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The Performance of a-Si Hybrid Solar Collector that uses Low Iron Glass as Top-Surface of PV Module

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Abstract : This paper is concerned with data base extension of experimental thermal performance of a-Si hybrid solar collectors that use low iron glass (white glass) on the top-surface of a PV module as an additional absorber. The study is focused on the thermal efficiency of a-Si hybrid solar collector by varying the PV modules configuration for determining the good operating condition of this kind of collector.

The scope of the present work is to study the hybrid solar collector system by using a-Si (Amorphous Silicon) instead of

the black Chrome – coated absorber, which is expensive, and to study suitable configuration of a-Si hybrid solar collector that is good for tropical climates. In this study we report the thermal performance of the following a-Si PV module configuration.

1. Stainless steel substrate with Tefzel top-surface
2. Stainless steel substrate with low iron glass top-surface
3. Without stainless steel substrate, low iron glass top-surface

The experimental results show that the thermal efficiency of a hybrid solar collector using a PV module without stainless steel substrate, low iron glass top-surface are highest while the PV module with stainless steel substrate, low iron glass top-surface are lowest. However, the difference in the water flowrate should be tested in future work.

Introduction

Thailand has a the tropical climate, with a yearly average daily global solar radiation for the whole country about 18.2 MJ/m^2-day [1]. This indicates that Thailand has fairly high solar energy potential.

The objective of a-Si hybrid solar collector is to generate as much solar energy as possible. The advantages are converting solar energy into both electrical and thermal energy at the same time. That is, the a-Si solar cell will absorb visible light and generate electricity by photovoltaic phenomena, while the aluminum absorber plate will absorb infrared light and generate heat. A further advantage, the a-Si hybrid solar collector can operate at high temperature without power loss. The heat is transferred to water as a working fluid flowing in round cross-sectional copper tubes which are attached under the aluminum-late. The round cross-sectional copper tubes are fixed under the aluminum-plate by using Force Fitting method, which applies pressure for perfect heat transfer. In addition, the hybrid solar collectors were tested under condition with one layer glass cover and rock wool was used as back insulation to prevent conduction loss.

As the a-Si PV module is not a perfectly selective surface as in a conventional coated metal absorber, so it may cause the hybrid solar collector to not reach optimum thermal efficiency. To improve the thermal efficiency of the hybrid solar collector, a new configuration of PV modules have been tested in this work.

Experimental

The prototype hybrid solar collectors were tested during November, 2003 with a tilt angle of 15^{o}. Three PV modules in hybrid solar collectors were placed under a glass layer cover in order to obtain the greenhouse effect or in other words, to complete absorption of the radiation energy. The water flow meter used was a variable area type and is calibrated in the range of 0.3 to 3 litre/min by the manufacturer. Temperatures of the water, a-Si solar cells and aluminum-plate were measured by

Type–K thermocouples with accuracy +/- 0.1^{o}C. To minimize the temperature measurement error, each thermocouple probe was located as close as possible to the inlet and outlet of the collector.

Also, a pyranometer with accuracy 5.14x10^{-6} V/W.m^{-2} was used for measuring irradiance and mounted in a coplanar position with the plane of the hybrid solar collector. All the signals from thermocouples and pyranometer were simultaneously recorded by a data recorder (HIOKI, Model 8421-01 MEMORY HiLOGGER) at 10 second time intervals. In this work the tested water flow rate in the hybrid solar collector is 0.8 liter/min-m^2 of collector area.

Result

The performance of the hybrid solar collector was measured outdoors in summer with sunny weather. Fig 1 shows the variation of the measured thermal efficiency of the hybrid solar collectors with $(T_m-T_a)/I_{rr}$ for different PV module configuration. As shown, the thermal efficiency of all of the hybrid solar collectors tends to decrease with increasing $(T_m-T_a)/I_{rr}$ across the range of $(T_m-T_a)/I_{rr}$. The thermal efficiency of the hybrid solar collector using a PV module without stainless steel substrate, low iron glass top-surface are highest while the thermal efficiency of the hybrid solar collector using a PV module with stainless steel substrate, low iron glass top-surface are lowest.

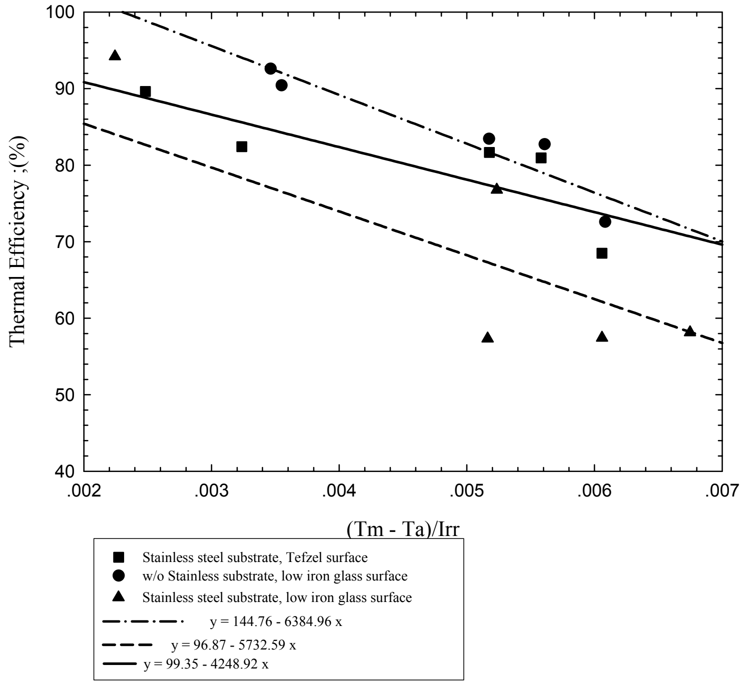

Figure 1. The variation of the measured thermal efficiency with $(T_m\text{-}T_a) / I_{rr}$.

Conclusion

Through tests on the thermal efficiency in hybrid solar collectors, the following results are obtained:

(a) The thermal efficiency of the hybrid solar collector that uses a PV module without stainless steel substrate, with low iron glass top-surface is about 20% higher than that using stainless steel substrate with low iron glass top-surface

(b) As show in Figure 1, the slope of the hybrid solar collector with stainless steel substrate, Tefzel top-surface is slightly lower than both other types of PV modules. Regarding heat loss of PV module with stainless steel substrate, the Tefzel top-surface is lower than other types of PV configuration because of the difference in thermal conductivity of Tefzel and low iron glass.

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