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

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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[2], 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 which is a rectangular channel of 56 mm square equipped with finger structures with periodical arrangement of cylindrical shape of 28 mm diameter. The whole test section is made of acrylic resin and working fluid is sodium iodide solution to match refractive indices so as to visualize the flow in detail. 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 finger arrangement of the FSS was measured. In the experiment, *h* was set at 0, 1 and 2 mm, and Reynolds number based on the finger diameter and the specific velocity in the channel was ranged from 4,200 to 4,600. The finger arrangements of 2-1-2 and 2-2-2 were adopted in the experiment and two dimensional PIV experiment was conducted.

Figures 2 and 3 shows time-averaged flow fields and turbulent kinetic energy distribution in visualization planes parallel to the mean flow direction and finger centerline in the case of 2-1-2 arrangement with $h = 1$ mm. Each plane is 3.5 mm away from the successive ones, and plane 1 is located in the center of the channel. It is found that high velocity region appears in the gap between the finger tips and channel wall, and velocity fluctuation in the region is much large. This means flow stagnation near a heat transfer wall hardly appears in the FSS channel and high heat performance can be expected by using this channel.

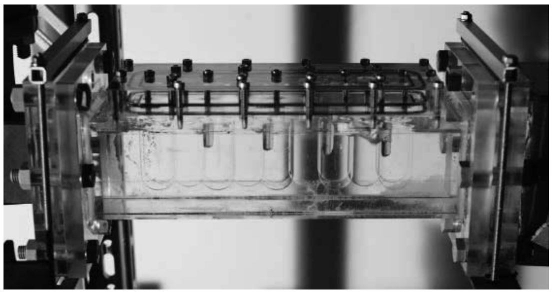

Fig. 1 Test section made of acrylic resin with sodium iodide solution as working fluid

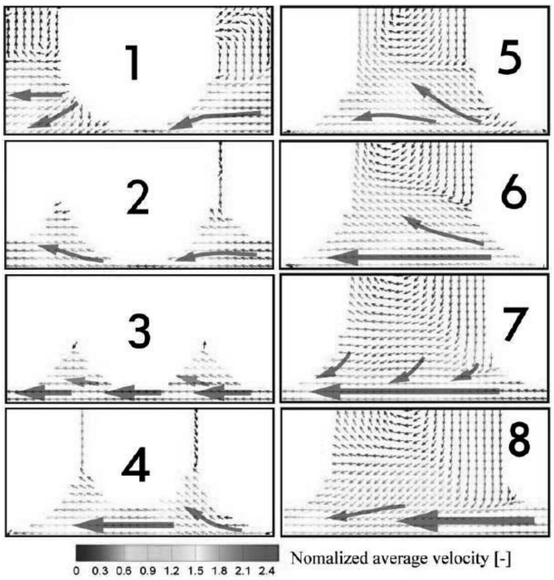

Fig. 2 Time-averaged velocity field in the case of 2-1-2 arrangement with *h*=1 mm

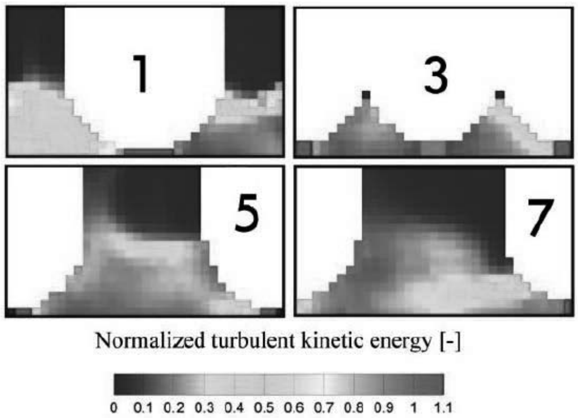

Fig. 3 Kinetic energy distribution in the case of 2-1-2 arrangement with *h*=1 mm

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