บทความวิจัย

การเพิ่มสมรรถนะของแผงเซลล์แสงอาทิตย์ด้วยระบบหล่อเย็น

Increasing Performance of Solar Cell Panels by Cooling System

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คำสำคัญ : โซลาร์เซลล์, เซลล์แสงอาทิตย์, ระบบหล่อเย็น, อุปกรณ์หล่อเย็น

Keyword : Solar cell, Photovoltaic, PV/T system, PV/T collector

บทคัดย่อ

อุณหภูมิของแผงเซลล์แสงอาทิตย์ที่สูงมากเกินไปจะทำให้ประสิทธิภาพการทำงานของเซลล์แสงอาทิตย์ลดลง งานวิจัยนี้จึงมีวัตถุประสงค์ที่จะศึกษาการเพิ่มสมรรถนะการทำงานของแผงเซลล์แสงอาทิตย์โดยการลดอุณหภูมิส่วนเกินของแผงเซลล์แสงอาทิตย์ ในการทำวิจัยนี้ใช้แผงเซลล์แสงอาทิตย์ชนิดซิลิกอนผลึกเดี่ยวรุ่น BP 253 ศึกษาร่วมกับระบบหล่อเย็น 2 ระบบ คือระบบหล่อเย็นด้วยน้ำและระบบหล่อเย็นด้วยแผ่นครีบ สำหรับระบบหล่อเย็นด้วยน้ำศึกษาที่อัตราการไหลของน้ำในช่วงต่าง ๆ คือ 2.88×10^{-6}, 3.60×10^{-6}, 4.24×10^{-6} และ 5.88×10^{-6} m^3/s ส่วนระบบหล่อเย็นด้วยแผ่นครีบศึกษาในสภาพอากาศแบบธรรมชาติ

ผลการทดลองพบว่า ระบบหล่อเย็นด้วยน้ำที่อัตราการไหล 4.24×10^{-6} m^3/s ให้ผลดีที่สุด ระบบหล่อเย็นด้วยน้ำที่อัตราการไหลดังกล่าวและระบบหล่อเย็นด้วยแผ่นครีบ มีผลทำให้อุณหภูมิของแผงเซลล์แสงอาทิตย์ลดลง 23.15 °C และ 10.70 °C ตามลำดับ ซึ่งส่งผลให้แผงเซลล์แสงอาทิตย์มีประสิทธิภาพการทำการทางไฟฟ้าเพิ่มขึ้น 0.46 % และ 0.32 % ตามลำดับ และทำให้แผงเซลล์แสงอาทิตย์สามารถผลิตกำลังไฟฟ้าได้เพิ่มขึ้น 7.26 % และ 5.39 % ตามลำดับ เมื่อเปรียบเทียบกับแผงเซลล์แสงอาทิตย์ที่ใช้งานโดยปราศจากระบบหล่อเย็น

Abstract

The excessive temperature on photovoltaic (PV) modules causes diminishing the PV efficiency. The objective of this research was to study the methods of increasing performance of PV module by eliminating of the excessive temperature. In this work, we used PV model BP 253 installed with 2 cooling systems: photovoltaic/thermal-water (PV/TW) system and photovoltaic/thermal-fin (PV/TF) system. For the PV/TF system was applied by ambient air and in case of study the PV/TW system, it was supplied by 2.88×10^{-6}, 3.60×10^{-6}, 4.24×10^{-6} and 5.88×10^{-6} m^3/s of flow rate.

According to our result, the PV/TW system at the flow rate 4.24×10^{-6} m^3/s provided the best result and it could decrease 23.15 °C of the excessive temperatures on the PV module and increase electrical efficiency equal to 0.46 % and 7.26 % of electric yield. For the PV/TF system, it could cause the excessive temperatures on the PV module decrease 10.70 °C and increase electrical efficiency equal to 0.32 % and 5.39 % of electric yield when compared with the PV module alone.

