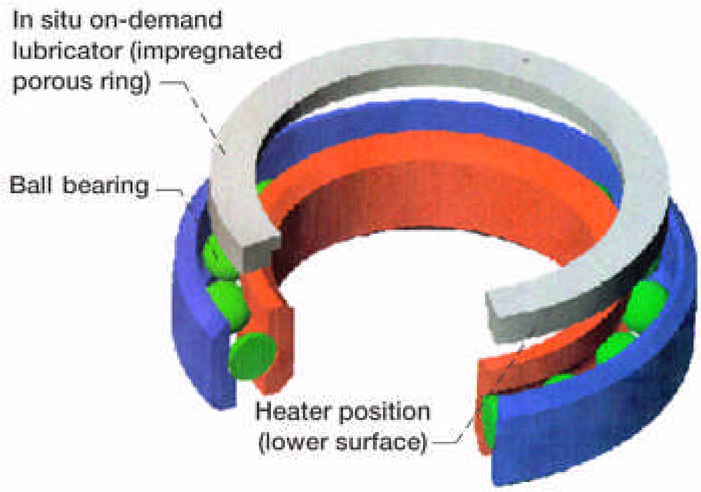
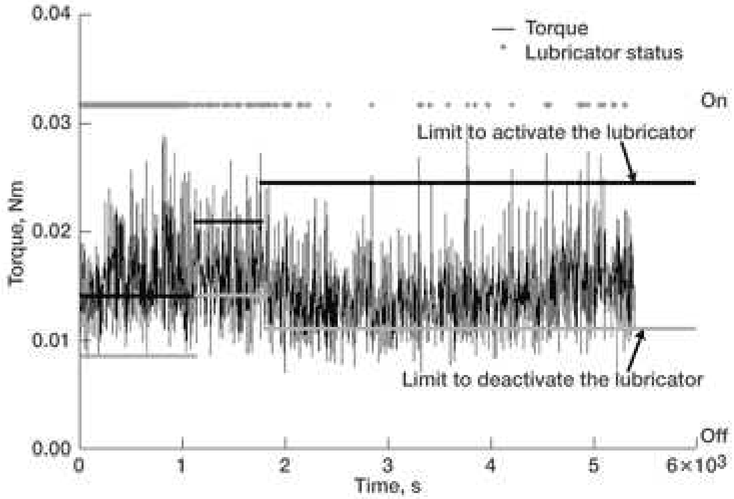
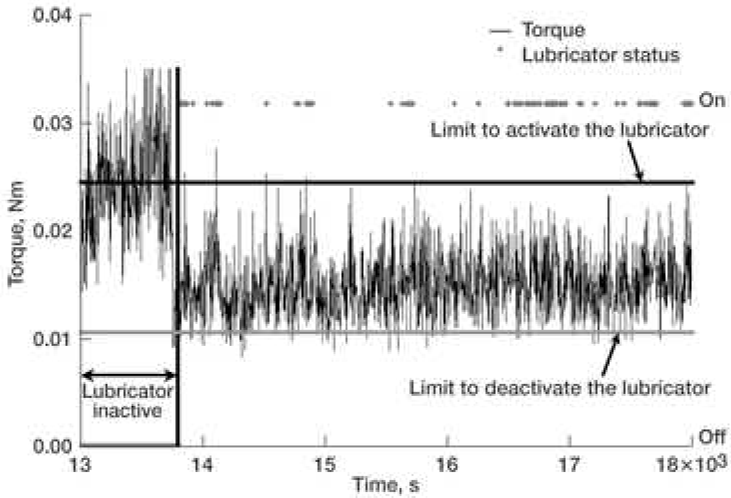
In Situ, On-Demand Lubrication System Developed for Space Mechanisms



Drawing of the in situ, on-demand lubricator (porosity » 25 vol% of oil that can be stored » 94 mm3) attached to the inner ring of a full complement ball bearing. Bore diameter, 19.05 mm (0.75 in.); outer diameter, 29.97 mm (1.18 in.); 24 balls with diameters of 3.175 mm (1/8 in.).



