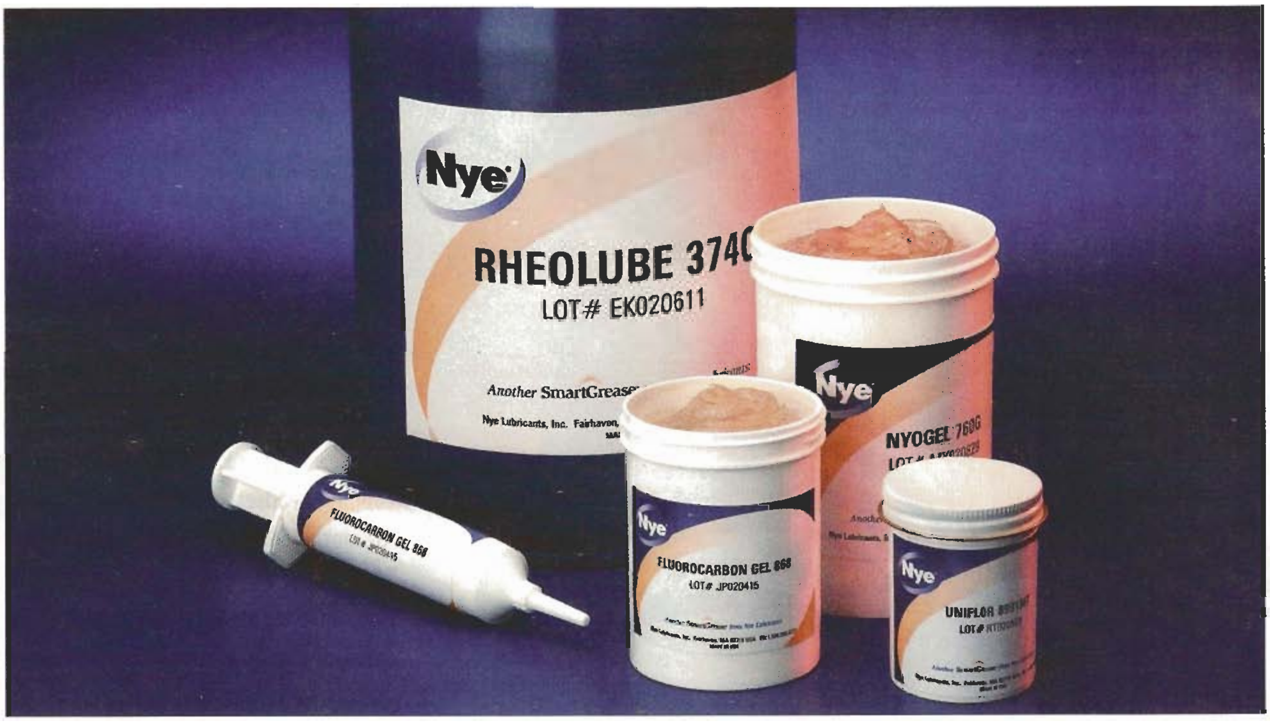
Lubes and seals: Running relay races



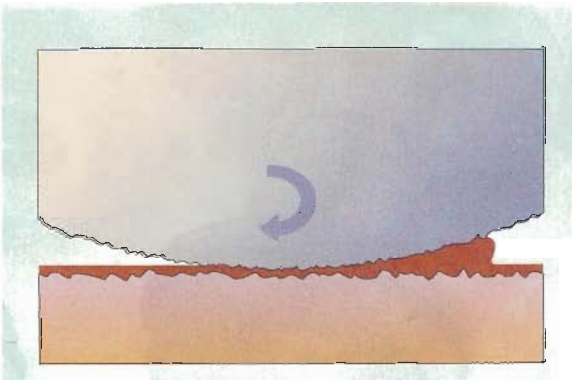
On reversing gantries and other systems, lubrication and seals are subject to oscillating motion. For example, on some pumps, the rotation of one part is converted to oscillating plunger motion to draw, pressurize, and deliver fluid.

How does lubrication behave in these situations? Optical interferometry and numerical analysis show that oil film thickness under reciprocation is thinner than that under unidirectional motion. Why? A starved condition is induced by cavitation (generated during previous contact-region passes) that briefly persists after reversal.

How else can this affect lube and seal systems? "Under high temperature and pressure, contact pressure gets so high that the lubricant is squeezed from the interface between shaft and seal, and then the system works under sparse or boundary lubrication," explains Alex Paykin, director of advanced product development, SKF Sealing Solutions, Chicago. Normally if contact area is small, load pressure is high, to thousands of pounds per square inch in many cases — but viscosity increases under high pressure so that oil resists expulsion. But any film rupture can result in high wear, high temperature, and premature heat aging of the elastomers of seals.

