§2. Long-term Monitoring of Hydraulic Characteristics of LHD Poloidal Coils

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Twelve-year data summary of hydraulic characteristics of the large helical device (LHD) poloidal coils is presented in this report. The superconductors of the poloidal coils are cable-in-conduit conductors (CICC) cooled by circulated supercritical helium. Because the CICC has narrow cooling channels, impurities in helium, such as a metal piece, ice of impurity gas and oil from helium compressors, might obstruct the circulated helium flow in the conductor. The flow obstruction results in degradation of stability of the conductor. Therefore, we have continuously monitored a pressure drop between the inlet and the outlet of each coil since 1998 when the LHD operation started. The observed pressure drops were converted into dimensionless friction factors to eliminate the effects of a flow rate and a configuration.

The coils experienced a cool-down, an experimental campaign and a warm-up in every fiscal year. Fig. 1 (a) shows the Darcy's friction factor as a function of the Reynolds number at room temperature just before the cool-down. The mass flow rate was approximately 2 g/s. The solid line indicate the Katheder's scaling low, expressed as

$$\lambda_{KF} = \upsilon^{-0.72}(19.5Re^{-0.88} + 0.051) \qquad (1)$$

where v is the void fraction and Re is the Reynolds number[1]. The observations show that all data for twelve years agree with $0.6\lambda_{KF}$.

Fig. 1 (b) shows the friction factor at cryogenic temperature during the experimental campaigns. The mass flow rate was approximately 60 g/s and the Reynolds number was 2000-3000 during the experimental campaign. The observations show a trend towards a decrease in the friction factor. The factor decreased from $0.8\lambda_{KF}$ to $0.6\lambda_{KF}$ between 1998 and 2009.

Fig. 2 shows long-term changes in friction factor for six poloidal coils. The decreasing trend was observed for all the coils. That is a change for the better. The long-term operation of the LHD demonstrates that the initial hydraulic characteristics of CICC can be maintained for years.

In the poloidal coils, fine mesh filters were installed at the inlet to trap particles of impurities. The filters actually trapped impurities during cool-down of the coils, which were confirmed by monitoring the pressure drop of the filters. A clogged filter were warmed up and evacuated to clear the impurities. The cool-down was able to continue by using the other filter connected in parallel. The filter system probably has an important role in maintaining the initial hydraulic characteristics of the coils.

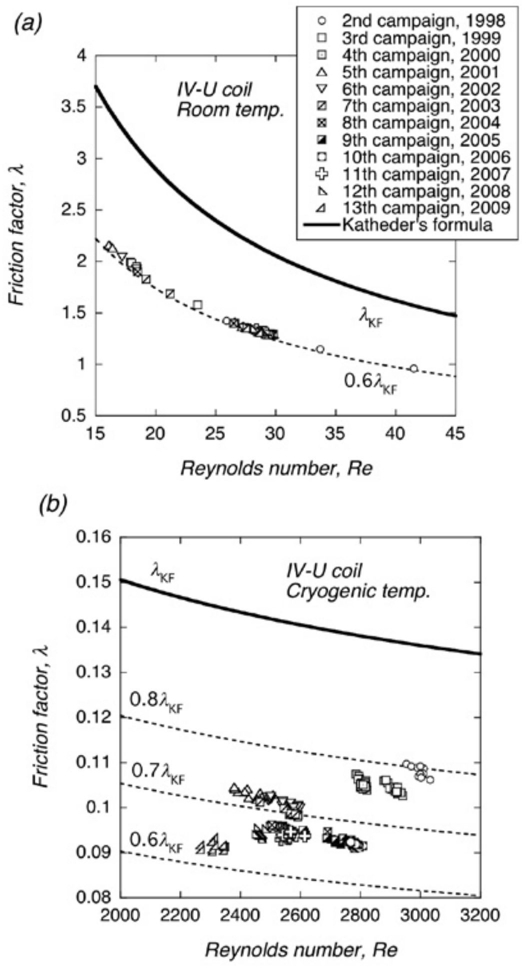

Fig. 1. Friction factor versus Reynolds number at (a) room and (b) cryogenic temperature in the IV-U coil.

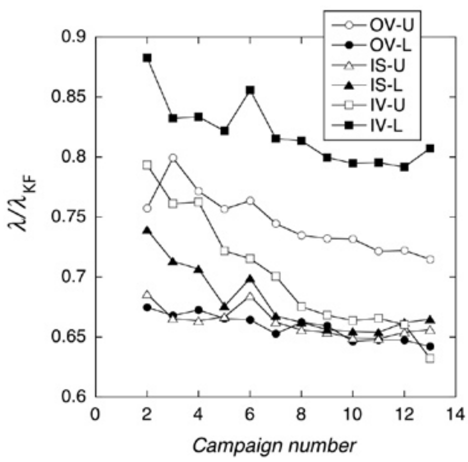

Fig. 2. Long-term changes in friction factor for six poloildal coils.

1) Katheder, H.: Cryogenics **34** (1994) 595