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Performance Optimization Po Solar PV Modules by Cooling

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ABSTRACT

In present work an approach is made to enhance the performance of PV module by cooling in present study the weather data is taken from weather reports for Jabalpur region. Parametric equations have been established to calculate the performance of the panels of 200 watt. Calculation work is performed by using Ms -excel. The comparison in made for electricity production by panels with and without cooling.The results of calculation represents that the power out-put of the system improve by 9 % approximately, and overall efficiency of the system increase by 8.37 % on average. By identifying the peak temperature hour, the consumption of water also minimized for cooling.

KEY WORDS: Solar Module, Efficiency, Cooling, Noct, Cooling Time, Solar Irrdance

Introduction

P-V panel directly convert solar contamination into electrical energy. Each cell contained layers of a semiconducting material, P and N-Type. When occurrence with light, the cell passes an electric field amongst layers, resulting in an output voltage and current. The cells are moreover poly-crystalline, made up of pieces from number of silicon crystals, or mono-crystalline, which are cut from a single big crystal. The monocrystalline cells have a higher transformation efficiency and cost. This grants an issue since current PV technology has comparatively low transformational efficiencies, “6-20%”. Temporarily, the other 80-94% of occurrence solar radiation is transformed to heat, significantly growing the PV cell’s temperature, and dropping the efficiency. The influence of the functioning temperature on a PV panel’s performance has been well recognized, where high temperatures meaningfully effect the power output. As presented in Figure 1, an upsurge in temperature affects a slight increment in the output of panels, but a considerable reduction in the production voltage resulting in a noteworthy drop in the energy output for a specified quantity of solar radiation. This has been associated to a decrease in PV modules translation efficiency of nearly 0.4–0.5% for every degree Celsius of temperature increase. Moreover, the semiconductor effect itself generates heat, as all electronics do, so that also compounds this problem.

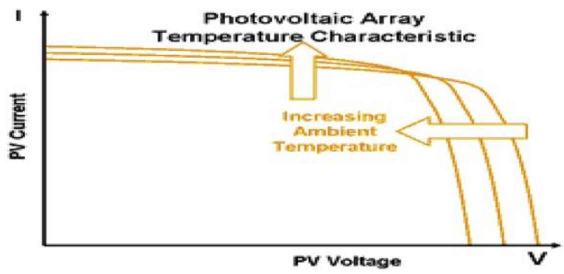

Fig 1.1 P-V characteristics of solar panel

Objective of Work

My objective from this study and research is to maximize solar panels, and in particular solar cells, efficiency by cooling down techniques more precisely water-cooling technique with an new design adopting some mathematical models, and this for arid regions and desert areas. The cooling system that I need to develop is based on water spraying of PV panels by a moving fan. Moreover, I will use a mathematical model in order for me to determine the pick point, once the temperature is 45°C or up, so that the system can start the cooling of the PV panels. I will start by computing the efficiency of the panels in normal temperatures and get its maximum value, also comparing it to some data found in research collected from real experiment done in the field. Furthermore, I need to implement a cooling model that will determine the right period of time that takes to cool down the PV panels to its normal operating temperature, using on the previous cooling system technique. Regarding the design of the system and all dimensions of the solar panels.

Literature Review

1 An improved cooling system design to enhance energy efficiency of floating photovoltaic systems by Author : Y. A. SheikhA. D. Butt K. N. Paracha, A. B. Awan M. Zubair…………2020

This work presents a lightweight and minimally invasive cooling system design with forced water cooling, which can improve photovoltaic (PV) system performance by thoroughly reducing the temperature of its solar cells. This design is an improved version of traditional PV-thermal cooling systems that are bulky and mostly limited to land-based applications. Thermal and fluid flow analyses of this system have been presented to numerically assess output efficiency improvement with a commercial solar panel. The proposed serpentine cooling block structure has been optimized to maintain module efficiency better than Standard Testing Conditions (STC) under all conditions. For a 395 W commercial solar panel, an output power improvement of up to 49.4 W (14.29%) at an irradiance level of 1000 W/m^2 at an ambient temperature of 35 °35 °C has been achieved. The corresponding water pump operation and associated losses are limited to a maximum of 8.5 W/module. The impact of cooling system performance has also been evaluated for the region of Mangla Dam Lake, Pakistan, where an annual increase in electricity output of around 9.58% is foreseen. Consequently, this work is envisioned to provide guidance on increasing the efficiency of the PV system to those who would install it near water reservoirs.

