§24. Possibility of Divertor Cooling Design Utilizing Water Impinging Jet Flow in a Metal Particle Bed

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In a divertor region, a heat flux of approximately 10MW/m^2 is steadily loaded. The ITER divertor utilizes water cooling under high pressure, high-speed, and highly subcooled conditions. However, development of heat removal technology with much lower pumping power becomes essential from the viewpoint of achieving low cost of electricity of the fusion power reactor.

To cope with this difficulty, we focus on boiling heat transfer of water impinging jet flow with porous media for divertor cooling. To take full advantage of the latent heat of vaporization, utilization of microchannels inside porous medium is proposed. The porous media with the microchannels have large heat transfer surface and superior mixing effect of fluid, which enhances the boiling heat transfer performance by improving the evaporation rate of the coolant. In a proposed cooling device, the water jet is supplied from the center of the top surface of the porous medium and the vapor is discharged from the side of the porous medium.

The experimental apparatus as shown in Fig. 1 is composed primarily of a coolant supplying section, a test section, a vapor discharge section, and a heat exchanger section. Distilled water is used as coolant. The test section mainly consists of a heat transfer block and a porous medium attached at the heat transfer surface. High power of eight cartridge heaters are utilized as the heat source and the heat transfer copper block is designed in order to achieve a heat flux of over 10 MW/m^2 at the heat transfer surface of 20 mm in diameter. The porous media are of non-sintered particle beds that are formed by packing two layers of copper particles with the diameter of 1.0 mm on the heat transfer surface, as shown in Fig. 2. The diameter of the porous medium is 20 mm and the thickness is less than 2 mm in order to reduce the flow resistance in the porous medium and the porosity is almost 0.35.

As a result, in a single-phase heat transfer regime, the heat transfer performance at a stagnation point was enhanced by 1.6 times at an inlet flow velocity of 7.1 m/s. On the other hand, in a boiling heat transfer regime, the heat transfer coefficient was improved by 1.6 times. In particular, a high heat flux removal of approximately 9.5 MW/m^2 was obtained at low velocity and a high subcooled condition.

As the next step, we further try to enhance the heat transfer performance of the water impinging jet flow in the metal particle bed in order to evaluate the feasibility of this cooling system.

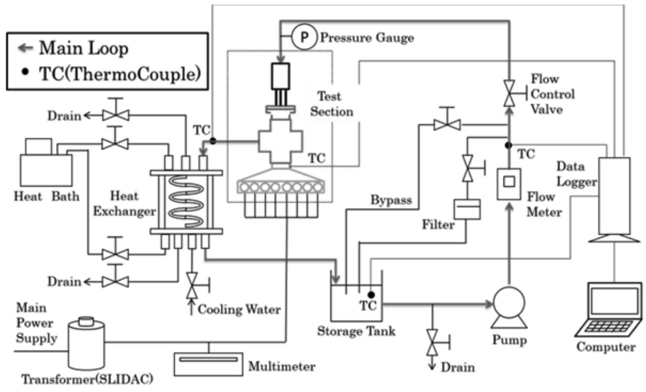

Fig.1 Experimental set up of gas cooling

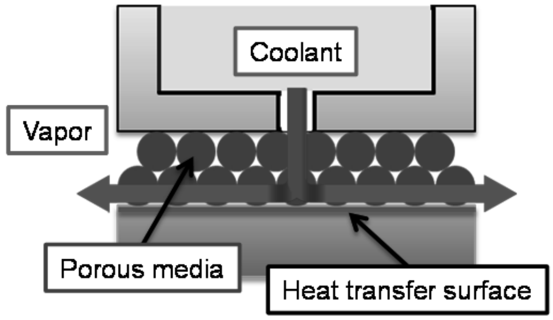

Fig. 2 Packing structure of particles

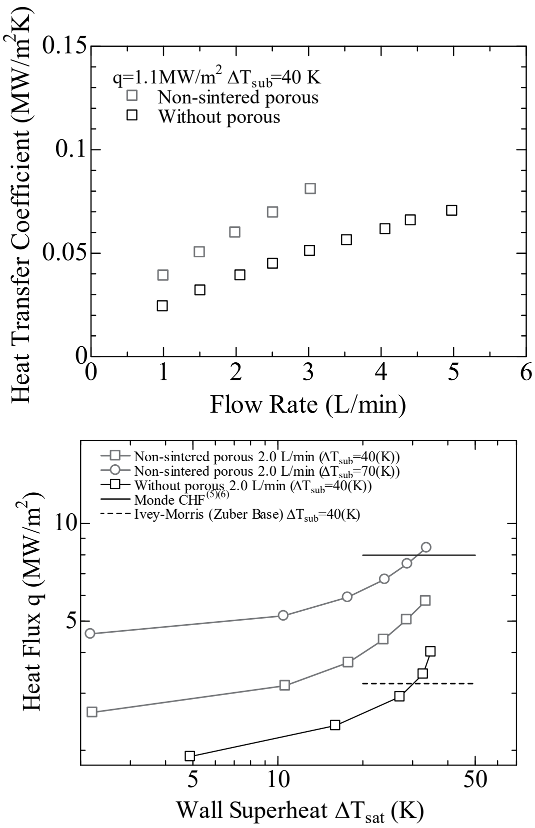

Fig. 3 Experimental result
(Upper: Single-phase, Lower: Two-phase)