§7. Excitation Tests of a Miniature Double-Pancake Coil Made of High Temperature Superconductor

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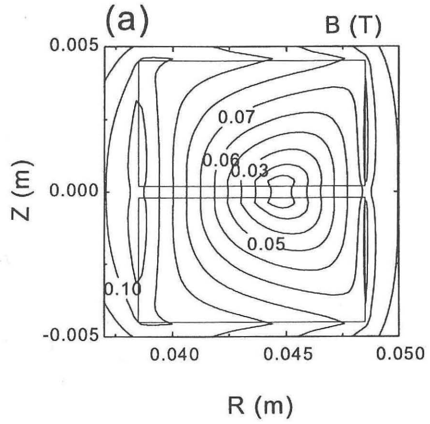
Application of high temperature superconductors (HTS) for fusion magnet systems is widely discussed because of the advantage of HTS having sufficient critical current at high temperature where the conductors would have much higher cryostability than that for conventional low temperature superconductors. One of the most outstanding progresses of HTS is recently found in the development of Ag-sheathed Bi-2223 tape conductors, which assures critical current density of higher than 300 A/mm^2 at 77 K and self-field. From the engineering point of view, it might be a challenging issue to apply these HTS cables to fusion systems. One example is found in a magnetically levitated coil [1], which will be used for an advanced-type plasma confinement device with dipole-like magnetic configuration. Another idea is to use them for existing machines, such as the Large Helical Device (LHD), in order to flexibly modify the intrinsic magnetic configuration for achieving better plasma confinement.

As one of the engineering R&D programs to investigate the feasibility of HTS application for fusion magnet systems, we have fabricated a miniature HTS coil and carried out its excitation test. The inner and outer diameters of the coil are 77 mm and 94.5 mm, respectively, and 12 m of Ag-sheathed Bi-2223 tape was wound into a double-pancake of 44 turns with a lap joint (150 mm) at the ends. The tape has a cross-section of 4.1 mm × 0.3 mm and is reinforced by stainless steel foils. Prior to the experiment, the critical current of the coil was estimated by assuming that the local current density is determined depending on the magnetic field distribution inside the winding section. The obtained value is 59.2 A, and the field and current density distributions are shown in Fig. 1.

The HTS coil was cooled by liquid nitrogen and excited by decreasing the external magnetic field. The magnetic field generated by the coil was measured using a Hall probe at the center and its waveform is shown in Fig. 2. The magnetic field decays with a time constant of 3306 s in the long range. This time constant well agrees with the value obtained from the estimated joint resistance. The coil current decays rather quickly at the initial phase (time constant: 41.7 s), and this might be due to the inherent flux flow resistance of the tape. By conducting a numerical simulation, the n-value is estimated to be about 9.

It should be noted that after the excitation test, the miniature HTS coil was magnetically levitated using an external coil as well as a control system with laser displacement gauges. By installing thermal insulation with GFRP, polycarbonate and styrene foam, the maximum floating time of four and a half minutes has been achieved.



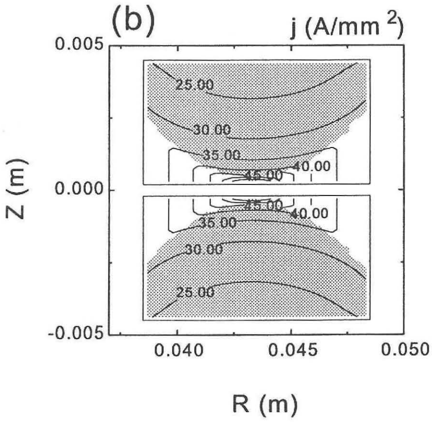


Fig. 1 Spatial distributions of (a) magnetic field and (b) current density inside the winding section of the HTS coil. In (b), the shaded area is in the critical state.

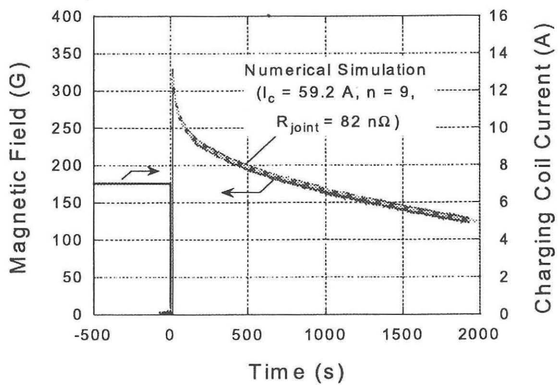


Fig. 2 Temporal decay of the magnetic field measured at the coil center after the turn-off of the charging current.

References

1) Morikawa, J. et al.: submitted to Jpn. J. Appl. Phys.