Sampling Scenario for the Trojan Asteroid Exploration Mission

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ABSTRACT

JAXA is now planning a Trojan asteroid exploration mission using a solar power sail. In this mission, in-situ analysis of the collected samples will be performed by a high-resolution mass spectrometer. In this paper, a proposed scenario and some experiment results of the sampling devices are shown.

トロヤ群小惑星探査計画におけるサンプリングシナリオの検討

要旨

現在 ISAS/JAXA では，ソーラー電力セイルによるトロヤ群小惑星探査を計画中である．本計画では，小惑星サンプルを採取後，質量分析器によるその場分析を行う．本論文では，提案されているサンプリングシナリオと，搭載デバイスの試験状況について報告する．

I. INTRODUCTION

Japan Aerospace Exploration Agency (JAXA) is now planning a Trojan asteroid exploration mission using a 50m-wide solar power sail as shown (Fig. I) [1]. The sail is fully covered with thin-film solar cells in order to generate huge electric power by which ion engines are driven at outer regions of the solar system. The use of ion engines makes it possible to realize a round trip (sample return) mission from the outer region of the solar system. In this mission, a 100kg-weight-class lander (Fig. II) is soft-landed on an asteroid in order to perform in-site analysis. The most important science mission on the asteroid is to analyze a volatile constituent such as ice by a mass spectrometer. It has been estimated that the surface of the asteroid is covered with regolith layer and the volatile constituent exists under this layer. It is, therefore, required to excavate the surface of the asteroid in order to realize this science mission. Collected samples, moreover, have to be transported to the mass spectrometer which the lander is equipped with. In order to succeed in this mission, two engineering key technologies are required; (1) Excavating Device (2) Sample Transfer Mechanism. In order to verify the new technology (1), some experiments have been performed in JAXA. In this paper, the concepts of this technology and the results of these experiment are shown.

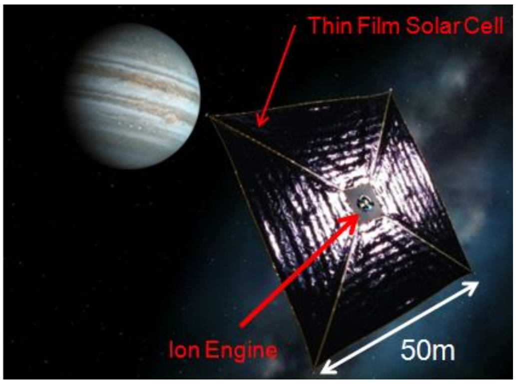

Fig. I: Solar-Power-Sail Spacecraft

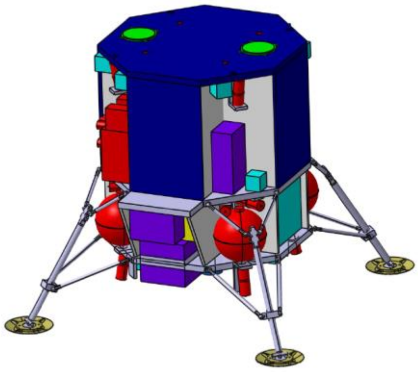
Fig. II: Small Lander

II. CONFIGURATION OF SAMPLING PACKAGE

In this mission, the lander collects surface samples and subsurface samples respectively. After sampling, these samples are analyzed by the mass spectrometer. Differences between HAYABUSA/HAYABUSA-2 mission and this Trojan mission are as follows;

(i) It is required to excavate regolith layer to collect the subsurface samples.

(ii) Collected samples must be transported to the mass spectrometer.

This sampling package consists of five components; (a) Sampler Horn (for surface samples) (b) Bullet Firing Mechanism (c) Pneumatic Drill (for subsurface samples) (d) Sample Transfer Mechanism (Revolver) (e) Mass Spectrometer. Component (a): Sampler Horn is a sampling device for surface samples which was used in HAYABUSA mission. A bullet is shot by component (b): Bullet Firing Mechanism and the surface samples are blown up. These blown samples are guided by Sampler Horn and collected in the lander. These components have already been developed in HAYABUSA/HAYABUSA-2 mission. Component (c) which is the excavating device and component (d) are the newly developed devices.

