*International Journal of Engineering & Technology*, 7 (3.7) (2018) 179-181

International Journal of Engineering & Technology

*Website: www.sciencepubco.com/index.php/IJET*

***Research paper***

# Temperature Compensation of Photovoltaic cell using Phase Change Materials

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## Abstract

The performance of photovoltaic module (PV) situated outdoors suffers from high temperature. When the high temperature of surrounding atmosphere is increased, the generation of electricity power drops rapidly. This paper is concerned with the temperature compensation technique of the cooling PV cell by using the phase change materials (PCMs). PCM used in this research is palm wax with the melting point at 52 °C. We used a stainless steel container that is designed with three types of installation (fin type, groove type and tube type) to cover the surface area for heat exchanger purpose. The heat exchanger is installed at the back of PV cell. The test is conducted for all day (9AM-5PM) under the climatic condition of Khon Kaen, Thailand (latitude, 16° 26’ 20” N and longitude, 102° 49’ 43” E) during winter. It was found that the PV cell that is used PCMs installed container with fin type was able to produce more electric power to an order of 8.178 per cent than the controlled reference module.

***Keywords***: *Photovoltaic cell, Phase change materials*

## 1. Introduction

Today photovoltaic cell (PV cell) used for alternative energy because it is the best performance such as high power and reduce the pollution. The temperature of PV cell over 25 °C, The power drop of 0.65 % /°K [1].

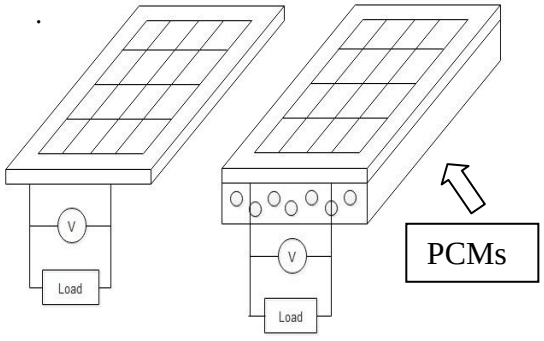
The Researcher are divided type of cooling into 3 types; passive cooling (heat pipe based and fins), active cooling(spraying water and wind) and cooling by phase change material (PCMs) [2]. The passive cooling type used the copper water heat pipe can rejected heat with a total cell to an ambient temperature rise of only 40°C [3]. Active cooling type use the fan for reduce heat and it can increase the peak power up to 7.5% [4]. When water flow over PV Cell, it decreases temperatures up to 22°C [5]. The PCMs used the paraffin wax from natural for reduce heat from PV Cell under climatic condition [6]. The paraffin wax based RT42 was used within an in-house designed and fabricated PCMs containment was found an increase in relative electrical efficiency by 7.7% and an average reduction in module centre temperature by 3.8 °C [7] but the paraffin wax are expensive and low melting point.

This research designed of PCMs container and used palm wax replacement the paraffin wax because the melting point higher than paraffin wax and reduce cost of PCMs.

## 2. Materials and methods

### 2.1 Photovoltaic Cell

Type of photovoltaic cell is poly-crystalline silicon with dimensions of 430x330x25 mm. The maximum power of PV cell is 20 W. PV cell is installed on an easel. It is inclined with an angle of 15 degrees to the horizontal and facing south. The experiment compares reference module (without PCMs container) and test module (with PCMs container) in Figure 1 During experiment, measurement of voltage and surface temperature on PV cell were made. The voltage evaluation of the module was measured using digital multi-meter uni-t® ut 106. The temperature evaluation of the module were recorded using a thermocouple type k model WR 22 in Figure 2 and data logging system was used to collect the temperature profile. The data were then recorded for 8 hours in a day (9AM-5PM) at an interval of 3 minutes.




(a) (b)

**Figure 1:** Measurement of voltage (a) reference module without PCMs container and (b) tested module with PCMs container.

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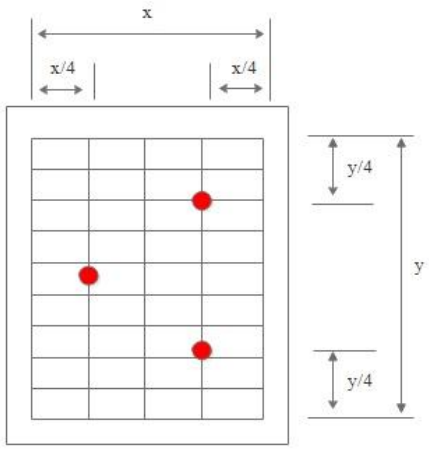
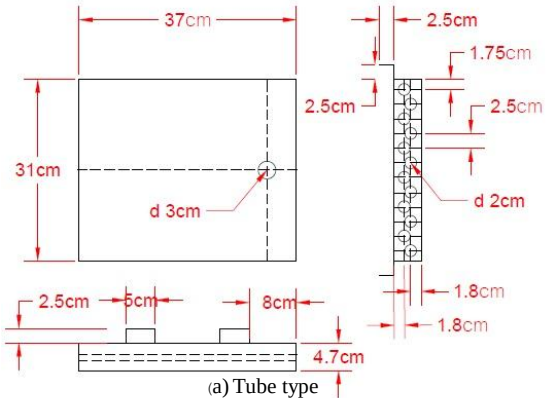


