§1. Construction and Operation of the Internal Coil Device Mini-RT with an Levitation of a High Temperature Superconducting Coil

Ogawa, Y., Morikawa, J., Ohkuni, K. (The University of Tokyo)
Iwakuma, M. (Kyushu University)
Mito, T., Yanagi, N.

The internal coil device Mini-RT, in which the high temperature superconductor coil is levitated, has been constructed, and the levitation experiments have been carried out[1,2].

The floating coil of the Mini-RT device is operated at the temperature range 20-40 K, and Bi-2223 tape conductors were selected because of their high performance based on the recent technological progress. The Persistent Current Switch (PCS) is equipped, so as to excite the coil current through the external DC power supply. The HTS coil and the PCS are cooled down with cold gas helium, which is supplied to the internal coil with a cooling pipe and a check valve.

The excitation of the coil has been carried out. The coil current was evaluated by measuring the magnetic field with a Hall probe. Initially the HTS coil was cooled down to 21 K, and then the PCS temperature was raised above the critical temperature (about 106 K) using a Manganin heater so as to hold the turn-off condition.

The coil current was supplied by the external power supply within a few minutes. When the coil current was increased up to the nominal value of 118 A, the PCS was quickly cooled down below 40 K to hold the turn-on condition. Then, the current of the power supply was decreased, and the persistent current mode was achieved. The persistent current gradually 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 can be 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.

Levitation experiments of the superconductor coil have been carried out in the spherator and so on, and the coil has been successfully levitated during a few hours. The feedback system such as a stabilizing shell and a feedback coil could be installed near the floating coil, because the plasma is mainly produced at the inner region of the torus. While, in the Mini-RT these stabilizing tools could not be installed inside the vacuum vessel.

A levitation coil made of a normal conductor is installed at the upper region of the vacuum vessel, and its coil current is feedback-controlled. A nominal value of the levitation coil current is 15.25 kAT at the floating coil current of 50 kAT.

Since the floating coil has six freedoms (X-Y-Z movements and rotations), the detection and control for these freedoms is, in general, required. However, the control of five freedoms is sufficient, because the rotation of the floating coil in the toroidal direction is not requisite. In addition, the floating coil is vertically unstable and other motions are stable, when other magnetic fields such as the external vertical magnetic field and the toroidal one are not introduced. Therefore, at present, the Mini-RT device has three sensors from the top of the torus, so as to detect the vertical position of the coil.

The coil position is measured with laser position sensors with an accuracy less than 10 μm. The feedback control of the levitation coil current is carried out with PID analog system[3].

The HTS coil is cooled and excited at the bottom region of the vacuum vessel, and mechanically lifted at the middle of the vacuum vessel. By exciting the levitation coil current, the floating coil is smoothly launched. Figure 1 shows the photo of the levitated HTS coil in the vacuum vessel, and the position data of the coil is given in Fig. 2. As the HTS coil current is gradually decaying, the levitation coil current is slowly increased. The coil position is artificially changed with 7 mm at the time of 50 minutes. The accuracy of the coil position is less than 20 μm. We have succeeded to levitating the HTS coil during about one hour.

Fig. 1 Photograph of the floating HTS coil.

Fig. 2 Waveforms of the floating and levitation coil currents and the position of the floating HTS coil.

References