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Thermal Performance of Hybrid PVT Collector with Natural Circulation

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***Abstract*—**Hybrid photovoltaic thermal (PVT) collectors allow simultaneous production of electrical energy thus heat energy. There are several configurations of hybrid collectors (to produce water or air). For hybrids water collectors, there are several configurations that differ by the nature of the absorber (serpentine, tubes...). In this paper, an absorber tank is studied. The circulation of the coolant is natural (we do not use the pump). We present the obtained results in our experimental study and we analyzed the data, and then we compare the results with the theory practices. The electrical performances of the hybrid collector are compared with those of conventional photovoltaic module mounted on the same structure and measured under the same conditions.

We conducted experiments with natural circulation of the coolant (Thermosyphon), for a flow rate of 0.025kg/m².

***Keywords*—**Experimental, Photovoltaic, Solar, Temperature, Tank.

I. Introduction

THE hybrid photovoltaic thermal collector consists of a thermal collector and a photovoltaic module housed in a single collector. This allows increasing the total conversion efficiency of solar energy received. Y. Tripanagnostopoulos applied the cooling system based on collectors to photovoltaic hybrid collector [1]. Returning a can back, Kern and Russell [2], give the main concepts of these systems by the use of water or air as coolant. Bhargava et al. [3] and Prakash [4] present the results of their work on the effect of flow rate and air channel.

Work on the performance of hybrid collectors have been studied by Sopiane et al. [5]. In the works above the thermal efficiency of PV/T was in the range from 45% to 65%. Bergen and Lovvik [6] analyzed the energy transfer between different components of the hybrid PV/T using the liquid as coolant. A parametric study for housing has been submitted by Brinkworth et al. [7].

Garg and Adhikari [8] studied the PV/T system using air for heating in single and double glazing.

The collector hybrid PV/T with hot water tank was proposed by Huang et al. [9] and another design of the PV/T was included recently. B. S. Sandnes et al. [10] studied the thermal photovoltaic absorber-based on polymer.

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Elswijk MJ et al. [11] concluded in a study in the home that a hybrid collector PVT needs 38% less roof space a combined system of PV modules and thermal collectors with approximately the same yield.

II. Experimental Study

We conducted a natural circulation of coolant without using any pump.

Global radiation was measured by a pyranometer Kipp and Zonen type coefficient: 0.00000457 Vm ² / W. The wind speed is 1m / s.

The PVT hybrid collector was connected to a water tank containing 80L, and for the volume of water flowing through the heat exchanger (13.65L), 6 times lower than the tank, we considered that the circuit is open and that hot water is consumed and renewed continuously.

The parameters of the photovoltaic collectors used during the tests are given in the following table.

TABLE I
ELECTRICAL PARAMETERS OF THE TWO COLLECTORS (HYBRID AND FREE PV)

Parameter	Free PV	hybrid collector
G Radiation : (W/m²)	939	939
Form Factor: ff (%)	0.607	0.583
Short-circuit current : I_{cc}(A)	2.58	2.67
Open circuit voltage : V_{co}(V)	18.6	18.2
Maximum current : I_{pmax}(A)	2.63	2.61
Maximum voltage: U_{pmax}(V)	14.44	13.4
Maximum power: P_{max} (W)	37.9	34.9
Number of cells	36	36

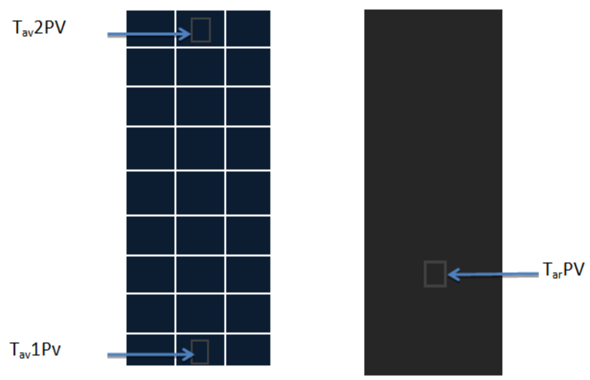

Fig. 1 Mesh temperature for free PV

III. Thermal Performance

We selected temperatures PV module using witness an acquisition type Agilent Bench Link Data logger3 bringing reference 34970A connected to thermocouples placed at different points on both fronts device. The mesh is made of the temperatures shown in Fig. 1.

