§25. Design of Testing Sample of High-current Superconductors for A 15 T Test Facility

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Fusion power plants need larger scale and higher field superconducting magnets than the ITER magnets. Therefore, higher current superconductors with high strength against strong electromagnetic forces are needed. In order to examine the superconducting properties of such large conductors in real conditions, we are preparing a new test facility that is equipped with a solenoid coil of the highest field of 13 T with the bore of 0.7 m, a pair of temperature-variable current leads, and a vacuum chamber for conductor samples, as shown in Fig. 1. The highest field can be increased to 15 T by installing an additional coil with the cold bore of 0.6 m. The nominal sample current is 50 kA that can be increased up to 75 kA by installation of additional current feeder lines. Since the inlet temperature of the samples can be varied from 4.4 K to 50 K, it is possible to examine properties of advanced conductors at actual operating temperatures.

We propose coil-shaped conductor samples instead of straight samples in order to apply electromagnetic hoop forces on the conductors to realize the real condition[1]. Figure 2 shows a reference design of a coil-shaped conductor sample. The ITER-TF conductor is considered here. In order to withstand the electromagnetic force by itself, the conductor is supported by a rigid outer supporting ring, as well as the two feeders are firmly clamped to each other to cancel the force. The preferred turn number of the sample is two or higher to apply uniform tension by the electromagnetic force on the strands in the testing region. Considering the strength of the conduit of the CIC conductor, the thickness of the outer supporting ring can be reduced. We propose a screw-shaped groove to enlarge the occupied area of the ring with a fixed outer diameter, as shown in Fig. 2. Before the heat treatment for production of Nb_3Sn, the sample is inserted in the groove of the ring with being rotated. Ceramic electrical insulation is lapped on the conductor. The structure of the terminal is planned to be similar to the ITER conductors. Since the electromagnetic force on the vertically bent section in the feeder induces the overturning force, the supporting ring is fixed from the inside with an inner support that prevents the rotation of the ring. In order to reduce the net horizontal force on the conductor sample, it is important to optimize the route and figure of the two feeders.

The magnetic field distributions in horizontal planes are shown in Fig. 3. In the case of the highest field of 13.0 T, the central field is 11.12 T at the operation current of 765 A, and the field at the sample position, where is the radius of 0.30 m, is 12.41 T. Since the self-field of the sample is in the range of ±0.5 T for the 50 kA conductors, the highest field in the sample is almost 13.0 T. In the case of the highest field of 15.0 T, the central field is 13.34 T at the operation current of 761 A, and the field at the sample position, where is the radius of 0.25 m, is 14.45 T.

1) Imagawa, S. et al.: Plasma and Fusion Research, Vol. 10 (2015) 3405012.

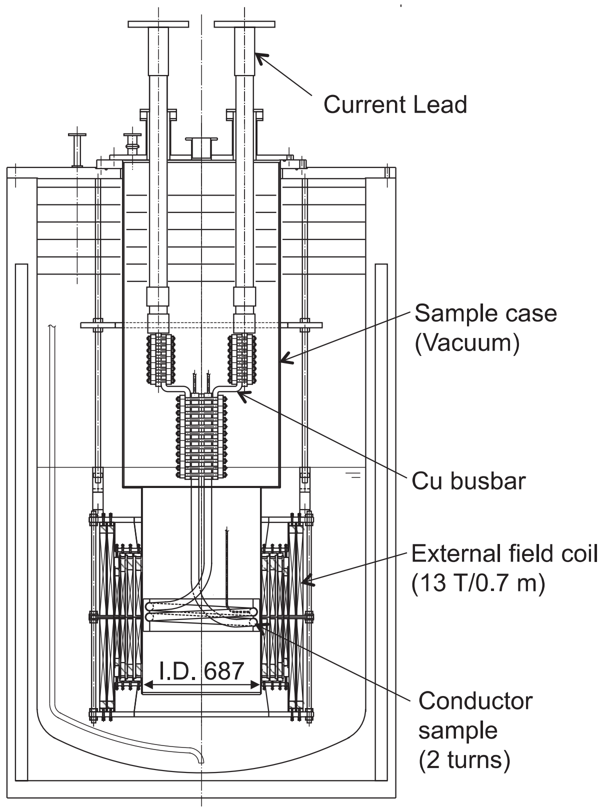

Fig. 1. Setup of the new test facility with the 13 T–0.7 m external field coil and a conductor sample.

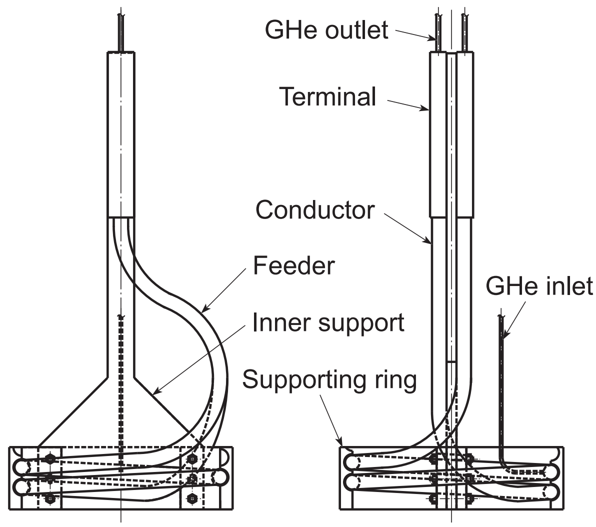

Fig.2. A reference design of conductor samples.

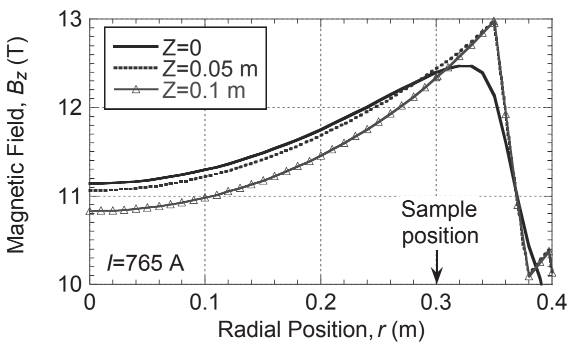

Fig. 3. Magnetic field distributions in horizontal planes at the axial (Z) positions of 0 (center), 0.05 m, and 0.10 m.