

Space qualified dry lubricant films based on WC-MoS_x

Category: Materials

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Abstract

Thin solid films (based on MoS_x-WC) have been developed with enhanced endurance life (under vacuum) and improved tribo-properties (under atmospheric conditions including higher humidity).

The development of these films has also led to an improved ground test capability for space mechanisms in a humid air environment (atmospheric), with a focus on both space and terrestrial industrial applications.

Description

WC alloyed MoS_x thin films have been deposited by means of magnetron sputtering. The films exhibit good tribology properties under vacuum, in a low earth orbit (LEO) environment and also for terrestrial conditions at different humidity levels.

These novel WC-MoS_x coatings have been tested in orbit on the International Space Station (ISS) using TriboLAB, which is a tribology laboratory installed in the EuTEF (European Technology Exposure Facility), fixed to ESA's Columbus laboratory. The test program ran from February 2008 to September 2009. The European Technology Exposure Facility was transported to the International Space Station (ISS) on flight STS-122/1E along with the Columbus module.

The main objective of the experiment was to study the behaviour of new solid lubricants (alloyed MoS₂ with WC) under real space conditions. The thermal control of the instrument was designed, assembled, integrated and tested by a team of engineers of Tecnalía and INTA. The techniques were needed to ensure that the temperature range of the experiment components achieved those of the possible mission scenarios.

Innovations and advantages of the offer

- Testing under in-service conditions has shown that the novel solid lubricating films maintain very low friction levels of 0.04 and reach a maximum of over 1,000,000 wear cycles when tested on a ball on disk geometry at 0.75 GPa.

- The in-orbit results have demonstrated a similar behaviour to those measured on the ground under laboratory conditions.
- The WC alloyed MoSx thin films also have good tribology behaviour under atmospheric conditions at different humidity levels (from 40 to 80% RH), showing endurance up to 322,000 wear cycles with average friction coefficients as low as 0.07 (at 40 %RH).
- The WC alloyed MoSx thin films show also good tribology properties when deposited on different substrates and evaluated vs different counterpart materials (17-4PH, 15-5PH, Cronidur, Ti-6Al-4V etc)
- Pin-on disk testing at cryogenic temperatures (80K) shows an endurance value of 770,094 cycles and low mean friction coefficient (0.15) and specific wear rates of the coatings (6.45E-08 mm³/N.m) have been measured.
- The WC alloyed MoSx thin films compare very favorably with unalloyed conventional MoS₂ films and also with other alloyed MoSx films.
- Reproducibility of the MoSx-WC based coating has been demonstrated.

Further Information

These materials were developed by TECNALIA within the EU FP7 funded Space project HARMLES (263162).

Testing was carried out under vacuum in a commercial CSEM tribometer, and then under atmospheric conditions, varying levels of RH using a commercial Falex ISC tribometer. Selected films were tested under vacuum using the Vacuum Tribological Model of TriboLAB, with final testing on the TriboLAB (International Space Station).

Application

The MoSx based dry lubricant films are suitable for novel designs of harmonic drives for space applications. Potential terrestrial applications identified for these films include:

- Cutting tools (reduction or removal of need for cutting fluids)
- Engine components
- Coining dies

The coatings have also exhibited good performance in cryogenic environments.

Comments on the technology by the broker

This technology has a good space heritage and work has started to investigate its use in spin off applications. The use of this technology in several industrial sectors has already been identified, with ongoing developments focused on their application in industrial cutting tools and engine components.

Description of Space Heritage

Coatings have been tested in orbit using TriboLAB, on the International Space Station (ISS). TriboLAB is a tribology laboratory installed in the EuTEF (European Technology Exposure Facility), attached to the ESA Columbus laboratory. The European Technology Exposure Facility was transported to the International Space Station (ISS) on flight STS-122/1E along with the Columbus module.

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