Heat Transfer Enhancement Technique with Copper Fiber Porous Media

Hisae Togashi[1], Kazuhisa Yuki[1], Hidetoshi Hashizume[1]

[1]*Dept. of Quantum Sci. & Energy Eng., Tohoku Univ., Sendai, Miyagi, and htoga@karma.qse.tohoku.ac.jp*

In a fusion reactor, almost 30% of fusion energy is deposited on plasma facing components. In the diverter region, it is, however, difficult to utilize this energy with conventional cooling techniques based on high velocity flow with highly subcooled cooling. From this viewpoint, the authors have been developing a cooling technique with metal porous media, and have succeeded in removing inlet heat flux of over $50MW/m^2$. In this study, in order to attain both the higher cooling performance and the acquisition of high-energy density, high heat removal experiments are performed by using cylindrical homogeneous and functionally graded metal porous media to estimate their fundamental heat transfer performances. The sintered porous media made of copper fibers are used with water coolant flowing through the porous media.

From the experiments with the homogeneous porous media whose porosity and fiber-diameter are spatially uniform, it is verified that the cooling performance of porous media becomes higher as the pore size is smaller. It is also clarified that the heat transfer mechanisms including phase change can be classified into three patterns depending on the flow velocity of coolant. In these regions, there exists an optimum flow rate in which it becomes possible to achieve both the high cooling performance and the high outlet temperature simultaneously.

On the other hand, as for the porous media with the finer pore, the pressure loss becomes higher, which prevents the increase of flow velocity of cooling water. For this reason, the heat transfer enhancement by forced-convection is quite low. To overcome this disadvantage, the heat transfer experiments are carried out by using functionally graded porous media whose pore size changes along the longitudinal direction.

The functionally graded porous media can reduce the pressure loss. In case of the porous media with the fine pore, the heat transfer coefficient is higher than that obtained in homogeneous case under the low inlet-pressure condition. As for the outlet temperature, the difference is not seen between the functionally graded and the homogeneous porous media. This result indicates that the evaporated ratio of water coolant increases, while the steam temperature is not raised.