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Investigation of RANS Model Deficiencies for Flow and Heat Transfer Simulations in a Pin-Fin Array[1] ZENGRONG HAO, CATHERINE GORLE, Stanford University, CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT TEAM — Quantifying turbulence model-form uncertainties of Reynolds-averaged Navier-Stokes (RANS) models is a challenging topic, largely because model inaccuracies can vary greatly across flow regions. The objective of the present study is to gain knowledge on where and how RANS models violate reality in representative heat exchanger geometries, such that a UQ method for use in optimization studies can be developed. To achieve this objective we performed a large-eddy simulation (LES) of the flow and heat transfer for a pin-fin array, and analyzed where RANS fails to predict the key features. The LES results are validated against experimental data available from Ames et al. (J. Turbo., 2005) and Ames and Dvorak (J. Turbo., 2006). The RANS simulations showed significant deviations from the LES for mean velocity profiles downstream of certain pins and for the Nusselt number distribution on the fins. A detailed comparison of the turbulent quantities illustrates a general underestimation of the Reynolds stresses and turbulent heat fluxes in near-fin regions, and incorrect trends in some pin-wake regions near the channel center plane. Based on this analysis, we draw conclusions that will support the development of a turbulence model UQ method for heat exchangers.

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