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PV PANEL COOLING USING STACK EFFECT

Kudithi Nageswara Rao, Ganesamoorthy Rajkumar
Hindustan Institute of Technology and Science, Department of Electrical and Electronics Engineering, Chennai, India

Abstract. *Unsatisfactory feat of the photo-voltaic cell is solitary in every of the foremost issues among the promotion of PV technology. A vital strand changing cell performance is operative temperature of the cell. The voltage of the cell, declines near directly with a rise in the operative temperature of the photo-voltaic cell. The temperature condition on the in-operative surface of a photo-voltaic panel remains usually 22–30°C beyond the normal temperature conditions. Upon the premise concerning those issues, the potency of the photo-voltaic cell will be refined by sustaining their operative temperatures as low as possible. This paper portrays a technique of PV/solar panel cooling using convection generated by the chimney effect. This paper considers the diminution of warmth from the Photo-voltaic panel for both active and inactive conditions.*

Keywords: air-cooling, convection, solar-cell cooling, solar photo-voltaic

CHŁODZENIE PANELI FOTOWOLTAICZNYCH Z WYKORZYSTANIEM EFEKTU STOSU

Streszczenie. *Niezadowalająca wydajność ogniwa fotowoltaicznego jest jednym z najważniejszych problemów związanych z promocją technologii PV. Istotnym czynnikiem wpływającym na wydajność ogniwa jest jego temperatura robocza. Napięcie ogniwa spada niemal bezpośrednio wraz ze wzrostem temperatury roboczej ogniwa fotowoltaicznego. Temperatura na powierzchni działającego panelu fotowoltaicznego pozostaje zwykle o 22–30°C wyższa od normalnych warunków temperaturowych. Zgodnie z założeniami dotyczącymi tych kwestii, moc ogniwa fotowoltaicznego zostanie poprawiona poprzez utrzymanie ich temperatury roboczej na jak najniższym poziomie. Niniejszy artykuł przedstawia technikę chłodzenia paneli fotowoltaicznych/solarnych z wykorzystaniem konwekcji generowanej przez efekt kominowy. W artykule uwzględniono zmniejszenie ciepła z panelu fotowoltaicznego zarówno w warunkach aktywnych, jak i nieaktywnych.*

Słowa kluczowe: air-cooling, convection, solar-cell cooling, solar photo-voltaic

Introduction

Today, the world is dealing with some serious issues of energy deficiency, warming and degeneration of environment sources and energy power resources, renewable-resources have gotten more attention. Energy is one amongst comparable candidates. Energy source is widely obtainable with no cost. Energy is transformed into electric power by PV effect. PV system is consistent, quiet and freed from moving parts which leads to reduction of operation cost and servicing cost of the system. Being pollution free and pure source of energy, PV method has earned far more importance. Power output of PV method depends mainly on solar irradiance, temperature of cell and operating voltage. Anyway they actually present an infinite region of rivalry contrasting to straightforward energy assets by reason of their hefty expense and low potency during energy change.

The PV cells are ready to produce energy source from the abundant resource of sunlight. Since the PV components are exposed directly to the sunlight, it produces heat still as electricity. A PV module transforms solely 12–15% of the input solar power to electricity and also the undefined power is actually released as heat energy. The good and comfortable atmosphere affects this density/voltage (J/V) features of the photo-voltaic components wherever their electrical capabilities are adversely stricken with the numerous rise of cell operative temperature throughout absorption of radiation [10].

By applying a cooling methodology to a PV component, the worth of different energy is reduced in 3 ways. First, cooling improves the electrical output of PV components. Second, cooling method makes doable the utilization of concentrating solar cell method by shielding the photo-voltaic cells from outreaching the temperatures and so permanent loss occurs, even below the irradiation of several suns. As these drives it doable to alter solar cells with probably more cost-effective concentrators. Finally, the heat is unfastened by the photo-voltaic cell cooling method is employed for constructing the heating system or cooling system, or in commercial applications. to the current outcome, hybrid PV/T solar systems are explored as a way of reducing the heat of PV components and boost their electrical capabilities. This category of a PV scheme is termed Solar PV thermal collector (PV/T collector), which create thermal and current concurrently.

