§8. Performance of the LHD Poloidal Coil System

Takahata, K., Iwamoto, A.

LHD poloidal coils are forced-flow cooled coils. Conductors are Nb-Ti cable-in-conduit types cooled with supercritical helium. The coils consist of 3 pairs, inner vertical (IV), inner shaping (IS) and outer vertical (OV) field coils. The OV coil, the largest one, has a center diameter of 11.1 m and weighs 45 tons. The OV coil is one of the largest forced-flow coils.

COOLING

The coils experienced cool-down and warm-up twice in FY 1998. The cool-down and warm-up were carefully made as maintaining the temperature difference between inlet and outlet within 50 K. Figure 1 shows the pressure drop characteristics, friction factor versus Reynolds number curves. Open circles indicate the data for a short sample conductor. Closed circles shows the data during the cool-down and warm-up. Both curves agreed well, and it was then confirmed that there was no obstruction inside the conductors.

Mass flow rate was 60-80 g/s for each coil at 4 K operation. Pressure drop was then about 0.14 MPa. The flow rate and pressure drop were stable during all operating period. Because the obstruction due to ice of various gases did not occur, the inlet filters seemed to be useful. The inlet and outlet temperatures were approximately 4.4 and 4.6 K. The outlet temperature increase due to ac losses was less than 0.1 K. All temperatures satisfied the specifications in which the inlet and outlet temperature are 4.5 and 4.8 K.

EXCITATION

Excitations were stably made up to now. The total operating time reached 1100 h. The maximum currents for IV, IS and OV coils were 13.2, 13.7 and 18.6 kA. The maximum fields were 4.2, 3.5 and 3.0 T, respectively. Figure 2 shows the maximum operating points on the load lines. The maximum points reached about 60 % of the design points. The temperature margin was then approximately 3 K. The excitations at the specified points will be performed in the second experimental phase.

Figure 3 shows the typical balance voltage between the upper and lower OV coils. Voltage spikes were observed, and the signs were almost minus for charge and plus for discharge. It was suggested that one coil generated the spikes due to coil motions. The numerical calculations confirmed that a vertical movement causes the spike. The movement was then evaluated to be less than 1 μm. Therefore, the average heat power density inside the coil is negligible compared with the stability margin of the conductor. The asymmetry between the upper and lower coils is considered to be caused by filling materials between the coil and a supporting structure.

In conductor joints and feeders, unusual temperature increase and voltage were not observed.

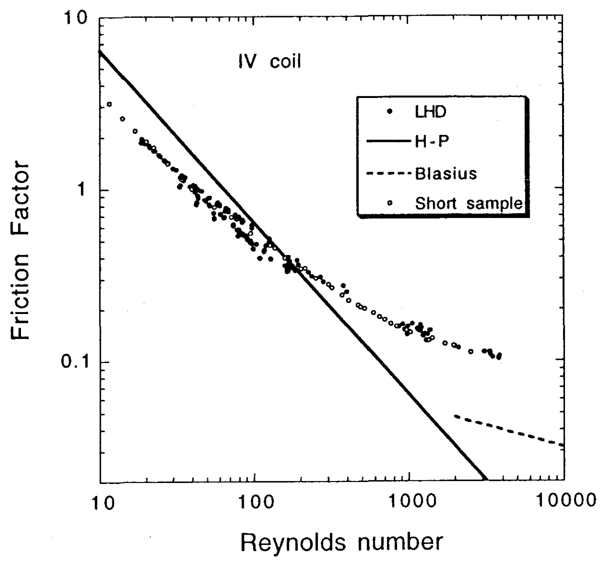

Fig. 1. Friction factor versus Reynolds number

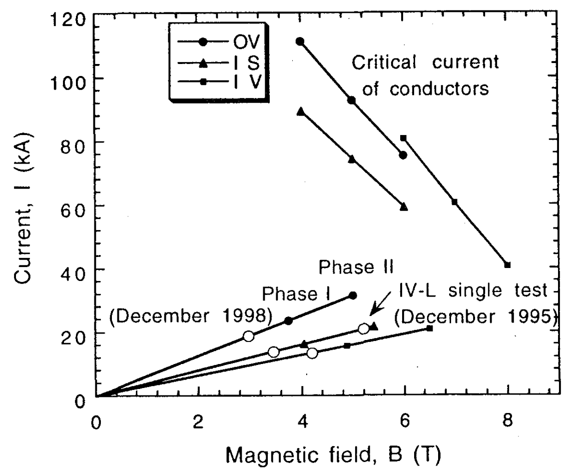

Fig. 2. Maximum operating points on the load lines

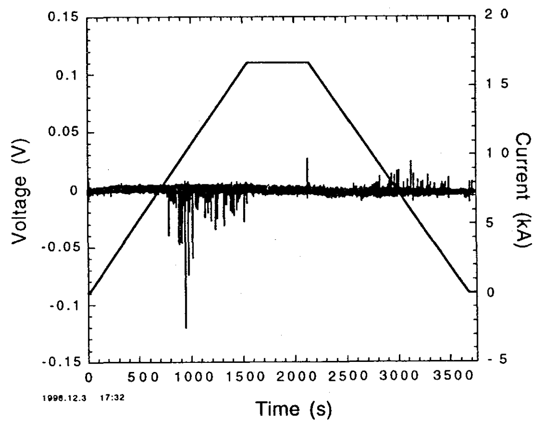

Fig. 3. Balance voltage of the OV coils