III. EXCAVATING DEVICE

Requirements for the excavating device in this mission are as follows;

- Before the landing, the device must be shortened.
- After the landing, the device must excavate the regolith layer by 1m without anchoring.
- During the excavating, the regolith must enter inside the device.
- The number of actuators must be reduced as much as possible.

In this mission, the excavating is placed in not only science mission but also

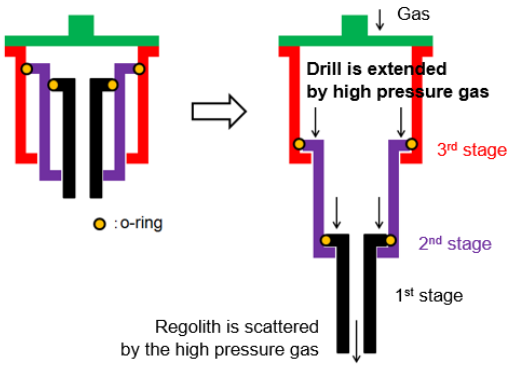

Fig. III Section Drawing of Pneumatic Drill

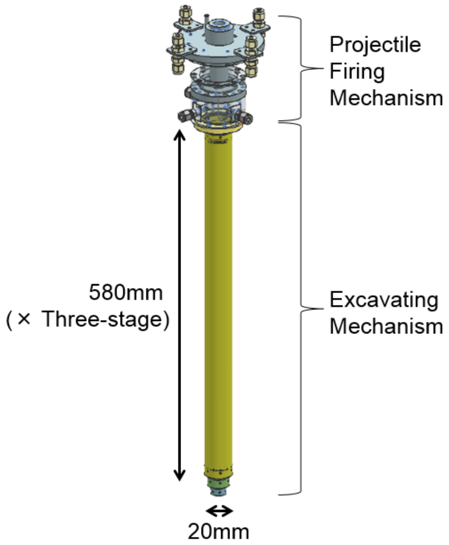

Fig. IV: Pneumatic Drill: TEST MODEL

engineering mission. "1m below" in the second requirement is determined from the engineering view. In order to satisfy the requirements, a pneumatic drill [2] is adopted in this mission. This drill is driven by high pressure gas. Fig. III shows a section drawing of this device. High pressure gas blown down pushes each stage and the pneumatic drill is extended. The most important feature of this concept is that no actuator is required to drive this drill. That is, this device is drived only by opening a valve to blow the high pressure gas. In addition, the surface regolith of the asteroid can not enter inside the drill because of the flow of the high pressure gas. This guarantees that the collected samples were the subsurface samples 1m below. During the excavating, several thrusters should be driven to cancel counter force.

The reasons of the adoption are as follows;

- There is no actuators.
- Since the direction of the counter force is vertical direction, it is easy to cancel the counter force.
- The mass of the required gas is small.

IV. DEMONSTRATION EXPERIMENTS AND RESULTS

Fig. IV shows the BBM of the pneumatic drill and Fig. V shows the configuration of this experiment. The experimental conditions are summarized in Table. 1. In this experiment, it was shown that 103cm excavating can be realized by using 21g N_2 gas.

