§2. Estimation of Induced Current Flowing in the Support Structure of LHD

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To realize the dynamic control of the magnetic field of the LHD, the pulse power supplies for IS and IV coils were constructed. When the magnetic field is swept with these power supplies, some induced current flows in the structural material. This current makes some losses and an error field, so the estimation of it is necessary.

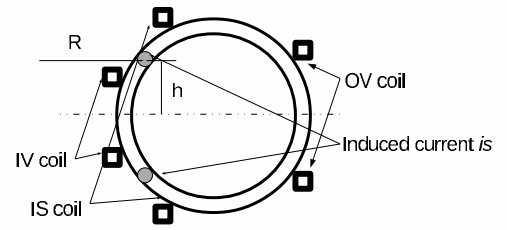

Fig. 1: A coil model for the induced current in LHD.

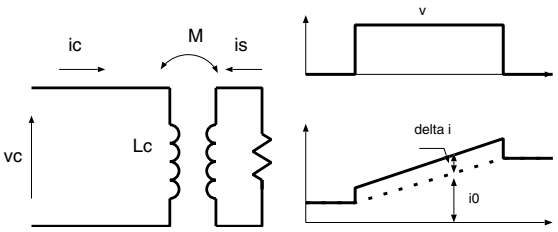

Fig. 2: The equivalent circuit model including coupled structure.

To estimate the induced current, we assumed two coupled one turn coil that simulate induced current, as shown in Fig. 1. For this induced current, the equivalent circuit and the coil current response, when the IV coil is driven by the high voltage power supply, is shown in Fig. 2. In this circuit, the voltage equation is as follows;

$$[V_c] = [L]\frac{d[i]}{dt} \quad (1)$$

$$= [L]\frac{d[i_0]}{dt} + [L]\frac{d[\delta i]}{dt} \quad (2)$$

where $[V_c], [i_c]$ are the coil terminal voltage and current, $[L]$ is inductance matrix including the mutual inductance between structure and coils, $[i_0]$ and $[\delta i]$ are the current components which are shown in Fig. 2, respectively. In the above equation, $[V_c] = [L]\frac{d[i_0]}{dt}$ is satisfied and $[L]\frac{d[\delta i]}{dt}$ becomes zero. After that, $[\delta i]$ can be separated to coil current components $[\delta i_c]$ and structure component δi_s , then the following equation is obtained.

$$[L_c][\delta i_c] + [M]\delta i_s = 0. \quad (3)$$

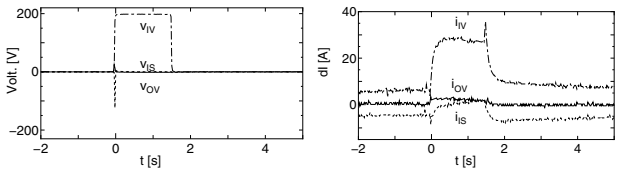

Fig. 3: Waveforms of coil terminal voltage and δi

Table I: The estimated current flowing in the structure.

	IV coils were driven	IS coils were driven
M_{IS}/M_{IV}	0.84	1.73
M_{OV}/M_{IV}	0.67	2.27
R[m]	2.3	3.4
h[m]	1.1	0.95
V[V]	200	180
I_s [kA]	4.5	4.0

From these relations, the mutual flux $[M]\delta i_s$ can be estimated from δi_c and the ratio between mutual inductance $[M]$ can be estimated. By calculating inductance in the origin of various R and h and comparing them with estimated inductance, R and h can be estimated. Table 1 shows the estimated results, and Fig. 4 shows the position of the induced current. This figure shows that the center of the induced current path stays near by the IV coils when the IV coils are driven. On the other hand, the center of the current moves moves toward the equatorial plane of the LHD when IS coils are driven. It is thought that this difference is caused by the difference of the boundary condition, that the total magnetic flux enclosed by the connected superconducting coils are kept constant.

In the next step, the effects by the helical coils or plasma will be studied.

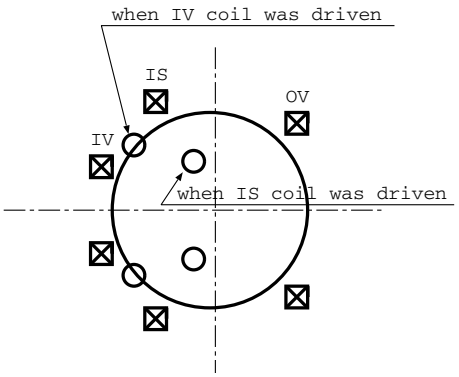

Fig. 4: The estimated currents in the LHD when the IS or IV coils were driven.