§14. Applicability of Gas Divertor Using a Porous Medium with High Thermal Conductivity Material

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In fusion reactors, a heat flux of approximately 10MW/m^2 is steadily loaded to the divertor. In order to remove this heat, in EU and the U.S., utilization of a finger tube with multiple impinging jet has been proposed under high pressure condition of almost 10MPa. However, from the view point of the safety of the cooling line and its maintenance activity, heat removal technology under much lower pressure and lower pumping power conditions should be discussed more. In this study, we focus on the heat removal characteristics of gas cooling with high thermal conductivity metal porous media, and set up a high heat flux removal equipment which enables a heat transfer experiment of 10 MW/m^2.

Figure 1 shows the experimental set up that consists of a gas tank, a pre-heater, a flow meter, a test section, and a heat exchanger. The gas from the gas tank is adjusted its inlet temperature and flow rate, flows into the test section, cooled in the heat exchanger, and then exhausts to the air. In order to evaluate of the heat transfer performance of gas, Nitrogen is used as the simulant of He gas as the first step. The test section is composed of a heat transfer block and a heat transfer area with a metal porous medium. The heat transfer block has eight cartridge heaters at the bottom with an allowable temperature of 950 ^{o}C and the maximum heat input of 1800 W. The maximum total heat input is 14.4 kW. As shown in Fig. 1, by decreasing the cross section of the copper heat transfer block, it is possible to finally achieve a high heat flux of over 5 MW/m^2 at the heating surface of 50 mm in diameter, while a heat flux of 10MW/m^2 is also possible by changing to the heat transfer surface of 30mm in diameter. On this heating surface, a copper-particles-sintered porous medium is mechanically attached as the reference porous media. The particle diameter is 500 μm and average pore size is 100 μm, and the porosity is approximately 30 %. The shape of the porous medium is like a circular plate. The diameter is 50 mm and the thickness is 1.5 mm. The porous medium is attached onto the heat transfer surface by pushing a stainless steel rod of 49 mm in diameter that has a jet nozzle at the central axis. The jet from the nozzle outlet flows into the porous medium, impinges to the heat transfer surface through the porous medium, expands in a radial direction, and discharges outside the porous medium. In order to discuss the radial profile of heat flux, wall temperature, and heat transfer coefficient, the temperature field inside the heat transfer block is simulated by solving an equation of heat conduction in the cylindrical heat transfer block. The Inlet temperatures of N_2 gas in a shakedown experiment is 17 ^{o}C and the flow rates are 50 L/min.

Figure 2 shows the radial profiles of the heat transfer coefficients of the copper-particles porous medium. The heat transfer coefficients with/without the porous medium are the highest near the center area due to impinging effect of gas flow and decreases in a radial direction due to the decrease in the flow velocity, which indicates that, also in this cooling, a cooling unit of 10 ~ 15 mm in diameter is conceivably needed. Furthermore, the heat transfer performance with the porous medium is much higher than that of the impinging jet cooling. However, it was also confirmed that there was a thin gap between the porous medium and the heat transfer surface, which conceivably produces a large temperature difference and decreases the heat transfer coefficients.

In this study, the heat transfer characteristics of gas cooling with particle-sintered porous media was evaluated. It was proved that the heat transfer performance must be enhanced more by decreasing the thermal resistance between the heat transfer surface and the porous medium. In the next finical year, the particle-sintered porous medium itself will be sintered on to the heat transfer surface, completely new porous media will be introduced.

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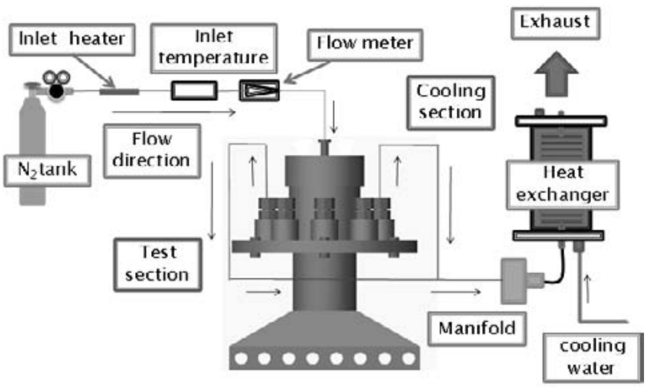

Fig.1 Experimental set up of gas cooling

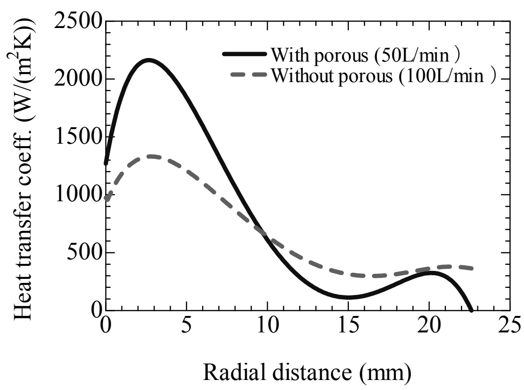

Fig. 2 Heat transfer coefficient in a radial direction