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SIMULATION OF THE EROSION BEHAVIOUR OF A ROCKET ON A LUNAR LANDING PAD

Abstract

Several initiatives, such as NASA's Artemis and ESA's Argonaut missions, are ongoing to bring recurrent cargo and crew to the Moon. To establish infrastructure on the lunar surface, it is essential to

minimize potentially harmful dust emissions caused by a rocket plume interacting with the lunar surface. For this, a furnace-sintered lunar landing pad (LLP) could be used. Due to the extreme conditions on the lunar surface (e.g. vacuum and low gravity) and limited amount of data, the experimental characterization of the erosion of the LLP is challenging. Numerical simulations are a valuable tool for this, as they allow rapid parameter changes. In this study, a simulation model was built to describe the erosion caused by a rocket's plume using the Discrete Element Method (DEM). Particle sizes similar to those found on the Moon, ranging from 55 to 550 m, were selected. Sintered structures are modeled using bonds based on an elastic beam model. A heat transfer model is included to simulate the fracture behavior of sinter bridges caused by mechanical stress and temperature. To calibrate the numerical model, a combination of continuum methods such as bending and shearing tests, and interparticle techniques like nanoindentation, are employed. The calibration process involves adjusting parameters such as Young's modulus, shear modulus, radius and maximum bond length to best match the experimental results. Shear force and surface heat flux, calculated from a macroscale Computational Fluid Dynamics (CFD) simulation, are applied to the top surface of the LLP. The erosion rate is calculated by evaluating the movement of particles over time. The simulation results indicate that the particle erosion rate is affected by the porosity of the LLP, as well as its thermal conductivity and thermal capacity. Additionally, the erosion rate is influenced by the position under the rocket, its altitude and the heat flux onto the LLP.