Greasy Times - Part 1

The hows and whys of greases.

Courtesy of the Lubrizol Corporation

A grease consists of two basic structural components: a thickening agent and the base fluid in which that thickening agent is dispersed. Many types and combinations of thickeners and base fluids, along with supplemental structure modifiers and performance additives, give final grease formulations their special properties.

Simple Soap-Based Thickeners

Simple soaps are formed when a fatty acid or ester, of either animal or vegetable origin, is combined with an alkali or alkaline earth metal and reacted, usually with the application of heat, pressure or agitation.

Thickener	Grease Characteristics	Applications
Aluminium	Smooth, gel-like appearance Low dropping point Excellent water resistance Softening/Hardening tendencies Greatly dependent on shear rate	Lubricate low-speed bearings Wet applications Usage decreasing
Sodium	Rough, fibrous appearance Moderately high dropping point Poor water resistance Good adhesive (cohesive) properties	Older industrial equipment Where relubrication is frequent Rolling-element bearings
Calcium	Smooth, buttery appearance Low dropping points Good water resistance	Bearings in wet applications Railroad rail lubricant
Lithium	Smooth, buttery to slightly stringy appearance High dropping point Resistant to softening and leakage Moderate water resistance	Automotive chassis and wheel bearings General industrial grease Thread lubricants for the oil-drilling industry

The consistency of a soap-based grease depends on the following thickener-related parameters:

- Amount of soap
- Chain length of fatty-acid substrate
- Degree of branching
- Amount of unsaturation
- Presence of polar groups in the fatty-acid chain
- Inclusion of special structure modifiers
- Particle size

Increasing the amount of soap almost always produces a corresponding increase in consistency or stiffness. The consistency, as well as other physical properties, of soap-based greases may be modified by incorporating certain chemical agents called structure modifiers. Particle size is also an important parameter affecting the consistency of soap-based greases.

Calcium soaps: Conventional calcium soap or lime-based greases are prepared by reacting fatty acids or esters with calcium hydroxide in a mineral-oil medium. As a result of the small, closely packed fibres which constitute their structural framework, products thus produced have a smooth texture.

The principal advantages of calcium-soap greases are:

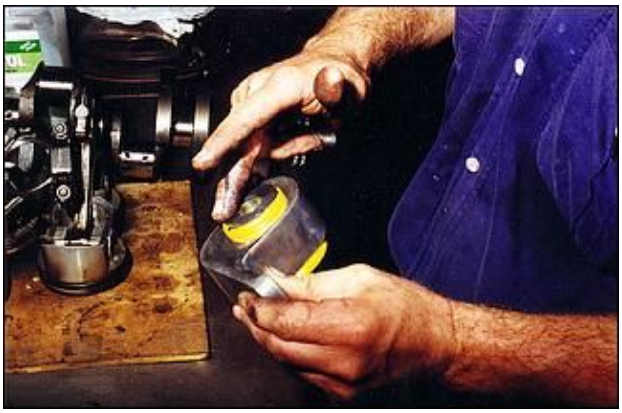
- They are, perhaps, the least expensive soap-based greases to manufacture.
- They are not emulsifiable in water; therefore, they resist washout from bearings. At low temperatures, they suffer no phase transformation and remain pumpable.

Their major disadvantage is that the maximum working temperature of water-stabilized, calcium-soap greases is only about 90 degrees C; greases derived from 12-hydroxystearate can function at 120 to 130 degrees C. Calcium-soap greases are primarily used to lubricate water pumps, wire ropes and machinery components operating under mild conditions. Their use in plain and rolling-element bearings is severely limited by their low thermal stability and susceptibility to shear.

Sodium soaps: The thickener in sodium-based greases is formed by the reaction of fatty acids or esters with sodium hydroxide in a mineral oil medium. Sodium-soap greases have a spongy texture. These greases have largely been displaced in industrial applications because of their lack of versatility. Also, sodium-soap greases are extremely limited in modern bearing applications because of their high degree of water solubility. Sodium greases are also susceptible to phase transformations and hardening. However, sodium greases do possess certain desirable features which make them useful in some rolling-element bearings, high-speed spindle bearings and gears, including:

- Excellent rust and corrosion inhibiting properties
- Good high-temperature stability
- Average shear stability

The maximum temperature for sodium greases in rolling-element bearings is about 100 degrees C, although sodium 12-hydroxystearate greases are slightly more thermally stable.



