§3. Measurement of Acoustic Emission Signals from the LHD Helical Coils

Yanagi, N., Seo, K., Sekiguchi, H., Yamada, S., Imagawa, S., Mito, T.
Ishigohka, T., Tsuchiya, T., Adachi, Y., Ninomiya, A. (Seikei Univ.)

During the past six experimental cycles, the mechanical properties of the helical coils (HC) have been investigated in the Large Helical Device (LHD) using the balance voltage signals measured between the corresponding pairs of the HC blocks. During excitation processes, a number of spike signals are observed on the balance voltages. They might be generated by rapid changes of the self-inductances of the coil windings due to mechanical displacements (conductor motions) caused by large electromagnetic forces. The spike signals can be quantitatively analyzed using the technique of pulse height analysis (PHA). One of the most important results of this analysis is that the total intensity of the spike signals significantly reduces from the second excitation with the same operation condition [1, 2]. This observation is very similar to the ones that have been universally seen by acoustic emission (AE) sensors for many other superconducting magnets [3]. In this connection, in the seventh cycle in 2003, four AE sensors were attached to the HC-cans and we started direct comparisons between the results obtained with balance voltage signals and the ones by AE sensors. Figure 1 shows a photograph of one of the AE sensors attached to the surface of the HC-can.

The signals from the AE sensors are taken out of the LHD cryostat through feed-through connectors and fed into AE analyzers through preamplifiers. The envelopes of the actual AE signals are provided by the analyzers and they are digitized with a sampling frequency of 10 kHz. The AE data can be observed and stored by computers in the control room via a LAN with optical fibers.

After the AE sensors were installed, the stainless-steel surface of the HC-cans and the supporting structure were hit by a hammer before closing the cryostat in order to check the sensors by applying artificial mechanical disturbances to them. The obtained results showed that the AE sensors clearly detected the mechanical disturbance signals that propagated in the structures with the sound velocity.

Figure 2 shows a typical example of the measured AE signals during an excitation process up to the central toroidal magnetic field of 2.7 T with the #1-o operation mode. The balance voltage of H-I (the innermost blocks of HC) is simultaneously obtained with two different frequency resolutions so that it can be directly compared with the AE signals. It is seen by expanding the data such as of Fig. 2 that many of the AE signals are correlated with the spike signals of the balance voltage. There are, however, also many other signals that are not correlated. We consider that the later signals are originated from mechanical disturbances generated outside the HC windings, such as the poloidal coils.

The AE data will have to be further analyzed using such as the PHA technique and the correlations with the spike signals of the balance voltages will be examined.

Fig. 1 Photograph of one of the AE sensors attached to the HC-can.

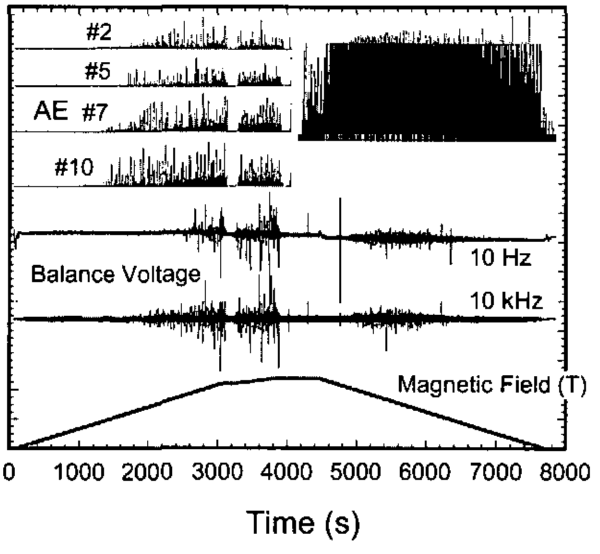

Fig. 2 Waveforms of the four AE sensors (the vertical axis is 2 V per division) and balance voltage signals of the H-I blocks during a #1-o mode excitation process. The balance voltage is obtained with two frequency resolutions of 10 Hz (10 mV/div) and 10 kHz (200 mV/div). The magnetic field (measured by a Hall probe at the HC coil-can) is also shown.

References

1) Yanagi, N. et al.: in Proceedings of ICEC18 (Mumbai, 2000) pp. 179-182.
2) Yanagi, N. et al.: IEEE Trans. Appl. Supercond. 12 (2002) pp.662-665.
3) Y. Iwasa, IEEE Trans. Magn., 1992, pp. 113-120.