Design of Efficient Photovoltaic Thermal (PVT) Systems

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Abstract - A new idea of thehybrid photovoltaic thermal(PVT) collector is planned to improve electrical efficiency and to use unnecessary heat in the form of thermal energy. The project is to improve heat efficiency. The use of air, water and their combination is considered as ordinary and common. With sophisticated high-tech models, the difficulties were increased in order to develop the efficiency of PVT such as nanofluids, nano-Phased Material, heat pumping and jet impingement. This paper provides an analysis of new concepts that are being proposed in the literature to boost the PVT collectors' efficiency and from which the assessment criteria are extracted. In terms of parameters such as pumping capacity, scale, design and the elements for comparison, we have compared the different PVT modules. The bias is to improve electrical or thermal efficiency.

Keywords - Nano-fluids, Phase-modification material, Nano-phase change products, Heat pump and Jet impingement.

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INTRODUCTION

The photovoltaic modules are commercially sold in standard test conditions with a measured performance of power and efficiency and other electrical features. Those are classified as 1000 W / m2 of solar irradiance, the equivalent of 1 sun, 25 ° C ambient temperature and 1.5 AM atmospheric pressure. However, the efficiency of the photovoltaic device under outside conditions changes associated with environment and the manufacture of solar cells [1-2]. The heat rise in solar cells contributes to a decrease of the open voltage circuit, which eventually decreases energy[3]. The power loss of many PV systems over time is shown in Figure 1. Hence manufacturers supply a cumulative output energy temperature coefficient of the PV to demonstrate the losses incurred by a cell temperature rise of 1 ° C. The PV form (JKM315P-72 295-315 W)[4] coefficient, for instance, was 0.41%/ ° C higher than STC. In some projects, an efficiency reduction of up to 5 percent is recorded when the cell degree is 10 ° C higher[5]. Therefore, cooling mechanisms must be added to the extent of boost the PV modules' operation. Purposeful and low maintenance and operating costs are passive cooling approaches such as the use of fins materials or phase shift material. For PV heat dissolution, Cuce et al. has been implanted a heat sink [6]. In order to formulate the heat sink design with dimensions, the authors performed a stable state heat transmit review for the technique. Authors observed a 20 % growthin the photovoltaic power outturn of the heat sink. The use of an inactive cooling system with simpler frame and configuration of cotton windings to minimize the temperature of the PV modules was studied on the other hand by Chandrasekar et al.[7]. The investigation has also been extended to the use of water and nanofluids to test the PV action of refreshing and non-cooling modes. Stritih et al. [8] operate statistical investigations with TRNSYS to investigate the effect of putting a tank of the PCM module on the rear. The objective is to improve electrical efficiency through the use of PCM materials by providing thermal control. Outdoor tests were used to validate. As a result of the passive refrigeration by PCM, the efficiency has risen from 1.1 percent to 2.8 percentfor 1 year's simulation system power generation for the installation site has risen from 7.3 percent[8].

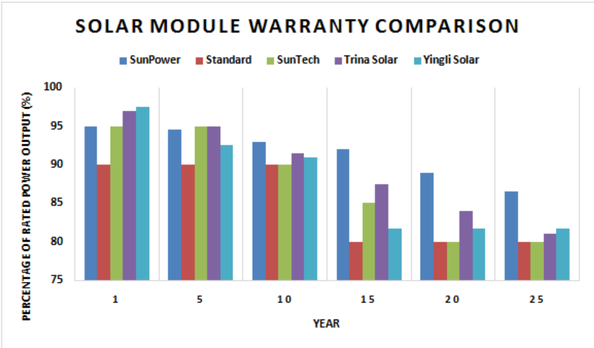

Figure 1: Degradation of multiple PV products across the years in terms of power output

Althoughactive cooling offers various features to make it simple to have passive cooling. Active PVT Systems are useful for the electrical and thermal energy production at the same time. The hybrid PVT collector normally includes a PV module and a thermal safeguard that is connected to it and that has an in-house work fluid. The job fluid form can be used to describe the various PVT types.

