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Cooling of Photovoltaic Panel with Water Spray Technique

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Abstract: The main aim of this experiment is to show that the use of water spray technique for the cooling of Photo-voltaic Panel to improve its performance parameters. The increase in temperature of Photo-voltaic panel due to accumulation of heat affects the performance parameters of it negatively. It also focuses on the why adaption of water spray technique cooling method over the other conventional cooling methods is effective. The effective design of the cooling system for Photo-voltaic panel was made and the procedure to carry out the experiment is describe. Experiment was carried out to check the performance of Photo-voltaic panel. The data was collected and is mentioned accordingly, analysis of experimental data and the calculations were done to show the improvement in performance parameter. Improvement in the efficiency by using water spray technique cooling system is found to be 2.14%. At last the results are shown in accordance with performance of Photovoltaic panel and discussions is made. It can be concluded that cooling of Photovoltaic panel using water spray technique can be one of the effective methods to improve its performance.

I. INTRODUCTION

A PV panel converts the energy possessed by photons to electricity. This input energy increases with the intensity of sunlight. Thus, a bright, intense sun could be understood to be in favour of photovoltaic panels. But with an increase in intensity of sunlight we get an increase in temperature, Typically silicon solar cells coverts 10-20% of solar energy into the electrical energy and rest gets stored as heat. This increase in temperature, no doubt increases 2 the current produced by panel proportionally but it decreases the voltage produced logarithmically thus, giving a net decrease in power output of photovoltaic panel. Hence, the ideal condition of high intensity sun with low temperature is aimed to attain using a water spraying cooling system for photovoltaic panels. This study is the contribution towards the area of preserving and making efficient use of high grade electrical energy by making use of minimised work input method. The excessive heat, which gets stored in the PV panel can be utilised for the other purpose or application with suitable extraction methods suggested in design in this report

The aim of this project is to study the cooling techniques and come up with an effective and feasible design for the cooling system. The study tests for increase in efficiency of photovoltaic panel with the attached cooling system. It also focuses on the methods for testing the performance of any PV panel with or without cooling system. Along with these, it evaluates economic feasibility of the cooling technique.The study is carried out according to the weather conditions of Amravati district in Maharashtra, India. This study is contribution towards the area of preserving and making efficient use of high grade energy, electrical energy, by making use of minimised work input method. The excessive heat, a low grade energy, which gets stored in the PV panel can be utilised for the other purpose or application with suitable extraction methods suggested in design in this report.

II. METHODOLOGY

In this model the technique utilised is water spray for cooling of photovoltaic panel. The components are used to perform this project are pump, nozzles, temperature switch, pipe. Water inside the pipe gets sprayed all over the panel through nozzles, which is attached to the pipes at equidistance from each other. Pump is connected to the temperature switch, which is an electromechanical device which open and closes the electric supply at predetermined temperature electric supply is given to the pump and temperature switch to obtain desired readings. Same procedure has to be followed by adding baking soda into water.

A. Specific Heat

Specific heat is the quantity of heat required to raise the temperature of one gram of a substance by one Celsius degree.

In this project the specific heat capacity of water has to be increased by adding a baking soda into the water. After increasing the specific heat capacity of water, the heat absorbing capacity increases and also decreases the wastage of water. After adding baking soda into the water following changes occurs. Baking soda, also referred to as sodium bicarbonate ($NaHCo3$), combines with water, heat and carbonic acid are formed. This type of heat is known as an exothermic reaction rather than an endothermic reaction because an endothermic reaction requires heat to be added to cause the reaction.

Exothermic reactions occur when there is heat leftover. Since there is no heat being added to the water, it is an exothermic reaction. At this point, the carbonic acid is unable to remain stable. This is where the classic fizziness comes into play. When baking soda reacts in water, carbon dioxide is formed, causing the iconic fizz. Specific heat of water without baking soda mean value is obtained which is **2.99J/g** °C.

