Experimental analysis of Solar PV Panel Cooling by Using Back Water Tube Array to Improve Efficiency

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***Abstract* - In this paper an experimental setup is designed in which array of water tube is fitted to back of solar panel to reduce its temperature and bring temperature to normal operating point. Before this both air-cooling model and water-cooling model conditions are investigated under normal operating condition. After getting result for various model we compared our back water cooling tube array results with the ordinary solar panel. A maximum photoelectric conversion efficiency difference is 2.6%, and the temperature decreases by 2-3 degree Celsius, the output power generation efficiency is increases by 2.3 % for the solar PV panel when using heat pipe for air-cooling, when the daily radiation value is 26.3 MJ. Compared with the solar panel with heat pipe using air-cooling, the maximum difference of the photoelectric conversion efficiency is 3%, the temperature reduces maximally by 8 %, the output power increases maximally by 13.9% for the solar panel with heat pipe using water- cooling, when the daily radiation value is 21.9 MJ.**

Keywords: Photoelectric conversion efficiency, Maximum allowable temperature, solar panel cooling, back water heat tube array

1.INTRODUCTION

Cooling of solar PV module is important because it have a non-linear voltage-current characteristic with a unique point where the power produced is maximum. This point depends on the temperature of the panels and on the irradiance conditions. Both conditions change during the day and are different depending on the season of the year. Moreover, irradiation can alter rapidly due to varying atmospheric conditions such as clouds and sky. It is important to trail the maximum power point accurately under all possible conditions so that the maximum available power is always obtained. Temperature of solar PV module is decreased by providing back water tube filled with water and circulate it by using natural convection technique. In this paper an experimental setup is designed in which array of water tube is fitted to back of solar panel to reduce its temperature and bring temperature to normal operating point. Before this both air-cooling model and water-cooling model conditions are investigated under normal operating condition. After getting result for various model we compared our back water cooling tube array results with the ordinary solar panel. The efficiency of a PV plant is affected mainly by the factors like: the efficiency of the PV panel (in commercial PV panels it is between 8-15%), the efficiency of the inverter (95-98 %) and the efficiency of generation due to increase in module temperature. The efficiency of photovoltaic solar panel decreases with increase in operating temperature. This is because, the photo voltaic modules take only the visible light intensity for converting it to electrical energy and rest of the spectrum of light is converted to heat leading to the increase in operating temperature. Reflection from top surface is another reason for increase in operating temperature.

2. EXPERIMENTAL SETUP

A working experimental setup is developed to determine how long it takes to cool down the module based on proposed cooling system. Fig
2.2 water circulation tank use natural convection to circulate water. An experimental validation of hat rate model and cooling rate model has been done. Based on heating and cooling rate model it is found that the PV panel yields the highest output energy if cooling of the module starts. When temperature (Tm) of PV module reaches to value of maximum allowable temperature (MAT) of 45 degree Celsius. The work done in this thesis proposes modelling of photovoltaic model in which temperature and sun’s irradiance, of the PV array is taken into account .A photovoltaic system is modelled and its voltage , current characteristics and the power are calculated. This makes the dynamics of PV system to be easily simulated and optimized. It is worth noticed that the output characteristics of a PV module are affected by the environmental factors such as temperature, cloud and wind .Due to this the conversion efficiency is low. Therefore, a cooling technique is needed to decrease the temperature of solar module so as to increase the peak power to maximize level .By doing so the generated output power is increase to a certain height.

To check the correctness of the solar PV model predicted values of solar radiation data are compared with calculated hourly values. The radiation effect of solar radiation on the tilted surfaces and vertical surfaces for different orientations from horizontal, have also been calculated. The calculated values and results are found to be very close agreement with measured values. The method presented in this thesis can be used to do approximation hourly, global, diffuse solar radiation on inclined and vertical surfaces and horizontal surfaces and at different angles with greater accuracy for any location. This tells us the power generation capacity rated of power plant with the actual power generation capacity of the plant.

