Cryogenic Solid Particle Erosion of Advanced Materials For Lunar Applications

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Introduction

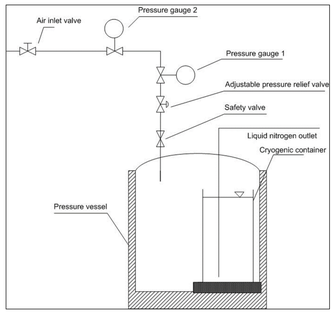
NASA is developing new materials and testing technologies for successful lunar habitation capabilities. These new generation of advanced materials will be subjected to the extreme temperatures that range from boiling hot to freezing cold depending on the Moon's position relative to the sun. Furthermore, lunar dust can significantly impede the performance of equipment deployed on the Moon. Optimization of materials, designs, and innovative techniques used to mitigate the effects of lunar regolith dust is key to sustained lunar surface presence.

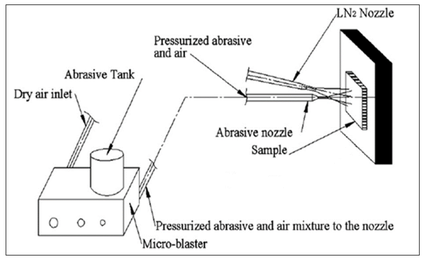
Objectives

1) Establish an experimental setup for cryogenic SPE experiments on newly developed materials
2) Characterize particles (i.e. determine shape, and size distributions)
3) Conduct cryogenic SPE experiments on these materials at six angles of impact, at different particle velocities, using different particle sizes and particle flux (mass of particles striking a target per unit area per unit time), and determine cryogenic SPE wear resistant properties
4) Conduct surface analysis of the materials after the cryogenic SPE experiments to identify dominant wear mechanisms (such as cutting, deformation, fracture, or combination of this)
5) Conduct particle embedding experiments and quantify the area covered by embedded particles

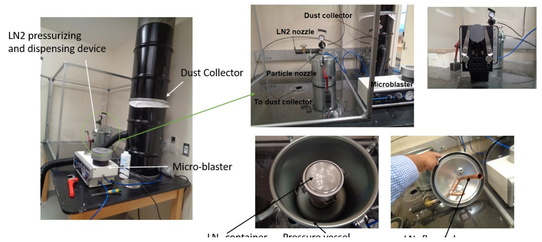
Approach

- •Objective of the project is to design an experimental setup and conduct SPE tests under cryogenic temperature conditions
- •Particles will be blasted at high speed (up to 160m/s) using a pressurized micro-blaster
- •The target material will be cooled using liquid nitrogen
- Specimens include: Ceramic coated metallic specimens, Aluminum 6061, Titanium, and Silicon Carbide (SiC)

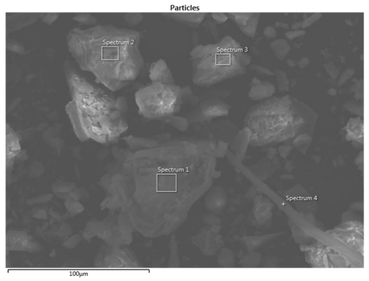




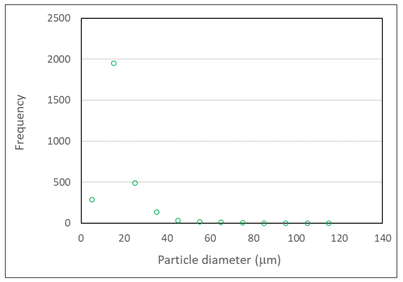
Experimental Setup Schematic



Experimental Setup



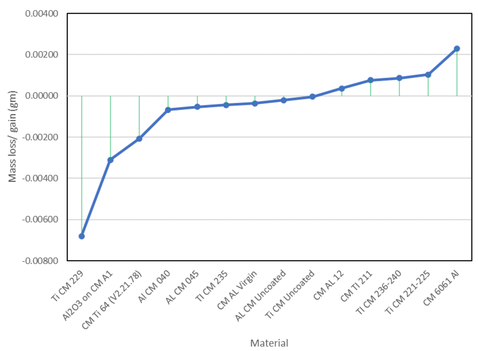
Platelet-type Geometry of Simulant



Simulant Particle Size Distribution

CSPE Resistance

Sample Name	Mass loss/gain (gm)
Ti CM 229	-0.00680
Al2O3 on CM A1	-0.00310
CM Ti 64 (V2.21.78)	-0.00207
Al CM 040	-0.00067
AL CM 045	-0.00053
TI CM 235	-0.00043
CM AL Virgin	-0.00037
AL CM Uncoated	-0.00020
Ti CM Uncoated	-0.00003
CM AL 12	0.00037
CM TI 211	0.00077
TI CM 236-240	0.00087
Ti CM 221-225	0.00103
CM 6061 Al	0.00230



Mass gains in conventionally manufactured (CM) metallic specimens (1.5" diameter pucks) show indications of particle embedding

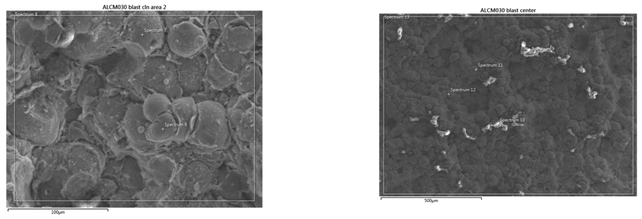
What is SPE?

SPE is a dynamic process in which material is removed from a target surface because of mechanical interaction between impinging particles and the target surface.

Particle Characterization

- •EDX analysis shows simulant contains substantial amount of iron
- •Impact angle, impact velocity and particle flux (mass of particles striking a target per unit area per unit time)
- •Erodent particles (size, shape, hardness and mass), affect the local concentration of SPE wear energy on the impacted surface.
- •Volcanic soil from Mauna Kea, Hawaii Island, Hawaii was found to be useful in simulating lunar regolith
- •Particle size distribution was obtained using microscopic images and image

Particle Embedding



Pretest and Post Test Scanning Electron Microscopy of metallic specimens showing embedded iron particles

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