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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 (PV) technology is one of the most popular methods to produce power. In hot days of the year, when the maximum irradiation of sun is available, the efficiency of PV cells falls down and the cells must be kept cool. In this paper, Polyethylene-Glycol 600 (PEG-600) is used as a phase change material (PCM) is in order to decrease the temperature of PV cells. Moreover, to enhance the heat transfer rate, adding some fins was investigated. The panel equipped with PCM, reached the same temperature as the conventional panel at the last 80 mins of the test, nevertheless, the panel equipped with both PCM and fins, at the end of the experiment, had still about 9°C temperature difference compared with the conventional panel. Furthermore, the maximum efficiency difference between the conventional panel and the one with PCM and the panel with PCM + fins, were about 2.4 % and 4.6 %, respectively. This means that adding fins, plays an important role to increase the efficiency by controlling the cell temperature due to increase the heat exchange between the panel and PCM. Finally, an economical assessment is also presented to verify the industrial feasibility of the proposed prototypes.

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1. Introduction

Nowadays, environmental protection and efforts to reduce the pollution caused by industrial activities on one hand and researches in order to find novel and optimal ways to generate energy from the other hand, have become one of the important concerns of governments all around the world. Photovoltaic (PV) technology is one of the most global accepted method to produce power. However, increasing the temperature of these cells, causes to decrease their power generation. Different methods are offered to cool PV cells e.g. Nanofluids [1-3], thermo-electric [4, 5], wind blowing [6], etc. Moreover, using Phase Change Material (PCM) is another common way to absorb the heat of PV cells.

Stritih [7] carried out both numerical and experimental studies on using RT28HC with melting point of 28°C as PCM behind the panel in order to increase the efficiency. The results showed that the uppermost temperature difference between the panels with and without PCM, was up to 36°C. Sharma et al. [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 by two identical 10 W panels and the increase of 21.6 % in efficiency was illustrated.

In this paper we focused on enhancing the thermal potential of PCM, by using a number of aluminum fins, in order to decrease the temperature of PV panels. Furthermore, a financial assessment 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. PEG-600 is a non-toxic and odorless material and has a wide industrial applications. The thermo-physical properties of PEG-600 are 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-Watt polycrystalline PV modules, made by Yingli Solar Company, have 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,

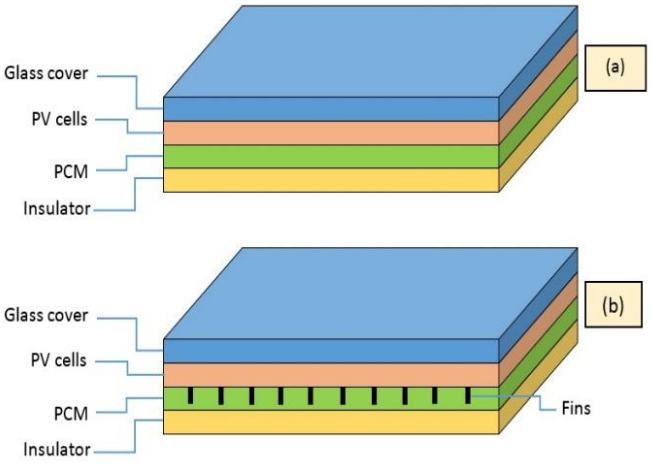

Fig. 1. Schematics of (a) prototype 2 and (b) prototype 3

Prototype 2: PV panel with PCM behind it,
Prototype 3: PV panel integrated with both PCM and aluminum fins.
Figure 1, shows a schematic picture of prototypes 2 and 3.

