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A review of artificial neural network approach for modelling of heat exchanger with different baffle segment configurations

Sanjay Sharma
sanjay7june@gmail.com
Patel College of Science and Technology, Bhopal, Madhya Pradesh

Amit Kumar
amitavit689@gmail.com
Patel College of Science and Technology, Bhopal, Madhya Pradesh

ABSTRACT

Development of computer-based algorithms for various heat transfer applications is emerging as a successful tool in the field of thermal engineering. Artificial intelligence algorithms used in this field are simple models of human intelligence and evolutionary experience. The methods used for such analysis include using fundamental equations, employing conventional correlations, or developing unique designs from experimental data through trial and error. Also, the heat transfer problems are becoming increasingly more complex and that the need for modelling single steady phenomena requires dealing with dynamics, system performance, optimization, and control. To overcome this difficulty, a simple artificial neural network (ANN) method has been implemented in various heat transfer studies based on databases available from experimentation. This work provides an overview of the literature on the works carried out in the analysis of Heat Exchangers, Shell and Tube Heat Exchanger, Compact Heat Exchangers and emergence of ANN simulation for thermal systems which are relevant for present studies.

Keywords— *Shell and tube heat exchanger, Feed forward, Artificial neural network*

1. INTRODUCTION

ANN has been successfully employed for various heat transfer applications like solar energy, the design of a steam generating plant, estimation of heating loads of buildings, prediction of air flows in a naturally ventilated test room, waste heat recovery heat exchangers, gas-solid fluidized beds as modelling and thermal process analysis [1].

The advantage of using ANN to simulate thermal processes is that, once they are trained, they represent a quick and reliable way of predicting their performance. The ANN modelling includes numerous advantages, such as accurate approximations of complex problems, greater efficiency than phenomenological models even for multiple response computations, and greater effectiveness even with incomplete and noisy input data [2]. ANN does not need a definition of correlations and iterative method; it needs only input/output samples for training a special neural network, in turn, obtaining output results as test samples fed into trained network [3].

The models using first principles are obtained by deductive process whereas the tendency of human being to learn any activity for a particular action/reaction process is by an inductive process which goes on reducing the errors or increasing the accuracy and efficiency of an activity. The empirical models and correlations developed by conventional methods are complex in nature, difficult to predict non-linear relationship, less accurate, and require long computing time. ANN can provide a platform for solving such thermal processes with a quick and reliable way of predicting their performance. The changes in the system can also be continuously updated easily. Neural network (NN) has the ability to learn highly non-linear relationship which processes information by its dynamic system response to external inputs [4].

2. REVIEW OF PAST RESEARCH

N. Mohana Sundaram et al (2016) considered four different neural networks namely Elman Recurrent Neural Networks (ERNN), Time Delay Neural Networks (TDNN), Cascade Feed Forward Neural Networks (CFFNN) and Feed Forward Neural Networks (FFNN) are modelled for the prediction of the outlet liquid temperature of a saturated steam heat exchanger from its liquid flow rate. A benchmark dataset consisting of 4000 tuples is used to train, validate and test the performance of each neural network model.

L.V. Kamble et al (2014) reviewed the effective utilization of artificial neural network (ANN) modeling in various heat transfer applications like steady and dynamic thermal problems, heat exchangers, gas-solid fluidized beds etc. It is not always feasible to deal with many critical problems in thermal engineering by the use of traditional analysis such as fundamental equations, conventional correlations or developing unique designs from experimental data through trial and error. Implementation of ANN tool with different techniques and structures shows that there is a good agreement in the results obtained by ANN and experimental data. The purpose of the present review is to point out the recent advances in ANN and its successful implementation in dealing with a variety of important heat transfer problems. Based on the literature it is observed that the feed-forward network with back propagation technique implemented successfully in many heat transfer studies.

Singh et al. (2011) compared the performances of three training functions (TRAINBR, TRAINCGB, and TRAINCGF) used for training NN for predicting the value of the specific heat capacity of working fluid, LiBr-H2O, used in vapour absorption refrigeration system. The parameters used for the comparison was on the basis of percentage relative error, the coefficient of multiple determination, RMSE and sum of the square due to error. The inputs parameters are vapour quality and temperature and one output parameter selected was specific heat capacity. Training was continued up till the least value of mean square error (MSE) at the definite value of epochs which was represented. Based on the results by performance parameters it was found that TRAINBR function showed better performance as compared to the other two training functions.

Hisham Hassan Jasim (2013) applied Artificial Neural Network for heat transfer analysis of shell-and-tube heat exchangers widely used in power plants and refineries. The commonly used Back Propagation (BP) algorithm was used to train and test networks by divided the data to three samples (training, validation and testing data) to give more approach data with the actual case. Inputs of the neural network include inlet water temperature, inlet air temperature and mass flow rate of air. Two outputs (exit water temperature to the cooling tower and exit air temperature to the second stage of an air compressor) were taken in ANN. 150 sets of data were generated in different days by the reference heat exchanger model to training the network. Regression between desired target and prediction ANN output for training, validation, testing, and all samples show reasonably values are equal to one (R=1). 50 sets of data were generated to test the network and compare between desired and predicated exit temperature (water temp. and air temp.) show a good agreement.

