Amirkabir Journal of Mechanical Engineering

Amirkabir J. Mech. Eng., 50(4) (2018) 1-3
DOI:

Using Polyethylene Glycol, as a Phase Change Material and Fins for the Cooling of Photovoltaic Cells of the Crystalline Type

M. Firoozzadeh[1], A. H. Shiravi [1]*, M. Shafiee[2]

[1] Department of Mechanical Engineering, Jundi-Shapur University of Technology, Dezful, Iran
[2] Department of Chemical Engineering, Jundi-Shapur University of Technology, Dezful, Iran

ABSTRACT: Photovoltaic technology is one of the most popular ways to producing power. In hot days of year, which the maximum irradiation of sun is available, because of the temperature value is high, the efficiency of photovoltaic cells is falls down. In this paper, in order to decrease the temperature of photovoltaic cells, using Polyethylene-Glycol 600 as phase change material, for cooling the photovoltaic panel was studied. Moreover, integrating some fins was investigated too. The panel with phase change material included, in about 80 mins of the end of test, had a same temperature with the conventional panel, as well as panel with both phase change material and fins, at the end of experiment, had a temperature difference of about 9°C compared with conventional panel. Furthermore, the maximum efficiency difference between the panel with phase change material and panel with phase change material + fins, were about 2.4 % and 4.6 %, respectively. This means that fins, due to the increased amount of heat exchange between the panel and phase change material, has been able to play an important role to increasing the efficiency and controlling the temperature of the panel. Finally, for economic and industrial feasibility of the proposed prototypes, the economical estimation is also presented.

Review History:

Received:
Revised:
Accepted:
Available Online:

Keywords:

Phase change material
Photovoltaic
Fin
Economical feasibility

1. Introduction

Nowadays, environmental protection and efforts to reduce the pollution caused by industrial activities on the one hand and researches in order to finding novel and optimal ways to generating energy from the other, have become one of the important concerns of governments around the world. PhotoVoltaic (PV) technology is one of the most global accepted method to producing power. Unfortunately, increasing the temperature of these cells, caused to decrease to their power generation. Different methods are presented to cooling PV cells i.e. Nanofluids [1-3], thermo-electric [4, 5], wind blowing [6], etc. Moreover, using Phase Change Materials (PCMs) is the other common way to absorb the heat of PV cells. Thus, Stritih [7] has carried out both numerical and experimental studies on using RT28HC with melting point of 28°C as PCM behind the panel in order to increasing the efficiency. The results showed that the highest temperature difference between the panels with and without PCM, was up to about 36°C. Sharma [8] used RT40 behind PV panel under constant irradiation of 1000 W/m2. They showed the electrical efficiency increasing of 13.7 %. Vaseline was used as PCM, by Indartono et al. [9].

This study was located in Indonesia country by two identical 10 W panels and the increase of 21.6 % was illustrated. So, in this paper we focused on enhancing the thermal potential of PCM, by using a number of aluminum fins, in order to decreasing the temperature of PV panels. Furthermore, a financial estimation of proposed prototypes is presented.

*Corresponding author's email:Ahshiravi@yahoo.com

2-PCM Selection

Because the temperature of 25°C is known as the best operating temperature for PV panels, PolyEthylene-Glycol 600 (PEG 600) with the melting range of 23-26°C was selected as PCM. PEGs are odorless, non-toxic, colorless, low vapor pressure and have various industrial applications such as application in ceramics, adhesives, dough and paper, electroplating metals, lubricants, agriculture and detergents. The thermo-physical properties of PEG-600 is presented in Table 1.

Table 1. Thermo-physical properties of PEG 600

Melting range (°C)	Density (kg/m^3)	Viscosity (m^2/s)	Latent heat of fusion (kJ/kg)
23-26	1125	10.8	146

3-Experimental Procedure

Three similar 60 Watts polycrystalline PV modules, made by Yingli Solar Company, has been tested in the photovoltaic laboratory of Jundi-shapur University of Technology, Dezful. In order to observe the effect of using PCM and fins, three prototypes were studied as follows:

Prototype 1: Conventional PV panel,

Prototype 2: PV panel with PCM behind it,

Prototype 3: PV panel integrated with both PCM and aluminum fins.

Fig. 1, shows a schematic of prototypes 2 and 3.