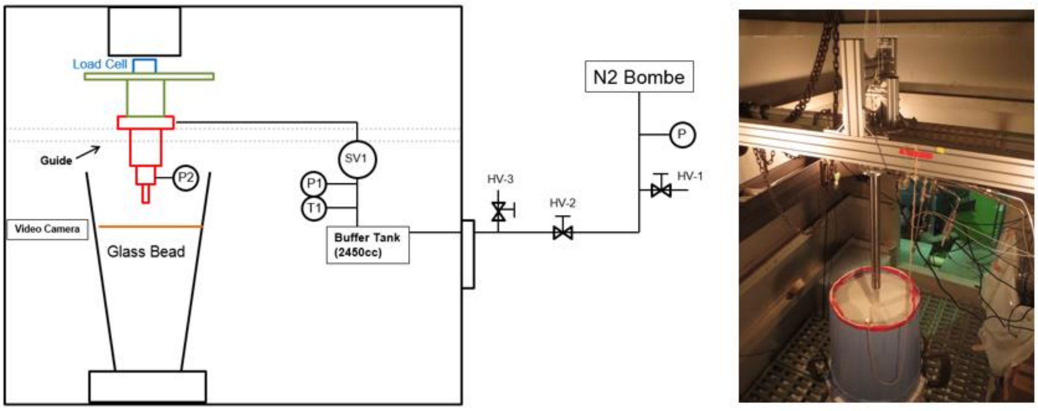

Fig. V: Experimental Configuration

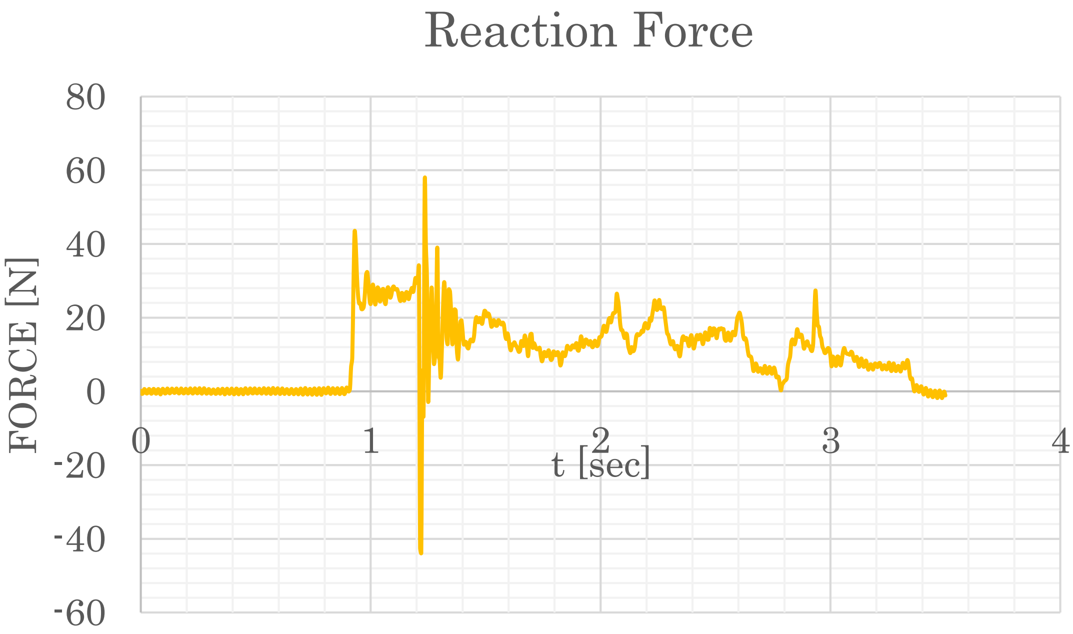

Fig. VI: Counter Force

Table. 1 Experimental Condition

High Pressure Gas	GN_2
Initial Gas Pressure	3.9 MPaG (Blow-Down)
Dummy Regolith	Sphere Glass Bead
Size of Dummy Regolith	0.5 mm

In this experiment, counter force was also measured. The time history of the counter force is shown in Fig. VI. This counter force, in the actual operation, should be canceled by RCS.

V. CONCLUSION

In this paper, the new sampling technology for the Trojan mission is explained. The key device, pneumatic drill for subsurface sampling has been developed and the functions of this devices have been demonstrated by some experiments. In near future, the sampling package including all components will be developed and demonstrated by experiments.

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