§1. Analysis of the LHD Superconducting Coils by Correlation of AE Signals and Balance Voltage Signals

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1. Introduction

The superconducting coils of LHD experience large electromagnetic forces at the time of magnetic excitation, which influence the mechanical stability of the coils greatly. In order to monitor the mechanical behaviors of the coil windings, acoustic emission (AE) sensors were attached to the helical coils in the 2003 fiscal year and examination was advanced regarding the relation between the mechanical disturbances and the stability of the coils.

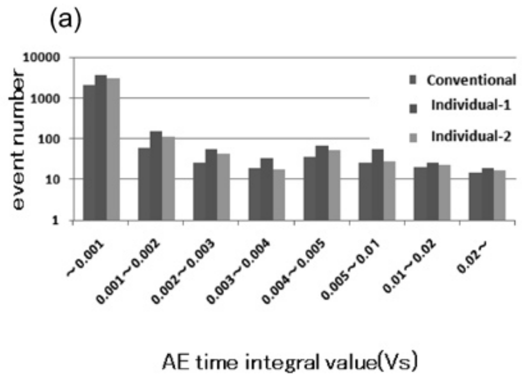
We consider that mechanical stability would be changed also with coil excitation methods. Thus, excitation tests were conducted in the 12th cycle by changing the excitation method. The LHD helical coils are excited using three sets of power supplies Although the power supplies are usually used synchronously as connected individually to each block of the coils, the proposing method was to excite blocks separately[1]. In the current fiscal year, we examined quantitatively the mechanical stability by varying the excitation mode using AE data obtained by a series of tests. The obtained result shows that the conventional magnetic excitation method, i.e., the synchronously excited operation, generates smaller disturbances generating in the whole excitation process up to 2.5 T. However, if focused only at the higher magnetic-field region, it has turned out that the individual excitation method has smaller events.

2. Data-processing method and result

The specificity of AE signal is that the frequency expands into an ultrasonic range. Thus, a sampling frequency of 100-kHz or more is needed for satisfying this. However, if such a sampling frequency is used at the time of excitation of the LHD superconducting coils, data volume will become immense and its handling will become a serious problem. Thus, in NIFS, only the envelope waveforms of the acquired signals are processed, and the sampling frequency is 10-kHz. As a result of continuing the measurement in the excitation test for about an hour, the obtained data exceeds about 36 million words. In order to process this large data, we use a software “DIAdem” supplied by National Instruments (NI), and divide the data into ten files so that the data capacity reduces to about ten percent. Then we read and process each split file one line at a time using a graphical analysis software “LabVIEW”.

The signals are analyzed by setting a threshold level of 0.5 V in consideration of avoiding noise signals. The examined items are the maximum values of generated AE signals, the amount of time-integral values equivalent to the energy of each AE signal, and an event number of AE signals. Fig. 1(a) classifies the magnitude of AE events with three excitation modes during the excitation up to 2.5 T. From this figure, it is seen that the excitation mode of the conventional one has smaller disturbances. On the other hand, Fig. 1(b) analyses only the higher magnetic-field region beyond 1.66 T, which indicates that an individual excitation method is better in mechanical stability in the higher magnetic-field region.

Although it is difficult to draw concluding remarks from the present analysis with limited examples of excitations, when aiming at further higher magnetic field excitation, reexamining the excitation method seems to be an important issue.



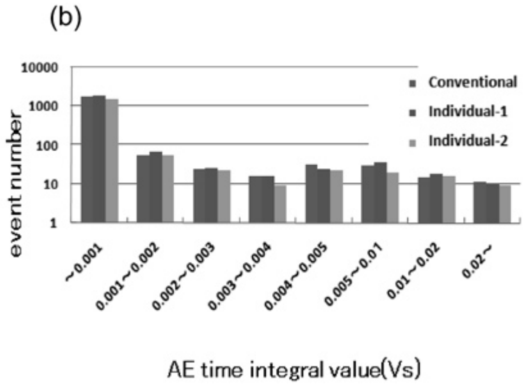


Fig.1 Event distribution characteristics of time integral values of AE signals with three excitation modes for (a) the total range of excitation from 0 to 2.5 T and (b) only for more than 1.66 T.

1) Ishigohka, T. et al., Annual Report of NIFS April 2008 – Mach 2009 (2009) 81.