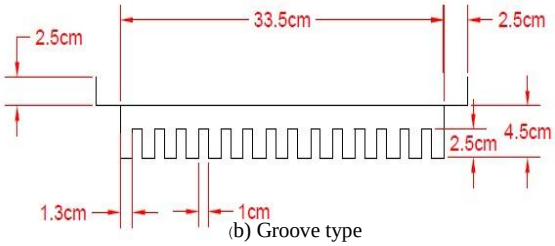

**Figure 2:** Measurement of temperature using thermocouple 3 point.

## 2.2 PCMs Container

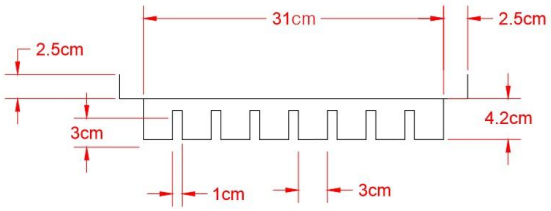
PCMs container designed are 3 types namely; groove, tube, and fin are shown in Figure 3**.** The design of PCMs container is of mass equal. PCMs container was design to the increase the surface area for heat exchanger purpose. The PCMs container tube type was developed using 6 mm thick stainless steel with the dimension of 370**x**310**x**47 mm. It is buried with pipes using the dimension of 20 mm in diameter and 12 pieces with surface area of 2**,**667.48 $cm^2$**.** The PCMs container groove type was developed by using 6 mm thick stainless steel with the dimension of 370**x**310**x**42 mm. The size of the fin width is 30 mm with 8 rows and surface area of 4**,**158.8 $cm^2$**.** The PCMs container fin type was developed by using 6 mm thick stainless steel with the dimension of 370**x**310**x**45 mm. The size of the fin is 13 mm and 15 pieces with the surface area of 5**,**402 $cm^2$**.** PCMs is used in this research is palm wax with melting point of 52 °C.




