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Comparative Experimental study on a Photovoltaic Panel with Low Cost Performance Improvement Techniques

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Abstract- The main objective of our project is to increase the efficiency of the solar panel by removing the heat from it. The photovoltaic (PV) cells suffer efficiency drop as their operating temperature increases especially under high insolation levels. The operating temperature is one of the important factors that can affect the efficiency of the PV panels. We rectified this problem by using two techniques which reduces the temperature of the panel. One is cooling the solar panel by water where heat transfer takes place and reduces the panel temperature and the other is placing the Low E-glass which allows only visible light and reflects the non-visible light. In the solar spectrum heat is produced due to non-visible light, temperature of solar panel is reduced by the reflection of non-visible light. Decrease in temperature of the solar panel results increase in the efficiency.

Index Terms— Photovoltaic (PV) cells, Efficiency, Cooling, Resistance temperature detector, low E-glass.

I. INTRODUCTION

Like all other semiconductor devices, solar cells are sensitive to temperature. Increases in temperature reduce the band gap of a semiconductor, thereby effecting most of the semiconductor material parameters. The decrease in the band gap of a semiconductor with increasing temperature can be viewed as increasing the energy of the electrons in the material. Lower energy is therefore needed to break the bond. In the bond model of a semiconductor band gap, reduction in the bond energy also reduces the band gap. Therefore increasing the temperature reduces the band gap. 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 heat energy and causes a decrease in electrical efficiency. This is 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. In a solar cell, the parameter most affected by an increase in temperature is the open-circuit voltage.

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II. METHODOLOGY

To increase the efficiency of the solar panel, temperature of the panel has to be reduced. To do that, we selected the solar panel having maximum power output 40W, DC 20V bulb and two multimeters. Load is connected to the terminals of the solar panel and one multimeter is also attached to the circuit to measure the current obtaining from the panel to the load. To measure the surface temperature of the solar panel, Resistance Temperature Detector (RTD) sensor is placed above the panel surface. To know the performance of the solar panel, we measured the current, short circuit and open circuit voltages in a period of intervals on clear sunny days and taken the maximum values obtained from all the days. From the values, power output and efficiency are calculated. Next, to decrease the temperature of the panel, two techniques are used in our project. One is cooling the panel by passing water and the other is placing the low E-glass on the solar panel. To cool the panel by water, tubes are arranged on the back side of panel and passed the water through the tubes. So that temperature of the panel can be reduced. By passing the water from back side of the panel, performance of the solar panel is calculated by taking the readings with the help of multimeters and RTD.Low E-glass is placed on the surface of panel which allows only visible light and reflects non-visible light. Performance of the solar panel is calculated with the arrangement of low E-glass. Efficiency of the panel with low E-glass and by passing water is calculated and it is more than the ordinary solar panel.

III. COMPONENTS USED

A. Solar Panel
B. Multimeter - 2
C. RTD (Resistance Temperature Detector)
D. Load - DC bulb
E. PVC Tubes
F. Water storage source and sink
G. Low E-glass

IV. EXPERIMENTAL WORK

A. Solar panel alignment:

- Direction - Along Latitude
- Angle - 17.5°

B. Circuit connection:

Circuit connection is connected in series. As shown in below figure1-1. Two wires from the solar panel one as positive and other negative is given directly to the load.

To measure the current coming from the panel, multimeter is joined in between the panel and the load. From the multimeter, we can measure the current. At the same time, short circuit current can be measured by another multimeter attaching the ports one at COM and other at volts. Then the output voltage can be measured from the below setup.

