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Neutron diffraction measurement of residual stresses in an ITER-like tungsten-monoblock type plasma-facing component

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Neutron diffraction measurements have been carried out for non-destructive characterization of the residual stress fields in a mock-up of the ITER-like divertor target plasma-facing component which consists of 4 tungsten blocks joined to a copper alloy (CuCrZr) cooling pipe via a thick soft copper interlayer. The mock-up was manufactured by the hot radial pressing technique at ENEA-Frascati in the frame of a EUROfusion task (WPDIV 2.1-T001). The neutron diffraction measurements were carried out at FRM II reactor in Garching utilizing the STRESS-SPEC diffractometer at room temperature, with a gauge volume 2x2x2 mm3. Parallel to the mock-up, specimens of stress-relieved W and CuCrZr of the same kind as the armor blocks and the pipe, respectively, were examined to measure initial micro-stress field in the macroscopically un-strained reference state before joining. The 3D stress tensor was determined in two different W-blocks and CuCrZr pipe segments, scanning the mock-up from the outer surface of the W block towards the inner wall of the CuCrZr pipe with the interval of 0.4-0.5 mm. Similar profiles of stress components (axial, hoop and radial) were found in the two investigated mock-up segments. Namely, a tensile residual stress is measured in the CuCrZr pipe side near the bond interface region (up to approximately 300MPa) and a corresponding compressive residual stress in the W block side as expected from the requirement of force balance. Significant magnitude of residual stresses was found in the reference specimens of W and CuCrZr, probably due to incomplete relaxation of the micro-strains during the fabrication process. The results are discussed together with the comparative FEM-based numerical prediction obtained for the same mock-up geometry and fabrication history.

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