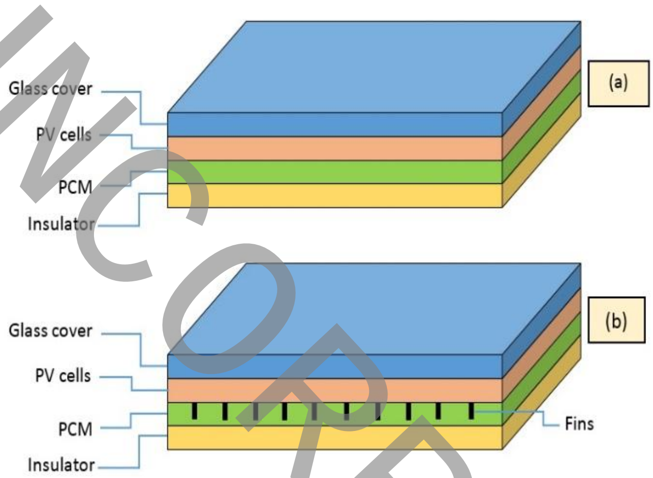

Fig. 1. Schematics of (a) prototype 2 and (b) prototype 3

In prototype 3, the number of 10 longitudinal aluminum fins with the thermal conductivity of 204 W/m.K were used. The mentioned experiment was carried out in an indoor condition which both ambient temperature and irradiation are adjustable with using three identical 1-kW projectors. In this study, temperature and irradiation are fixed on 85°C and 630 W/m2, respectively.

4-Results and Discussion

In this paper, the effect of both PEG-600 as a phase change material and fins, in order to controlling of the temperature of PV panels have been presented. All tests were done for 270 minutes and finally, results were compared together. In order to keep assurance of experimental data, each test was twice performed.

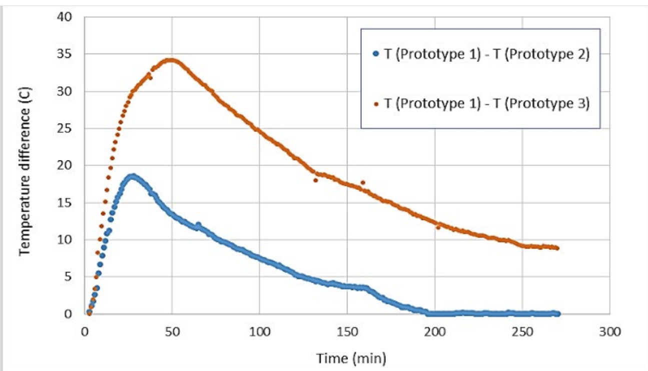

Fig. 2. The variation of (a) Temperature, (b) Efficiency and (c) Power during time.

The variation of temperature, efficiency and power are illustrated in Fig. 2. In this figure, temperature is plotted during time. As expected, during time, the temperature is increased and both efficiency and power are decreased. But the third prototype which is integrated with PCM and fins had less temperature of other prototypes, and this temperature behavior caused to be more efficient.

In order to provide a better mindset of temperature difference between prototype 2 and 3 with prototype 1, Fig. 3 is plotted. This figure reveals that in about 90 minutes of the end of experiment, prototype 2 had the same temperature with prototype 1. Despite, prototype 3 had a temperature difference of about 9°C at the end of test.

