INCREASING THE EFFICIENCY OF THE SOLAR PANEL USING THERMOELECTRIC MODULE

THENNARASU.SP[1], VASANTHAKUMAR.V[2], VASANTHA RAJAN.N[3], VIJAY.G[4] MANIMARAN.M[5]

[1,2,3,4] *UG Students, Department of Mechanical Engineering,*

[5]*Assistant Professor, Department of Mechanical Engineering,*
K. Ramakrishnan College of Engineering,Trichy -621112.
E-mail: iniyavanthennarasu@gmail.com,vijayrojer850@gmail.com

ABSTRACT

Performance of solar panel decreases with increase in the temperature of the panel. Output power of PV module drops by 0.45% per ^{o}C rise in temperature if heat is not removed. Cooling of the modules would enhance the performance of the module. In order to cool this system thermoelectric system is developed. Thermoelectric module is attached at the back of PV module and it is operated in cooling mode. The role of TEC is to reduce the temperature of the PV cells, to increase the efficiency of the system, its power capacity and lifetime. The use of thermoelectric devices based on silicon material results in increasing efficiency of PV system of 3.6% with a maximum efficiency of 13.06%.

Keyword: *Thermoelectric cooling, thermoelectric module, Peltier-Effect, photovoltaic, efficiency.*

1.INTRODUCTION

Solar energy can be a major source of power & can be utilized by using thermal and photovoltaic conversion systems. India, receives solar energy equivalent to more than 5,000 trillion KWh per year, which is far more than its total annual consumption. The daily global radiation is around 5 kWh per sq. m per day with sun shine ranging between 2,300 and 3,200 hours per year in most part of India. Though the energy density is low and the availability is not continuous, it has now become possible to harness this abundantly available energy very reliably for many purposes by converting it to usable heat or through direct generation of electricity. Photovoltaic cell / Solar cell has a potential to convert the solar energy into electricity.

The solar cell works in several steps:

- Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.
- Electrons are excited from their current molecular/atomic orbital. Once excited an electron can either dissipate the energy as heat and return to its orbital or travel

through the cell until it reaches an electrode. Current flows through the material to cancel the potential and this electricity is captured.

- An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

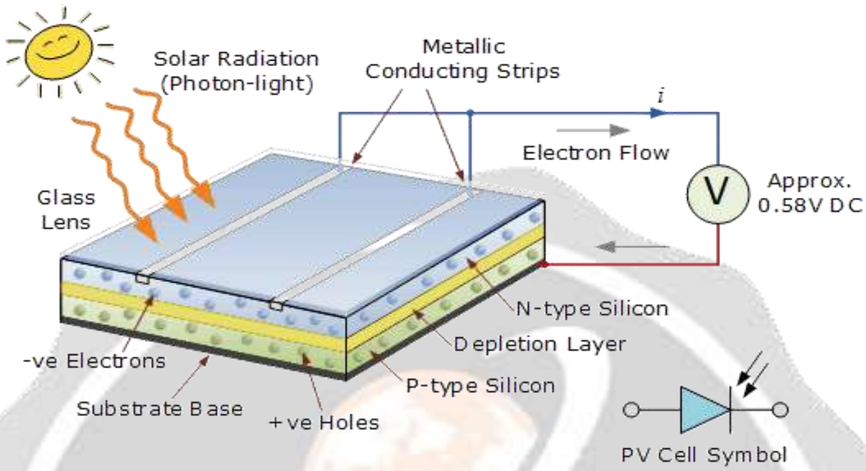

Fig 1.1 working of pv cell

2. NEED OF COOLING SYSTEM IN SOLAR PANEL

A general rule of thumb is that the efficiency of solar cell decrease with 0.5% of a every 1°C. This means that the efficiency of a solar cell could drop as much as 25%, as the temperature of the solar panel increases, its output current increases exponentially, while the voltage output is reduced linearly. In fact, the voltage reduction is so predictable, that it can be used to accurately measure temperature. As a result, heat can severely reduce the solar panel's production of power. Excessive heat can significantly reduce the output of a PV system. It is therefore extremely important to keep your solar panels well ventilated. Make sure the wind is able to cool on all sides, including the underside.

