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Performance of the recoil-compensation mechanism used for a throw-up type absolute gravimeter

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Absolute gravimeters can measure gravity acceleration in the accuracy of 8 to 9 digits. They are accurate and useful for many applications, however the apparatus is too bulky and heavy. Therefore, in the field observation, their installation site is limited. As a result, for volcanic observations, a gravity value is usually measured by an absolute gravimeter at a reference point of foot, and then a gravity value of an observation point can be obtained from the gravity difference between a reference point and an observation point measured with a relative gravimeter; such a method is laborsome, and requires long time. Furthermore it is hazardous to approach the observation points when the volcano is active. This study is to minimize absolute gravimeter in order to improve these situations. The original point of our new apparatus is to incorporate a recoil-compensation mechanism to improve the measurement accuracy.

In the absolute gravity measurements, we adopted a rise-and-fall method, while conventional absolute gravimeters usually adopt a simple free-fall method. The simple free-fall method has several problems such as bulky mechanism to lift up a test mass, repeated measurements, and long time to take for the preparation. Hence, we developed a throw-up equipment that had no need for lifting up a test mass and could measure repeatedly. This enabled to minimize one of the biggest parts in the absolute gravimeter.

The equipment which we developed this time can throw up the test mass by 3mm in height simply by applying the signal to a piezoelectric element which is incorporated in the expansion mechanism. When the test mass was thrown up, it rotated by an anchoring effect and it may cause the error in the gravity measurement. We applied other piezoelectric elements which separate the stage from the test mass just before the test mass leaves the stage to cut off the anchoring force. At the end of 2012, we carried out a performance test of the throw-up equipment at Esashi Earth Tidal Station in Iwate. At Esashi, we replaced the free fall equipment of the existing absolute gravimeter with the throw-up equipment. As a result, the throw-up equipment was able to detect a gravity change of earth tides. The resolution of the gravity measurement δg was estimated to be 40μgal. However, the absolute gravity deviated from the value expected from the past measurements up to $\triangle$g= 3mgal. This big error was inferred from the recoil effect at the time of throw that induces vibration to the interferometer.

We developed the recoil compensation mechanism of the throw-up equipment to improve the measurement accuracy $\triangle$g. Specifically, we put the same piezoelectric element and the expansion mechanism on the other side of the baseplate to which the throw-up mechanism is attached. These expansion mechanisms move symmetric by applying the same signal to the piezos. When the test mass is thrown up, the counter mass fixed by springs is launched downward at the same time to compensate the recoil effect. We could observe the recoil reduction as much as 2.7% of peak acceleration without the compensation mechanism. After performing fine adjustment of the equipment, we plan to conduct gravity measurement by the same method to 2012, and the result and the development status will be reported.

Keywords: absolute gravimeter, throw-up equipment, miniaturization, recoil effect, compensation mechanism, gravity measurement