Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD022-04 Room:201A Time:May 23 15:15-15:30

Development of a gravimeter for underwater hybrid gravimetry

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Gravity profiling has been an important geophysical method combined with seismic profiling. For example, it has been recognized from dense gravimetry in Japan that a belt of large gravity gradient coincides with an active fault. After several destructive earthquakes occurred in coastal areas of Japan, gravimetry has been carried out on the shallow seafloor using an ocean bottom gravimeter to detect an unrecognized active fault. However, it requires considerable time to make a detailed gravity map in such a way of gravimetry. While a surface ship gravimeter can carry out continuous gravity measurement with precision of about 1 mgal, or 10**(-6) G, required precision for such field works is 0.05 to 0.1 mgal. In this way a gravimetry system onboard an underwater vehicle has been required to carry out continuous gravity measurement with one-order better precision than a sea surface gravimetry.

We once tried to develop an underwater gravimeter onboard a large AUV (autonomous underwater vehicle) powered with a diesel engine developed under a fund from the MEXT to Institute of Industrial Science, University of Tokyo. The basic design was to keep the gravity sensor, a static gravimeter Scintrex CG-3M with some modifications, vertical with the aid of the signal from a gyro. The system was not completed due to limited specifications of the gyro and mechanical parts for the system as well as limited chances of sea trials. In 2009 we improved on the system with the doubtful parts replaced, and examined its performance on a test bed simulating pitching and rolling as well as strong vibration. The gravity sensor remained unchanged. The revised system worked fairly well under a condition of pitching and rolling of the amplitudes 3 degrees and the period several seconds. Averaged gravity values under such conditions were observed with a precision of 0.2 mgal. Because the mechanism of the forced gimbals was not fully rigid, tilt of the gravity sensor was larger than a theoretical value by about 20 percent, and the averaged gravity values fluctuated by about 0.2 mgal. The strong vibration was successfully cut off with double-layered shock absorbers.

We began to build a brand-new hybrid gravimetry system in 2010 with another fund from the MEXT to Earthquake Research Institute, University of Tokyo. It consists of a gravimeter and a gradiometer both for underwater gravimetry. The former aims at quantitative mapping of density anomalies below the seafloor, and the latter can be more sensitive in detection of density variations. The hybrid system can estimate the subterranean structure more accurately than a gravimeter alone. The gradiometer consists of a pair of high precision accelerometers that have been developed for an absolute gravimeter (Araya et al., this meeting). Both of the sensors will be kept vertical with each gyro. We plan to carry out a sea trial onboard the AUV Urashima, JAMSTEC, in the near future.

The new underwater gravimeter of the hybrid system was designed considering the results of the examination of the old one in the previous year. While the concept of design remains unchanged; a gravity sensor is kept vertical with forced gimbals by use of a gyro, the gravimeter has adopted a newly developed dynamic gravity sensor, a high precision gyro, and a highly rigid mechanism for the gimbals in order to improve the precision. The sensor unit of the system is installed with batteries in a pressure-tight Ti sphere. A logging unit is contained in a smaller housing. The whole system is being assembled and will be examined indoors as was carried out for the older gravimeter.

Keywords: gravimeter, underwater, hybrid gravimetry, gradiometer, forced gimbals, AUV