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Development And Testing Of Photovoltaic Panel For Cooling Under Natural Condition

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Abstract: Solar energy is the most abundant source of energy available on earth. This can be used by converting it into either thermal energy or electric energy with the help of collector & photovoltaic cell. PV cell is one of the most popular renewable energy products. It can directly convert the solar radiation into electricity which can be utilized to power household appliances. However, during the operation of the PV cell, only around 15% of solar radiation is converted to electricity with the rest converted to heat. The electrical efficiency will decrease when the operating temperature of the PV module increases. In this work, we developed two different cooling techniques (one passive & one active) to maintain the temperature of PV module & compared with conventional panel under natural convection. For the active cooling, wood wool is attached at the backside of the panel. The water is provided on that after 2 hours for heat removal. For the passive cooling, honeycomb fins made up of aluminium sheet of 0.8 mm thickness are used & pressed fit at the backside of the panel with the help of plywood & nut bolts. The experimental result shows 15% improvement in electrical efficiency than the conventional panel.

***Index Terms* - Photovoltaic panel, Renewable energy, Cooling, Efficiency**

I. Introduction

Photovoltaic (PV) is a method for electrical power generation by converting solar radiation into electricity using semiconductors without using any heat engine. Photovoltaic devices are simple in design requiring very little maintenance. They can work as stand-alone systems to give outputs from microwatts to megawatts depending on the application. The application of photovoltaic is very wide including water pumping, remote buildings, solar home systems, communications, satellites, space vehicles and for large power plants. Owing to this capability, the demand for photovoltaic is increasing all over the world and has begun to become economically competitive with conventional energy sources. The photovoltaic cell consists of at least two layers of semiconductor material, one with a positive and the other with negative charge. Some of the photons from the incidence sun light are absorbed by the semiconductor atoms which causes electrons of the semiconductor negative layer to be freed from the cell. The released electrons flow through a circuit and finally back into the positive layer to complete the circuit.The performance of the PV system is affected by several parameters including temperature. The part of absorbed solar radiation that is not converted into the electricity converts into thermal energy and causes a decrease in electrical efficiency. This undesirable effect which leads to an increase in the PV cell’s working temperature and consequently causing a drop of conversion efficiency can be partially avoided by a proper method of heat extraction.

Many researchers have investigated & proposed different methods to optimize the performance of Photovoltaic panel& to reduce the installation costs.Aram Mohammad Ahmad [1] improved the efficiency of panel by spraying the water at different flow rates (3 L /h, 6 L /h and 9 L /h)on the surface of the panel. The results showed that the efficiency of panel increased with a flow rate of 3 liters/ hour by 8.3 % than conventional panel.Abdolzadeh and Ameri [2] improved the performance of a photovoltaic water pumping system by spraying water over the top surface of PV array experimentally. They pointed out that the efficiency of a photovoltaic water pump system can be increased due to spraying water over the front of PV array. Furushima and Nawata [3] evaluated the performance of PV-power generation system equipped with cooling device utilizing siphonage. The study showed that the cooling of the PV modules increased the electrical power output and produced hot water which could be for heating purposes thereby contributing an energy efficient system. Pravesh Kumar et al [4] designed a cooling system in which array of water tube was fitted to back of solar panel to reduce its temperature and bring temperature to normal operating point by forced convection. The result showed a maximum photoelectric conversion efficiency difference of 2.6%, and the temperature decreased by 1-2 degree Celsius, the output power generation efficiency was increased by 0.5 to 1 % for the solar PV panel when using heat pipe for air-cooling. H.G.Teo et al. [5] studied hybrid PV/T solar system experimentally & used air to extract heat from the PV module rare surface. They pointed out with an active cooling; temperature dropped significantly leading to an increase in efficiency of solar cells to between 12% and 14%.R. Rajaram et al [6] investigated the use of phase change material (PCM) to maintain the temperature of panel close to the ambient temperature. The performance of solar panel improved by using the phase change material Cobalt Sulphate Hepthahydrate situated atthe back of the solar panel.The implementation of the phase change material under the solar panel has increased the performance of the solar panel by 5.02% and an increase in power production by