The Following are the type of cooling system used in PV module,

- Passive cooling system
- Active cooling system

3.Thermoelectric module:

Thermoelectric Cooler (TEC) is a semiconductor based electronic part incorporates a number of thermoelectric components, which are connected thermally in parallel and electrically in series. The thermoelectric elements are made out of a couple of p-type and n-type semiconductors. When electric current flows across the thermoelectric components, the heat is conveyed from the cold side to the hot side caused by the Peltier effect.

Two unique semiconductors, one n-type and one p-type, are used because they need to have different electron densities. The semiconductors are placed thermally in parallel to each other and electrically in series and then joined with a thermally conducting plate on each side. When a voltage is applied to the free ends of the two semiconductors there is a flow of DC current across the junction of the semiconductors causing a temperature difference. The side with the cooling plate absorbs heat which is then moved to the other side of the device where the heat sink is. The cooling ability of the total unit is then proportional to the number of TECs in it

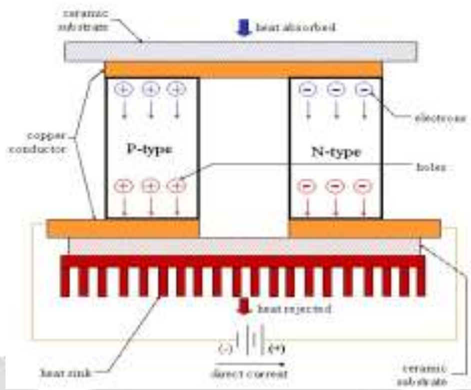

Fig 3.1 Principle of TEC

Some benefits of using a TEC are:

- No chlorofluorocarbons (CFC)
- Temperature control to within fractions of a degree can be maintained
- Flexible shape (form factor); in particular, they can have a very small size
- Can be used in environments that are smaller or more severe than conventional refrigeration
- Long life, with mean time between failures (MTBF) exceeding 100,000 hours

4. EXPERIMENTAL SETUP AND WORKING

In this method, first the solar panel is placed in the wooden stand at an optimum angle of 45˚(SE-SW).Because the solar panel are more productive when the sun ray's are perpendicular to the surface of panel. Then the negative electrode of thermoelectric module is set in contact with the medium to be cooled i.e, back side of solar panel with the help of thermal grease, while the positive electrode is set free that dissipates thermal energy into the external environment.

When a DC power is supplied in between the electrodes, the negatively charged side becomes cooler while the positively charged side becomes warmer. Thus the waste heat dissipate from the panel and the efficiency of panel get increased.

Fig 4.1Experimental setup

For measuring temperature, four sensors are connected at different points on the solar panel. The temperatures are noted using infrared thermometer. For measuring the voltage and current under various load. The readings are noted using digital micrometer. The readings are taken with and without TEC.

6.RESULTS AND DISCUSSION

The temperature is measured at five different points on the back surfaces of the PV module. It is observed that the difference of temperature between the five points of measurements on the photovoltaic module is very low. This fact confirms that the temperature is uniform in the photovoltaic panel. The solar radiation data demonstrates the rising and falling solar irradiation values during the time of experimentation. It is revealed that the radiation intensity on the subsequent days of the experimentation was not similar but however it seems to be fairly constant after 12 noon on those days. Since the conditions of maximum power prevailed at around 1pm, it is reasonable to consider constant solar intensity for the sake of clarity in the present analysis on the electrical performance of the PV module.

6.1 THERMAL CHARACTERISTICS

Thermal performance comparisons have been performed employing the hourly temperature data of PV module and ambient in which the variation of PV module temperature with time under different operating conditions is depicted.The profiles of temperature distribution of PV module is almost same for different cases of experiments i.e., without cooling and with cooling. This reveals the reliable functioning of the PV module under different operating conditions.

It is observed that the temperature of PV module without cooling is higher than the ambient temperature throughout the day with a maximum temperature of 54^{O}C at 1 PM. The temperature of the module is reduced to about 48.5^{O}C at the same time of around 1 PM when cooling is provided with TEC.

