IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures I - Development and Verification (Space Vehicles and Components) (1)

Author: Ms. Shiori Matsumoto
Aoyama Gakuin University, Japan, ssmats72@gmail.com

Mr. Shun Yamaguchi
Aoyama Gakuin University, Japan, c5619131@aoyama.jp
Mr. Takumi Takise
Aoyama Gakuin University, Japan, a5616056@aoyama.jp
Dr. Yoshiki Sugawara
Aoyama Gakuin University, Japan, sugawara@me.aoyama.ac.jp
Dr. Masakazu Takeda
Aoyama Gakuin University, Japan, takeda@me.aoyama.ac.jp
Prof. Shinichi Nakasuka
University of Tokyo, Japan, nakasuka@space.t.u-tokyo.ac.jp
Dr. Yasuko Kasai
National Institute of Information and Communications Technology (NICT), Japan, ykasai@nict.go.jp

IMPACT FORCE CALCULATION USING NON-SMOOTH DEM AND CONSIDERATION OF LANDING CONTACT SURFACE SHAPE OF LANDING LEG FOR SMALL MARS LANDER

Abstract

THz observations by the Herschel Space Observatory suggested that the surface of Mars may be rich in oxygen. Atmospheric observations have not been made on the surface of Mars or around the orbit, including the Herschel Space Observatory, and continuous observations on and around the surface of Mars are required. Therefore, low-cost, short-term development of a small THz Mars spacecraft is underway for the purpose of continuous Mars landing exploration with short-term development. This plan requires a proposal for a new landing system. Conventional landing systems are complex and heavy.

In the project, the landing legs made of foamed aluminum with shock-absorbing capacity are studied. Aluminum foam has a range called plateau region where displacement increases under constant stress. From this characteristic, it is possible to absorb the landing shock by deforming, and at the same time, reduce the load applied to the landing spacecraft body. A multi-stage landing model is proposed, in which foam aluminum as shock absorbers are installed.

A drop experiment was performed on the proposed landing legs. The landing leg used in the experiment was three-stage hollow cylinders with the upper side closed each, and the upper two stages were filled with shock absorbers. A landing leg of 0.6 m in length and a total weight of 41 kg was dropped from a height of about 15 m, and the landing speed was 16 m/s. On the landing ground, a 30 mm thick gravel was laid on a 30 mm thick concrete panel. The landing legs penetrated the ground and the impact material did not deform sufficiently. It is considered that the stress was large due to the small contact area of the hollow circle surface. This indicates that the impact of shock absorption was influenced by the landing leg contact surface and the ground.

In this study, the interaction between the landing leg and the ground is analyzed. The purpose of this analysis is to investigate whether the contact surface geometry of the landing leg should be designed to tolerate penetrating the ground or to absorb the impact. In the analysis of the interaction, the non-smooth discrete element method is used to represent the soil dynamics. In addition, the impact force on

the landing spacecraft and the amount of energy dissipated by penetrating the ground are calculated for each landing leg contact surface shape.