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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.