Performance Investigation of Solar Photovoltaic System using Passive Cooling Method

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2020-21

A B S T R A C T

This paper reviews the performance investigation of solar photovoltaic system using passive cooling method. In which phase change material is used as cooling material. Main aim is to reduce the temperature of PV panel using PCM and Fins. A large part of the PV conversion losses are related to the temperature increase of the solar cells. Maintaining the temperature of the module at an optimum level was the aim of this study. Experimental research on a silicon PV module in a PV/PCM system in which the optimum operating temperature of the cell was stabilized through the use of a suitably selected PCM has been conducted. Measurements of electrical parameters of the loaded modules under constant intensity of radiation and with various configurations of the system were performed. An appropriately selected PCM should be used for the PV module modification: the basic criterion is a suitable melting point, which must be higher than 30^0 C, so that the material remains in the solid state under ambient temperature in the summer season. At the same time, the material should possess the highest possible enthalpy change h.

Keywords: passive cooling, phase change material, solar energy.

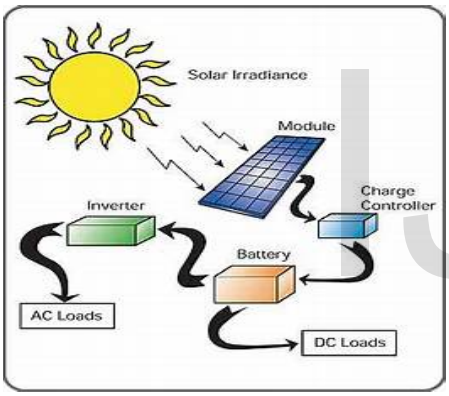
1 Introduction

A solar cell is an electrical device that convert the energy of light directly into electricity by the photovoltaic effect. Individual solar cell device can be combine to from modules known as solar panels. In basic terms a single junction silicon solar cell can produce a maximum open circuit voltage of approximately 0.5 to 0.6 volts. Solar cell are described as being photovoltaic irrespective of whether the source of sunlight or an artificial light. In addition to producing energy they can be used as a photo detector. Solar energy is a major renewable energy source with the potential to meet several challenges. We faces as humankind. This power source is increasing in popularity and many benefits to people and the environment.

In recent years research has moved towards designing and manufacturing lightweight, flexible and highly efficient solar cell. Terrestrial solar cell technology generally uses photovoltaic cell that are laminated with a layer of glass for strength and protection. A solar photovoltaic system refers to the component and equipment that convert DC energy produced by solar panel to absorb and convert sunlight into electricity. The climatic changes across the globe and depletion of fossil fuel drive the urge towards renewable sources. Among them, various developments have taken place in solar energy in the recent years. Continuous developments on solar projects has increased the challenges in maintaining system stability and efficiency. Photovoltaic (PV) cells are semiconductor materials which convert the solar radiations into electric current. Generally, PV modules have a conversion efficiency of 5%−20%. Therefore, the efficiency of the PV panel depends on the type of solar cells, the weather condition, the temperature of the cell, etc. Only some solar rays falling on the panel are converted into power, and the other few rays are dissipated as heat. It is reported in the literature that only about 15–20% of solar radiation that absorbed by the photovoltaic modules is changed to electricity and the residue is dissipated to heat. Mixing nanoparticles to PCMs decreases the obtained maximum temperature in charging mode, this not only enhances the electric conversion efficiency but also increases the PV plate duty life because of decreasing the temperature variation in charging and discharging modes

1.1 Photovoltaic Effect

The photovoltaic effect is the generation of voltage and electric current in a material upon exposure to light. It is a physical and chemical phenomenon. The photovoltaic effect is closely related to the photoelectric effect. For both phenomena, light is absorbed, causing excitation of an electron or other charge carrier to a higher-energy state. The main distinction is that the term photoelectric effect is now usually used when the electron is ejected out of the material (usually into a vacuum) and photovoltaic effect used when the excited charge carrier is still contained within the material. In either case, an electric potential is produced by the separation of charges, and the light has to have a sufficient energy to overcome thepotential barrier for excitation. The physical essence of the difference is usually that photoelectric emission separates the charges by ballistic conduction andphotovoltaic emission separates them by diffusion, but some "hot carrier" photovoltaic device concepts blur this distinction.



