Experimental Investigation on PV Module through Passive Cooling using Phase Change Material– A Review

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Abstract*— High operating temperatures induce a loss of efficiency in solar photovoltaic and thermal modules. This paper investigates the used of phase-change materials (PCM) to maintained the temperature of the modules close to ambient. The huge amount of solar energy has reached to the earth can be provided electric energy by photo voltaic (pv) module. The solar pv module has a exciting technology but suffer from the low efficiency. So to improve the efficiency of the photo voltaic module it is used passive cooling with the help of heat technique. In this way, the temperature of solar cell could be effectively reduced to improved the efficiency of power generation and the heat dissipation of solar module could be minimized through the phase change material as it absorb the heat from the pv module and stored in the reservoir.

Keywords - PV modules: efficiency improvement, passive cooling, heat technique, phase change material.

I. INTRODUCTION

The huge amount of the solar energy is concentrate on the earth from that so many forms of energy is convert to other forms. Direct conversion of solar irradiance through solar energy systems are obviously link to the sun as well as much interest to researchers. The efficiency of solar modules depends on three factors: the intensity of the solar radiation flux, the quality of the semi conductor in use, and the operating temperature of the semi conductor cell. The variations of solar radiation cannot be controlled.

There are several solar energy systems that harness solar irradiance directly. Active cooling techniques that contain the water sprinkle, pressurized air, fins, cold water etc. Another technique is passive technique that cools the pv module and increases the efficiency of pv module. However, photovoltaic (PV) module arrays convert solar irradiance directly into electricity through a solid state system. The main focus of this paper is on efficiency improvement of solar PV modules. By the solar collector, the solar energy is collect and convert into the eclectic energy but some amount of energy is remain as it is on the surface of solar collector. So that with excessive amount of energy the solar collector or pv module is damage. So that the efficiency of pv module reduces, the converting of one form of energy into another is decreases. The whole body of solar system is damage and affect by the

increasing of heat. So we have reduces the heat of the module and introduce the new techniques to improve the efficiency of solar system.

In this paper we implement the passive technique for cooling purpose, the heat technique is use. In heat technique use the phase change material like capric acid ($CH_3(CH_2)_8COOH$) insulator for any leakage, fins and reservoir. The phase change material (PCM) is convert one form after heating or cooling into another form after cooling or heating like wax. The melting point of capric acid is 32^0c. The melting enthalphy is 153 KJ/Kg density is 901 for liquid 30^0c.

The pipe is containing the phase change material capric acid in liquid form and fins. So that the excessive energy that heat is absorb by the PCM capric acid and start melting after reaching the melting point the material converts its original form into another form means liquid into vapour. That vapour is travel into the reservoir and store into it. The reservoir is containing fins along with it. In summer the maximum temperature of surrounding reaches upto 50^0c, so that the temperature of solar collector reach upto 75^0c to 80^0c and in night temperature is reduces and goes upto 30^0c. The phase change material melt after 30^0c and convert into vapour and this vapour store into reservoir and after temperature going decreases at night the vapour is again convert from vapour to liquid and flowing to the original place. Hence the recycling of material is continuous from day to night and night to day and process of cooling is continuous. So that cooling of pv module is done. The insulator is present around the material for any leakage of heat if that heat transfer to the surrounding the material cannot be melt and the process is fail. The operating temperature of solar module in summer is 70^0c to 80^0c and after cooling it goes to 35^0c to 40^0c in night at summer season. So that in this paper discuss about cooling of solar module with the help of pcm material.

Heat pipe- The heat pipe use in that technique are develop especially for space applications during the early 60´ by the NASA. One main problem in space applications are to transport the temperature from the inside to the outside, because the heat conduction in a vacuum is very limited. Hence there are a necessity to develop a fast and effective way to transport heat, without having the effect of gravity force. The idea behind is to create a flow field which transports heat energy from one spot to another by means of convection, because convective heat transfer is much faster than heat transfer due to conduction. Nowadays heat pipes are used in several applications, where one has limited space and the necessity of a high heat flux. Of course it is still in use in space applications, but it is also used in heat transfer systems, cooling of computers, cell phones and cooling of solar collectors.

Material- In this paper use capric acid material the melting point of this material is 32^0c and the important point is the melting enthalphy of capric acid is 153KJ/Kg so that the efficiency of that material us greater than other material. The change rate of that material is quietly good than other material. Following are the material that also use instead of capric acid but the efficiency of these material is comperately low.

Sr. No	Material	Melting temprature	Melting enthalphy (KJ/Kg)	Density
1	capric acid	32^0c	153	901
2	Paraffin (C_{18})	28^0c	244	-
3	n-eicosane	38^0c	283	779
4	n-octadecane	28^0c	200245	774
5	Cooper foam and water	24^0c	156	-
6	1-dodecanol	26^0c	200	-

Table 1: Phase change materials

Table1. Shows that the different materials for phase change use in various researches and in various techniques of cooling solar pv module and other applications.

B. Limitations of materials-
The phase change materials are not easily available in market. The special demand for these materials are available or for special purpose these materials are obtain from the chemical industries.

Literature review-
The aim of this study was to investigate the performance of a passive cooling system for concentrated solar cells incorporating phase change material thermal storage. This literature review provides an overview of the current state-of-the-art of cooling solar cells in concentrated solar power (CSP) systems. The review focuses on both passive and active cooling methods for concentrated photovoltaic (CPV) and concentrated thermoelectric generator (CTEG) solar power systems. A review of phase change thermal storage is presented in the next chapter.
[1] Sayran A. Abdulgafar, et al has studied the water immersion method for improving the efficiency of solar module. Cooling of the solar cells is a critical issue, especially when designing concentrating photovoltaic (PV) systems. In the present work, the cooling of a photovoltaic module via Water immersion technique is investigated. The aim of this project is to optimize the efficiency of a solar module by submerged it in distillates water at different depths. Experiment is done for polycrystalline silicon module. An evident increase of efficiency is found with increasing the water depth.
[2] H.G. Teo, et al has studied the active cooling system for photovoltaic module. The electrical efficiency of photovoltaic (PV) cell is adversely affected by the significant increase of cell operating temperature during absorption of solar radiation. A hybrid photovoltaic/thermal (PV/T) solar system was designed, fabricated and experimentally investigated. To actively cool the PV cells, a parallel array of ducts with inlet/outlet manifold designed for uniform airflow distribution was attached to the back of the PV module. Experiments were performed with and without active cooling. A linear trend between the efficiency and temperature was found. Without active cooling, the temperature of the module was high and solar cells can only achieve an efficiency of 8–9%. However, when the module was operated under active cooling condition, the temperature dropped significantly leading to an increase in efficiency of solar cells to between 12% and 14%.
[3] A. Benuel Sathish Raj, et al has studied the Experimental Study on the Performance of Concentrated Photovoltaic System with

Cooling System for Domestic Applications. As the Concentrated Solar radiation reaches the PV module system, the temperature increases rapidly and because of this increase in temperature, the output efficiency will be decreased. In order to reduce the temperature and to increase the output efficiency, the Cooling System is used.
It has been found that the electrical output of the water cooled CPV is 4.7 to 5.2 times more than the PV module (without concentration and cooling). The cooling system has a heat pipe filled with Acetone.

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