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PERFORMANCE EVALUATION OF SOLAR PVT AIR COLLECTOR SYSTEM

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ABSTRACT
Solar PV-T is a hybrid system that combines solar photovoltaic and solar thermal systems to provide electricity and heat at the same time. This article presents a method to study the thermal and electrical characteristics of collectors. Measure air inlet and outlet temperature, thermal efficiency, electrical efficiency, and overall system efficiency in Jaipur, India weather conditions. This article also performed an exergy analysis. Exergy is the available low-grade energy that can be used for conversion. It is found that the total efficiency varies between 30-60% and the maximum exergetic efficiency is 9.72%. The results show that compared to separate solar thermal and photovoltaic collectors, more energy can be obtained per unit area.
KEYWORDS: ***Solar PVT, Performance Evaluation, Exergy Analysis, Hybrid Systems, Efficiency***

1. INTRODUCTION

Solar energy is one of the most important renewable energy sources the world needs. Once the electrical energy is converted, more than 82% of the absorbed electrical energy is discharged back into the environment [1]. The main applications of solar energy can be divided into two categories: thermal systems (T) and photovoltaic system cells (PV). In traditional photovoltaic systems, the high incident solar radiation on the panels (PV) should provide a high electrical power [2]. However, a high incidence will increase the temperature of the solar cell, thus reducing the efficiency of the panel. For every 1 ° C increase in temperature, the efficiency decreases by 0.5% [3]. Also, the life of the solar cell will be shortened if it is exposed to high temperatures for a long time [4]. Therefore, to achieve higher battery efficiency and higher electrical output, we must cool the battery by removing the heat in some way. Therefore, to cool the cells of the photovoltaic system, we integrate photovoltaic panels with solar air collectors [5]. This type of system is called photovoltaic (PVT) or hybrid (PVT) collector, the advantage of this system is that it can generate heat and electricity at the same time. Cooling from photovoltaic energy improves efficiency, the heat can be used to heat spaces or for drying systems, and is more economical than two independent units. This article discusses the design of a photovoltaic / T solar air collector, its performance, and the exergy and energy analysis of the design [6-7].

2. METHODOLOGY

2.1 SOLAR PV/T AIR COLLECTOR CONSTRUCTION

Solar PVT is built with 30 W polycrystalline silicon solar panels. The panel area is 0.301 square meters and it is enclosed in a mild steel box with a glass lid on top. The shell acts as an absorbent. The 12V DC fan is used to circulate air in the system.

2.2 MEASUREMENTS

A portable solar energy meter (Tenmars TN-207, Taiwan) was used to measure the total instantaneous global solar irradiance with an uncertainty of ± 10%. Use a digital thermometer and hygrometer to measure the ambient temperature and humidity. The electrical characteristics of PV and PVT are measured using a solar module analyzer (MECO 9009). Inlet and outlet air velocities are measured with anemometers. Measure the air inlet and outlet temperature with a digital thermometer. The front and back temperatures of the photovoltaic and PVT panels are measured using infrared thermometers.

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2.3 EXPERIMENTAL PROCEDURE

The experiment was carried out in Jaipur, India (latitude 26.91º N; longitude 75.78º E) from 10 am to 5 pm in June 2021. Air is used as a refrigerant in the system with a constant mass flow rate of 0.02 kg / sec. Measure wind speed, solar intensity, ambient temperature, relative humidity, open circuit voltage, short circuit current, maximum power, module front and rear temperature, fill factor, voltage and current maximum power, air inlet and outlet temperature, photovoltaic solar energy and PVT solar systems for 1 hour. Efficiency describes the performance of the air collector, including thermal efficiency and electrical efficiency.

Photo Electric conversion efficiency, $\eta e = \frac{I_m * V_m * FF}{GA}$ (1)

Thermal Efficiency, $\eta th = \frac{mc_p (T_{out} - T_{in})}{GA}$ (2)

Overall Efficiency, $\eta_o = \eta_{th} + \eta_e$ (3)

Energy saving efficiency, $\eta_f = \eta_e / \eta_{power} + \eta_{th}$ (4)

Maximum Power, $P_{max} = V_{OC} \times I_{SC} \times FF = V_{mp} \times I_{mp}$ (5)

Exergy Input = Exergy Output + Exergy Loss + Irreversibility

$$n_{ex} = \frac{E_x output}{E_x input} \quad (6)$$

3. RESULTS AND DISCUSSION

In this study, commercial 30 W polycrystalline photovoltaic modules were used to build an integrated PVT air collector system. The concept of energy efficiency has been used to evaluate the energy gain of PVT collectors. Current test results show that the energy saving efficiency of the hybrid PVT system exceeds 50%, which is higher than that of traditional solar air heating system. The overall performance of the PVT system includes electrothermal conversion, which is affected by many factors such as mass flow, wind speed, inlet and outlet wind temperature, intensity of solar radiation, ambient temperature, the wind speed and direction of the system.

