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Research article

Effect of weather conditions on the Hybrid solar air Collector in variation of Cell Temperature

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Abstract

A laboratory scale hybrid solar air collector has been developed and tested for unload conditions at the Maulana Azad National Institute of Technology, Bhopal, India. The collector has been tested under two weather conditions firstly in clear sky and secondly in cloudy and partly hazy. The cell temperature in the clear sky conditions is found to higher than other weather conditions. The reduction in cell temperature in cloudy and partly hazy weather condition vary from 4.4-15.2 ^{0}C as compared to the clear sky conditions. **Copyright © IJRETR, all rights reserved.**

Keywords: hybrid solar air collector, cell temperature, weather conditions, ambient air temperature

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Introduction

Demand of energy and the environmental issues are compelling us to move towards the utilization of renewable energy resources. Among all available renewable energy resources solar energy is one of the finest, clean, inexhaustible and most abundant renewable energy resource. The Sun emits energy at a rate of 3.8×10^{23} kW, of which, approximately 1.8×10^{14} kW is received by the earth [11].The effective conversion of solar energy into electricity is becoming a very important issue since past few years in terms of rising energy costs and needs. The electricity conversion efficiency of a solar cell for commercial application is about 6–15%. More than 85% of the incoming solar energy is either reflected or absorbed as heat energy[12].Two methods often proposed for harnessing renewable energy: One is Photovoltaic and another one is solar thermal, each of these systems independently presents unique engineering challenges but when coupled together the challenge intensified due to competing operating requirements. When the photovoltaic system is coupled with the heat extraction unit, it is called as hybrid photovoltaic thermal system or PV/T system. The main purpose of heat extraction unit is to extract heat from the photovoltaic system and keep its temperature at sufficient level so that it can work efficiently. Flat-plate collectors are the basic and most common devices that combine thermal and electrical outputs. In order to evaluate these types of collectors,an experimental analysis must be carried out according to the standard test methods available.These methods are important for providing the basic information, which are valuable and important for designers for a specific application. Furthermore, it will be easy for the consumers to compare the performance and cost-effectiveness ratio of a competing product.Although, no dedicated guideline, as a standard tests procedure,exists for the performance testing of PV/T flat-plate collectors tillnow. Weather condition and its effect on the PVT hybrid system appeared in the few references this field has not been investigated extensively in the literature .Moreover, various studies concerning with the PV/T collectors have been observed in the literature.F. Sarhaddi et al.[1] made an attempt to investigate the thermal and electrical performance of a solar photovoltaic thermal (PV/T) air collector by developing a detailed thermal and electrical model to calculate the thermal and electrical parameters of a typical PV/T air collector.The thermal and electrical parameters of a PV/T air collector include solar cell temperature, back surface temperature, outlet air temperature, open-circuit voltage, short-circuit current, maximum power point voltage, maximum power point current etc.They made some corrections on heat loss coefficients in order to improve the thermal model of a PV/T air collector. They also developed a computer simulation program to calculate the thermal and electrical parameters of a PV/T air collector.They used either water or air for the heat extraction from the PV module, depending on the thermal needs of the application and the efficient operation of system regarding the weather conditions and the used heat removal fluid .Most of them are studies about electrical and thermal performances understeady-state conditions [4–6]. S.A.Kalogirou,Y. Tripanagnostopoulos [3]constructed and tested two types of PV/T experimental models one with pc-Si and another with a-Si for determination of the steady state thermal efficiency and the electrical efficiency. They studied PV/T systems consist of PV modules in combination with water heat extraction units. Results are simulated with the TRNSYS program. They found that the overall energy production of the units is increased. Swapnil Dubey et al.[2] studied four different configurations of two types of PV modules, glass to glass and glass to tedlar.They observed that the The overall electrical efficiency of the photovoltaic (PV) module can be increased by reducing the temperature of the PV module by withdrawing the thermal energy associated with the PV module.They made an attempt to develop analytical expression for electrical efficiency of PV module with and without flow as a function of climatic and design parameters.so that four different configurations of PV modules are considered. Rakesh Kumar, Marc A. Rosen [7] performed a detailed analysis of a double-pass solar photovoltaic/thermal (PV/T) air heater with fins They observed that the presence of fins in the lower air channel on the absorber surface increases the heat transfer area to air and improves the thermal, electrical and total equivalent thermal efficiencies. The extended fin area also reduces the cell temperature considerably. They found that electrical efficiency is significantly affected by the cell temperature, which depends on solar irradiance, inlet air temperature, air flow rate and packing factor. Thermal modeling has been done for system of PVT integrated with EAHE and greenhouse in [8-10]The paper presents an attempt to obtain a suitable PV/T model design which gives better thermal and electrical performances of the system under stationary and transient conditions.

