Experimental Investigation To Study The Effect Of Cooling Medium (Air) In Controlling The Solar Panel Temperature

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Abstract: Paper An experimental study has been conducted to control the solar panel temperature during the peak noon hours. Due to the high solar intensity during noon hours, the solar panel temperature attains very high temperature in the range of 65°C to 70°C. High temperature is not advisable for the better performance of the solar panel. Hence to control the temperature, some heat removal method has to be considered. In this study, air has been considered as a cooling medium as it is available abundantly. To predict the effect of the cooling medium (air), experiments are conducted without cooling medium and with cooling of panel from the top or from the bottom of the panel. Parameters like glass temperature, power generation and efficiency of the solar panel are compared for the three types of experiment (without cooling, with air cooling from the top and air cooling from the bottom of the panel). It is concluded that solar panel can be maintained in the range of 40°C to 45°C with the cooling arrangement and short circuit current can also be maintained in the range 13 Amperes to 15 Amperes, whereas without cooling, short circuit current varies in the range of 9 Amperes to 15 Amperes. Hence the power generation is maintained in the specified range. Comparing the cooling of panel either from top or from bottom of the panel it is concluded that cooling from the bottom is more effective as thickness of the Tedlar plate is less than thickness of glass cover.

Index Terms: Solar panel, Glass cover temperature, Air cooling, Power generation, Short circuit current, Open-circuit voltage

I. INTRODUCTION

Solar energy is the vast energy received to the earth. The amount of solar energy received by the earth from sun for 2 minutes is equal to the amount of energy used by the total world for 1 year. So, effective usage may lead to reduce the energy crisis. Photovoltaic cells convert solar energy in to electricity to provide electricity for the billions of people where conventional electricity is hardly accessible. The performance of solar panel depends on different parameters like temperature, type of cells, wind velocity, irradiance, and material of solar cell. In this research article an attempt is made to evaluate the effect of temperature on the parameters of solar panel. [1] conducted experiment to find the improvement in the efficiency of solar panel by using water cooling method at the top of the solar panel. They found that the system output is increased by 15% when compared to without cooling. [2] conducted experiments to minimize the losses of the performance of the photovoltaic panel using air cooling arrangement by placing the fan at the rear end of the photovoltaic panel. They concluded that by the above arrangement the efficiency is increased by 29.5% and the temperature can be reduced by 39.29°C. [3] conducted experiments to study the performance of PV panel under water conditions at different depths and different flow rates. She concluded that the temperature can be reduced about 43.1% for no flow conditions and for flow conditions it is 47.6% in comparison with the dry panel conditions. [4] analyzed the efficiency of solar hybrid PV systems experimentally and mathematically. It is found that the combined efficiency of both air and water heater is high when compared to the individual air heating and water heating system. He also demonstrated that the efficiency is high when glycerin is mixed with water al the proportion of 1:50. [5] proposed a model and analyzed experimentally and numerically to decrease the usage of water and electricity for cooling of solar panel in hot arid regions. He proposed a technique through which usage of water and electrical energy is reduced. [6] conducted experiments to find the variations of operating temperatures of silicon based solar panel in tropical conditions. They found that the mono crystalline solar PV panel reacts more to the temperature difference compared to poly crystalline and amorphous silicon PV panel. They concluded that the temperature difference between the mono crystalline and the amorphous material is 10°C. [7] summarized different methods through which the efficiency of solar panel can be improved. They also demonstrated that the active cooling methods are used to larger extent when compared to passive cooling methods. [8] conducted experiments to find the effect of efficiency of solar panel by placing water absorbing sponge at the bottom of the solar panel and supplying water drop by drop.

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From this experiment he concluded that the temperature of solar panel is reduced by 40C through which the efficiency can be increased by 12%. [9] analyzed the effect of cooling of solar panel experimentally and analytically by using air as cooling medium. He concluded that cooling method is applicable in large scale photo voltaic power plants through which the efficiency and maximum output can be improved. [10] proposed a mathematical model to reduce the temperature of PV panel by using ribbed wall as a heat sink. He analyzed the reduction in operating temperature of solar panel at different rib angles and found that the operating temperature at 90° and 45° are less when compared to the rib angle of 135°. [11] conducted experiments to find the effect of temperature of solar panel without cooling and with active cooling method using air as cooling medium through which the efficiency can be improved from 8% to 12%.

[12] demonstrated the effect of efficiency of solar panel integrated with PV/PCM layer by formulating mathematical equations using finite difference method. He concluded that the energy output is increased by 6% compared to without cooling. [13] conducted experiments by simulating with different halogen bulbs with different intensities. It is concluded that by using water cooling the temperature of solar panel can be reduced within range of 5-23% and efficiency can be improved by 9%. [14] investigated the effect of different climatic conditions on the power output and efficiency of solar panel when cooled with water at the top of the panel. They concluded that the efficiency of solar panel is high during winter compared to summer. [15] investigated the effect of dust on the performance of solar panel. He concluded that the reduction in performance of solar panel by dust accumulation is nullified by cooling arrangement. [16] conducted experiments on solar panel under three different conditions namely on floor conditions, solar panel placed on stand and using air cooling arrangement. He concluded that the air cooling arrangement provides better performance when compared to other two conditions.

