§ 4. Excitation Test of the High Temperature Superconducting Coil in the Mini-RT Device

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A magnetically levitated superconducting coil system, Mini-RT, has been constructed at the High Temperature Plasma Center of the University of Tokyo for the purpose of examining the magnetic confinement scheme of high-beta plasmas with a new relaxation process [1]. The floating coil (diameter: 300 mm, weight: 20 kg) has become the world first application of high temperature superconductors (HTS) for a plasma fusion device.

After the HTS floating coil was successfully wound using an Ag-sheathed Bi-2223 tape (critical current: 108 A at 77 K, self-field) of ~400 m length, its superconducting performance was examined in a liquid helium cryostat in the Cryogenics Laboratory at NIFS. The HTS coil has successfully reached its nominal operation point (overall coil current: 50 kA, cable current: 118 A) at the specified temperature of 20-40 K. Good performance of the newly developed HTS persistent current switch (PCS) was also confirmed. The coil was then installed in a stainless-steel coil case and delivered to the Mini-RT device.

In the Mini-RT device, cold gas helium is supplied through GM refrigerators to cool the HTS coil. In the initial cool-down test, which was performed using one unit of refrigerator, the coil temperature could reach only to 40 K due to the unexpectedly large heat in-leak (of ~30 W) especially from the detachable transfer tubes. It was then decided to add one more set of refrigerator and the coil temperature could successfully be lowered to the specified value of 20 K.

On the other hand, it was found in the initial excitation test, that the HTS cables at the coil-lead sections, where 3at%-Au-doped Ag-sheathed Bi-2223 cables were used, did not fully become superconducting due to the large heat in-leak from the detachable current feeders. We then added thermal anchors to these sections (connected from the radiation shield panels) so that their temperature could be lowered. However, the coil current still could reach only to half the nominal operation point and the coil-lead se sections turned into normal conducting above this operation point. Figure 1 shows a typical example of waveforms in an excitation when a normal-transition was observed. According to this experimental result, we finally decided to cool the room temperature part of the current feeders by liquid nitrogen. Then, we found that we could successfully raise the current up to the nominal value of 118 A without observing a quench.

After achieving the nominal current, a persistent current mode was realized by switching off the PCS heater and the decay time constant of the persistent current was measured by holding the coil temperature at 20 K. As is shown in Fig. 2, the current decays with a time constant of ~20 hours at the initial phase. This time constant seems to be considerably shorter than the expected value of ~200 hours which is obtained by integrating the flux-flow resistance and the joint resistance along the coil cable. We should consider some kind of electromagnetic effect for explaining the observed unexpectedly large resistance in the coil cable.

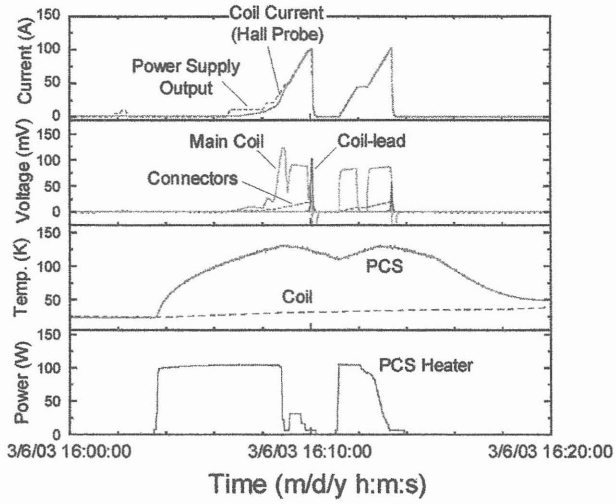

Fig. 1. Waveforms of the coil current, voltage, temperature and PCS heater power during an excitation test.

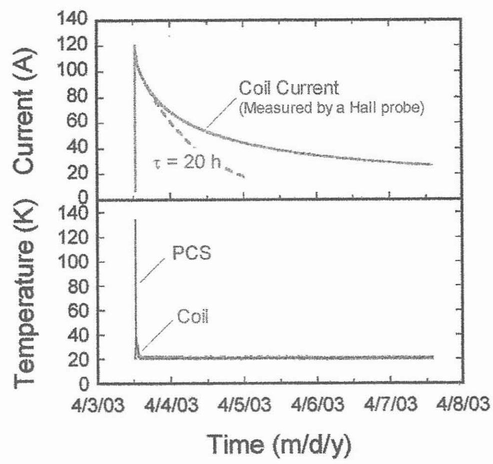

Fig. 2 Temporal decay of the magnetic field measured at the coil center. The coil temperature was kept at 20 K.

References

1) Y. Ogawa, et al., AIP Conf. Proc. (1999) pp. 417-422.
2) Yanagi, N. et al.: IEEE Trans. Appl. Supercond. 12 (2002) pp.948-951.