2 Mechanics and material

2.1 Experimental setup

The photograph of the hybrid solar PV/T collector is shown in Fig. 1. The orientation of hybrid solar PV/T collector was kept in the east-west during experiment to extract maximum advantage of incident solar radiation. The PV/T collector is inclined with 23^{o}.

Fig. 1: Photograph of the Experimental set up

2.2 Instrumentation

The solar radiation measured on the inclined surface of the PV/T collector with the help of TM 207 model solar power meter manufactured by Tenmars, Taiwan having experimenting accuracy ±10 W/m^2 and measuring range of 0–2,000 W/m^2. Calibrated digital hygrometer ofAM-3003 model manufactured by Lutron, Taiwan probe type is used to measure the temperature and relative humidity at inside, outlet of greenhouse and ambient conditions. The measuring accuracy and range for measurement of relative humidity are ±3 and 10–95 %; ±0.8 and 0–50 ^{0}C are the measuring. Ground temperature was recorded with the help of MT Raytek infrared thermometer non-contact gun type having accuracy and precision ±2 % and 0.2 ^{0}C respectively. Air speed is measured with the help of hot-wire 490 Testo anemometer probe having resolution and range are 0.1 and 0.2–60 m/s respectively.

2.3 Experimentation

The experiments were conducted in no-load condition on 16-17 June 2014 on the site of Maulana Azad National Institute of Technology (Bhopal, India) located at 23.15 ^{0}N latitude, 77.25 ^{0}E longitude and 500 m altitude. Experiments were conducted only during the day time hours from 10 a.m. to 5 p.m.

Result and Discussion

After construction of the hybrid solar air collector, it was tested. Theanalysis was carried out such as solar radiationintensity, relative humidity, wind velocity, ambient temperature and cell temperature. First day (Day 1) of experimentation was found to be the clear sky conditions and on second day (Day 2), the weather was hazy and partly cloudy condition. The variation of these five parameters were observed hourly basis during experimentation and it is presented in Fig 2-6. Fig. 2 depicts the variation of solar radiation with respect to time. It showsthat the maximum solar intensity was 815 and 645 W/m^2 for day 1 and day 2 of experimentation respectively.

