CONCEPTUAL DEVELOPMENT OF A HELIUM-COOLED DIVERTOR FOR FUSION REACTORS

P. Norajitra[a], R. Giniyatulin[b], T. Ihli[a],
W. Krauss[a], R. Kruessmann[a], V. Kuznetsov[b], I. Mazul[b], I. Ovchinnikov[b]
[a]Forschungszentrum Karlsruhe,
P.O. Box 3640, D-76021 Karlsruhe, Germany
[b]D.V. Efremov Institute, Scientific Technical Centre "Sintez,"
196641 St. Petersburg, Russia

Modular helium-cooled divertor concepts [1] have been investigated at the Forschungszentrum Karlsruhe within the framework of the EU power plant conceptual study in cooperation with EFREMOV. The design goal is to achieve a high heat flux of 10 MW/m^2, a value which is considered relevant to future fusion power plants. Tungsten is chosen as divertor material 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 current divertor design is based on the jet impingement cooling technique. It employs small hexagonal tiles of tungsten with 5 mm thick sacrificial layer which is brazed to a finger-like thimble structure made of W-alloy forming a cooling finger unit. The inner surface under each thimble is cooled by 10 MPa He at 600°C that is provided by a jet cartridge which is placed concentrically inside the thimble and carries an array of jet holes on its top. Another back-up solution based on the use of a tungsten flow promoter in the form of a slot array to enhance the cooling surface is also under investigation. The cooling finger is connected to the supporting structure made of oxide dispersion-strengthened (ODS) steel (e.g. an advanced ODS EUROFER or a ferrite version of it) by means of e.g. brazing and/or mechanical interlock. This transition joint has to survive about 100 – 1000 thermal cycles between operating and room temperatures.

The respective technological investigations with respect to e.g. the W/W joining by means of high-temperature brazing have been carried out successfully at EFREMOV. Gas puffing experiments were carried out on the basis of a dynamic method for the purpose of screening the design options and verifying the CFD calculations. A helium loop is presently under construction at EFREMOV for high-heat-flux integral tests of divertor mock-ups and determination of the pressure loss and HTC of the design variants. Results and the status of divertor development shall be outlined in this report.

[1] 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.