The hybrid PV thermal systems are still under development. J. K. Tonui, Y. Tripanagnostopoulos [16] discussed about an enhanced solar PV-thermal collector an addition to warmth extortion of air passage by forcibly and naturally, while R. Mazon-Hernandez et al [7] discussed about the heat reduction process out of the photo-voltaic arrays located on top of the hothouse by using air because the thermal energy carriers. The steady-state effect concerning the fins that's been vertical in structure, working on PV/T air warmer was been studied by Marc A. Rosen, Rakesh Kumar [6] while experimental research of air formed in Photo-voltaic Thermal gatherer in addition to various styles of Heat exchangers was being carried by H. J. Mohd. Yusof [9].

This paper illustrates a photo-voltaic array cooling method. The uninvolved cooling method is within the model of an oblong channel, which envelops the rearmost of the console and expands up-above towards the zenith of console. The cooling effect is induced here by stack effect. Both dynamic and uninvolved cooling is being studied using the identical system with an addition of fan connected at the very best section that's being powered using the device. During this technique, air is used for the reason that of the warmth carrier. Designing and Theoretical investigation of the technique is explained below.

1. Proposed system

The design comprises of an absorber section additionally to the planning proposed by Tonui and Tripanagnostopoulos [15]. the pace of air ascending within the tube (chimney) is commensurate to the energy utilized by the air, so addition of an absorber section will assist to stiff the natural draft of air which might be employed for reducing the heat of photo-voltaic arrays. The uninvolved cooling method will accommodate mainly two segments, top portion and center segment as in Fig. 1. Top-head section contains of the upright addendum to the center segment. It will also act sort of a chimney during this structure arrangement to uphold the natural draft fabricated by the nice and cozy uprising breeze. The beam of radiated energy falling over the absorbent section that's product of glass. These incident solar rays are soaked up by means of the air that's under the absorber section that in due course gets thaw out furthermore its density declines. The nice and cozy air will attempt to arise, thanks towards the buoyant force and flee all the way through the vent. The elevated vent will deliver a pressure variation in the middle of the underside and also the zenith which can further assist within the breeze of the surrounding air.

The middle portion of cooling chimney includes section of PV array as well as absorber section. The absorber section is meant such its size is greater than the size of PV array. As in Fig. 2 a glass sheet, which is transparent, is planted over the duct that's formed of low- carbon steel. Photo-voltaic array is implemented on the lower 1/2 middle section whereas the glass sheet at the upper 1/2 the centre section acts because the absorber section. Centre segment of it, is fixed at an slant inclination capable local range to create sure that the photo-voltaic array as well as the absorber part obtains maximal energy over the year.

