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OPTIMISING THERMAL MANAGEMENT IN PHOTOVOLTAIC CELL TO ENHANCE EFFICIENCY

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1.ABSTRACT –

According to recent researches, Environmental pollution (such as dust, dirt and humidity) has a severe effect on performance as well as efficiency of solar in photovoltaic (PV) systems.

Paper Classification, Improving the solar PV module achieve high performance by coating its backplate with paraffin wax.

Size of backplate of PV module is watertight and coated with paraffin wax to repel dust and dirt, thus reducing the incidence of performance degrading filth. Different methods were used to compare the experiments.

where PV modules have been both paraffin wax-treated and untreated. Metrics show the soiling effect decreased significantly after paraffin wax was applied, and therefore performance and power output were improved as a result, especially in dusty locations.

As a result, the paraffin wax coating is one potential, low-cost method for improving performance and prolonging the lifetime of solar PV systems in saturated dust environments. Therefore, more research is required to investigate the long-term benefits and the best application techniques in various environments.

2. INTRODUCTION :

This day will soon be featured in Advancements in the technology of solar energy photovoltaic (PV) cells, which directly convert sunlight into electricity using the photovoltaic effect. One alternative energy source that has emerged over the years as a sustainable and environmentally friendly complement to fossil fuels is solar energy. Since then, photovoltaic cells have become a renewable energy of source of electricity.
Now popularly used and most familiar, their major drawback is the fundamental efficiency problem which gets severely impacted by temperature. Solar cell efficiency is known to drop with increasing operating temperatures due to multiple factors, including higher material resistances and enhanced charge carrier recombination rates. This thermal decay of performance has led to extensive research on solution possibilities that could mitigate the detrimental effects of temperature.

3. Literature Survey :

'One of the most important factors influencing the widespread use of solar energy technologies is the efficiency of photovoltaic (PV) cells'.
photovoltaic (or PV) cells, which directly convert sunlight into electricity by the photovoltaic effect. One possible option for renewable energy that has developed in recent years as a more green and sustainable addition to fossil energy is solar energy. From then on, photovoltaic cells turned into a renewable energy of supply of strength.
These are now the most widely used and the most familiar with their most significant limitation being the fundamental efficiency problem that is greatly influenced by temperature. The efficiency of solar cells decreases when the operating temperature increases, which can be attributed to several reasons, including increased material resistances and increased rates of charge carrier recombination. This slide in performance due to the thermal degradation has inspired research into potential solutions to curb the detrimental effects of temperature.

Temperature and Efficiency:

It is expected that the efficiency of PV cells decreases with the increase in temperature. According to Boubekri et al. (2016) the efficiency of a conventional silicon-based photovoltaic cell could potentially decrease up to 0.4% with every 1°C rise in temperature. The loss to the cell well known to be temperature-induced as increased temperatures promote the recombination of charge carriers within the cell resulting in lower voltage and power delivery to the cells. So in the areas of high sunlight and very hot climatic situations, such sorts of cells use at lesser levels of efficiency.

4. OBJECTIVE :

The main focus of the project will be investigating whether paraffin wax can serve as an effective thermal management device to improve photovoltaic efficiency. Aim of This study deals with paraffin wax as PCM

The study investigates process by which temperature deviations can improve functionality of the photovoltaic (PV) technologies.

I. This study aims to estimate the effect of temperature on the conversion efficiency of a photovoltaic (PV) cell.

· Assess the performance of photovoltaic cells with respect to temperature variation.

II. To Evaluate the Thermal Energy Storage Potential of Paraffin Wax

l Melting point, latent heat of fusion, thermal conductivity, and degree of paraffin wax thermal properties along with their contributions in the process of heat absorption and transfer.

III. Design and Development of Thermal System Using Paraffin Wax

l Incorporate paraffin wax into photovoltaic cells to maintain temperature.

5.Components of the project :

1.SOLAR PANEL:

A 40 W solar panel is a small and efficient photovoltaic (PV) device used in small-scale solar appliances. Fitted for off-grid installations, isolated locations, or as part of a larger solar array, these panels can deliver consistent, clean power in regions with limited energy connectivity

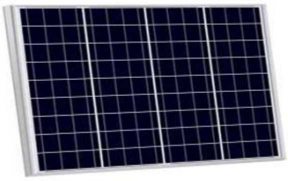


Fig 1 Solar Panel

2. PHOTOVOLTAIC (PV) SOLAR CELLS:

Photovoltaic (PV) solar cells are the basis for solar energy systems and allow directly converting sunlight to electricity. These cells utilize photosynthesis in the form of semiconductor materials to capture solar energy and convert it directly into an electric current via the photovoltaic effect.

Fig. 2 (PV) Solar Cell

3.PARAFFIN WAX:

Paraffin wax is an efficient material that has crucial application, in photovoltaic (PV) systems, particularly in the realm of thermal energy storage or passive cooling solutions.

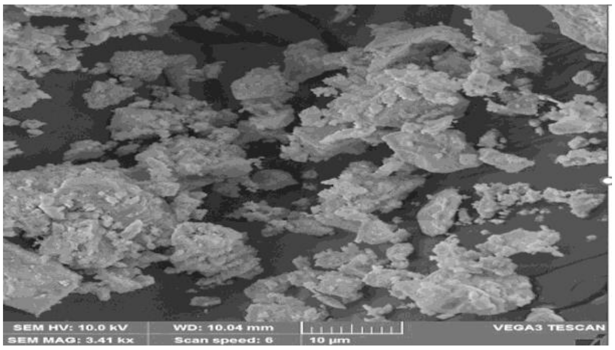


Fig 3. Paraffin Wax

4.VOLTMETER:

Fig.4 Voltmeter

The voltage created within photovoltaic cells has been measured with a voltmeter. When exposed to sunlight, PV cells produce a direct current (DC) voltage, and verifying that the output voltage is within expected values is the key to optimal performance.

