§1. Analysis on Winding Motions of the LHD Helical Coils by Balance Voltage and AE Signals

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We have been investigating the mechanical disturbances observed in the LHD helical coils and conducting research on exploring more stable excitation schemes.[1)] In particular, the disturbances in the innermost helical coil blocks (H-I) have been intensively monitored using the balance voltage signals and acoustic emission (AE) signals.[2)] The balance voltage signals contain noise components, such as caused by flux jumps and plasma discharges. These noise components should be sufficiently removed to analyze the characteristics of the mechanical disturbances happening in the helical coils. Up to now, these unwanted signals have been removed manually for a limited number of datasets. If these noise signals are removed automatically, however, it is beneficial to carry out the analysis for a much larger number of them. Thus, we have developed an algorithm to remove the unwanted signals from the detected voltage signals. As a result, we are able to obtain only the mechanical disturbances much more quickly than before.

The present analysis is carried out by using a software termed "DIAdem" developed with a help from Kyowa Electronic Instruments Co., Ltd. A feature of this software is that it can handle huge data, such as AE signals. The first three graphs in Fig. 1 show the balance voltage signals obtained for the three blocks of the helical coils H-I, H-M and H-O blocks in a series excitation. These voltage signals contain components other than mechanical disturbances, such as flux jumps and inductive signals due to the coil excitation. We examined an algorithm to extract only the mechanical disturbances by removing the noise components. For example, when the polarities of three balance voltage signals are different, we regard that the signal to be due to a flux jump, since the mechanical disturbance signal should all have the same polarity. In addition, other noise components are removed by considering the current sweep rate and a threshold level. The fourth graph of Fig.1 shows the judgment of the flux jump occurrence; if a spike signal is due to a flux jump, it returns "0" and if not "1". The final signal containing only the mechanical disturbances is shown in the fifth graph, which was obtained by multiplying the original balance voltage signal of H-I by the judgment for flux jumps.

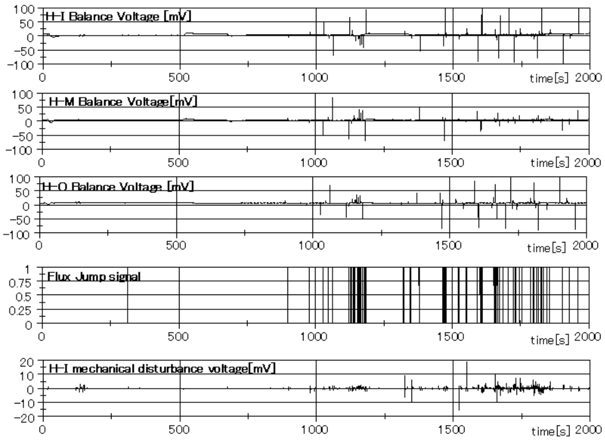

Fig.1 Balance voltage signals of the LHD helical coils: (from the top to bottom) the original signals obtained for H-I, H-M and H-O blocks containing noise components with flux jumps, judgment for flux jump occurrence and the final signal of H-I by removing flux jumps.

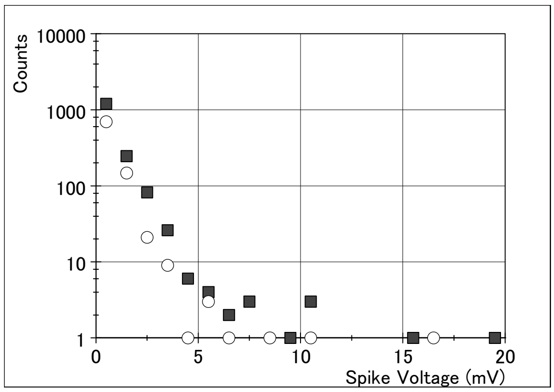

Fig.2 Comparison of mechanical disturbance signals of the LHD H-I blocks for a series (■) and simultaneous excitations (○).

Figure 2 shows the histogram of mechanical disturbances obtained by the fifth graph of Fig.1 for two excitations: a series excitation and a simultaneous excitation of the three blocks. From Fig. 2, we are now able to investigate the difference of mechanical disturbances happening in the LHD helical coils by changing the excitation method.

1) Ishigohka, T. et al.: Annual Report of NIFS April 2008 - March 2009 81.
2) Yanagi, N. et al.: Fusion Science and Technology **58** (2010) 571.