PERFORMANCE EVALUATION OF PHOTOVOLTAIC SOLAR PANEL USING THERMOELECTRIC COOLING

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ABSTRACT

As a great potential renewable energy source, solar energy is becoming one of the most important energies in the future. Performance of PV panel decreases with increase in temperature of the PV panel. Hence, output power of PV module drops with rise in temperature, if heat is not removed. The cooling of PV modules would enhance the performance of PV panel. In order to cool this thermoelectric system is used. Hybridization of PV module with thermoelectric modules used to increase the overall efficiency of the solar energy conversion system by keeping temperature constant within the limits. Model of hybrid combination of PV–Thermoelectric has been developed and study of thermoelectric has done to illustrate its usefulness in hybrid model of PV and thermoelectric modules. This paper shows the performance of PV panel through augmentation of thermoelectric cooling system to increase overall electric conversion efficiency of PV array

Keywords**: *Electric Conversion efficiency of panel, thermoelectric module, PV panel, Types of PV panel, Thermoelectric cooler.***

I. INTRODUCTION

As the total world is facing critical problem of energy deficit, global warming detonation of environment and energy sources, renewable energy sources are getting more attention. Solar energy is one of the comparable candidates. Solar energy is widely available and it is free of cost. Solar energy can be converted into direct electricity by Photovoltaic effect.

Solar cells, or photovoltaic cells, transform light, usually sunlight, into electric current. Few power-generation technologies are as clean as photovoltaic (PV). As it silently generates electricity, photovoltaic produces no air pollution or hazardous waste, free of moving parts. Which reduces the maintenance cost of the system photovoltaic cells are semiconductor.

1.1 Principle of Photovoltaic Cell:

Two important steps are involved in the principle of working of solar cell. These are,

i) Creation of pairs of positive and negative charges (called electron hole pairs) in the solar cell by absorbed solar radiation.

ii) Separation of the positive and negative charges by a potential gradient within the cell.

1.2 Conversion Efficiency:

The maximum conversion efficiency of PV cell,

$$\eta_p = \frac{V \times I}{G \times A}$$

Where

η_p= Electric conversion efficiency of solar Panel without cooling

V = Maximum Voltage

I = Maximum current

G = Total Incident solar flux, 1000w/m^2

A = Area of PV Panel [1]

Electrical energy is one of the components of solar energy conversion process. A typical PV module has ideal conversion efficiency in the range of 15% the remaining energy is converted into heat and this heat increases the operating temperature of PV system which affects the electrical power production of PV modules this can also cause the structural damage of PV modules shorting its life span and lowering conversion efficiency. The output power of PV module drops due to rise in temperature, if heat is not removed [2]. The temperature of the solar cell generally reach to the 80^{0}C or more where when the solar cell is a silicon series solar cell. Various studies have been conducted in order to develop solar cell having improved PV conversion efficiency.in order to increase electric conversion efficiency of PV cell, it should be maintained at a temperature which is as low as possible. Therefore to remove the excess heat generated by PV module the thermoelectric system use to cool the PV module [3].

1.3 Working of Thermoelectric Module

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice-versa. Thermoelectric devices can convert electrical energy into a temperature gradient, this phenomena was discovered by Peltier in 1834. The application of this cooling or heating effect remained minimal until the development of semiconductor materials. [4].

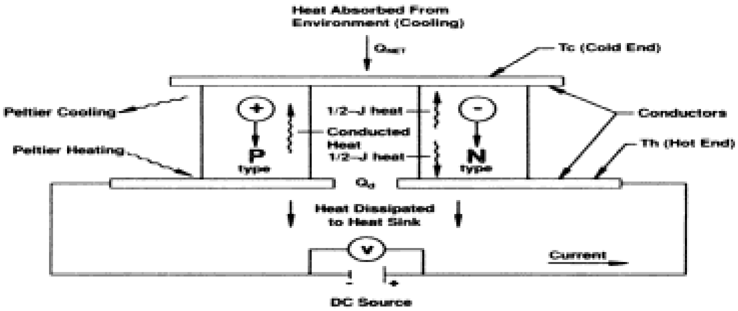

Fig 1: Working of thermoelectric modul

II. EXPERIMENTAL ANALYSIS

2.1 Working of Experimental set up:

Experimental set up consist of two Working methods

A) Without using thermoelectric cooling

B) With using thermoelectric cooling

2.2 Following are the component used for Experimental set up

Microcontroller 89C51 is used to analyze complete process ADC 0809 is interfaced with microcontroller at port 1 and value of voltage of solar panel and value of atmospheric temperature via temperature sensor LM35 interfaced with channel 1 and 2 of ADC 0809. LCD Display 16 x 2 is used to display the values of atmospheric temperature and voltage so that analysis is possible when channel 1 is selected and giving start of conversion pulse at pin 1.2 of microcontroller the ADC sends voltage data to LCD which shows the value of voltage possible when channel 2 is selected and giving start of conversion pulse ADC sends temperature data to LCD.

