An artificial neural network-based automated identification system for selection of appropriate turbulence model for numerical simulation of tube thermal enhancement using nanofluids

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Abstract

The choice of appropriate turbulence model for numerical simulation of tube thermal enhancement using nanofluids by the means computational fluid dynamics (CFD) remains crucial since turbulence models contribute to numerical errors, and minimizing these errors is highly desirable for ensuring maximum accuracy of the simulated results. This selection process, however, via CFD is significantly time-consuming, computationally expensive, problematic and requires tremendous efforts. The difficulty is further augmented when a large range of input variables are involved in the process. Despite the availability of machine learning assisted CFD in recent years, till date, no convenient technique exists to facilitate the choice of turbulence models for simulation of nanofluids tube thermal enhancement with maximum accuracy. As the first stepping stone toward rectifying the

issue, this work—via employment of a classification modeling-based surrogate model using artificial neural networks (ANN)—develops an automated system for identifying the most appropriate turbulence model for heat transfer enhancement simulation of tube flows with nanofluids, in order to ensure optimal results of numerical simulation. Three versions of the k-ε turbulence model coupled with the multiphase mixture model—which by far remain as the most heavily used turbulence and flow models—were considered for a wide range of nanofluid configurations and degree of turbulences. The statistical analysis of results shows that the classifier with optimal ANN architecture can detect the most suitable turbulence model for each nanofluid configuration and degree of turbulence with validation and testing accuracies of 94% and 93.55%, respectively. Additionally, it exhibits exceptional discriminatory ability, high robustness and reliable efficiency for both seen and unseen sets of data.

Author keywords

Artificial neural networks; Classification; Nanofluids; Tube thermal enhancement; Turbulence model detection

Indexed keywords

Engineering controlled terms

Automation; Computational fluid dynamics; Heat transfer; Learning systems; Numerical models; Thermal modeling; Tubes (components)

Engineering uncontrolled terms

Automated identification systems; Computational fluid; Fluid-dynamics; Maximum accuracies; Nanofluids; Network-based; Neural-networks; Thermal enhancement; Tube thermal enhancement; Turbulence model detection

Engineering main heading

Classification (of information); Nanofluidics; Neural networks; Turbulence models

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