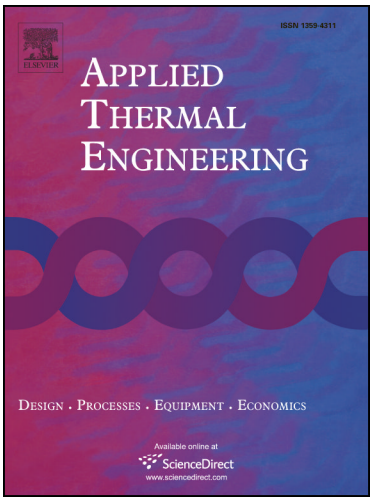

Research Paper

Correcting energy balance error in heat exchanger data by maximum likelihood method

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Correcting energy balance error in heat exchanger data by maximum likelihood method

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Abstract

In this paper, the uncertainty propagation during the heat exchanger performance data analysis is examined through Monte Carlo simulations. Using the simulation tool, different methods for averaging redundant heat transfer rate measurements for heat exchangers are compared in terms of the uncertainty propagation. When compared to the popular arithmetic mean method, it is found that the weighted linear averaging method is superior for minimizing the uncertainty of the average heat transfer rate, but not necessarily resulting in a minimized uncertainty for the overall performance characteristic (i.e. UA). Also, it is found that the calculated UA values from UA-LMTD method and effectiveness-NTU method are not exactly the same when there is an energy balance error in the redundant heat transfer rates. These issues are caused by the underlying discrepancies in the measured variables during the data reduction. In the present work, a full reconciliation of all measured variables is proposed which makes adjustments to not only heat transfer rates but also other underlying measurements such as mass flow rates and temperatures. The amounts of corrections to individual variables are determined by straightforward formulas derived from a constrained, weighted least squares method. From Monte Carlo simulations, these corrections to variables are confirmed to be the most likely errors with given uncertainties and observed energy balance error. The proposed method consistently yields a minimum uncertainty for both heat transfer rate and UA, and it also produces identical results from UA-LMTD and effectiveness-NTU methods. Using sample data for an air conditioning heat exchanger, the advantage of the proposed method is demonstrated.

Keywords: heat exchanger, experimental uncertainty, Monte Carlo simulation, maximum likelihood

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