COMPARISION OF THREE DIFFERENT ANTI-REFLECTIVE COATING MATERIALS ON A SOLAR PANEL

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Abstract - *A conventional solar photovoltaic cell has a drop in electrical efficiency as the day passes by. This is due to the fact that the efficiency largely depends on the operating temperature. The surface temperature of the photovoltaic cell is inversely proportional to the electrical efficiency. As a consequence of this phenomenon, the efficiency of the solar panel is approximately in the range of 15-16% and it gradually decreases further when the day passes. To eliminate this drawback there are two methodologies employed in this research work. Coating a layer of polyethylene terephthalate serves as an anti-reflective material on the surface of the panel. This aids in collecting all possible photons emitted from the sun without much scattering and hence the utilization is improvised. Another technique is by circulating cooling water all over the panel so as to mitigate the surface temperature. The cooling water is discharged at the rate of 1L/hour. By employing this, the surface of the solar panel is almost maintained at a constant level of temperature and thus the electrical efficiency is also increased.*

Key words: **Solar energy, irradiation, antireflective coating, open circuit voltage, surface temperature**

1. INTRODUCTION

Solar energy is abundant in nature and is a clean source of energy. Solar panels are used to convert solar energy in electricity which can used for household purposes. According to many researcher if the amount of solar energy incident on earth is to be collected and converted into electricity it can power the entire earth of more than a decade. The production of electricity from solar energy do no releases any harmful gases. The intensity of solar radiation differs from place to place. According to Indian meteorological department solar energy incident on Chennai, Varanasi , Vishakhapatnam have the highest intensity. So in this place the solar panel work more effectively than compared to other places. But in various other places the solar radiation is incident at a particular angle so in order to obtain maximum efficiency various methods are followed some of them are by place the solar panel at an angle so that the solar radiation falls at 0° with the vertical.

The solar energy conversion efficiency of a standard solar panel is in the range of 15%-17%. This journal paper mainly discusses about how to increase the efficiency of the solar panel. The two methods which we use in this project are increasing efficiency by using an anti-reflective coating and by using a water cooling system. First of all usage of anti-reflective coating made up of material poly ethylene terephthalate(PET). By using anti-reflective coating made up of PET the efficiency is increased by 0.9% to 1.4%. This anti reflective coating reduces the scattering of the solar radiation incident on the solar panel. By absorbing more amount of solar radiation the amount of energy the solar panel collects increases increasing the efficiency and other method which we followed to increase the efficiency of solar panel is by using a cooling system. Generally as the temperature of the solar panel increases the efficiency of solar panel decreases so in order to overcome this problem we are using a cooling system to maintain the temperature of the solar panel. There are two types of cooling systems available they are water cooling and air cooling systems. Air cooling system is not so efficient as air is used as a convective medium and it requires more powerful motor to circulate air across the solar panel. So in this case we are using water

cooling system in this water is used and the cold fluid. The panel is kept at an inclination and water is released from the top of the panel using a motor so due to the inclination the water can flow over the solar panel cooling it. By using the water cooling system the efficiency of solar panel can be increased by 0.8% - 1.2%. Polyurethane is a type of thermoplastic. It is most versatile, modern, and reliable polymer that is being extensively used now-a-days. Its properties are intermediate between the characteristics of plastic and rubber. Compared to elastomers it have various benefits such as high tensile strength, high elongation and excellent load bearing capacity Poly methyl methacrylate (PMMA), is also known as acrylic glass. It is a transparent and rigid thermoplastic material which is widely used as a shatterproof replacement for glass. Compared to other types of polymers like polyesters or polyurethanes. Poly methyl methacrylate (PMMA) has many advantages such as High resistance to UV light and weathering, excellent light transmission, Unlimited colouring options over other polymers (poly urethane, polystyrene etc.). PMMA is produced by using monomer methyl methacrylate.

2. DESIGN

The solar panel which we used for this experiment is luminous solar panel. It is a 100W and 12V solar panel. It is made of polycrystalline cells type solar panel. The voltage at maximum power V_{max} is 18V and open circuit voltage is 22V. The current at max power i_{max} is 5.56A and short circuit current is 6.06A. It consists of back surface coating to obstruct the sun rays to from escaping the panel. And the panel is encapsulated with advanced ethyl vinyl acetate. And high strength light weight aluminium frame design for high torsion resistance against winds and snow loads. It has potential induced degradation for safety against substantial power loss due to stray currents triggered by certain climate conditions. It have excellent low light performance in low visibility in clouds, evening and morning. A anti-reflective coating is used to reduce the irradiance of solar radiation. And a water cooling method in which the water is circulated throughout the solar panel to maintain the temperature of the solar panel. The water pump we are using a 12V dc pump to pump water at a constant flow rate on to the solar panel. The anti-reflective coatings used are polyethylene terephthalate, poly urethane and PMMA. The fabrication of the solar panel is as follows.