7.92%.Hongbing Chen et al. [7] conducted an experimental study to compare the performance of photovoltaic panel with & without fin cooling to investigate the effect of PV panel inclination, ambient temperature, and solar radiation & wind velocity on the electrical efficiency & power output. The study showed that the average poweroutput of the PV panel with fin increased by 1.8% - 11.8% than without fin.D.Bhaskar [8] investigated the effect of automatic water spraying on the performance of photovoltaic panel. He developed a control system consists of solenoid valve & microcontroller for spraying the water over the cells automatically if the temperature of the cell exceeds a certain limit. Experimental results showed the cells power was increased due to spraying water over the photovoltaic cells.

1.1 Objective

The objective of this study is to investigate the possibility of improving the performance of PV panel with different cooling under natural convection.The aims of this study are to:

- To maintain the temperature of PV cell.
- To improve the conversion efficiency of the panel.
- To design a system for cooling the solar cell in order to increase the electricity efficiency and also to extract the heat energy.
- To reduce the damage of the environment.
- To cool and clean the photovoltaic panels using the proposed cooling system in summer and winter season.

II. EXPERIMENTAL SETUP

The experimental setup consists of two identical but separate photovoltaic panels having area of 0.351 m^2. The maximum output voltage and current are respectively 17.7V, 2.09A and with maximum power output of 37W. Both the panels are kept side by side for experimentation.For the active cooling, wood wool is attached at the backside of the panel as shown in fig2.1. The water is provided on that after 2 hours for heat removal. For the passive cooling, fins made up of aluminium sheet of 0.8 mm thickness are used &pressed fit at the backside of the panel with the help of plywood & nut bolts as shown in figure 2.2. Fins are made in honeycomb structure to restrict the flow of air in order to improve the heat transfer rate from the PV panel.

Fig: 2.1 Panel with Wood Wool

Fig: 2.2 Panel with honeycomb fins

2.1 Procedure

1. One of the panels is modified with different cooling system & other panel is kept conventional.
2. Place both the panel side by side to have same atmospheric condition.
3. The panels tilt angle are set to 21° with respect to the horizontal, which is the local latitude of Nagpur (Latitude 21.1500° N, Longitude 79.0900° E), India, so as to face in the south direction.
4. Comparative study will be done keeping both the panel into same atmospheric condition.
5. Solar radiation is measured with the help of pyronometer to check the intensity of radiation. Wind velocity, temperature of panels, current & voltage is measured with the help of anemometer, thermocouple, and multimeter respectively.
6. The experimentation is carried out in winter as well as summer season from 9.00am to 3.00pm & data will be recorded after every 5 minutes of interval in the Month of March & April
7. The analysis is done by comparing the modified panel data with conventional one & will find out the conversion efficiency of panel & percentage of performance enhancement.