Hybrid PVT Systemsgenerate higher energy than separate solar thermal and photovoltaic systems, which means that this technology has tremendous potential for marketing and solar energy industry transformation. The nature of the thermal absorber depends on the intended configuration (for example, direct flow, parallel flux, serpentine ...), various safeguard frames (triangular, rectangular, circular, etc.), size (for example solidity, diameter ...). Obviously, to guarantee a minimization of air gaps and a stronger heat transfer (e.g. silicone oil), hugely thermal conductive element must be put between them. For increased thermal transfers which are demonstrated in the documentary, the working softened and the set mass flow rate are crucial.

The function of the tube is to soak up the heat either quickly from the PV or the guard plate. The heat is changed to the operating fluid at a fixed flow rate. The areas that are left are heated and the temperature dispensation over the PV may be minimal. Another issue that requires ventilation, etc. is the phenomenon of hot spots.

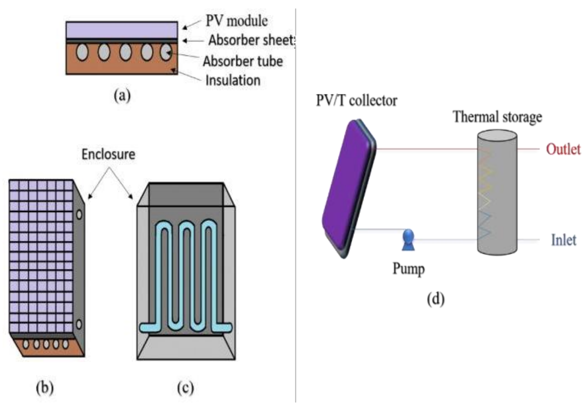

Figure 2: Typical PVT collector (a) cross-sectional side view (b) 3-D view of collector (c) 3-D view from the inside of PVT enclosure and (d) schematic drawing of PVT system

The components used to assemble a standard PVT board, an absorber, tube (whether or not part of an absorber) and perimeter containing all components are as defined in figures 2.b and 2.c. The elements described in Figure 2. In addition, Figure 2.c illustrates the enclosure tube outline. During Figure 2d elements such as pumps, thermal storage, etc. are displayed outside the collector. Figure 3 illustrates further how the principle of PVT is changed into thermal and electrical energy that can be measured along with system performance. The idea of PVT is also demonstrated. In solar heat, photovoltaic and total PVT performance, the efficiencies are defined [9-11].

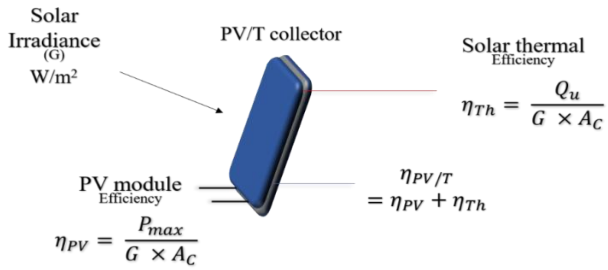

Figure 3: Efficiency equations of PVT

The warmth gain is called the solar thermal output and is expressed by Qu. The PV module output is Pmax, which is the Vmpp and Imppmultiplication [10]. The outputs may supply thermal and electricity requirements or convert to electric power supply to optimize the thermal output, vice versa.

NEW CONCEPTS OF PVT SYSTEMS

Studies published on state-of-the-art PVC systems have numerous innovation aspects that can be accomplished by using methods to boost heat transfer or by using engineered work fluids. Therefore, in addition to higher performance material, its elements like concentrators and indicators are added to the blueprint.

Additionally the tests carried out by Sardarabadi et al [12] in outdoor Iran, they tested the efficiency of hybrid nanfluid PVT using PCM as medium. Silica-nanofluid (SiO_2) is the nanofluid that is used. In order to assess the novel system's efficiency, outlet temperature, energy and energy efficiency were assessed and improved on conventional PVT collector designs. Al-Waeli et al.[13] improved the device further, using nano-substances in the PCM layer. This is explained by the author's weak thermal conductivity. The performance of PVT based on nano-pcm in the humid climate of Malaysia using nanofluid coolant. The author says nanoparticles are added to the PCM layer, which results in refined thermal control and heat reclamationfor the PVT system. In addition, the total experimental duration results in improved electrical and thermal efficiency. Nevertheless, the authors[13] stress that pumps for refrigeration after sunset must continue to operate to discharge heat cornered in nano-PCM layer. The energy calculation for charging and discharging of nano-PCM are other aspects which must be included.

