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Prediction of thermal performance of unidirectional flow porous bed solar air heater with optimal training function using Artificial Neural Network

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Abstract

In the present work, Artificial Neural Network (ANN) has been used to predict the thermal performance of unidirectional flow porous bed solar air heater. The ANN model was structured on the basis of data sets obtained from experiments and values of thermal efficiency of solar air heater. Four types of training functions are used in ANN model for training process with feed forward learning procedure. The aim of this work is to examine the performance and comparison of four training functions (TRAINCGP, TRAINSCG, TRAINLM and TRAINOSS) applied in training process of neural model. A comparison was based on the RMSE and R^2. It was found that training function TRAINLM exhibits optimal result with the experimental data.

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Keywords: Artificial neural network; Solar air heater; Porous bed; Training function

1. Introduction

The most reliable source of renewable energy is solar energy that can be used in solar systems. A solar air heater is a type of heat exchanger which absorbs the solar radiations and transfers the absorbed thermal energy to the air

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Nomenclature

A_c	area of collector surface (m^2)
a_i	input data
b_j	bias
C_p	specific heat of air ($J\ kg^{-1}K^{-1}$)
I	solar intensity (W/m^2)
LM	Levenberg–Marquardt
m_f	mass flow rate of air ($kg\ s^{-1}$)
MSE	mean square error
MLP	multi-layered perceptron
$RMSE$	root mean square error
R	correlation coefficient
R^2	coefficient of multiple determination
T	temperature K
w_{ij}	weights
X_A	actual value
X_P	predicted value

Greek letters

η_{th}	thermal efficiency of collector

Subscripts

a	ambient air
fi	inlet air
fo	outlet air

flowing through it [1, 2]. The heated air is used for space heating, crop drying and various low temperature heating applications. In packed or porous bed solar air heater the solar radiations penetrate deeply and it gets absorbed proportionally according to the density of packing materials. A porous bed solar air collector has high heat transfer surface area density and hence high heat transfer rate resulting an increased thermal efficiency. Different types of novel designs of packed bed solar air heaters such as slit and expanded aluminium foil matrix, wire screen matrix, glass beads [3-5], etc have been used.

The experimental and thermodynamic analysis of solar air heater is very complicated because of the numerous measurements and heat transfer processes taking place. Analytical computer codes including the solution of complex differential equations are involved in programming algorithms for the estimation of performance of solar air heaters. The solutions of these algorithms are time consuming to obtain accurate predictions. To avoid the complex solutions of these mathematical equations, ANN is used in present study. The ANN model enables the system to read the primary information patterns within a multi-dimensional information network. ANN technique is significantly more popular in engineering fields because of its fast processing speeds and ability to solve complicated problems and equations. In the near past, many researchers have been used ANN to predict the thermal behavior of energy systems, Kalogirou [6, 7] used ANN in renewable energy systems applications, Kalogirou [8] also used ANN technique for predicting the performance parameters of flat plate collector. Kalogirou et al. [9] applied ANN for performance analysis for solar systems. Kurt et al. [14] have used ANN for estimating the parameters of solar cooker. Sozen et al. [11] applied ANN for calculate the thermal performance of solar collectors with flat absorber plate. Caner et al. [12] used ANN for thermal performance analysis of solar air collectors. H. Benli [13] used ANN for estimate the thermal performance of corrugate and trapeze shapes solar air collectors. Kamble et al. [14] used optimal ANN model for estimate the heat transfer analysis from horizontal tube in gas–solid fluidized bed by analysing the performances of different training functions.