1.1 Photovoltaic effect[researchgate.net]

1.2Phase Change Material

A phase change material (PCM) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage (LHS) units. There are many different types of phase change material, usually capable of changing between a minimum of two physical states. They are used in many different commercial applications where energy storage is required

2 Literature Survey

E. Abdelrahman et al. The present experimental work aims to enhance the photovoltaic cells performance. The effect of changing configurations and using PCM mixed with nanoparticles are experimentally investigated.

Kalaiselvam, Sivaet all - This work focused on experimental investigation of using a novel phase change material (PCM) in a PV module to enhance its cooling performance. Phase change material by absorbing a lot of heat from the surface of the PV module and control the heat capacitance of the system causes to raising its overall efficiency.

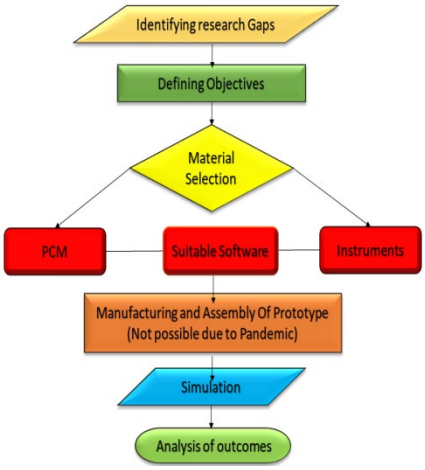
SouravKhannaaet all - The present work aims at the optimization of fins fitted phase change material equipped photovoltaic system under different working circumstances for proper power enhancement. Setup has been modelled and the best deepness of fins fitted phase change material enclosure has been computed for a range of daily collective solar flux at photovoltaic panel surface, wind pace, wind azimuth, surroundings temperature, melting point, successive fins distance, fins deepness and fins width in order to analyse the influence of working circumstances.

Asghariana, E. Baniasadiet all - Phase Change Materials (PCM) have been widely used in different applications. PCM is recognized as one of the most promising materials to store solar thermal energy in the form of latent heat. Utilization of PCMs for solar energy storage compensates for the intermittent characteristic of this energy source.

Rosendo Lopez-Delgadoa et al. Chlorophyll-A/PMMA has been characterized as a promising photoluminescent material and employed as a down-shifting layer on silicon based solar cells. A relative straightforward method has been employed for the extraction and redispersion of chlorophyll in a PMMAmatrix host.

Tao Ma et al. Research demonstrates the high operating temperature of crystalline silicon based photovoltaic (PV) module will lead to an obvious decrease in conversion efficiency and lifetime. In this study, the

phase change material (PCM) is employed and attached at the back of PV module, which is called PV-PCM system, to absorb excess heat from PV module for PV



thermal regulation and electrical efficiency improvement.

3 Problem Statement

Overheating of silicon PV panels due to excessive solar irradiance and high environmental temperatures is a major problem. During day time temperature of PV system increases above its ambient temperature. Due to this voltage decreases rapidly. The net effect is decrease in output power And reduction in efficiency of PV system.

To overcome this problem we use passive cooling method to maintain the temperature ambient by using suitable PCM.

4 Objectives

- To select suitable PCM having suitable melting temperature .
- To Select different type of instrument and assemblies for experimentation .
- To select suitable software for simulation.
- To perform case study to collect input radiation data.
- To simulate the model according to radiation data.
- To Analysis simulation result.

5 Methodology

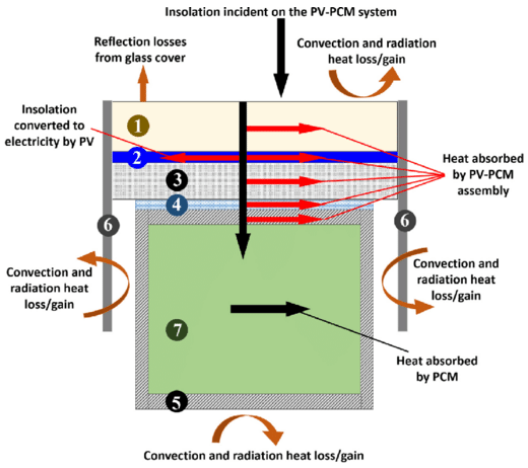
The methodology we are going to follow while working on our project is as mentioned in above flow chart. As initial steps we are going to study some previous research paper from our topic related journals to identify the research gaps to work on. We will built up a problem statement accordingly.

