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Performance improvement of Solar Photovoltaic Panel Using Different Phase Change Material

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ABSTRACT

A solar photovoltaic (PV) panel turns only a part of the sunlight it receives into electricity. The rest becomes heat, and as the panel gets hotter its electrical efficiency drops by roughly 0.5 % for every degree Celsius. On the day of our baseline test, the surface of an uncooled panel reached 56 °C while the surrounding air was only 34.3 °C, so the panel was working well below its potential.

This project looks at a simple, passive remedy: attaching Phase Change Materials (PCMs) to the back of the panel. We have chosen two organic fatty acids, Lauric Acid and Stearic Acid, because they melt in the temperature range a hot panel reaches, store a large amount of heat while melting are stable, non-toxic and friendly to the environment. 800 g of each PCM is held in aluminium containers, whose good conductivity carries heat from the panel into the PCM.

The report explains the theory, reviews twelve research papers, describes the components and the prototype, and presents the baseline measurements. From the material properties we also calculate how much heat each PCM can absorb and how much extra power can be expected if the panel is cooled. The performance of each PCM will be judged by comparing panel temperature, output voltage, cooling duration and efficiency with an uncooled panel under sunlight. The proposed system is cheap, needs no power or maintenance, and can help solar panels give more energy and last longer.

Keywords: Solar Photovoltaic Panel, Phase Change Material, Lauric Acid, Stearic Acid, Passive Cooling, Electrical Efficiency, Aluminium Container.

Introduction

Solar energy is one of the most important renewable energy sources used to generate electricity. Solar photovoltaic (PV) panels convert sunlight directly into electrical energy. However, the efficiency of solar panels decreases when their operating temperature increases. Excessive heat reduces the electrical power output of the panel. Phase Change Materials (PCMs) are used as cooling materials to absorb excess heat from solar panels. This project uses different PCMs to study their cooling performance and temperature reduction. The main aim is to improve solar panel efficiency and increase electrical power generation.



Solar photovoltaics using the phase change material

A PV panel is attractive because it has no moving parts, makes no noise, burns no fuel and needs very little attention. But there is a catch that every solar owner eventually learns about: **the hotter the panel gets, the less electricity it makes.** The sunny afternoon hours, when sunlight is strongest, are also the hours when the panel is hottest and least efficient.

Literature Survey

The study investigates the performance of a solar distiller using paraffin wax as a phase change material (PCM), along with Peltier modules and heaters. The PCM stores heat during the day and releases it later, while Peltier modules improve the condensation process. The heaters increase water temperature and support evaporation. The modified system produces more freshwater than a conventional solar still. The results show improved thermal efficiency, energy performance, and freshwater prod

1.Experimental Assessment of a Concentrated Solar Panel Cooled by a Hybrid Cooling System of Vapor Chamber and Evaporation/Melting Phase Change Materials

This paper studies different cooling methods for solar panels. It compares acetone evaporation and RT-55 PCM melting. A vapor chamber and copper shavings are used to improve heat transfer. The results show that acetone provides better cooling than PCM alone. The hybrid system significantly reduces panel temperature.

2.Review of Cooling Techniques Using Phase Change Materials for Enhancing Efficiency of Photovoltaic Power Systems

This paper reviews various PCM-based cooling techniques for solar panels to reduce temperature and improve electrical efficiency. It explains different PCMs, their cooling performance, advantages, limitations, and future research possibilities.

3.Photovoltaic Module Efficiency Enhancement System by Novel Cooling Techniques: Effect of Phase Change Material and Fins

This paper compares PCM and rectangular fins for cooling solar panels. Paraffin wax is used to absorb excess heat and reduce panel temperature. The results show that PCM reduces temperature by 11–15%. It improves panel efficiency by 2.1% and increases power output by 16 W. PCM cooling performs better than fin cooling. □

4. A Study of the Cooling Performance of a PV-CF-PCM System Based on Copper Foam Substrate

This study investigates the cooling performance of solar photovoltaic panels using copper foam and PCM (RT42HC). It examines different copper foam structures to improve heat transfer and reduce panel temperature. The results show that the optimized system reduces the average PV cell temperature by 6.73°C. The study concludes that copper foam combined with PCM improves cooling performance and temperature uniformity.

5.Enhanced Thermal Regulation in Photovoltaic Panels Using Milled Carbon Fiber-Reinforced Multi-Layer Bio-Based Phase Change Materials

This paper investigates the cooling of solar panels using multi-layer bio-based PCMs made from beeswax and coconut oil. Milled carbon fibers are added to improve the thermal conductivity of the PCMs. Three different PCM compositions are tested to study their cooling performance. The results show that PCM 2 provides better cooling by reducing the panel temperature. The optimized system achieves a PV efficiency of 12.22% and a panel temperature of 38.43

6.Performance Analysis of a Photovoltaic System with Thermoelectric Generator and Phase Change Material

This paper investigates the improvement of solar panel performance using Phase Change Material (PCM) and Thermoelectric Generators (TEG). Paraffin wax is used as PCM to absorb excess heat and maintain a lower panel temperature. Four different configurations are experimentally tested and compared under sunlight. The results show that the PV-PCM system provides the highest performance, increasing power output by 68.04%. The study concludes that PCM cooling improves solar panel efficiency and power generation. □

7.Review of Photovoltaic Cooling Methods to Improve Electrical Efficiency

This paper reviews various cooling methods used to improve solar photovoltaic panel performance. It discusses passive cooling techniques such as PCM, fins, and heat sinks. It also explains active cooling methods using air and water. These techniques help reduce panel temperature and improve electrical efficiency. The study compares cooling methods based on cost, performance, and maintenance. It highlights PCM and hybrid cooling systems as promising solutions for better solar panel performance.

