§32. Fundamental Engineering of Divertor Element as Heat and Particle Load Convertor for Helical Reactor

Konishi, S., Kasada, R. (Kyoto Univ.),
Yamamoto, Y. (Kansai Univ.),
Masuzaki, S.

This study examines the feasibility of the divertor concepts to distribute the heat load on the target surface to coolant. Helical DEMO has an advantage to have longer divertor, but heat flux load on it is anticipated to exceed 10 MW/m2 and possibly be localized. In order to realize fusion power, conversion of the heat and particle load for effective use is required. However with the current technology for tokamak, only subcool water or extremely large flow rate helium are the possible candidate, and both can yield low temperature heat that cannot be used at high efficiency. While studies on tungsten and plasma facing material are making progress, divertor element as a component to convert and transfer heat is in early stage. The purpose of this study is to provide a possible concept of divertor for this function.

Fig. 1 Concept of the divertor component developed under this study. The entire component is designed to transfer heat flux given on the surface of the target locally through the divertor heat sink duct to the heat exchange part, that is out side of the strong magnetic field to heat the main coolant used for blanket or any other secondary coolant that will drive turbine.

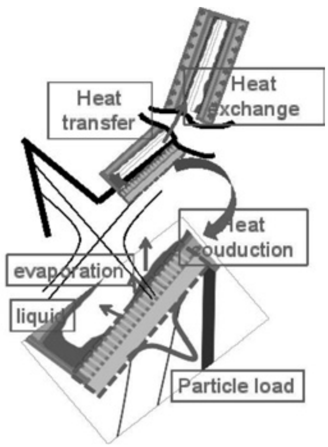

Fig. 1 Concept of the divertor component developed under this study.

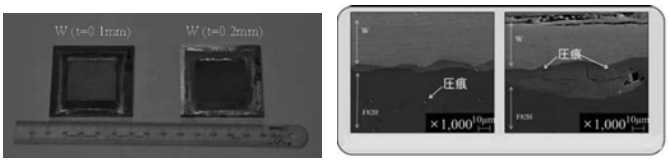

Fig. 2 Exprosive joining of tungsten on RAFM, right picture shows its SEM image.

Armor material exposed to particle loads and is subject to sputtering will be made of tungsten as a limited option. In this study, joining technique for tungsten and target , heat conduction material of target, and the heat sink, that transfer localized and sometimes unstable heat load to coolant, are identified as issues.

The surface of the target of the divertor suffers high heat flux localized onto the 5-10 cm surface area. In this study, tungsten joining technique using explosive detonation in water is applied. Fig. 2 shows the example of joining of W on RAFM. This technique is expected to provide industrial scale fabrication technology of divertor units with large area component.

Target material under the armor is required to conduct heat from tungsten to the heat sink. In the concept shown in the fig.1, SiC composite with enhanced thermal conductivity with fiber is used for unisotropic heat conduction. Figure 3 shows the fabrication of CfSiC material for this purpose. With high thermal conductivity fiber, SiC showed ca. 400 w/mK range of directional conductivity. A FEM numerical analysis was also performed to understand this heat conduction behavior.

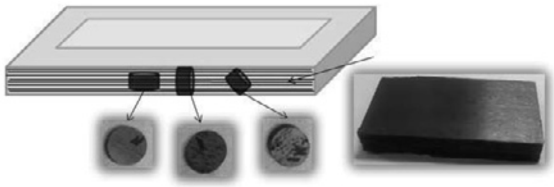

Fig. 3 SiC composite with carbon fiber to enhance the heat conduction

This heat is used to evaporate liquid medium in a closed duct. Heat is then transferred as latent heat by phase change, and condensation on the larger area of heat exchange part will provide constant and uniform heating to the secondary medium.

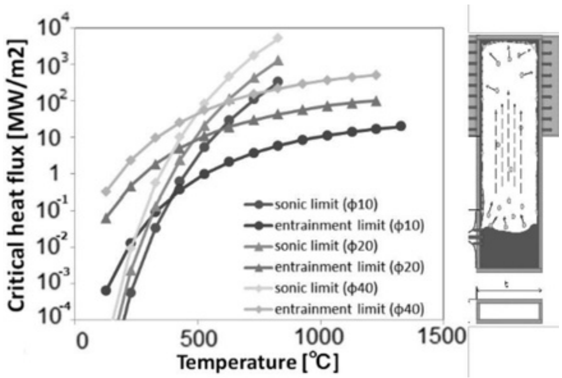

Fig. 4 Heat transfer characteristics for circular heat pipe.

Analytical evaluation with existing heat pipe data suggests the heat transport capability of Na as working fluid used for this concept..In the Na system with inner diameter 40mm is expected to exceed 100MW/m^2 in the operating temperature 727-1027 degree. The result is expected to relax the stringent requirements on the divertor design for the reactor. In the next year, validation with ion beam load will be conducted.