"Experimental Investigation of Photovoltaic Panel Cooling System Assisted With Artificial Roughness" A Review

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ABSTRACT

Photovoltaic cell converts solar energy into electrical energy. These systems combine a photovoltaic cell with a solar module i.e. converts solar radiation into electricity. A PV module converts 6-20% of the incident solar radiation into electricity according to its type and climate conditions. Mainly incident solar radiation is converted into heat which increases the temperature of Photovoltaic module and reduces its efficiency.The photovoltaic cell can be effectively improved by using artificial roughness in different forms, shapes and sizes. Artificial roughness is provided in the form of different geometries such as ribs, dimple shape roughness, wire mesh, baffles, delta winglets etc.The various roughness element geometries employed in solar cell in terms of heat transfer, friction factor and flow simulation geometries. Correlations developed for heat transfer and friction factor for different roughness geometries by various investigators in solar cell. By using roughness geometry on photovoltaic panel with working fluid of cooling air the temperature of solar panel decreases then efficiency of solar panel increases.

Keywords*: Photovoltaic Cell, Solar, Electrical, Roughness Geometry, Friction Factor, Heat Transfer.*

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1. INTRODUCTION:

When Sun light on a photovoltaic (PV) cell, it may be reflected, absorbed, or pass right through it. The PV cell is composed of semiconductor material, which combines some properties of metals and some properties of insulators. That makes it uniquely capable of converting light into electricity. When light is absorbed by a semiconductor, photons of light can transfer their energy to electrons, allowing the electrons to flow through the material as electrical current. This current flows out of the semiconductor to metal contacts and then makes its way out to power your home and the rest of the electric grid. In the recent span, when there is a continuous demand of energy for the economic progress and industrialization, renewable sources are playing vital role in this regard. They are used to design high routine heat transfer systems. Heat transfer enhancement in these thermal systems has numerous applications including cooling of electronics systems, industries, agriculture, space heating etc. Photovoltaic cells have an important advantage over PV module, collecting materials attached to conventional PV modules. On the other hand, the air type requires a high volume of air flow to obtain good thermal efficiency and bring up the corresponding matters of large diameter tubing, noise and fan losses. The large tubing required may cause problems, especially in retrofitting.

Ribs used in cooling channel and heat exchanger channel are most commonly used passive heat transfer techniques. So that the work related to fluid flow and heat transfer in ribbed channel is go so far. Each rib on downstream separates the flow, recirculation and impinges on channel wall and these are the main reason for heat transfer enhancement in such channel. The use of rib in heat exchanger not only increase the heat transfer rate but also substantial the pressure loss. The rib arrangement and geometry resulting in different heat transfer distribution by changing the flow field. Therefore by making the modification in rib geometry we can increase the heat transfer rate but at the same time we need to consider the pressure drop also because it increases significantly.

2. LITERATURE REVIEW:

2.1 Vipin B. Gawande, A. S. Dhoble, D. B. Zodpe :

The performance characteristics of a solar heater and heat exchangers can be effectively improved by using artificial roughness in different forms, shapes and sizes. Artificial roughness is provided in the form of different geometries such as ribs, dimple shape roughness, wire mesh, baffles, delta wing lets etc. relative roughness height, relative roughness pitch, angle of attack and relative gap position are some of the parameters studied for their effect on heat transfer and friction characteristics in both heat exchangers and solar air heaters. The paper has given geometrical parameters for individual geometry, specifying the heat transfer enhancement in terms of Nusselt number and pressure drop penalty in terms of friction factor values.

2.2 Huan-Liang Tsai, Chieh-Yen Hsu And Yung-Chou Chen:

This paper presents the efficiency enhancement for a novel photovoltaic/thermal (PVT) air collector in which PV and thermal efficiency is simultaneously enhanced with a reciprocal aid. With the encapsulation of solar cells directly on a fin-type heat sink, the direct conduction mechanism and the convective area for the thermal transportation are effectively increased. With direct lamination of solar cells on heat sink, the thermal efficiency of the proposed PVT air collector can be enhanced up to above 52% owing to cooperative effect of thermal conduction and convective area for the air flow channel. The increase in the ability of waste heat removal reciprocally improves the PV efficiency and consequently makes the total efficiency of PVT module up to 63%. The novel PVT configuration simultaneously enhances PV and thermal efficiency without increase of electrical power consumption.

