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P3.208 Creating high-resolution simulations of manufactured divertor components from X-ray and neutron tomography

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The ability to estimate the in-service performance and lifespan of components is key to realising a commercially viable fusion energy device. The finite element method (FEM) is used to estimate performance of a component design with computational simulations. Image-based FEM (IBFEM) converts 3D images (e.g. X-ray tomography) into high-resolution models for part-specific simulations that account for minor deviations from design due to manufacturing processes (e.g. machining tolerances or micro-defects). To investigate the potential of this technique for fusion applications, IBFEM was used on three samples: (1) ITER reference divertor monoblock; (2) CCFE 'thermal break' DEMO monoblock concept; (3) IPP tungsten fibre / copper matrix composite. 3D imaging was performed with high-power X-ray tomography and neutron tomography for a comparison. 3D images were converted into high-resolution IBFEM meshes using the software ScanIP. Thermo-mechanical analysis was performed with ParaFEM using boundary conditions that simulated reference in-service divertor conditions. IBFEM simulation results successfully resolved the impact of minor deviations on performance. For example, in the CCFE monoblock, void regions existed in the braze layer which behaved as micro thermal barriers at the material interface between the coolant pipe and tungsten armour. In the IPP composite pipe, the exact positioning of the tungsten fibres caused variations in the location and value of peak temperatures on the armour's plasma facing surface. This work demonstrates the value of the technique's capability to digitally test 'real' components. Because results can be interrogated through the sample's full volume, this has the potential to yield more sophisticated information than pass/fail experimental tests. This could be used to individually rate each component, in a manner similar to material purity, so that the best performing parts could be placed in the most demanding regions of the tokamak.

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