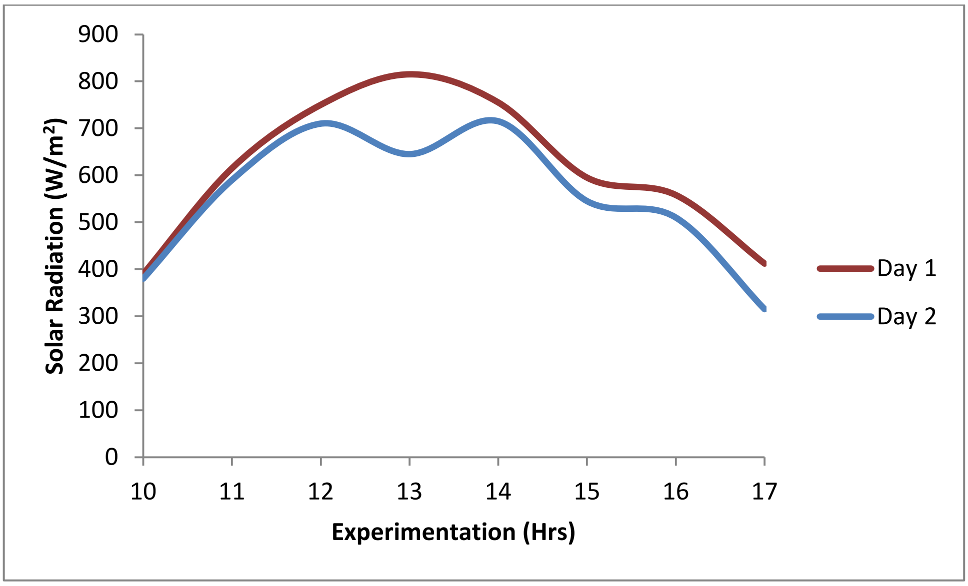

Fig. 2: Variation of Solar radiation

Fig. 3 shows the variation of ambient temperature on the both day of experimentation. On the day of clear sky, which is day 1 is found to be always greater temperature than cloudy and hazy weather conditions. The average ambient temperature on day 1 is 43.85 ^{0}C and 35.72 ^{0}C for day 2 respectively.

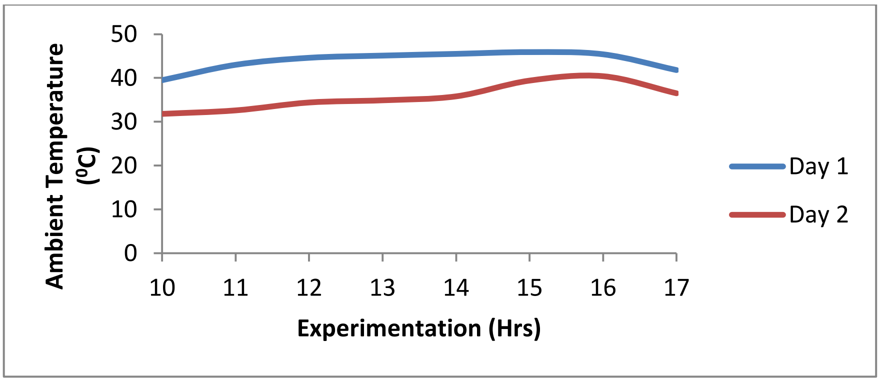

Fig. 3: Variation of Ambient Temperature

Fig. 4 shows the variation of ambient relative humidity of day 1 and day 2 respectively.The average ambient relative humidity is 20.95 % for day 1 and 35.58 % for day 2 respectively. It is found that day 2 have higher ambient relative humidity as compared to day 1 of the experimentation.

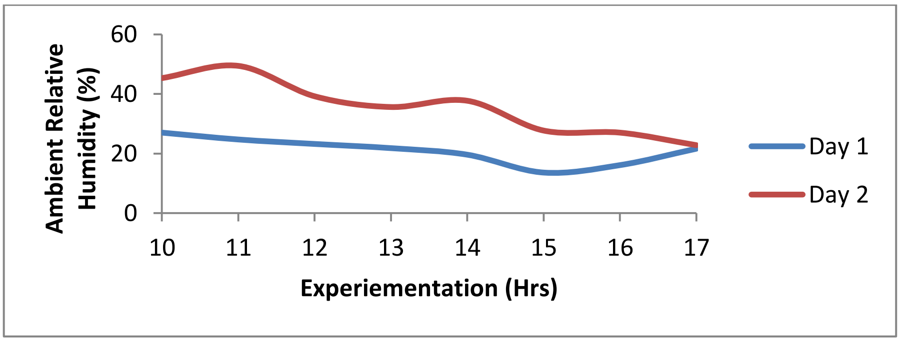

Fig. 4: Variation of ambient relative humidity

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Fig. 5 demonstrates the variation of ambient wind velocity. It is observed that day 2 of experimentation having higher wind velocity as compared to day 1. The range of wind velocity on day 1 is 0.51-2.1 m/s for day 1 and 1.71-2.44 m/s for day 2 respectively.

