

# Lubricating Greases

## Description

There has been a need since ancient times for lubricating greases. The Egyptians used mutton fat and beef tallow to reduce axle friction in chariots as far back as 1400 BC. More complex lubricants were tried on ancient axle hubs by mixing fat and lime, but these crude lubricants were in no way equivalent to the lubricating greases of modern times. Good lubricating greases were not available until the development of petroleum-based oils in the late 1800's. Today, there are many different types of lubricating greases, but the basic structure of these greases is similar.

In general, grease consists of a thickening agent dispersed throughout lubricating oil. The thickening agents or gellants include alkali metal soaps, clays, polymers, carbon black, colloidal silica and aluminum complexes. The lubricating oil may be petroleum oil or synthetic oil. The most common type of grease is the soap-based grease. The soap comes from animal or vegetable fats or fatty acids, wool grease, rosin or petroleum acids. The lubricating oil is commonly mineral oil from paraffinic, naphthenic or aromatic hydrocarbons. Other components of these greases include unreacted fat, fatty acids and alkali, unsaponifiable matter (including glycerol and fatty alcohols), rosin or wool grease and water. Some of the other additives used in grease are oxidation inhibitors, rust and corrosion inhibitors, color stabilizers, metal passivators, water repellants and viscosity index improvers.

In soap greases the metallic soap consists of a long-chain fatty acid neutralized by a metal such as aluminum, barium, calcium, lithium, magnesium, sodium or strontium. The fatty acids usually contain 16 to 18 carbon atoms. A common form of soap-based grease uses lithium 12-hydroxystearate as the thickener. To properly thicken the grease the soap must be in the form of fibers of suitable size

dispersed throughout the lubricating oil. The crystalline fibers are usually in the size range of 1 - 100 micrometers with diameters 0.1 to 0.01 of their length. For good shear stability the fiber should have a large ratio of length to diameter, and for good oil retention the fiber should be as small as possible. Therefore, greases need a mixture of these two types of fibers. Also, there must be a balance between the solvency of the fluid and the solubility of the soap to get suitable thickening.

Another type of thickener that is not soap-based is prepared from clays. The clay, such as bentonite or attapulgite, is reacted with a quaternary amine to change the clay from hydrophilic (water-loving) to hydrophobic (water-rejecting) and oleophilic (attracting oil). Effective thickening is achieved by combining the clay with a polar activator or dispersant, such as acetone, methanol or ethanol, with small amounts of water and by delaminating and reducing the platelets to a small size. This process will increase the total surface area of the dispersed clay, which immobilizes a very high percentage of oil based on the weight of clay. This will thicken the grease.

Other solid additives produce thickened grease by the nature of their fine dispersion throughout the fluid and by their particle-particle interactions. Solid-additive greases extend the operating temperature range over soap greases. The solid-type greases do not have a melting point, and their upper temperature limit is that of the oil being used.

The melting point of greases made with various soaps will differ appreciably. For example, using the grease dropping-point temperature, which measures temperature limitation of the grease, the following demonstrates the differences in these temperatures: aluminum - 230°F (110°C); sodium - 325 - 350°F (163 - 177°C); calcium (conventional) - 205 - 220°F (96 - 104°C); calcium (anhydrous) - 275 - 290°F (135-143°C); lithium - 350 - 400°F (177 - 204°C).

The dropping temperature of soap-based greases can be increased by using soap complexes. These complexes consist of a soap-salt thickener. For example, an aluminum complex might consist of aluminum with a fatty acid, a nonfatty acid and an alkali. Then each molecule of thickener consists of aluminum complexed with stearate, benzoate and hydroxide. The dropping point of a complex grease is at least 100°F (56°C) higher than the dropping point of the corresponding soap grease. The range of application of greases is also extended by "multipurpose" greases that consist of mixtures of soap bases or different metals and soaps.

## Processing

Greases can be made in either a batch or continuous process. Batch production is the most common manufacturing method. The steps of manufacturing include the following. Bulk ingredients are metered or weighed into the processing reactor. For soap-based greases made by saponification (the process of forming soap by splitting a fat with an alkali), the fatty ingredient, alkali and a portion of the oil are added to the reactor. By heating (300 - 450°F) and mixing, the fat is converted to soap, and the soap is dispersed throughout the mixture. This may be done in open kettles or in closed pressure kettles. After completion of saponification and dehydration (removal of water), the remaining oil is added to the batch to lower the emperature. Next, the grease is milled or homogenized.

This step of homogenization or milling is very important, because it will produce a uniform crystal and gel structure that will not change when the grease is used. Homogenizing the grease will break down the solid particles or fibers and will disperse the resultant small particles in the liquid. It also breaks up lumps, eliminates graininess and produces a smooth product. Homogenization of certain types of greases will stiffen the grease producing lower penetration value. Homogenization can improve texture and "brighten" a grease's appearance. In many cases this homogenization process is carried out at temperatures greater than 200°F (93°C).

After homogenization, the grease is further cooled, deaerated and packaged. Of course, it is understood that there are many different grease manufacturing methods depending on the type of grease and the manufacturer.

APV homogenizers are used for processing grease. The single-stage homogenizer with wear-resistant parts may be operated at up to 10,000 psi. The homogenizer is the preferred piece of equipment for the solid-additive type greases, because high energy is needed to break up and delaminate the particles such as with clay dispersions. Although a colloid mill can be used to process grease, there are advantages to using the homogenizer. First, the homogenizer is a constant-displacement pump, and its capacity does not vary with different grades of greases. This makes it possible to tie into filling equipment, if desired. The colloid mill must be pump fed and the capacity will be significantly decreased on the stiffer grades of greases. The homogenizer has sufficient pressure to deliver the grease to any point in the process after it has been homogenized; but a second pump must pick up the colloid mill product, if the grease is to be delivered to another location.

There are other methods of producing grease. A continuous process for grease manufacturing is described in European Patent Specification 0072184B1 (October 29, 1986), which also mentions other continuous methods.

These particular techniques will not be discussed here. However, another patented method (US Patent 2,704,363, March 15, 1955) will be briefly described. In this process a homogenizer was used to accelerate the saponification reaction by recycling the batch of ingredients from the reaction kettle through the homogenizer and then back to the kettle. This reduced the reaction time needed to make the grease. In one example given, a batch produced by homogenization was compared to a batch produced by conventional means. The results were that the homogenized batch had an improved consistency; it possessed greater mechanical stability; the operating temperature of the homogenized batch was 320°F compared to 400°F (conventional) and the total operating time was reduced from 18 hours in the conventional fire-cooking process to 3.5 hours for the steamcooking and homogenization procedure.

## Quality and Evaluation

The formulation and processing of grease will determine the type of structure the product has and its physical properties. This is why homogenization can have an important influence on the quality of the grease. There are several desired characteristics for grease

such as: body or consistency, stability to shear, surface affinity, thermal stability, flow or viscosity, thixotropy, syneresis, texture and appearance and water resistance. There are many tests that can be performed on grease to measure these properties. One important test is penetration. Penetration is determined by an instrument that measures the depth (in tenths of millimeters) to which a standard cone sinks into the grease under prescribed conditions. Higher penetration numbers indicate softer greases. The National Lubricating Grease Institute (NLGI) uses consistency numbers that correspond to penetration values to classify greases. The numbers are given below.

<b>NLGI Number</b>	<b>ASTM Worked Penetration</b>
000	445-475
00	400-430
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

## References

E. Armstrong, US Patent 2,704,363; 1955.

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