1. Introduction

In the present, the energy is necessary for life and it seems that in the near future, the crude oil will be run out for consuming. Searching for the renewable energy is necessary. In general, sunlight energy was a good choice since we obtained it from the sun everyday [1]. Photovoltaic (PV) cell had invented to transfer sunlight energy to be electrical energy by absorbed the intensity of solar radiation on the surface area of PV module [2], [3]. However, the excessive temperature on PV module caused electric yield to decrease 0.4-0.5 %/°C for mono- and multi-crystalline silicon solar cell [4]. Similarly, the electrical efficiency was decreasing 0.06%°C [5]. Previously, many researchers suggested the method of reduce excessive PV temperature for improvement the PV efficiency. Both of the PV/T-Water system and PV/T-Air system could apply for temperature reduces on the PV modules. Moreover, the PV/T-Water system helped to keep more efficiency than the PV/T-Air system [6].

The cooling system had improved to reduce excessive temperature on PV module by flowing water at the flow rate 17 m^3/h over the module front in form of thin water plate [4]. Also, the results were illustrating that the system could decrease excessive temperature down to 22 °C and conducted to increase 9% of the electricity yield.The PV/T-Air sytem had classified into 2 configurations:single-pass and double-pass PV/T-Air system. The results had presented that the double-pass PV/T-Air system could reduce more PV temperature and gain of the PV efficiency than the single-pass PV/T-Air system [7].

Recently, the PV/T-Air systems was developed and consisted of glazed and unglazed system. The glazed system assigned by thin aluminum sheet (PVT/AIR-TMS+GL) and fin (PVT/AIR-FIN+GL) system. In case of the unglazed system assigned by PVT/AIR-TMS+UNGL and PVT/AIR-FIN+UNGL systems. Their result was showed clearly that the PVT/AIR-FIN+UNGL system could increase more PV efficiency than other configurations [5].

2. The objectives

2.1. To study the method of improvement the performance of the PV module.

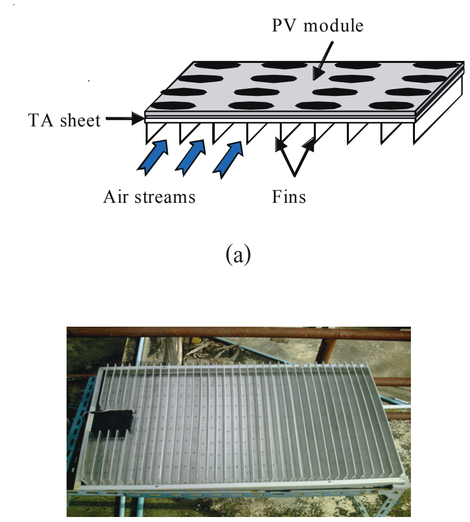
2.2. To suggest the appropriate method of application in the different condition.

2.3. To compare between the performance of the PV/T systems and PV module alone.

3. Material and Methodology

3.1 PV/T collectors

In Fig.1, we show the cross-section views of PV/TF system (Fig.1a) and installation by attached to the rear surface of each PV module (Fig.1b). In our designed system, the PV/TF collector composed of a thin aluminum (TA) sheet which were about 4 mm of thickness and surface area equaled to , for fins (made from thin aluminum) were 2 mm of thickness, 49.5 cm of length, 6 cm of height and 49 cm of length. We installed 30 pieces of the fins and each fin had been separated by 2 cm.



(a)

(b)

Fig.1. (a) Show cross-section view of the PV/TF collector model and (b) installation of the PV/TF collector with PV module.