B. Plain Water

Sr. No.	Mass of water (g)	Temperature of water before heating (˚C)	Temperature of water after heating (˚C)	Time taken for reading (sec)
1	380	27	37	21 sec
2	433	26	36	27.18 sec
3	433	38	48	25.27 sec
4	433	47	57	23.55 sec
5	380	27	37	25.89 sec

Reading of plain water for measuring specific heat

Calculation

$Q = m\times C \times \Delta T$

$Q = W \times Time = 500 \times 21 = 10500$

$10500 = 380 \times C \times (37-27)$

$C = 10500 / 380 \times (37-27)$

$C = 2.76$ J/g ˚C

C. Water with Baking Soda

Sr. No.	Mass of water (g)	Mass of baking soda (g)	Temperature of water before heating (˚C)	Temperature of water after heating (˚C)	Time taken for heating (sec)
1	510	5	27	37	34.94
2	410	5	27	37	30.83
3	404	4	27	37	31.94
4	414	4	28	38	27.86
5	414	6	27	37	27.75

Reading of water with baking soda for measuring specific heat

Calculation:

$Q = m\times C \times \Delta T$

$Q = W \times Time = 500 \times 34.94 = 17470$

$17470 = 510 \times C \times (37-27)$

$C = 174700 / 510 \times (37-27)$

$C = 3.42$ J/g ˚C

III. EXPERIMENTAL SETUP AND PROCEDURE

Cooling System Consists of parts

1) PV Module of 125W Peak Power
2) Water Tank
3) Submersible pump
4) Temperature switch (STC 1000)
5) Nozzles for spraying water over the panel
6) Drain pipe for collecting water and return it to tank

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A. Experimental Setup

Water flows through pipes and it gets sprayed all over the PV modules for cooling through nozzles, which is installed at the upper side of the module, Afterward, the water used for cooling is collected at the bottom of the PV modules via drain pipe and it gets returns to the water tank such that the water cycle is closed. This design is employed to minimize the consumption of water which is crucial nowadays. The hot water releasing out from the PV panels is cooled due to mixing with the large amount of cold water inside the tank, and the ground, and therefore, the temperature of the cooling water is assumed to be constant.

Experimental setup of model

B. Experimental Procedure

In this project the model is established for the cooling of PV panel and for that purpose the parts which is used are pump, temperature switch, pipe, nozzle, temperature sensor and multi-meter for taking the readings of voltage and current.

First few readings of PV panel temperature were taken with the help of temperature sensor, after that the mean value of temperature is taken and the sensor of temperature switch is located at that point. On the temperature switch the initial value of the temperature is set and so as the difference value, temperature switch opens the electric circuit for the pump which is connected to temperature switch in parallel, when the temperature of the PV panel reaches the difference value, while performing the experiment the difference value is set at 5˚C pump starts working, the temperature of the Panel is increase by 5˚C then pump starts working as the water starts flowing on the panel and the temperature of the PV panel starts decreasing, when the temperature of the PV panel reaches to the initial temperature value the electric circuit closes by the temperature switch, this process gets continue in cycle.

The reading of the voltage and current is taken with the help of multi-meter. First the multi-metre is used as voltmeter and the readings for the voltage are taken, then the multi-meter is set as ammeter and the readings for the current is taken by implementing this technique, also the stopwatch is being used to measure the time taken for the cooling of PV panel.

IV. CALCULATION AND RESULT

A. Readings Without Cooling of PV Panel

Sr. No	Temperature (˚C)	Voltage (V)	Current (A)	Power (W)
1	47	19.56	6.21	121.46
2	48	19.30	6.26	120.81
3	50	19.52	6.24	121.80
4	51	19.49	6.25	121.81

Reading of PV panel without cooling

From above table consider,

Temperature = 48 ˚C

V_m = 19.30 V

I_m = 6.26 A

1) Output = $V_m \times I_m$

= 19.30 × 6.26

= 120.81 × 100

= 12181 W

2) Fill Factor, FF = $V_m \times I_m / I_{sc} \times V_{oc}$

= 19.30 × 6.26/ 22 × 8.1

= 0.6779

3) Efficiency = output / input

Consider solar irradiance as 1000 W/ m^2

P_{in} = I × A

= 1000 × 1.4224 × 0.6856

= 975.197 W

η = 12081 / 975.197

η = 12.38

B. Readings of PV Panel After Performing Cooling with Water

Sr. No	Initial Temperature (˚C)	Final Temperature (˚C)	Time (min)	Voltage (V)	Current (A)	Power (W)
1	41.9	46	2.5 min	19.81 V	6.38 A	126.38 W
2	44.4	49	2.7 min	19.51 V	6.41 A	125.05 W
3	45.2	51	3.2 min	19.72 V	6.40 A	126.20 W
4	46.9	52	2.2 min	19.67 V	6.39 A	125.69 W