2.2Calculation

1. Incident solar radiation on the PV panel gives the input power (in W) to the system which is given by

$$Pi = Is \times Ac$$

2. The D.C. output power from the PV panel is given by

$$Po = V \times I$$

3. Panel efficiency (η) is the measure of how efficient the PV panel is in converting sunlight to electricity.

$$\eta = Po / Pi$$

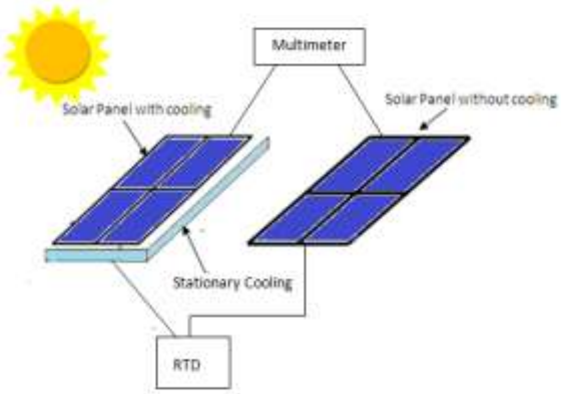


Fig: 2.3 Schematic view of experimental setup

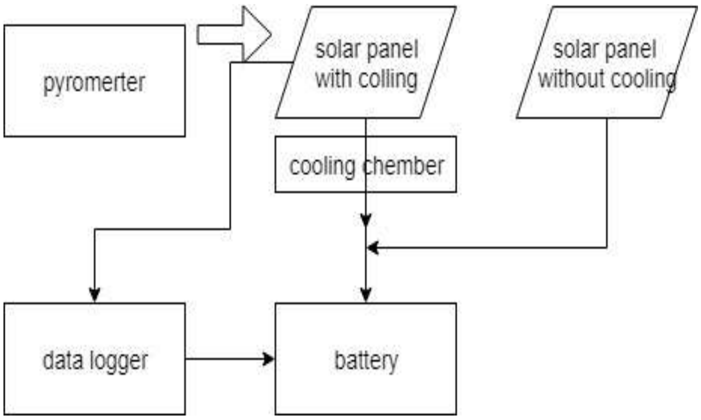
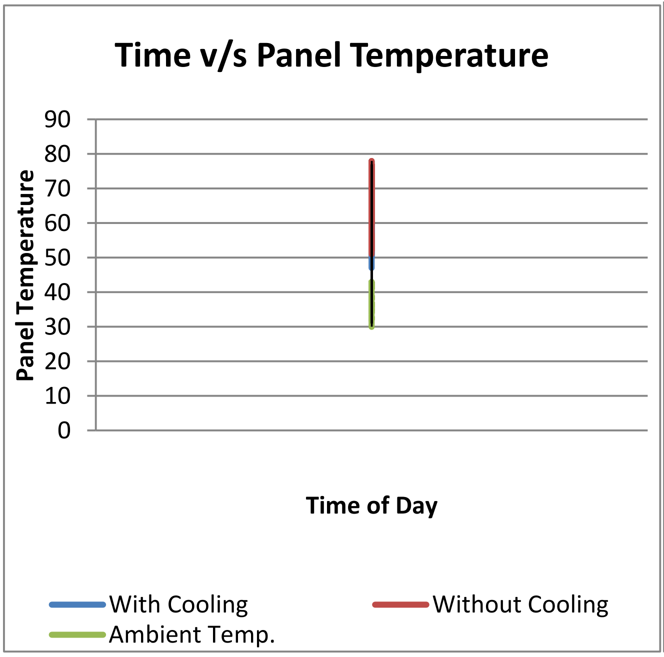


Fig:2.4 Block diagram of experimental set up of photovoltaic panels

Fig: 2.5Experimental setup(PV panel with & without cooling)

III. RESULTS AND DISCUSSION

The conversion efficiency of photovoltaic panel depends upon the temperature of individual cell. As the cell temperature increases its current increases but voltage starts to drop. Study reveals that by keeping the cell temperature into a certain limit, the conversion efficiency can be improved. For that purpose two different cooling systems were designed to evaluate the performance of PV panel, method- I (PV Panel cooling with wood wool), method- II (PV Panel with honeycomb fins). Readings of all the systems were taken separately in comparison with conventional panel & plotted the various graphs. The temperature & power developed (I,V) by all the systems are measured with the Multimeter & RTD respectively.