(a) Tube type




(b) Groove type



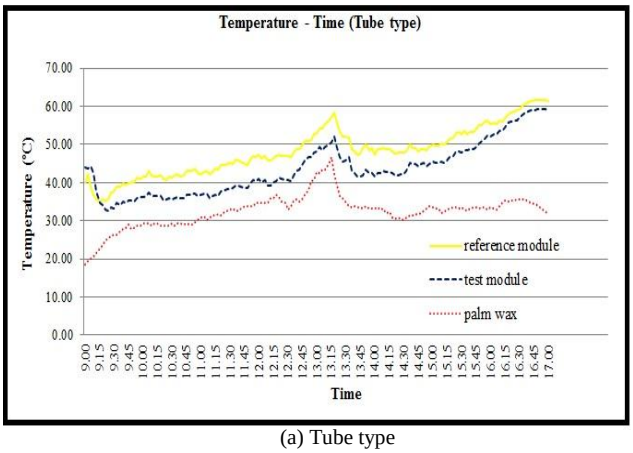

(c) Fin type

**Figure 3:** PCMs container (a) Tube type, (b) Groove type, (c) Fin type

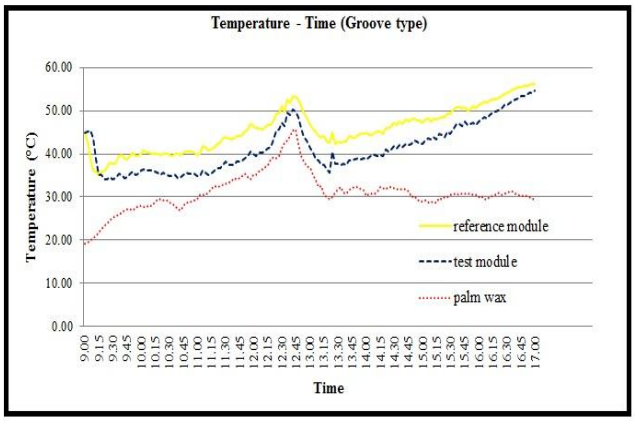
# 3. Results and Discussion

## 3.1 Temperature-Time

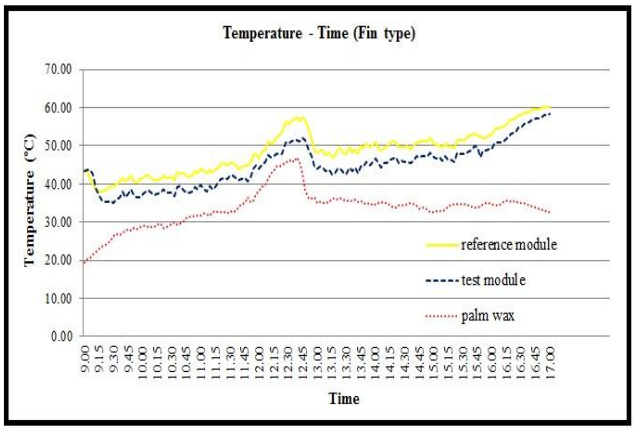
Figure 4a shows a comparison between temperature and time of tube type. Palm wax absorbed temperature from the test module. Its maximum temperature of palm wax is 42.3 °C. Figure 4b shows the comparison between temperature and time of groove type. Palm wax absorbed temperature from the test module. Its maximum temperature of palm wax is 42.20 °C. Figure 4c shows the comparison between temperature and time of fin type. Palm wax absorbed temperature from the test module. Its maximum temperature of palm wax is 45.90 °C. The temperature of PV cell shown in table 2.




(a) Tube type




(b) Groove type




(c) Fin type

**Figure 4**: Comparison between temperature and time (a) type tube (b) type groove (c) type fin.

**Table** 1: Temperature of PV cell

| Type | Electric power (reference module) (W) | Electric power (test module) (W) | ΔP (W) | %P |
|---|---|---|---|---|
| **tube** | 6.716 | 6.962 | 0.246 | 3.657 |
| **groove** | 9.744 | 10.310 | 0.566 | 5.813 |
| **fin** | 4.260 | 4.608 | 0.348 | 8.178 |

### 3.2 Electric Power

Figure 5 shows electric power of the experiment. Power increased of tube type is 3.657%. Power increased of groove type is 5.831%. Power increase of tube type is 8.187%.The generation of electric power is shown in table 2

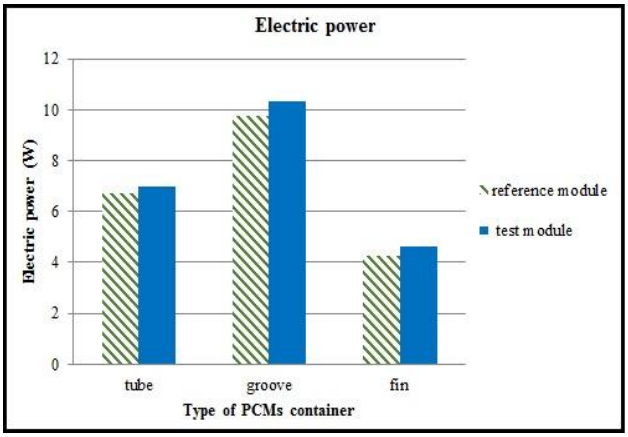



**Figure 5: S**how electric power

**Table** 2: Electric power produced

| Type | Temperature (reference module) (°C) | Temperature (test module) (°C) | ΔT (°C) | %T |
|---|---|---|---|---|
| **tube** | 53.277 | 48.640 | 4.637 | 8.703 |
| **groove** | 48.443 | 44.373 | 4.070 | 8.402 |
| **fin** | 52.343 | 47.107 | 5.237 | 10.004 |

60 g/cm$^3$ density
70 g/cm$^3$ density
80 g/cm$^3$ density

## 4. Conclusion

The design of PCMs container has a major contribution on decreasing temperature of PV cell. PCMs materials will operate with the melting point at 52 °C. Heat conduction of PCMs starts at room temperature until a melting point. The best results of cooling PV were achieved by using PCMs container with fin type, second groove type and finally tube type. As for electricity generation, it was found that the PV cell that is used PCMs container fin type was able to produced more electric power than reference module to an order of 8.178 %

## Acknowledgement

Authors would like to thank you to the Insulation Technology and High Voltage Engineering Laboratory, Department of Electrical Engineering, Khon Kaen University for supported this research. Also and Laboratory in Department of Chemical Engineering, Khon Kaen University for testing all of the specimens in this research, Lastly, Center for Alternative Energy Research and Development, Khon Kaen University.RUN : Research University Network Project ,Granted by RUN – Energy cluster, Thammasat University.

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