§25. Cool-down and Excitation Tests of the REBCO Coil for the Torus Plasma Experimental Device Mini-RT

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Recently, internal coil devices have been constructed for exploring new frontiers of plasma physics related with the relaxation theory developed at the University of Tokyo. Meanwhile, the progress of high temperature super-conductors (HTS) has been remarkable. Since long HTS tapes of more than a few hundred meters are presently available with sufficient critical currents, large coils can be constructed. The floating coil of the Mini-RT device was the first application of HTS for fusion research [1], followed by the larger device RT-1. Both coils were wound with BSCCO tapes. For further advances of the RT project, the upgrading plan of Mini-RT was initiated to replace the floating coil by a new one wound with the latest REBCO tapes.

The new HTS floating coil wound with REBCO tapes has the same diameter of 300 mm with that of the former BSCCO coil. The nominal operation condition requires the tape current of 100 A, which corresponds to 55 kA for the total coil current having 552 turns of windings. A persistent current switch (PCS) for the direct charging method is also made by the same REBCO tape. The floating coil is indirectly cooled to 20 K by forced flow of cold helium gas with a cooling pipe attached to the surface of the winding bobbin.

The performance of the HTS floating coil has been examined at the National Institute for Fusion Science (NIFS) before it was actually installed in the Mini-RT at the University of Tokyo. A schematic view of the experimental set-up for the performance test of the Mini-RT/RE coil at NIFS is shown in Fig. 1. The coil was placed in a cryostat with a thermal shield. Helium gas in the cooling pipes was circulated by a compressor and cooled by the GM cryocooler. The excitation test was carried out by gradually increasing the current up to 100 A. The coil current was evaluated by measuring the magnetic field at the coil center using a Hall probe. Voltage taps were attached on the tapes in various positions to measure the coil voltage and the joint resistances at the leads (Fig. 2).

Fig. 3 shows the waveforms of the coil current, the temperatures and the PCS heater power. The coil has been successfully excited up to 100 A with a proper PCS operation. The central field given by the Hall probe was 0.21 T, which was the same with that expected by a numerical calculation. The time constant of the current decay during the persistent current mode operation was evaluated at the coil temperature of 36 K and 41 K to be 306 and 228 hours, respectively. These values are consistent with the estimation based on the measured joint resistances and they are much longer than that of the previous floating coil of Mini-RT made of BSCCO tape (41 hours before the aged deterioration)[2]. By the test results, it has been confirmed that the promising performance of the manufactured REBCO floating coil should be achieved to further promote the Mini-RT project.

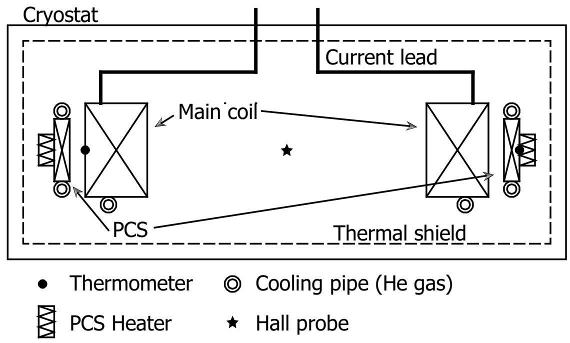

Fig. 1 Schematic view of experimental set-up

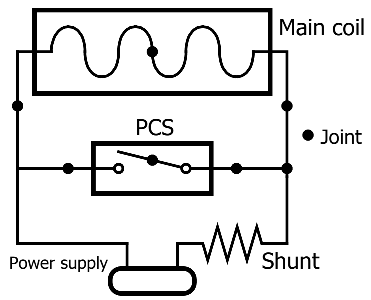

Fig. 2 Current circuit of the Mini-RT floating coil.

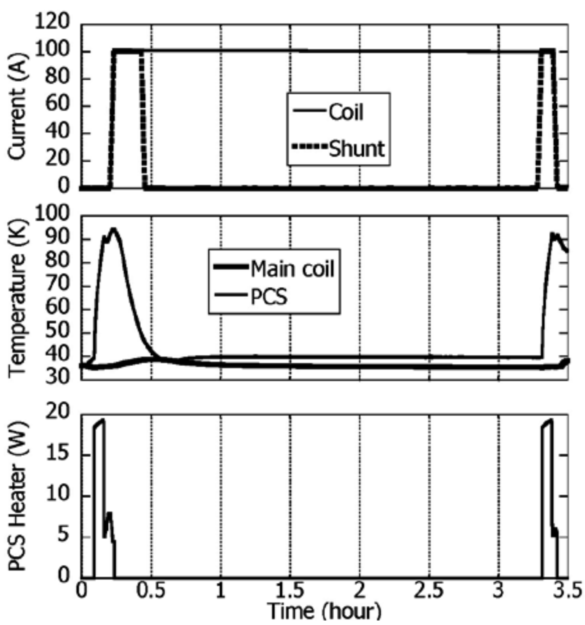

Fig. 3 Waveforms of the current of the power supply, the coil current (evaluated by a Hall probe), the temperature of the main coil and PCS, and the PCS heater power.

1) Ogawa, Y. et al.: Fusion Eng. Des. **81** (2006) 2361.
2) Yanagi, N. et al.: IEEE Trans. Appl. Supercond. **13** (2003) 1504.