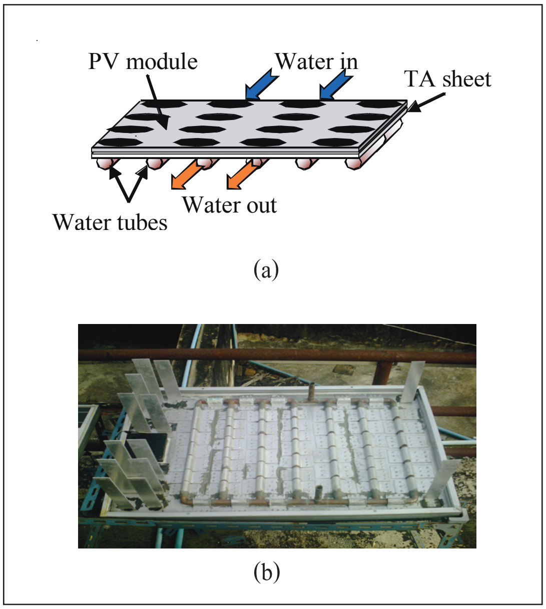


Fig.2. (a) Show cross-section view of the PV/TW collector model and (b) installation of the PV/TW collector with PV module.

In Fig.2, we show PV/TW collector (2a) and PV/TW system (2b). The PV/TW collector composed of a TA sheet and water tubes (made from copper tube). TA sheet was about 2 mm of thickness and surface area equaled to 0.496 x 0.796 m^2. Water tube was 1 mm of thickness, 0.15 mm of diameter and 42 cm of length. In this work, we installed 7 tubes and the free space between each tube was 10 cm.

In this work, all the related analyzation about PV/T collectors, we applied from [8], [9] and [10].

3.2 Conditions of the experiment study

In our experiment, we used 2 mono-silicon PV modules (model BP 253) and their electrical power outputs were equivalence. The system had installed at a tilt angle of 7 $^{\circ}$C (approximate tilt angle of Songkla Province, Thailand) on a mobile structure and a front of PV modules turned to the north. Irradiance was measured by a DL-204 of TENMARS luxmeter at the same incidence plane of the PV modules. Data Logger model DL 2100 (K type of sensors) had used to record temperature. Ambient temperature had measured in the shade (under PV modules), while PV temperature had measured on the rear of the 2 PV modules. In addition, we measured temperature at inlet and outlet of water and at the middle position of fin.

Tracking of the maximum power point was done manually by a variation of an ohmic load and measure electrical power output. Data was recording every 10 min from 8:00 AM to 5:00 PM. In Fig.3 and Fig.4 illustrated installations and structures of the PV/TW system and the PV/TF system, respectively. In the PV/TW system, we provided the flow rates of water at 2.88 x 10^{-6}, 3.60 x 10^{-6}, 4.24 x 10^{-6} and 5.88 x 10^{-6} m^3/s from water tank. For the PV/TF system, we had used free air force from the ambient air.

4. Results and Discussion

Due to the various weather conditions in each day, the characteristic electricity yields of the PV modules shall be depended on the incident sunshine and the operator temperature on the PV modules. For the analyzation of thermal efficiency of PV/T collectors in reduce excessive temperature on the PV modules could be adopted from [8], [9] and [10]. For the electrical analysis, it could be taken from [2] and [3].

4.1 Effect of reducing temperature

In Fig.5, we present the result for the case of the PV/TW system at the flow rate 4.24 x 10^{-6} m^3/s compared with a lonely PV module. Similarly, in Fig.6, we present the experiment result of the PV/TF system compared with the PV module alone.

The result had been illustrating clearly that PV/T system could help to take excessive temperature on PV module down.

Fig.3. Show location and structure of the PV/TW system in tested outdoor.

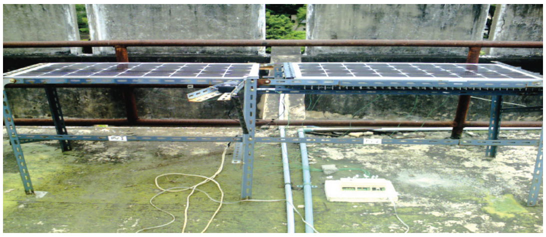


Fig.4. Demonstrate location and structure of the PV/TF system in tested outdoor.

