§37. Thermofluid Research for the First Wall Cooling of Flibe Blanket

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Flibe blanket using molten salt Flibe as breeding material as well as coolant, is one of the advanced liquid blankets for fusion DEMO reactors and its conceptual design is in progress for LHD-type fusion reactor, FFHR, to date. Although the blanket has many strong points, e.g., MHD pressure drop is negligibly small because of low electric conductivity of Flibe, there are still several issues to be solved. High melting temperature of Flibe (459 deg. C) is one of the issues because a temperature window of the blanket design is very limited due to the upper limit of temperature of the structural material (RAFS) of about 550 deg. C. In addition, heat transfer performance of Flibe is very poor because of its high Prandtl (Pr) number. Therefore, some measures should be required to enhance heat transfer characteristic of Flibe in order to use it for the first wall cooling. In this study, a sphere-packed channel is adopted as a heat transfer promoter, and the heat transfer characteristic is evaluated in detail to design the Flibe blanket precisely. As for the sphere-packed channels using circular and rectangular ones, good heat transfer performances have been demonstrated by experiments in which all circumferences of the channel were heated as heat transfer walls. Considering the first wall cooling, the heating condition is almost imposed on one side wall of the cooling channels. For the precise blanket design, therefore, heat transfer characteristic of the sphere-packed channel in the condition of one side heating is necessary to be evaluated. In this study, the heating condition is change to the one side heating from previous all circumferences heating, and heat transfer experiment is conducted using silicon oil as a simulant of Flibe in terms of Pr number.

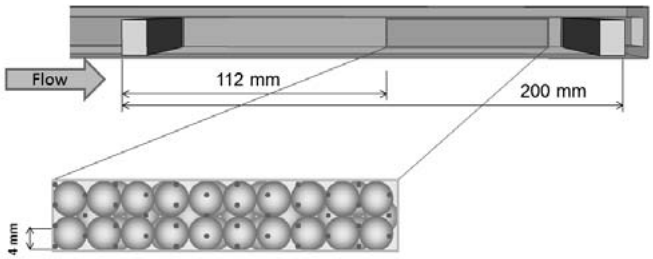

Fig. 1 Schematic view of Sphere-packed pipe (d=1/2D)

Figure 1 shows the test section and install positoins of thermocouples. The test section is a rectangular channel with a cross-section of 14 mm × 14 mm, and comprises a SS plate as a heated wall and the other three walls mad of PPS resin. Spheres with diameter of 6.9 mm are regularly packed as shown in Fig. 2, and imposed heat flux is ranged from 26 to 176 kW/m^2. First, flow experiment is conducted to measure the pressure drop of the channels, and heat transfer experiment is conducted to evaluate heat transfer characteristic in terms of Nusselt number based on sphere diameter as length scale.

Pressure drop in the channels are shown in Fig. 3. The data obtained in the present study are slightly larger than that of the previous ones using all channel walls made of SS. Since pressure drop is considered to depend only on the channel structure, these results must be confirmed in further experiments. Fig. 4 shows the heat transfer characteristic of the channels. In the experiment, some oil leak has occurred at some installation locations of TCs and the electrodes, and accurate measurement is not likely to be done this time. Some modifications are necessary for the test section to obtain accurate data.

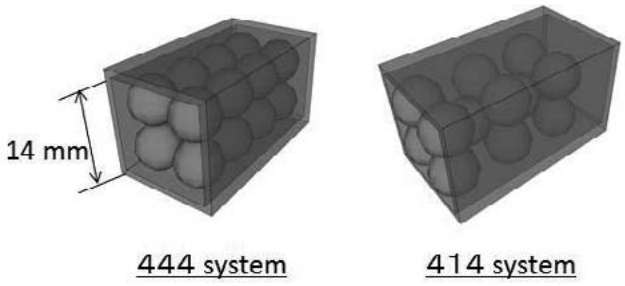

Fig. 2 Packing structure of spheres

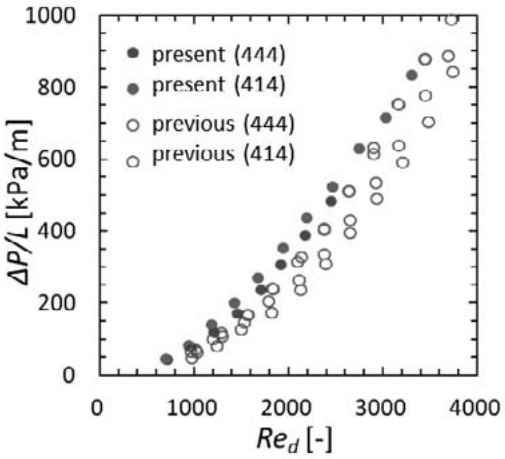

Fig. 3 Pressure drop in the channels

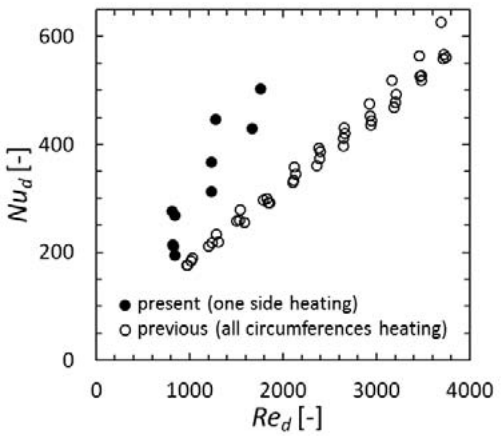

Fig. 4 Heat transfer characteristics of the channels