Stabilization of the torque trace of a ball bearing (load, 89 N (20 lb); speed, 200 rpm), initially unlubricated, with an in situ, on-demand lubricator impregnated with a synthetic oil.



Decrease in the torque of a ball bearing (load, 89 N (20 lb); speed, 200 rpm), initially unlubricated, after reactivation of an in situ, on-demand lubricator impregnated with a synthetic oil.

Many moving mechanical assemblies (MMA) for space mechanisms rely on liquid lubricants to provide reliable, long-term performance. The proper performance of the MMA is critical in assuring a successful mission. Historically, mission lifetimes were short and MMA duty cycles were minimal. As mission lifetimes were extended, other components, such as batteries and computers, failed before lubricated systems. However, improvements in these ancillary systems over the last decade have left the tribological systems of the MMAs as the limiting factor in determining spacecraft reliability.

Typically, MMAs are initially lubricated with a very small charge that is supposed to last the entire mission lifetime, often well in excess of 5 years. In many cases, the premature failure of a lubricated component can result in mission failure (refs. 1 to 3).

MMAs fail tribologically when the lubricant degrades or evaporates and, therefore, loses its ability to lubricate rubbing surfaces-bearing balls contacting raceways for example. Since the MMA is still mechanically intact when the lubricant degrades, if lubricant could be resupplied to the contact, the life of the MMA could be extended. Lubricant reservoirs have been used to resupply lubricant, but they are bulky, add complexity, and cannot be activated when needed (ref. 4). Rather, they continuously supply lubricant to the contact, often leading to an excess of lubricant.

The lubricator reported here provides fresh lubricant to the ball-race contact in situ and on demand. The lubricant is stored in a porous cartridge attached to the inner or outer ring of a ball bearing. It is released by heating the cartridge to eject oil, taking advantage of the greater thermal expansion of the oil in comparison to the porous network. Heating can be activated by torque increases that signal the depletion of oil in the contact. The low surface tension of the oil in comparison to that of the ball bearing material is used, and the close proximity of the cartridge to the moving balls allows the lubricant to reach the ball-race contacts. This oil resupply system was successfully used to avoid a mechanism failure and reduce the torque to an acceptable level in a ball bearing initially operating without lubricant. The lifetime was extended in comparison to that of a similar ball bearing operating in the same conditions but without the lubricator attached to it. In addition, the in situ, on-demand lubricator consumes less than 1 W of power. This work was done in cooperation with the NASA Glenn Research Center’s Tribology and Surface Sciences Branch.

References

1. Shapiro, Wilbur, et al.: Space Mechanisms Lessons Learned Study Volume I¾Summary. NASA TM--107046, 1995.

2. Shapiro, Wilbur, et al.: Space Mechanisms Lessons Learned Study Volume II¾Literature Review. NASA TM-107047, 1995.

3. Jones, William R., Jr.; and Jansen, Mark J.: Space Tribology. Modern Tribology Handbook, Vol. Two, CRC Press, Boca Raton, FL, 2001, pp. 1159-1186.

4. Zaretsky, E.V.: Liquid Lubrication in Space. Tribol. Int., vol. 23, no. 2, 1990, pp. 75-93.

National Research Council at Glenn contact: Mario Marchetti, 216-433-5843, Mario.Marchetti@grc.nasa.gov
Glenn contacts: Dr. Stephen V. Pepper, 216-433-6061, Stephen.V.Pepper@nasa.gov
Sest, Inc., contacts: William R. Jones, Jr., 216-433-6051, William.R.Jones@grc.nasa.gov; and Mark J. Jansen, 216-433-6054, Mark.J.Jansen@grc.nasa.gov
Authors: Mario Marchetti, William R. Jones, Jr., Dr. Stephen V. Pepper, Mark J. Jansen, and Roamer E. Predmore

Headquarters program office: OAT
Programs/Projects: GOES **Special recognition:** This work was performed while the main author held a National Research Council Research Associateship Award in Glenn’s Tribology and Surface Science Branch