For controlling the temperature of Peltier module we are using relay which is connected to 2.1 of microcontroller. Relay is the electromagnetic switch and when temperature goes above 25^{0}C, relay operates and supply of Peltier module is connected so that it start cooling and when temperature is goes below 25 ^{0}C relay will off so the supply will be disconnected and cooling stops so that temperature will be maintained within the range continuously.

Fig 2: Experimental Set up without Using Thermoelectric cooling.

1-PV Panel, 2- LCD Display, 3- Microcontroller 89C51, 4- ADC 0809, 5- LM35.

Fig 3: Experimental Set up with Using Thermoelectric cooling

6-Peltier Module (cooler)

2.3 Design and Heat Transfer Analysis of Solar Panel

Design and Analysis of PV Panel has done in CFD Star CCM+8.06. In design part, the symmetric section of PV Panel of 0.9 watt has taken which has size of 0.1m×0.06m. On lower side of PV panel copper is selected as a heat conducting material due to its high thermal conductivity for attachment of thermoelectric module. The surface mesh using surface remesher and volume mesh using thin mesher has generated.

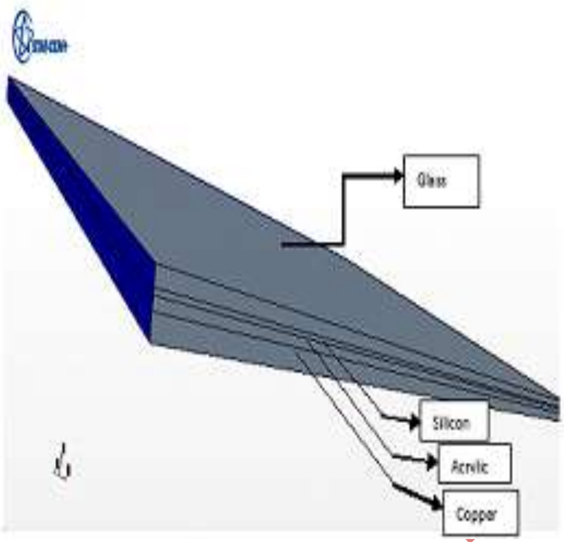

Fig 4- Geometry of PV Panel with Heat Conducting Material as a Copper

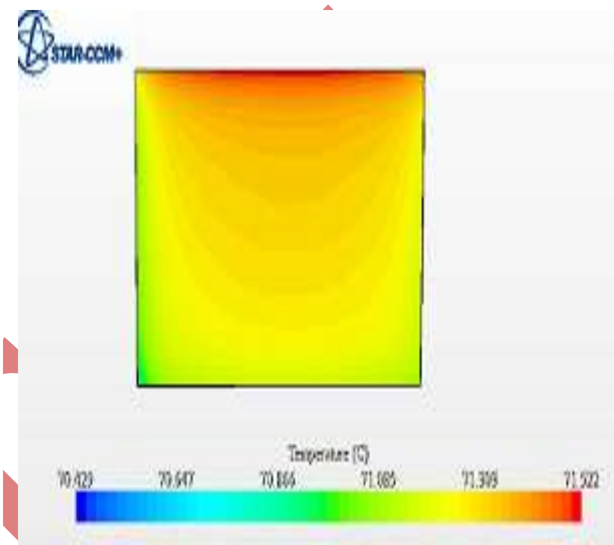

Fig 5:- PV panel with maximum temperature

Above fig 5 shows the temperature distribution over the panel surface the heat transfer analysis of panel without cooling of solar panel. Thermal Specification as Environment. Having atmospheric temperature of 40^{0}C. It is found that the temperature attained by panel is 71.522^{0}C by considering solar load on top glass of the panel.

2.4. Simulation in MATLAB/Simulink:

A solar cell is the building block of a solar panel. A PV module is formed by connecting many solar cells in series and parallel. [5]

