§4. Feasibility Study on SMES Systems Using Stress-Minimized Helical Coils

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Large-scale superconducting magnetic energy storage (SMES) coils require special considerations for induced electromagnetic forces to limit allowable tensile stresses. Force-balanced coil (FBC) is a helically wound hybrid coil of toroidal field coils and a solenoid. The FBC is an optimal SMES coil configuration that can minimize the required mass of the structure for induced electromagnetic forces. In order to demonstrate the feasibility of the FBC concept for large-scale SMES, a model coil, which will be geometrically one tenth the size of a 100-MJ class SMES coil, has been developed [1], [2].

Fig. 1 shows a photograph of the model coil based on the FBC design. The model FBC will have 270-kJ stored energy at the magnetic field of 7 T using NbTi strands. The critical coil current and the self inductance are 552 A and 1.8 H, respectively. The hand-made winding of the model FBC was carried out without reinforcing materials, such as stainless steel wires, for the NbTi strand with an outer diameter of 1.17 mm. The total number of poloidal turns is 10584 turns.

The first experiment was conducted with liquid helium cooling. The quench properties of the model FBC were mainly investigated. The model FBC was usually excited with a ramp rate of 1 A/sec. Figs. 2 and 3 show the load line and the training history of the model FBC, respectively. The first quench current is 293 A, which is 53% of the critical coil current. Training phenomena were observed in the model FBC, and after repeated excitations it was successfully excited up to 5.4 T without reinforcing materials for the NbTi strand.

As a second step, the ramp rate dependence of the superconducting properties will be investigated in order to demonstrate the validity of the FBC concept as a large-scale SMES coil.

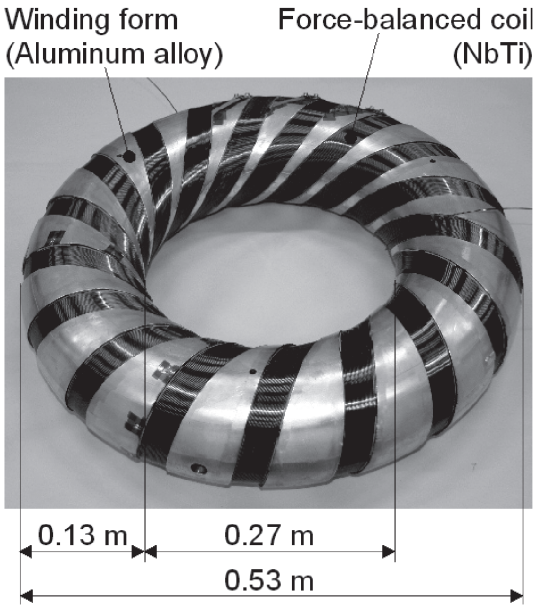

Figure 1: Photograph of the model coil based on the FBC design.

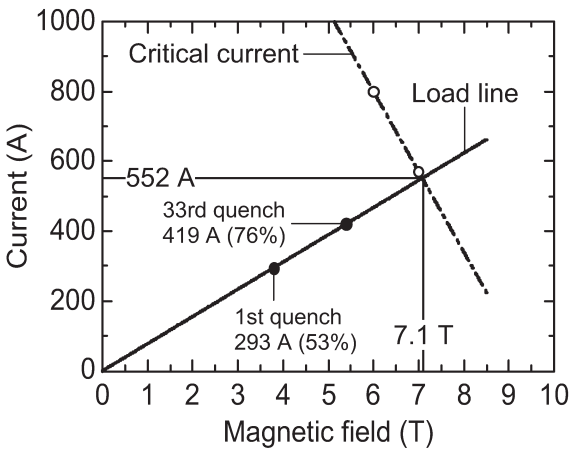

Figure 2: Load line of the model FBC. The dots indicate the test data.

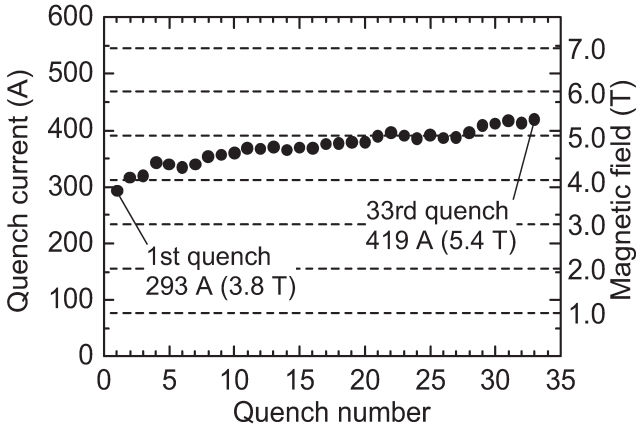

Figure 3: Training history of the model FBC.

References

[1] Nomura, S., Tsutsui, H., Tsuji-Iio, S., Chikaraishi, H., Shimada, R., "Feasibility Study on High Field Magnets Using Stress-Minimized Helical Coils," Fusion Engineering and Design, **81** (20-22) (2006) pp. 2535–2539.

[2] Nomura, S., Kasuya, K., Tanaka, N., Tsutsui, H., Tsuji-Iio, S., Shimada, R., "Development of a One Tenth Sized Model Coil for 100-MJ Class SMES Using Force-Balanced Coil Concept," to be published in IEEE Trans. Applied Superconductivity.