Development of a temperature regulated photovoltaic module using phase change material for Malaysian weather condition

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This work represents an effective design of a temperature regulated PV module by integrating phase change materials for Malaysian weather condition. Through the initial experimental setup it has been shown that if a PCM layer of width 0.02 m of (RT 35) is used as a cooling arrangement with a PV module; the surface temperature of the module is reduced by 10°C, which remains constant for a period of 4-6 hours. This reduction of temperature will definitely increase the conversion efficiency of the module. Experiment and analysis has been carried out considering typical Malaysian weather. Finally, obtained result has been included to evaluate the performance of the prototype.

(Received June 16, 2014; accepted November 13, 2014)

Keywords: PV, PCM, Temperature, Efficiency

1. Introduction

The power generation of PV module is highly influenced by the temperature. Typical commercial silicon based cells convert only 10-20% of the incident light into electricity, the rest is transformed into heat, which causes a rise in temperature of the PV module. This elevated operating temperatures are known to reduce the solar to electrical conversion efficiency making temperature a significant factor of consideration. To enhance the efficiency of the PV module it is important to keep the operating temperature as low as possible, preferably at the level of so-called standard test conditions (STC) or 25°C temperature with 1000 W/m^2 irradiation [1-10]. So, the efficient temperature regulation of PV module can increase its efficiency by a significant level. The application of phase change materials (PCM) can be a better solution for this purpose, because phase change materials have a high heat of fusion, they can absorb a lot of energy before melting or solidifying and the temperature remains constant during this phase transition. As a result when PCM is integrated with PV module due to the heat absorption property the temperature of the module will also remain at a constant level for this transition period. Trace of research on this specific field has been found form the last decades especially a number of people from Europe such as from Netherlands and Irelands have done a number of good works. At present a lot of universities around the world doing research on this topic and all them are working based the specific requirements of the environmental conditions of that area. So it is an important issue that, the application of PCM on PV matters need some specific criteria which should be matched with the environmental conditions of that region [6-10]. However, based on this fundamental conception this work has been carried out with an intension to develop an efficient temperature regulated PV system for Malaysian weather condition. By considering Malaysian weather paraffin wax (RT 35) has been chosen as a phase change material.

The organization of the paper is as follows: in section.2 a complete overview of the system has been included with a schematic design; section.3 represents necessary results discussion to analyze the performance of the system followed by a brief conclusion, which has been added to finalize the work.

2. Development of the experimental prototype

The prototype is based on the heat exchange properties between the phase change materials and PV modules. The excessive heat absorbed by the PV module will be transferred to phase change materials. When the temperature of the PV module reach to the melting point of the PCM it will got stacked at that level because of the high heat fusion of the materials.

The development of the experimental proto-type has been carried out according to some sequential steps, which are shown on Fig. 1.

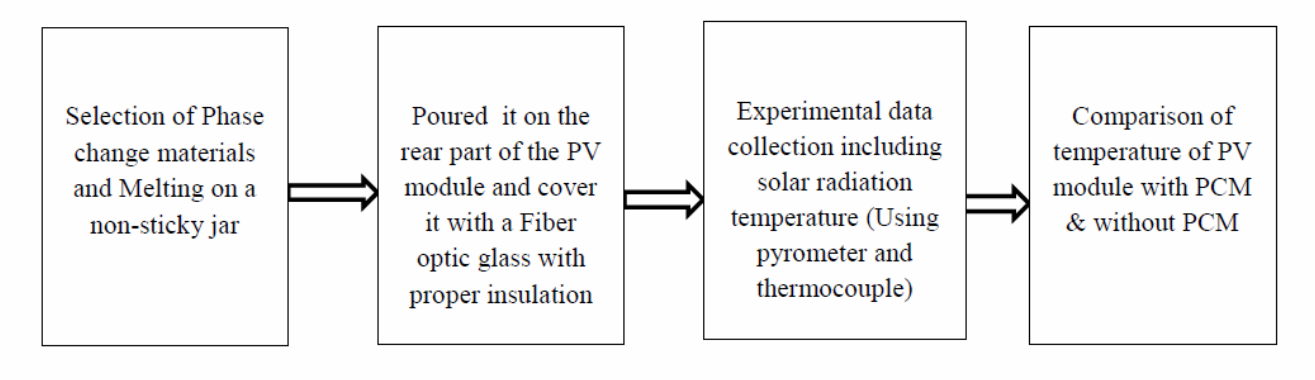

Fig. 1. Steps of the prototype development procedure.

However, after completing all the above steps the proto-type will be built up.

Fig. 2 represents the schematic arrangement of the integrated PV-PCM system.

