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Space Structures I - Development and Verification (Space Vehicles and Components) (1)

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PERFORMANCE INVESTIGATION OF SOLID AND SOLID-GREASE HYBRID LUBRICATED HARMONIC DRIVE GEARS UNDER THERMAL-VACUUM ENVIRONMENT

Abstract

Because of its advantages like very low backlash,high transmission accuracy,high torsional stiffness,high torque capacity,compact size and light weight,harmonic drive gears has become the preferred choice for compact,powerful positioning drives which are widely used in space pointing,scanning and robotic arm joint precision mechanisms. Six types of solid or solid-grease hybrid lubrication processes:Magnetron Sputtered(MS)MoS2-Ti,Plasma Enhanced Chemical Vapor Deposition(PECVD)WC:H-DLC and either of these two coatings cooperated with Perfluropolyether(PFPE)or Multiply-Alkylated Cyclopentanes(MAC)grease are applied to the surfaces of Circular Spline(CS),Flexspline(FS) and Wave Generator Bearing(WGB) of type 40 harmonic drive gears which has a reduction ratio of 100:1 and a tooth modulus of 0.2. A self-designed test rig which could run six harmonic drive gears simultaneously and measure their transmission performances in-situ under thermal-vauum environment was used to carry out the vacuum endurance tests.The tests were performed under the following conditions:Pressure:below 1E-3Pa,Temperature:room temperature,Input speed:100rpm,Output torque:5Nm,Rotation mode:output shaft oscillating at 360degree.The test was carried on until the harmonic drive gears blocked or the input revolutions accumulated above 1E7r.Prior to the test,every 10days during the test and after the test,each of the six test units was characterized by No Load Start Torque(NLST),transmission accuracy,stiffness and efficiency in vacuum over a range of temperature(from -60degree to +80degree).The dependency of these transmission parameters on temperature and the number of input revolutions under different lubricating types were quantified.After the test,the harmonic drive gears were disassembled and the wear surface of the teeth and the contact zone between FS and WGB out ring were inspected by optical microscope and was confirmed by EDS analysis.XPS and Raman spectroscopy were used to analyze the chemical composition and structure of the solid coating wear surface and debris.Infrared spectroscopy was used to study the chemical structure change of the lubricating greases after lift testing.