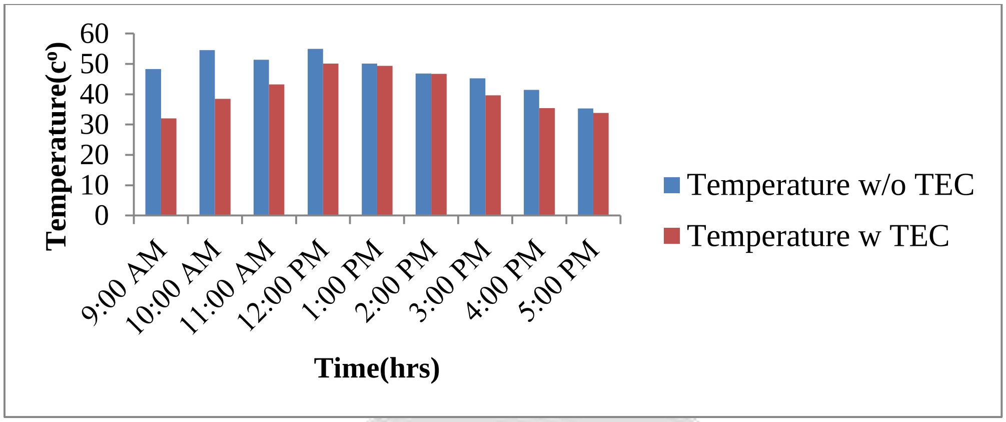

Fig 7.1 Comparison of Temperature

This graph indicate that the comparison of various temperature like without cooling with cooling atmosphere. From these curve clearly understood the Temperature of without cooling is high compare to with cooling.

6.2 ELECTRICAL CHARACTERISTICS

The variation of output power of PV module with time under different operating conditions is depicted in Fig (a). It is inferred that output power is maximum when the module is provided with cooling arrangement. A maximum output power of 9.18W is obtained with the use of cooling (TEC). However the output power is least at a value 9.18W without cooling arrangement. This indicates that the module temperature has a considerable effect on the output power of PV system.

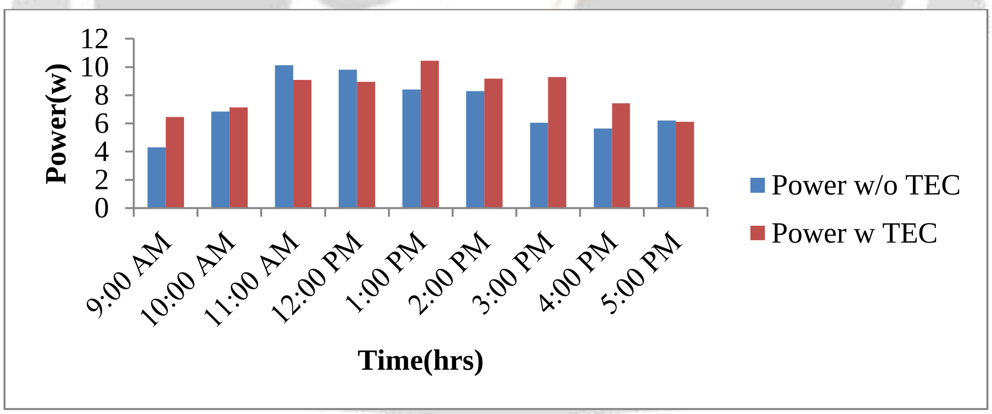

Fig 8.1 Comparison of power

It is very obvious from above graph, the output power of the module is increased with the use of TEC compared to the case of without cooling. The output power is about 9.18W when cooling is provided with TEC. Hence it is evident that maximum output power is obtainable when the PV module is cooled with TEC.

6.3 EFFICIENCY

A maximum efficiency of 13.06% is obtained with the use of TEC. Hence the experimental results indicate that the module temperature has a considerable effect on the output power and efficiency of PV system. This is due to the fact that when the temperature of the PV module increases, photons are excite which impends the uniform movement of electrons and this impedance reduces the power output which in turn reduces the efficiency of the module.

