

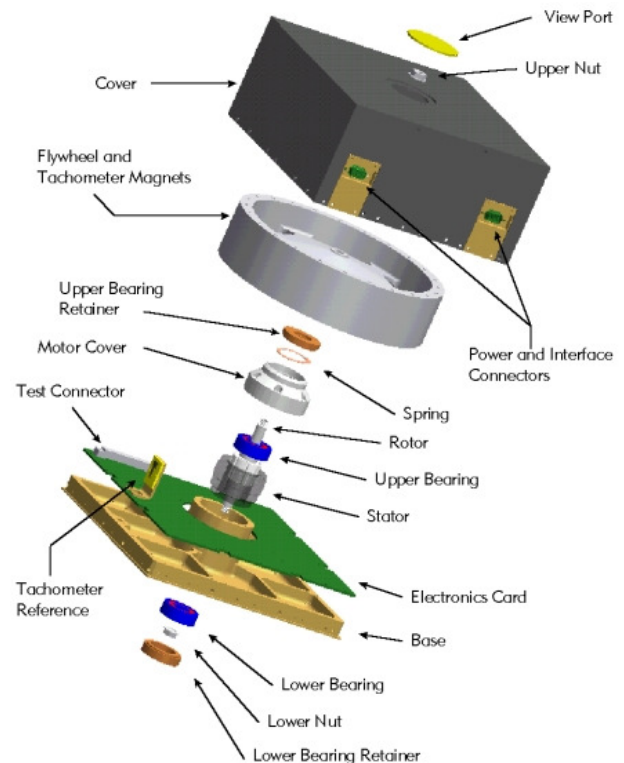
Spacecraft Bearing Health Monitoring

Pushing the Boundaries of Machinery Prognostics

Motivation

Momentum/reaction wheels and control moment gyros provide mission-critical orientation, stabilization, and energy storage for most satellites. These devices, referred to as attitude control wheels, typically consist of a flywheel, a spindle that typically contains two precision angular contact ball bearings, an electric motor, and control electronics integrated into a sealed housing. On the right is a figure depicting an exploded view of a typical attitude control wheel design.

Bearing lubrication problems are the primary cause of premature failure in attitude control wheels. In addition to causing premature wear, lubrication problems can cause cage vibration and instability that adversely effects sensitive satellite instrumentation. Typical lifetimes are 5-7 years, and redundant systems are often carried on board to accommodate failures. New spacecraft will be required to have a service life of 15-20 years without maintenance and without backup mechanical assemblies.



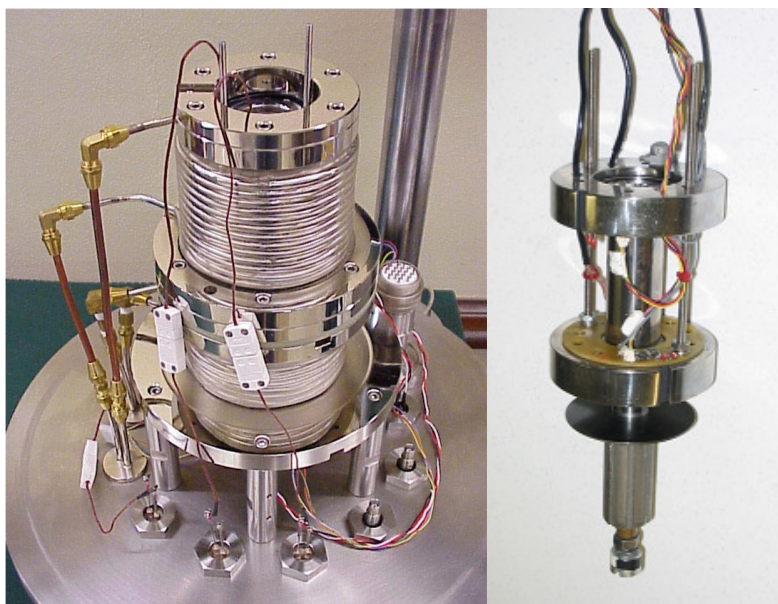
Although passive lubrication systems (i.e., ones in which the flow rate is predetermined, with no active control) have been used in some spacecraft, the rates of lubricant migration, depletion, and degradation are impossible to predict accurately, resulting in over- or under-lubrication problems. A bearing monitoring system combined with an active lubricant delivery system would have the ability to optimize its own lubrication, resulting in increased life, lower torque and torque noise, lower vibration, and better reliability compared to current systems.

Solution

Sentient has unique capabilities for studying bearings used in spacecraft applications. The Attitude Control Wheel Simulator (shown on the left) is a test rig used to test bearing in a simulated space environment. The ACWS permits the testing of bearings in a vacuum while tight control is maintained over ambient temperature, load, and

spindle speed. Extensive instrumentation permits the monitoring of race temperatures, bearing cage temperatures, motor torque, cage rotation rate, cage motion, vibration, and spindle motor current and voltage. The sensor suite can be easily modified. A more detailed view of the test rig can be seen to the right.

A novel cage sensor, developed by Sentient, has proven to be an invaluable tool for understanding bearing health. The sensor simultaneously monitors cage temperature and motion, permitting an analysis of the lubrication state at the ball-cage interface. Pictured below, the sensor consists of two parts, an activation/receiver circuit and a cage-mounted transponder component. The transponder component weighs only .12 grams. The activation/receiver circuit (left in the picture below) is mounted above the bearing and communicates with the transponder unit on the bearing cage (right in the picture below) by inductive coupling; no contact with the cage or the embedded transponder unit is necessary.



The technology described here can also be applied to terrestrial applications in which the desire is to monitor the lubrication status of bearings. Sentient is also creating a next generation bearing sensor that is completely contained on the bearing itself and provides measurements of bearing temperature and vibration. The data is wirelessly transmitted to a remote receiver that is not required to be mounted directly next to the bearing. For more information on the next generation of bearing sensors ask for our brochure on the “Wireless Sensor for Bearing Health Monitoring”



Contact Sentient Corporation for more information high performance bearing sensors and a discussion about how this technology can improve your maintenance capability:

850 Energy Drive
Suite 307, Room 428
Idaho Falls, ID 83401
208-522-8560
info@sentientscience.com

www.sentientscience.com