[17] conducted experiments to find the performance of solar panel when cooled with air and water in different directional arrangement. They concluded that the cross flow cooling arrangement gives far better efficiency and power output. [18] conducted experiments on different cooling arrangements and concluded that the combined top and bottom cooling arrangement gives better power output. [19] proposed a new technique namely immersion technique where solar panel is immersed in water or any fluid for cooling through which the efficiency is increased by 20-25%. He also illustrated that the water is best fluid for immersion technique. [20] conducted experiments at 5 different intensities to find the effect of intensity on the voltage. He concluded that the voltage is high at the reduced temperature. [21] conducted experimental and theoretical investigation of solar panel which was integrated with PCM material and found that the temperature of solar panel can be reduced by 100C. [22] conducted experiments on solar panel to control its temperature by making tea light candle as a phase change material. He found that the above material is not so effective so proper care should be taken in selecting phase change material. [23] investigated the effect of finned heat exchanger on the temperature of solar panel analytically and found that the heat exchanger arrangement can remove the temperature of solar panel by 200C.

[24] investigated the performance of different solar panels which are semitransparent and opaque. They found the semitransparent solar modules are efficient than opaque modules. [25] proposed a thermal model for solar panel based on climate variables, he shown that the temperature of the module is in non-steady state with time. [26] investigated the different components which improves the efficiency of solar panel. The components are solar concentrators, solar panel cooling and solar tracking system. Among them, solar tracking system is the best practice which is more effective irrespective of climatic conditions.

II. EXPERIMENTAL ARRANGEMENT AND PROCEDURE

Experiment is conducted with a commercial solar panel system installed with 8 numbers of solar panel array each having capacity of 275 W with area of 1 m ×1.6 m to operate a pump with capacity of 2 HP. The maximum output voltage and current are 140 V, 15.7Amp and with maximum power output of 2.2 kW. The solar panel is made of polycrystalline silicon. With the Data logging system, intensity of solar radiation, Voltage and Current of the solar panel, ambient temperature are recorded continuously for 24 hours. Temperature of the top surface of the panel (glass cover) and bottom surface of Tedlar are measured by attaching thermocouples which are connected to the digital temperature indicators.

Experiments are conducted without providing any cooling arrangement and observations are recorded for several days to get the concurrent value of the solar intensity. Then solar panels are cooled by circulation of air by a blower to all the panels. To study the effect of cooling of panel from the top or from the bottom of the solar panel, experiments are conducted separately with cooling arrangement from the top and from the bottom. In each mode of cooling arrangement, experiments are conducted for number of days to get the concurrent values of the solar radiation. These observations are tabulated as given below.

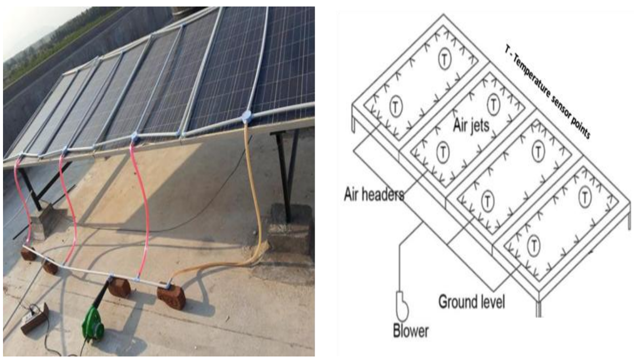

Fig.1: Air cooling arrangement from the top of the solar panel

Table.1: Experimental observations of solar PV panel without and with air cooling arrangement

Experimental observations																
		Without cooling					Top cooling					bottom cooling				
Time h	solar intensity	glass temp Tgl °C	Current I in Amp	Voltage in V	Power P in W/m²	Efficiency η in %	glass temp Tgl °C	Current I in Amp	Voltage in V	Power P in W/m²	Efficiency η in %	glass temp Tgl °C	Current I in Amp	Voltage in V	Power P in W/m²	Efficiency η in %
9	240	31.2	8	116	928	32	31.2	8	112	896	31	32.2	7	128	896	31
10	475	42.2	10	120	1200	21	42.4	13	110	1430	25	41.2	9	126	1134	20
11	680	47.4	5	130	650	8	43.4	13	110	1430	18	43.2	14	118	1652	20
12	840	51.5	12	120	1440	14	44.2	13	108	1404	14	43.8	14	116	1624	16
12:30	920	51.5	8	130	1040	9	44.6	14	108	1512	14	44.8	14	114	1596	14
13	800	52.8	13	108	1404	15	45.2	13	106	1378	14	45.2	13	114	1482	15
14	680	53.4	7	122	854	10	42.4	13	108	1404	17	44.3	13	110	1430	18
15	620	46.2	8	114	912	12	42.2	11	110	1210	16	43.2	12	110	1320	18
16	520	44.4	5	124	620	10	40.2	9	116	1044	17	43	9	124	1116	18

III. RESULTS

In this research, experiments are conducted with a commercial solar panel system installed with 8 numbers of solar panel array each having capacity of 275 W with area of 1 m ×1.6 m to operate a pump with capacity of 2 HP. Figure shows the experimental observations of solar panel without and with cooling.

