International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 03 | Mar 2020 www.irjet.net p-ISSN: 2395-0072

Ameliorate the Performance of PV Module by Inventing Heat Dissipation System

Abhishek Deshpande[1], Amartya Musandi[2], Pranav Joshi[3], Swapnil Nikam[4], Sachin S. Morti[5]

[1,2,3,4]Students, Department of Mechanical Engineering, Sant Gajanan Maharaj Rural Polytechnic, Mahagaon.
[5]Lecturer, Department of Mechanical Engineering, Sant Gajanan Maharaj Rural Polytechnic, Mahagaon, Maharashtra, India.

---***---

Abstract - *The recent trend of non-conventional energy sources has increased the demand of solar PV system for electricity production in domestic as well as commercial applications. These systems are very convenient to handle and maintain. These are clean and pollution free sources for the generation of electricity. Considering the increasing demand, the drawbacks of these systems must be worked out, in order to improve their overall output. The solar panel consists of PV cells or PV modules. These modules are very sensitive to temperature. While absorbing the sunlight to convert it into electricity, PV modules also absorb heat from solar irradiation. The heat is not easily dissipated from the modules and is situated in them for a long time, causing their electrical resistance to increase. This drops the output wattage of the panel, causing significant drop in efficiency. This problem mainly occurs in solar power plants in desert regions or dry regions. The main agenda of this research study is to invent a passive heat dissipation system, to dissipate heat from the solar panels, and to increase their power output. Aluminium heat sinks and thermal grease are used to construct the dissipation system. Epoxy resin has been used for fitting the heat sinks. The system is tested on a domestic solar panel, giving an average 2.96 % of efficiency growth.*

***Key Words*: Heat Dissipation System, PV Module, Solar PV systems, Overall Efficiency etc.**

1. INTRODUCTION

Today's world is the world of technology. Technology is gaining a lot of space in human's life. Some years ago, messages were sent to each other through letters. Today, mobile phones and electronic communication gadgets are used. Film cameras were being used film to take shots. That had been taking week to develop the photos and print hard copies. Today, high end digital cameras with electronic CCD and CMOS sensors are used. This technology requires energy to work. Energy is the heart of any electric and electronic system. Without energy, no any mechanical system will function. Without energy, no industries will run. Energy is the fuel of universe.

This energy is required worldwide to run all the human creations. Basically, all this energy is converted, stored and utilized in different forms by human being. Conventionally, energy is made from utilization of fossil fuels like coal, oil, natural gas and others. But these sources are depleting in nature. As their use is increasing day by day, they are depleting very fast causing a serious energy shortage. This problem is a worldwide crisis known as energy crisis. This problem is very serious because there are no efficient energy sources as conventional ones and those which are non-conventional are not much economic with respect to efficiency.

There are some sort of non-conventional and renewable sources of energy such as wind energy, solar energy, geothermal energy and tidal energy. But these sources are not that much efficient as the conventional ones. They are also expensive to manufacture and not give much power as that of conventional ones. But, they can be redeveloped and customized in order to get most of the energy from them. Also, if they are redesigned properly, they can be manufactured at low cost.

Most widely used and foreknown energy is solar energy. Mainly, electric and heat energy is produced from this source. Solar panels are used for these purposes. As these panels are very durable and lightweight, they are much more used for electricity production. They come in different power ratings, qualities and different forms. Silicon crystals are used with some doped materials to form a semiconductor in order to convert photons into electrical current. This is the working principle of solar panels. The semiconductor so made is known as a PV (photo voltaic) cell.

Every photo voltaic cell has several different properties which contribute a lot to its working pattern, such as temperature, humidity, doping materials, doping method, direction of sunlight, reflectivity, and resistance. They also matter while setting solar panels for power production. Several techniques are implemented in order to prevent energy loss from these panels, and to improve their design. But, still there are some problems which must be overcome to get more energy and increase efficiency.

Solar PV modules are being used in a large scale today, and will be used more in future. They are very effective and convenient way of harvesting nature's free energy source. Therefore development should be made in Photovoltaics in order to make it more affordable and efficient. Considering this future scope, performance improvement of PV modules is kept as main agenda of this research.