2 Advanced cooling techniques of P.V. modules: A state of artAuthor PushpenduDwivedia, K.Sudhakara,b,c,, Archana Sonia, E Solominc,……2020

The efficiency of solar systems, in particular photovoltaic panels, is generally low. The output of the P.V. module is adversely affected by their surface rise in temperature. This increase is associated with the absorbed sunlight that is converted into heat, resulting in reduced power output, energy efficiency, performance and life of the panel. The use of cooling techniques can offer a potential solution to avoid excessive heating of P.V. panels and to reduce cell temperature. This paper presents details of various feasible cooling methods, including novel and advanced solutions for P.V. panels and indicates future trends of research. Different features and capability about each cooling techniques are presented, to provide better insight and valuable guidelines for researchers who intend to study, improve or optimise any type of cooling techniques of P·V. modules.

3 A new method for reducing the performance evaluation cost of the photovoltaic module cooling techniques using the photovoltaic efficiency difference factor by Sakhr M. Sultan*, C.P. Tso, ………….2020

In this work a new method is proposed to solve the performance evaluation cost issue related to solar panel. This method can execute the performance evaluation of the PV coolers as the existing method but under various solar radiation values. It also depends on the output power of a PV with a single solar cell only (without a cooler) when conducting the performance evaluation for a PV with a cooler that has a known number of solar cells. The applicability conditions of the proposed method are illustrated. It is shown that the performance evaluation cost of PV cooling techniques can be greatly reduced. It can be concluded that the new method is a cost-efficient as compared with the existing method. PV cooling techniques designers and manufacturers are the potential users of the proposed method.

4 Heat Transfer Modeling And Temperature Experiments Of Crystalline Silicon Photovoltaic Modules BY WusongTao, YafengLiu, …………………2017

In this study, the time-dependent thermal performance of crystalline silicon photovoltaic (PV) modules with glass-glass (GG) and glass-back sheet (GB) configurations were investigated. A heat transfer model for PV modules was created in COMSOL Multiphysics environment, to illustrate the time dependent thermal behavior of the implemented module during operation. A thorough understanding of the heat sources, temperature distribution, as well as the performance of heat dispersion and temperature uniform by the solar module in operation was presented with colorful maps, graphs and temperature difference between different locations within PV module. All the analysis leading to the conclusions that the GG modules has a better temperature uniform and heat dispersion performance with respect to GB module although GG module undertakes a slightly higher temperature. However, the temperature of GG module can also be reduced by choosing proper encapsulate and protective covers.

5 A computational fluid dynamic study of PV cell temperatures in novel platform and standard arrangements by Ross EdgarSteveCochard ………January 2017.

In this work The degree to which the design of PV system platforms influences module temperatures and consequently stress outcomes is investigated. The aim is to estimate the PV-cell temperature of modules in novel platforms from the physical properties of their materials in a way that may be readily adapted to address unique conditions. The ability to analyse the thermal impact of new solar system features and elements is important to enable thermal analysis during the design phase.

A coupled computational fluid dynamic – finite element model with material properties is used to predict the PV-cell nominal temperature. It is shown that a novel PV-platform is 5 °C cooler in no wind conditions due to passive convection.

Methodology

The Heating Rate Model

The first step of the mathematical modeling is the heating rating model. It is used for computing how long it takes to the solar cell to heat up to maximum allowable temperature and therefore maximum efficiency. The main significant parameters for this model are the ambient temperatures at normal time and sunrise, plus the solar radiation that defines how much does cell absorbs. Based on the previous parameters it is possible to determine the cooling frequency of the silicon PV modules. In order to do so, the module temperature change in function of time should be determined so that we can specify the heating rate which will enable us subsequently to find the cooling frequency. The following formula represents the module temperature Tm:

$$Tm=Tamb+(NOCT-20)E/800$$

***Tamb* :** ambient Temperature
***NOCT*:** nominal operating cell temperature
***E* :** solar irradiance

For the NOCT, it represents the ambient temperature in a specific period of the day, sunrise-time:

NOCT=20°C+Trise

From the two equations bellow, it can be noticed that the heating rate, **dTm/dt**, has three dependent variable: the irradiance and the ambient temperature, they both vary on time, sunrise and sunset; plus, the NOCT which is a constant.
The figure bellow states the temperature module as a function of the three parameters stated before. Moreover, it is used to define the right time for the model to start cooling once the temperature reaches the module allowable temperature (MAT).

The Cooling Rate Model

Concerning the cooling period, which is also another important parameter for this mathematical model can be determined from an energy balance equation. However, the physical properties of silicon, which is mainly glass covered by glass, need to be taken into consideration. This model is called the cooling rate model. This model is responsible for the period of time that is needed to bring back the module temperature to the normal operating one (allowable T, 25°< T< 45°C). Its main function is to minimize the time it takes for the system to cool down and therefore minimize water introduced to the system and energy.