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

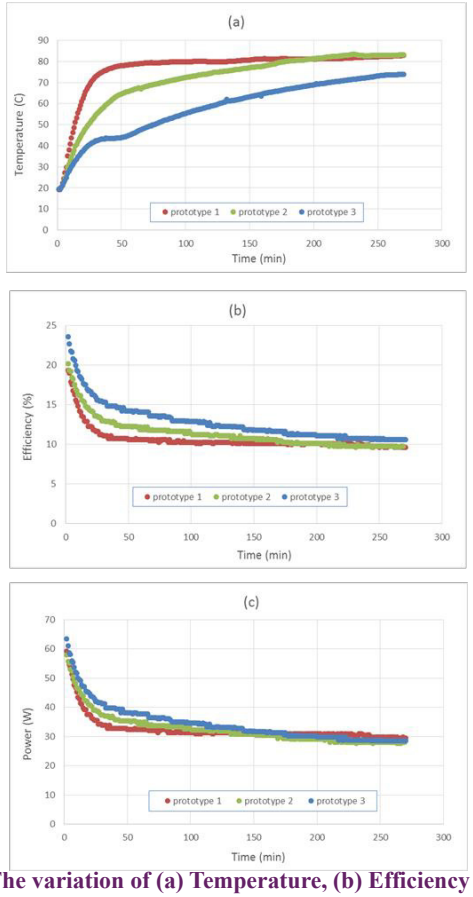

Fig. 2. The variation of (a) Temperature, (b) Efficiency and (c) Power during time.

4-Results and Discussion

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

The variation of temperature, efficiency and power are illustrated in Figure 2. In this figure, temperature is plotted against time. As expected, the cell temperature is increased and both efficiency and power are decreased. However, the temperature of the third prototype which is integrated with PCM and fins is less than the other prototypes, and consequently caused to be more efficient.

In order to provide a better presentation of temperature difference between prototype 2 and 3 with prototype 1, Figure 3 is plotted. This figure reveals that in the last 90 minutes of the experiment, prototype 2 took the same temperature with prototype 1. However, prototype 3 kept a temperature difference of 9°C with two other prototypes at the end of the test.

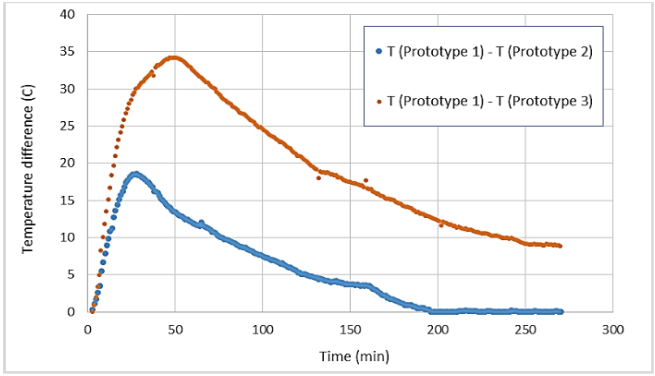

Fig. 3. Temperature difference between prototype 2 and 3 with prototype 1

Finally, the Financial Estimation (F.E.) of proposed cases is presented in Figure 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.

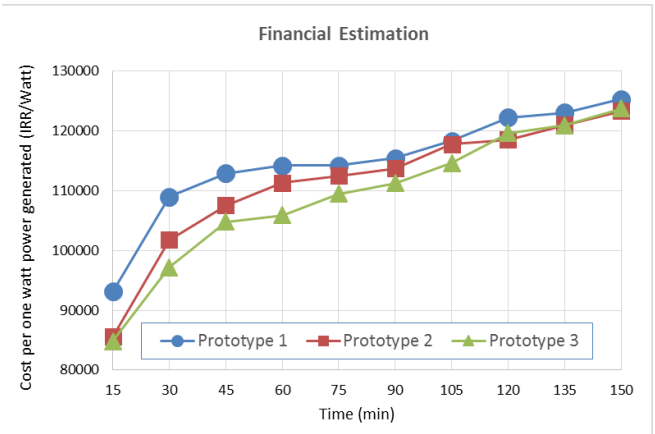

Fig. 4. Financial estimation of proposed prototypes

5-Conclusions

In this paper, experimental and cost analyses 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.

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