 10°C (18°F) would double the rate of reaction, reducing the life expectation by 50 percent. Elevated temperatures drive grease failure modes quickly as they increase.

Complex soaps generally provide better thermal resistance compared with simple soaps, while polyurea and organic clay thickeners can resist extremely high temperatures. Synthetic base oils have inherently better oxidation stability than conventional mineral oils and can bring high-temperature benefits to lubricating grease life, while many EP/AW additives can promote thermal-oxidative degradation.

Summary

Selecting the correct lubricating oil viscosity for the application is the most important factor influencing grease lubrication. Once the proper oil viscosity and type have been selected, ensuring the proper level of oil release becomes the limiting factor affecting a grease's ability to perform in application, providing trouble-free grease lubrication.

Any factor that deteriorates a grease's ability to provide lubricating oil to an application in a controlled manner will affect the ability of the grease to provide effective lubrication and can lead to lubrication failure. Grease consistency and shear stability of the thickener matrix are key performance features that must be considered when selecting a lubricating grease.

In service, a grease can be affected by excessive mechanical shear, low and high temperatures, thermal-oxidative degradation of thickener and lubricating oil, as well as water ingress and other contaminations that can inhibit the ability to provide optimum lubrication and peak performance.

If you're in doubt or want to know more about Mobil™ greases, contact your Mobil™ Technical Help Desk or Field Engineer for assistance.

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