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Generating hot water by solar energy and application of neural network

Cuma Cetiner, Fethi Halici, Hamit Cacur, Imdat Taymaz *

Department of Mechanical Engineering, Sakarya University, Esentepe Campus, 54187 Adapazari, Turkey

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Abstract

Solar technology already boasts a century of research and development, requires no toxic fuel and relatively little maintenance, is inexhaustible and with adequate financial support, is capable of becoming directly competitive with conventional technologies in many fields. These attributes make solar energy one of the most promising sources for many current and future energy needs.

In this study, an experimental solar hot water generator, consisting of a cylindrical concentrator, an absorber, a heat exchanger, a water store, a pump and a control unit has been constructed and tested in order to establish the thermodynamic efficiency of the system.

Experimental data were obtained and used to train an artificial neural network in order to implement a mapping between easily measurable features such as environmental conditions, input and output water temperatures, solar radiation and flow rate of hot water.

Keywords: Hot water generation; Solar energy; Neural-network

* Corresponding author. Tel: +90 264 346 0353; fax: +90 264 346 0351.
E-mail address: taymaz@sakarya.edu.tr (I. Taymaz).

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Nomenclature

a	real value
A_c	surface area of the reflecting mirror (m^2)
A_r	absorber surface area (m^2)
C	concentration ratio
c_p	constant pressure specific heat of the water (kJ/kg K)
I_{dr}	direct radiation (W/m^2)
$\dot{m}$	mass flow rate (kg/s)
ME	mean square error
MRE	mean relative error
p	predicted value
$T_{r\text{-in}}$	inlet temperature of water (°C)
$T_{r\text{-out}}$	outlet temperature of water (°C)
ηd	thermal efficiency of the system

1. Introduction

After the energy crises of the 1970s and the subsequent increases in the cost of petroleum-based fuels, interest in active solar energy systems surged. Increasing of energy needs and decreasing of the fossil based energy sources, accelerates the researches for the alternative energy resources. Thousands of systems were installed from the late 1970s through middle 1980s. Alternative energy resources are far less polluting than traditional fuels, although they may have other drawbacks. The great feature of solar energy is the fact that it is likely to continue to exist so far into the future that we can think of it as being unending. Sunlight can be concentrated by solar collectors. For many applications it is desirable to deliver energy at temperatures higher than those possible with flat-plate collectors. Energy delivery temperatures can be increased by decreasing the area from which heat losses occur. Many designs have been set forth for concentrating collectors.

Studies about concentrating collectors sped up in early 1970s by the oil crisis. Thomas and Güven investigated the thermal analysis of the cylindrical and parabolic concentrator and optic errors related to manufacturing [1]. Halici has evaluated the performance of the concentrating collectors having a constant absorber [2]. Odeh and coworkers have produced steam by using synthetic oil as a working fluid in a parabolic type reflector in 1997. The produced steam was used to work a Rankine turbine and its efficiency and thermal loss were calculated [3]. Kalogirou, in his experimental study, has produced steam in a low temperature with a parabolic focuser and worked on the system design and performance characteristics [4]. In these studies the parabolic reflector and absorber in the focus are tracing the sun light in together. In the present study, focus surface is kept fixed, and the cylindrical reflector traces the solar rays.

Solar thermal systems convert sunlight into heat. Flat-plate solar thermal collectors produce heat at relatively low temperatures (27–60 °C), and are generally used to heat air or a liquid for space and water heating or drying agricultural products. Concentrated collectors achieve higher temperatures by using a concentrating reflector to direct sunlight from a large area to a smaller