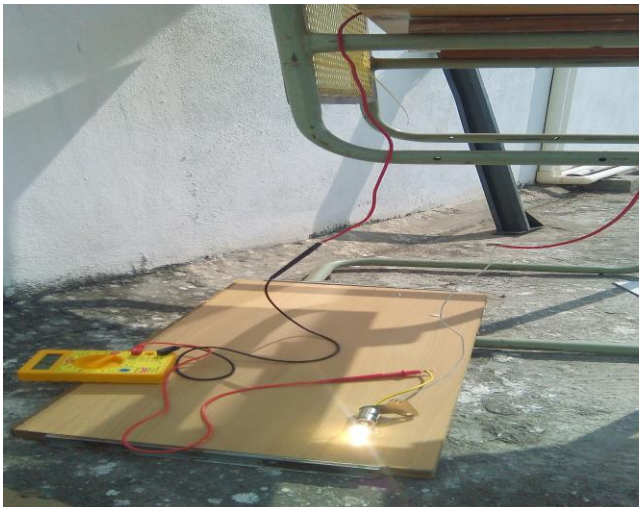

Fig: 1-1 Measurement of current by Multimeter

Fig: 1-2 Temperature of the solar panel can be measured by RTD

V. EXPERIMENTAL SET UP

Fig: 1-3 Experimental Setup

A. Performance of solar panel on a sunny day

Sl. No.	Time	Surface temp(°C)	Current (amp)	Voltage (sc)	Power output
1	9:00 AM	40.6	1.5	5	7.5
2	9:30 AM	42.2	1.72	5.1	8.77
3	10:00 AM	45.6	1.92	7.4	14.2
4	10:30 AM	50.8	2.01	10.8	21.70
5	11:00 AM	53	2.06	12.2	25.13
6	11:30 AM	55.2	2.1	12.7	26.67
7	12:00 PM	58.6	2.16	13.5	29.16
8	12:30 PM	62.3	2.19	13.8	30.22
9	2:00 PM	60.9	2.13	13.7	29.18
10	2:30 PM	57.2	2.08	13.3	27.66
11	3:00 PM	56.9	1.94	12.7	24.63
12	3:30 PM	54.4	1.7	10.45	17.76
13	4:00 PM	52	1.39	8.38	11.64

B. Arrangement of PVC Tubes

Tubes are arranged on the backside of the panel to pass water through them. Tubes are arranged like that to cover the maximum area of panel and to transfer more heat from the panel to water, then the output voltage and current increases. They can be arranged in many ways but to transfer more heat from the panel, tubes are placed as shown in the figure.

In this setup, water is passed from the source to the tubes with certain velocity and collected the water at sink. Heat is collected by the water which is passing in the backside of the panel. To measure output voltage and current, circuit connection is shown in below diagram.

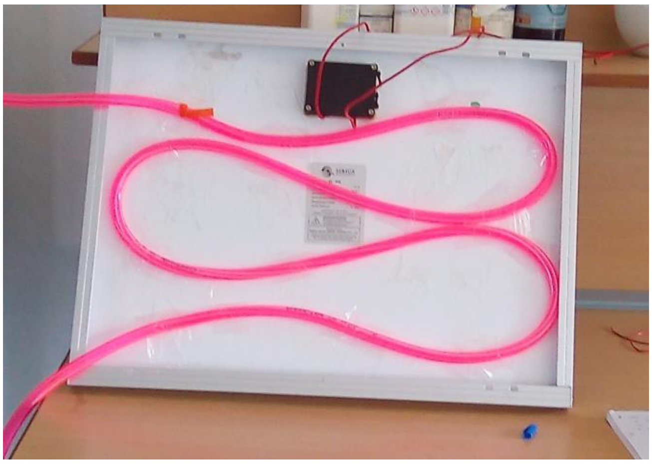

Fig. 1-4 Arrangement of water tubes on the back side of the Solar Panel.

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Q = ∏ / 4 * V * D^2 (1)

Q = Flow rate in m^3 / sec

V = Velocity of water in m/sec

D = Inner diameter of the tube we taken is 14mm

The velocity of the water flow through the tube is 1.5 m/sec.

