§26. Design Study of Dc Power Supply of Super-conducting Coils for Helical Reactor

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A helical-type reactor is suited to steady-state operation and has the advantage that the electro-magnetic force acting on the helical coil is balanced. In particular, the overturning forces on helical coil become zero in the top and bottom positions, so a simple self-supporting structure that can provide a large space for vertical ports is required. It is not a fusion plasma experimental device, and the magnetic field configuration will be optimized for steady-state plasma burning and the flexibility of the magnetic field control will be minimized. This report introduces a conceptual design for a dc power system to excite the superconducting coils of the helical type reactor. In this design, the poloidal coils are divided into a main part, which generates a magnetic field for steady-state burning, and a control part, which is used in the ignition process to control the magnetic axis. The feasibility of this configuration was studied using the LHD coil parameters, and the coil voltages required to sweep the magnetic axis were calculated.

To control the magnetic axis, the following two-coil set system is considered.

Main coil set This set is used to create the basic magnetic field for operation. The axis of the magnetic field is optimized for steady-state plasma burning.

Control coil set This coil set generates a vertical field and is used to shift the magnetic axis while the plasma heating process proceeds toward ignition.

A feasibility study of this system requires the detailed parameters of the coils, and we use the parameters of the LHD. Figure 1 shows the coil configuration and Figure 2 shows the power system for excitation. To connect the main coil sets in series, the turn number of the coil are adjusted as shown in Table I. The total inductance of coil sets are calcurated and the necessary volt-second to control the magnetic axis is calcurated as shown in Table II.

For case 1 in this table, the magnetic field is maintained at 2.75 T at the magnetic axis. In this case, some voltage is necessary for driving the main power supply when the magnetic axis is swept. It is approximately 1/40 of the voltage supplied by the control power and can be supplied by the main power. If the magnetic field is decreased by approximately 0.1%, the main coil voltage can be almost zero, as shown in case 2. In this second case, the main power does not charge the coil system even though it supplies current to the coils. This result demonstrates that a small adjustment in magnetic field or coil position can reduce the voltage required by the main power supply if the required voltage is not sufficiently small when this configuration is applied to FFHR.

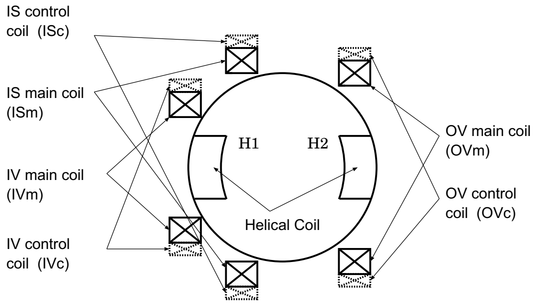

Fig. 1: Assumed coil arrangement of LHD

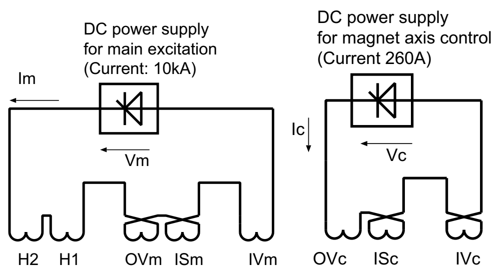

Fig. 2: Main and control coil excitation for LHD

Table I: Coil parameters after turn number adjustment.

	H1, H2	OV	IS	IV
Main coil set				
Turn num.	450	-233.9	-46.1	264.7
Current at R = 3.55m	9,861 A	←	←	←
Current at R = 3.60m	10,000 A	←	←	←
Control coil set				
Turn num.	-	144	-422.6	-918.8
Current at R = 3.60m	-	255.6 A	←	←

Table II: Terminal volt-second for the axis shift.

	Control coil current	Volt-sec of coils	
		Main	Control
Case 1 B=2.75 T	255.8 A	73 Vs	2,792 Vs
Case 2 B=2.748 T	255.4 A	-0.1 Vs	2,825 Vs