Damping Grease – An Economical Approach to Motion and Noise Control

By Tracy Montour

When faced with the challenge of reducing cost without sacrificing quality, damping greases can be useful tools in a design engineer's bag of tricks.

Damping greases are specialty lubricants. They reduce wear and seal out dust and moisture like traditional greases, but their primary function is to control motion and noise in mechanical and electromechanical devices. Think of a zoom lens on a 35mm camera. The "velvet feel," virtually silent operation, and the fact that the lens doesn't coast are all the work of a damping grease on the focusing threads.

Damping greases were first formulated to build fine tolerances economically into microscopes, telescopes, and binoculars. Though available for more than 60 years, their use didn't extend far beyond optical instruments because of their limited low-temperature capabilities. At room temperature they worked well, but they became so viscous at low temperatures that they actually made parts difficult to move.

That changed in the mid-1980s when Nye Lubricants, Inc. introduced the first broad-temperature line of synthetic damping greases. Switch manufacturers, especially suppliers to the automotive industry, where -40°C is the low-temperature norm, were among the first to take advantage of these unique materials. A small amount of damping grease on switch detents softened plastic-on-plastic clicking, which could easily be perceived by consumers as poor quality. Further, damping grease gave a smooth "Lexus feel" to the hand-actuated parts of a switch — without the expense of fine engineering tolerances.

Camera/lens
Damping grease on the focusing threads enables smooth, quiet motion without coasting or backlash.

Damping greases are now found in many industries on many types of components, including potentiometers, switches, clutches, springs, screws, gears, gearboxes, hinges, solenoids, and dozens of sliding mechanisms. A new line of damping greases commercialized by Nye in 2001 will take these specialty lubricants where no damping grease has gone before: high-shear, high-load applications.

HOW DAMPING GREASES WORK

All greases are formulated by mixing an oil with a thickener, typically a soap, clay, silica, or a synthetic material like polytetrafluoroethylene (PTFE). Thickeners hold the oil in place. When the grease is sheared — by a rotating shaft, a sliding lever, or a rolling element bearing, for example — oil is released from the thickener to lubricate the moving parts.

The distinguishing difference between standard greases and damping greases is shear resistance. In fact, the performance of a damping grease depends more on the internal structure of the lubricant than on its ability to reduce friction between mating surfaces. Damping greases are formulated with viscous, i.e., high-molecular-weight synthetic oils, which give them a much higher internal shear resistance than standard greases. Most standard

Fax Machines
Office equipment OEMs are beginning to replace more expensive mechanical motion and noise components with damping grease, thereby reducing manufacturing cost.

greases are slick, even buttery in consistency. Damping greases are sticky, much like non-hardening adhesives. It takes a degree of force to move an object through a damping grease. Contrast a knife sliding through soft butter and a knife moving through molasses. This internal shear resistance enables damping greases to "damp" or control motion and noise: The higher the shear resistance, the greater the degree of damping.

When damping grease is applied to mating surfaces, it's difficult for one surface to come into contact with the other. It's also going to require some degree of force to move those surfaces in opposition to one another. Therein lies the "magic" of damping grease. Since parts move within the grease and do not come into contact, there is little if any noise — or wear. And because manual or motor force is required to move an object through a damping grease, there is little chance of free motion when the force is removed.

The amount of force required to move a device lubricated with damping grease can be controlled by proper selection of base oils. Higher molecular weight oils create greater internal shear resistance, which requires more torque. Put another way, by controlling the shear resistance of the damping grease, you determine the "feel" of a hand-operated device. An additional benefit, because of their viscous consistency, damping greases seal out moisture, dust, and other pollutants, thereby extending component life.

ENGINEERING PERCEIVED QUALITY

Consumers frequently judge quality by how a device feels and sounds. So important are these "perceived quality" standards, that automotive manufacturers have developed entire engineering groups devoted to eliminating buzzes, squeaks, and rattles. Damping greases are important materials when faced with tactile and acoustical design goals. High-viscosity synthetic hydrocarbon oils are typically the base oils of choice.

Damping greases are frequently used in potentiometers that have a rotating shaft with a hand-operated control knob. As the shaft is turned it moves a contact finger on a conducting surface to control resistance in a circuit. Since these devices are usually small, very slight rotary motion can significantly change in the electrical result, so very precise settings are the design goal. In most cases it would be impossible for the steadiest of hands to keep from coasting past the desired setting. A small amount of damping grease on the shaft is a solution. It's like rotating the shaft within a soft adhesive. Not only does this smooth, incremental motion enable precise settings by hand, it delivers a velvety, high-quality "feel." Importantly, precise settings are achieved without expensive mechanical solutions to control free motion.

