# DESIGN OF THE EUROPEAN DEMO WATER-COOLED BLANKET WITH A MULTISCALE-MULTIPHYSICS FRAMEWORK

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A tightly-coupled multiphysics-multiscale design approach is developed and performed on the Water-Cooled Lithium-Lead (WCLL) blanket, which is one of four possible embodiments under consideration for the European Demonstration Power Plant DEMO, beyond ITER. The objective of this work is to assess the structural reliability of the blanket by applying the proposed multiphysics-multiscale design methodology. The multiphysics aspect of the design is demonstrated via coupling of Computational Fluid Dynamics (CFD), heat transfer and solid mechanics. 3D CFD simulations are directly coupled with thermal analysis to precisely determine forced heat transfer rates from the first wall tubes, especially because they are single-sided heated and contain bends. Heat transfer analysis in the fluid is coupled with heat transfer in the solid, together with linear elastic stress analysis based on the ITER Structural Design Criteria for In-Vessel Components (ISDC-IC). The framework extends the ISDC-IC rules to progressively incorporate continuum plasticity models in two steps. The first step is based on approximate approaches avoiding performing expensive plasticity calculations by post-processing the data obtained from elastic analysis. The second step is a global-local elasto-plastic analysis within the multiscale framework. We also introduce advanced fracture mechanics concepts based on development of a Materials-Specific Failure Assessment Diagram (MS-FAD), in which precise calculations of the J-integral of an elasto-plastic material is required. This is especially important for the water-cooled design because of the limited fracture toughness of Eurofer 97 below 300 °C. The results indicate that the FW/ Blanket structure of the WCLL DEMO is safe for operational conditions up to a FW heat flux of approximate 0.7 MW/m$^2$.

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