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Performance analysis of a double-pass photovoltaic/thermal (PV/T) solar collector with CPC and fins

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Abstract

The use of PV/T in combination with concentrating reflectors has a potential to significantly increase power production from a given solar cell area. A prototype double-pass photovoltaic-thermal solar air collector with CPC and fins has been designed and fabricated and its performance over a range of operating conditions was studied. The absorber of the hybrid photovoltaic/thermal (PV/T) collector under investigation consists of an array of solar cells for generating electricity, compound parabolic concentrator (CPC) to increase the radiation intensity falling on the solar cells and fins attached to the back side of the absorber plate to improve heat transfer to the flowing air. Energy balance equations have been developed for the various nodes of the system. Both thermal and electrical performance of the collector are presented and discussed.

Keywords: Photovoltaic-thermal (PV/T); Solar collector; CPC; Fin

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Nomenclature

A	Surface area (m^2)
C	Specific heat ($J\,kg^{-1}\,K^{-1}$)
d	Gap loss correction
h	Heat transfer coefficient ($Wm^{-2}\,K^{-1}$)
h_f	Fin height (m)
k_f	Thermal conductivity of the fin
L	Collector length (m)
m°	Mass flow rate ($kg\,s^{-1}\ m^{-2}$)
Nu	Nusselt number
P	Solar cell packing factor
Re	Reynolds number
S	Solar irradiance (Wm^{-2})
T	Temperature (°K)
U	Heat loss coefficient ($Wm^{-2}\,K^{-1}$)
w_f	Fin thickness (m)
W	Collector width (m)
Subscripts	
ab(T)	Top absorber surface
ab(B)	Bottom absorber surface
a	Ambient
B	Beam radiation
bp	Back plate
c	Convective
D	Diffuse radiation
f1	Working fluid (air) at first channel
f2	Working fluid (air) at second channel
r	Radiative
R	Reflector
S	Solar cell
tot	Total
g	Glass cover
p	Absorber plate
Greek letters	
α	Absorptivity
η	Efficiency
τ	Transmitivity
ε	Emissivity
θ	Acceptance half-angle
ρ	Reflectivity