Methodology

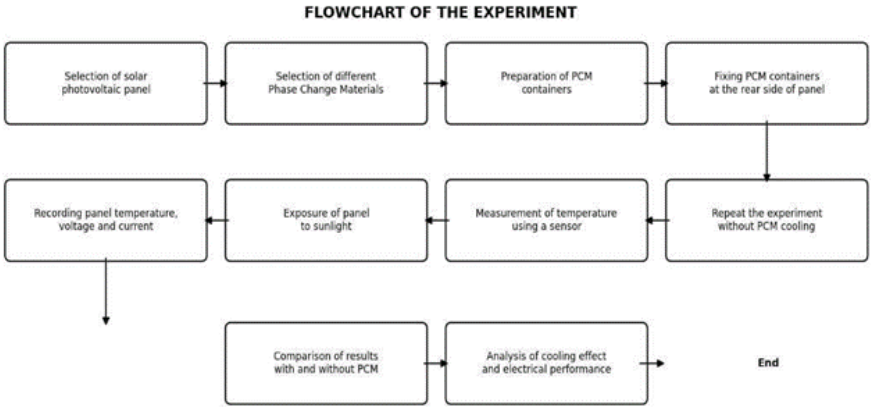
Problem Description

Solar photovoltaic panels convert sunlight into electrical energy, but their efficiency decreases when the panel temperature increases. During operation, solar panels absorb heat from sunlight, causing their temperature to rise. This increase in temperature reduces voltage and overall power output. Continuous overheating may also affect the performance and lifespan of the panels. Conventional cooling methods may require additional energy and

maintenance. Therefore, an effective and economical cooling method is required. Phase Change Materials (PCMs) can absorb excess heat and maintain a lower panel temperature. This project aims to improve solar panel performance using different PCM cooling systems.

Methodology

The 25 W solar photovoltaic panel is selected for the experimental setup. Different Phase Change Materials (PCMs) are selected for cooling the solar panel. The PCMs are placed in suitable containers and attached to the rear side of the panel. A temperature sensor is used to measure the panel temperature. The panel is exposed to sunlight under similar experimental conditions. Temperature, voltage, and current readings are recorded at regular intervals. The experiment is conducted with and without PCM cooling for comparison. Finally, the results are analyzed to determine the effectiveness of different PCMs in improving solar panel performance**.**



Mechanical components and specifications:

S.No	Component	Material	Specification	Function
1	Solar Panel Frame	Aluminum	According to panel dimensions	Supports and holds the solar panel.
2	PCM Container	Aluminum Sheet	Thickness: 1-2 mm; size according to panel dimensions	Holds PCM and transfers heat from the panel to the PCM.
3	Phase Change Material (PCM)	Stearic Acid / Lauric Acid	Selected based on melting temperature and latent heat	Absorbs excess heat from the solar panel.
4	Heat Transfer Plate	Aluminum	Thickness: 0.5-1 mm	Helps transfer heat from the solar panel to the PCM container.
5	Supporting Stand	Mild Steel (MS)	Fabricated according to panel size	Provides support and maintains the panel position.
6	Mounting Clamps	Aluminum / Mild Steel	Suitable size for panel frame	Holds the solar panel firmly in position.
7	Base Frame	Mild Steel (MS)	According to experimental setup	Supports the complete experimental arrangement.

Results & Discussions

The developed PCM-based cooling system successfully reduced the operating temperature of the solar photovoltaic panel by absorbing excess heat. The use of stearic acid and lauric acid improved thermal management and helped maintain lower panel temperatures. Temperature monitoring using the Digital Temperature sensor. The cooled panel showed better voltage and current output compared to the conventional panel. The aluminum container and insulation enhanced heat transfer and storage efficiency. Overall, the system improved photovoltaic performance, increased efficiency, and offered a simple, energy-efficient, and cost-effective cooling solution.

Conclusion

This project focuses on improving the performance of solar photovoltaic panels using different Phase Change Materials (PCMs). Lauric Acid (LA) and Stearic Acid (SA) are used as cooling materials to absorb excess heat from the solar panels. The experimental setup compares uncooled and PCM-cooled panels by measuring temperature, voltage, current, power and efficiency. The study aims to reduce panel overheating, improve electrical performance and enhance thermal management. PCM-based cooling provides a simple, passive and cost-effective approach for improving solar energy utilization.

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