The purpose of the mesh is to determine the temperature distribution on both sides of the PV collector (front and rear) (see Table I).

Such as:

Tav1PV : Temperature of the front (on the glass, lower end) of the first point of the PV collector.

Tav2PV : Temperature of the front (on the glass) of the second point of the PV collector.

TarPV : Temperature of the rear surface (the layer of Tedlar) PV.

Using the same apparatus and performing the same steps we have taken different temperatures on the PVT collector.

Fig. 2 shows a photo taken for this installation.

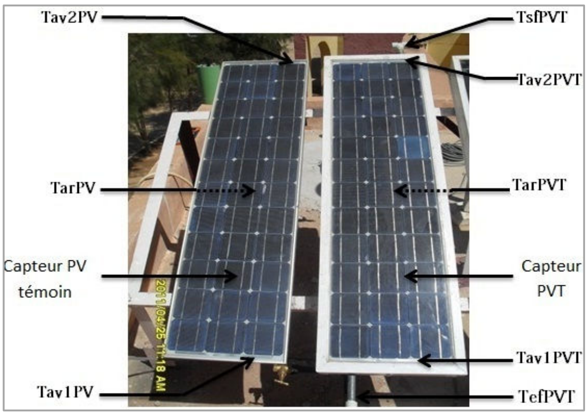

Fig. 2 Photo showing the mesh temperature for PVT collector and free PV

Such as:

Tav1PVT : Temperature of the front (on the glass, lower end) of the second mesh point PVT collector.

Tav2PVT : Temperature of the front (on the glass top end) of the second mesh point PVT collector.

TarPVT : Temperature of the rear face (layer Tedlar) hybrid collector PVT.

TefPVT : inlet temperature of the coolant.

TsfPVT : outlet temperature of the coolant.

The use of two sampling points for the temperature of the front faces of the two collectors has allowed us to conclude that the temperature is uniform over an entire face of the collector.

Fig. 3 shows the appearance temperatures TefPVT, TsfPVT and Ta 08heure to 20 h PM.

From this figure, we note, from 11:30 AM a significant increase in fluid temperature at the exit of hybrid PVT collector relative to the input, up to 11°C difference although the movement is natural (thermosiphon).

This increase in temperature is due to the heat absorbed by the water that is passed to the heat exchanger integrated in its rear side by the solar collector.

Fig. 4 shows the temperature distribution of the front face of the two collectors with respect to time for a given variation in radiation in the same figure.

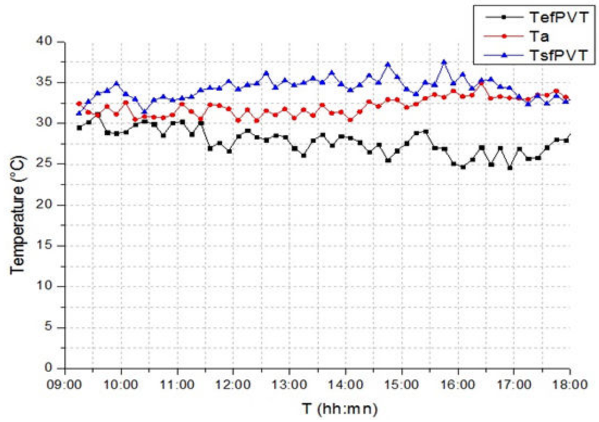

Fig. 3 Variation of the inlet temperature, outlet coolant

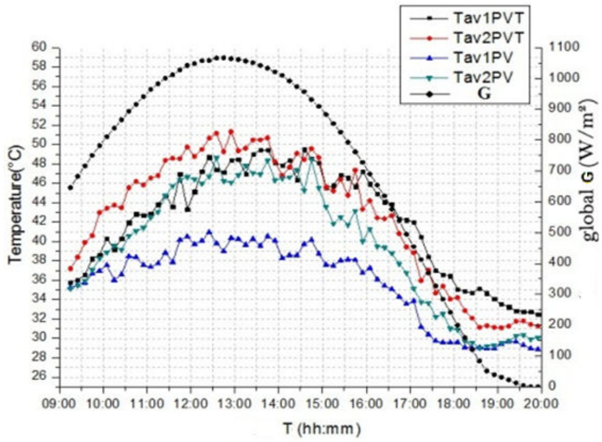

Fig. 4 Distribution of temperature for the two front collectors

We note that the temperatures are almost uniform on the front of the PVT collector, as each layer is made of the same material (glass for the front), and thanks to the coolant which distributed heat homogeneously.