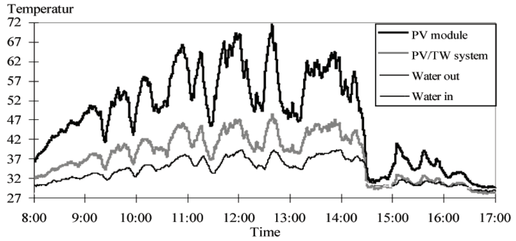


Fig.5. Comparison between the PV module and the PV/TW system at of the flow rate on April 09, 2008.

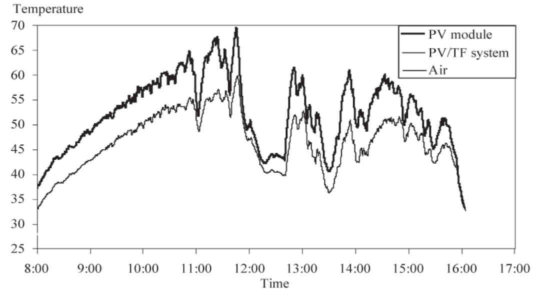


Fig.6. Comparison between temperature on PV/TF system and PV module alone on June 05, 2008.

In Table 1, we showed our results of reduce excessive temperature on the PV module by the PV/TW system and the PV/TF system. Clearly, it was illustrated that the best result could obtain from the PV/TW system at the flow rate 4.24 x 10^{-6} m^3/s.

4.2 Electrical and thermal efficiency

In Fig.7, 8, 9 and 10 we were illustrating the results of the electric power and electrical efficiency obtained from the PV/TW system and PV/TF system, respectively. It is noted that I parameter in Fig.7 and 9, it present irradiance intensity of sunlight in Watt per square meter.

In Table 2, we summarize the best values of thermal efficiency and increasing of electrical efficiency for each condition. Thermal efficiency is the heat loss of PV module due to PV/T collectors. At higher thermal efficiency of PV/T system was showing that the system could more reduce excessive temperature on PV module.

According to this result, we suggested that the PV/TW system at the flow rate 4.24 x 10^{-6} m^3/s could prevent more power loss than the other system (see Table2).

In Fig.11, we are showing effect of fin in case of PV/TF collector and depending of the thermal efficiency on flow rate of water flow in case of PV/TW collector.

In Table 1 and 2, we were presenting dependent of the results on the flow rate for the case of the PV/TW system and the influence of fins for the case of the PV/TF system. Obviously, we obtained the maximum electrical yield from the PV/TW system when the system was supplied at the flow rate 4.24 x 10^{-6} m^3/s.

5. Conclusion

The results of this experiment could confirm that the PV/T collectors could help on increasing performance of PV module more than using the PV module alone. Clearly, our results presented that the PV/TW system could be given higher thermal efficiency and the electrical efficiency than the PV/TF system. Increasing of the electrical efficiency causes increasing of the electric yield of PV module.

Indeed, the flow rate 4.24 x 10^{-6} m^3/s of PV/TW system gave the best result. Our results were illustrated clearly that The PV/T system could prevent electric efficiency loss from effect of excessive temperature.

However, we suggested that in each application which is depending on location, the appropriate system must be concerned.

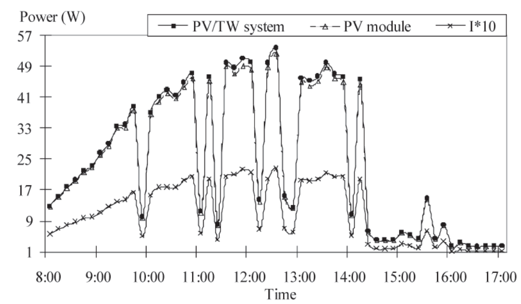


Fig.7. Showing comparison the electrical power output between the PV module and the PV/TW system at the flow rate on April 09, 2008.