Noise, not motion control, is sometimes the primary design concern. Case in point: a squealing worm gear in a household stand mixer. An off-the-shelf grease chosen by a major appliance manufacturer was "channeling," i.e., getting pushed aside by the gears, and not slumping back into the gear teeth, causing a shrill, metal-on-metal squeal. By experimenting with various amounts and types of thickener and base oil, a lubricant can be custom-formulated for a specific set of operating conditions. In formulating a custom lubricant, a lubricant engineer has to get the right "apparent viscosity," a measure of how stiff

a grease remains under shear, and the right "kinematic viscosity," which is the viscosity of the base oil alone. For the mixer, the noise problem was solved with a "pourable damping grease." It had the internal shear resistance necessary to quiet the gear, but was soft enough to slump back into the gear teeth and not channel.

Getting the viscosity of the grease just right was a problem a European auto manufacturer had when it was designing a gear motor for a massage device for the seat-backs in a luxury vehicle. Damping grease was applied to the gear teeth, but the massage unit was still too noisy. After an acoustical study, it was discovered that the gears weren't making the noise, it was the motor, straining to overcome the high shear resistance of the gear grease. By reducing the viscosity of the damping grease, the motor noise was resolved.

Dashboard
Damping greases are used in more than 30 automotive components to quell buzzes, squeaks, and rattles.

A more common application for damping greases is household appliances. Control knobs and timer motors are often lubricated with a damping grease to ensure smooth, quiet performance. Some washing machine manufacturers use damping grease to cut noise on pump motor shafts.

Adjustable pedal systems are one of the newest technologies to rely on damping greases. Auto safety experts recommend that drivers position themselves at least 10 inches from the steering wheel air bag, and adjustable pedals enable persons shorter than 5 feet, 2 inches as well as pregnant women to create that critical safety distance. There are various design configurations. One consists of brake and accelerator pedals moving simultaneously on a shaft, powered by a single electric motor. The shaft as well as the spring that returns the pedal to zero position use a damping grease to prevent wear and ensure smooth, quiet performance. Another design has independent adjustment of the pedals using cable-driven transmission gears. Damping greases quiet the plastic gears and reduce mechanical noise from the cables.

Other applications that rely on synthetic hydrocarbon damping greases include outdoor recreation equipment, laser controls, surveying instruments, stepper motors, hospital beds, coin-return mechanisms on vending machines, and more than 30 automotive applications such as window visors, HVAC air flow vents, retractable cup holders, ashtrays, glove box latches, lumbar adjustment knobs, sunroof motors, and more than a dozen hand-actuated cables and switches.

High-viscosity, silicone-based damping greases are available for applications where material compatibility or high temperature are issues. Silicone damping greases, typically thickened with PTFE, are compatible with all but silicone-based rubber. Their temperature range extends from -60°C to 200°C. Though silicone oils are known to migrate, the molasses-like viscosity of the silicone base oil gelled in PTFE virtually eliminates migration issues.

Stabilizer bar bushings rely on silicone-based damping grease. Sometimes called anti-sway or anti-roll bars, stabilizer bars are the part of the suspension system that keeps the car's body from "rolling" in a sharp turn. The bar is attached through bushings to the car's frame, so that the bar is free to rotate. Stabilizer bars don't wear out, but the rubber bushings do. That's where the silicone grease goes to work. It's compatible with the rubber, doesn't wash out, provides a very low-friction interface, and greatly extends the life of the original bushings. It also eliminates squeaks.

Oven Control Knob
Appliance manufacturers use damping greases on hand-operated controls and timer motors.

Disc brake caliper pins and drum brake adjustment screws are lubricated with silicone grease because of sensitive rubber components and high internal temperatures. Grip shifters, the handle-bar mechanisms used to change gears on multi-speed bicycles, also use silicone damping grease. Grip shifters on motorbikes, motorcycles, snow mobiles and jet skis are also likely candidates.

HIGH-SHEAR APPLICATIONS

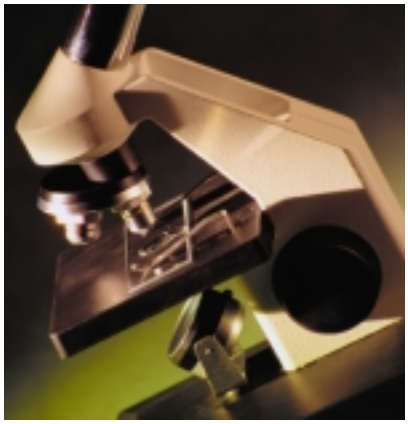
Most components that have incorporated synthetic hydrocarbon damping greases have been low to moderate shear applications or, worse case, high-shear for short periods of time. What would happen to the mechanical stability of the damping grease after extended, high-shear exposure, was a question we asked at Nye R&D. We discovered that the grease lost its mechanical stability.