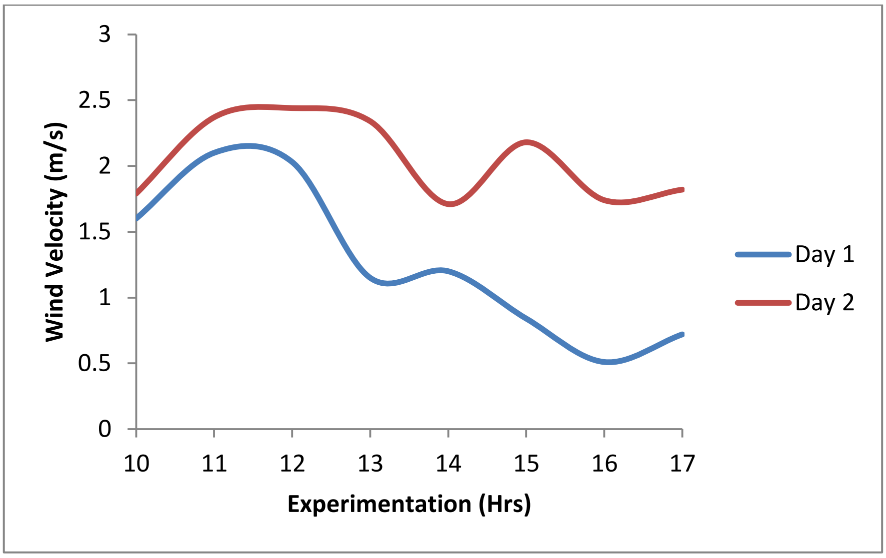

Fig. 5: Variation of ambient wind velocity

Fig. 6 shows the variation of the cell temperature of the hybrid solar air collector. Due to clear sky conditions on day 1, cell temperature is always found to be the higher than the day 2. The higher cell temperature decreases the efficiency of the solar panel. The variation of cell temperature on day 1 is 45.3-61.4 ^{0}C for day 1 and 35.4-53.8 ^{0}C for day 2 respectively.

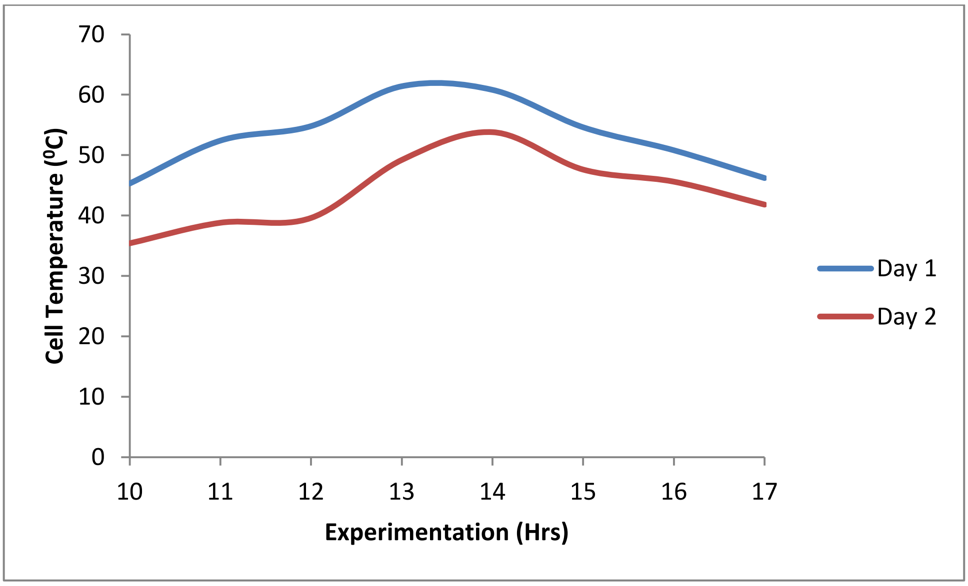

Fig. 6: Variation of cell temperature

Conclusion

The study can be used to provide the design and testing data for this type of hybrid solar air collector in other locations of the world. Experimental result reveals that there is a significant increase in the cell temperature due to clear sky conditions as compared to cloudy and partly hazy weather conditions. In order to increase the efficiency of the collector, suitable modification can be applied in the collector to provide proper cooling.

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