2. PROBLEM STATEMENT

When the PV module absorbs light energy along with heat energy from solar irradiation, light energy is converted into electric potential. But, the heat is not utilized, instead, it situates in the module, increasing its electrical resistance. This leads to loss of conversion ability.

Temperature increase causes efficiency drop of the PV system. The efficiency drop seems to be very low with respect to low power rated panels, but, in case of high power rated panel, this power loss is much more. Also, most cooling systems for solar panels include water and pump sets. But, it consumes a lot of power. So, a system with passive cooling ability without water must be implemented along with PV system for its cooling.

3. OBJECTIVES AND SCOPE

The main objectives of this research are :

1. To increase efficiency of solar PV systems when they suffer from high temperature ranges.
2. To develop a cooling system in order to reduce temperature of PV modules.
3. To construct an economically convenient cooling system, to increase cost effectiveness.
4. Considering water crisis, redesign cooling techniques to use much less water.

Considering the energy crises and increasing use of non-conventional sources, use of these sources must be increased; this will also help to reduce pollution. But, the initial cost of non-conventional energy sources is so high. Development of non-conventional sources is essential in order to reduce cost and increase their power output. This project is an attempt for further development in solar photo voltaic systems, for increasing the efficiency.

There are several applications of solar photo voltaics. Mainly, these types of systems are used in areas where good and uninterrupted solar irradiations are present. Such regions are generally desert regions, where light is present in ample level, but temperature is also high, that causes the loss in efficiency. Therefore, it is required to invent the effective heat dissipation system for the PV module. Also, due to lack of water in those areas, water cannot be used for cooling. So, cooling system without water is considered in core designing.

4. METHODOLOGY

4.1 Study of the topic & defining the objectives

Solar energy is one of the most fundamental and non-diminishing source of energy on the earth. Considering the future scope, the topic about performance improvement of PV modules was selected for research. A detailed study on the topic was performed in order to define the objectives. After the study process, objectives and problem statement were defined. On the basis of these definitions, designing process was carried out.

4.2 Designing and material selection for the heat dissipation system

The most prominent parts of the heat dissipation system are heat sinks. Focus is made in order to select the material and surface pattern of the heat sink. Overall weight of the heat sinks is considered. The material is selected on the basis of its rate of heat radiation as well as conduction. Aluminium, being a good radiator as well as conductor of heat, is selected for the fabrication of heat sinks. Also, the effective surface pattern of heat sinks is selected which would be easy to fabricate and handle. A commercial poly crystalline solar panel of dimensions 805×665×34 mm is used. The panel has total 36 PV modules, each having dimensions of 85×155 mm, thus covering a total 0.474 m^2 of area. This whole area is covered with Aluminium heat sinks in order to perform heat dissipation. The heat sinks are fabricated as of the same size as a PV module, thus, exactly covering whole backside of a module. HY 510 thermal paste (thermal grease) with thermal conductivity >1.93 W/m-k is used to interface between the flat surface of solar panel and heat sink, so creating an effective conducting path for heat from panel's rear side to the heat sink. Air cooling is used for heat dissipation. No other power source than natural air draught is used. This is done so as to save any other power sources like electricity, especially used in conventional active cooling systems, i.e. fans. Also, water is not used at all for cooling purpose, making the system useful in hot and water deficient areas.

4.3 Fabrication and Assembly

First of all, the Al heat sinks were fabricated, as per RCONTINUEthe size of PV modules. Then the white back-side of panel was prepared and cleaned for permanently sticking the heat sinks on it. The locations and borders of PV modules were marked up by using a pencil. A thin layer of thermal grease was manually applied over the flat rear side of heat sinks. Then, the heat sinks were pasted on the marked locations by using epoxy adhesive. Care was taken to avoid the resin to go between the surfaces of panel and heat sinks, thus, pasting is done by applying the adhesive only on the edges and the nearby area. Concrete blocks were used as dead weights for clamping with pressure.