In order to specify the cooling period of the PV cells, it is crucial to look for each cell's cooling rate. An energy balance, describing the heat gained and dissipated, can define the cooling period. This equation states that the energy gained is equal to the energy dissipated from the module. The following equation helps retrieve t, the cooling time:

$$Q_{\text{gained by cooling water}} = Q_{\text{dissipated from PV panels}}$$
$$\dot{m}_w \times t \times c_w \times \Delta T_w = m_g \times c_g \times \Delta T_g$$
$$\therefore t = \frac{m_g \times c_g \times \Delta T_g}{\dot{m}_w \times c_w \times \Delta T_w}$$

ṁ w : mass flow rate of water $\mathbf{m_g}$: the mass of glass

$\mathbf{c_w}$: specific heat capacity of water $\mathbf{c_g}$: heat capacity of glass,

$\mathbf{\Delta T_w}$: the water temperature rise,

$\mathbf{\Delta T_g}$: glass temperature change due to water cooling

The solar cells that are used for this model are made from silicon which is approximately glass. The cells are also covered by glass. As a result, the physical properties of glass define the physical properties of the PV panels. I t is also assumed that 45°C is the maximum temperature allowed for the PV panels. Beyond this value, the system should start the cooling by spraying the amount of water needed for that specific temperature (45°C =<T).
Trying to solve the previous equation (energy balance equation) for t, the results are given in the next figure: (- assuming $\Delta Tw = \Delta T_g = 10$ °C -)

Summarised Results

Average value of every day has been taken in order to summarize the calculations which shows that cooling of PV panel can be a effective solution in order to optimize the overall performance of the panel and to get the maximum power out put.

15 days summerised results										
date	E w/m2	Tamp °(	Tm	pm1	total tir	pm2	performan	η1	η 2	ηi
27-May	501.67	36.67	52.34	184.32	14.64	191.67	4%	0.43	0.43	3.83
28-May	236.67	38.67	46.06	192.60	1.71	193.67	1%	0.75	0.75	0.55
29-May	784.50	39.33	63.85	175.48	39.14	194.33	11%	0.19	0.21	9.71
30-May	739.83	40.83	63.95	176.88	40.13	195.83	11%	0.22	0.24	9.69
31-May	734.00	40.17	63.10	177.06	37.20	195.17	10%	0.20	0.22	9.28
01-Jun	543.33	39.83	56.81	183.02	24.14	194.83	7%	0.35	0.37	6.04
02-Jun	720.00	42.00	64.50	177.50	41.59	197.00	11%	0.22	0.24	9.90
03-Jun	766.00	42.17	66.10	176.06	45.48	197.17	12%	0.20	0.22	10.70
04-Jun	712.00	42.33	64.58	177.75	42.49	197.33	11%	0.24	0.26	9.91
05-Jun	761.67	42.00	65.80	176.20	44.58	197.00	12%	0.20	0.22	10.56
06-Jun	772.50	40.83	64.97	175.86	42.76	195.83	11%	0.20	0.22	10.19
07-Jun	778.17	41.00	65.32	175.68	43.46	196.00	12%	0.20	0.22	10.37
08-Jun	784.83	40.00	64.53	175.47	41.27	195.00	11%	0.19	0.21	10.01
09-Jun	770.33	39.33	57.62	181.71	31.81	194.33	8%	0.21	0.22	6.48
10-Jun	748.17	37.83	61.21	176.62	34.88	192.83	9%	0.22	0.23	8.33
avg	690.24	40.20	61.38	178.82	35.02	195.20	9%	0.27	0.28	8.37

Cooling will be more effective during peak hours of day due to higher ambient temperature, plate temperature also increases due to that performance to pv panels reduces, which can be improve by cooling.

Conclusion

Due to increasing energy demand of the world and also considering environment condition generated by conventional energy sources the requirement of new and renewable energy sources is coming up on high demand, solar pv panel are using largly now a days to produce power. various govts of different countries making effort to increase the energy production by solar systems. Solar system requires large area and big investment.
In present study the weather data is taken from weather reports. perimetric equations has been established to calculate the performance of the panels of 200 watt. Calculation work is performed by using Ms -excel.
the results of calculation represents that the power out-put of the system improve by 9 % approximately, and overall efficiency of the system increase by 8.37 % on average. By identifying the peak temperature hour, the consumption of water can also be minimizing for cooling.
This work is focused on increasing performance of "solar pv panels" by proving cooling of panels the performance of panels are evolute form 15 days from 27 may 2021 to 15 June 20121 without cooling and with cooling. the study shows that performance of panels improves with cooling. Which make us enable to take more power output with same system.

Future scope

The more experiment work can be conduct to enhance the performance of solar PV system and some simulation and modelling technique can be implemented in order to specify the specific cooling technique. And same work can be implemented on large scale power plant to improve the performance.

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