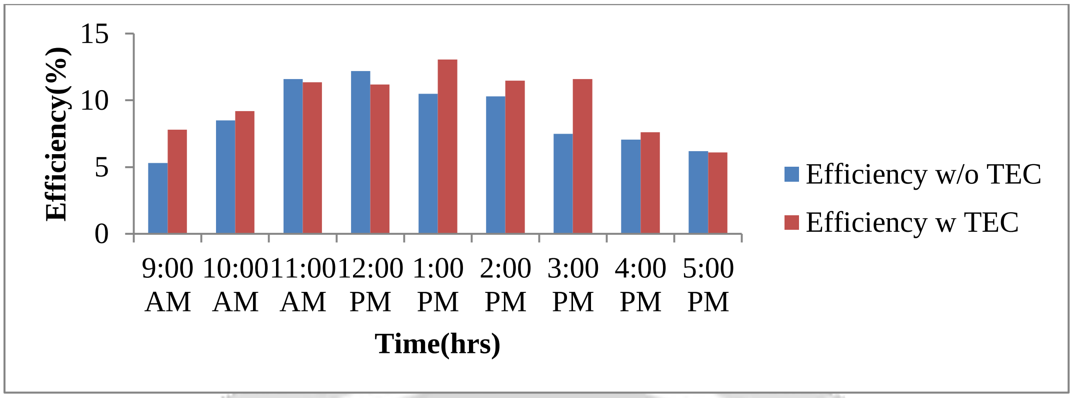

Fig **9.1 Efficiency Vs Time curve**

The variation of efficiency of PV module with time under different operating conditions is depicted in Fig (a). It is inferred that the efficiency is maximum when the module is obtained with cooling arrangement. From this Fig (a) the efficiency of PV panel without cooling is less than with cooling (TEC). The efficiency of cooling panel at 1 PM is 13.06%. But without cooling efficiency of PV panel 12.6 only. From these variations of efficiency indicate the cooling of PV panel increase the efficiency PV panel.

6.4 EFFICIENCY CALCULATION

Efficiency of without cooling (Normal PV) panel 12.6 %

Efficiency of with cooling (TEC) is 13.06 %

Increasing Efficiency = TEC - Normal PV

= 13.06-12.6

= 0.46%

Increasing Efficiency percentage = [(TEC - Normal PV)/Normal PV] x 100

= (0.46/12.6) x100

= 3.6 %

7. CONCLUSION

We investigate the effect of temperature on the efficiency of a conventional solar cell, then we calculate the amount of electric power generation in TE device resulting of waste energy (heat) in photovoltaic cell and finally calculate the efficiency of the hybrid system. The use of thermoelectric devices based on silicon material results in increasing efficiency of PV system of 3.6% with a maximum efficiency of 13.06%.

8. REFERANCE

[1]H.G. Teo, P.S. Lee, M.N.A. Hawlader. An active cooling system for photovoltaic modules. Applied 2012; 90: 309-315.

[2]Tony Kerzmann, Laura Schaefer. System simulation of a linear concentrating photovoltaic system with an active cooling system. Renewable Energy 2012; 41: 254-261

[3]Spertino F, D'Angola A, Enescu D, Di Leo P, Fracastoro GV, Zaffina R. Thermal–electrical model for energy estimation of a water cooled photovoltaic module, Solar Energy 2016, 119:40-133.

[4]C.S. Malvi, D.W. Dixon-Hardy, R. Crook. Energy balance model of combined photovoltaic solar-thermal system incorporating phase change material. Solar Energy 2011; 85: 1440–1446.

[5]Liu Z, Zhang L, Gong G, Li H, Tang G. Review of solar thermoelectric cooling technologies for use in zero energy buildings, Energy and Buildings 2015, 207:16-102(1).

[6]R. Daghigh, M.H. Ruslana, K. Sopiana. Advances in liquid based photovoltaic/thermal (PV/T) collectors. Renewable and Sustainable Energy Reviews 2011; 15: 4156-4170.

[7]Shirin Ahadi , Hamid Reza Hoseini , Rahim Faez, "Using of thermoelectric devices in photovoltaic cells in order to increase efficiency", Iran, 2014

[8]Arati Kane, Bharati Vidyapeeth College of Engineering, "Performance Enhancement of Building Integrated Photovoltaic Module using Thermoelectric Cooling", Delhi, India, vol.3, no.2, 2013

[9]Najafi H, Woodbury KA. Optimization of a cooling system based on Peltier effect for photovoltaic cells. Solar Energy. 2013; 91:152–60.