Hybrid Technology in Solar Energy Utilization

I. Kocsány, I. Seres

Department of Physics and Process Control, Szent István University, Páter K. u. 1, Gödöllő, H-2103, Hungary

e-mail of corresponding authors: *kocsany.ivett@gek.szie.hu*, *seres.istvan@gek.szie.hu*

Abstract
Initially the solar system which was installed (2011) in the Department of Physics and Process Control, Szent István University is presented. The aim of this work is to study the behaviour of hybrid collector under different load test. The most important measured parameters and settings of the experiments are introduced. Based on the measurement data analysis was elaborated for understanding the behaviour of different technologies.

Key words: *hybrid collector, PV/T, measurement, modelling*

Introduction

Among the solar energy application possibilities the solar thermal systems can reduce the consumption of traditional energy resources. By using less energy obviously leads us to less pollution. Photovoltaic solar energy is one of the renewable sources. As a result of developing the photovoltaic solar energy system the hybrid photovoltaic/thermal system found, which combined both systems into one system know, (Tripanagnostopoulos, 2007). The solar market has shown an effective 33% growth per year since 1997 until today (Hoffmann, 2006). The PV/T system can be segregated into two parts; the thermal solar technology what converted the solar energy into heat, and the photovoltaic technology which derived from solar cell technology and convert the solar radiation into electricity (Zondag, 2008). The hybrid technology can reduce the main problem of photovoltaic systems: the high temperature of the solar cell effects reduction in the efficiency. However high solar radiation, which is necessary for the solar panels to produce more energy, naturally causes high temperature in the cell. To solve the problem flat plate hybrid collector has developed, which produces both thermal energy (by cooling back the module) and electricity at the same time.

At the Department of Physics and Process Control, Faculty of Mechanical Engineering, Szent István University, Gödöllő various solar applications were installed for educational, demonstrational and research purposes, such as PV and solar thermal units, transparent wall insulation and solar dryer unit. The examination of the PV/T (installed in 2011) is performed in this paper. Initially the solar-thermal system in the Department of Physics and Process Control Szent István University is presented. In this paper the flat plate PV/T collector design and analysis of measurements are performed. The solar energy technology has many advantages and disadvantages comparing to the conventional energy. At first the potential advantages come below:

- low maintenance costs,
- do not makes noise,
- do not pollute the environment,
- do not produce any toxic waste or radioactive material,
- the system life cycle expectation is between 20 and 30 years,
- It can be substitute the conventional energy.

The disadvantages:

- large space needed for separate systems (hot water and electricity production),

- high cost of the solar system installation,
- long payback time period.

Material and methods

Usually a simple PV module is converted the incoming solar radiation into electricity around 10-15%. The rest, as unutilized energy is wasted what effects worsen efficiency of solar cells. On a typical summer day when the ambient temperature is high and the sky is clear the solar panels could be heated to 60 - 70°C. Despite the high solar radiation because of the degradation of the efficiency, higher power utilization cannot be achieved. The back of PV/T collector is used as a thermal layer which collecting the heat and lead it away so the solar layer cools down.

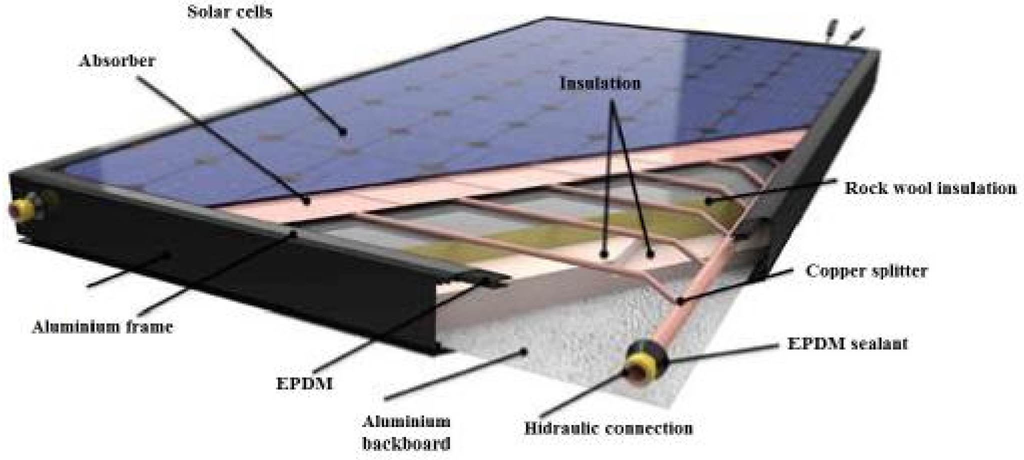

Figure 1 Structure of flat plate photovoltaic-thermal (PV/T) collector

The construction of the flat plate PV/T collector is shown in *Fig.1*. A complete flat plate PV/T collector should have composed of a glass cover, solar cells, insulation, copper splitter and absorber plate underneath. The absorber plate plays important function in PV/T system. It cools down the PV cell or module, simultaneously collecting the thermal energy produced in the form of hot water or hot air. PV/T collector can be designed variety etc. air PV/T collector, water PV/T collector, combination of water/air PV/T collector depending on type of working fluid used. Aste et al. (2008) noted that, amongst all types of PV/T solar collectors, the most wide-spread PV/T collector which is working with air. Despite of this type of collector has less application compared to the water collectors. The collector's glass is made by low iron and tempered solar glass, which optimally utilized over the 700 nm wavelength of incoming radiation. The nominal electric power of the PV/T applied in the experiment is 170 W.

