§4. Study on High Beta Plasma Confinement Device with Floating HTS Coil

Ogawa, Y., Yoshida, Z., Himura, H., Nihei, H., Morikawa, J., Ohkuni, K. (Univ. of Tokyo), Iwakuma, M. (Kyushu Univ.), Sumiyoshi, F. (Kagoshima Univ.), Mito, T., Yanagi, N., Hishinuma, Y.

To explore two-fluid relaxation theory proposed by Mahajan-Yoshida [1], a toroidal device with an internal coil is under construction. The internal coil device Mini-RT is equipping a levitated ring with a HTS coil, where the major radius of the HTS coil is 0.15 m and the coil current is 50 kAturns. The vacuum chamber is 1 m in diameter and ~ 0.7 m in height. Typical magnetic configuration is shown in Fig. 1. The weight of the floating coil is around 20 kg, and the coil current of the levitation coil located at the upper part of the vacuum vessel is 15 kA. In Fig. 1, the separatrix can be seen just below the levitation coil, and plasma will be confined at the inner region of the separatrix. The magnetic field strength near the floating coil is around 0.1 T, and the plasma production with 2.45 GHz Electron Cyclotron Heating is planned.

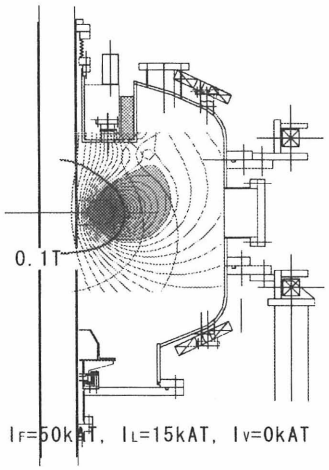

Fig. 1 Magnetic configuration of the Mini-RT device

A strong plasma flow in toroidal direction is expected by introducing a radial electric field, yielding the toroidal flow velocity of E_r / B_p. In order to build up the radial electric field in the plasma, we are preparing several techniques. In the Proto-RT experiments, electrons have been injected through the separatrix, and the build-up of the radial potential has successfully achieved.

The direct insertion of the electrode inside the plasma would be possible candidate to drive the radial electric field, as demonstrated by the CCT tokamak for achieving H-mode plasmas[7]. In addition, we consider the utilization of direct orbit loss of high energy electrons produced by ECH, because the ECH could produce high energy electrons more than a few tens keV. The high energy electrons would escape from the magnetic surface through the separatrix region due to its large Larmor radius. This might yield a bulk plasma to non-neutralize.

The specifications of the HTS coil is listed in Table I. The coil is cooled down to 20 K by introducing a 20 K helium through the removable check valve. The coil current is directly charged by the power supply through the removable current feed-through. Attachments for these purposes are equipped in the floating coil.

Table I. Specification of the floating HTS coil.

Major/Minor radius	150/28 mm
Total current	50 kAturns
Number of turns	428
Nominal coil current	117 A
Superconductor	Ag-sheathed Bi-2223
Cable width/thickness	4.3mm/0.26mm
Silver ratio	1.57
Critical current (77K, s.f.)	108 A
Stored magnetic energy	598 J
Max. magnetic field	0.51 T(perp.) / 0.76 T(para.)

In addition, so as to achieve the persistent current mode during the floating phase, the persistent current switch (PCS) is equipped, as well. The tape Bi-2223 (Ag-0.3wt%Mn sheathed) is adopted, and the turn off resistance is designed to be 0.27 W.

The excitation test of the HTS floating coil has been carried out. Figure 2 shows the waveforms of the output current of the power supply, coil current and temperatures of the HTS and the PCS coils. Here the coil current is evaluated by measuring the magnetic field with a Hall probe. Initially the HTS coil is cooled down to 20 K, while the PCS is kept at the elevated temperature around 70 K, resulting in the switch-off condition. During this period the coil current is supplied by the power supply. When the coil current is increased up to the nominal value (i.e., Ic = 118 A), the PCS is quickly cooled down to 20 K or less, expecting to transit to the turn-on condition. Then, the current of the power supply is gradually decreased, resulting in the replacement of the power supply current with the PCS one. In Fig. 2 we can see that the persistent current mode is achieved around the time 6:20:00.

Here we have examined the decay constant (e-folding time) of the persistent current for various temperatures. At the temperature of 20 K, the decay constant is estimated to be 40 hours, while that is to be 6.5 hours at 20 K.

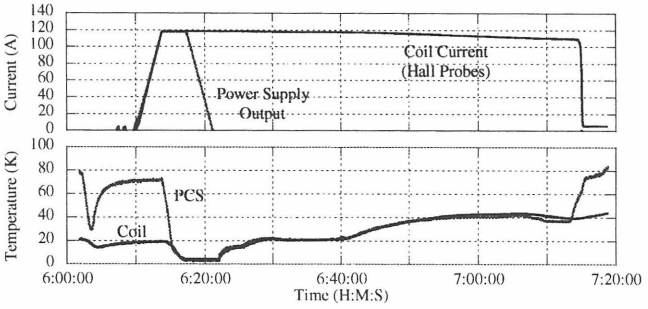

Fig. 2 Excitation test of the HTS coil.

Reference
1) Z. YOSHIDA and S.M. MAHAJAN, *Phys. Rev. Lett.* **88**, 095001 (2002).