3. FABRICATION

For the experiment we require an anti-reflective coatings which are made from polyethylene terephthalate, poly urethane and PMMA solutions separately diluted to 40% by volume by using ethyl alcohol and a the prepared solution is applied on the solar panel. Generally the thickness of this anti-reflective coating is in order of microns(10^{-6}m). The solar panel is kept on a inclined frame the angle of inclination of the solar panel frame is 90°-θ°. Where θ° is the angle at which the sun rays are falling on the solar panel. And a small water tank is connected to a 12V DC pump which is used in water filters and oxygen tanks in aquarium tanks. The tube is set along the top of the solar panel to facilitate the flow of water over the solar panel to maintain the temperature of the solar panel. The solar panel coated with anti-reflective coating and water cooling system is used for our experiment.

4. EXPERIMENTATION

A complete day session is required to perform the experiment. The second reading is noted at 7AM. Similarly, every reading has to be noted at an hour interval. The values of voltage keep increasing steadily until the maximum number of photons fall on the panel. In other words, the voltage increases until the time in which the maximum temperature is observed on a day. After this the values of open circuit voltage start to fall gradually.

Open circuit voltage is taken into consideration purpose to show the significant rise in voltage. In practical cases, voltage with loads connected has to be used. On a particular day, the value of maximum open circuit voltage occurs at around 1PM. Hence the experimentation for with coating and without cooling system gets completed. On another day, the experiments for with

both coating and cooling system are to be conducted. For this the power supply to the pump is switched on along with the temperature control unit.

The temperature to be set on the top of the solar panel for cooling system also plays a part in the efficiency of the panel. For the purpose of experimentation in this case, a threshold value of 40^0C is set on the temperature control unit. This means that when the temperature on the surface of the solar panel exceeds the set value in the temperature control unit, the pumps get actuated. The pumps draws water from the mild steel tank stored underneath the solar panel and circulates it. When the temperature again falls back in position, the temperature control unit recognizes this and disconnects the cooling system using a relay. So the cooling system has its effect momentarily. Once again when the temperature exceeds the set value, the same aforementioned process repeats. The noted values of voltage can be plotted in a trend line graph to see the behaviour of the solar panel in various circumstances and conditions on various times of the day. The graphs for both the conditions are plotted in a single graph such that the maximum voltage can be found to be observed at 1PM in both the cases.

Table 1: Voltage outputs for various values of irradiation for PET

IRRADIATION LEVELS (W/m^2)	VOLTAGE OUTPUT (without cooling) (V)	VOLTAGE OUTPUT (with cooling) (V)
200	14.304	14.312
400	19.894	20.003
600	21.241	21.414
800	22.301	22.487

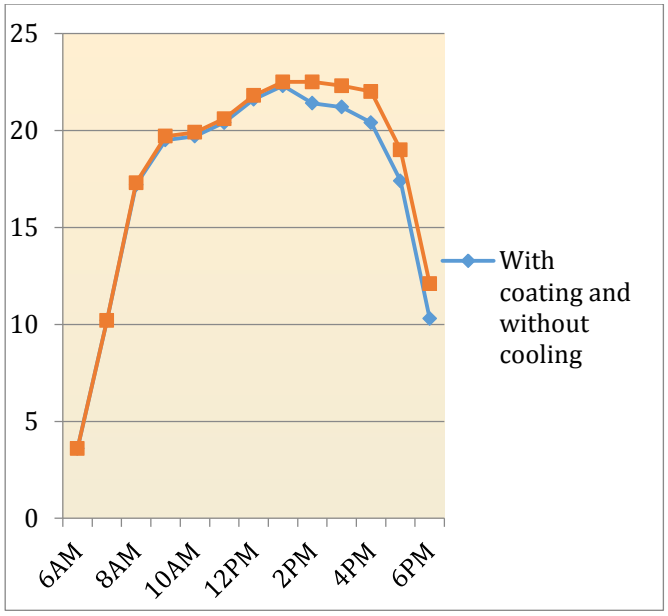

Fig 1: Trend line pattern for polyethylene

Table 2: Voltage outputs for various values of irradiation for polyurethane

IRRADIATION LEVELS (W/m^2)	VOLTAGE OUTPUT (without cooling) (V)	VOLTAGE OUTPUT (with cooling) (V)
200	14.3	14.307
400	19.854	19.902
600	21.167	21.264
800	22.358	22.487

