IAF SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Science, Instruments and Technologies (3B)

Author: Dr. Kris Zacny
Honeybee Robotics, United States, zacny@honeybeerobotics.com

Mr. Stephen Indyk
Honeybee Robotics, United States, sjindyk@honeybeerobotics.com
Mr. Phil Chu
Honeybee Robotics, United States, pcchu@honeybeeroboics.com
Mr. Fredrik Rehnmark
Honeybee Robotics, United States, flrehnmark@honeybeeroboics.com
Mr. Gale Paulsen
Honeybee Robotics, United States, paulsen@honeybeerobotics.com
Mr. Justin Spring
Honeybee Robotics, United States, jspring@honeybeeroboics.com
Mr. Peter Ngo
Honeybee Robotics, United States, pxngo@honeybeeroboics.com
Mr. Joseph Sparta
Honeybee Robotics, United States, jsparta@honeybeeroboics.com
Mr. Tigh Costa
Honeybee Robotics, United States, JTCosta@honeybeeroboics.com
Mr. Zach Mank
Honeybee Robotics, United States, zdmank@honeybeeroboics.com
Dr. Seiichi Nagihara
Texas Tech University, United States, nagihara@ttu.edu
Dr. Ralph D. Lorenz
The John Hopkins University Applied Physics Laboratory, United States, ralph.lorenz@jhuapl.edu

APPLICATION OF PNEUMATICS TO DRILLING, EXCAVATION, SAMPLE ACQUISITION AND TRANSFER ON PLANETARY MISSIONS

Abstract

Pneumatic systems are used extensively on Earth to move drill cuttings out of the hole during a drilling process as well as to transfer powders. Pneumatic systems have been well characterized and both fundamental equations as well as empirical data can be used to size tanks, valves, and hose diameters.

The main benefit of pneumatics is that they are extremely well suited for handling unstructured material such as powder or rock cuttings. In the most basic design, sample to be transported is placed on one side of a tube and some time later it appears on the other side of a tube with the help of a carrier gas. Even sticky material can be moved with increased gas pressures and flow rates.

For almost twenty years, Honeybee Robotics has been developing pneumatic-based systems for planetary surface missions requiring samples for the in-situ instruments, sample return, or for deployment of instruments at some depth [1-3]. Reduced gravity flights (lunar g) in vacuum conditions (5 torr) revealed that with 1 gram of gas at 60 kPa pressure, up to 6000 g of gas can be lofted at high speeds [3]. This high mass ratio efficiency is mainly attributed to vacuum, with secondary effect being lower gravity.

Although specific applications require some technology development to increase the so-called Technology Readiness Level (TRL), the heart of the pneumatics (valves, tanks, pressure regulators etc.) is at much higher TRL, since it is used in liquid propulsion (Helium pressurant) and cold gas propulsion systems. Pneumatic systems could either use dedicated gas canisters or the system could tap into residual Helium pressurant used in a lander's propulsion system. Here we present several applications of pneumatic based systems in drilling and sample handling.

References: [1] Zacny et al., (2004) Lunar soil extraction using flow of gas, (RASC-AL), [2] Zacny, et al., (2008) Pneumatic Excavator and Regolith Transport for Lunar ISRU and Construction, AIAA Space. [3] Zacny et al., (2010) Investigating the Efficiency of Pneumatic Transfer of Lunar Regolith Simulant in Vacuum and Lunar Gravity During Parabolic Flights, AIAA Space