2.3 Jin-Hee Kim, Se-Hyeon Park, Jun-Tae Kim:

In this study, a PVT air collector with a mono-crystalline PV module was designed, and an experiment was performed in order to confirm its electrical and thermal performance in an outdoor environment. From the experimental results, it was found that the heated air from air-based PVT collector had, on average approximately 5ć higher temperature than the outdoor air. The experimental results indicated that the thermal and electrical efficiencies of the PVT collector were, on average, 22% and about 15%, respectively. For the electrical efficiency, the PVT air collector was operated as the maximum output due to the prevention of PV temperature rise through forced exhaust. These mean that the performance of the PVT air collector was similar to performance of standard test condition (STC) without a decrease in efficiency due to PV temperature. Therefore, it was concluded that the heated air taken from the PVT collector can be supplied into the ventilation system in building as pre-heated fresh air, and contribute to better electrical performance at the same time.

2.4 R. Kunnemeyer, T. N. Anderson, M. Duke, J. K. Carson:

The idea of concentrating solar energy to increase the output of photovoltaic and solar thermal collectors is an area that has received significant attention. In this study, a design model for a V-trough concentrating photovoltaic/thermal solar collector was theoretically analysed and validated with experimental data. The results showed that the V-trough offered improved electrical yields from both concentrating radiation onto the photovoltaic cells and also by actively cooling them. Also, it was shown that the V-trough could be made of a durable (long life) stainless steel, rather than the more reflective aluminium, while still offering a 25% increase in incident radiation over a typical year. However it was noted that modifications would be needed to improve cooling and to increase the thermal efficiency by reducing heat losses.

2.5 Tony Ho, Samuel S. Mao And Ralph Greif:

The solar concentration limit for densely packed, high-concentrated photovoltaic (HCPV) cells was analyzed for a novel two-phase cooling design. Eight working fluids were examined in the two-phase cooling analysis: R134a, R11, R113, R114, R123, R141b, water, and ammonia. In addition, the study investigated the concentration limit for mass flow rates ranging from 10 À3 to 1 kg s À1 . Results from an analysis of a novel HCPV two-phase cooling system showed that the practical limits of solar concentration for the design to be approximately 2000 suns for the six organic fluids examined, whereas the limits approached 4000 and 6000 suns for water and ammonia, respectively. This observed higher concentration limit for water and ammonia at a given flow rate can be attributed to their larger heat capacities and latent heats when compared with the organic fluids examined. Using a thermal analysis developed by Royneetal. The temperature for typical, densely packed silicon PV cells was plotted.

2.6 Karima E. Amori, Mustafa Adil Abd-AlRaheem:

In the present work a comparative study for thermal and electrical performance of different hybrid photovoltaic/thermal collector's designs for Iraq climate conditions have been carried out. Four different types of air based hybrid PV/T collectors have been manufactured and tested. Three collectors consist of four main parts namely, channel duct, glass cover, axial fan to circulate air and two PV panels in parallel connection. The measured parameters are, the temperature of the upper and the lower surfaces of the PV panels, air temperature along the collector, air flow rate, pressure drop, power produced by solar cell, and climate conditions such as wind speed, solar radiation and ambient temperature. The thermal and hydraulic performances of PV/T collector model IV have been analyzed theoretically based on energy balance. A Matlab computer program has been developed to solve the proposed mathematical model. The obtained results show that the combined efficiency of collector model III (double duct, single pass) is higher than that of model II (single duct double pass) and model IV (single duct single pass). Model IV has the better electrical efficiency. The pressure drop of model III is lower than that of models II and IV. The root mean square of percentage deviations for PV outlet temperature, and thermal efficiency of model IV are found to be 3.22%, and 18.04% respectively.

2.7 J. Manohar, J. Sundhar Singh Paul Joseph, J. Lakshmipathy & M. Satishkumar:

The double pipe heat exchanger is a device used to transfer heat from hot fluid from cold fluid. In which the inside tube carrying hot water and outside tube carrying cold water. Considerable enhancements were demonstrated in the present work by using numbers of rectangular fins fitted over inner tube along its length. For various increase surface area the rate of the heat transfer was calculated theoretically by logarithmic mean temperature difference method. It is show that the suggested method of heat transfer enhancements is much more effective than existing methods, since in an increase in the heat transfer co-efficient. The aim of augmentation heat transfer is to reduce the size and cost of the heat exchanger.

