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Thermal and electrical analysis of a linear parabolic CPVT system

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Abstract. Thermal and electrical analysis of a linear parabolic concentrated photovoltaic/thermal hybrid solar collector (CPVT) was studied in this article. The energy balance equations were written for different parts of the CPVT collector. A non-linear algebraic equations system was derived for determining the temperature of the photovoltaic module, solar collector, the metallic layer and outlet fluid. Because of the presence of electrical efficiency in the energy balance's equation, the thermal analysis of PVT collector is dependent on the electrical analysis. The four-parametric current-voltage model was employed for electrical analysis. The CPVT system's equations were solved by numerical methods. The result of this simulation had a good conformity with the previous studies. The effect of different operational and design parameters on the electrical and thermal performances was also investigated.

Keywords: thermal efficiency; electrical efficiency; linear parabolic; photovoltaic/thermal collector

1. Introduction

Depletion of fossil fuel reserves and the harmful environmental impacts of their combustion products have convinced scientists to find alternative energy resources for sustainable and safe future in the context of energy and preventing energy crisis (Dincer and Rosen 1995). Renewable energy sources such as solar, wind, biomass, and geothermal can provide sustainable energy carriers via conversional facilities like reactors, turbines and photovoltaic panels (Najjar 2013, Granovskii *et al.* 2007). Solar energy is one of these resources developed dramatically within the last decade. Solar energy can be used for direct electricity generation by Photovoltaic panels (PVs) or for heating by solar collectors (SCs) (Tyagi *et al.* 2012). As of the end of 2014, 177 GW PV systems have been installed all over the world and only in 2014, 37.8 GW have been installed in the world. In addition, the amount of solar water heating collectors installed globally have been grown from 240 GW_{th} in 2010 to 406 GW_{th} in 2015 (IEA 2014). One of the new technologies for using solar energy is thermal photovoltaic (PVT) which basically combines the functions of a solar collector and a photovoltaic panel for both heating and electricity generation (Devabhaktuni *et al.* 2013). Electricity generation and heating are performed simultaneously in this system and the working fluid cools the PV module to increase its efficiency (Chow 2010, Zondag 2008).

Although the main idea of PVT has been proposed for 40 years, this technology is not

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ρ	Density [Kg/m^3]
ρ_{PVT}	PVT reflectance
σ	Stephan-Boltzmann constant
ϑ	Angle of incidence [Degree]
μ	Viscosity [Kg/m/s]
η_{PV}	PV efficiency
η_{opt}	Optical efficiency
η_{th}	Thermal Efficiency
η_{el}	Electrical efficiency

Subscripts

amb	Ambient
ap	Aperture
b	Beam
c,Cell	Cell, module
Conc	Concentrator
D	Diode
el	Electrical
f	Fluid
Hex	Heat exchanger
in	Inlet
mp	Maximum power
oc	Open circuit
out	Outlet
PVT	Photovoltaic/Thermal
rec	Receiver
ref	Reference condition
s	Series
sc	Short circuit
sky	Sky
sub	Substrate
top	Top surface
tot	Total
t	tube
th	Thermal