Figure 2 shows the changes in the electrical efficiency of the PV and PVT systems. The electrical efficiency of the photovoltaic thermal varies between 5.8% and 6.5%, while the electrical efficiency of the photovoltaic varies between 6% and 8.4%. The change in electrical efficiency of the two systems is due to reflection losses in the PVT system.

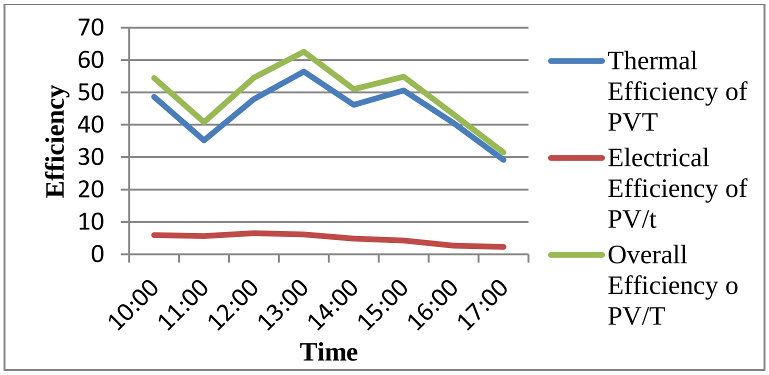

Figure 1: Variation of various efficiency of PV/T

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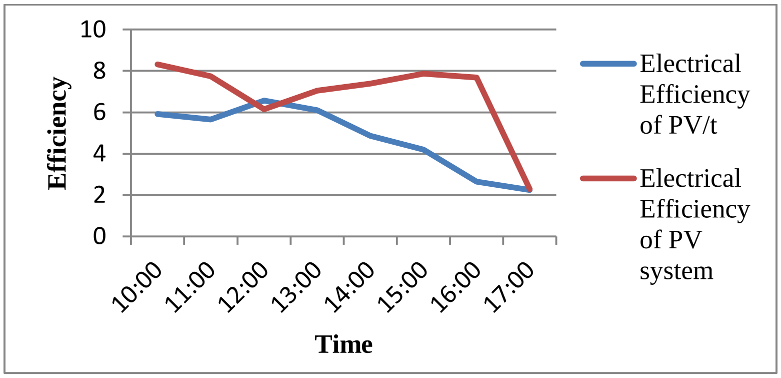

Figure 2: Variation of Electrical Efficiency of PV and PV/T

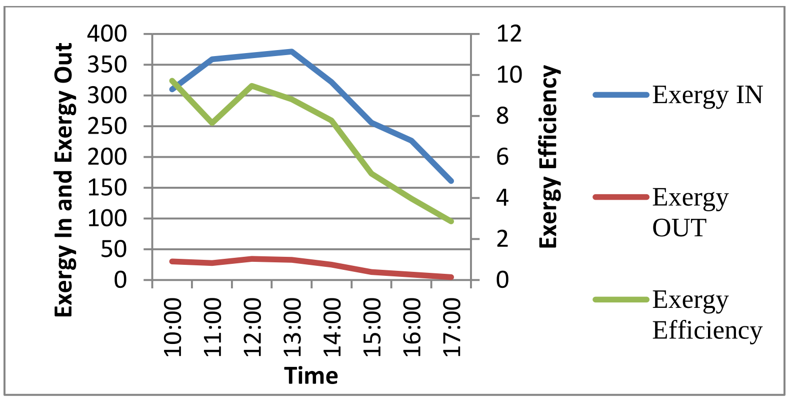

Figure 3: Exergy Efficiency of PV/T

It can be seen that at a constant mass flow rate of 0.02 kg / sec the average thermal efficiency is about 46.43% and the temperature rise of the flowing air is about 116 ^{0}C. The final air temperature exceeds 58 ^{0}C. The average daily energy efficiency of the photovoltaic system is approximately 5.86%, while the average daily energy efficiency of the photovoltaic system is approximately 7.5%. Average comprehensive efficiency and energy saving efficiency exceed 52.30% and 47.52% respectively. The maximum exergetic efficiency of PVT is approximately 9.92% and the mean exergetic efficiency exceeds 7.97%.

4. CONCLUSION

This article describes the thermal and electrical performance of hot air / photovoltaic collectors. The experiment was carried out in an outdoor environment with a fixed air flow rate of 0.02 kg / sec and different initial air temperatures. Under the proposed design and operating conditions, the daily energy efficiency is approximately 5.86%, the daily thermal efficiency is approximately 47.5%, and the total system efficiency exceeds 50%. The results show that, compared to using PV alone, the overall performance of the PVT system is improved by integrating solar PV and thermal energy [8]. PVT applications can provide sustainable solutions to maximize solar production from building-integrated photovoltaic systems. This PVT system is particularly suitable for low temperature applications such as mixed greenhouses, drying or space heating [9-10].

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