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Analysis of Efficiency of PV Panel – A Review

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Abstract – *Solar cell converts solar energy into electric energy. The output of the P.V. module is negatively impacted by the increase of surface temperature. As its surface is continuously exposed to sun the efficiency of panel decrease with increasing temperature of the surface of the panel. The present work deals with the comparative study on experimental investigation of thermal behavior of PV panels. An experimental setup is designed to analyze the output of PV panel using different cooling method. After getting result for various method we compared our results with the baseline solar panel.*

I- INTRODUCTION

In our industrial world, we live in an environment where we consume a great amount of energy. This contributed to the rapid decline in fossil fuels, which is the main source of electricity production. Due to this it became very essential to find sustainable sources if we are to reduce our dependence on fossil fuels. Solar is the most used non-conventional form of energy all over the world.

A solar panel absorbs radiation of Sun and converts it into to electricity. Photovoltaic (PV) panels are able to convert 13–20% of solar radiation into electricity, The remainder is converted into heat and causes the solar panel's temperature to rise. If the temperature increases too much, this can have a negative impact on the effeciency of the solar panel. The temperature coefficient of a solar panel indicates the extent to which the effeciency of a solar panel will decrease as the temperature increases. Solar panels produce maximum efficiency between 15°C and 45°C. As the temperature rises, the efficiency will drop and the solar panel will produce less energy. In order to compensate the efficiency decrement caused by the surface temperature, Cooling system can be utilized. This system can be attach at the front or at the back of the panel. Cooling system can be differentiate into two types.

1.1 COOLING METHOD

1.1.1 HEAT SINK

A heat sink is a passive heat exchanger that transfers the heat generated by a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device. A heatsink is designed to maximize its surface in contact with the cooling fluid around it, such as air. The speed of the air, the choice of material, the design of the projection and the surface treatment are factors that influence the efficiency of a heat sink. Thermal adhesive or thermal paste improves the performance of the heat sink by filling the air spaces between the heat sink and the heat spreader on the unit. A heat sink is generally made up of a aluminium or copper.

1.1.2 ALUMINIUM WATER CIRCULATION TUBE

Aluminium water circulation tube is an active cooling method in which water is used as a cooling material. In this method, water circulated on the back of the panel to maintain the panel surface temperature by means of a water pump.

II-METHODOLOGY

For the comparative study of thermal behavior of PV panels we compared the output power of the Baseline solar panel with heat sink cooling and aluminium water tube cooling system.

A solar panel of 25w 12v is used to carry out this experiment with dimension of 460mm in height and 300mm in width. The measurement is performed by using temperature sensor and Multimeter to measure current and voltage. The value of open circuit votage for the baseline solar is 17.6v. The value of short circuit current for the baseline solar is 0.52A.

Heat sink is designed by an aluminum plate with fins on it that is attached to the back of the solar panel. Fins are projections that increase the surface area from which heat can be radiated away from a surface. It have a very large surface area to dispurse the heat to the surrounding atmosphere as quickly as possible. Therefore, the use of aluminum heat sinks could provide a potential solution to prevent PV panels from overheating.

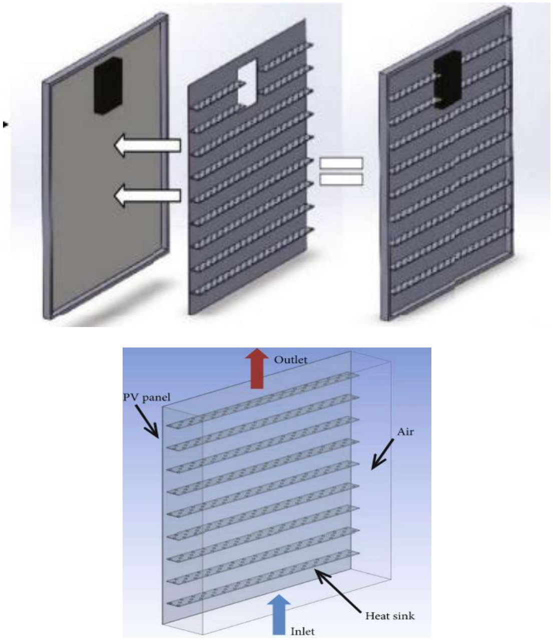


Fig. 1 Model of a P.V. panel with heat sink [5]