At the free PV collector we note a slight increase of the temperature at the upper end with respect to the lower end, and this is because the hot air tends to mounted, thereby heating the collector to advantage.

As there is a proportional increase in temperature at the two collectors according to the increase of solar illumination.

Fig. 5 shows the temperature distribution of the rear face of the two collectors with respect to time for a given variation in radiation in the same figure.

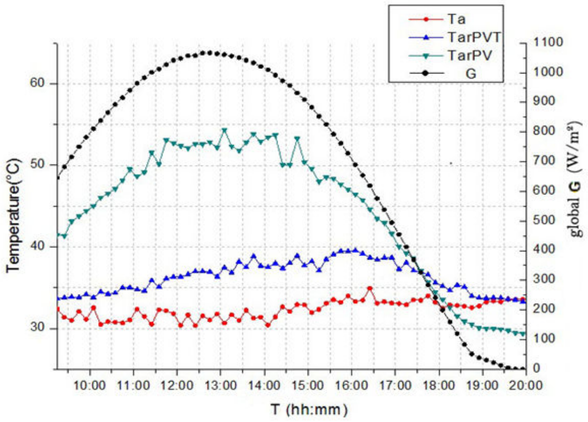

Fig. 5 Distribution of the temperature on the rear face of the two collectors

We record a large difference between the temperature of the rear face of the collector and indicator PV hybrid PVT collector, such as 1:05 p.m. the rear face of the PV collector vacated reached 54°C and such a temperature, that against the PVT hybrid collector reaches only 39.54°C as maximum temperature throughout the day and it and because it is insulated.

The shape of the thermal efficiency of the hybrid collector is shown in Fig. 6, we chose the period between 10heure up to 14 hours.

We note that the values of the reduced temperature

(T * = (Tef-Ta) / G) are all negative, this is explained by the fact that the inlet temperature of the fluid during the test was less than ambient temperature.

From this figure we see that the performance will be even better than the inlet temperature will be close to the temperature of the ambient air to minimize heat loss by convection. In this case our PVT collector can provide hot water suitable for heating low temperature.

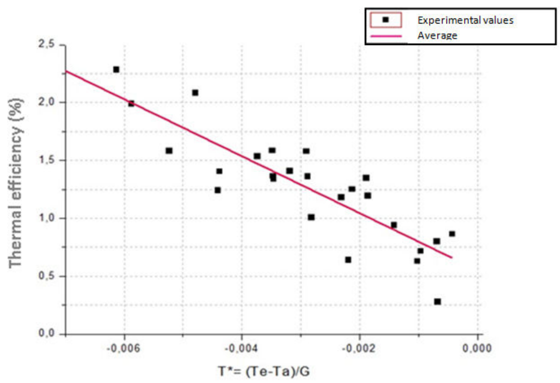

Fig. 6 Thermal Performance of the hybrid collector

IV. Conclusion

Solar energy can be exploited by two ways, one that will generate photovoltaic electricity and heat for another production of heat that can be used for air heating or hot water. But during a photovoltaic heat is generated at the collector which will increase the temperature of the photovoltaic cells and cause a drop in performance.

This is due to the portion of solar radiation not absorbed by the cells and which will cause them to heat up, on the other hand, this part of the radiation absorbed is lost as heat which can be exploited for various uses.

This heating was considered detrimental to the performance of photovoltaic solar panels, to improve the latter it becomes clear that the cooling of solar cells by the combination of a photovoltaic system with another heat, is one of the largest solutions energy for this improvement is partly this fact that the hybrid collectors PV/T have existed, to take full advantage of the facility.

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