EXPERIMENTAL INVESTIGATION OF SOLAR PANEL COOLING
BY THE USE OF PHASE CHANGE MATERIAL
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ABSTRACT

High operating temperatures induces loss of efficiency in solar photovoltaic and thermal panels. This project investigates the use of phase change material (PCM) to maintain the temperature of panel close to the ambient temperature. The main focus of the study is to improve the solar panel performance by using the phase change material Cobalt Sulphate Heptahydrate situated in the back of the solar panel (SP). A variation in the enthalpy allows simulating the material’s thermo physical properties to change. For validation process, voltage and current is measured day by day and power is calculated from the experimental set up to draw a power-time graph and performance is identified from the graphs. Results show that adding a phase change material to the back of the solar panel can maintain the panel’s operating temperature under 40°C for around two hours under a constant solar radiation of 1000 W/ sq. m. The implementation of the phase change material under the solar panel has increased the performance of the solar panel by 5.02% and an increase in power production by 7.92%.

Keywords: Temperature, Phase change material, radiation, solar panel

INTRODUCTION

Solar panels use light energy from the sun to generate electricity through the photovoltaic effect. The majority of the modules use wafer based crystalline silicon cells or thin film cells based on cadmium telluride of silicon. The structure member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide the desired current capability. The conducting wires that take the current off the modules may contain silver, copper or other non magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system. Externally, popular terrestrial usage PV modules use MC3 or MC4 connectors to facilitate easy weatherproof connections to the rest of the system. Bypass diodes may be incorporated or used externally in case of partial module shading, to maximize the output of module sections still illuminated.

Depending on the construction, PV modules can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range. Hence much of the incident sunlight energy is wasted by the PV module. Another design concept is to split the light into different wave lengths and direct the beams onto different cells tunes to these ranges. This has projected an increase of efficiency by 50%. To lower the operating temperature, one can improve the back cooling of the panel thanks to the natural and forced convection or to absorb the excess heat by modifying the panel’s architecture. The latter solution includes the use of PCM situated in the back of the solar panels.

A phase change material is a substance with a high heat of fusion which by melting and solidifying at a certain temperature is capable of storing and releasing large amounts of energy. Heat is absorbed or released by the change of state from solid to liquid and vice versa, thus PCM is classified as a latent heat storage system. PCM latent heat storage can be achieved through solid-solid, solid-liquid, solid-gas and liquid-gas phase change. However, the only phase change used for PCM is the solid-liquid change. When PCM reaches the temperature at which they change phase, they absorb large amounts of heat at an almost constant temperature. The PCM continues to absorb heat without a significant rise in temperature until all the material is transformed to the liquid phase. When the ambient temperature around a liquid material falls, the PCM solidifies, releasing its stored latent heat. A large number of PCM are available in any required temperature range from -5 to 190°C.

Experimental set up: The experimental set up is depicted in figure 1. The set up is made of a two supporting frame for holding the solar panel. The angle of inclination of the frame is decided from the incidence angle of the sun. The phase change material is placed in the box. The top cover of the box is made of copper to improve the heat conduction between the solar panel and the phase change material.
RESULTS AND DISCUSSION

The readings are taken on a day to day basis and the current, voltage and power are recorded. The temperatures of the panels during operation with and without the phase change material are recorded. This helps in plotting the graph. In figure 2, the power vs. time graph depicts the power production of the solar panel with time. The panel which is cooled by the phase change material shows increase in power production compared to the panel without cooling.

In figure 3, the comparison between temperature and time is done. The panel cooled by the phase change material shows uniform temperature distribution over the time when compared to the panel not cooled by the phase change material. In figure 4, the comparison of the performances between the solar panel cooled by the phase change material and not cooled is depicted. The performance of the cooled solar panel is considerably higher than the solar panel not cooled.

CONCLUSION

From our experimental analysis, we were able to find the following result,

- Increase of production of power by 7.92%.
- Increase in performance of the solar panel by 5.02%.
- Reduction in temperature during continuous operation of the solar panel by 4°C.

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