Analytical models of PV/T collectors

Sopian et al. (1996) analysed the performance of single and double-pass PV/T air collectors with steady-state models. The results showed the double-pass PV/T air collectors have significant differences in efficiency compared to the single-pass ones, thermal and combined efficiencies and packing factor are not directly proportional. Packing factor is defined as the ratio of the photovoltaic cell area to absorber area.

Florschuetz (1979) developed the Hottel–Willier (1958) analytical model of flat plate collectors to made analytical calculations on PV/T collectors. Bergene and Lovvik (1995), recommended a detailed model based on energy transfer analysis and to some extent on the models for flat plate solar collectors presented by Duffie and Beckman (1991) which predicting the performance of PV/T collectors. The model estimated PV/T efficiency (thermal + electrical) to be about 60–80%.

Numerical models

Chow (2003) developed an explicit dynamic finite difference approach model for a single glazed PV/T collector. The model can create results for hourly performance analysis, including immediate thermal/electrical benefits and efficiencies. Zondag et al. (2002) developed a numerical model predicting the performance of PV/T collectors. The model was included two types of models 3D (three dimensional) dynamic and steady state (3D, 2D and 1D) models. It was concluded that for the determination of the efficiency curves the simple steady state 1D model performs well and dynamical effects is very small.

Experimental work

Sandnes and Rekstad (2002) developed an analytical model for the hybrid system by modifying the previously mentioned Hottel -Willier (1958) model. The PV/T collector was constructed by single-crystal silicon PV cells onto a black plastic absorber. They interpreted that to reduce the heat losses to the environment a glass cover is needed to the PV/T collector. The energy absorption was also reduced by reflection (around 10%) from the glass.

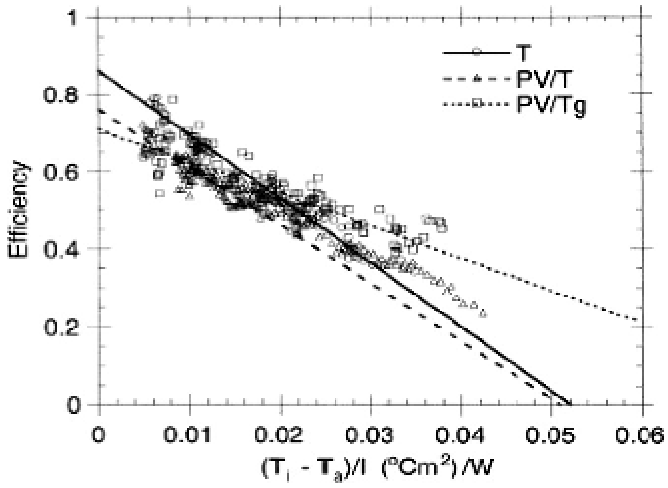

Figure 2 Thermal efficiency curves from experimental results for three collector configurations: thermal absorber (T), photovoltaic/thermal absorber (PV/T) and photovoltaic/thermal absorber with glass cover (PV/Tg). Sandnes and Rekstad (2002).

Picture above (Fig. 2.) shows the thermal efficiency curves for the three configurations: photovoltaic/thermal absorber (PV/T), thermal absorber (T) with no glass and photovoltaic/thermal absorber with glass (PV/ Tg).

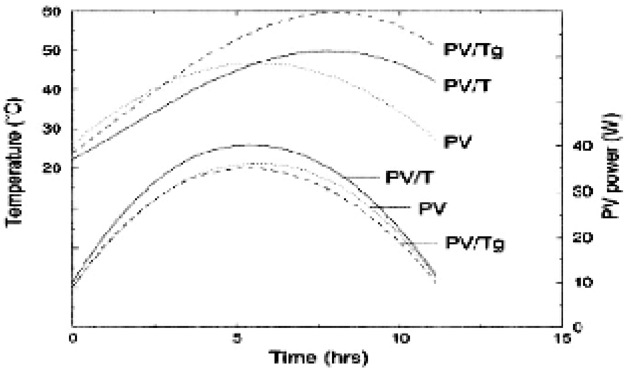

Figure 3 Simulated cell temperature and PV power output for a clear summer day for the PV, PV/T and PV/Tg configurations Sandnes and Rekstad (2002).

Fig. 3. shows the simulated cell temperature and photovoltaic power output for the PV/T system, the PV/Tg system and the PV module without thermal insulation. From this graph it is clearly seems that the black thermal absorber (T) absorbs more efficiently the incoming radiation, covering the absorber with PV cells (PV/T) reduces the converted energy and the heat loss coefficient.

Conclusions

This paper has presented a review of design configurations of flat plate PV/T collector. In the frame work it can be concluded that the hybrid flat plate collector can be used to overcome the problem in the PV system, because it provides with cooling system. In addition the system has low maintenance costs, environmentally friendly, do not produce any toxic waste or radioactive material, it can be substitute the conventional energy and the system life cycle expectation is significant (20-30 years).

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