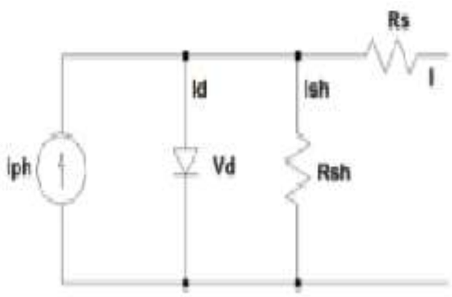

Fig 6:-Equivalent Circuit of PV Module

III. EXPERIMENTAL WORK

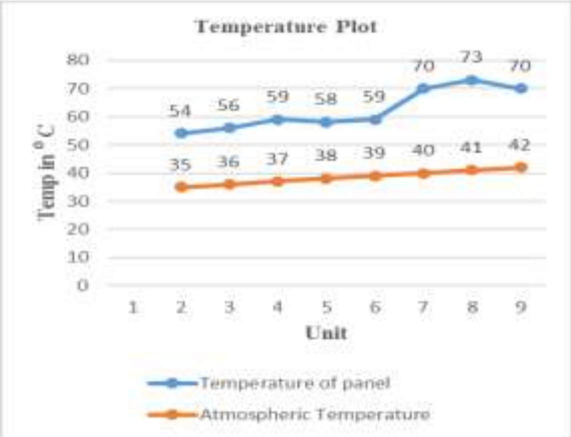

Fig 7: Experimental results of maximum temperature gained by PV panel

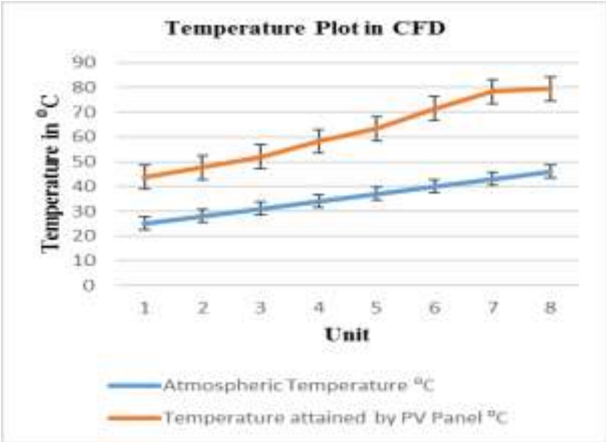

Fig 8: Analytical results in CFD for maximum temperature gained by PV panel

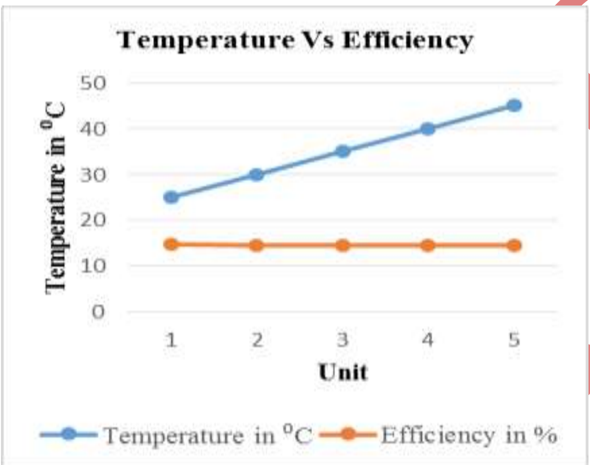

Fig 9: Analytical results MATLAB/Simulink

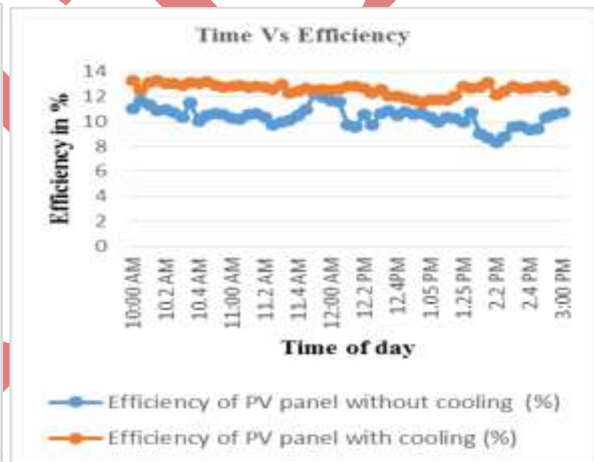

Fig 10: Experimental results of PV Panel with And without cooling

The experimentation were carried out on different days and various reading have taken to find the performance of PV panel without and with thermoelectric cooling. Various performance graphs have plotted based on experimental data. CFD analysis and MATLAB analysis also done to validate the experimental result shown in above fig7 to fig 10

IV. RESULTS AND DISCUSSIONS

4.1 Analysis in CFD:

Fig 8 shows the temperature attained by PV panel at various atmospheric condition, in CFD Star CCM+ 8.06. And results are found to be validate by comparing with Experimental values From the fig7, the heat transfer analysis of PV panel has done in Computational Fluid Dynamics (CFD) Star CCM+8.06 the similar kind of result has found out, as it has been found out by experimentally where at minimum atmospheric temperature 25^{0}C maximum temperature of panel obtained is 43.733^{0}C, at 31^{0}C is 51.947 ^{0}C and at 40^{0}C is 71.522^{0}C. Thus, result of maximum temperature attained by PV panel is found to be validate in CFD by comparing it with experimental results from fig 7.

4.2 MATLAB/Simulink Analysis:

In the MATLAB analysis it is found that as the temperature increases the efficiency of panel is decreases Fig 9 shows the analytical results of variation of temperature with electric conversion efficiency of PV panel. As the temperature of PV panel increases the electric conversion efficiency of panel going to decrease.

4.3 Experimental Analysis

Fig 10 shows the Experimental results of PV panel electric conversion efficiency with and without cooling at different atmospheric temperature and days. It has found that minimum and maximum electric conversion efficiency without cooling are 8.35% and 11.46%. At the same time when actual experimentation is carried out with thermoelectric cooling and minimum and maximum electric conversion efficiency are 12.26% and 13.27% respectively.

V. CONCLUSION

This Experimental paper work shows an application of thermoelectric cooling system for PV module for the enhancement of electric conversion efficiency and life of PV module. Results of the simulation shows that at low temperature 25^{0}C of the PV panel there is improvement in efficiency of PV module. The detailed analysis of the model indicates that performance and life enhancement of PV module could be achieved with 25^{0}C cooling without loss of power.

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