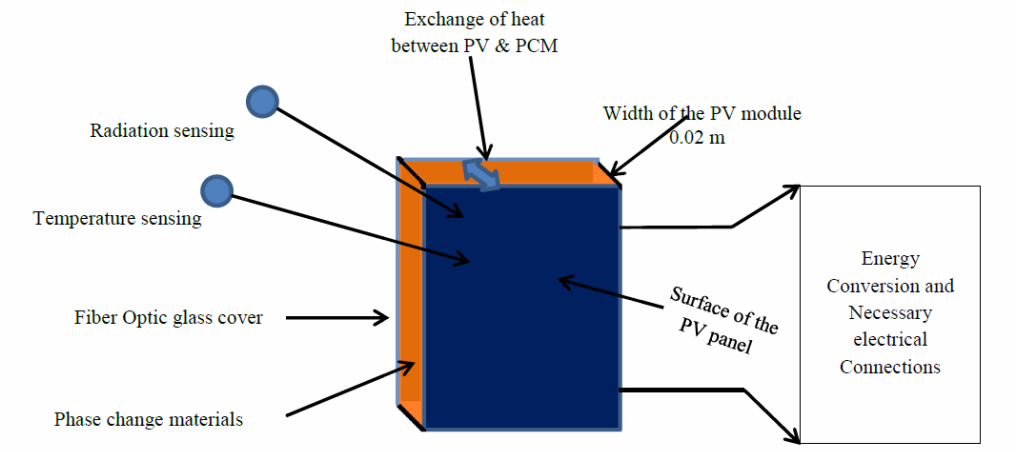

Fig. 2. Initial schematic design of a PCM integrated PV module.

However while designing the prototype some issue should be considered such as melting of PCM should be done on a non-sticky jar, poured it on the back of PV panel electrical connection should not be affected

Herewith while covered the Panel with fiber-optic glass properly makes sure it has got a perfect insulation. Otherwise the phase change materials can come out while melted.

3. Results and discussion

To carry out the necessary investigation it is important to collect the environmental data associated with the experiment. For this reason in Fig. 3 and Fig. 4 the radiation and temperature pattern of a typical Malaysian sunny day has been represented.

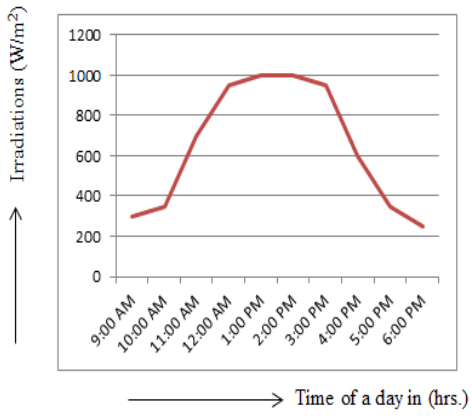

Fig. 3. Irradiation pattern of Malaysian sunny day.

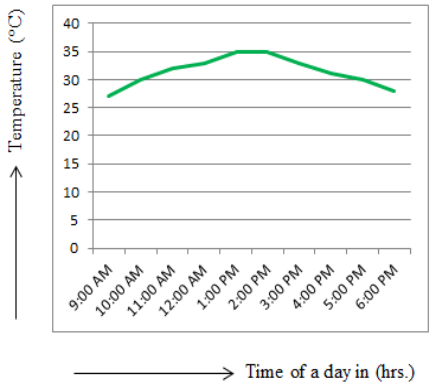

Fig. 4. Temperature varriation of a Malaysian Sunny day.

With respect to this weather condition experiment has been performed in open air, the results obtained from the experiment is given on Fig. 5; it is shown that the temperature of the PV module goes rise to 53°C without integrating Phase change materials but the rise of temperature limited to 42° C for a period of 4 hours due to the effect of phase change materials.

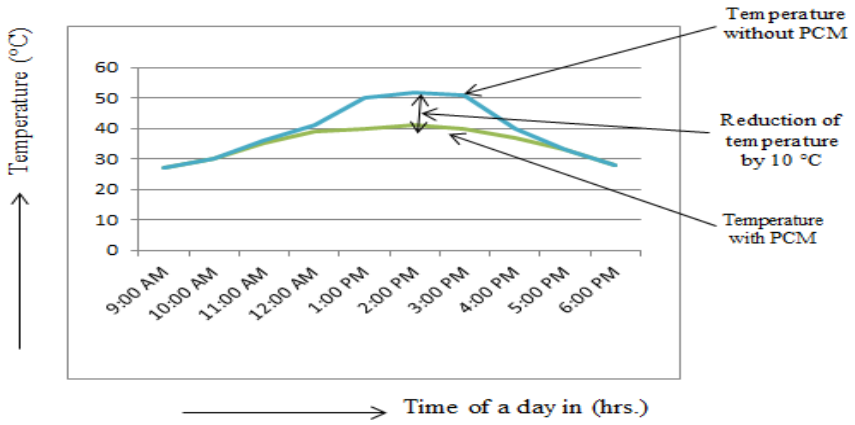

Fig. 5. Temperature comparison of the PV module with PCM and with out PCM.

4. Conclusion

Finally it has been shown the application of phase change materials is capable to regulate the temperature of PV module by 10° C for a period of around 6 hours at Malaysian weather. This definitely implies the significant enhancement of conversion efficiency of PV module. However, there occur some problems due to the issue of volume change of the PCM, if a shape stabilized phase change material can be used the problem will be solved. This will be the future step of this work.

Acknowledgement

The authors wish to thank all the members of Renewable energy cluster of University of Malaya for their kind co-operation .This work is under an on-going project of the University of Malaya (Project no:RP021-2012A). Authors would like to thank the University Research grant authority for their necessary economic supports.

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