

Evaluation of flow structure in packed-bed tube by visualization experiment

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Liquid blanket system in a nuclear fusion reactor has a role of generating tritium and transporting the fusion energy. Molten salt Flibe, which is a mixture of LiF and BeF₂, is one of the candidates for the liquid blanket material. The Flibe blanket system, however, needs heat transfer enhancement device under high heat flux because the Flibe is a high Prandtl number fluid. The packed-bed tube, which is filled with a number of spheres, is one of the heat transfer enhancement techniques. The heat transfer characteristics of packed bed tube have been evaluated by using Heat Transfer Salt (HTS) as the Flibe simulant in Tohoku-NIFS Thermofluid (TNT) loop at Tohoku University. [1]

The heat transfer enhancement performance of the packed-bed tube is determined by the filling structure of spheres, the material of spheres, the flow structure and properties of the fluid. Since the mechanism is not clarified how the flow structure affects the heat transfer enhancement and pressure drop characteristics, it is necessary to evaluate the flow structure in the packed-bed tube. The purpose of this study is, therefore, to investigate the flow structure in the packed-bed tubes through visualizing the flow field by a PIV system.

The test section of experimental apparatus is made of an acrylic tube whose inner diameter is 56mm and is filled with acrylic spheres with the diameter of 27.7mm and 18.5mm. In order to measure the pressure drop in the test section, the Bourdon tube pressure gage is installed in the upstream and the downstream sides of the test section respectively.

Generally, the visualization inside the packed-bed tube is difficult due to the existence of spheres. It is, therefore, necessary to match the refractive index of working fluid with that of spheres to visualize the whole flow field in the packed-bed tube. It is confirmed that the refractive index of sodium iodide solution (NaI) with the concentration of 61-62% at the temperature of 298K corresponds to that of acrylic spheres. Through the experiment using this NaI fluid, the flow structure in the packed-bed tube can be visualized by the PIV system. It is clarified that the flow structure near the tube-wall is strongly influenced by the flow in the center area of tube. The pressure drop shows almost the same tendency given by the experimental formula of Ergun. [2]

[1]Saburo Toda et al., Experimental research on molten salt thermofluid technology using a high-temperature molten salt loop applied for a fusion reactor flibe blanket, Fusion Eng. and Design, vol. 63-64, pp. 405-409, 2002

[2]Sabri Ergun, Fluid flow through packed columns, Chemical Eng. Progress, vol. 48 no. 2, pp. 89-94, 1952