For aluminium water tube cooling system it is assumed that the maximum allowable temperature of the PV panel is 35°C. There will be temperature sensor attach to the surface of solar panel which will monitor the temperature. If the surface temperature goes beyond 30°C, Sensor will send the signal input to the microcontroller which will activate the cooling system. In the cooling system there is water tank connected to a peltier module which cools down the temperature of water in the tank. After input signal by microcontroller system will start pumping water through water tank with the help of water pump to aluminum water jacket which is attach with the panel. The water will continuously flow through this system of the PV panel till its temperature goes down to 30°C. The water flow through water jacket then, it returns back to the water tank such that the water cycle is closed. This design is used to acquire the minimal wastage of water.

Fig.2 Aluminium water tube

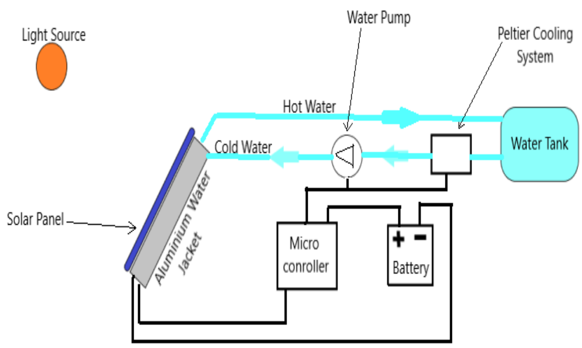


Fig 3 Working Principle & Diagram

In all the cases mentioned above the values of surface temperature of PV module, output current and output voltage are recorded at every interval of 180 sec. This values will be used to compare it with the other cooling method for better analysis.

Then, the power output for the solar PV panel was calculated using the following equation.

Power = Voltage * Current

After calculating the output power, Efficiency ratio and percentage of the solar PV panel was calculated by the equation.

Efficiency ratio = Power /Total Radiation * Area

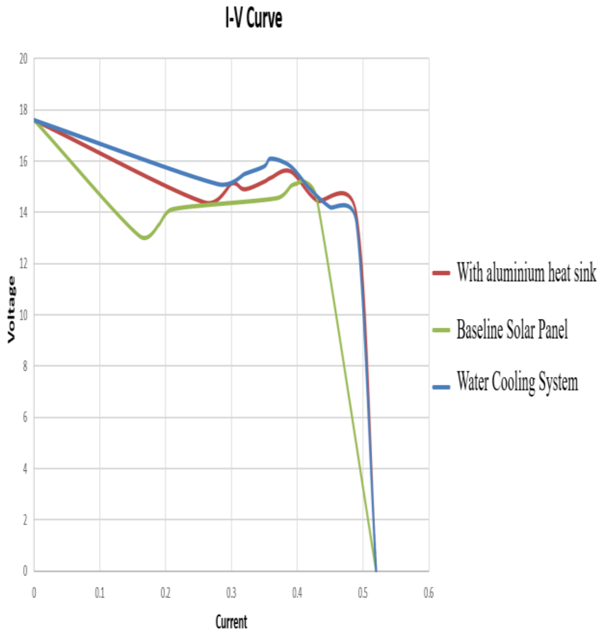
Hence, the efficiency percentage was calculated

Efficiency , % = Efficiency ratio x 100

.III - RESULT AND DISCUSSION

After getting all the values in different methods and comparing it we get the following results as

- The Average Surface temperature of the panel in case of water cooling is 7.81% less than the Baseline solar panel and in heat sink method it is decreased by 1.4% within short interval of time.
- The Average output voltage of the panel in case of water cooling and in heat sink method are increased by 6.1% and 3.5% with respect to Baseline Solar Panel.
- The Average Load current of the panel in case of water cooling and in heat sink method are increased by 21.8% and 12.5% with respect to Baseline Solar Panel.



