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P4.128 Locally adapted heat transfer using variable height rib structures for Optimization of HCPB DEMO FW cooling channels

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Several European First Wall (FW)/blanket concepts for DEMO are high-pressure (8 MPa) Helium-cooled systems. Typical radiative steady state loads delivered from the fusion plasma are predicted up to $0.45MW/m^2$, but peak values could reach and excess $1MW/m^2$. At such high heat fluxes, it is a major engineering challenge to dimension the cooling for moderate temperatures and moderate stresses, while limiting the coolant pumping power. Ribs promoting turbulence and secondary flows in the coolant have already been identified by experiments and Computational Fluid Dynamics as effective measure to increase to heat transfer coefficients by about factor two, with only a moderate penalty on increased pumping power

In a previous publication, a design point capable to sustain heat flux densities of $1MW/m^2$ at an average shell temperature lower than 500 ℃ has been found by running thermal-mechanical simulations for a FW channel segment, with correlations to describe heat transfer and pressure drop. In this paper, we apply hybrid RANS/LES methods at high Reynolds numbers to predict the detailed temperature distribution in the structures. The FW channel is a two-side heated (breeder side and plasma side), one-side rib-roughened FW channel with rounded corners. Local heat transfer tuning like increasing the heat transfer coefficient along the channel should economize the pressure drop. Therefore this paper deals with the investigation of upstream 60° V-shaped ribs elements with squared cross section with a rib-pitch-to-rib-height-ratio of 10 and a rib-height-to-hydraulic-diameter-ratio in the range of 0.072. The heat transfer coefficients for promising configurations and the pressure drops compared to smooth channels are identified. Strategies in order to reduce the mesh count and its subsequent impact on the accuracy of the solution are assed in order to bring down computing time down considerably to be able to calculate a complete first wall channel.

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