Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 141 (2017) 61–65

Energy Procedia

www.elsevier.com/locate/procedia

4th International Conference on Power and Energy Systems Engineering, CPESE 2017, 25-29 September 2017, Berlin, Germany

Performance enhancement of the concentrated photovoltaic using different phase change material configurations

Ramy Rabie[a] , Hamdy Hassan[a,b], Shinichi Ookawara[c], Mahmoud Ahmed[a,b,*]

[a]*Department of Energy Recourses Engineering, Egypt-Japan University of Science and Technology (E-JUST), Egypt*
[b]*Department of Mechanical Engineering, Assiut University, assiut 71516, Egypt*
[c]*Department of Chemical Science and Engineering, Tokyo Institute of Technology, Tokyo, Japan*

Abstract

Concentrator photovoltaic (CPV) systems are used to generate electrical power with a relatively lower cost per KWh .Because of high solar concentration, the cell temperature increases rabidly, and accordingly an efficient cooling method is needed. Therefore, the use of intensive cooling with PCM can reduce the cell temperature and enhance the system performance. The disadvantage of using this technique is that a hot spot appears at the top of CPV system due to the high-temperature gradient. Therefore, the main objective of the current work is to overcome such problem by first, adding a bulk of PCM at the top of the regular configuration and second changing the PCM tank configuration to a parallelogram shape. The performance of the CPV system with the developed configuration of PCM is investigated numerically. Results indicate that a significant reduction of hot spot temperature of about 9 ºC is attained using the new configurations.

Keywords: Solar cell, Photovoltaic, Phase Change Material, Cooling, Numerical, Concentrated photovoltaics.

1. Introduction

Solar energy is a major energy resource for the production of electricity. Unfortunately, it has some drawbacks of requiring large areas and high capital costs per kWh. Therefore, researches have been directed to concentrated photovoltaics that offer lower capital cost per kWh by using curved mirrors or Fresnel lenses[1]. Only about 20% of

* Corresponding author. Tel.: +20-1008370279.
E-mail address: mahmoud.ahmed @ejust.edu.eg

10.1016/j.egypro.2017.11.012

the solar radiation is transformed to electricity while the rest is released as heat. That heat deceases the efficiency of the solar cell. Moreover, when the temperature reaches high value, the cell could be damaged[2].Various cooling techniques are used in order to cool the solar cell such as water cooling,air cooling and Phase Change Material (PCM) cooling. [3]

In the current work, cooling of PV using PCM is used. Many researches have admitted that the integration of PCM with PV is a promising cooling technique as it absorbs a large amount of heat during melting and realizes it during solidification [4], and [5]. Yet, the main barrier of using PCM is its very low thermal conductivity. In order to overcome this problem, many experimental and numerical researches have been conducted. B. Kamikari and H. Shoukohammed studied the effect of adding fins to the PCM tank experimentally and they found that fins enhanced the thermal conductivity of the model, but decreased the natural convection current [6]. Emam [7] numerically investigated tank inclination angles effect on the temperature distribution over PV and reported that an angle of 45^{o} allows the best uniform temperature distribution.

Hot spot area at the top portion of PCM tank has been reported by many researches [5], [7], [8]. The aim of this work is to reduce the effects of this hot spot on the cooling process and to enhance the uniformity of temperature distribution over the cooled surface.

2. Physical model

The schematic diagram of the 2-D model with all dimensions and boundary conditions is illustrated in Fig.1. The PV layers are then shown in Fig.2. These layers are followed by Aluminum sheet of thickness of 3 mm which is used to ensure uniform temperature spreading over the system. Moreover, it affords a high rate of heat transfer to the PCM.

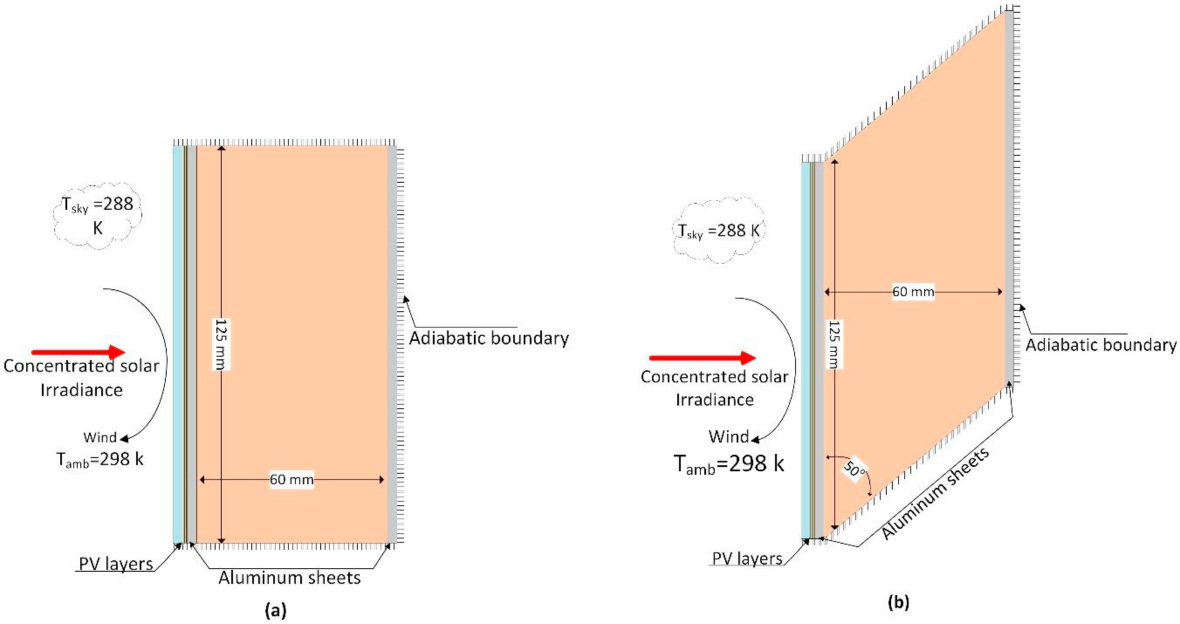

Fig. 1. The configurations used: a) regular rectangular configuration; b) parallelogram with angle 50^{o} configuration

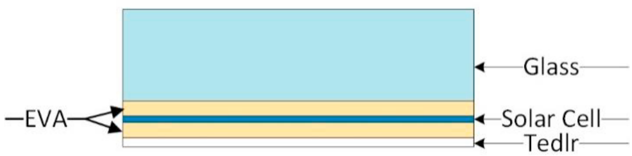

Fig. 2. The PV layers