§17. Development of Novel Heat Transfer Promoters for First-wall Cooling in a Heliacal Type of Fusion Reactor

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In the case that the first wall of FFHR [1] is cooled by molten salt Flibe, development of novel heat transfer promoter, which is excellent in reductions of MHD pressure loss, electrolysis, and chemical compatibility as well as achieving high economical efficiency and maintainability, becomes one of pressing needs. In this study, the optimum heat transfer promoter is evaluated in order to not only overcome these complicated requirements but also enable high heat removal of the first wall.

In Tohoku University, heat transfer data of Flibe simulant, which is high-Pr number fluid HTS, have been obtained so far using TNT loop [2] and it was proven that the similarity of heat and momentum transfers was also applicable under high temperature and high Pr-number conditions [3]. On the other hand, the data in high Re number regime haven't been obtained yet due to restriction of the performance of the circulating pump. Therefore, the heat transfer experiments under high Re number regimes are newly carried out using silicone oil as Flibe simulant with Pr=28.1@30℃ whose thermal properties are almost the same as Flibe (see Figure 1). To begin with, the heat transfer performance of the Sphere-Packed Pipes (SPP) that seem to be useful as a prototype heat-transfer promoter in the Flibe blanket is compared with a circular pipe and a swirl pipe. Here, the material of the sphere is alumina, and the inner diameter of each pipe, D, is 19mm. From Figure 2, flow velocities of the SPP with the sphere diameters of D/3 and D/2 necessary for achieving heat transfer coefficient of 20000W/m^{2}K as a primary goal are 6.9% and 22% against the flow velocity for the circular pipe flow. They are also respectively 9.5% and 30% against the swirl pipe with the twisted ratio of 3.0, so that it is obvious that the SPP flows have much superior high removal performance. In order to reflect these heat transfer data to the evaluation of Flibe thermofluid flow,

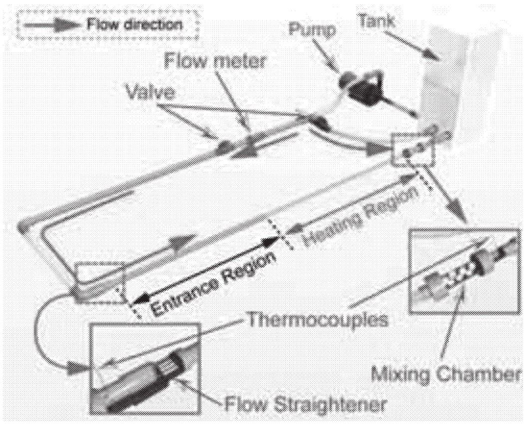

Fig. 1 Silicone oil circulating loop

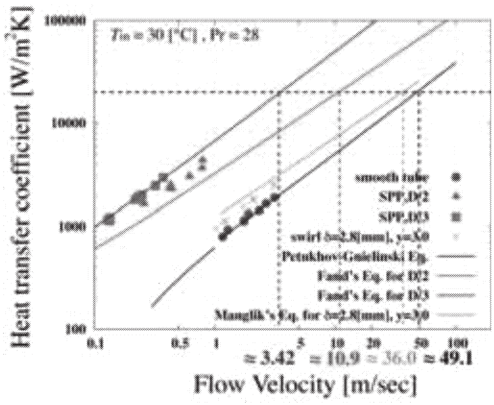

Fig. 2 Heat transfer performances for flow velocity

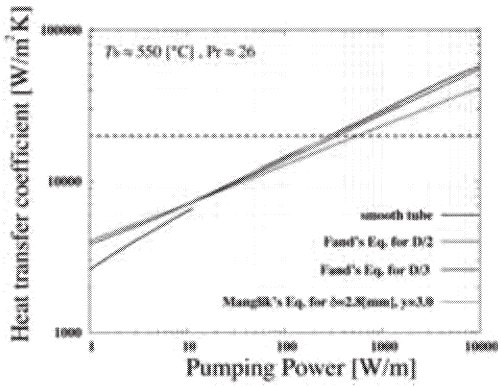

Fig. 3 Heat transfer performances for pumping power

heat transfer correlations for the SPP flows are constructed by generalizing the obtained data and then the heat transfer performance of Flibe with the SPP promoter is evaluated especially for the relationship between the heat transfer performance and pumping power. From Figure 3, it is confirmed that the pumping power necessary for achieving the 20000W/m^{2}K, is almost the same for each pipe. The relative relation between the heat transfer coefficient and the flow velocity for these pipes is equivalent to the oil experiment. It means that the heat removal of the first wall becomes possible under low flow velocity conditions at equal pumping power, by utilizing the SPP promoter.

As the next step, we will make an effort to enhance the fin effect by using metal sphere and furthermore by improving the contacting degree between the sphere and the heating wall. In addition, the sphere packing structure that is optimum for one-side heating such as the first wall will be developed by twisting the packing spheres in spiral.

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