Abstract for 11th Low Cost Planetary Missions Conference
June 9-11, 2015, Berlin, Germany

Sampling of Regolith on the Moon and Mars Utilizing Electrostatic Force, Magnetic Force and Mechanical Vibration

Kawamoto, H., Department of Applied Mechanics and Aerospace Engineering, Waseda University;
Shigeta, A., Department of Applied Mechanics and Aerospace Engineering, Waseda University;
Adachi, M., Department of Applied Mechanics and Aerospace Engineering, Waseda University

To realize reliable and autonomous sampling of regolith on the Moon and Mars, the authors have developed a unique sampling system that employs combination of electrostatic force or magnetic force for the capture of particles into a sampling tube and mechanical vibration for the transport of captured particles in a collection capsule located at the upper part of the tube. In an electrostatic capturing system, a high ac voltage is applied between parallel screen electrodes mounted at the lower end of the tube. Regolith particles on the surface of the Moon are captured after they are passed through the openings of the screen electrodes using an electrostatic force. This system is adaptable for capturing lunar regolith, because high voltage can be applied in the vacuum environment on the Moon. On the other hand, in the Mars environment, because the threshold voltage is less than 1.0 kV in the low-pressure atmosphere on Mars as a result of the gas discharge, almost no regolith particles can be captured by the electrostatic means with applied voltages less than 1.0 kV. We are developing a magnetic capture device as an alternative method to capture magnetic particles on Mars. Pulse current was applied to a solenoidal electromagnet attached at the lower end of the sampling tube to generate pull-in force to magnetic regolith particles in the vicinity of the electromagnet. The pulse width was adjusted that magnetic pullback force was minimized and maximize the amount of captured regolith. By adopting any capturing method, the captured particles are then transported through an inclined tube to a capsule against gravity utilizing mechanical vibration. A conventional electromagnetic vibrator was used to generate vibration, and we are developing an alternative vibrator using a dielectric elastomer actuator that would realize not only low power consumption but also high reliability because sliding or sticking parts are not necessary for its operation. Experiments demonstrated that some amount of regolith is sampled for a short time period if the end of the tube is in contact with the regolith layer, even in the 1-G environment of the Earth. Because the gravities on the Moon and Mars are respectively one-sixth and three-eighths of that on the Earth, the process of sampling particles on the Moon and Mars will be easier than on the Earth. It was demonstrated that both simulant particles and crushed ice can be sampled using this system.