In the above graph we compared all the experimented I-V curve of Baseline solar panel, panel with attached aluminum heat sink at the back surface and panel with water cooling system. This will help us to calculate the efficiency of solar panel in all three cases and to determine the outcome of this experimentation. In this we can also see the I-V curve for water cooling system is slightly above from both previous curves.

The over all efficiency of the Water cooling system to generate power was calculated and came out to be 29.1% more than the Baseline Solar panel and in case of Heat sink method it was improved by 16.41%.

Parameter	Baseline solar panel	Water Cooling	Heat sink
Average Surface Temperature (°C)	47.02	43.35	46.48
Average Output Voltage (v)	14.29	15.15	14.78
Average Load Current (Amp)	0.32	0.39	0.36
Average Power (watts)	4.57	5.90	5.32

IV - LITERATURE REVIEW

The output energy from the solar cells can be increased by reducing the operating temperature. In addition, it can also affect the lifetime of P.V panel by extending it and the total amount of energy produced will be further improved. Hardly 5–20% of the sun radiation entering the surface of Solar cell is transformed into useful energy, While the remaining radiation is either transmitted backwards or absorbed in the form of heat by the cell. Different Methods for cooling the P.V panel are discussed by Various authors.

Matias, Calebe Abrenhosa, Licínio Moraes et. al [1] presents the work of development of a cooling system using water in a commercial photovoltaic panel in order to analyze the increased efficiency by decreasing the temperature of panel. In his experiment, without cooling system, the panel reached upto 70°C and the power generate approximately is 62Wh and with the cooling apparatus, the module reached to 50°C and produced upto 77Wh approximately. Therefore by using cooling system on the module efficiency was increased by 16.66%.

Sunarno A. Rakino et. al [2] give report on Performamce improvement of solar panel output by proposing the combination of heat sink and water cooling system. It reduces the average surface temperature about 12.66%, 10.13% and 8.96% lower than basic solar panel. As results, the ouput voltage of proposed method is 21.49%, 4.66%, 8.34% higher than others. The output power of proposed cooled panel exerts 47.71% higher power than basic solar panel.

Kumar, Pravesh, and Rajesh Dubey et. Al [3] "Efficiency Improvement of Photovoltaic Panels by Design Improvement of Cooling System using Back Water Cooling Tubes." an experimental setup was designed in which array of water tube is fitted to back of solar panel to reduce its temperature and bring temperature to normal operating point A maximum photoelectric conversion efficiency difference is 2.6%, and the temperature decreases by 1-2 degree Celsius, the output power generation efficiency is increases by 0.5 to 1 % for the solar PV panel when using heat pipe for air-cooling.

Zainal Arifin et. al [4] Designed experimental setup in which array of water tube is fitted to back of solar panel to reduce its temperature. Before this both air-cooling model and water-cooling model conditions are investigated under normal operating condition. After getting result from various method, they are compared with the ordinary solar panel. A maximum photoelectric conversion efficiency difference is 2.6%, and the temperature decreases by 1-2 degree Celsius, the output power generation efficiency is increases by 0.5 to 1 %.

Pushpendu Dwivedi et. al [5] study offers an overview of the various cooling method and its key features Air-based cooling, liquid based cooling (forced and immersion), Water spraying, Heat pipe, Heat sink/fins/extended surfaces/heat exchanger. Study revealed that active water cooling is the easiest and effective cooling technique and should continue to be pursued.

Moharram, Khaled A., M. S. Abd-Elhady, H. A. Kandil, and H. El-Sherif et. al [6] "Enhancing the performance of photovoltaic panels by water cooling."The objective of the research is to minimize the amount of water and electrical energy needed for cooling of the solar panels, especially in hot arid regions. A cooling model was developed to find out that how long it will take to cool down the PV panels to its normal operating temperature. The cooling rate for the solar cells is 2 Celcius/min based on the concerned operating conditions, which means that the cooling system will be operated each time for 5 min, in order to decrease the module temperature by 10 Celcius.

