§7. Measurement of Dynamic Stability of Composite Conductors for LHD Helical Coils

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The propagation and recovery of normal zones were observed repeatedly in the innermost block, *I*, of helical coils at higher than 11 kA. This is lower than the expected cold-end recovery current. The main reason is considered to be additional heat generation due to slow current diffusion into a pure aluminum stabilizer. A threshold current seems to exist. When a current is slightly higher than it, a normal zone can propagate and recover because of a ripple of the magnetic field or change of heat transfer to the coolant. This may be called "a minimum dynamic propagating current". That of the *I* block became clear in the real helical coils, but those of the *M* and *O* block were not known. These threshold currents were considered to be lower than that of the *I* block, because of the higher magnetoresistivity by the Hall effect or the higher spacer rate. These values are important to increase the currents of *M* and *O* blocks.

Measurement of the dynamic propagating current has been tried with a new test sample, which is circularly bent to extend the length in the uniform bias field, as shown in Fig. 1. A normal zone was initiated by a heater inserted between the conductor and a spacer at the bottom. The propagation of a normal zone was detected by voltage taps and thermometers. The duration of the heat input was set to 20 ms. The heat input power was limited below 100 W by the power supply. In the case of B//18.0, normal zones propagated in both sides at fairly high currents, and recovered to superconducting after stopping at the low field region at the top. As the currents were decreased, the existing time of normal zones became shorter. Besides, the normal zones propagated in the one side at the currents close to the threshold current. This may be caused by the electromagnetic interaction between the diffusing current and the bias field. In the case of B//12.5, normal zones propagating in both sides stagnated at the low field region at the top or ran away because of high magneto-resistance. One side propagation was rarely happened at just the threshold current.

The minimum heat input to initiate propagation of a normal zone is shown in Fig. 2. The minimum heat input for the propagation becomes higher at the lower bias field, which is caused by the increase of critical temperatures. The necessary heat input becomes higher at the lower current in the same bias field, and it increases sharply at the certain current, which can be defined as a minimum dynamic propagating current. The length of an initiated normal zone by the heater may not reach the next spacer even in the case of 100 W. The dependence to the bias field is shown in Fig. 3. The effect of the direction of the bias field is small for the minimum dynamic propagating current in spite of the large difference of cold-end recovery currents. The dynamic stability is determined by the heat balance before the current flows in the pure aluminum. The currents of normal-zones propagating in the helical coil are also indicated in Fig. 3, and these are close to the threshold current measured in the test sample.

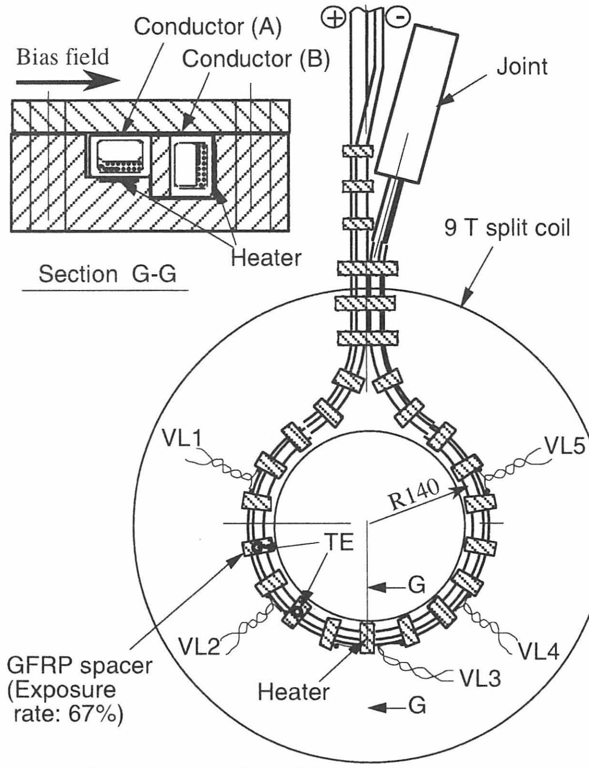

Fig. 1. Set up of samples of the composite conductor.

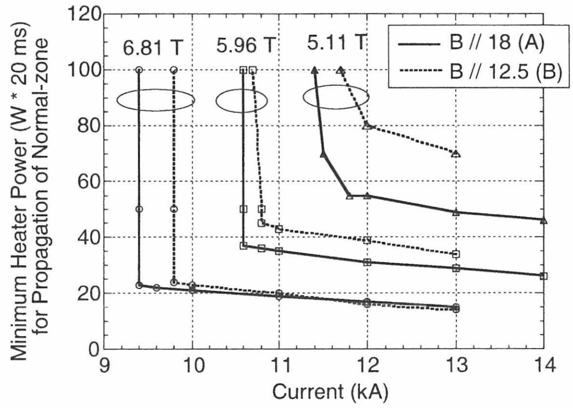

Fig. 2. Minimum heat input for dynamic propagation.

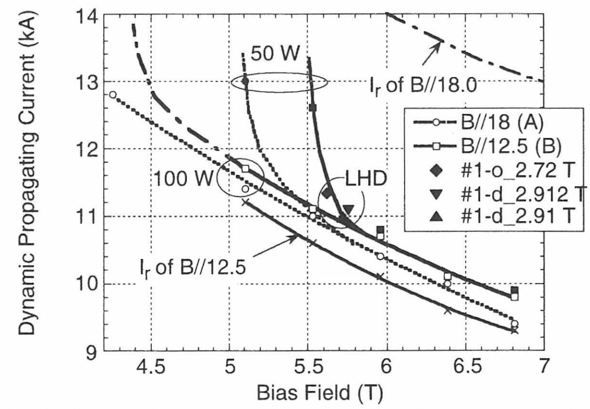

Fig. 3. Dynamic normal-zone propagating current and cold-end recovery current.

Reference

1) N. Yanagi, et al.: Proc. of ISS'98, Nov. 16-19, 1998, Fukuoka (1999) pp991-994.