Fig - 1 : Initial Marking and Pasting

Fig - 2 : Adhesive kept for drying using clamping with dead weights

(a) (b)

Fig – 3 : Panel after complete assembly – (a) Rear side, (b) Front side

4.4 Defining Testing Parameters and method

Generally, solar PV modules are rated on the basis of their Open Circuit Voltage (V_{oc}) and Short Circuit Current (I_{sc}). So, these parameters were selected for the tests of ideal/net output. The ideal output of the panel was rated about 95 W at STC, by the manufacturer. The tests were performed for total 4 days, 2 days without heat sinks and 2 days after pasting the heat sinks. Tests were performed considering maximum irradiance duration of daytime, from 11:00 A.M. to 3:00 P.M. Hourly samples of power output were taken. Also, temperature samples were collected each hour to monitor the rate of heating. K-type thermocouple was used to monitor the temperature. Time-wise average of power output was calculated before pasting the heat sinks, and after pasting the heat sinks, to find out the percentage increase in the power output.

Fig – 4 : Testing Setup

4.5 Tests before pasting the heat dissipation system

Fig -5 Manufacturer's rating leaflet

Tests were performed before pasting the dissipation system. Power and temperature samples of the PV panel were taken. They are tabulated here.

Time (hrs)	V_{oc}	I_{sc}	Power (W)	Temperature (℃)
11:00	20	3.95	79.00	48.9
12:00	19.3	4.65	89.75	54.8
13:00	19.4	4.57	88.66	60.1
14:00	18.9	4.25	80.33	57.7
15:00	18.8	3.71	69.75	50

Table -1: Readings before cooling – Day 1

Time (hrs)	V_{oc}	I_{sc}	Power (W)	Temperature (℃)
11:00	19.7	3.92	77.22	51.7
12:00	20.1	4.52	90.85	57.5
13:00	19.8	4.56	90.29	60.9
14:00	18.8	4.21	79.15	56.1
15:00	18.7	3.9	72.93	52.8

Table -2: Readings before cooling – Day 2

Time (hrs)	Wattage (W)
11:00	78.11
12:00	90.30
13:00	89.47
14:00	79.74
15:00	71.34

Table -3: Timewise Average of wattage before cooling

4.6 Tests after pasting the heat dissipation system

The heat dissipation system was pasted to the PV modules and then, power and temperature samples of the panel were taken again. They are tabulated here.

Time (hrs)	V_{oc}	I_{sc}	Power (W)	Temperature (℃)
11:00	19.8	4.15	82.17	50.9
12:00	19.5	4.74	92.43	52.7
13:00	20	4.55	91.00	57.9
14:00	19.7	4.08	80.38	56.7
15:00	19.6	3.58	70.17	48.3

Table -4: Readings after cooling – Day 1

Time (hrs)	V_{oc}	I_{sc}	Power (W)	Temperature (℃)
11:00	19.9	4.05	80.60	49.1
12:00	20.2	4.62	93.32	54.8
13:00	18.4	5.01	92.18	58.9
14:00	19.3	4.35	83.96	53.8
15:00	19.5	3.89	75.86	52.6

Table -5: Readings after cooling – Day 2

Time (hrs)	Wattage (W)
11:00	81.38
12:00	92.88
13:00	91.59
14:00	82.17
15:00	73.01

Table -6: Timewise Average of wattage after cooling

4.7 Final Results

The data obtained from the tests before and after pasting the heat dissipation system to the PV modules was compared. The difference between time wise average of two days of testing was found and percentage increase was calculated. This data is then processed to plot graphs.

Time (hrs)	Before cooling (W)	After Cooling (W)	Difference (W)	Percentage increase (%)
11:00	78.11	81.38	3.27	**4.19**
12:00	90.30	92.88	2.58	**2.86**
13:00	89.47	91.59	2.12	**2.37**
14:00	79.74	82.17	2.43	**3.05**
15:00	71.34	73.01	1.67	**2.34**

Table -7: Final results – Time wise percentage increase in power

By computing the average of percentage increase from the above table, it is seen that, **2.96% of efficiency increase** is seen in the overall performance of PV modules. Thus the cooling system seems to effective in improvement of net power output.

