§26. Development of HTS Loops for Long-Time Plasma Diamagnetic Measurements

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In the conventional diamagnetic measurement, the time variations of plasma energy and beta-value are evaluated using diamagnetic loops made of normal conductor, such as copper. In order to obtain the diamagnetic flux, the induced voltage is integrated. However, the integrator has drift characteristics. Therefore, the diamagnetic measurement using integrators are considered to be difficult in long pulse operations, such as longer than 1 hour. In order to improve this problem, another diamagnetic measurement system, which converts the magnetic flux into a current of a superconducting loop, is being studied. In order to arrange a loop in locations with high temperature near plasma, high-temperature superconducting (HTS) loop can be used. Here, an HTS loop is operated in a persistent current mode. In this study, a long-time plasma diamagnetic measurement system has been designed, fabricated and tested.

The schematic of a superconducting diamagnetic loop and the photograph are shown in Figs. 1 and 2. The HTS loop consisting of two double-pancakes were wound using a Bi-2223/Ag tape. The tape has a dimension of 4.1 mm width and 0.23 mm thickness, and it has the critical current of 104 A and the n-value of 24.4 (at temperature 77 K under self-field). The HTS coils have a number of turns of 80, the inner and outer radius of 50 and 65 mm, respectively. A persistent current switch (PCS) and another superconducting coil were wound by NbTi/Cu superconducting wires. The current of the HTS coils was measured by a Hall probe. The PCS is turned off during the excitation. The superconducting coil has limited the current of the HTS loop.

The HTS loop was excited using a copper coil as the primary loop, which imitated plasma diamagnetic flux. The test results are shown in Fig. 3. From Fig. 3(a), the decay time constant of the superconducting loop is evaluated to be 814 hours. The joint resistance determines this decay behavior in this system. Fig. 3(b) is the measured magnetic field when the current of the copper coil is changed.

In summary, a plasma diamagnetic measurement system using an HTS loop has been examined for long-time measurement. From the test results, the principal of this system has been demonstrated. In the future, reduction of joint resistance and high-resolution current sensor will be developed for a high-performance system. Installation of an HTS diamagnetic loop to the Large Helical Device will be considered.

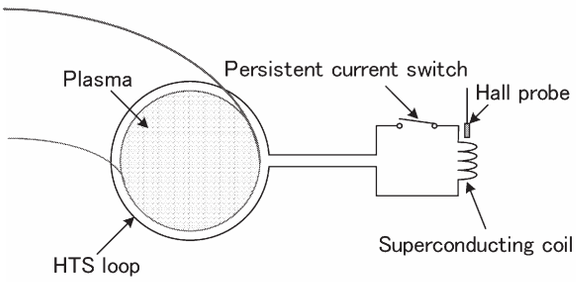


Fig. 1. Schematic of a superconducting diamagnetic loop.

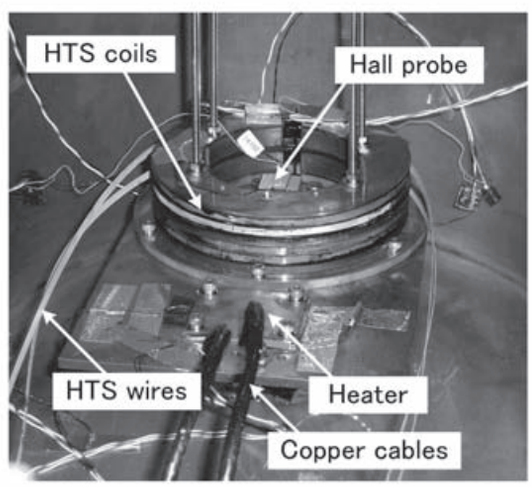
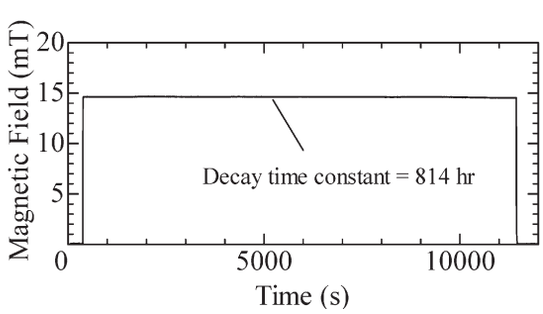
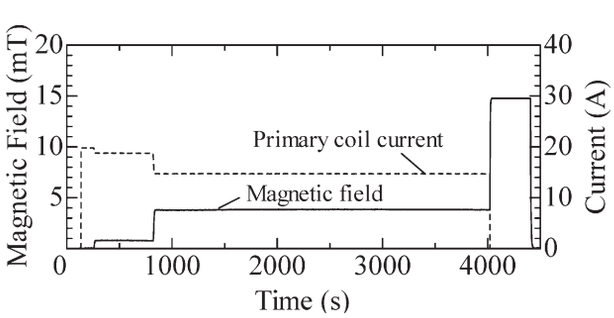


Fig. 2. Photograph of the fabricated HTS loop.



(a) Measurement of the decay time constant.



(b) Operational test.

Fig. 3. Test results of the HTS loop.