So as to increase solar radiance landing on PV module, Jaaz et al. [14] used a concentrate CRP type, and introduced cooling using water as a coolant in the jet paddock. The system was tested experimentally in Malaysia's exterior conditions. Hasan et al. [15] performed another installation of a PVT injection without CPC and as coolant of nanofluid. The tests were conducted on the spot, using a 36-nozzle jet. The key difference is the use of nanofluids in the outdoor experiments in Jaaz et al. [14] and indoor experiments in Hasan et al. [15]. The two experiments demonstrated new approaches and high energy efficiency. Nanofluid can serve as a base fluid instead of water in the same system developed by Jaaz et al.[14]. While the manufacture and operation of the PVT system is made more complex and expensive, improvements are important.

For the systems presented further analysis of the LCA and LCCA could be performed [14-15]. Finally, MWCNT-paraffin was used for a PVT system by Du et al[16] as a phase-change material. MWCNT-WEG 50 nanofluid was used as a coolant in the device. The results reveal that between 12 and 4 p.m. local time around 40 percent of the electricity generated was achieved. The measurement was based on energy efficiency and the system's electric-thermal equivalent capacity. The results show that around 292.1 W / m^2 had the highest thermal and electric efficiency.

The above table illustrates the impact on the thermal efficiency of the system when implementing nano-fluids, but this comparability is also not realistic specified the different conditions, operating conditions and the environment. The range of mass-flow rates ranged from 0.012 kg / s to 0.17 kg/s in the literature.

THEORITICAL ANALYSIS

Nearly all the original studies are theoretical analyzes. The theory of the given technology is essentially a mathematical explanation of physical concepts. As illustrated in Figure 3, for example, PV electrical conversion efficiency can be defined via equation. Theoretical analysis for the development of the mathematical bases for numerical analysis is usually performed. Theoretical analysis of the heat driving term of pv-cells in x-direction for the PVT sheet and tube collector was performed by Jarimietal.[17]. the author[17] employed a final difference method and built temperature nodes because of the system's complexity. Of course, the theoretical analysis is generally assumed to be simplified. For example, a long straight tube was assumed to be a serpentine-shape copper pipe. The solar collector was divided into segments M in the y-direction, which is subsegments in m. The authors [17] often construct temperature nodes on the x-z plane, while nodes on the x-y plane are placed. The precision of the number or theoretical findings depends on the correctness of the physical dimension of the proposed system represented by the mathematical model, which is why it is important.

NUMERICAL AND EXPERIMENTAL STUDIES

PVT performance analysis is very important to evaluate the best parameters and actions for the configuration and/or frame that has been suggested. This technique enables time and money to be saved that is associated with the manufacture, installation and testing of the proposed PVT. Through numerical studies, the optimal performance and behavior parameters of the proposed PVT are therefore found. These studies must be validated by creating an experimental prototype. Various types of discern material (such as K-type thermocouple), wind speed (anemometer), solar irradiance (pyranometric), tension and current (multimeter, LIV testing, etc.) should be included in the tests. It should be noted, however, that PVT is still no distinction for PVT numerical software as a relatively new technology. Therefore, for numerical studies various software is used. Generally, CAD and Solid Works are used to design and export the conceptual design to thermal simulation software such as CFD software. The numerical method of the proposed PVT (PVT-1, PVT-2 and PVT-3) collector was used by Lu, al.[15] to assess the thermal conduct using CFD software. ANSYS Fluent 14.0 was used for simulation by the authors[15]. The CFD model took heat conduction, heat convection and thermal radiation into account. In addition, [15] authors used an S2S model in the determination of solar irradiance. The model was an S2S model. Fluid within the tubes was considered layered and compact because it was as thermosyphonic as the collector, where the water velocity is quite low. In addition, 1,000,000 meshed cells were established during the numerical meshing process.

