§1. Results of the Reverse Excitation of the Helical Coils for the Large Helical Device

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The reverse excitations of the LHD were carried out in the 5th cycle to examine the effect of the direction of neutral beam injectors to the toroidal field. The schedule is shown in Table 1.

Typical balance voltages in an usual charging process are shown in Fig. 1. The spike voltages appear frequently at higher than about 2 T of the central toroidal field when charging, and these disappear while holding the current or discharging within about 0.5 T. The voltages of the three blocks are coincident, and the pulse width is shorter than 1 ms. These should be caused by conductor motions in the innermost, *I*, block. 1) The hysteresis is caused by the static friction. Positive and negative voltages are induced by the motions in H1 and H2 coil, respectively. The slow balance voltages with fixed shapes appear when the current ramp-rate is changed. These should be induced by the secondary circuits such as the helical coil cases.

The balance voltages in the first reverse excitation are shown in Fig. 2. The spike voltages by conductor motions seem to be in the same level, which is a proof that the electromagnetic forces on the conductors are not changed in the reverse excitation. The slow balance voltages with fixed shapes were reversed as predicted. The direction of the secondary circuit was also reversed. The large spike voltages, however, were induced several times at higher than about 2 T, and the wave form is quite different from that of conductor motions. The balance voltages of *I* and *O* blocks are inverse, and the pulse width is about 0.2 s, as shown in Fig. 3. The same spike voltages were observed at the first positive excitation after the reverse excitations. The similar voltages are observed when the current center of the helical coil is shifted widely. These voltages are considered to be induced by flux-jump of the filaments in the helical coil conductor. Since the voltages of *I* and *O* blocks are inverse, the flux-jump occurs at the central area of the helical coil where the transverse field is very low. Since the flux-jump never occurs in usual excitations, combined conditions are necessary. Longitudinal magnetic fields may concern, but further researches are needed to comprehend the phenomena.

Table 1 Schedule of reverse excitations of LHD.

'01 9/11-12/14	2.72 T @3.75 m, 2.825 T @3.60 m, 2.917 T @3.60 m (grading) and others
'01 12/17	Change the polarity of power supplies
'01 12/18	-2.70 T @3.75 m, -2.825 T @3.60 m
'01 12/19-26	-2.91 T @3.60 m (grading) and others
'02 1/7	Change the polarity of power supplies
'02 1/8-2/14	2.70 T @3.75 and others

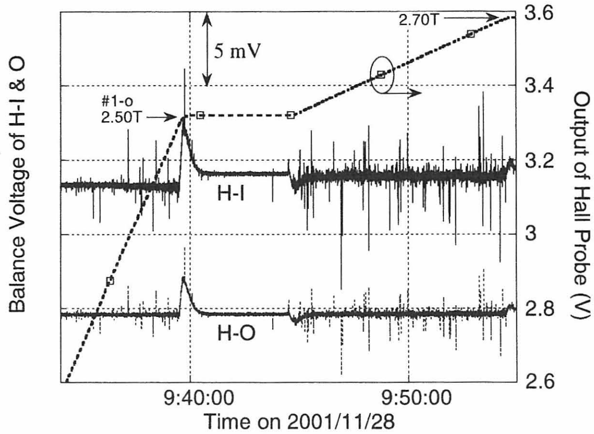

Fig. 1. Typical balance voltages of LHD helical coils.

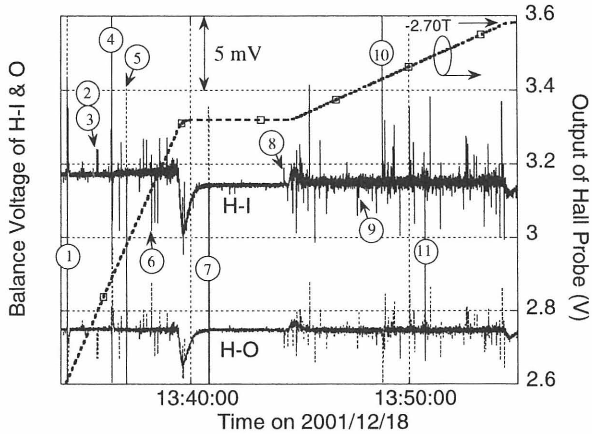

Fig. 2. Balance voltages of LHD helical coils at the first reverse excitation up to -11.25 kA (-2.70 T @ 3.75 m).

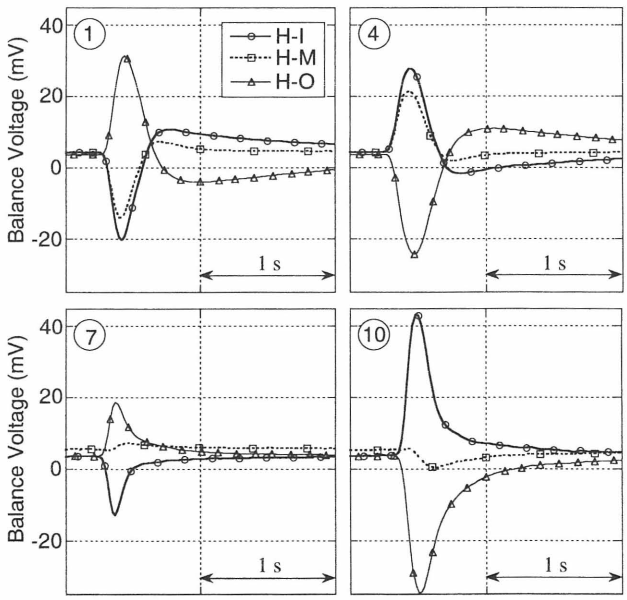

Fig. 3. Magnified waves of the balance voltages induced by the flux-jump. The number is indicated in Fig. 2.

Reference

1) S. Imagawa, et al., IEEE Trans. Appl. Supercond., Vol. 11 (2001) 1889-1892.