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Artificial Neural Networks Application on Nusselt Number and Pressure Drop Prediction in Triangular Corrugated Plate Heat Exchanger

Authors : Hany Elsaid Fawaz Abdallah

Abstract : This study presents a new artificial neural network(ANN) model to predict the Nusselt Number and pressure drop for the turbulent flow in a triangular corrugated plate heat exchanger for forced air and turbulent water flow. An experimental investigation was performed to create a new dataset for the Nusselt Number and pressure drop values in the following range of dimensionless parameters: The plate corrugation angles (from 0° to 60°), the Reynolds number (from 10000 to 40000), pitch to height ratio (from 1 to 4), and Prandtl number (from 0.7 to 200). Based on the ANN performance graph, the three-layer structure with {12-8-6} hidden neurons has been chosen. The training procedure includes back-propagation with the biases and weight adjustment, the evaluation of the loss function for the training and validation dataset and feed-forward propagation of the input parameters. The linear function was used at the output layer as the activation function, while for the hidden layers, the rectified linear unit activation function was utilized. In order to accelerate the ANN training, the loss function minimization may be achieved by the adaptive moment estimation algorithm (ADAM). The ‘‘MinMax’’ normalization approach was utilized to avoid the increase in the training time due to drastic differences in the loss function gradients with respect to the values of weights. Since the test dataset is not being used for the ANN training, a cross-validation technique is applied to the ANN network using the new data. Such procedure was repeated until loss function convergence was achieved or for 4000 epochs with a batch size of 200 points. The program code was written in Python 3.0 using open-source ANN libraries such as Scikit learn, TensorFlow and Keras libraries. The mean average percent error values of 9.4% for the Nusselt number and 8.2% for pressure drop for the ANN model have been achieved. Therefore, higher accuracy compared to the generalized correlations was achieved. The performance validation of the obtained model was based on a comparison of predicted data with the experimental results yielding excellent accuracy.

Keywords : artificial neural networks, corrugated channel, heat transfer enhancement, Nusselt number, pressure drop, generalized correlations
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