

Tribology of Solid Lubricant Coatings for Space Mechanisms and Cryo-turbopumps of Rocket Engine

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The general problem for the lubrication of space systems is the lack of oxygen. The space vacuum environment challenges the lubrication of frictional contacts in low speed space mechanisms like solar array drives, slip ring units, payload steering-mechanisms for long duration of 30 years, whereas the rocket-engine cryogenic turbopumps challenge the operation of bearings at high-speeds and in direct contact with cryogenic fluids (like liquid oxygen and liquid hydrogen). The need to improve space mechanism reliability is underscored by a long history of flight failures and anomalies caused by malfunctioning mechanisms on spacecraft and launch vehicles.

For meeting the above challenging tribological requirements a new high-current ion plated Pb coating has been developed. In order to improve the friction and wear properties of the conventional ion plated Pb coating on steel; the coating interlayer thickness has been improved, by processing the ion plating deposition at higher substrate voltage and current conditions. The effect of interlayer thickness on the endurance life, the friction and wear of ion plated Pb coatings were studied. For the experimental evaluation of friction and wear of the various coatings at high speeds in liquid nitrogen, a ball-on-disk cryo-tribometer has been developed. The tribological evaluation of the new high-current ion plated Pb coating has been carried out with (1) the low-speed sliding test in ultra high vacuum ball-on-disk tribometer, (2) the low-speed rolling-sliding test in gaseous nitrogen, (3) the high-speed sliding test as well as (4) the rolling-sliding tests in liquid nitrogen. The evaluation of friction and wear properties and wear mechanism of the high-current ion plated Pb coating in liquid nitrogen has been studied and compared with other solid lubricant coatings of ion plated Ag, ion plated Au, RF sputtered PTFE and Sputter ion plated MoST on SUS 440C steel.



The above experimental results confirms that the newly developed high-current ion plated Pb coating on steel is a promising candidate to meet the present and future requirements of low-speed space mechanisms and rocket engine cryo-turbopumps.