Analytical determination of louvered-fin heat exchanger thermal performance in relation with the air flow statistics

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Fins-and-tubes heat exchangers, particularly the louvered-fin heat exchangers are used in automotive applications due to their high heat transfer efficiency, their lightness and compactness and their low cost. Previous works on louvered-fin exchangers show that their thermal performance depends strongly on fin-spacing, tube pitch, louver angle and the operating conditions in the primary and secondary fluids such as mass flow rates and inlet temperatures. However, for a given internal geometry of a louvered-fin heat exchanger and fixed operating conditions, it has been shown that the topology of the cooling air flow has greater effect on heat-exchanger thermal performance than that of the cooled flow (in tube flow). In other words, louvered-fin heat exchangers cooled by two different upstream velocity distributions of the same flow rate do not have the same exchanged heat. Indeed, when integrated in complex-geometry environments (for instance in the vehicle underhood), a louvered-fin heat exchanger is always subject to a non-uniform upstream flow velocity distributions. These non-uniformities reduce heat-exchanger thermal performance from that of a uniform velocity distribution of the same flow rate. Little research has focused explicitly on the relation between non-uniformities in the upstream flow velocity field and louvered-fin heat exchanger performance.

The present work concerns analytical formulations of heat-exchanger performance as a function of the topology of the cooling fluid flow upstream of the heat-exchanger surface. These formulations are compared to numerical results obtained with a two-dimensional computation code developed by the authors. The analytical and numerical results show satisfactory agreement: the mean relative error in heat exchanger thermal performance determined by the numerical computation and the analytical approach is about 0.5%.