§20. Fundamental Research for Cooling Channel Structure to Enhance the First Wall Cooling and Tritium Recovery

Ebara, S., Hashizume, H., Yasunaga, S. (Tohoku Univ.), Sagara, A.

Flibe blanket using molten salt Flibe as a double-duty material, that is, breeding material and coolant, is one of the advanced liquid blankets for fusion DEMO reactors and its conceptual design activity is now in progress for LHD-type fusion reactor, FFHR. 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. Poor heat transfer characteristic of Flibe originated from its high Prandtl number is one of the issues. As for tritium recovery, Flibe blanket has a challenging issue since the solubility of tritium in Flibe is low.

In order to solve the above-mentioned issues, a flow channel with finger-stacked structures (FSS) has been proposed[1]. In this channel, narrow gaps are held between finger structures and a heated wall to avoid generating flow stagnations and hot spots, and high heat transfer performance can be expected. Besides heat transfer enhancement, using fingers with hollow structure as absorber of tritium is also expected to enable the blanket system to show good tritium recovery.

In this study, a flow visualization experiment adopting PIV method was conducted to obtain the flow field in the flow channel in detail, and the optimal channel structure for heat transfer experiment was considered.

Figure 1 shows the test section. The test section is a rectangular channel of 56 mm square, and finger structures of cylindrical shape of 28 mm diameter are inserted in 2-1-2 arrangement in the channel. The whole test section is made of acrylic resin to visualize the flow. The finger has a hemisphere on the tip, and a certain distance, *h*, between the tip and the channel wall is kept in the channel. In order to obtain a fully-developed complicated-channel flow, the third period of the 2-1-2 arrangement of the FSS was measured. In the experiment, *h* was set at 0 and 1 mm, and Reynolds number based on the finger diameter and the specific velocity in the channel 4,500. For the purpose of detailed evaluation of the flow field, iodide sodium solution was used as a working fluid to match the refractive indices of the channel wall and fluid.

Figures 2 and 3 show time-averaged flow field and kinetic energy distribution which was evaluated two-dimensionally on the visualization area in the cases of h=0 and 1 mm. The visualization area was parallel to and 2 mm off the channel bottom. In the figures, color-bars correspond to the magnitude of velocity and kinetic energy, respectively, and they are normalized by the velocity averaged in the fluid volume. It is found from these figures that the flows wind largely their ways and slow velocity areas are formed behind the fingers. Regarding velocity fluctuation, the kinetic energy is generated in the velocity shear layer formed both sides behind the fingers. The slow velocity area in the case of h=1.0 mm are fairly smaller than those in the case of h =0 mm. It is also found that velocity and kinetic energy in the case of h=1.0 mm are smaller than those of h=0 mm by about 30 %.

When considering heat transfer from the bottom plate of the channel, fast velocity and intense velocity fluctuation near the bottom are preferable, and this mean the case of h=0 mm is promising rather than 1.0 mm. However, from the viewpoint of slow velocity areas behind the fingers, the case of 1.0 mm is promising because the areas are smaller. At any rate, now that the flow aspect and characteristic of velocity fluctuation are very similar to those in a sphere-packed pipe which was well investigated previously and showed good heat transfer performance[2], heat transfer in the flow channel with FSS is expected to be good.

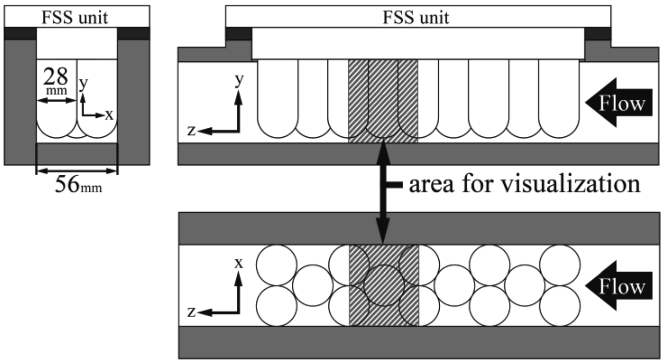

Fig. 1 Schematic view of test section

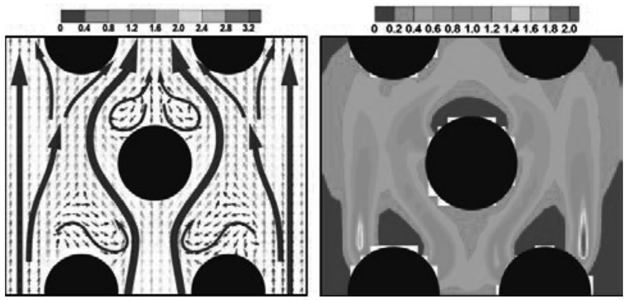

Fig. 2 Time-averaged velocity field (left) and kinetic energy distribution (right) in the case of h=0 mm

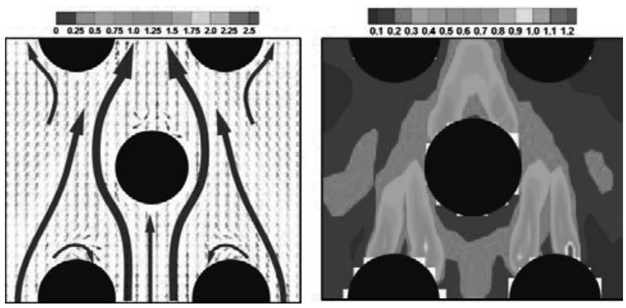

Fig. 3 Time-averaged velocity field (left) and kinetic energy distribution (right) in the case of h=1.0 mm

1) S. Ebara, et al., Fusion Eng. Des., **89** (2014), 1251.
2) K. Shimizu et al., Fusion Sci. Technol., 60(2) (2011), 528.