Reading of PV panel after performing cooling with water

Consider a temperature form table,

T = 44.4 ˚C

V_m = 19.51 V

I_m = 6.41 A

1) Output = $V_m \times I_m$

= 19.51 × 6.41

= 125.051 W

= 12505.1 W

2) Fill Factor FF = $V_m \times I_m / I_{sc} \times V_{oc}$

= 19.51 × 6.41 / 22 × 8.1

FF = 0.7017

3) Efficiency η = output / input

Consider solar irradiance as 1000 W/ m^2

P_{in} = I × A

= 1000 × 1.4224 × 0.6856

= 975.197 W

η = 12505.1 / 975.197

= 12.82

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C. *Reading of PV Panel After Adding Baking Soda in Water*

Sr. No	Initial temperature (˚C)	Final temperature (˚C)	Time (min)	Voltage (V)	Current (A)	Power (W)
1	42	47	2.1 min	19.47	7.66	149.29
2	42.5	48	2.5 min	19.89	7.35	146.91
3	43.5	49	2.7 min	20.12	7.31	147.27
4	44	49	2.3 min	20.10	7.34	147.53

Reading of PV panel after adding baking soda in water

Consider temperature form the above table,

$T = 43.5$ ˚C

$V_m = 20.12$ V

$I_m = 7.32$ A

1) Output $= I_m \times V_m$

$= 20.12 \times 7.32$

$= 147.27$ W

$= 14727$ W

2) Fill factor $FF = I_m \times V_m / I_{sc} \times V_{oc}$

$= 20.12 \times 7.32 / 8.1 \times 22$

$= 0.8264$

3) Efficiency η = output / input

Consider solar irradiance as 1000 W/ m²

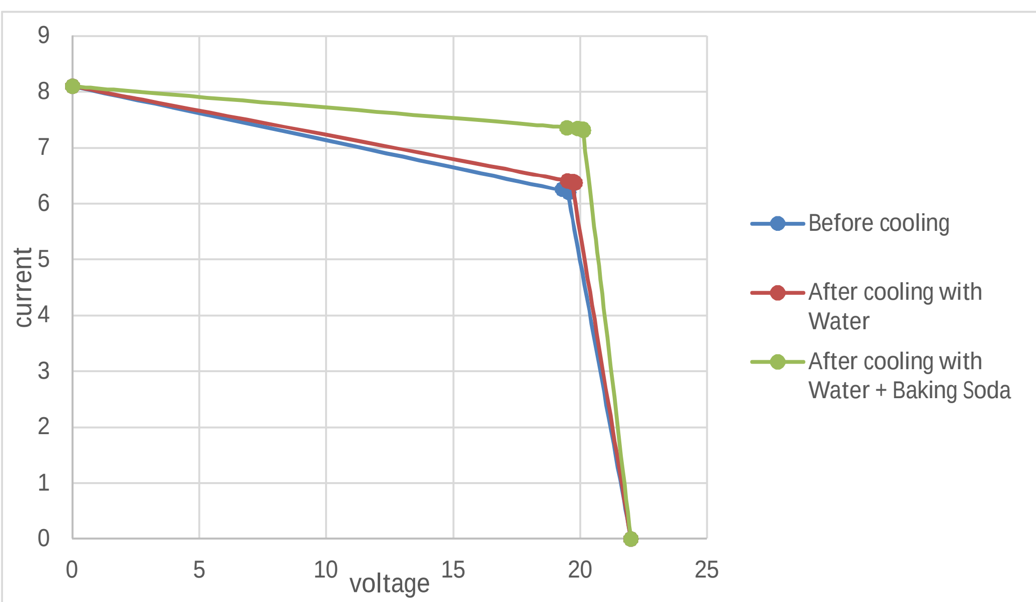
$P_{in} = I \times A$

$= 1000 \times 1.4224 \times 0.6856$

$= 975.197$ W

η = output / input = 14727 / 975.19

= 15.10



Current - Voltage Curve

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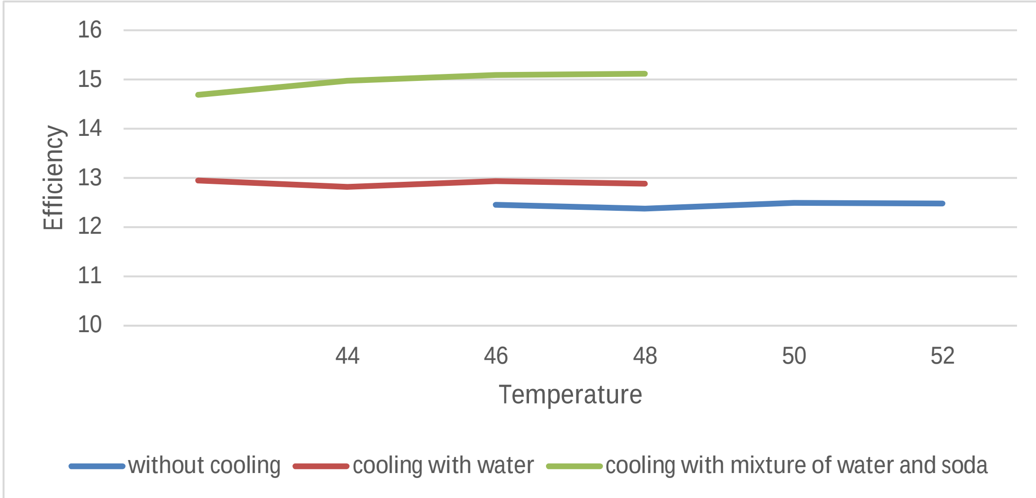
