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Transient analysis of a solar domestic hot water system using two different solvers

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Abstract

In the present work the unsteady numerical simulation of a solar domestic hot water (DHW) system composed of two flat plate collectors, a water tank for heat storage, and a coil heat exchanger is addressed. The simulations have been performed using two different solvers, namely a home-made code written in Matlab, and TRNSYS 17. In the first part of the paper, the analytical models used in the Matlab code, and the TRNSYS case are reported in detail. Successively, the results of the simulations realized by means of the two solvers are presented and compared.

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Keywords: analytical models; one-day simulation; experimental input data; home-made solver; TRSNSYS 17

1. Introduction

The use of solar thermal collectors for the production of domestic hot water (DHW) has experienced a considerable worldwide growth in the last years due essentially to its cost effectiveness.

In recent years, several studies have focused on transient mathematical models of solar DHW systems. Among these, the most regarded references for the present work are represented by the papers of Rodriguez-Hidalgo *et al.* [1,2], who developed and validated experimentally a transient model in order to achieve the design criteria of solar

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DHW plants under daily transient conditions.

This paper is focused on the numerical simulation of a solar DHW system composed of two non-concentrating flat plate collectors connected in series, a vertical cylindrical water tank for heat storage, and a coil heat exchanger immersed into the water tank. Fig. 1 shows a sketch of the present system. The numerical simulations of the system performances have been realized using a home-made numerical code written in Matlab, and the commercial software TRNSYS 17. The aim of this work is to present in detail the characteristics of the home-made solver, and to demonstrate its effectiveness in simulating the basic operation of a solar DHW system by comparing its results with those of the TRNSYS solver.

In the first part of the paper, the analytical models, the numerical schemes and algorithms used in the Matlab code, and the TRNSYS case are reported in detail. Successively, the results of the simulations realized by means of the two solvers and using as input data experimental values of the irradiance, ambient temperature and wind velocity are presented and compared.

Nomenclature

A	surface area (m^2)
c_p	specific heat (J kg^{-1} K^{-1})
D	diameter (m)
$\overline{h}$	mean convective heat transfer coefficient (W m^{-2} K^{-1})
INERZIA	thermal inertia (W)
k	thermal conductivity (W m^{-1} K^{-1})
L	thickness (m)
N	number of isothermal nodes
Q	heat power (W)
r	radius (m)
R	thermal resistance (K W^{-1})
T	temperature (K)
t	time (s)
$\dot{V}$	flow rate (m^3 s^{-1})
V	volume (m^3)
v	wind velocity (m s^{-1})
Greek symbols	
ε	emissivity
ρ	density (kg m^{-3})
σ	Stefan-Boltzmann constant (W m^{-2} K^{-4})
Subscript	
abs	absorber plate
absorbed	absorbed heat power
air	ambient air
amb	ambient
box	box back surface of flat plate collector
cd	convective at the collector downwards
cint	convective in the air enclosure of the collector
co	collector
coil	heat exchanger coil
cond	conductive
conv	convective
cup	convective at the collector upwards