§4. Temperature Evaluation of the LHD Helical Coils Cooled by Subcooled Helium

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The upgrade of the cooling system for the LHD helical coils has been carried out, and cooling the coils by subcooled helium has succeeded. The coils are not equipped with thermometers due to the problem of electrical insulation. The measurement of the coil temperature is thus impossible. In this study, the quasi-one dimensional numerical analysis on the coil temperature was performed by using the simple model of the coils in order to evaluate the coil temperature.

Longitudinal temperature distributions were calculated in the analysis. Fig. 1 illustrates the analytical model which simplifies a 3D configuration of the helical coils, and also the boundary condition of the analysis. The model consists of 3 parts including the helical coil, subcooled He and coil case. Equation 1 was used in the areas of the coil and coil case, and equation 2 was utilized in the area of the subcooed He.

$$\rho \cdot c_p \cdot \frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(\lambda \frac{\partial T}{\partial x}\right) + q_{thick} \qquad (1)$$

$$\rho \cdot c_p \cdot \frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(\lambda \frac{\partial T}{\partial x}\right) + q_{thick} - \rho \cdot c_p \cdot u \cdot \frac{\partial T}{\partial x} \qquad (2)$$

where ρ is the density, c_p is the specific heat at constant pressure, T is the temperature, t is the time, x is the longitudinal length, λ is the thermal conductivity, q_{thick} is the heat quantity in the transverse direction, and u is the flow.

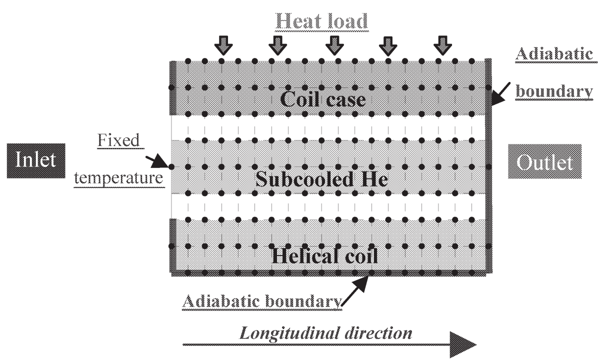

Fig. 1. Analytical model.

Figs. 2 and 3 show the temperatures at the outlet and coil case the position of which is on the LHD equator line. The calculation meets the experiment considerably under a variety of conditions as shown in Figs. 2 and 3. From the analysis, the temperature distribution of the coil is negligible in the longitudinal direction due to the effect of an aluminum stabilizer in the conductor of the coils. The average coil temperature is listed in Table 1. The coil temperature would be about 3.6 K under the rated operation of the cooling system in which the inlet temperature is 3.2 K, and the mass flow is 50g/s.

Table 1 Average coil temperature for each inlet temperature at the mass flow of 50g/s.

Inlet temperature	Average coil temperature
3.2 K	3.58 K
3.47 K	3.79 K
3.66 K	3.94 K

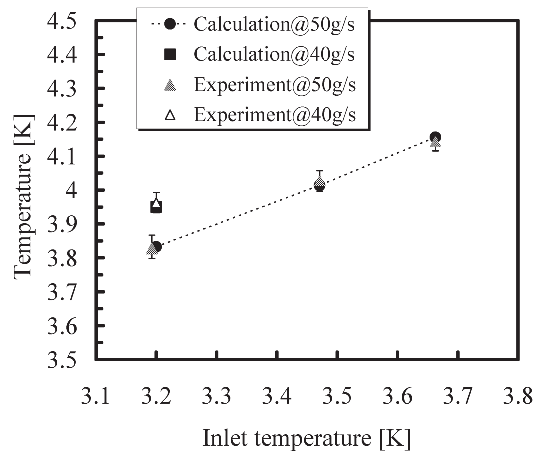

Fig. 2. Outlet temperature for each inlet temperature and mass flow.

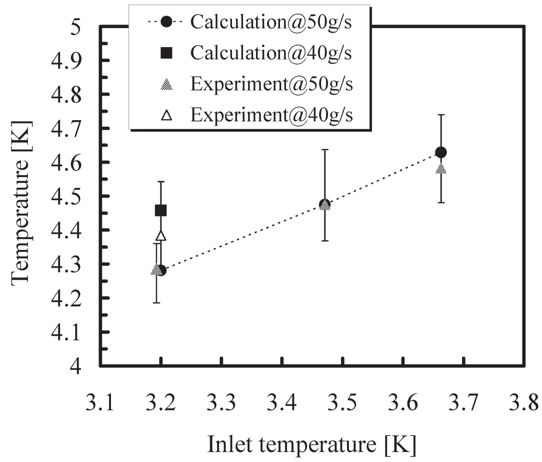

Fig. 3. Coil case temperature at the LHD equator line for each inlet temperature and mass flow.

Reference

1） T. Obana, et al.: Abstracts of CSJ Conference, Vol. 75 (2006) p.144