C. Performance solar panel while passing water

Time	Surface temp (°C)	Voltage (sc) V	Current (amps)	Power Output (W)	Water inlet temp(°C)	Water outlet temp(°C)	Efficiency (%)
9.00 AM	42.6	5	1.4	7	27.3	27.8	1.79
9.30 AM	43	5.4	1.52	8.2	27.3	27.9	2.1
10.00 AM	44.2	7.9	1.76	13.9	27.5	27.8	3.57
10.30 AM	48.6	9.2	2.01	18.49	27.5	27.8	4.75
11.00 AM	51.4	10.2	2.15	21.93	29	29.7	5.63
11.30 AM	54.9	12.4	2.24	27.77	31.4	34.6	7.12
12.00 PM	58.1	13.7	2.36	31.74	32.5	36.2	8.15
12.30 PM	59	15.06	2.42	36.44	34.8	40.4	9.36
2.00 PM	55.1	14.21	2.26	32.11	36.4	44.9	8.25
2.30 PM	52.6	13.64	2.12	28.91	39.6	46.4	7.43
3.00 PM	50.6	12.6	2.06	26.06	36.5	40.6	6.69
3.30 PM	49.8	11.35	1.93	20.16	34.5	39.4	5.18
4.00 PM	46.4	9.61	1.74	14.58	32.7	36.5	3.74

D. Performance solar panel while placing Low E-glass

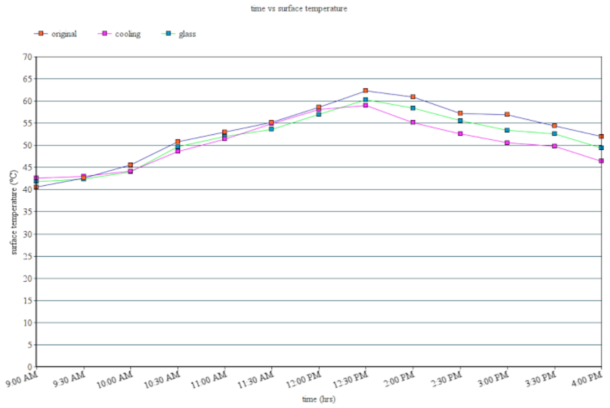
A Low E-glass is placed on the top of the panel.Low-e glass has a microscopically thin, transparent coating. It is much thinner than a human hair that reflects long-wave infrared energy (or heat). Some low-e also reflects significant amounts of short-wave solar infrared energy. When the interior heat energy tries to escape to the colder outside during the winter, the low-e coating reflects the heat back to the inside, reducing the radiant heat loss through the glass.

Time	Surface temp(°C)	Voltage(sc) V	Current (amps)	Power output(W)	Efficiency (%)
9.00 AM	41.8	5	1.45	7.25	1.86
9.30 AM	42.4	5.7	1.63	9.29	2.38
10.00 AM	44	8.1	1.84	14.9	3.83
10.30 AM	49.7	8.4	2.04	17.13	4.4
11.00 AM	52	9.6	2.1	20.16	5.18
11.30 AM	53.6	11.2	2.15	24.08	6.19
12.00 PM	57	12.6	2.19	27.59	7.09
12.30 PM	60.3	14.72	2.23	32.82	8.43
2.00 PM	58.4	13.9	2.18	30.3	7.78
2.30 PM	55.6	13.5	2.1	28.35	7.28
3.00 PM	53.4	12.5	1.96	24.5	6.29
3.30 PM	52.6	10.6	1.84	19.5	5.01
4.00 PM	49.4	8.89	1.65	14.67	3.77

IV. RESULTS & DISCUSSIONS

Comparing the performance of solar panel with and without the attachment of cooling system and Low E-glass. As the surface temperature increases, efficiency of the panel decreases. To decrease the surface temperature, two techniques are used, comparatively, cooling the solar panel by water reduces the panel temperatur***e*** rather than placing low E-glass, normal PV panel. Graphs are plotted according to the tabular column based on experimental setup.