Newer numerical analysis to predict oil film thickness, such as the *Elrod algorithm* (developed in the 1970s to improve Reynolds and Navier-Stokes models) is more practical and widespread with present-

The aim: a cushion



With elasto-hydrodynamic (EHD) lubrication, adhesion of oil to moving and stationary surfaces increases pressure. This spurs formation of an oil buildup at the leading interface edge, to prevent the direct surface contact that wears components.

Promising new technologies

"To address oscillation challenges, whole-sealing systems (seal, shaft and internal and external sealing media) balance different factors within each component to optimize overall performance. It means very good understanding of product design, elastomeric material design and possibly, the effect of aging on performance, and the effect of shaft and lubricant on parameters," says Paykin.

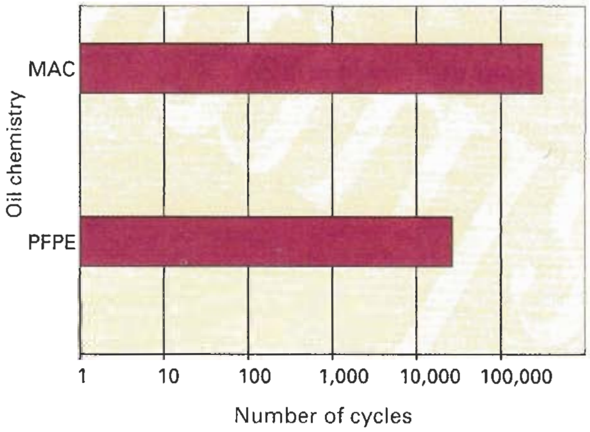
day computers and processor capabilities. It allows oil volume models on the trailing edge of one calculation domain to be used on the leading edge after reversal. In fact, this calculation verifies reduced oil thickness with cycle repetition.

Solid film and tradeoffs

Oscillatory motion in vacuum applications, whether it be in space guidance or semiconductor pick-and-place robotics, require low outgassing lubricants for long life (through low evaporative loss) and minimal contamination of critical components nearby. Fluorinated lubricants, using perfluoropolyether base oils, are historically the choice due to their wide temperature serviceability, material compatibility, and very low vapor pressure. They are still used in many applications and have a long flight history in spacecraft.

Drawback: *PFPE-based lubricants lack soluble additives for wear and corrosion protection.*

Life under oscillation



An alternative fluid for vacuum applications is multiply-alkylated cyclopentanes, or *MACs*. These MAC fluids provide excellent wear performance and allow many typical additives to be used.

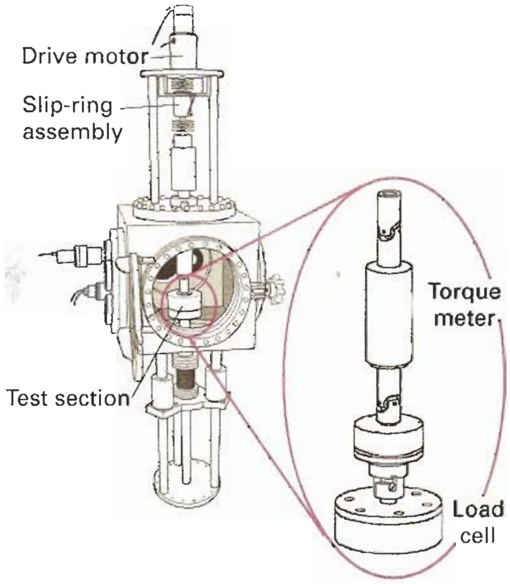
As oscillatory motion tends to lack EHD film formation and significant surface contact, surface modifier additives are critical to the life of the component. Under investigation are new fluorinated additives to determine their effectiveness in preventing wear and corrosion.

Drawback: *Another weakness with PFPE chemistry is their relatively low load capacity produced, especially with the linear PFPEs.*

The long chain length and flexibility of the molecular structure, which give excellent temperature performance, actually hinders film formation and the loading a fluid can support.

An alternative fluid for vacuum applications is multiply-alkylated cyclopentanes, or *MACs*. These MAC fluids provide excellent wear performance and allow many typical additives to be used. They do not have the same temperature capabilities as most PFPEs, but similar vapor pressure values, in the nTorr range or below. Too, they can resist attack of Lewis acids, which are sometimes formed on metal surfaces under high loads — another potential concern with PFPEs.

Oscillating bearing lubrication



At Glenn Research Center, Cleveland, Nye and NASA have compared MAC and PFPE performance in oscillating bearing test rigs.

Comments on additives for improved film formation made by Kevin D. Akin, assistant vice president of technology at Nye Lubricants, Inc., Fairhaven, Mass. For more information, visit impactmovie.com/nye.