Govind Maheshwari (2018) evaluated the performance of parallel flow heat exchanger using artificial neural networks (ANNs). Experiments are conducted based on the full factorial design of experiments to develop a model using the parameters such as temperatures, capacity ratio and a constant value of optimum NTU. ANN model for efficiency, entropy generation number and overall heat transfer coefficient multiplied with an area of a theoretical/clean heat exchanger is developed using a feed forward back propagation neural network and trained. The developed model is validated and tested by comparing the results with the experimental results. This model is used to assess the performance of the heat exchanger with the real/fouled system. It supports the system to improve the performance by asset utilization, energy efficient and cost reduction in terms of production loss.

3. CONCLUSIONS

This related review concludes the successful implementation of ANN in difficult and complex heat transfer problems in the field of energy systems, heat exchangers, and gas-solid fluidized beds, along with the authors own study of ANN implementation in gas-solid fluidized bed heat transfer. The basic structure and methodology of ANN implementation are discussed in general.

The ANN modelling is explained in basic heat transfer areas in the steady state and dynamic thermal modelling in general heat transfer applications. ANN results are shown in terms of accuracy and flexibility in its use, and also their computational and experimental validations. Thermal engineering analysis requires tedious equations and correlations to develop to satisfy the fundamental principles of the physical system which can be analysed in a simple manner by implementing the ANN approach.

The study shows that analysis with less and noisy input data and even non-linear relationship behaviour can be properly fitted in ANN modelling. It is one of the easy ways to implement with multiple response computations and complex thermal systems. Based on the results achieved by researchers in their analysis, it can be concluded that the BP algorithm is the powerful learning algorithm with feed-forward structure in many heat transfer applications. These models provide a better prediction with reduced standard and mean deviations.

The regression value of R=1 obtained in training the network in many cases and in other some cases this value ranged from 0.899 to 0.999, strongly support that the network predictions are found to be in good agreement with the experimentally observed values. Once the ANN model trained for a particular thermal process, a reliable and quick response is possible even we can continue the updating these models for the changes in the system.

4. REFERENCES

[1] L.V. Kamble, D.R. Pangavhane, T.P. Singh (2014), Heat Transfer Studies using Artificial Neural Network - A Review, International Energy Journal. 14, 25-42.
[2] Kwang-Tzu Yang (2008), Artificial Neural Networks (ANNs): A New Paradigm for Thermal Science and Engineering, Journal of Heat Transfer, 130(9), 112-120.
[3] Singh D.V., Maheshwari G, Shrivastav R., Mishra D. K., (2011), Neural network – comparing the performances of the training functions for predicting the value of the specific heat of refrigerant in vapour absorption refrigeration system, International Journal of Computer Applications, 18(4): 1-5.
[4] Gerardo Diaz, Mihir Sen, K.T. Yang, Rodney L. McClain (2001), Dynamic prediction and control of heat exchangers using artificial neural networks, International Journal of Heat and Mass Transfer, 44, 1671-1679.
[5] Ahilan C, Kumanan S, Sivakumaran N (2011), Prediction of Shell and Tube Heat Exchanger Performance using Artificial Neural Networks, Proceeding of the International Conference on Advanced Computing and Communication Technologies, 307-312.

[6] Hisham Hassan Jasim (2013), Estimated Outlet Temperatures in Shell-and-Tube Heat Exchanger Using Artificial Neural Network Approach Based on Practical Data, Al-Khwarizmi Engineering Journal, 9(2), 12- 20.
[7] Govind Maheshwari (2018), To Evaluate the Performance of Heat Exchanger through Artificial Neural Networks Approach, International Journal Of Core Engineering & Management, 5(3), 21-31.
[8] A.A Shrikant (2016), CFD simulation study of shell and tube heat exchangers with different baffle segment configurations, Applied Thermal Engineering, 1-29.
[9] Nader Jamali Soufi Amlashi (2013), Nonlinear System Identification of Laboratory Heat Exchanger Using Artificial Neural Network Model, International Journal of Electrical and Computer Engineering, 3(1), 118-128.
[10] Mahdi Jalili Kharaajoo (2004), Neural network based predictive control of a heat exchanger nonlinear process. Journal of Electrical and Electronics Engineering 4:1219–1226.
[11] A.R. Moghadassi (2011), An Expert Model For The Shell And Tube Heat Exchangers Analysis By Artificial Neural Networks, ARPN Journal of Engineering and Applied Sciences, 6(9), 78-93.
[12] M.Thirumarimurugan (2009), Simulation Studies on Plate Type Heat Exchanger using ANN, International Journal of ChemTech Research, 1(2), 349-354.
[13] Anurag Kumraa, Nikhil Rawal, Pijush Samui (2013), Prediction of heat transfer rate of a Wire-on-Tube type heat exchanger: An Artificial Intelligence approach, International Conference on Design and Manufacturing, ICONDM 2013, 11-22.
[14] Tan C.K., Ward J., Wilcox S.J., Payne R., 2009. Artificial neural network modeling of the thermal performance of a compact heat exchanger. Applied Thermal Engineering 29: 3609-3617.
[15] Sahoo A. and G.K. Roy. 2007. An artificial neural network approach to segregation characteristic of binary homogeneous mixtures in promoted gas-solid fluidized beds. Journal of Powder Technology 171 (1): 54-62.
[16] Shah R.K., 1985. Compact Heat Exchangers. Handbook of Heat Transfer Applications, 2nd ed., W. M. Rohsenow, J. P. Hartnett, and E. N. Garnic, eds., McGraw-Hill, New York, NY, pp. 4-174–4-312.

