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Development and evaluation of UAV hanging type sampling device for pyroclastic materials

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Observation method of active volcano is limited depending on the access restricted area for human safety. Therefore, technologies of unmanned volcanic explorations have been required and tele-operated mobile ground robots have been developed in Japan and Italy until now. As a result, it is becoming possible to get data of the inside of the restricted area, for example digital images from cameras and numerical values from sensors. However, there is no practical sample-return method for obtaining pyroclastic materials from such restricted areas. Therefore, in this research, I aim to realize an unmanned sample-return system, and I develop and evaluate a sampling device for obtaining pyroclastic materials that is most important in this system.

The sample-return system consists of 3 parts: (1) a multi-copter, (2) a sampling device, and (3) a tether. The multi-copter that hangs the sampling device with the tether flies from the out of the restricted area. The automatic flight setting is based on the GPS data. On the target area, the multi-copter comes close to the ground and releases tether to touch down the device to the ground, and keeps the altitude for sampling. During the hovering, the device conducts sampling. After sampling the multi-copter rises up, and comes back to the departure point.

The roller system is adopted for sampling device. Its size has a length of 180mm, a width of 190mm, a height of 130mm and its weight is 840g. It gathers pyroclastic materials by the following procedure: (1) the pair of rollers that rotate mutually and reversely shaves off pyroclastic materials on the weak ground, (2) the rollers catch up the pyroclastic materials and (3) they are captured into the buckets. The parallel link plays a role that changes the distance between two rollers to obtain various sizes of samples. The maximum particle size of pyroclastic materials that the device can obtain is 25mm (The maximum particle size of pyroclastic materials that the device can put between rollers is 65mm).

Sample size distribution was measured to evaluate the performance of this sampling device. Simulated standard sample in this work is ”Fuji sand”. Fuji sand having particle size of 4mm or less, Fuji sand having particle size of 4mm or more and mixtures of them were used as simulated field. The result of these experiments shows that the developed device can obtain samples that are approximately 100 g in weight and approximately 15 mm in depth. Furthermore, when the particle size of the weak ground is even-grained, the device obtains the same particle size distribution as the ground. However, when the particle size of the weak ground is uneven-grained, the device obtains samples containing a high proportion of large particle size.

Field test was held after evaluations by simulated standard sample in laboratory. The target fields were Mt. Asama, Sakurajima, and Izu Oshima. In these field tests, the sample-return system worked properly to obtain samples and succeeded in performing an autonomous sample-return motion based on GPS navigation of multi-copter’s flight system.

Keywords: sampling, sample-return, pyroclastic materials, UAV