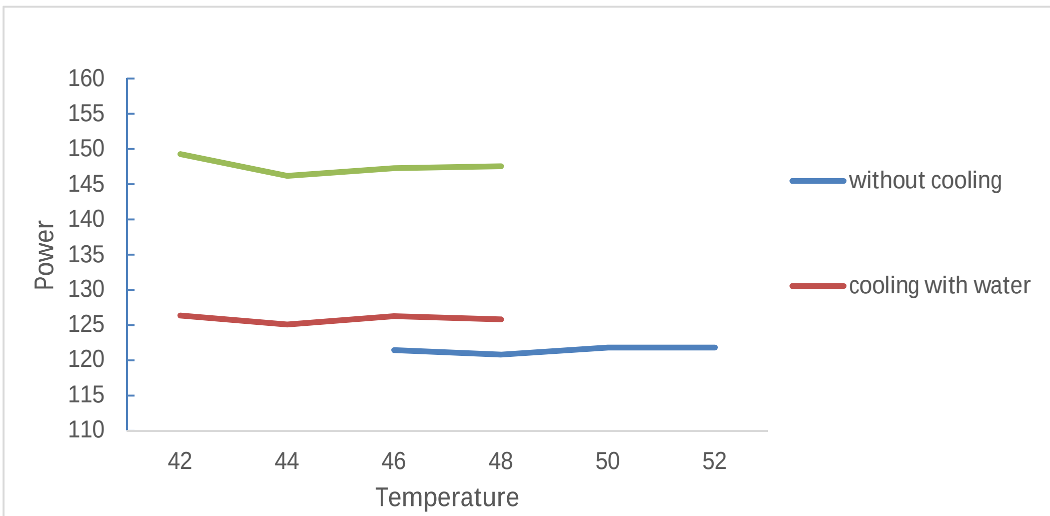


Temperature vs Efficiency



Temperature vs Power

V. CONCLUSION

The main purpose of the project was to increase the Efficiency and Power output of photovoltaic panel. The importance of this project was first realized while studying the output parameters of PV cells available in market. The input source of energy is abundant but the conversion efficiency was significantly low. Thus, an effort is made to improve this condition which has turned out to be successful. Firstly, Parameters of PV cell and effect of temperature on them were thoroughly studied. Different cooling systems were analysed out of which Ideas for the designs of cooling system using were formed. Among these the suitable design was selected which is used for the study. Procedures for measuring the output parameters of any panel were studied and a simple and easy method has been deduced out of it. A step-by-step guide is given in the report.

The study concludes the following points:

1) Increase in irradiation enhances the performance of PV panel while increase in temperature depletes it.
2) Photovoltaic panels benefit from the cooling.
3) The cooling system developed has increased the efficiency by 2.241 %.
4) The cooling system developed and maintain the reduction in panel temperature by 5°C.
5) An Increase in 25 watt per hour has been achieved in output power of panel.

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