§2. 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 fifth cycle. The cryogenic stability and mechanical properties of the superconducting helical coils (HC) have been one of the most important items to be clarified. For these purposes, the balance voltage signals measured between the corresponding pairs of the helical coil blocks play an important role.

As is reported in [1] and [2], 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 the coil blocks due to mechanical displacement (conductor motion) of the windings caused by electromagnetic force. Pulse height analysis (PHA) has been successfully applied to quantitatively analyze these signals and it was confirmed that the spike counts obey exponential distribution functions [1].

The total intensity of spike signals measured in a single excitation is an effective measure to investigate the variation of the mechanical properties of the windings. As has been found in the former experimental cycles, it was again found in the fifth cycle that the total intensity drastically reduces from the second run with a same excitation condition. This observation clearly indicates a favorable training effect of the windings. Moreover, it is observed that the total intensity obtained in the first excitation in each experimental cycle shows a decrease as is shown in Fig. 1. This suggests that the training effect is not fully lost after a warm-up and re-cooling of the coils.

Up to the former experimental cycles, the balance voltage was measured using the voltage monitors situated in the HC quench detectors. In these circuits, low-pass filters of 10 Hz are used for the purpose of eliminating high-frequency electrical noises to avoid a false activation of the quench detectors. Thus, the frequency resolution is not enough with this system. In this connection, a new monitoring system was installed in the fifth cycle, which has a frequency resolution of up to 10 kHz, and a low-pass filter of 400 Hz is presently used. Comparing the waveforms observed by the two monitoring systems, it is found that the low-frequency measurement contains many distorted waveforms of spike signals, such as pile-ups and cancellations. On the other hand, the high-frequency measurement has clarified that the large spike signals are often accompanied with oscillatory waves, and according to the conventional PHA program, they give extra counts. Thus, the oscillatory signals are eliminated in the new algorithm, and the low energy part of the distribution function shows a similar curve as that obtained with the low-frequency measurement.

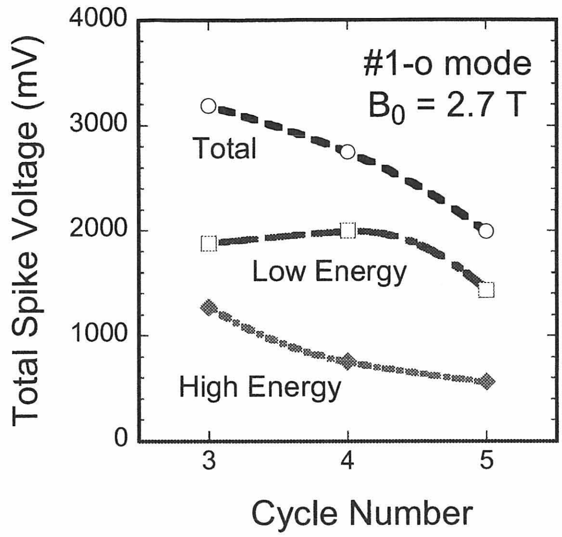

Fig. 1 Total intensity of the spike voltage signals observed in the first excitation as a function of operation cycle.

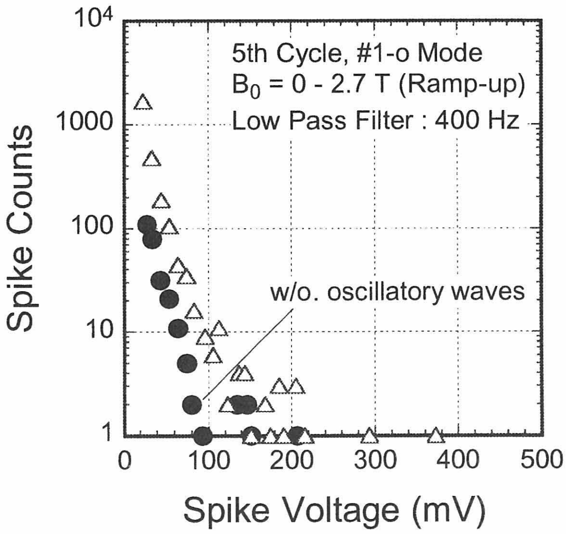

Fig. 2 Distribution functions of the spike voltage signals obtained by the high-frequency monitor. Comparison is made between the original distribution function and the one obtained by subtracting the oscillatory waves.

References

1) Yanagi, N. et al.: in Proceedings of ICEC18 (Mumbai, 2000), pp. 179-182.
2) Yanagi, N. et al.: to be published in IEEE Trans. Appl. Supercond.