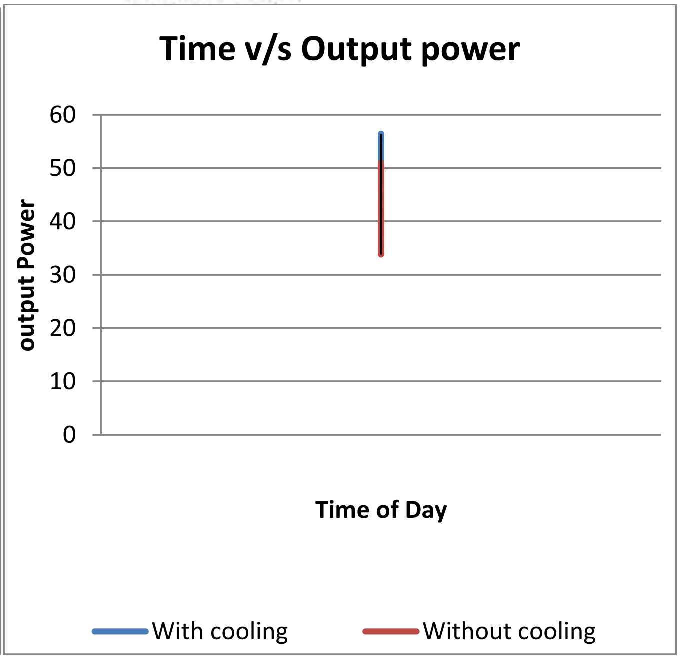
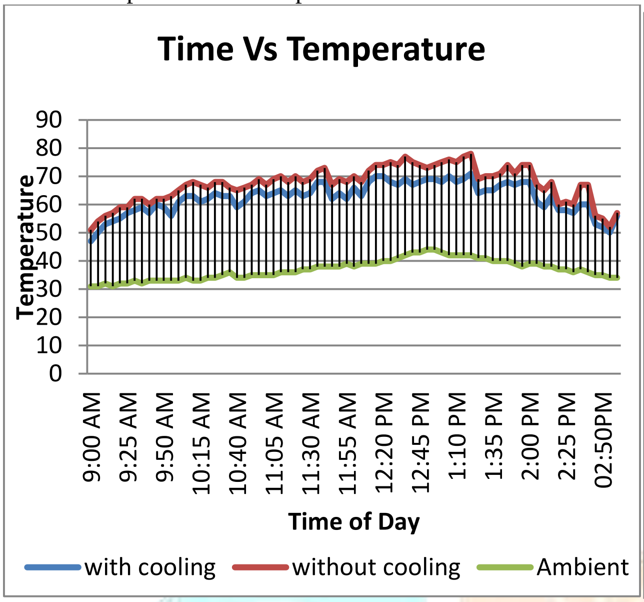


Fig: 3.1Variation of Panel Temperature of method-I with Time of day Fig: 3.2Variation of output power of method-I with Time of day

From the figure 3.1, it is clear that by providing wood wool at the backside of the panel, the temperature of the panel decreases as compare to conventional panel. The decrease in temperature tends to drop the current but increases the voltage. Experimental results indicate that the Output power of the modified panel is higher than the conventional panel.The average output power for PV panels with wood wool cooling is 48.01W and the average output power for the PV panels without cooling is 44.65 W. Therefore, one can see 4% improvement in power generation. For some hours the relative difference in Power output of panel is more than 10% as shown in figure 3.2. The improvement was peak from 11:00 A.M. to 1:00PM



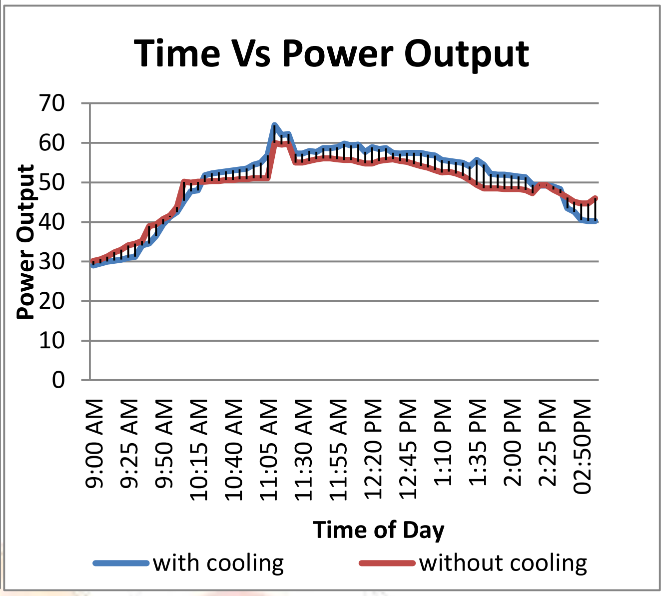


Fig: 3.3Variation of Panel Temperature of method-II with Time of day Fig: 3.4Variation of output power of method-II with Time of day

It was noticed that with proper wind velocity, the temperature of the panel with fin decreases than conventional panel but with poor wind velocity the temperature of the modified panel may increase. The figure 3.3 shows the temperature of modified panel less than conventional panel. This decrease in temperature decreases the voltage but increases the current developed by panel.The effect of the fin on the power generation of photovoltaic panels has been investigated. Figure 4.4shows the effect of the fin on PV panel's output power during the operational period. The average output power for PV panels with fincooling is 50.33W and the average output power for the PV panels without fin cooling is 48.99 W. Therefore, one can see 2-3% improvement in power generation for the case of using fin cooling .Figure 3.4 also shows that at the starting hours the conventional panel output power is more than modified panel. This means that if the air circulation is not proper we cannot get the proper result.