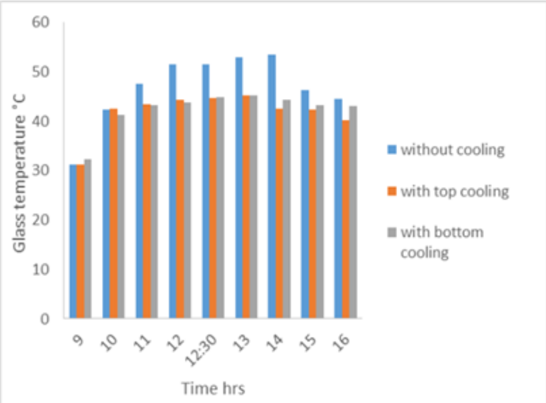

Fig.2: Observations of glass temperature

From Fig.2, it is observed that the temperature of glass surface for without cooling is high compared to with cooling. Since the air is in direct contact with glass surface, the temperature of glass cover during top cooling is reduced higher compared to bottom cooling.

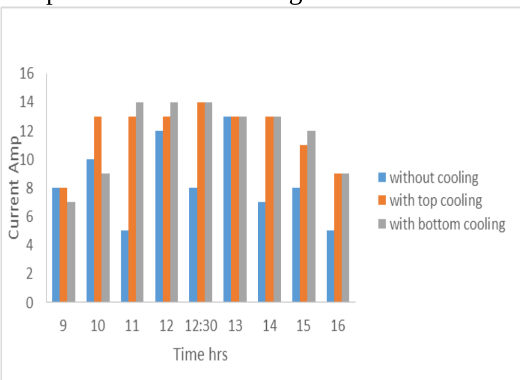

Fig.3: Observations of short circuit current

Fig.3 shows that in without cooling, the short circuit current fluctuates randomly at peak hours. It is stabilized by cooling arrangement.

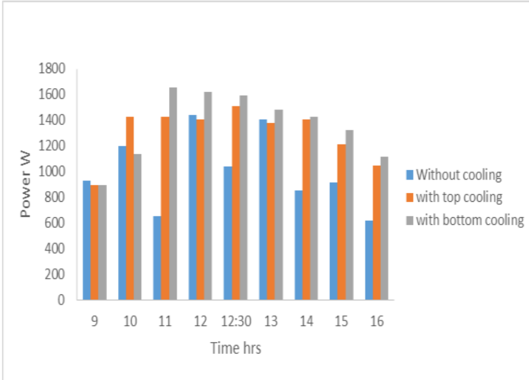

Fig.4: Observations of power output

Comparison of the power output of solar panel without and with cooling is shown in the fig.4 above. From the above graph it is observed that the power also fluctuates randomly in the case of without cooling. It is also observed that the power output is high in the case of bottom cooling.

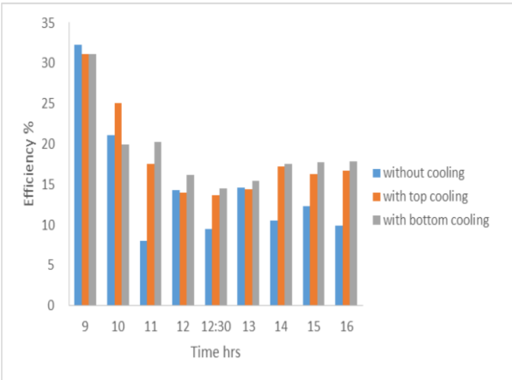

Fig.5: Observations of efficiencies

Fig.5 shows the variation of efficiencies of solar panel without and with cooling arrangements with respect to time. From the above graph it is observed that the efficiency of solar panel with bottom cooling arrangement is high during the peak hours since the thermal conductivity of Tedlar surface is higher than glass cover through which heat is dissipated effectively.

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IV. CONCLUSION

In this study, the effect of cooling of solar panel on its parameters has been discussed. The Cooling arrangement provided either at the bottom or at the top will maintain the panel temperature in the range of 40°C and maintain efficiency of the solar panel by 18 %. By providing the cooling arrangement at the bottom, the radiation falling on the top surface of the panel will not be affected. As thickness of the Tedlar surface which supports the solar cell is less, the convection heat transfer coefficient between the air and Tedlar surface is high and hence the efficiency of the bottom cooling will be more than the top cooling.

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