2.8 S. H. Barhatte, M. R. Chopade:

Extended surfaces, commonly known as fins, often offer an economical and trouble free solution in many situations demanding natural convection heat transfer. Heat sinks in the form of fin arrays on horizontal and vertical surfaces used in variety of engineering applications, studies of heat transfer and fluid flow associated with such arrays are of considerable engineering significance. In the present study, the fin flats are modified by removing the central fin portion by cutting a triangular notch. This dissertation report presents an experimental analysis of the results obtained over a range of fin heights and heat dissipation rate. Attempts are made to establish a comparison between the experimental results and results obtained by using CFD software.

2.9 Sandhya Mirapalli, Kishore. P. S:

Heat transfer by convection between a surface and the fluid surrounding can be increased by attaching to the surface called fins. The fins increase the effective area of a surface thereby increasing the heat transfer by convection. Rectangular fin and triangular fins are straight fins. Triangular fins are attractive, since for an equal heat transfer it requires much less volume than rectangular fin. Hence the fins have practical importance because it gives maximum heat flow per unit mass with ease of manufacture. In an air-cooled engine, rectangular and triangular fins are provided on the periphery of engine cylinder. Heat transfer analysis is carried out by placing rectangular and then triangular fins. Analysis is carried out by varying temperatures on the surface of the cylinder from 200 ºC to 600ºC and varying length from 6 cm to 14 cm.

2.10 Kunpeng Guo, Nan Zhang, Robin Smith:

A major challenge in designing optimal multi-stream plate-fin heat exchangers is the large number of combinations of standardized fin geometries for various fin types to choose from, which adds discrete aspects to an already complicated design problem. In this work, a new design algorithm is proposed to address this issue. By treating basic fin geometries such as plate spacing, fin pitch, fin length and fin thickness as continuous variables for all the fin types, different fin types are characterized based on the work published by different researchers. Then by taking into account thermal hydraulic performance of different fin types, optimal fin types and their corresponding design parameters can be obtained simultaneously by minimizing the total volume of heat exchanger. The design parameters can be rounded to the nearest standardized fin parts for a feasible design.

2.11 Dipak Saurabh P, And S. G. Taji:

Fin arrays on horizontal and vertical surfaces are used in variety of engineering applications to dissipate heat to the surroundings. Studies of heat transfer and fluid flow associated with such arrays are therefore of considerable engineering significance. The main controlling variables generally available to the designer are the orientation and the geometry of the fin arrays. In case of short horizontal arrays, it is observed that the air entering symmetrically from both the ends gets heated as it moves towards the centre of the fin channel, as well as it rises due to decrease in density. So, the central portion of the fin becomes ineffective because hot air-stream passes over that part and therefore it does not bring about large heat transfer. The purpose of the present study is to investigate thoroughly the possibility of performance improvement of such arrays by providing triangular perforation at the centre and suggest for selection of optimum notch dimensions and spacing by analyzing variety of fin arrangements.

3. SUMMARY OF REVIEW:

1. Several investigators conceded away number of experimental and numerical studies for better understanding of heat transfer enhancement and flow processes due to turbulence generated by the presence of roughness on absorber plate of a solar air heater. The paper presents are view of experimental as well as numerical analysis carried out by the researchers.
2. The relative roughness height, relative roughness pitch, angle of attack and relative gap position are some of the parameters studied for their effect on heat transfer and friction characteristics in both heat exchangers and solar air heaters. The paper has given geometrical parameters for individual geometry, specifying the heat transfer enhancement in terms of Nusselt number and pressure drop consequence in terms of friction factor values.
3. Comparisons between various roughness geometries can be made on the basis of a parameter known as thermo hydraulic performance parameter. It is observed that multi V-rib with a gap gives better performance in comparison to others roughness geometries for Reynolds number range between 2000 and 20,000.

4. The existing model, the thermal efficiency was decreased with the increase of solar radiation. This is accompanied with a noticeable increase in both PV module and air temperatures with a decrease in the power generated.
5. A small enhancement in the generated electrical energy by PV is obtained with the increase of air flow rate, so the available electrical efficiency is inconsiderable affected by increasing air flow rate.

4. OBJECTIVES:

1. To evaluate the different research in terms of artificial roughness geometries, which can improve convective heat transfer in heat exchanger and solar air heaters with minimize friction losses.
2. To use various types of roughness geometries to compare with existing geometry.
3. To determine various types of roughness geometry by changing various geometry.
4. To determine the modification of Nusselt and friction factor dependence with respect to operating parameters.

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