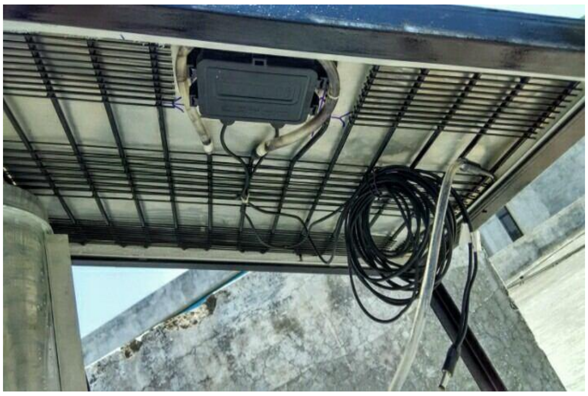

Fig 2.1 PV module fitted with copper tube filled with water to cool PV module

Fig 2.2 water circulation tank use natural convection to circulate water

3. EXPERIMENTAL SCHEME

To Down the module temperature we designed a back water tube system which is made up of copper. Water is circulating in the tube from colleting tank by making use of natural convection. Hot water from tube comes and collects in the water tank fitted with fins, when air is circulated through the fins water temperature is reduced to acceptable level. The whole design of the system is done according to the climatic condition of Madhya Pradesh region in India. The PV module is inclined at 45 degree and fitted to stand up to a height if 1.5 feet. Voltage, current and solar irradiation reading is to taken in the month of March to June when there is hot summer to get accurate value of the difference in temperature of solar PV module. Figure 3.1 shows the experimental set of the design.

Fig 3.1 Solar PV modules and water circulation tank use natural convection to circulate water

It can be concluded from the above literature survey that using water as a coolant is found to be more effective than using air. Thus, the objective of this research is to build a water- based cooling system to solve the solar cells over heating problem with the minimum amount of water and energy. To minimize the amount of water and energy needed for cooling of the PV panels, a heating rate model is used to determine how long it takes to heat up the panels to the maximum allowable temperature limit that can lead to the maximum energy yield. The heating rate model is based on the operating conditions, i.e., solar radiation, ambient temperature, and ambient temperature at sunrise. Based on this model, it can be determined when to start cooling of the PV panels.

A mathematical Model is developed to determine how long it will take to cool the PV panels to the normal operating temperature. This model will be named as the cooling rate model throughout the paper

4. RESULTS & DISCUSSION

With so many different cooling techniques tried, if one wants to compare cooling effect, One needs to define universal value that describes the cooling. Since very few works made complete measurements and calculations of gained power, relative and total increase in efficiency, and complete description of cooling method, it is difficult to compare the gained results. If maximum power gain is taken into account, and divided with effective surface of the PV cell, a specific power gain per surface can be defined for each experiment. Unfortunately, experiments without those information's can't be taken into consideration. Also, this way of comparing is only qualitative, because in several works, crucial information's are missing and can only be logically deduced (i.e. the effective area deduced approximately from total area, etc.).

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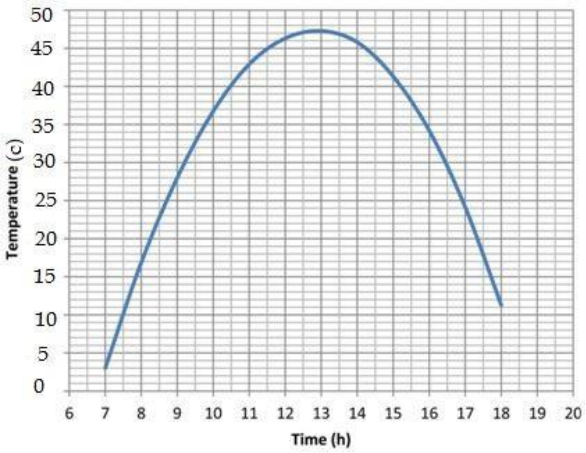

Fig 4.1 Temperature Vs time graph of PV module

From above we can Say that when temperature of PV module is increased to a certain level its efficiency get decreased. Fig 4.1 shows temperature and time relation of PV module which find close agreement with the find result shows in next figures

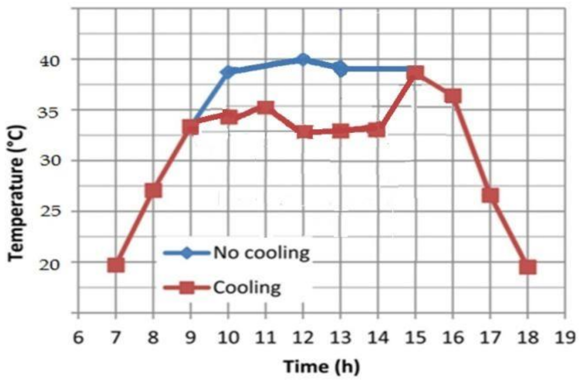

Fig 4.2 Temperature Vs time graph of PV module when cooling is done and without cooling