Nicolas Barthet et. al [7] This study focuses on analyzing the thermal behavior of PV panels using finite element simulations (FEM). The main effective technologies for PV electricity consists in PV cells as stocking piles of thin films that are semiconductors dedicated to collecting electricity through the photovoltaic effect arising near the engineered p-n junctions. Without accounting, in a very detailed way, for the solar irradiance and the electrical model of the PV panel, which were treated in a separate work.

Kartini Sukarno, Ag Sufiyan Abd Hamid, Halim Razali, Jedol Dayou et. al [8] "Enhancing the performance of photovoltaic panels by water cooling." this paper discusses the comparison of output power and efficiency between continuous cooling system, cooling system every one hour and non-cooling system of solar photovoltaic panel. When continuous cooling system was active the output power was calculated as 68.8 Watt, With cooling system every one hour was found to be 65.11 Watt and 59.06 Watt for the non-cooling system. The maximum power output for continuous cooling system was 68.8 Watt, cooling system every one hour was 65.11 Watt and 59.06 Watt for noncooling system, respectively.

Sequeira, Anil Antony, Sawan Shetty, S. S. Sampath, and M. Chithirai et. al [9] "Improvement of power output from PV panel using water cooling system." . This research is to maximize the power generated by the PV solar panel using water cooling system in dry regions especially United Arab Emirates where temperature rises from 40˚ to 60˚ during summer. The panel can be cooled to attain maximum power and the cooling rate for the solar panel is 4.5°C per minute based on the operating conditions, which means that the cooling system will be operated each time for 10 minutes for 10°C.It is possible to attain 8.9 watt-hour energy output using the proposed cooling system compared to without using cooling system.

Sayran A. Abdulgafar , Omar S. Omar ,Kamil M. Yousif et. al [10]. In this work, the cooling of a photovoltaic panel via Water immersion technique is investigated. Experiment is done for polycrystalline silicon panel. A slight increase of efficiency is found when the water depth start increasing. Results are discussed; thermal drift has been reduced and the solar panel efficiency has increased by about 11% at water depth 6 cm.

W. Z. Leow, Y. M. Irwan, M. Irwanto, N. Gomesh and I. Safwati et. al [11] The purpose of this paper is to design a solar cooling system to decrease operating temperature of PV module in order to improve the efficiency of PV output power. The DC hybrid cooling system with PIC controller is a great solution for the problem of low efficiency of PV module in order to generate more output energy with respect to PV module without cooling system.

