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Analysing the Performance of a Flat Plate Solar Collector with Silver/Water Nanofluid Using Artificial Neural Network

Ashly Maria Tomy[a], Nizar Ahammed[b], M S P Subathra[a], Lazarus Godson Asirvatham[b,]*

[a]Department of Electrical and Electronics Engineering, Karunya University, Coimbatore-641114, Tamil Nadu, India
[b]Department of Mechanical Engiineering, Karunya University, Coimbatore-641114, Tamil Nadu, India

Abstract

In the present study performance of flat plate solar collector with silver/water nanofluid is simulated using Artificial Neural Network (ANN). The solar radiation heat flux was varied between 900W/m^2 and 1000W/m^2. The Reynolds number is varied from 5000 to 25000. The effect of radiation heat flux, mass flow rate, and inlet temperature on the heat transfer coefficient, thermal efficiency was analyzed. The ANN results were compared with the experimental results; also by using the ANN the thermal efficiency of flat plate solar collector was predicted up to the Reynolds number of 100000. It was observed from this study that, the ANN results agree well with the experimental results with the deviation less than ±2%.

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Keywords: Flat plate solar collector; Artificial Neural Network (ANN); Solar Radiation Heat flux; Mass flow rate; Heat transfer coefficient.

1. Introduction

In the era of energy crisis, the renewable energy sources and high efficient systems get more attention. The solar radiation is used as a heat source for various applications such as water heating, desalination etc with the help of solar collectors. The main problem faced by these collectors was the inferior absorption properties of conventional fluids used in these collectors. By the incorporation of new class of fluids known as nanofluids[1] which show improved properties over the conventional fluids, these type of collectors can gain importance. The nanofluid is

* Corresponding author. Tel.: +91 422 2614430; fax: +91 422 2615615.
E-mail address: godson@karunya.edu, godasir@yahoo.co.in (Lazarus Godson Asirvatham)

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prepared by suspending nanometer sized high thermal conductivity solid particles of metals, metal oxides etc. in the base fluid[2,3,4].

The researches for heat transfer and efficiency enhancement in solar devices attracts significance nowadays. Alim et al.[5] theoretically analyzed the effect of nanofluids in entropy generation, heat transfer enhancement capabilities and pressure drop of a flat plate solar collector. The nanoparticles Al_2O_3, CuO, SiO_2 and TiO_2 dispersed separately in water with different volume concentrations are used as the heat absorbing medium for laminar flow regime. The results show that the CuO-water nanofluid gives a reduction of 4.34% in entropy generation and a enhancement of 22.15% in convective heat transfer coefficient compared to base fluid. Mahian et al.[6] conducted an analytical study on the performance of Al_2O_3-water nanofluid in a flat plate solar collector. The volume concentration of nanoparticles, with four different particle sizes, including 25, 50, 75, and 100nm varied upto 4%. The results show that with an increase in the volume fraction of nanofluid, the outlet temperature increases. Parvin et al.[7] investigated the performance of direct absorption solar collector in terms of heat transfer, efficiency and entropy generation with Cu-water nanofluid in forced convection flow regime. The results show that both the mean Nusselt number and entropy generation increase as the volume fraction of Cu nanoparticles and Reynolds number increase.

The simulation of a solar device using an analytical method saves time and cost of experimentation; without sacrificing the accuracy. The artificial neural network (ANN) is better, easier and more accurate method to simulate the performance parameters to generate the result using the MATLAB software. The back propagation learning algorithm in the artificial neural network is widely used for solving various classifications and forecasting problems [8]. Vaferi et al.[9] presents the best artificial neural network (ANN) model for convective heat transfer coefficient of nanofluids flowing through a circular tube for different flow regimes. Caner et al.[10] designed ANN model to estimate thermal performances of solar air collectors.

The above literature reviews show that the nanofluid enhances the absorption properties of fluids and thereby increases the efficiency of the solar collectors. It also shows that the artificial neural networking is a better method to predict and optimize the performance of any thermal system.

In the present paper, the artificial neural network (ANN) is used to simulate the performance parameters of flat plate solar collector and the results are compared with the experimental results. Furthermore, the various results which couldn't find out by the experimental setup are predicted.

2. Experimental analysis

The experimental investigation carried out in the flat plate solar collector with silver-water nanofluid to study the heat transfer performance and efficiency is taken as the reference[11] for comparison with the predicted results by the artificial neural network. The schematic of the experimental test set up is shown in Fig. 1(a). The main components of the experimental test set up are the flat plate solar collector, heat exchanger, coolant tank, liquid pump, flow meter etc. A bypass valve is provided in the circuit to avoid the pressure in the pump at lower mass flow rate. The K type thermocouples with an uncertainty of $\pm 1^oC$ are provided at various relevant points to measure the temperatures. The pressure sensors are provided at the inlet and outlet of the flat plate solar collector to measure the pressure drop along the collector. A pyranometer is used along with the collector to measure the incident radiation on it.

The distilled water and silver-water nanofluids with volume concentration of 0.01%, 0.03%, and 0.04% are used as the heat absorbing medium in the collector. The estimated solar radiation heat flux varied from $900W/m^2$ to $1000W/m^2$. The experimentation is conducted for 180 minutes each. The performance parameters selected are outlet temperatures, solar radiation heat flux, mass flow rate, Reynolds number.

The experimental results show that the outlet temperature of the liquid increase with addition of nanoparticles in the base fluid. The results also show that the efficiency of the flat plate solar collector increases with increase in the mass flow rate or Reynolds number and volume concentration.