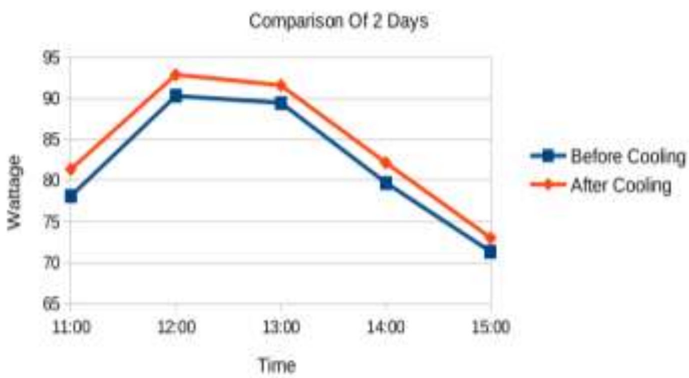

Chart -1: Percentage Increase

Time (hrs)	Average Temperature Before Cooling (℃)	Average Temperature After Cooling (℃)	Difference (℃)
11:00	50.3	50	**0.3**
12:00	56.1	53.7	**2.4**
13:00	60.5	58.4	**2.1**
14:00	56.9	55.2	**1.7**
15:00	51.4	50.4	**1**

Table -7: Final results – Time wise temperature difference

In the table above, temperature differences between averages of two days are found. By computing the average of differences, it is seen that **1.5℃ temperature drop** is observed, thus achieving intended cooling effect. Also, the system is achieving this cooling effect without water of external power source.

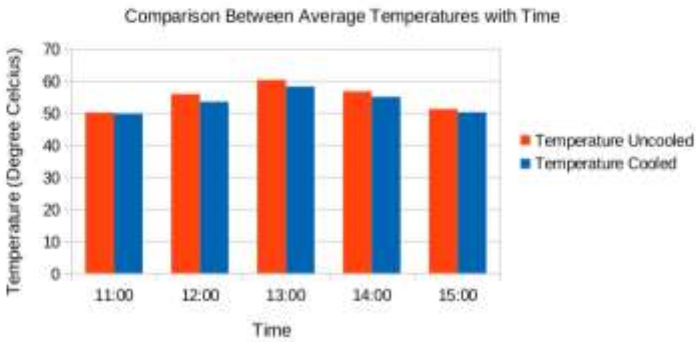

Chart -2: Temparature Differences

5. CONCLUSIONS

From the data in the final results, it is concluded that :

1. The net output of the PV panel was increased by about 2.96%, which is a considerable and appreciable growth in the efficiency.
2. The temperature of the panel was dropped by about 1.5℃ on an average. This shows that the heat dissipation system seems to be effective in cooling of PV modules.
3. This type of heat dissipation system is suitable in dry and water deficient regions due to its nature of cooling without water.
4. The system is passive in nature, thus saving external power which is extensively required in conventionally used mechanical cooling systems.

REFERENCES

[1] Efsilon K A Fatoni et al., Solar Panel Performance Improvement using Heatsink Fan as the Cooling Effect J. Phys.: Conf. Ser. 1167 012031 (2019)

[2] Linus Idoko, Enhancing PV modules efficiency and power output using multi-concept cooling technique, www.elsevier.com/locate/egyr/Energy Reports 4 (2018) 357–369.

[3] D. Revati et al., Enhancing the Efficiency of Solar Cell by Air Cooling, Indian Journal of Science and Technology, Vol 9(5), DOI: 10.17485/ijst/2016/v9i5/87274, February 2016

[4] M.S. Abd-Elhady et al., Enhancing the performance of photovoltaic panels by water cooling, Ain Shams Engineering Journal (2013) 4, 869–877

[5] Book Of Renewable Energy Engineering by Janaka Ekanayake and Nicholas Jenkins, (Cambridge University Press), ISBN : 9781107680227 (2017)