EFFECTS OF THE STREAMWISE EXTENT OF PERIODIC COMPUTATIONAL DOMAINS ON TURBULENT FLOW AND HEAT TRANSFER IN RIB-ROUGHENED COOLING CHANNELS

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Periodic boundary conditions in streamwise direction are commonly applied for scale-resolving numerical simulations of turbulent flow and heat transfer in cooling channels structured with periodically repeated rib-turbulators, as an approach to approximate fully developed conditions with limited computational effort. The number of rib-pitch sections defines the streamwise extent of the periodic computational domain. To evaluate the effect of the streamwise extent on integral values and turbulence statistics of the flow in cooling channels rib-roughened by attached and detached V-shaped ribs, Large-Eddy-Simulations (LES) were performed for a computational domain of a rib-roughened channel with one, three and five rib-pitch sections. The Reynolds number was $Re = 5.0 \times 10^4$. The square channel was structured by attached as well as fully detached 60° upward directed V-shaped ribs on the (single) heated channel wall. The rib-height-to-hydraulic-diameter ratio was $e/D_h = 0.1$, the rib-pitch-to-rib-height ratio was $p/e = 9$ and the gap-height-to-rib-height ratio for the detached ribs was $c/e = 1.0$. The results showed that friction factor and Nusselt number differed slightly for varying periodic computational domain sizes. Little differences were observed for the mean velocity profiles and the mean temperature distributions, whereas the Reynolds stresses and Reynolds heat flux showed the same trends but varied locally. The longitudinal autocovariance functions determined from two-point correlation showed that different turbulent mechanisms characterize the turbulent channel flow. Depending on the rib configuration, the length scales of the large turbulent flow structures and their anisotropy at different channel regions were resolved with periodic computational domains of three or five rib-pitch section.

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