Our next step is to a define the objectives to complete while working on our project, followed by the selection of materials and instrument required in order to accomplish our project. In materials election we are selecting three types of materials; which includes the required phase change materials(PCM) and nanoparticles, Required instruments such as pyranometer, multimeter, solar panel, thermocouples, etc, and a suitable software for simulation.

Next step should have been manufacturing and assembly of a prototype, But due to pandemic that wasn't possible. So we move towards the simulation of geometric model of our project on a suitable software.

After performing simulation our final step is to analyze the results and outcomes of simulation

6 Experimentation and Simulation

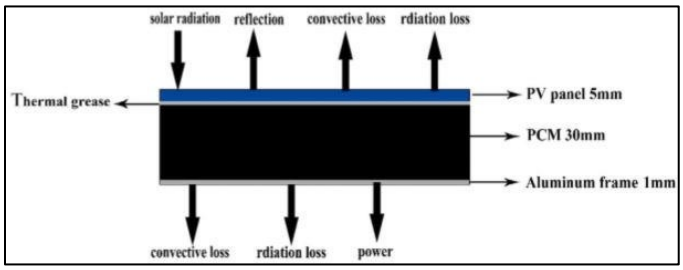


6.1 Experimental Setup

6.1 Working

Solar panels work by absorbing sunlight with photovoltaic cell generating DC energy

andthenconvertingittousableACenergywiththehelpofinvertortechnology.Aphotovoltaicsystem convert the suns radiation in the form of light into usable electricity.It comprises the solar array and the balance of the system component. PV system can becategorizedbyvariousaspectssuchasgridconnectedvs.stand-alonesystem.Theircapacities range of solar panel from few kilowatts to hundreds ofmegawatt. A typicalresidentialsystem is around 10kilowatt and mounted on slopedroof.



6.2 Physical Domain

7 Conclusion

A large part of the PV conversion losses are related to the temperature increase of the solar cells. Maintaining the temperature of the module at an optimum level was the aim of this study. Experimental research on a silicon PV module in a PV/PCM system in which the optimum operating temperature of the cell was stabilized through the use of a suitably selected PCM has been conducted. Measurements of electrical parameters of the loaded modules under constant intensity of radiation and with various configurations of the system were performed. An appropriately selected PCM should be used for the PV module modification: the basic criterion is a suitable melting point, which must be higher than 30^0 C, so that the material remains in the solid state under ambient temperature in the summer season. At the same time, the material should possess the highest possible enthalpy change h.

The results show that, for constant solar irradiance, the unmodified solar PV module heats up to a higher temperature than one in a PV/PCM system. The modification also made it possible to obtain higher values of maximum power and efficiency than the unmodified module. The best results were obtained for the PV/PCM configuration of a PV module with a tank filled with PCM and water cooling, but the PV/PCM with water cooling is not worthwhile for future application Maintaining a reduced temperature of the module during intense solar radiation for more than five hours will
increase the efficiency of the module in this most efficient period of the day, while the losses associated with maintaining the temperature of the module near the melting point of the PCM in the afternoon, when the ambient temperature goes down, are smaller due to the much lower yields of energy because the solar radiation is of low intensity.The utilization of PCM constitutes a simple and low-cost method of removing heat from a PV module and keeping the electrical efficiency at an acceptable level.

8 Future Work

- Experimentation can be done on this configuration and set up.
- Simulation and experimentation can be done by changing the PCM configuration on similar setup.
- Further performance of setup can be improved by adding nanoparticles along with PCM for passive cooling.

Acknowledgement

We express our sense of gratitude towards our project guide**Prof. S.V.Chavan**for his valuableguidanceat everystep of the study of this project, also her contribution to thesolution ofevery problemateach stage.
We are overwhelmed to **Prof. S.M.Gaikwad,** Head oftheDepartment,MechanicalEngineering,andallthestaffmembers who extended the preparatory steps of this project.We are very much thankful to respected Principal **Dr. M.S.Gaikwad**forhissupport.
Finally, we want tothank all of our friends for their support& suggestions. Last but not least we want to express thanks toour family for giving us support and confidence at each stageofthisproject.

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