PNEUMATIC PLANETARY REGOLITH FEED SYSTEM FOR IN-SITU RESOURCE UTILIZATION.

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Introduction: The NASA In-situ Resource Utilization (ISRU) project requires a regolith feed system that can transfer lunar regolith several meters vertically into a chemical reactor for oxygen production on the moon. A high mass flow rate of regolith into the reactor is desirable given that tens of kilograms of regolith may need to be delivered into the reactor as feedstock for a chemical reaction process. Pneumatic conveying is a viable method of supplying regolith to a reactor that uses a small mass of reusable compressed gas to transfer a large mass of regolith material [1]. A pneumatic regolith feed system also shares a commonality with the ISRU reactor system which already requires a gas handling subsystem for the ISRU process. Additionally, a pneumatic feed system does not expose any moving parts to lunar regolith particles that could be rendered inoperable due to jamming or breakdown. The pneumatic regolith feed system uses a compressed gas as input for a venturi eductor to create a partial vacuum at a nozzle that draws regolith particles into the eductor where the granualar material becomes entrained in the gas flow. The resulting dusty gas travels along an enclosed metal pipe to the first of a pair of cyclone separators which deliver regolith at the bottom of the cyclones while filtered gas is exhausted at the top of the cyclones. The exhaust gas from the first cyclone becomes the input dusty gas for a second (smaller) cyclone which filters the incoming gas and allows the remaining finer sized regolith particles to exit the bottom. In a closed loop system, the exhaust gas from the second cyclone passes through a HEPA filter before returning to a gas compressor.

An IPP collaboration [2] between Honeybee Robotics, Corp. and NASA Kennedy Space Center resulted in the development of the pneumatic regolith feed system shown in Fig. 1 which was demonstrated at the 2010 ISRU field test at Mauna Kea, Hawaii for the Orbitec Carbothermal reduction reactor [3]. Results are presented for this feed system operating in an closed-loop configuration and using local Tephra on Mauna Kea as lunar regolith simulant, Tephra being fragmented mineral ash formed by volcanic eruptions.

Results: Using compressed air from an electric powered compressor, Tephra was conveyed pneumatically from an open hopper located above the compressor shown in Fig. 1 to a vertical height of 1.6 meters and into a cyclone separator system that deposited the Tephra into a receiving hopper attached to the Carbothermal reactor (not shown) while the remaining exhaust air passed through a HEPA filter before returning to the air compressor.

Figure 1. The Pneumatic Regolith Feed System demonstrated for the 2010 ISRU Carbothermal field test on Mauna Kea.

Tephra was sieved (<2 mm) by the field team prior to being deposited into the input hopper to prevent clogging components in the pneumatic feed system. A “dust sock” attached to the cyclone solids outlet prevented Tephra fines from being lofted by wind as they exited the cyclone. Approximately 35 kg of Tephra was transferred during the Mauna Kea field test. The average mass transfer rate was found to be 0.52 kg/min. Actual rates varied from 0.37 - 0.70 kg/min.

Conclusions: We have field tested a closed-loop pneumatic regolith feed system for ISRU reactors using Tephra as a lunar regolith simulant and airflow as a recyclable working fluid. Improvements in cyclone separation efficiency are needed.

References: [1] Mueller, R.P. et al. (2010) "*Pneumatic Regolith Transfer Systems for In-Situ Resource Utilization*," Proc. Earth & Space 2010 Conf., Am. Soc. Civil Engin. [2] NASA’s Innovative Partnerships Program (IPP) allows companies to leverage their resources with NASA centers in order to promote the development of technologies to meet NASA's needs. http://www.nasa.gov/offices/ipp/home/index.html.
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