Renewable Energy and Power Quality Journal (RE&PQJ), ISSN 2172-038 X, No.9, 12th May 2011, Reference Paper: 480

Optimization with genetic algorythms of PVT system global efficiency

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Abstract

Photovoltaic (PV) solar panels generally produce electricity in the 6% to 12% efficiency range, the rest being dissipated in thermal losses. To recover this amount, hybrid photovoltaic thermal systems (PV/T) have been devised. These are devices that simultaneously convert solar energy into electricity and heat. A significant amount of research on PV/T collectors has been carried out over the last decade and water PV/T glazed flat plate collector systems turned out to be the most promising to develop (Zondag[1]). It is thus interesting to study the PV/T system as part of a closed loop single phase water CDU (coolant distribution unit) in laminar forced convection. In particular, the analysis was conducted on the optimal cooling performance of the thermal part, testing polynomial channel profiles of varying order (from zero to fourth) for channels of a real industrial module heat sink, under the following conditions: ideal flux of 1000 W/m² on one side, insulation on the opposite side, periodic conditions on the remaining sides, fully developed thermal and velocity profile in laminar flow of water. Through the use of a genetic algorithm, we have optimized the shape of the channel's sidewalls in terms of heat transfer maximization. In terms of Nusselt number, results show that fourth order profiles are the most efficient. When limits to allowable pressure loss and module weight are introduced, these bring generally to a lower efficiency of the system than the unconstrained case.

Key words

Fins ,Genetic Alghoritms, Multi Objective Optimization,Cooling, PVTsystems

1. Introduction

Photovoltaic solar panels generally produce electricity in the 6% to 12% efficiency range, while most of the incident radiation is lost to the environment as thermal energy, whereas, in comparison, a solar thermal collector can operate in the 40% to 70% efficiency range. A lot of work has been done in the past to improve efficiency of PV panels, to reduce manufacturing costs and to integrate PV panels into walls and roofs of buildings. On the contrary, very little effort has been devoted in the past decades to the recovery of the dissipated thermal energy. By integrating the PV modules into a system designed to collect the heat lost to the environment, a solar cogeneration system is possible which holds enormous potential for improving the cost-benefits ratio of PV integrated roof and wall systems. Good results are expected also for stand alone applications.

Hybrid photovoltaic/thermal (PV/T) air-water collectors are devices that simultaneously convert solar energy into electricity and heat.

A significant amount of research on PV/T collectors has been carried out over the last decade. The review by Zondag [5] covers analytical and numerical models, simulation and experimental work, and qualitative evaluation of thermal/electrical output.

A PV/T collector typically consists of a PV module on the back of which an absorber plate (a heat extraction device) is attached. The purpose of the absorber plate is twofold. Firstly, to cool the PV module and thus improve its electrical performance (electrical efficiency losses amount to 0.4% for each degree of increase of cell temperature with reference to standard test conditions (STC): 25°C, q''=1000W/m²) and secondly to collect the thermal energy produced, which would have otherwise been lost as heat to the environment.

As reported by Zondag et al. [1] the electrical and the thermal performance of PV/T collectors is lower than that of separate PV panels and conventional thermal collectors.

However, they emphasized that two PV/T collectors together produce more energy per unit surface area than one PV panel and one thermal collector next to each other.

A lot of parameters affects PV/T performance (both electrical and thermal) such as covered versus uncovered PV/T collectors, optimum mass flow rate, absorber plate parameters (i.e. tube spacing, tube diameter, fin thickness), absorber to fluid thermal conductance and configuration design types. Based on an exergy and cost analysis,water PVT glazed flat plate collector system results the most promising to develop (Zondag [1]).

Moreover, in the last few decades, in the field of electronic components the request for power dissipation continued to increase rapidly following Moore's law (the number of transistor in a microprocessor would double every 18 to 24 months). Advanced air cooling solutions like heat pipes or high flow rate fans were developed to manage the heat load in CPU and GPU devices at the expense of significant increase in noise level , energy cost and weight. At last, new liquid cooling CDU(coolant distribution unit), after late 80's stopping, looked strategically to meet the combined high heat loads with low thermal resistence.

Thus, it seems interesting to improve the thermal efficiency of a PV/T system as part of a closed loop single phase water CDU in laminar forced convection.