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Progress in high heat flux testing of European DEMO

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In the framework of the DEMO divertor project of EUROfusion an extensive R&D program has been carried out to develop advanced design concepts for hot water cooled divertor targets. These plasma-facing components made of W blocks as plasma facing material and CuCrZr tubes as cooling tubes should allow a reliable DEMO operation for 2 h long pulses and maximum heat fluxes up to 20 MW/m². Compared to ITER, the operation at higher coolant temperature of 150 ℃, the longer required lifetime, and the significantly higher neutron fluence are the design challenges exceeding the current extent of experience.

In the pre-conceptual design phase, eight types of target mock-ups were designed and manufactured by the involved research groups. Finally, 25 of these unirradiated mock-ups were assessed by high heat flux (HHF) examination in the test facility GLADIS at IPP Garching. The applied hot water cooling at 130℃ inlet and 16 m/s velocity ensures thermal conditions similar to the expected DEMO operation. To reduce the experimental effort of the HHF testing each individual mock-up was subjected to a screening test up to 20 MW/m² at 20℃ cooling water inlet for first selection, followed by HHF fatigue tests between 10 and 20 MW/m². After the cold water HHF testing, six concepts were qualified for the subsequent hot water HHF testing with 300 cycles at 20 MW/m². Four of them were successfully loaded up to 500 cycles. Extensive diagnostics such as high-resolution infra-red and visible light cameras were employed for in-situ assessment of surface temperature evolution during the cyclic HHF loading.

This contribution presents the summary of HHF testing and results from the post exposure investigation. Overall HHF performance of the various design concepts will be discussed together with other non-destructive investigations including ultra-sonic examination and transient IR thermography.

Co-authors: Dr GREUNER, Henri (Max Planck Institute for Plasma Physics); Dr BÖSWIRTH, Bernd (Max--Planck-Institut für Plasmaphysik); Dr BARRET, Tom R (Max-Planck-Institut für Plasmaphysik); Dr CRESCANZI, Fabio (ENEA); Dr GALLAY, Franklin (CEA); Dr REISER, Jens (Institute for Applied Materials, Karlsruhe Institute of Technology); Dr RICHOU, Marianne (CEA); Dr VISCA, Eliseo (ENEA); Dr V. MÜLLER, Alexander (Max-Planck--Institut für Plasmaphysik); Dr YOU, Jeong-Ha (Max-Planck-Institut für Plasmaphysik)

Presenter: Dr GREUNER, Henri (Max Planck Institute for Plasma Physics)

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