§7. Some Observation Results on the Voltage Measurement of the LHD Helical Coils

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Voltage signals of the helical coils (HC) have been measured throughout the operation period of the Large Helical Device (LHD). In this short report, we describe some of the interesting observation results obtained with this measurement during the second cycle operations.

During the cool-down and warm-up processes, the resistance of windings was measured by continuously supplying a small DC current of 10 A. Figure 1 shows the time traces of the measured voltage signals of the six windings just before and after the superconducting and normal-conducting transitions. As is seen in Fig. 1, each transition occurred when the coil temperature (measured on the stainless steel coil-cans by Cernox sensors) reached at about 9.5 K which corresponds to the critical temperature of NbTi used in the superconductor. Since the H1 and H2 coils have independent cooling paths, there was a slight difference in their coil-can temperature, which caused a time lag for each transition. It should be noted that for the warm-up phase, the voltage signals showed temporal negative values just before the normal-conducting transition. This phenomenon seems to be brought about by the release of magnetic flux trapped in the superconducting filaments 1) during excitations.

Another interesting example noted here on the voltage measurement of HC is induced spike signals of the balance voltage during plasma discharges. As shown in Fig. 2, the balance voltage, especially that of H-I blocks, shows large spikes in some neutral beam heated discharges. In the case of Fig. 2, the plasma current reached up to 60 kA in the counter direction. At the end of the discharge, the balance voltage showed a short-time peak caused by a sudden change of the coil current (of 200 A level) induced by a collapse of the plasma current in a short period of time. Although the amplitude of this spike was almost close to the threshold value of 200 mV for triggering the quench detecting circuit, the duration (FWHM $\approx$ 0.1 s) was sufficiently shorter than the threshold of 3 s.

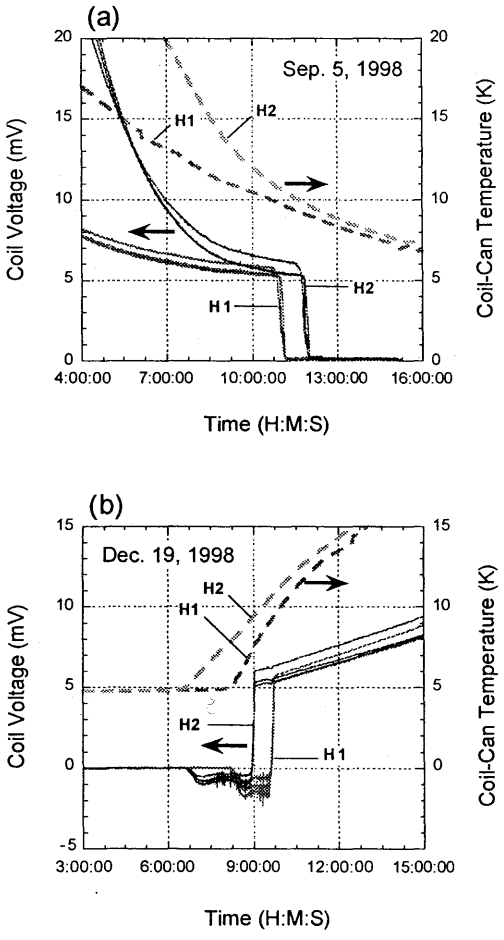

Fig. 1 (a) Superconducting and (b) normal-conducting transitions of HC in the 2nd cycle operation.

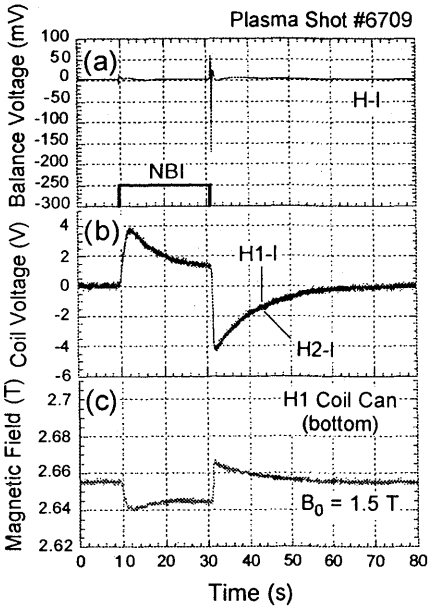

Fig. 2 Waveforms of HC coil signals during a NB heated plasma discharge.

During the LHD excitations, the voltage signals of HC, especially the balance voltage, were continuously monitored as the most important tool to detect a normal-conducting transition. The time evolution of the balance voltage observed during a quench event on Oct. 21, 1998 is shown in Ref. 2) and the detail is described there.

References

1) Wilson, M.N, "Superconducting Magnets", Oxford University Press, Oxford, UK (1983) p. 162.
2) Imagawa, S., et al., "Properties for excitation of helical coils of the Large Helical Device", in this report.