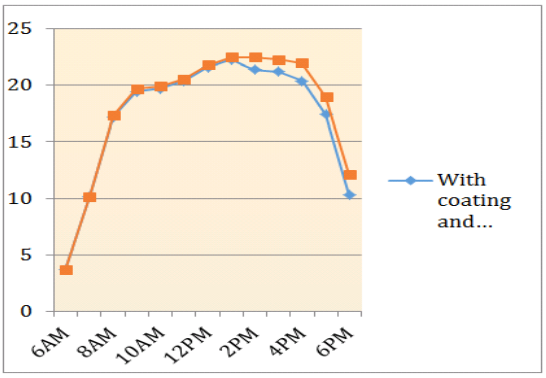

Fig 2: Trend line pattern for polyurethane

Table 3: Voltage outputs for various values of irradiation for PMMA

IRRADIATION LEVELS (W/m^2)	VOLTAGE OUTPUT (without cooling) (V)	VOLTAGE OUTPUT (with cooling) (V)
200	14.126	14.134
400	18.523	18.741
600	19.91	20.023
800	22.063	22.117

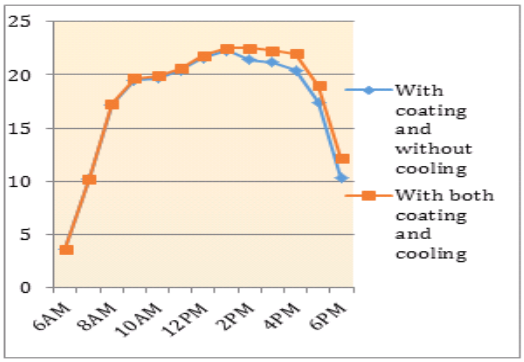

Fig 3: Trend line pattern for PMMA

5. CONCLUSIONS

The coating of polyethylene terephthalate was coated for about 1 to 1.5mm on the surface of the solar panel and a significant rise in the electrical efficiency of the panel was observed. In addition to that cooling water of discharge 1 litre/hour was recirculated by using a vacuum pump. In total an efficiency rise of 3.2% was found to occur. Whereas, for the coating of polyurethane the rise in efficiency was found to be 0.91% and for PMMA the increase in efficiency was found to be 2.63%.

It can be ultimately inferred from the graphs and table of voltage values that the observed readings are found to be higher than that of polyurethane and lesser than that of polyethylene terephthalate. Polyurethane was hydrophobic in nature but polyethylene terephthalate was not exhibiting hydrophobicity. Still the voltage produced by a polyethylene terephthalate coated solar panel was found to be higher. By having a compromise in the power production, a material with both hydrophobicity and intermediate power production can be chosen. It can be understood from the above experimentation that such a material would be poly methyl meta acrylate. For the irradiation value of 416.67 W/m^2, PMMA can be the best suited material for a poly crystalline solar panel.

6. ACKNOWLEDGEMENT

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7. REFERENCES

[1] Jalaly, Sadegh&Shahabadi, Mahmoud &Vahdani, Mostafa. (2019). Design, fabrication, and measurement of a polymer-based anti-reflection coating for improved performance of a solar panel under a specific incident angle.Solar Energy Materials and Solar Cells.189. 10.1016/j.solmat.2018.10.001.

[2]Demenkova, T.A. &Korzhova, O.A. &Phinenko, A.A.. (2017). Modelling of Algorithms for Solar Panels Control Systems. Procedia Computer Science. 103. 589-596. 10.1016/j.procs.2017.01.072.

[3]Balling, Peter & Christiansen, Jeppe& Christiansen, Rasmus&Eriksen, Emil &Lakhotiya, Harish &Mirsafaei, Mina &HanghøjMøller, Søren&Nazir, Adnan &Vester-Petersen, Joakim&Jeppesen, B. & Jensen, P. & Hansen, J. & Ram, Sanjay & Sigmund, Ole & Madsen, Morten & Madsen, Søren&Julsgaard, B.. (2018). Improving the efficiency of solar cells by upconverting sunlight using field enhancement from optimized nano structures. Optical Materials.83.10.1016/j.optmat.2018.06.038.

[4]Biwole, Pascal &Eclache, Pierre &Kuznik, Frédéric.(2013). Phase-change materials to

improve solar panel's performance.Energy and Buildings. 62. 59–67. 10.1016/j.enbuild.2013.02.059.

BIOGRAPHY

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