Lithium soaps: Lithium greases are the most important and versatile of the soap-based products and account for at least 50% of US grease production. The substrate of choice in 60 to 70% of all domestically produced greases is 12-hydroxystrearic acid. Lithium greases are prepared by reacting fatty acids or esters with lithium hydroxide in mineral oil. They exhibit a smooth, stringy texture.

The advantages of lithium greases include:

- Exceptional shear stability; suitable for use in high-speed plain and rolling-element bearings.
- High dropping points and good thermal stability. Maximum service temperature approaches 140 degrees C.
- Good tolerance for water.
- Rust and corrosion protection is at least equal to that of sodium greases.

Additives (rust inhibitors, oxidation inhibitors, EP agents) usually show greater response than in other soap media; therefore, lithium greases are more easily tailored to specific conditions and environments.

Calcium complex soaps: Calcium complex greases are used to lubricate rolling-element bearings operating at temperatures of 160 to 200 degrees C. (Compare with a maximum working temperature of only 90 degrees C for simple calcium soap greases.) Beyond this range, they begin to destabilize.

Thickener Type	Grease Characteristics	Applications
Aluminium Complex	Smooth, slight gel-like appearance Dropping points above 260 degrees C Good water resistance Resistant to softening Shorter life at high temperature	Steel mill roll neck, rolling and plain bearings
Calcium Complex	Smooth, buttery appearance Dropping points above 260 degrees C Good water resistance Inherent EP/load-carrying capability	High-temperature industrial and automotive bearing applications
Lithium Complex	Smooth, buttery appearance Dropping points above 260 degrees C Resistant to softening and leakage Moderate water resistance	Automotive wheel bearings High-temperature industrial service including various rolling-element applications

Lithium complex soaps: Lithium complex soaps tolerate higher temperatures and offer longer service life than their simple-soap counterparts. Typically, dropping points are above 260 degrees C, or about 80 degrees C higher than those of conventional lithium greases. The maximum service temperature for lithium complex greases is about 175 degrees C while simple lithium greases generally will not tolerate service temperatures above 140 degrees C.

Aluminium complex soaps: Aluminium complex greases of optimal composition have dropping points approaching 260 degrees C, while simple aluminium-soap greases may have a dropping point of only 110 degrees C. In addition to having good high-temperature properties, aluminium complex greases are shear stable and resist water washout. Thus, they are a competitive alternative to calcium complex greases for the lubrication of rolling-element bearings. Their principal shortcoming is inherently poor rust and corrosion resistance, which cannot always be easily corrected with supplementary additives.

Organic Non-Soap Thickeners

Polyurea greases are characterized by good water resistance and good thermal stability. Because of their durability, polyurea greases are frequently used in sealed-for-life bearings which are filled during assembly, permanently sealed and operated without relubrication for the normal life of the equipment. Polyurea greases tend to be more costly than conventional soap-based greases because they require more sophisticated processing and their raw materials are more expensive. The poor pumpability of certain polyurea greases limits their use in large centralized systems.

Thickener Type	Grease Characteristics	Applications
Polyurea	Smooth, slight opaque appearance Dropping points above 230 degrees C Good water resistance Oxidation resistant Less resistant to softening and leakage	Industrial rolling-element bearings Automotive constant velocity joints
Organo-Clay	Smooth and buttery appearance Dropping point above 260 degrees C Resistant to leakage Good water resistance	High-temperature bearings with frequent relubrication Steel mill roll neck Steel mill roll neck bearings

Inorganic Thickeners

The special characteristics of greases based on inorganic thickeners - primarily clays and silica - have made them useful in specific, demanding applications.

Clays: Two clays of the montmorillonite group - bentonite and hectorite - are the most important inorganic thickening agents. Greases based on these materials are functional over extremely wide temperature ranges because they lack melting points and resist other phase transformations. Thus, clay-based greases are valuable for aerospace applications.

Silica: Silica-based thickening agents are prepared by treating finely dispersed sodium silicate with di-isocyanates or epoxides. The resulting gel structure is amorphous rather than crystalline. Because of their tolerance for radiation, silica greases containing aromatic base fluids are often used for lubricating rolling-element bearings in nuclear power plants.

Next week: the base fluids

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