Artificial neural network for numerical uncertainty quantification of water-al2o3 nanofluids heat transfer enhancement simulation using CFD multiphase mixture model

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Abstract

Simulating nanofluids heat transfer enhancement using numerical methods like Computational Fluid Dynamics (CFD) is a popular practice. Whereas it's known that errors play an important role in numerical simulations and quantification of errors is extremely crucial for further proceedings using

CFD, even after having a generated set of results, deducing errors for the interpolated points is very difficult due to the erratic and non-linear nature of CFD errors. And estimating these errors by numerical simulation is highly time consuming, computationally expensive, strenuous and problematic especially when a large range of input variables are involved. The soft computing techniques hold the potential to solve this issue. Even though these techniques were considered for estimating few nanofluid parameters previously, their employment for numerical uncertainty prediction in the domain of nanofluids heat transfer enhancement is still left unstudied. In this study, Artificial Neural Network (ANN) has been employed for predicting the numerical error of water-Al_2O_3 nanofluids heat transfer enhancement simulation using the very reliable CFD multiphase Mixture model. The results show that along with determining the nature of numerical errors hence identifying the overestimation and underestimation of heat transfer enhancement by the CFD model perfectly, ANN can efficiently predict the CFD discrepancies with Mean Squared Error values of $1.12230*10^{-3}$ and $1.32714*10^{-3}$ for training and testing data, respectively, and with correlation coefficient value of 1. Also, the model is able to forecast CFD discrepancies when deployed on a completely unseen set of data with Root Mean Squared Error, Predicted Residual Error Sum of Squares and Absolute Relative Deviation of 0.1151, 0.8472, and 2.7472%, respectively.

Author keywords

ANN; heat transfer; mixture; nanofluids; uncertainty quantification

Indexed keywords

Engineering controlled terms

Alumina; Aluminum oxide; Computational fluid dynamics; Errors; Forecasting; Heat transfer coefficients; Mean square error; Nanofluidics; Numerical methods; Numerical models; Soft computing; Uncertainty analysis

Engineering uncontrolled terms

Dynamic error; Heat Transfer enhancement; Input variables; Interpolated points; Multiphase mixture model; Nanofluids; Non linear; Numerical errors; Numerical uncertainty; Uncertainty quantifications

Engineering main heading

Neural networks

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