§2. Cooling Stability Test of He II Cooled LHD Conductor

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Cooling stability tests of the LHD conductor immersed in pressurized He I and He II were carried out. A small test coil wound and short-circuited with a LHD conductor of 4.2 m in length on a stainless steel bobbin of 162 mm in outer diameter was used. The test coil was set in a Claudet-type cryostat. There was a superconducting magnet (field magnet), which supplied a certain magnetic field to the test conductor, outside of the test coil. A large current was supplied to the test coil conductor by use of a transformer effect, that is, the test coil current was induced by increasing the field magnet current.[1] The expanding diagram of the test conductor to the longitudinal direction is shown in Fig. 1. A resistive nichrome heater was mounted between the spacer and the conductor at the central part of the test part. The heater section with the length of 18 mm was covered with a polyimide tape. For the test part, the contact sections with each stainless spacer were similarly insulated with the polyimide tapes and the ratio of exposure was set up to 67 %. Experiments were performed according to the following procedure. Set the test conductor current and the external magnetic field. Give the pulsive heat input (125 W, 20 to 200 ms) by use of the heater to cause a bud of normal transition in the conductor. Measure the tap voltages and the temperature signals to know the behavior of the normal zone propagation.

Stability tests of the LHD conductor at a certain pulse heat input were performed for the magnetic flux densities from 1.2 T to 6.8 T and the bulk liquid He temperatures from 2.0 K to 4.2 K at atmospheric pressure. Characteristics of the normal zone propagation were classified into three groups.[2] (Group I) The normal zone arises only around the heater, and disappears after shutting off the heat input. (Group II) The initiated normal zone propagates to only one direction of the test coil and disappears in the lower magnetic field part. (Group III) The initiated normal zone propagates to both sides. Fig. 2 shows the typical waveforms of the measured test coil current and the voltages between each taps belonging to Group III. The test coil current decreased with the propagation of the normal zone into the rewinding part without the aluminum stabilizer. The classification of the test results was determined until about 60 ms from the addition of heat input, and the attenuation ratio of the test coil current was about 2 % at the time. The attenuation of the test coil current hardly affects the classification of the test results.

Fig. 3 shows the stability limit currents versus the magnetic field for the different cooling conditions. In this figure, shaded areas indicate the dynamic one-side propagation regimes (Group II) and the solid lines indicate the stability limit currents I_r, which are the maximum transport currents without the both-sides propagation. The experimental result shows that the stability limit current I_r under a certain magnetic field slightly increases by shifting to subcooled He I cooling (2.2 K) from saturated He cooling (4.2K), and increases greatly by shifting to He II cooling (2.0 K). The advantage of the He II cooling on the stability of the LHD conductor is confirmed. However, in the He II regime, the dynamic one-side propagations were observed for the wider transport current range than in case of He I cooling. The one-side propagation may be a serious problem when the higher excitation of the LHD magnet is realized by lowering the liquid He temperature. In order to find a clue for elucidating this phenomenon, cooling stability tests under various test conditions were also carried out. As the results, it turned out that the direction of the dynamic one-side propagation depends on the direction of the magnetic field instead of the transport current. The dynamic one-side propagation will be due to the Hall effect as the result of the interaction of the magnetic field and the diffusion current into the pure aluminum stabilizer with long current diffusion time.

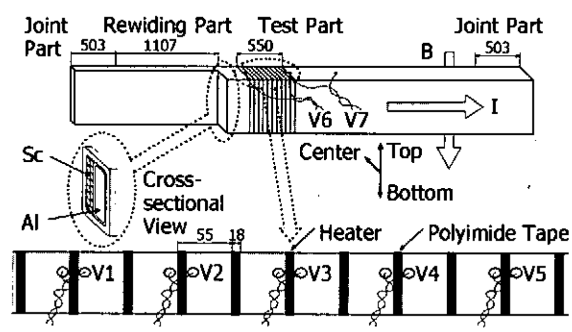

Fig. 1. Expanding diagram of the test conductor

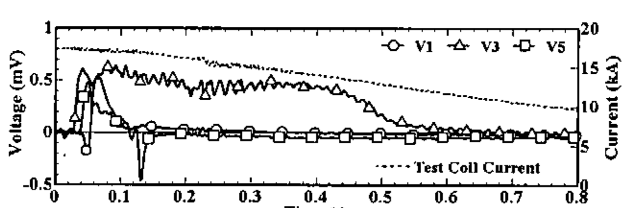

Fig. 2. Typical test result belonging to Group III

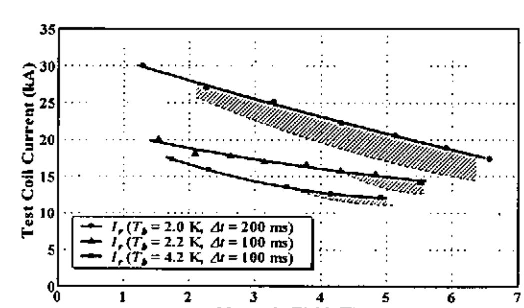

Fig. 3. Stability limit currents for the LHD test coil

Reference
1) Higuchi, Y. et al. : presented at MT18
2) Ohya, M. et al. : presented at MT18