§19. Investigation of Hybrid-evaporator for FFHR Divertor Cooling

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The divertor of the nuclear fusion reactor is locally exposed to extremely high heat flux which exceeds $10MW/m^2$. To develop a heat removal device which combines high thermal efficiency, safety, and maintainability is one of the most important issues which directly influences the cost of electricity of a power reactor. In this study, new porous material is fabricated in order to develop the heat removal technology using hybrid functioned two pore structures.

In the previous water cooling experiments [1], the heat flux of $\sim 4MW/m^2$ was cooled by the normal porous media. Simultaneously, high heat transfer coefficient was achieved under the wall temperatures below 200 deg. C. or and the inlet pressures below 100kPa. In addition, it was clarified that a stable cooling was possible also under the temperatures over 200 deg. C. though the heat transfer coefficient decreases. It was concluded that active discharge of vapor generated in the porous medium was indispensable for the heat removal over $10MW/m^2$. In the continuously performed experiments, the heat transfer performance of metal foams with high porosity was evaluated in order to enhance the vapor discharge. However, it was not possible to obtain the drastic improvement in the heat transfer coefficient, which indicates that not only high permeability for vapor discharging but also vast heat transfer area are necessary.

In this year, hybrid dual structured metal porous material which satisfies the two contradictory characteristics of high permeability and large heat transfer surface is fabricated. The metal porous material with the dual pore structure is produced by sintering copper particles. In this newly introduced porous medium, the pore of the microscale coexists with the coarse pore of the millimeter scale. The porosity of the microscale pore is almost 30% because the each copper globular particle is packed closely each other. This microscale pore works as the heat transfer area as well as liquid supply. In the meantime, it is possible to control the milliscale of the coarse pore. The vapor produced in the microscale pore area passes through this coarse pore and is discharged to the outside. The averaged diameter of the copper particles is 20 μm, and the diameter of the coarse pore is approximately 1.2mm, as the first step. In the first trial, however, it was judged that the mechanical strength of this double scale of porous medium was weak and that the long-term use under the boiling heat transfer conditions is quite difficult. Therefore, the particle size was changed to 15 μm, and in addition, the sintering time was lengthened. As the result, the test specimen with the strong mechanical strength was obtained. Figure 1 is the surface photograph of a molded cylindrical porous medium. The holes which can be confirmed in the visual observation are the coarse pore. Fig. 2 shows the micrograph of the one milliscale coarse pore with the surrounding microscale pores. This dual pore structure porous material newly fabricated does not exist, as far as the author knows.

In this study, hybrid dual structured metal porous media which satisfy two contradictory characteristics of high permeability and large heat transfer surface were fabricated. As the next step, heat transfer performance of this newly introduced porous media will be continuously evaluated under the extremely high heat flux conditions.

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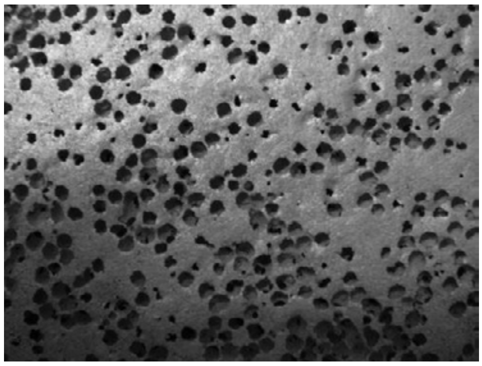

Fig. 1 Dual structured porous medium

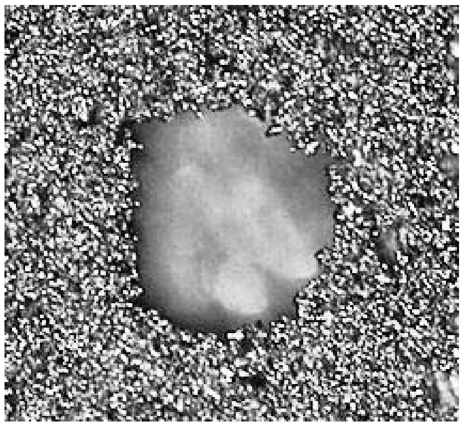

Fig. 2 Micrograph of one milliscale coarse pore with the surrounding microscale pores

[1] K. Yuki, et al., Special Topics & Reviews in Porous Media - An International Journal, vol. 1, no. 1, pp. 1-13, 2011.