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Flowability of Lunar Regolith Simulant

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Abstract

Further exploration of the Moon and destinations beyond requires a deeper understanding of the granulate matter and rheology.

Flow behaviour of the lunar regolith plays an important role in producing a fundamental database in order to find a safe landing site; predict the regolith deposition on the rovers and; minimize the Moon walk challenges for future manned missions. Moreover, understanding the flow behaviour of the regolith will improve the construction quality for on-site manufacturing using in-situ resources.

Currently, the flowability of various lunar simulants is experimentally studied on Earth as well as on board of parabolic flights in order to investigate the effect of reduced gravity on the static and dynamic angle of repose under ambient and vacuum conditions [1-4]. However, the impact of temperature variation under reduced gravity and vacuum condition on the regolith flow behavior has not been studied yet.

Based on this, flow behavior of the lunar regolith simulant under different pressures and temperatures is investigated in this study.

Objectives

In this study, static angle of repose [5] of JSC-2A is initially studied within the temperature range of -150 ºC to 150 ºC, representing of the lunar surface temperatures. Based on this, JSC-2A powder was dried at 250 ºC for 48 hours and then subsequently exposed to liquid nitrogen while its temperature was constantly recorded. Results regarding the static angle of repose measurements of JSC-2A under ambient conditions showed an average maximum angle of repose of 42.8º at -100 ºC, while the average minimum angle of repose was measured to be 33.7 º at 50 ºC. As the static angle of repose was shown to be significantly influenced by the temperature, dynamic angle of repose studies under vacuum conditions were investigated further. Based on this, a rotating drum setup capable of measuring the dynamic angle of repose at different temperatures under vacuum conditions was developed. Both sides of the rotating drum were sealed with transparent observation glass windows. Different back scattered light source colours and intensities enabled the recording of the powders' dynamic angle of repose (avalanche angle) on-site. The developed setup for the dynamic angle of repose measurements is shown in Figure 1.

Figure 1: Rotating drum setup for dynamic angle of repose measurements

Outlook

Dynamic angle of repose will be analyzed by varying the rotating drum's pressure, temperature and speed for variety of the lunar simulants' particle sizes and distributions. Furthermore, relations of the indicated parameters under reduced gravity will be studied. Consequently, different rheological flow regimes will be classified for different applications such as Additive Manufacturing (AM) on the Moon.

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