§18. Heat Removal Characteristics on High-thermal-conductivity Sphere-packed Pipe Applied for a Spectral-shifter's First Wall and Approach to Designing it into the Blanket

Yuki, K. (Tohoku Univ.),
Sagara, A.

High Prandtl number fluid Flibe whose Prandtl number is almost 30 has been proposed as the cooling and breeding liquid in the FFHR blanket system [1]. In this study, heat transfer experiments with sphere-packed pipes, which are the heat transfer promoter for Flibe flow, are conducted using silicone oil that is the simulant of Flibe. In order to elucidate the effect of thermal conductivity of the sphere, the experiment is performed especially under low Re number conditions.

Fig.1 shows a schematic drawing of experimental apparatus. A stainless circular pipe of 14.4mm in inner diameter is used as a heating test section. The stainless spheres are packed inside it. Sizes of the sphere are 7.14mm and 4.76mm. This test section is electrically heated and the range of the uniform heat flux input is 6.9～290kW/m^2. 16 thermocouples are attached onto the outer wall of the pipe in a fully developed temperature region, and the inner wall temperatures are estimated using the outer wall temperatures measured.

In high Re number conditions of over 5000, it has already been confirmed that the correlation constructed in the last fiscal year has the high reliability (see Fig. 2). However, it is proven that the Nusselt number data obtained under low Re number conditions (Re<~1000) is much lower than the correlation. This suggests that the correlation overestimates the heat transfer performance of the SPPs especially in a low Reynolds number regime. The difference decreases with the increase in the Reynolds number, so that flow structure conceivably changes in this regime. Furthermore, there is a possibility that the thermal conductivity of the sphere strongly affects the heat transfer performance. In special, when the high Prandtl number fluid is applied under low Re number conditions, the thermal resistance layer also develops around the sphere. That is to say, it is necessary to construct the new correlation taking into account the thermal conductivity ratio of the sphere and the Flibe.

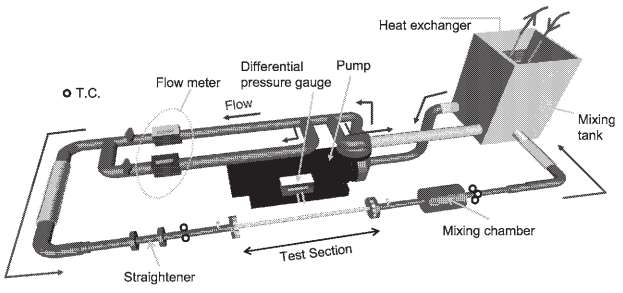

Fig. 1 Silicone oil circulating loop

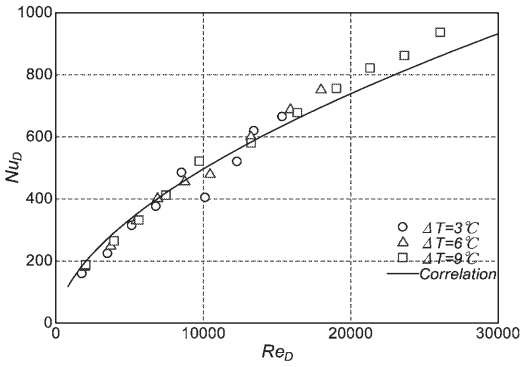

Fig.2 Heat transfer performance under high Re numers

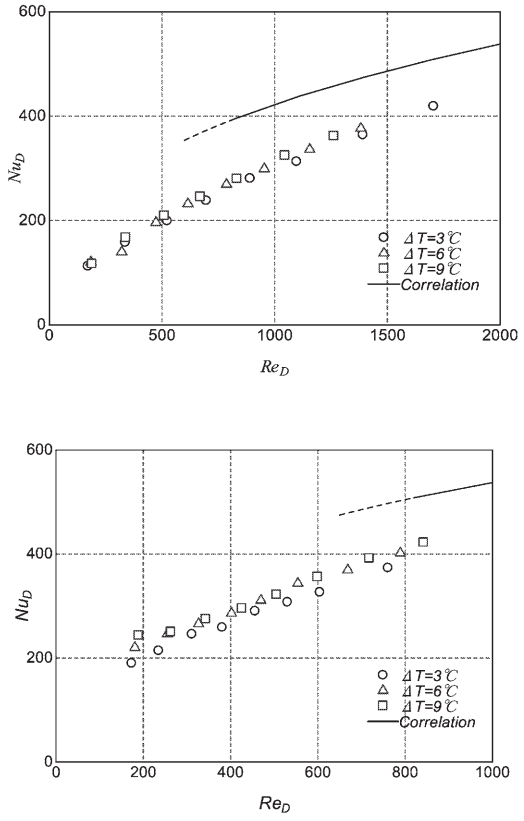

Fig. 3 Heat transfer performance under high Re numers (Upper: d=D/2, Lower: d=D/3)

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[2] T. Sato, K. Yuki, et al., Fusion Science & Technology, vol.52, no.3, 2007, pp. 618-624.
[3] Nao Seto, Kazuhisa Yuki, et al., Fusion Engineering and Design, Volume 83, Issues 7-9, December 2008, Pages 1102-1107.