International Journal of Sustainable Engineering

Country	United Kingdom - SIR Ranking of United Kingdom
Subject Area and Category	Engineering Engineering (miscellaneous)
Publisher	Taylor & Francis
Publication type	Journals
ISSN	19397038
Coverage	2008-ongoing

22

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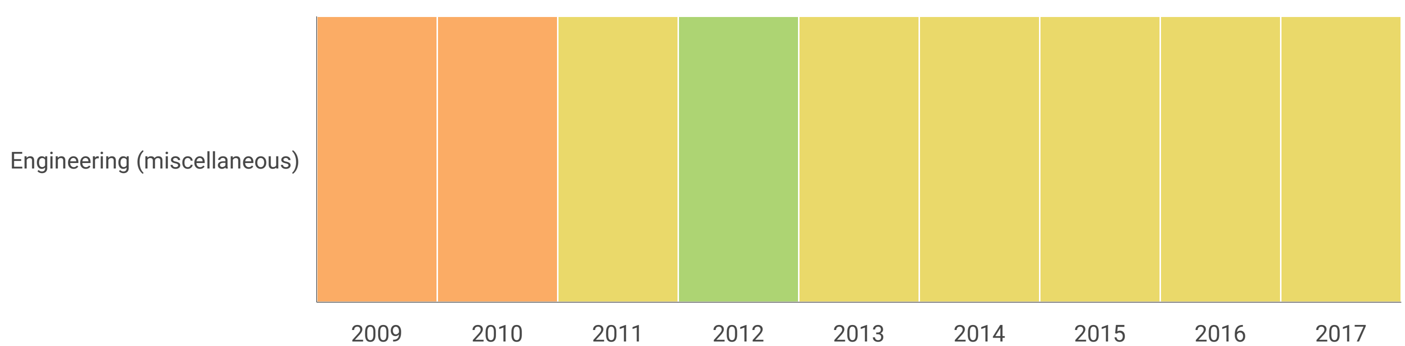

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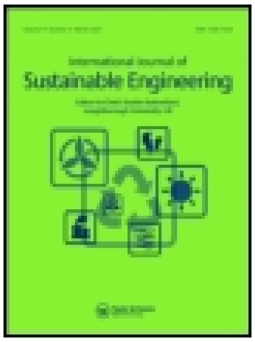

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International Journal of Sustainable Engineering

ISSN: 1939-7038 (Print) 1939-7046 (Online) Journal homepage: http://www.tandfonline.com/loi/tsue20

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INTERNATIONAL JOURNAL OF SUSTAINABLE ENGINEERING, 2017
https://doi.org/10.1080/19397038.2017.1333542

Performance of a hybrid solar collector system in days with stable and less stable radiative regime

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ABSTRACT

The aim of this work is to analyse the performance of a solar energy collector system for water and air heating in real working conditions. Two coupled mathematical models have been developed. One of them describes the thermal behaviour of the Hybrid Solar Collector (HSC) and the second one describes the simultaneous operation of the HSC and of a fully mixed water storage tank. The dependence of the performance of the HSC system on the following three parameters has been studied: (1) water and air mass flow rate; (2) water pipe diameter and air channel height; (3) water storage tank volume. The mathematical models were used to evaluate the HSC system performance during 29 different days, covering all four seasons. A higher water flow rate generally enhances the thermal efficiency of the HSC system, but the enhancement became significantly smaller at higher air flow rates. Positive but small values are recommended for the difference between the fluid temperature at solar collectors exit and the water temperature in the tank. The thermal efficiency of the HSC system is higher on nearly clear sky and decreases in case the amount of clouds on the sky increases.

ARTICLE HISTORY
Received 9 July 2016
Accepted 14 March 2017

KEYWORDS
Hybrid solar collector; water heater; air heater; modelling; thermal efficiency

Introduction

Solar energy is an economical alternative to today's energy demand. There is an increasing interest in solar energy utilisation for different purposes. For instance, hybrid photovoltaic/thermal (PV/T) solar systems have been designed and manufactured. The main advantage of this type of solar system is the simultaneous production of both electricity and hot water/air (e.g. Badescu, Landsberg, and De Vos 1997; Herrando, Markides, and Hellgardt 2014; Herrando and Markides 2016). Also, solar energy can be used for water and air heating. There are many studies concerning solar water heating and solar air heating technologies (Menzies and Roderick 2010).

In any solar water system, the amount of energy required to heat the cold water is dependent on many factors, such as the location and orientation of the solar system, temperatures of the water inlet and outlet and the desired hot water set temperatures (Azad 2012). For instance, Jaisankar, Radhakrishnan, and Sheeba (2009) have been investigated experimentally the efficiency of a thermosyphon flat plate solar collector system where the heat transfer has been enhanced by using tapes with spacers. Different design configurations were studied in that paper. Picón-Núñez, Martínez-Rodríguez, and Fuentes-Silva (2014) have proposed a design solution for networks of solar collectors in order to meet the thermal energy demand and also to keep pressure losses within the acceptable range. Khamis (2013) investigated the effectiveness of a new solar flat plate collector based on minichannels. The performance has been compared with that of several conventional solar collectors (flat-plate, evacuated-tube and heat-pipe collector). For this purpose, the author created a numerical mathematical model which was validated against experimental measurements. He also examined the performance of the new collector for different mass flow rates of the working fluid. A mathematical model consisting of four differential equations that describe the energy balance for the components of a flat-plate solar collector was presented by Hamed, Fellah, and Ben Brahim (2014). The system of equations has been solved by using the Runge–Kutta method under the MATLAB environment. The authors studied the influence of different parameters (working fluid mass flow rate and inlet temperature, number of pipes) on the collector performance. A water heating system composed of a solar collector and a water tank was studied experimentally by Razika et al. (2014). The incident flux of solar energy has been simulated using a high power electric lamp. The dependence of the collector efficiency on the working fluid mass flow rate and collector tilt angle has been analysed. The insulation effects of the solar water heaters have been studied by Andoh et al. (2010) where experiment study was conducted to evaluate the thermal performance of a solar water heater using a vegetable fibre, coconut coir as heat insulation. Hasan (1997) studied the influence of

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Supplemental data for this article can be accessed here. https://doi.org/10.1080/19397038.2017.1333542.