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Short Communication

Prediction of the heat transfer rate of a single layer wire-on-tube type heat exchanger using ANFIS

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ABSTRACT

In this paper, we applied an Adaptive Neuro-Fuzzy Inference System (ANFIS) model for prediction of the heat transfer rate of the wire-on-tube type heat exchanger. Limited experimental data was used for training and testing ANFIS configuration with the help of hybrid learning algorithm consisting of backpropagation and least-squares estimation. The predicted values are found to be in good agreement with the actual values from the experiments with mean relative error less than 2.55%. Also, we compared the proposed ANFIS model to an ANN approach. Results show that the ANFIS model has more accuracy in comparison to ANN approach. Therefore, we can use ANFIS model to predict the performances of thermal systems in engineering applications, such as modeling heat exchangers for heat transfer analysis.

Prévision du transfert de chaleur dans un échangeur de chaleur á serpentin monocouche á l'aide d'une méthode fondée sur la logique floue et des réseaux neuronaux (ANFIS)

Mots clés : Échangeur de chaleur ; Tube aileté ; Modélisation ; Transfert de chaleur ; Réseau neuronal ; Logique floue

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Nomenclature

A	Heat transfer surface area (m^2)
D	Diameter (m)
G	Volumetric flow rate (m^3/s)
L	Length (m)
$\dot{m}$	Mass flow rate (kg/h)
q	Heat transfer rate (W)
S	Spacing (m^2)
T	Temperature (°C)
W	Width (m)

Subscripts

a	air
cond	condensation
i	inlet
r	refrigerant
T	Sum of tube and wire
t	tube
w	wire
H	Hoke's correlation

1. Introduction

A heat exchanger is a specialized device that assists in the transfer of heat from one fluid to the other. Common appliances containing a heat exchanger include air conditioners, refrigerators, and space heaters. One of these devices is wire-on-tube type heat exchanger which has probably been the most widely used condenser in small refrigerant system (Lee et al., 2001).

Since the experimental research studies are difficult and time consuming, the computational intelligence techniques can be used for modeling the wire-on-tube type heat exchanger with high accuracy. With this model, we can analyze the effect of each geometrical parameter such as wire diameter, tube diameter, wire and tube lengths, etc. on heat transfer rate of the wire-on-tube type heat exchanger for designing purposes without need to repeat experimental studies.

The Computational Intelligence (CI) techniques, such as Artificial Neural Networks (ANNs), Fuzzy Logic (FL) and ANFIS have been successfully applied in many scientific researches and engineering practices.

ANN and ANFIS are widely used in various areas of heat transfer analysis and performance prediction researches, For example, Xie et al. (2007) presented a neural network methodology for heat transfer analysis of shell-and-tube heat exchangers with segmental baffles or continuous helical baffles. Ermis et al. (2007) used ANN for heat transfer analysis of phase change process in a finned-tube thermal energy storage system. Yigit and Ertunc (2006) predicted the air temperature and humidity at the outlet of a wire-on-tube type heat exchanger by using neural networks. Varol et al. (2008) presented an ANFIS model to predict temperature and flow field due to buoyancy-induced heat transfer in a partially heated right-angle triangular enclosure. Varol et al. (2007) compared the predicted results of flow and temperature field in a triangular enclosure due to natural convection with ANFIS and ANN.

In this paper, an ANFIS model based on the backpropagation algorithm was developed to determine heat transfer rate of the wire-on-tube type heat exchanger. For training the ANFIS model, we used experimental data evaluated by Lee et al. (2001) from the tests of single layer of wire-on-tube type heat exchanger. Finally, we compared the proposed ANFIS model to an ANN model presented by Islamoglu (2003). The results demonstrate that ANFIS can be easily used to predict the performances of thermal systems in engineering applications, especially for modeling heat exchangers for heat transfer analysis.

2. Materials and methods

The single layer of wire-on-tube type heat exchanger used by Lee et al. (2001) and Islamoglu (2003) is presented in Fig. 1. As far as, air flow in wire-on-tube type heat exchanger is concerned, it can be classified into the following three categories based on how each part contacts air flow:

- All cross (AC): the air passes through both the tubes and the wires.
- Wire cross (WC): the air passes through the wires, whereas it passes along the tubes.
- Tube cross (TC): the air passes through the tubes, whereas it passes along the wires.

The experiments were conducted for single layer sample of wire-on-tube type heat exchanger. Test conditions and results are given in Table 1.

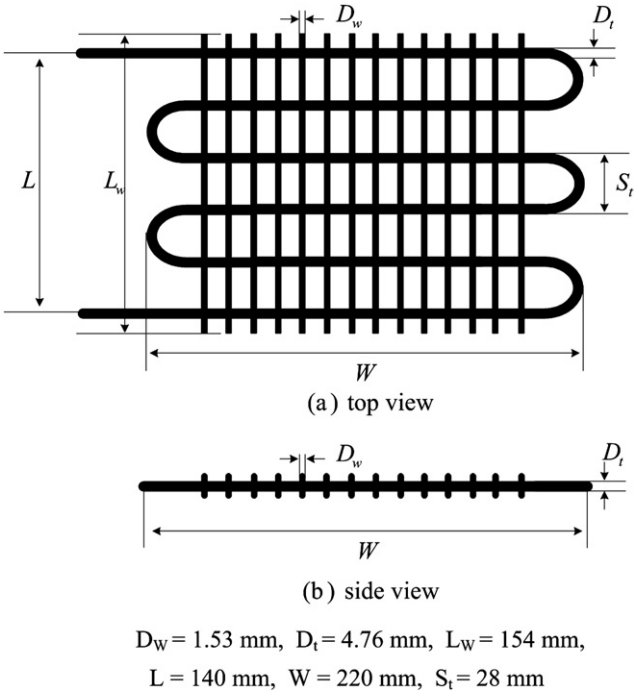

Fig. 1 – The single layer of wire-on-tube sample.