It is important to distinguish this rheological behavior from shear thinning. Most greases shear thin as a function of shear rate or time, but they recover their original viscosity when shear ceases. This was not the case when we subjected a high-viscosity, synthetic hydrocarbon damping grease to extended high shear. It experienced a non-recoverable reduction in viscosity, a permanent rheological change. Simply, it lost its damping characteristics.

Nye engineers discovered that the gellant, not the blend of synthetic hydrocarbon base oils, was the culprit. When the same high molecular weight oil blend was mixed with PTFE, the new grease returned to its original viscosity after 153 hours of continuous high shear. Interestingly, shearing the grease actually improved its damping characteristics because the shearing served to mill the PTFE. This research led to the recent commercialization of a new series of damping greases for high-shear components that need motion and noise control.

Applications are already surfacing. DaimlerChrysler specified one of these PTFE-thickened synthetic hydrocarbon damping greases for its 2001 tilt-steering gearing. Visteon reported favorable results in an adjustable steering column. Delphi chose a light version of the shear-stable grease to fix a warranty problem with tie rod boots, an application where the new damping grease's rust prevention additive is a plus. Not for high shear alone, Lear Corporation changed from a more traditional damping grease to the PTFE-thickened version, noting that the PTFE-thickened grease gave its switches a "silkier feel."

In the world of office automation, especially document and photo printers and copiers, these high-shear damping greases promise to play a major role in both noise and cost reduction.



Microscope
Damping greases were originally designed to enable precise, manual settings economically for microscopes, telescopes, and binoculars.

While the shear rate of gearing in printers and copiers is not as demanding as in tilt-steering columns, shear time in these constantly moving components presents an equally demanding set of criteria. Add the need to quiet office machinery and remove manufacturing costs to compete in the low-cost, OA revolution, and high-shear damping greases offer important value-adds. Damping greases take dollars out of the design by removing mechanical complexity. Some parts that are used for motion control and noise suppression can often be replaced with a low-cost damping grease.

SELECTING A DAMPING GREASE

Both objective and subjective criteria are used to match a damping grease to a specific application. Objectively, damping greases must retain their damping qualities throughout the tem-

Typical Damping Grease Applications

Damping Grease "Grade" *(Degree of Tack)*	Base Oil Viscosity @ 25°C	Typical Applications
Very Light	1,276 cSt	"Return" keys on keyboards Document and photo printers
Light	4,609 cSt	Auto dimmer switches Starter motor solenoids
Medium	13,200 cSt	Refrigerator temperature control Manual seat controls in cars
Heavy	17,500 cSt	Stereo volume controls Surveying equipment
Very Heavy	50,000 cSt	Auto suspension systems Focusing mechanisms Tilt-steering columns Medical devices

perature range of the application. Synthetic hydrocarbon greases are suitable for -40°C to 125°C. Silicone-based damping greases damp at room temperature and are still functional at -60°C and +200°C. Because of potential contamination problems, silicone-based greases are not recommended for optical and electrical applications.

Material compatibility must be tested. For example, synthetic hydrocarbons may weaken polyethylene, polystyrene, polyvinyl chloride plastics and some low-density elastomers, so for long-life applications compatibility problems may arise. While materials manufacturers offer compatibility charts, the best way to ensure material and lubricant compatibility is through life testing.

Subjectively, damping greases are selected for the "feel" the designer wants to achieve. Generally, the more delicate the device, i.e., the lower the torque, the lighter the grease. Engineers can choose from various grease consistencies, from very light to ultra heavy. For example, the volume control on a radio would call for a lighter grease; the release mechanism on a parking break, a heavier grease (*See Table 1, "Typical Damping Grease Applications"*). Generally, a damping grease can be custom-formulated to achieve the specific feel and sound the engineer wants. To achieve the right feel, testing various amounts of the candidate grease(s) at the lowest expected operating temperature is recommended.

Of note, attention should be paid to dispensing the grease in the manufacturing environment. When using high-speed, automated dispensing equipment, especially when small amounts of grease are applied to each device, air entrained in the grease may result in some parts' not being lubricated. De-aeration of the grease, a special process that removes entrained air from grease cartridges, helps minimize part rejection.

Damping greases are not appropriate for every application. While they have been used successfully in many low-torque devices, flea-power devices couldn't overcome even the lightest damping grease. And because there is a premium to be paid for a quality damping grease, very low cost devices may have to pass. ■