A. Time vs Surface temperature graph



B. Time vs voltage graph.

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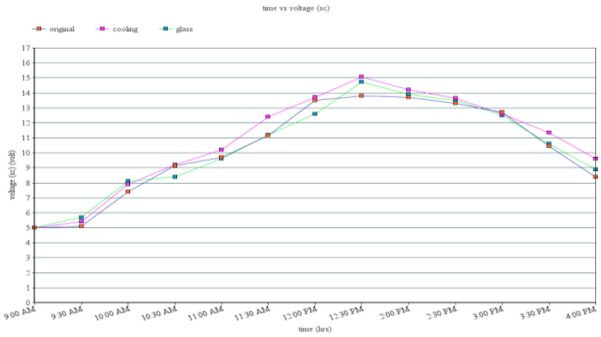
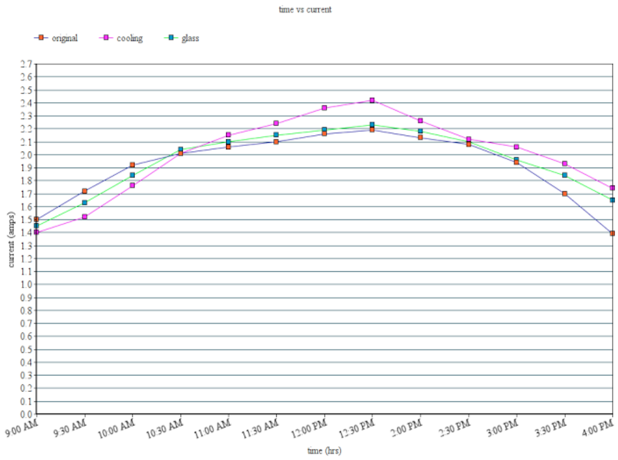
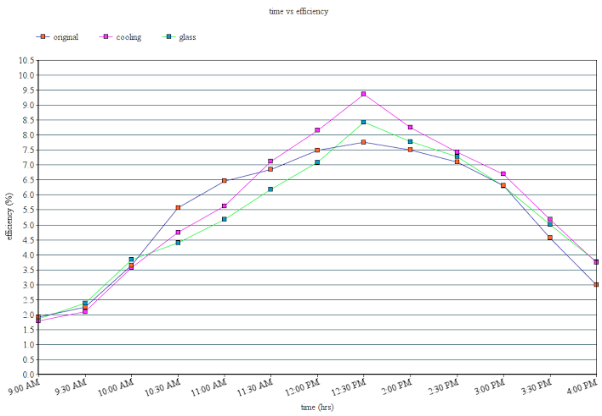


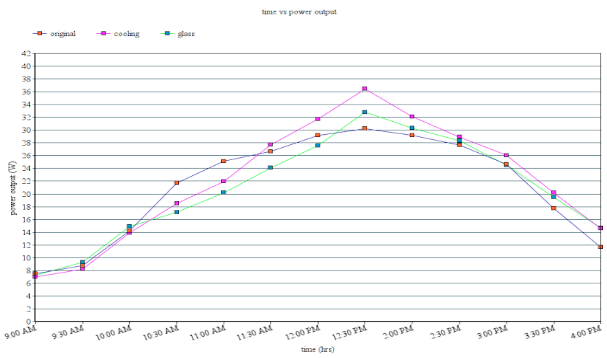
C. *Time vs current graph*



D. *Time vs power output*



E. *Time vs efficiency*



V. CONCLUSION

The temperature can be reduced to effectively increase the photovoltaic conversion efficiency of solar panel. Loss of efficiency due to increased temperature of PV panel can be reduced by the heat removed from the back surface of the solar panel. The performance of the 40W PV panel with the passive cooling technique, the operating temperature of the PV panel dropped significantly and an increase of 1.6 %(cooling system by water) and 1 %(Low E-glass) in efficiency was observed.

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