§18. Heat Removal Demo-research for Flibe Blanket Development

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Flibe blanket using molten salt Flibe as breeding material as well as a 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, it is very important from engineering point of view to demonstrate a heat removal of 1 MW/m^2 corresponding to the heat flux assumed to be imposed on the first wall of FFHR.

In the previous studies, heat transfer enhancement by means of Sphere-packed pipe (SPP), as shown in Fig. 1 has been demonstrated experimentally. However, its minute mechanism of heat transfer enhancement has yet to be clarified. In this study, a flow visualization experiment was done for the flow in the SPP by adopting a refractive index-matching PIV measurement. This method uses acrylic resin as a channel material, a pipe and spheres, and sodium iodide solution as working fluid to visualize the flow in complicated geometry.

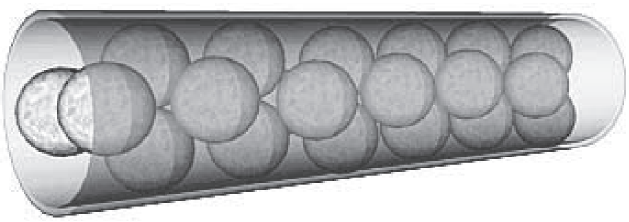

Fig. 1　Schematic view of Sphere-packed pipe（d=1/2D）

Figure 2 shows the test section and visualization areas. The diameter of the pipe, D, was 56 mm and that of the spheres 27.6 mm. A diode laser (Oxford Lasers) was used as a sheet light source for PIV measurement, which had the maximum output of 200 W (the maximum pulse energy of 15 mJ) and an infrared wavelength of 808 nm. By means of a digital high-speed camera (FASTCAM, Photron), 2,048 images with 1,024×1,024 pixels were obtained per one shot, and 1,024 serial velocity vector data were calculated by VidPIV (Oxford Lasers). Tracer particles of 10μm in diameter were made of glass coated with silver. Reynolds number based on the sphere's diameter and the specific velocity (Darcy velocity) was set at 5,000.

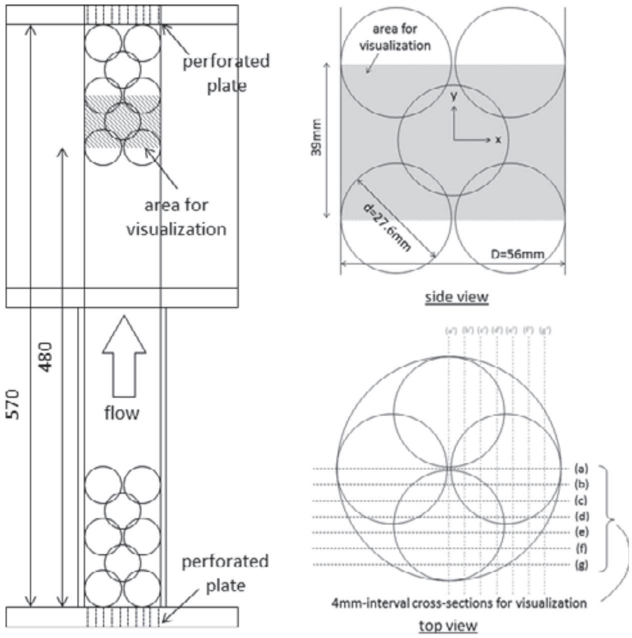

Fig. 2 Test section and visualization areas

Time-averaged velocity fields obtained in the experiment were shown in Fig. 3. It was found that high-velocity areas appeared near pebbles' sides in penetrating paths enclosing the pipe wall and spheres. Turbulent motions such as turbulent kinetic energy were also analyzed and it was found that the main production area of turbulent kinetic energy was in the velocity shear regions formed behind spheres near the pipe wall.

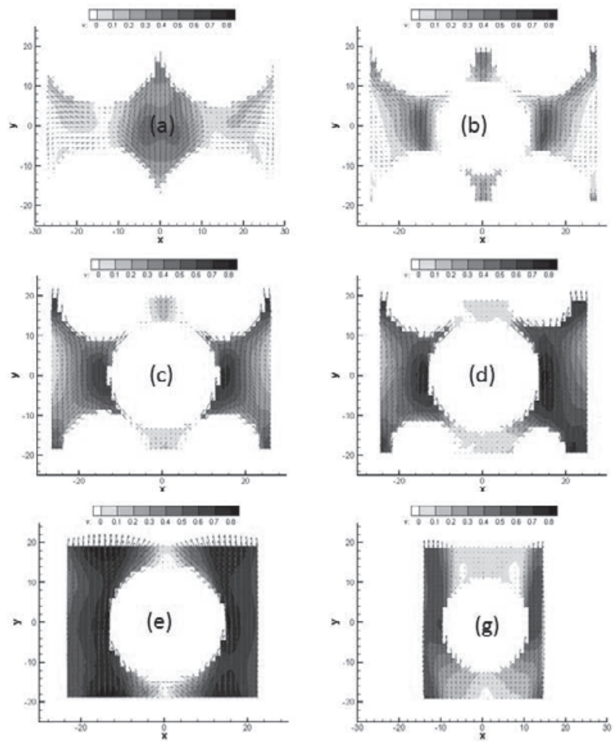

Fig. 3 Time-averaged velocity vector fields and contours of axial velocity component