The efficiency of both the methods is presented in the figure 3.5. Electrical efficiency is a linear function of Panel temperature. The electrical efficiency of PV module declines with increase in temperature of module. During the experiment, cooling and non-cooling cases are considered.

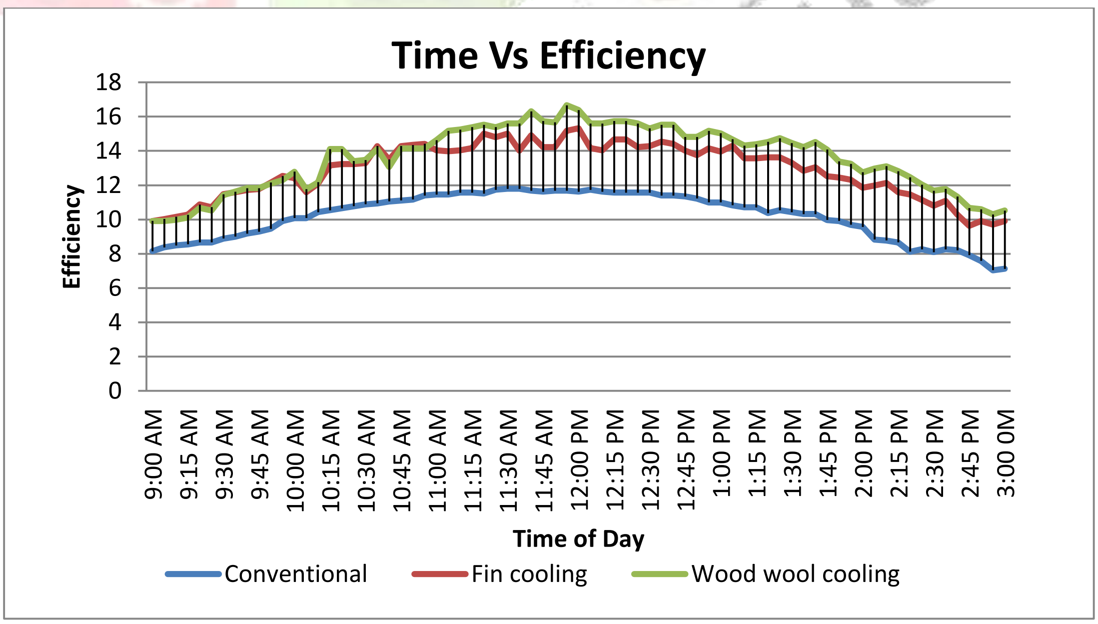


Figure 3.5: A comparison between efficiency of modified system & conventional system

It is clear from the figure 3.5, that the efficiency of PV panel with wood wool cooling & with fin cooling is almost same from 09:00am to 11:00 am but onwards that the efficiency of panel with wood wool cooling increases & become highest at 12 noon. The efficiency of panel by using method-I is increased by 15% as compare to conventional panel. The efficiency improved by method–II is 10%.Hence it is clear that the method-I is more efficient than the others.

IV. CONCLUSION

The described tests in this paper show that the output power from photovoltaic cells with wood wool cooling is higher than honeycomb fin cooling. It is shown that, by attaching the wood wool at the backside of the panel decreases the temperature of the panel which decreases the current but increases the voltage of the panel and consequently increases power output of the panel. It is also concluded that with poor wind velocity, the honeycomb fins may increase the temperature of panel & decrease the power output. Hence the wood wool cooling method is more convenient than honeycomb fins.

V. ACKNOWLEDGMENT

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