HETRA EXPERIMENT FOR INVESTIGATION OF HEAT REMOVAL FROM THE FIRST WALL OF HELIUM-COOLED-PEBBLE-BED TEST BLANKET MODULE

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This paper deals with cooling of the first wall (FW) of Helium-Cooled-Pebble-Bed Test Blanket Module (TBM). The FW cooling is considered as an atypical case of heat transfer due to an extreme asymmetry of heat loads - heat flux on the plasma facing TBM side is 4.5 times (in an excess times even 9 times) stronger than the one on the TBM inner side which faces breeding units. Our preliminary CFD analysis revealed that under such conditions the heat transfer coefficient is significantly lower than predicted by common heat transfer correlations [1]. For verification of these results HETRA (HEat TRAnsfer) experimental facility has been designed and built at the Institute for Neutron Physics and Reactor Technique in Karlsruhe Institute of Technology. The HETRA facility involves one U-sweep of the FW channel. The side parts of the U-channel serve to provide developed flow conditions and are not heated. The heated test section (see Figure 1) is fabricated from EUROFER steal. The heat flux of 270kW/m^2 at the plasma facing side is simulated by a set of 8 flat ceramic heaters, while the heat imposed by breeding units is neglected. To diminish effects of imperfect thermal contact, the gap between the heaters and the channel wall is bridged by two thin graphite layers between which a layer of copper is placed. Flange connections of the heated section to the side parts provide its replacement, i.e. performing tests with different roughness heights. In the current experimental campaign two cases are going to be examined: (i) a section with hydraulically smooth channel and (ii) a section with artificially fabricated microscopic roughness. These investigations will be used to prove reliability of the numerically based conclusion that the surface roughness of 20μm is necessary to provide satisfactory FW cooling. The computational results will be verified via experimentally determined steel temperatures. For that purpose 6 sets of temperature measurements are foreseen along the heated section. Within each set the temperature will be measured at 10 positions. The measurements have been started in March 2010, what gives us the chance to present the results in the full paper.

Figure 1: Final arrangement of heated HETRA test section.

[1] M.Ilic et al., Fusion Engineering and Design, volume 83, year 2008, pp 1253-1257