Indian Institute of Technology, Kanpur

SURGE 2022

“Optimization of cooling solution for Hybrid Photovoltaic system”

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Objective of the Project

The project objective is to build a PV-PCM 2D model, PCM model and PVT-PCM 3D model to analyze which PCM materials and for what thicknesses are suitable for obtaining lower temperatures throughout the year. Using PCM as a passive cooling material helps maintain a consistent temperature, thus maintaining the PV panels' efficiency. If the heat absorbed by PCM material is not utilized it goes in vain. This study utilized this heat by using a cooling solution to absorb and generate electricity, increasing the overall efficiency to 60-70%.

Key Points

- ➔ Photovoltaics **(PV)** is the technology of converting sunlight into electricity via certain semiconductor materials that exhibit the photoelectric effect.
- ➔ The efficiency of a photovoltaic (PV) panel depends on certain parameters, such as **solar radiation intensity falling on the PV surface, PV panel operating temperature, heat loss from the panel surface, and its material technology.**
- ➔ For a typical PV panel, **15 to 25%** of radiated solar energy on the PV panels front surface is transformed into electricity, and the remaining is transformed into heat that leads to enhancing the module temperature.
- ➔ Several studies have proven that the **higher operating temperature** of the PV module significantly **decreases the output power.**
- ➔ The PCM technique is a **passive temperature regulation** technique for PV modules which requires **less operational cost and has a higher energy density.**

Key Point

- ➔ PCM **latent heat storage** allows them to keep the absorbing **interface at temperature close to their melting point.**
- ➔ Studies conducted on PV-PCM model indicate its usefulness in **achieving better outputs** in terms of both **maximum output power and power conversion efficiency.**
- ➔ The study of the PVT-PCM model is conducted to use the heat absorbed by the PCM in the form of latent heat of fusion; otherwise, it will get wasted.
- ➔ The PVT-PCM model uses fluid channels and PCM material to enhance the maximum output power.

Result

When solar irradiance falls on the PV panel, approximately 83% of the incident solar irradiance is converted to heat within the cells, increasing the cell temperature beyond its standard operating temperature and decreasing its power conversion efficiency. To maintain power conversion efficiency, PV panel is incorporated with PCM material, which helps them keep the absorbing interface at a temperature close to their melting point. The energy absorbed by the PCM, if not utilized, will go in vain, so to utilize the absorbed energy, fluid channels are incorporated, which will absorb this energy and store it by doing so, we can increase our maximum power output to 60-70%. Several graphs are obtained by running numerical simulations on PCM model using COMSOL Multiphysics software.

Summary

The use of COMSOL Multiphysics software to perform numerical simulations on the PCM model produced several graphs like surface temperature vs. time and distance graph, surface velocity magnitude vs. time and distance graph, density vs. temperature graph, thermal conductivity vs. temperature graph, heat capacity at constant pressure vs. temperature, beta vs. temperature and graphs of surface velocity and surface temperature for 2 hours. This graph depicts the changes happening in values of specific parameters when other parameters like temperature, time, and distance change. We have built the PV-PCM 2D model and PVT-PCM 3D model using COMSOL Multiphysics software, but the numerical simulations and experimental verification is still going on.