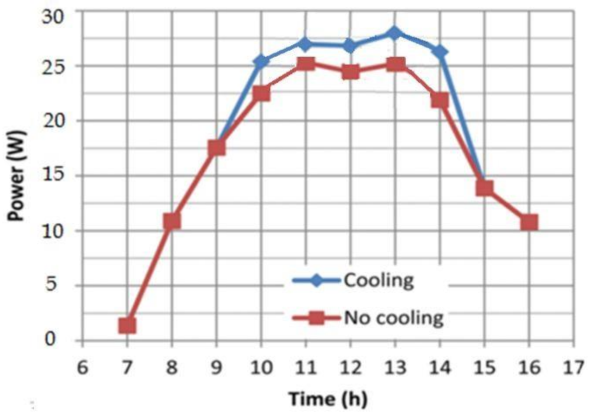

Fig 4.2 Power Vs time graph of PV module when cooling is done and without cooling

5. CONCLUSION

This thesis reports an Experimental Study and Comparison of Performance & efficiency of a PV (photovoltaic) module by rear face water cooling for hot climatic environment passive cooling system, which could be used for cool the PV modules in order to increase electrical efficiency. The most significant point of this approach is that it utilizes rainwater and solar energy to cool the PV panels improving PV system efficiency with no requirement for additional energy input.

The authors believe that it has the potential for further exploration.

The influences of the absorbing surface area on the water supply volume are not obvious, whereas a water tank with larger volume significantly increases the water supply. However, the actual chamber size should be comprehensively considered with roof area and available rainwater capacity. On the design day, the solar-driven water cooling system is able fill at least 1 L of water to backwater tubes of PV modules. The maximum reduction in the temperature of the cells reaches 3°C and average electrical yield is increased by 3.3%.

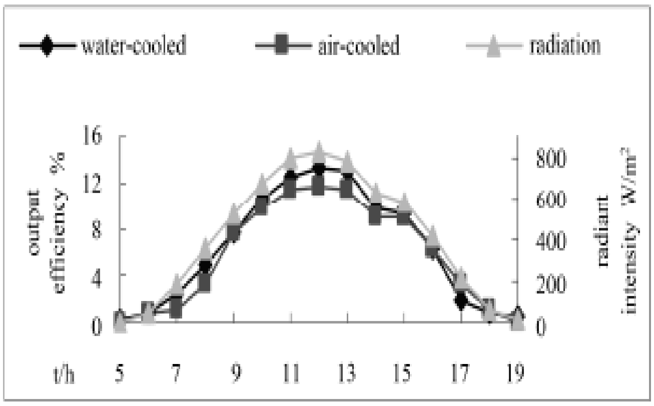

Fig: 5.1 Comparison of output efficiency of PV Panel cooling by air and by back water cooling tube.

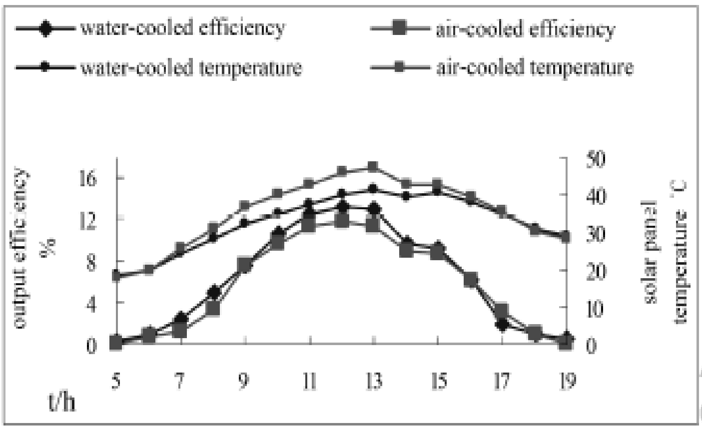

Fig: 5.2 Comparison of hourly output efficiency of PV Panel cooling by air and by back water cooling tube.

The global solar irradiance on horizontal surfaces has been measured. A computer model has been prepared to calculate the monthly average daily solar irradiance and hourly solar irradiance on inclined surfaces from the global solar irradiance. The hourly diffuse solar radiation and the average monthly daily diffuse solar irradiance are estimated.

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