Enhanced Transient Modeling of Hybrid Photovoltaic Air (PVT) Module

R. Kiflemariam[1], M. Almaz[1], F. Zevallos[1], C. Lin[1]

[1]Department of Mechanical & Materials Engineering, Florida International University, Miami, FL, USA

Abstract

Introduction
Solar photovoltaic/thermal units which are also known as Hybrid photovoltaic/thermal (PV/T or PVT) solar units are systems that could simultaneously produce solar photovoltaic and thermal energy. The Photovoltaic(PV) cells produce electricity from the solar electromagnetic radiation and the solar thermal collectors absorb the heat energy from the sun making use of the remaining energy and at the same time cooling the PV module. The removal of the waste heat from the PV cells increases the efficiency of the cells.

Use of COMSOL Multiphysics® software

There are some previous studies which applied COMSOL Multiphysics® software to model PVT modules. Kalogirou et al studied the air cooled building integrated PV panel using time dependent partial differential equations in COMSOL [1]. Fontenault and Miravete presented a 2D steady state COMSOL model for water cooled combined photovoltaic-thermal solar panel[2]

In this paper, the performance of a hybrid photovoltaic-thermal model is evaluated by utilizing COMSOL Multiphysics software and the results are validated against experimental data by Joshi et al [3]. The current 2D model attempts to capture major system and environmental variables which are usually time dependent.The solar irradiance and ambient temperature are varied throughout the day based on the environmental data. In the experiments [3], the inlet water temperature and velocity was recorded and they fluctuate with time. Thus, the input boundary condition are varied to simulate a more realistic boundary conditions instead of constant boundary conditions which are mostly used to simplify the numerical modeling. For the external convection heat transfer coefficient, the values are also written as an equation which varies with the wind velocity at each step time. In addition, the efficiency of the PV panels are also affected by temperature, thus the conversion efficiency of PV panels is also varied dynamically at each time step using the temperature information from the running steps. The general heat transfer and fluid flow is modeled using conjugate heat transfer module in COMSOL in conjunction with functions and equation modeling capabilities of COMSOL Multiphysics.

Results
The model has simulated the variation of solar cell temperature, back cell temperature and out let

temperature very well as compared to experimental data. Thus it is a useful tool that can be applied in parametric and performance analysis of PVT designs

Reference

References
[1] S.A. Kalogirou, L. Aresti, P. Christodoulides, G. Florides, The Effect of Air Flow on a Building Integrated PV-panel, IUTAM Symp. Nonlinear Interfacial Wave Phenom. Micro-Macro-Scale. 11 (2014) 89–97. doi:10.1016/j.piutam.2014.01.051.
[2] B. Fontenault, E. Gutierrez-Miravete, Modeling a Combined Photovoltaic-Thermal Solar Panel, in: Proc. 2012 COMSOL Conf. Boston, n.d.
[3] A.S. Joshi, A. Tiwari, G.N. Tiwari, I. Dincer, B.V. Reddy, Performance evaluation of a hybrid photovoltaic thermal (PV/T) (glass-to-glass) system, Int. J. Therm. Sci. 48 (2009) 154–164. doi:10.1016/j.ijthermalsci.2008.05.001.

Figures used in the abstract

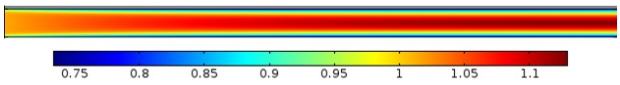

Figure 1: Velocity of air inside the duct.

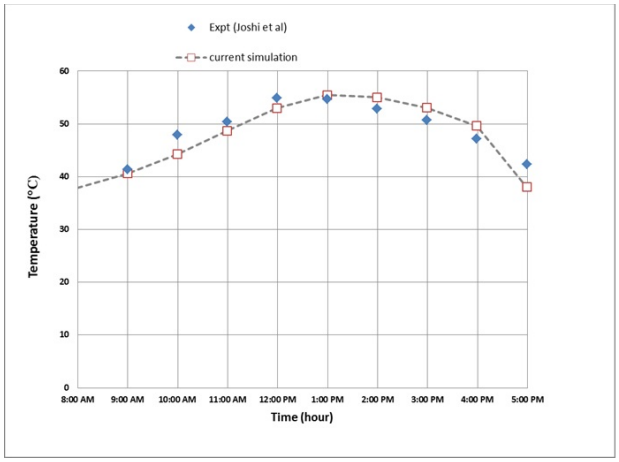

Figure 2: Comparison of experimental and numerical solar cell temperature.