§10. Measurement of Voltage Signals during Cooling Down and Excitation Tests of the Helical Coils of LHD

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The voltage signals of the helical coils have been monitored during the first cooling down and excitation tests of the Large Helical Device (LHD). The voltage signals are obtained using the potential taps attached to the coil leads of each block (H-I, H-M and H-O) of the two pairs of the helical coils (H1 and H2).

During the initial cooling down process (Feb. 23 to Mar. 23, 1998), the longitudinal resistance of the winding conductors was measured by continuously supplying DC 10 A to the coils. Figure 1 shows the time traces of the measured resistance of the six windings. As is seen in Fig. 1, the resistance showed a drastic decrease along with the decrease of the coil temperature (represented by HTE2221B; measured by a PtCo thermometer attached on the coil can). The transition to the superconducting state was observed at 4:00 PM, March 17 for the whole windings. From the resistance value observed just before the transition, the residual resistance ratio (RRR) of the conductor was determined to be 1000, which is very close to the expected value for the aluminum-copper stabilizer. The obtained relationship between the coil resistivity and temperature shows good agreement with that observed in the previously conducted short sample test

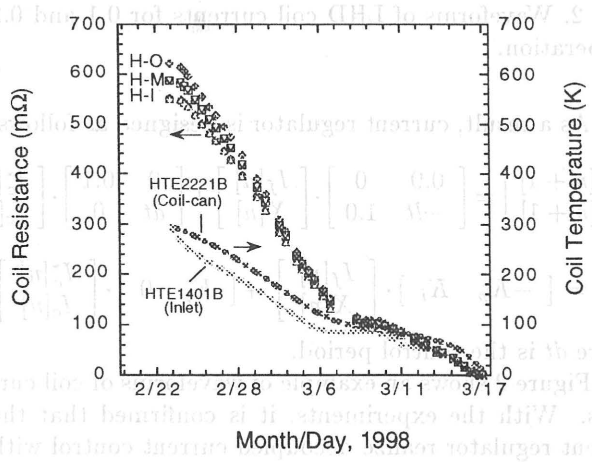

Fig. 1 Coil resistance and temperature during the first cooling down.

The voltage signals of the coils play an extremely important role during coil excitations, and the terminal voltages as well as the balance voltages have been carefully monitored. Here the balance voltage is obtained using a quench detection circuit in which the terminal voltages of two identical coils, i.e., {H1-I & H2-I}, {H1-M & H2-M} and {H1-O & H2-O} sets, are compensated. Prior to the excitation tests, the balance circuit was adjusted by switching on and off a DC 10 A power supply. As shown in Fig. 2, after the adjustment, the balance voltage could be well close to zero except for the short periods corresponding to the ramp up and down of the coil current. This imbalance might be brought about by the existing small difference for the mutual inductance between the two helical coils and the surrounding supporting structure.

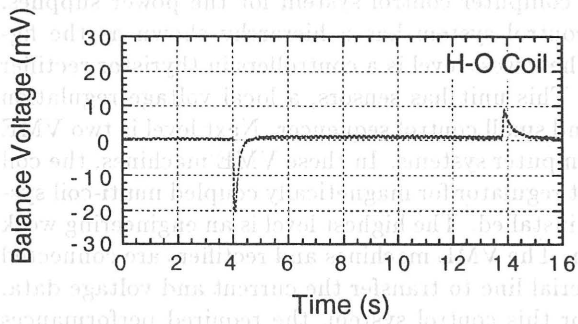

Fig. 2 Balance voltage with a 10 A switching on and off.

The balance voltage has been continuously monitored during the coil excitation tests while the quench detection circuit is ready for a normal transition. Figure 3 shows the time trace of the balance voltage during the first excitation of LHD up to the toroidal field of 1.5 T. As was expected from the result in Fig. 2, the balance voltage appears when changing the coil current. The sharp peak observed at t = 7000 s corresponds to a sudden decrease of the coil current caused by an "1-M" interlock signal which shut down the coil current with a time constant of 300 s.

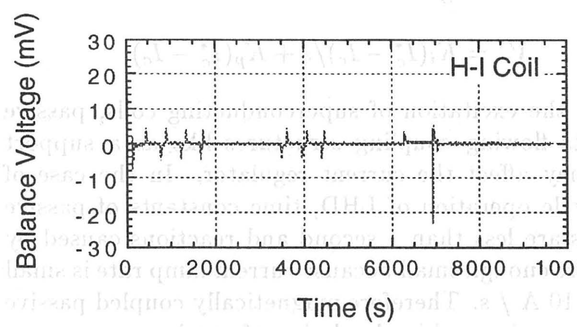

Fig. 3 Balance voltage during the first excitation test up to 1.5 T.

References

1) Yanagi, N., et al., Proceedings of ICEC 16 & ICMC (Kita-Kyushu) Part 2, Elsevier, Oxford (1997) 751.