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Comparative study of novel solar air heater with and without latent energy storage

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A R T I C L E I N F O

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A B S T R A C T

Two numerical models are accomplished to predict thermal effectiveness of a novel solar heater with and without paraffin-based on the latent heat storage. The conservation equations with enthalpy transforming method of phase change material (PCM) are analyzed using finite-volume with an explicit scheme. The influence of the main parameters is investigated such as; airflow rate ranging of kg/min, and heat flux ranging of ($625 \le I_s \le 825$) W/m^2. The results found that the air temperature rise is proportionate to the airflow rate inversely, during the charge/discharge processes. It was concluded that the useful power and the thermal performance are significantly depended upon the solar flux with airflow rate in both models. Moreover, the thermal effectiveness of the collector without and with paraffin was approximately (33.8 – 73.15)%, and (31.3 – 66.77)%, respectively, under the range of the studied parameters. It was noted that the decreased thermal efficiency is (5–7)% with PCM by absorbing the stored energy and releasing it to the system during sunset. To verify the accuracy of experimental and numerical results under the same operating conditions with a mean error of effectiveness with and without PCM was identified of ± 6.4% and ± 8.6%, respectively, and the results were acceptable.

Nomenclature

D_h	Equivalent diameter of channel (m)
W	Width of collector (m)
G	Generation source(kg.m/s^3)
H	The channel height (m)
h	Coefficient-heat convection (W/m^2.°C)
L	Fusion heat (kJ/kg)
$\bar{q}$	Mean heat source(W/m^3)
k	Conductivity (W/m.K)
T	Temperature (°C)
V, and W	Velocity in (x, y, and y) direction(m/s)
I_s	Heat flux intensity (W/m^2)
Q_{ua}	Useful power (W)
Q_{loss}	Lost power (W)
Q_{mech}	Mechnical power (W)

Greek letters

$\dot{m}_a$	Airflow speed (kg/min)
ε	Rate of dissipation of turbulence model
τ	time (s)
ν	Kinematics viscosity (m^2/s)
Δt	time change (s)
Δp	pressure drop (Pa)
η_{eff}	thermal effectiveness

Subscripts

f1	The air flowing in the first channel
f2	The air flowing in the second channel
a	air
e	effective
g	glazing plate
up	upper-absorber surface
lp	lower-absorber surface
bp	back plate surface
pcm	paraffin wax-PCM
o	out
i	in

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