CRITICAL REVIEW

In the field of PVT detailed research have been accomplished in order to verify the value of this technology and to test its various designs and operating modes. PVT has considerable potential for improved efficiency and efficient usage of the use of solar energy for residential, commercial and industrial purposes. This technology remains relatively developed, however, several degree that must be addressed in future studies were noted in this review. These items cover both technical and economic aspects and are recorded in the thermal and electrical fields of PVT.

Thermal aspect:

1. In terms of energy production and power production, PVT-based nanofluid systems

are compared with PVT water-based systems. Comparison on the basis of the same pump power should be made, however. This should certainly also apply to various types of absorbers. The various designs and fluids are related to varying pressure drops and power losses as a result of additional pumping requirements. This shows how effective the proposed systems are when pumping power is equalized.

2. What are the correct methods of disposal, if used in continuous cooling cycles in tropical areas, of temperatures in cooling water? In addition, some studies do not consider cooling or reducing the produced hot water for cooling PV or for the application at least. The temperature to the end user or the thermal application must also be viewed.
3. For several experiments, severe examples are taken to determine PVT's efficiency, such as summer and winter or even days when solar irradiance is high and poor. But is it appropriate to carry out experiments under clear sky, given the constant change in weather, particularly in tropical climates? And in severe weather evaluation of novel PVT systems?
4. In new PVT schemes, nano-PCM and nanofluids are used. Authors can, however, consider factors like the long-term assessment of results as well as latent heat monitoring with more specific methods. In addition, experimental aspects for nano-PCM testing, such as testing temperature when nano-PCM is placed in a tank are presented. In addition, how many cycles can and will be useful nano-PCM.
5. Longer area is required to support PVT collectors based on jet impingements for the tanks that cover them. What is the usefulness of these systems in series? Moreover, what precautions are taken to preserve thermal efficiency in the heat losses of such fluids through a tank?
6. Most theoretical studies seek to equate the PVT-based nanofluid systems with PVT-based water systems on the basis of the same number of Reynolds, while other parameters like equivalent pump power should be taken into consideration.
7. The performance of PVT is evaluated mainly by using total output, but this is not enough to properly assess the ability of PVT systems. Therefore, the amount of energy that is useful through energy analysis needs to be measured.

CONCLUSION

Therefore, this analysis offers comprehension to the applications of advanced PVT systems in research and development. Many features such as concentration systems, inactive cooling frames and heat change improvement material combinations can be implemented into PVT systems. Due to their different components, it is obvious that further exploration of weather impacts, importantly of solar irradiance and temperature, is essential if the main elements of making this technology solar future are to be more fully understood. From the literature the following points were observed:

1. Most studies of project parameters such as piping, configuration and fabric are carried out numerically, subsequently experimentally validated. This is clearly designed to avoid the costs of building many experimental installations that are labor intensive and inefficient. The optimal numerical configuration is then produced as an experimental set-up to test the validity of the forecast. Variations in the measurements and efficiency of the prototype due to uncertainties inevitably produce variations in the tests. If, however, the results are acceptable within an acceptable range and have similar curve shape.
2. The increase in solar irradiance leads to increased efficiency if the PVT collector achieves a good cooling rate. PV module cooling requires improved heat transfer, which is accomplished by improved contact area between PV and the absorber, material changes (i.e. the use of a high-thermal conductive material) and optimum mass flow.
3. PVT means that photovoltaic panels and solar heat collectors can be used in the same area, so that the device is suitable for residential applications. Systems such as integrated PVT buildings are also conducive to providing consumers with water heat and better PV electricity. Nonetheless, factors like extra weight and field maintenance maybe have to be taken into account and applied to different systems.

For future PVT review, design, optimization and Performance Assessment research, the following points should be considered:

1. To order to improve the heat transfer to the absorber connected the back surface of the PV module could be nano-coated.
2. To assess the efficacy of jet intrusion using a thermosyphon system for PV module cooling.
3. Compare the usefulness of focusing on PV system cooling or simultaneous generation of heat. Long-term performance testing of these systems is important to create a database that can offer industry definitive answers; for marketing.
4. A PVT standard is required to test, install and performance assessment.

5. Nanofluids can be tested as coolants in the CPC PVT device with jet impingement.

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