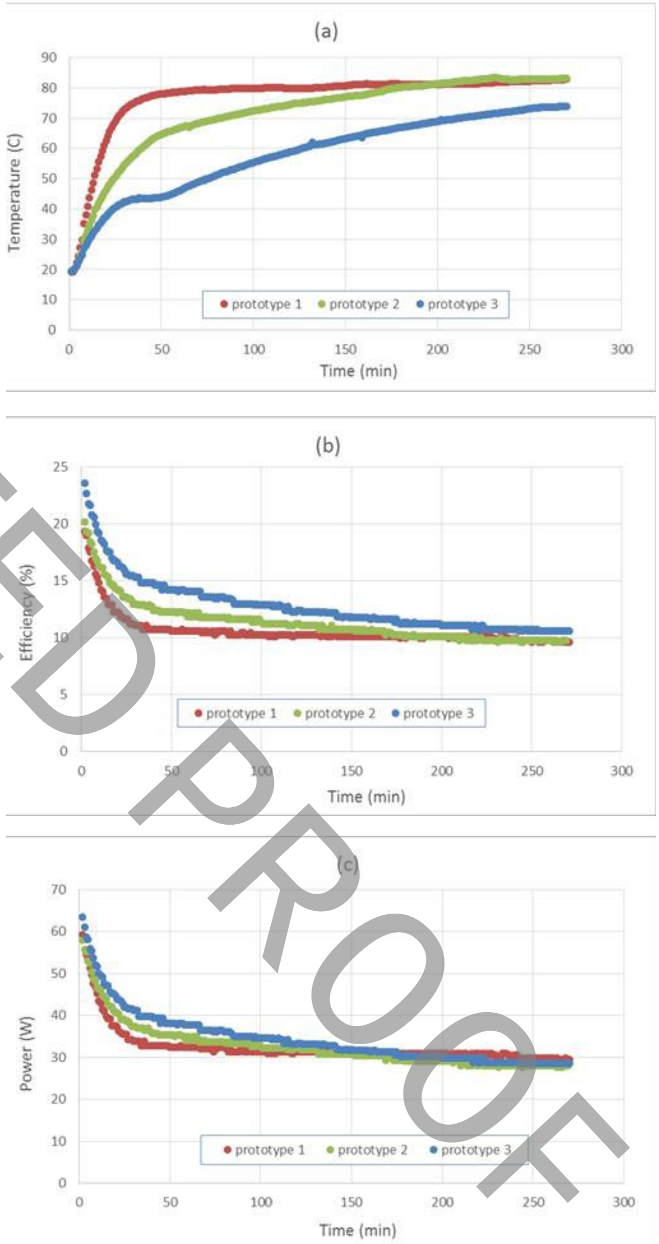

Fig. 3. Temperature difference between prototype 2 and 3 with prototype 1

Finally, the Financial Estimation (F.E.) of proposed cases is presented in Fig. 4. In this figure, the vertical axis is in Iranian Rials (IRR).

The financial estimation, illustrates that prototype 3, has appropriate performance compared with the others.

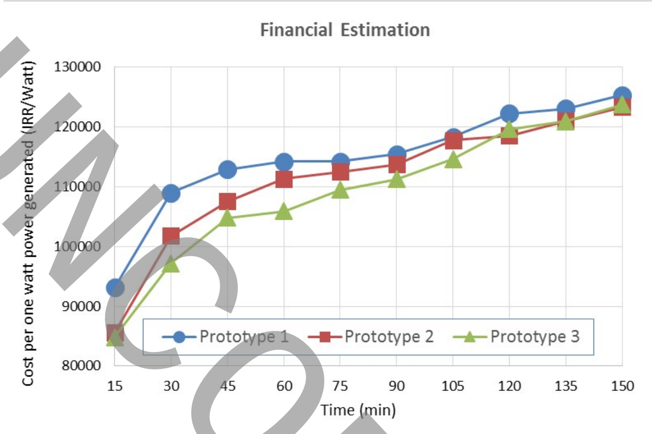

Fig. 4. Financial estimation of proposed prototypes

5-Conclusions

In this paper, experimental and economic analysis of using PEG-600 as PCM and fins were studied. The results showed that prototype 3 has a better performance for controlling the temperature of PV panel. Moreover, the mentioned prototype has a suitable results from the financial view point.

References

[1] M. Firoozzadeh, A.H. Shiravi, M. Shafiee, Experimental Study on Photovoltaic Cooling System Integrated With Carbon Nano Fluid, Journal of Solar Energy Research, 3(4) (2018) 287-292.

[2] M. Ghadiri, M. Sardarabadi, M. Pasandideh-fard, A.J. Moghadam, Experimental investigation of a PVT system performance using nano ferrofluids, Energy Conversion and Management, 103 (2015) 468-476.

[3] M. Hosseinzadeh, M. Sardarabadi, M. Passandideh-Fard, Energy and exergy analysis of nanofluid based photovoltaic thermal system integrated with phase change material, Energy, 147 (2018) 636-647.

[4] A.N. Kane, V. Verma, Performance enhancement of building integrated photovoltaic module using thermoelectric cooling, International Journal of Renewable Energy Research (IJRER), 3(2) (2013) 320-324.

[5] G. Li, X. Chen, Y. Jin, Analysis of the Primary Constraint Conditions of an Efficient Photovoltaic-Thermoelectric Hybrid System, Energies, 10(1) (2017) 20.

[6] J.K. Kaldellis, M. Kapsali, K.A. Kavadias, Temperature and wind speed impact on the efficiency of PV installations. Experience obtained from outdoor measurements in Greece, Renewable Energy, 66 (2014) 612-624.

[7] U. Stritih, Increasing the efficiency of PV panel with the use of PCM, Renewable Energy, 97 (2016) 671-679.

[8] S. Sharma, N. Sellami, A. Tahir, K. Reddy, T.K. Mallick, Enhancing the performance of BICPV systems using phase change materials, in: AIP Conference Proceedings, AIP Publishing, 2015, pp. 110003.

[9] Y.S. Indartono, A. Suwono, F.Y. Pratama, Improving photovoltaics performance by using yellow petroleum jelly as phase change material, International Journal of Low-Carbon Technologies, 11(3) (2016) 333-337.