§3. Pulse Height Analysis of the Spike Signals Observed on the Balance Voltage of the LHD Helical Coils

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A series of excitation tests have been carried out for the superconducting coil system of the Large Helical Device (LHD) during the fourth experimental campaign. During these tests, the cryogenic stability and mechanical properties of the helical coils (HC) have been one of the most important items to be clarified. For these purposes, the balance voltage measured between the corresponding pairs of the coil blocks plays an important role.

As is reported in [1], the balance voltage contains a number of spike signals during the ramp-up and ramp-down phases of excitation. They might be generated by rapid changes of the self-inductance of coil blocks due to mechanical displacement ("conductor motion") of the windings caused by electromagnetic force. Pulse height analysis (PHA) has been successfully applied to these spike signals and it was confirmed that the spike counts obey exponential distribution functions, which are characterized by two components for the ramp-up phase and one component for the ramp-down phase [1].

By multiplying each spike signal of the balance voltage by the magnetic field strength (proportional to the coil current) at the time of spike event, it is possible to evaluate the released energy through conductor motions. When this value is integrated with time and then differentiated by the magnetic field, the rate of energy release can be obtained. As is shown in Fig. 1, the spike energy appears at about half the value of the maximum toroidal magnetic field for #1-o mode 2.7 T excitation and the level increases more than four orders of magnitude during the ramp-up phase. It should also be noted that the high-energy component of the spike signals (voltage > 5 mV) appears only in the high magnetic field region and it is not observed in the ramp-down phase, as is indicated by the distribution function.

Another important finding obtained through pulse height analysis of the balance voltage is regarding the so-called training effect of the coil windings. As is seen in Fig. 2, the total intensity of spike signals considerably decreases from the second run (with the same operation condition) and it keeps almost the same level during one experimental campaign (one cooling period). It was also observed that after the coils are warmed up and cooled again, the training effect is partially lost. These properties will be further investigated during the future experimental campaigns.

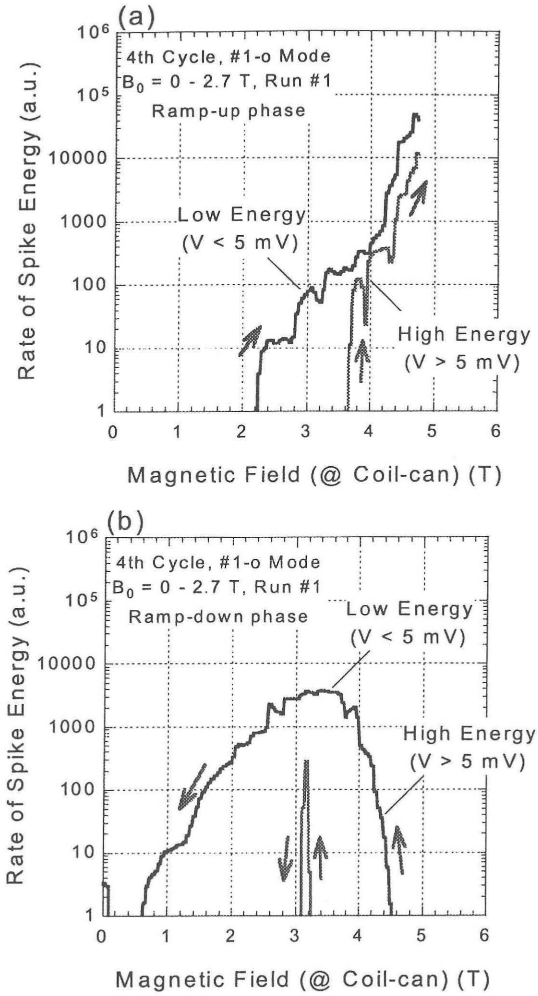

Fig. 1 Rate of released spike energy during the first excitation in the fourth experimental campaign with #1-o mode and the toroidal field of 2.7 T. (a) For ramp-up and (b) ramp-down phases.

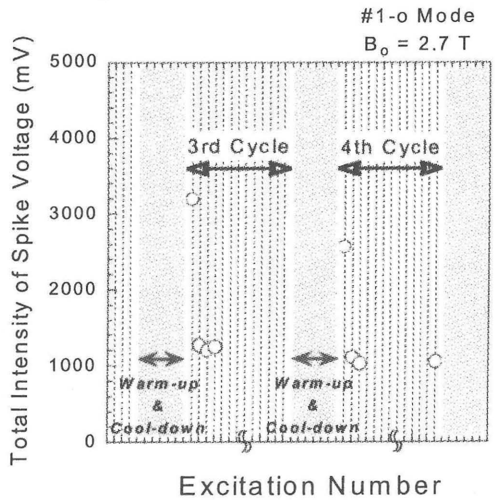

Fig. 2 Variation of the total intensity of spike signals as a function of excitation history.

References
1) Yanagi, N. et al.: in Proceedings of ICEC18 (Mumbai, 2000), pp. 179-182.