§9. Temperature and Field Dependence of the Normal Zone Propagation Velocity of the LHD Helical Coil

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In the previous studies, the stability tests of the small LHD conductor coil were explained[1], and advantage of He II cooling became clear compared with He I cooling.

In this study, in order to clarify the effect of the aluminum stabilizer on the transient stability of the LHD conductor and effect of Hall circulating current thought to cause asymmetrical propagation of normal zone, stability tests were performed by means of the conductor, which eliminated a pure aluminum stabilizer from LHD conductor.

The purpose of this study is twofold. First is to clarify the effect of the aluminum stabilizer on the transient stability of the LHD conductor at the normal transition. The transient stability of the conductor becomes worse compared to the steady-state one. This is due to the excess Joule heat generation caused by the delay of the current diffusion from the Rutherford cable into the aluminum stabilizer, whose electrical resistivity is very low. At the transient state, the thick aluminum may not effectively function as a stabilizer.

Second is to investigate the asymmetrical normal zone propagation phenomenon. The propagation velocity of a generated normal zone shows asymmetry along the conductor. This phenomenon is peculiar to the LHD conductor, and will be caused by Hall current generation in the aluminum stabilizer and Rutherford cable.

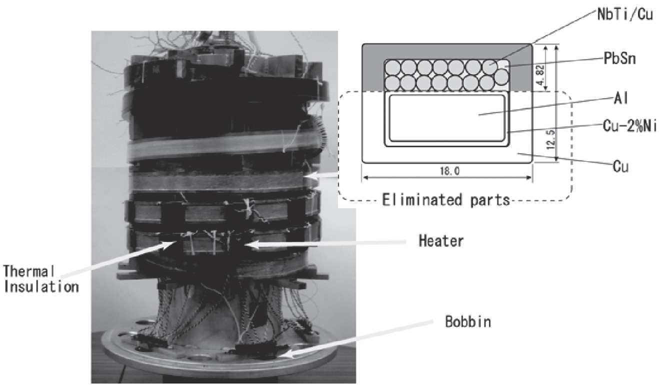
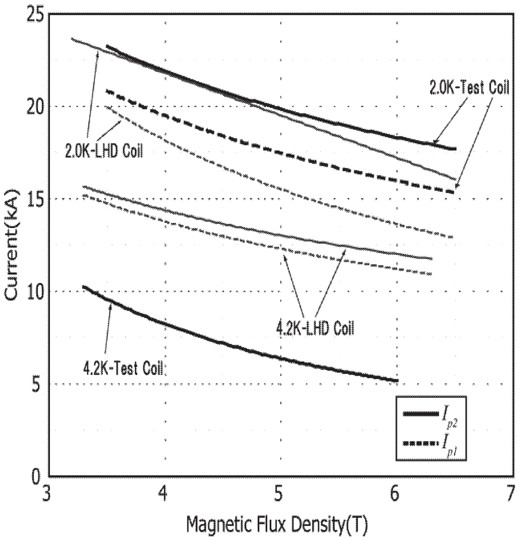


Fig.1 Cross-sectional view of the test conductor and Photograph of the test coil.

The stability tests in He I or He II cooling were performed by using the test coil wound with the Al-less test conductor (see Fig.1). Experimental results lead to the following conclusions.

Characteristics of the transients after the pulse heat input were classified into the following thee groups depending on the magnetic flux density and the test coil current ; *Group I: Non-propagation (below the line *Ip1*, *Group II: one-side propagation (between the lines *Ip1* and *Ip2*), *Group III: Both-side propagation (over the line *Ip2*). (see Fig.2)

One-side propagation was observed even without the Al-stabilizer. Hall current appeared in the copper sheath may cause the asymmetrical heat generation. The asymmetrical propagation is due not only to the aluminum stabilizer but to the copper sheath and the asymmetrical configuration. However the range of the transport current for the one-side propagation was smaller than that for LHD conductor. It is confirmed that the Al-stabilizer deeply affects the asymmetrical propagation.



Fig, 2 Stability test results for the test conductor at 4.2K(HeI) and at 2.0K(HeII, 1atm), and test results for the LHD conductor for comparison.

The "traveling normal zone" observed in the LHD conductor, was not seen in the Al-less test conductor. The normal zone was stationary and did not diminish. The steady state stability becomes worse without Al-stabilizer.

The one-side propagation direction depends on the direction of the magnetic field, but the transport current. It is confirmed that the one-side propagation is due to the effect of Hall current.

1) M.Ohya, A. Higuchi, Y. Shirai ,M. Shiotsu, and S. Imagawa, *IEEE Trans. Appl. Supercond.*, vol. 14, pp.1443-146,2004