PROPOSED EXPERIMENTAL SET-UP

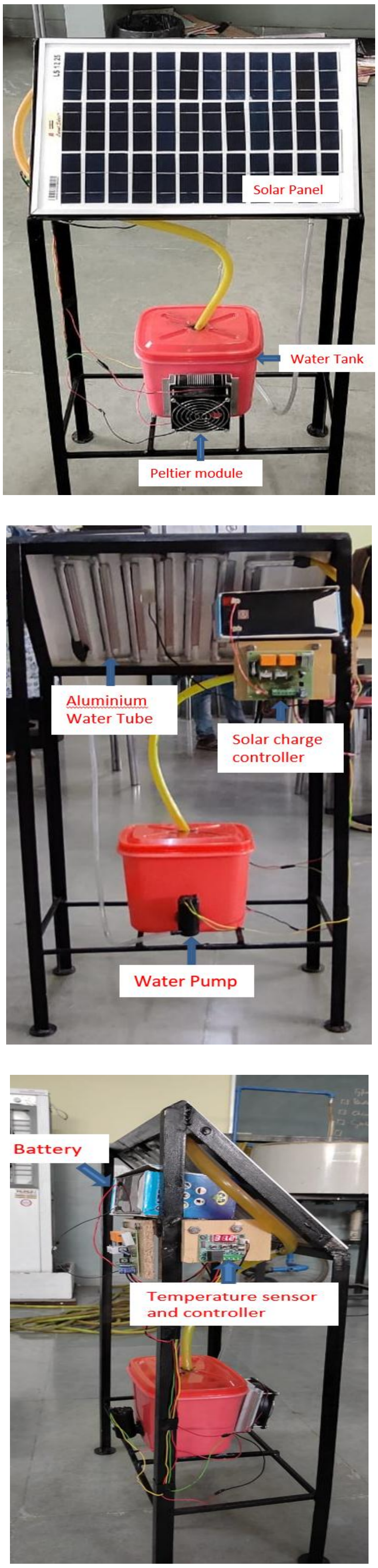


Fig: Experimental Set-up

V - CONCLUSION

- The Experiment revealed that active water cooling is the easiest and effective cooling technique and should continue to be pursued. However, active water cooling requires a steady supply of cool water, and it also consume energy to work.
- The passive cooling using heat sink of the P.V. system using natural convection has been observed to be the simplest way. Furthermore, the air is a less effective coolant than water but it does not consume any form of energy.

REFERENCES

[1] *Matias, Calebe Abrenhosa, Licínio Moraes Santos, Aylton José Alves, and Wesley Pacheco Calixto. "Electrical performance evaluation of PV panel through water cooling technique." In 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC), pp. 1-5. IEEE, 2016.J Siecker, K Kusakana, BP Numbi - Renewable and Sustainable Energy 2017 – Elsevier.*

[2] *Rakino, Sunarno A., S. Suherman, S. Hasan, and A. H. Rambe. "A Passive Cooling System for Increasing Efficiency of Solar Panel Output." In Journal of Physics: Conference Series, vol. 1373, no. 1, p. 012017. IOP Publishing, 2019.*

[3] *Kumar, Pravesh, and Rajesh Dubey. "Efficiency Improvement of Photovoltaic Panels by Design Improvement of Cooling System using Back Water Cooling Tubes." Int. J. Eng. Res. Technol 7, no. 01 (2018): 74-77.*

[4] *Arifin, Zainal, Dominicus Danardono Dwi Prija Tjahjana, Syamsul Hadi, Rendy Adhi Rachmanto, Gabriel Setyohandoko, and Bayu Sutanto. "Numerical and experimental investigation of air cooling for photovoltaic panels using aluminum heat sinks." International Journal of Photoenergy 2020 (2020).*

[5] *Dwivedi, Pushpendu, K. Sudhakar, Archana Soni, E. Solomin, and I. Kirpichnikova. "Advanced cooling techniques of PV modules: A state of art." Case studies in thermal engineering 21 (2020): 100674.*

[6] *Moharram, Khaled A., M. S. Abd-Elhady, H. A. Kandil, and H. El-Sherif. "Enhancing the performance of photovoltaic panels by water cooling." Ain Shams Engineering Journal 4, no. 4 (2013): 869-877.*

[7] *Barth, Nicolas, João Pedro Magalhães de Correia, Saïd Ahzi, and Mohammad Ahmed Khaleel. "Thermal analysis of solar panels." In Proceedings of the TMS Middle East—Mediterranean Materials Congress on Energy and Infrastructure Systems (MEMA 2015), pp. 441-450. Springer, Cham, 2015.*

[8] *Moharram, Khaled A., M. S. Abd-Elhady, H. A. Kandil, and H. El-Sherif. "Enhancing the performance of photovoltaic panels by water cooling." Ain Shams Engineering Journal 4, no. 4 (2013): 869-877.*

[9] *Sequeira, Anil Antony, Sawan Shetty, S. S. Sampath, and M. Chithirai. "Improvement of power output from solar panel using water cooling system." Global Journal of Advanced Engineering Technologies 5, no. 1 (2016): 58-63.*

[10] *Abdulgafar, Sayran A., Omar S. Omar, and Kamil M. Yousif. "Improving the efficiency of polycrystalline solar panel via water immersion method." International Journal of Innovative Research in Science, Engineering and Technology 3, no. 1 (2014): 8127-8132.*

[11] *Leow, W. Z., Y. M. Irwan, M. Irwanto, N. Gomesh, and I. Safwati. "PIC 18F4550 controlled solar panel cooling system using DC hybrid." Journal of Scientific Research & Reports 3, no. 21 (2014): 2801-2816.*