§2. Monitoring and State Estimation of LHD Coils

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The superconducting helical coil of LHD can excite independently the H-I, H-M, and H-O coils. Utilizing this ability, the authors have proposed a new excitation method in order to obtain higher magnetic field. In this method, the three excitation currents of H-I, H-M, and H-O coils are controlled independently[1].

In general, AE signals are observed during the charging and discharging processes[2]. The frequency of the AE generation is proportional to the increasing rate of the electromagnetic force, i.e. the product of the magnetic field and the current. By the generation of AE, the losses are generated in the coil, and the temperature rises. Therefore, it is necessary to suppress the increasing rate of the electromagnetic force and the frequency of AE generation.

The proposed excitation pattern is shown in Fig. 1. As shown in the figure, the H-I coil is excited to the rated value at first, the H-M coil is excited to the rated value next, and the H-O coil is excited to the rated value at last. By this excitation method, it is expected to suppress the increasing rate of the electromagnetic force in the H-I coil which is considered to be the weakest point in the helical coil.

Fig. 2 shows the calculated increasing pattern of electromagnetic force of H-O coil. From this figure, it is expected to mitigate the increasing rate of the electromagnetic force of H-O coil to 1/6 compared to the case of the conventional excitation method.

In the fiscal year 2008, the authors carried out the independent excitation test applying this principle. In the experiment, the excitation time is set to 30 minutes which is same to the conventional excitation. In this case, the excitation speed of each coil is 30.8 A/s which is 3 times higher then the case of conventional excitation. This excitation condition is considerably severe one particularly to the H-O coil which experiences the high speed excitation at the higher magnetic field level. Near the target magnetic field of 2.5 T, the increasing rate of the electromagnetic force becomes about 2.7 times higher than the case in the conventional excitation. However, the frequency of the observed AE signal and the balance voltage are suppressed as shown in Fig. 3. This result would be due to the decrease of the load applied to the H-I coil.

By the introduction of the independent excitation methods, it is obtained to suppress the disturbances in the helical coils. It is expected to test the excitation patter as shown in Fig. 1.

1) T. Ishigohka, A. Ninomiya, S. Kawashima, Y. Kondo, 78th 2008 Cryogenic and superconducting conference, No. 3B-a02, p.193, May 2008.
2) T. Ishigohka, T. Tsuchiya, Y. Adachi, A. Ninomiya, N. Yanagi, K. Seo, H. Sekiguchi, S. Yamada, S. Imagawa, and T. Mito, IEEE Trans. on Applied Superconductivity, Vol.15, No.2, pp.1423-1426, July 2005.

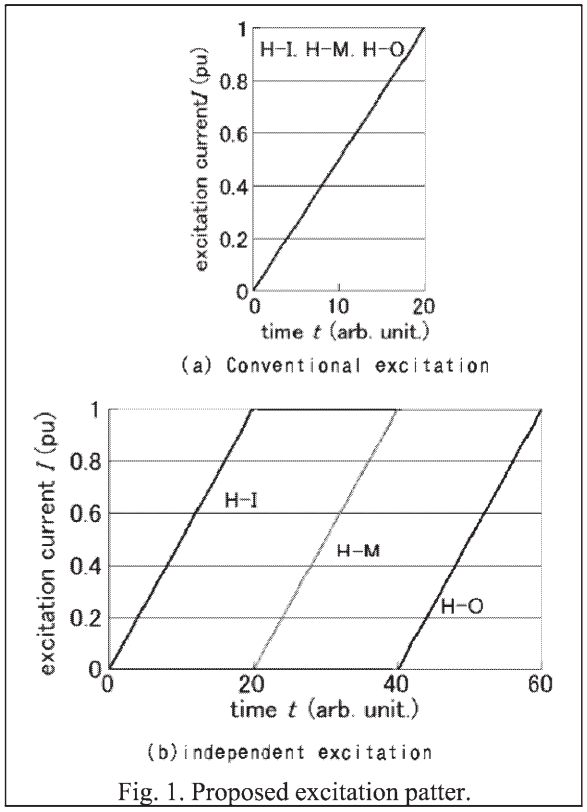

Fig. 1. Proposed excitation patter.

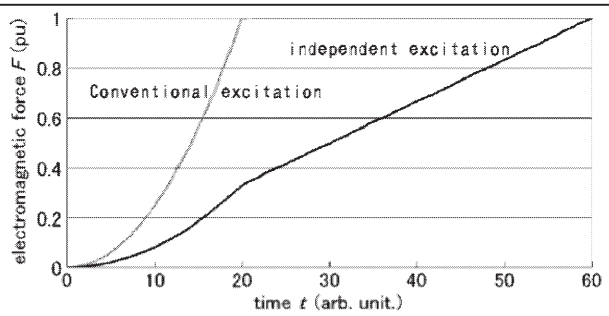

Fig. 2. Calculated electromagnetic force.

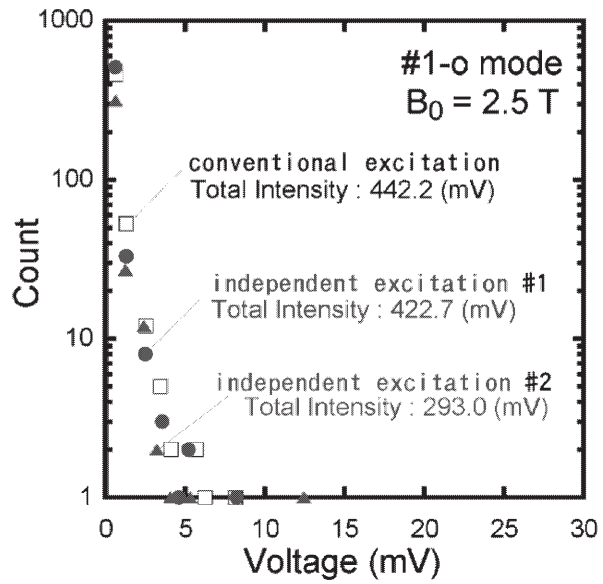

Fig. 3. Comparison of AE counts and balance voltages between conventional and independent excitation.