

§4. State Estimation of Large Superconducting Magnet Using AE Technology and Fuzzy Theorem

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1. Introduction

The authors tried to estimate the state of LHD superconducting coil using Fuzzy theorem. The fundamental variables are; [1]the coil current, [2]the balance voltage, and, [3]the equivalent stored heat. The equivalent stored heat is digitally processed from the balance voltage of the coil. Applying the fuzzy calculation, the dangerous rate of the coil is obtained. The state of the coil is represented by the dangerous rate.

On the other hand, the AE technique is introduced to this research in order to monitor the LHD superconducting coil.

2. High Utilization of Voltage Signal of LHD Coil

The equivalent stored heat is calculated taking into consideration the thermal dissipation time constant, that is the exponential dissipation of the generated heat.

In 2002, the absolute value of the balance voltage was multiplied by the current. In 2003, the absolute value of the integration as shown in equation (1) is adopted. By this method the effect of inductive noise with higher frequencies can be mitigated. In equation (1), T is present time, and τ is heat dissipation constant.

$$W_{eff} = \left| \int_0^T e^{-\frac{T-t}{\tau}} v dt \right| \dots \dots (1)$$

3. Monitoring of LHD Coil using AE Signal

In 2003, AE sensors are attached to the LHD coils. The AE signals are observed during the charge and discharge of the coils. We can expect more reliable monitoring and diagnosis by inspection of the correlation between the AE signal and the balance voltage. A preamplifier is located at the relatively high leakage magnetic field region, and a PC is remotely controlled via LAN system. Using this system, the AE signals of the LHD coils are measured. 1) The results are:

[1] Some AE signals are observed preceding the voltage signal as shown in Fig. 1.

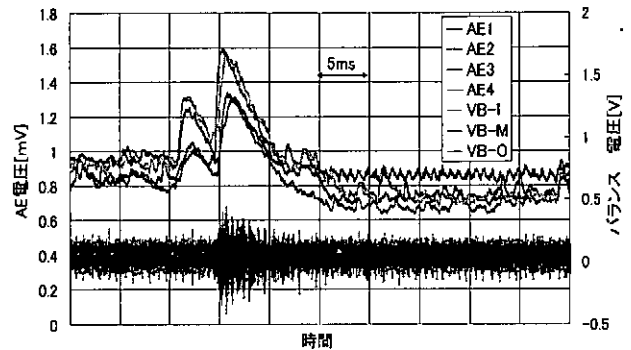


Fig. 1. AE signal and voltage signal

[2] AE signals are generated not only at charge but also discharge of the coil as shown in Fig. 2.

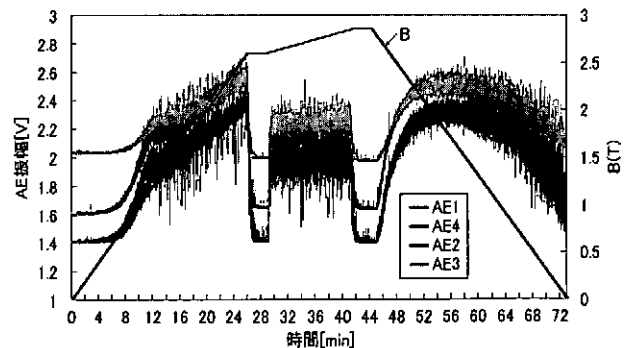


Fig. 2. AE signal at charge and discharge.

Reference

1) T. Ishigohka, T. Tsuchiya, Y. Adachi, A. Ninomiya, Y. Uriu, N. Yanagi, K. Seo, H. Sekiguchi, T. Mito, "AE measurement of LHD helical coil", Annual Meeting of IEEJ, No. 5-035, March 2004.