

Development of Helium-Cooled Divertors for Fusion Power Plants

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Helium-cooled divertors are considered suitable for use in fusion power plants for safety reasons, as they enable the use of a coolant compatible with any blanket concept, since water would not be acceptable e.g. in connection with ceramic breeder blankets using large amounts of beryllium. Moreover, they allow for a high coolant exit temperature to increase the efficiency of the power conversion system. Within the framework of the European power plant conceptual study [1], different helium-cooled modular divertor concepts [2] based on different heat transfer mechanisms are being investigated at ENEA, Frascati, Italy, and Forschungszentrum Karlsruhe, Germany. The design goal is to achieve a high heat flux of about 10-15 MW/m², a value which is considered relevant to future fusion power plants to be built after ITER.

The modular design which helps reduce thermal stresses is based on the use of small tiles of tungsten as sacrificial layer which is brazed to a finger-shaped structure made of W-alloy. The brazing joint helps stop the crack growth induced from the plasma-facing surface of the tile. Tungsten is chosen as thermal shield material for the divertor due to its high melting point, excellent sputtering resistance, and thermal conductivity. On the other hand, it possesses poor values of ductile-brittle transition temperature and recrystallisation temperature under irradiation, by which the operation temperature window of the divertor is restricted. The divertor fingers are cooled by 10 MPa He at 600°C that is provided by a system of He manifolds and cartridges. Different impinging and convective cooling techniques have been investigated. The development and optimisation of the divertor concepts require an iterative design approach with analyses, studies of materials and fabrication technologies, and the execution of experiments. Discussion of these issues and of the state of the art of divertor development shall be the subjects of this report.

[1] D. Maisonnier et al., “DEMO and Fusion Power Plant Conceptual Studies in Europe”,

Proceedings of the ISFNT-7, Tokyo, Japan, 2005.

[2] P. Norajitra et al., “The European Development of He-cooled Divertors for Fusion Power

Plants”, Proceedings of the 20th IAEA Fusion Energy Conference, Portugal, 2004.

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