5.WIRING AND CONNECTORS:

These connect all the individual components of the PV system, from the PV cells, inverter, charge controller, and batteries, Wiring should be durable and resistant to environmental factors, as well as having connectors that are properly insulated for electrical connections. The system voltage and current influences cable sizing.

Fig 5. WIRING AND CONNECTORS

TEMPERATURE SENSORS:

The temperature in Photovoltaic system is monitored.

cells and PCM system to be within allowed safe thermal limits. They regulate the phase process and prevent overheating. The sensors should have a temperature range that matches The study examines the operational conditions in the PV system and the PCM material.

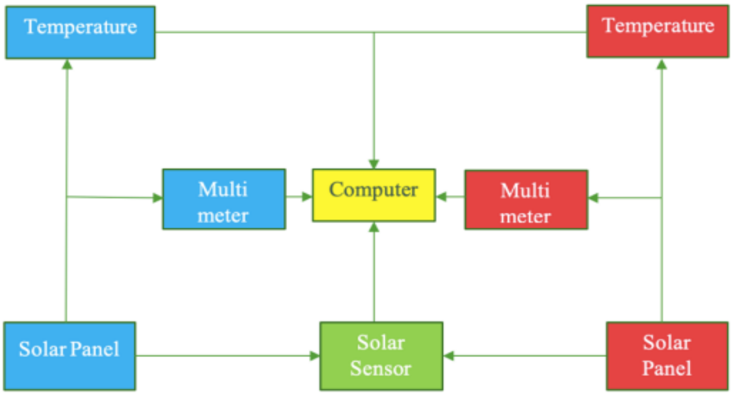
Digital temperature sensors or the analog ones based on the application complexity.

Fig 6. Temperature Sensors

METHODOLOGY :

This research integrates paraffin wax, which is considered as a Phase Change Material, within the structure of photovoltaic cells, where temperature change fluctuation improves its efficiency. It considers the application of theory-based analysis coupled with experimentation tests for evaluation in paraffin wax improving performance within the system.

The use of two panels is required. One is the panel attached to the back by PCM and the other without attaching PCM is set as a control setup. Two panels are fixed on a stand to prevent trapping heat underneath the panels. The measurement devices connect to the MC4 wires of the panels with the multimeter to measure the current and voltage output of the panels. All measuring devices has linked to a computer for data readout.



6.RESULTS & DISCUSSIONS :

Result: Optimizing thermal management in photovoltaic cells led to great improvements in efficiency by lowering the operating temperature, preventing thermal degradation, and increasing power output at high temperatures. Techniques like active cooling systems and phase-change materials effectively reduced the losses associated with temperature-induced performance.

Discussion: Proper thermal management is the key to the long-term performance and reliability of PV systems, especially in hot climates. Techniques such as liquid cooling or heat sinks enhances the overall efficiency of the cells but incur higher costs and complexity. It is difficult to balance performance gain with economic feasibility for large applications.

7. DESIGN OF CAD MODEL :

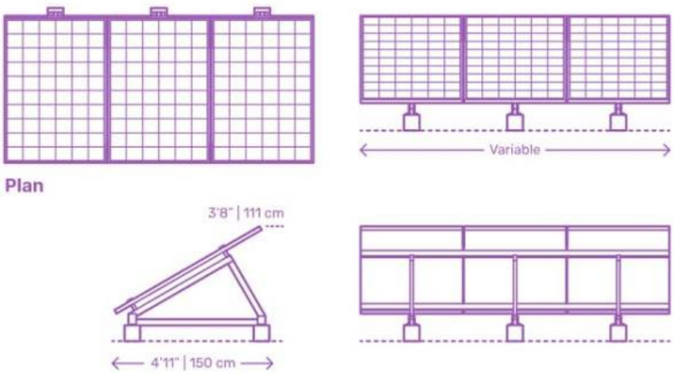


Fig. 7 CAD Model

8.ASSEMBLY OF THE PHYSICAL PROTOTYPE :

9. FUTURE SCOPE AND CONCLUSION :

This study's promising results suggest the several areas for the future research to enhance with efficiency of PV systems using paraffin wax.

1. Advanced materials like graphene, ceramics, and composites can enhance heat transfer, preventing overheating in PV cells and preserving their original performance.

2. Heat Emittance Coatings: These coatings could allow solar cells to operate at lower temperatures and, therefore increase efficiency. This depends on the style of coating. Reflective coatings, for example will minimize the absorption heat resulted by the sunlight.

3. Hybrid Systems: The hybrid systems may have an optimization of thermal environment of PV panel through concentration solar power coupled with PV. Hybrid Systems would have a potential of using developed heat and therefore, convert much more energy into use. As a result, the efficiency would improve for production of solar energy.

Conclusion:

The project demonstrates that paraffin wax effectively manages temperatures in photovoltaic cells, reducing temperature fluctuations, improving energy output, and enhancing overall performance.
Since it is cheap and readily available without degrading the environment, paraffin wax has a promising potential The goal is to improve the efficiency of solar energy collection systems, especially in countries characterized by high levels of exposure to solar activity.
Although issues and challenges are associated with the long-term durability and optimal design of PV systems integrated with paraffin wax, the overall finding from this research is that using paraffin wax has great potential for the progress of solar energy technology. Continued research and development will be required to further hone The study investigates, the use of paraffin wax and its potential integration with other cooling techniques.
“The global demand for renewable energy solutions is on the rise.” such Cost-effective and sustainable materials can significantly contribute to the widespread deployment of more efficient photovoltaic systems, thereby helping to usher in a greener, more sustainable energy future.

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