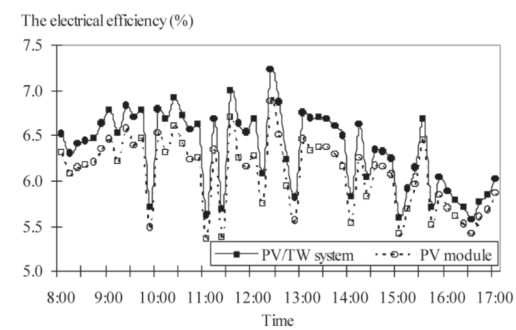


Fig.8. Comparison electrical efficiency between PV/TW system at of the flow rate and lonely PV module on April 09, 2008.

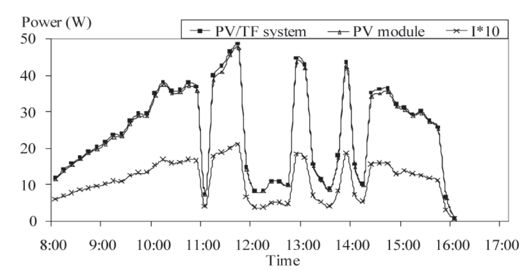


Fig.9. Illustrating comparison between electric power output of PV/TF system and lonely PV module on June 05, 2008.

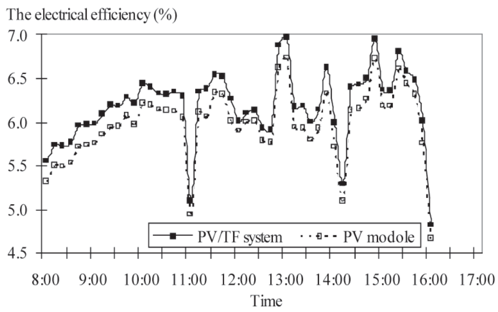


Fig.10. Comparison electrical efficiency between PV/TF system and lonely PV module June 05, 2008.

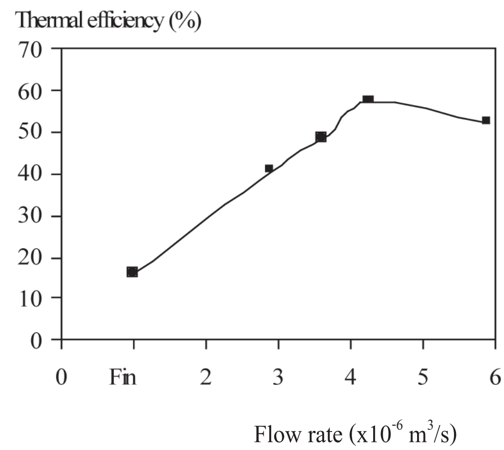


Fig.11. Plot of the thermal efficiency versus fin and flow rate for PV/TF system and PV/TW system, respectively.

Table 1. Summaries list of the effect of the PV/T collectors in decreasing of the excessive temperature

The PV/T collectors	Flow rate (x10^{-6} m^3/s)	Temperature (°C)				
		PV module alone	PV/T system	Decreasing	Inlet water	Outlet water
The PV/TW system	2.88	66.15	45.65	20.50	27.30	36.90
	3.60	69.95	48.90	21.05	29.00	36.60
	4.24	71.40	48.25	23.15	30.10	39.20
	5.88	69.50	48.05	21.45	29.20	34.30
The PV/TF system	Fins	67.15	56.45	10.70	-	-

Table 2. Summaries list of the best results from the experiment in this research

The PV/T collectors	Flow rate (x10^{-6} m^3/s)	Increasing of electrical efficiency (%)	Increasing of electrical yield (%)
The PV/TW system	2.88	0.38	6.00
	3.60	0.42	6.83
	4.24	0.46	7.26
	5.88	0.45	6.98
The PV/TF system	Fins	0.32	5.39

7. References

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