

§29. Application of Advanced High-temperature Superconductors for Fusion Plasma Experimental Devices

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We have constructed internal coil devices Mini-RT and RT-1, in which a high-temperature superconductor made of BSCCO is floating during a few hours with an accuracy of a few tens micrometers. In the Mini-RT device several new technologies such as a persistent current switch, a demountable transfer tube in the ultra vacuum condition and a demountable electrode have been successfully developed. Based on these experiences the RT-1 device has been constructed and the plasma experiments have been conducted.

The specification of a BSCCO tape employed for the RT-1 device is as follows;

Table I. Specification of a BSCCO tape for the RT-1 device

Tape	Ag-shiethed Bi-2223, no insulator
Size	$(t=0.23\pm 0.03) \times (w=4.2 \sim 4.6)\text{mm}$
Silver ratio	1.5
Critical current	$> 100\text{ A}$ and $> 115\text{ A}$ at 77 K, s.f., $1\mu\text{V}/\text{cm}$
n value at 77 K, s.f.	> 18 (at $10^{-9} \sim 10^{-6}\text{ V}/\text{cm}$)
Tensile stress at R.T.	$> 100\text{MPa}$

The schematic drawing of the RT-1 device is shown in Fig.1. The plasma is produced by microwaves of 8.2GHz and 2.45GHz, and the contours of the magnetic field strength for Electron Cyclotron Resonance are depicted in Fig. 1.

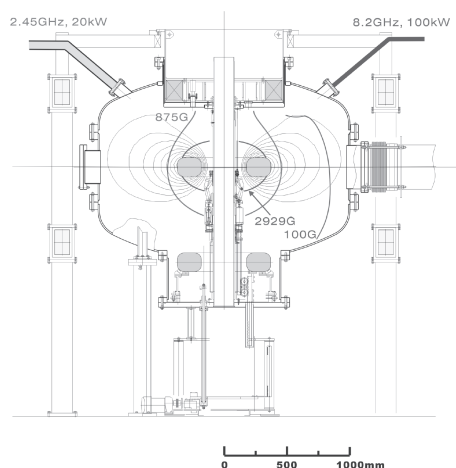


Fig. 1 A schematic drawing of the RT-1 device

The major radius, the total coil current and the total weight of the floating coil are 0.25m, 250 kAturns and 110 kg, respectively.

Progress on a high temperature superconductor YBCO tape is quite promising, and a long tape with a few hundreds meters has been developed. However, the fabrication for coil winding seems to be premature, and there are no applications for fusion plasma devices till now. Here we are considering to apply a YBCO tape for fusion plasma devices such as a LHD for the future application.

We have started a feasibility of a YBCO coil for a correction coil in the LHD. Present correction coil is made of copper, and located outside the cryostat. If the high temperature superconducting coil could be introduced for the correction coil, the flexibility of plasma experiments would be dramatically improved, because the HTS coil could be mounted inside the cryostat, and the passive and active control of the correction field would be available. The schematic drawing of the HTS correction coil for the LHD is shown in Fig. 2.

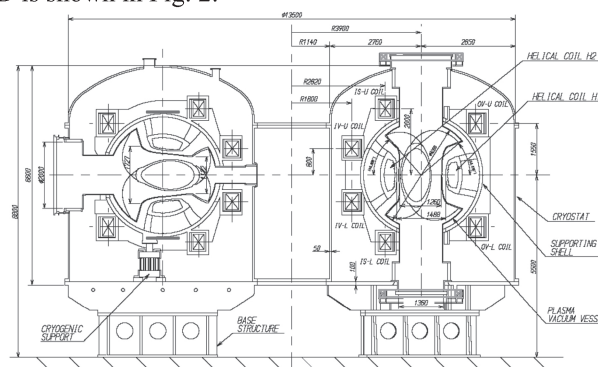


Fig. 2 A schematic drawing of the correction coil for the LHD. A left (right) side represents a HTS (copper) coil.

Here we have considered several cases for the winding; e.g., single tape, two tapes and five tapes cases. The double pancake is, eventually, adopted for the coil packing, and the stainless steel or aluminum is used for the coil casing. The maximum field is estimated to be 3.2 T at the coil region. When the persistent current switch would be introduced in this coil system, not only the passive but also the active controls of the correction coil current could be available.

Finally let us briefly summarize advantages of HTS coils in comparison with those of LTS ones, and feasibility of applications for fusion devices.

[Advantages]

- @ Operation at elevated temperature (20 – 80 K)
 - High stability with large heat capacity
 - Reduction of refrigeration power
- @ High field ($B_{\text{max}} > 20\text{ T}$)
- @ Persistent current operation

[Feasibility of Applications]

- @ Fusion reactors (high field coil might be available)
- @ Vertical position control (Miya and Uchikado have proposed)
- @ Correction coils for Helical devices
- @ Feedback-control coils for RWM in tokamaks