Paper ID: 10667
oral
student

MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Specialized Technologies, including Nanotechnology (8)

Author: Mr. Jeremiah Mpagazehe
Carnegie Mellon University, United States

Mr. Irebert Delgado
National Aeronautics and Space Administration (NASA), United States
Dr. Kenneth Street
National Aeronautics and Space Administration (NASA), Glenn Research Center, United States
Prof. C. Fred Higgs
Carnegie Mellon University, United States

A MULTI-PHYSICS COMPUTATIONAL FRAMEWORK TO PREDICT WEAR CAUSED BY LUNAR DUST PARTICLES

Abstract

The Earth's moon is covered in a fine layer of jagged and hard lunar dust particles. During NASA's Apollo missions, it was found that lunar dust is more abrasive than expected. Wear caused by lunar dust led to a series of mission complications such as abraded spacesuits, compromised seals, and scratched visors and instrument dials. Moreover, it was found that the exhaust plumes of landing spacecraft can act to accelerate lunar dust particles which, in the low-gravity low-pressure lunar environment, loose little momentum and significantly erode near-by lunar hardware. Recent efforts by Miyoshi et al. and Kobrick et al. at the NASA John Glenn Research Center have been put toward the experimental investigation of the lunar dust wear process. As a complement to such experiments, a robust model is needed that can simulate the wear caused by lunar dust particles in lunar environments which are challenging to reproduce experimentally. Therefore, this work proposes a novel computational framework to predict the wear caused by lunar dust particles on space structures. The model is comprised of in-house computational modules to simulate different components of the wear process. Computational fluid dynamics (CFD) is used to model rocket exhaust gases, while a discrete element model (DEM) is used to predict the trajectory of individual lunar dust particles. Coupling between the Eulerian (exhaust gas) phase and the Lagrangian (dust particle) phase is accomplished by inter-phase drag correlations and the modification of boundary conditions to produce a fully-coupled model. At each simulation time step, the surface topography is updated in response to the amount of wear caused by lunar dust particles. The model outputs the time-evolving material surface as well as the mass loss experienced during the wear process. Efforts are made to match the material properties of lunar dust simulants and the model predictions are compared to experimental data.