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Dynamic modelling and simulation of a new air conditioning prototype by solar energy

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Abstract

This work presents a new design of an air conditioning prototype by solar energy developed at the Laboratory of Electromechanical Systems of the National Engineering School of Sfax, Tunisia. The new conception permits to produce heat or cold by using solar energy without polluting the environment. The installation, composed of four compartments, consists of three functioning modes according to the season of the year and according to the climatic conditions.

A numerical model is developed to study the behaviour of the unit. This model uses real meteorological data to predict the performance of a thermal solar driven system. The dynamic modelling and simulation of only two modes of functioning (winter mode and summer mode without pre-cooling of air) are presented in this paper. This theoretical model is expected to help in predicting the behaviour of the installation in various climatic conditions. Besides, it would enhance the performance of such installation.

Keywords: Air conditioning; Solar energy; Heating; Cooling; Modelling; Numerical simulation

1. Introduction

In a world marked with an intensive use of energy and an excessive demand of electricity, air conditioning remains having the large share of energy consumption. Besides

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Nomenclature

A_c	area of the collector, m^2
C	specific heat, J/(kg K)
F_R	heat removal factor
h_a	air heat transfer coefficient at the air–water interface, $W/(m^2 K)$
h_w	water heat transfer coefficient at the air–water interface, $W/(m^2 K)$
I	flux of incident radiation, W/m^2
$\dot{m}$	fluid flow rate, kg/s
P_{ws}	saturation pressure, Pa s
$\dot{Q}$	rate energy, W
S	solar heat flux, W/m^2
s	air–water exchanger area in the humidifier, m^2/m^3
T	temperature, K
T_a	ambient temperature, K
T_{ci}	collector inlet fluid temperature, K
T_{co}	collector outlet fluid temperature, K
U_L	overall heat loss coefficient, $W/m^2 K$
v_a	mass velocity of humid air, $kg/m^2 s$
v_w	water mass velocity in the humidifier, $kg/m^2 s$
X	air humidity, kg_{water}/kg_{air}
X_I	saturation humidity in the evaporation tower, kg_{water}/kg_{air}

Greek letters

δ_c	control function
ε	volume fraction

Subscripts

1	bottom
2	top
c	collector
f	input environmental air
i	inlet
o	outlet
r	radiator
u	used air
w	water

Figure nomenclature

C	radiator
EC	heat exchanger
F	filter
H	humidifier
SR	sorption rotor
V	fan