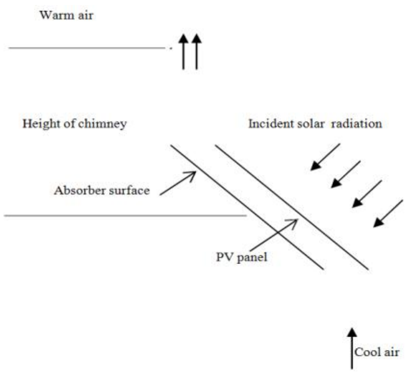

Fig. 1. Layout of cooling system

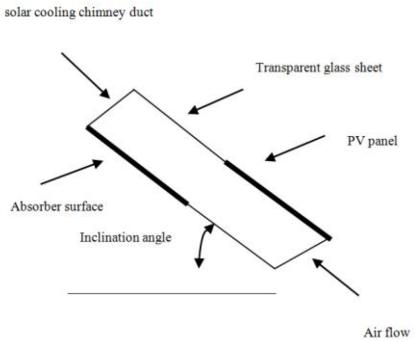

Fig. 2. Center portion of cooling system

The most of all solar beams which incident on it, will undergo the sheet, transparent in nature, reckoning on its reflectiveness and emissivity's and drop on surface of absorber, which is coated dense-black to maximise the portion of radiation energy absorbed. Consequently, a huge increment in absorbing the heat on the surface will occur. The heat transfer happens through the warmth absorbing surface to the atmosphere surrounding, impending from section of the photo-voltaic board panel. Updraft current with minor density will soar aloft in regard to the best section. Elevation about the superior part will aid the great and comfortable air current to soar towards the best owing to the static-head difference. Proportion of air gush will shoot-up if we increase the altitude of tube (chimney). The natural air draft within the channel duct instigated attributable to the variation in density between the current of air within the centre portion and nominal whiff of air up-above the best part will generate the suction force, in which it empowers the normal air draft to infiltrate from base section. Cool breeze entering from the underside tends to engulf the surface of heated photo-voltaic array and lessens the temperature of it.

2. Experimental setup

The cooling scheme was fabricated utilizing mild steel for demonstrating the concept. The particular experimental model embraces two key parts as illustrated in the "Design" segment. The head section was optimized to refine the natural draft in a better way. A photo-voltaic array of 10 W, 12 V Polycrystalline was utilized in the test setup. The panel is introduced on the inclined section, below the absorber and the same panel is attributed on a standalone frame to have a comparison study. The relative view of the system is made known in Fig. 4 Plain glass of 5mm thickness was accustomed to act as the transparent sheet that allow to pass solar radiation hooked on the absorber section. The channel wall or duct made of mild steel is insulated with glass wool so that to avoid heat loss. Fig. 3 portrays the isometric view of the air channel for the air conditioning setup with dimensions in mm.

The system is installed on a stand that is fabricated using mild steel L angle. During experiments temperature of the photo-voltaic array Tpv, inlet Tin and outlet Tout air temperatures for different solar insolation's are estimated using a Infrared thermometer and the readings are noted for further calculations. Here, Submissive (passive) temperature reduction of the photo-voltaic panel is being studied using this experimental setup.

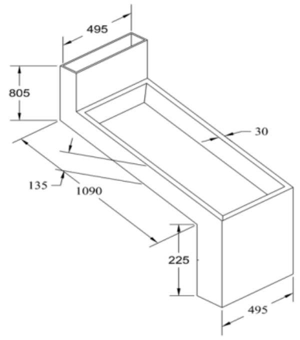

Fig. 3. Isometric view of cooling system

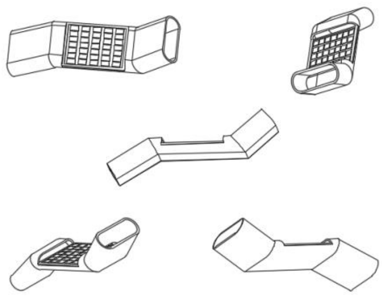

Fig. 4. Relative view of cooling system

The active cooling of photo-voltaic panel by means of the same setup can be studied by making small changes in the design. In dynamic cooling scheme exhaust fan driven with help of photo-voltaic panel that is employed to provide the desired cooling effect as in Fig.4. Here cooling effect is expected to be more than that could be achieved by any passive heat reduction system. 12 V exhaust fan is connected at the top part of the particular system. 12 V, 7 Ah battery is also used here.

3. Model analysis

A logical framework is defined to replicate the level of energy balance. Rays from the sun, falls on the chamber of absorber and the photo-voltaic array in the replica. The altitude of head segment is enhanced to maximize the natural air draft and also to reduce the shading effect. Profundity of duct is regarded as 0.1m. As considering the surface of the absorber, its size is greater than the size of the photo-voltaic array. Warmth quantity that penetrates the respective system, which should be equivalent up to the volume of energy that abandons the same system. Energy of heat that infiltrate to the structure, can be stated as (Randall,Mitchell [12]; Brinkworth, Frank P. Incropera [3]; Johnson et al, Akbarzadeh [1]):

$$Q_{in} = I \times A_{absorber} \times (1 - r) \times \tau \quad (1)$$

Fig. 5 illustrates the photo-voltaic array section where the photo-voltaic array is seated onto the inclined channel (duct) of the cooling chimney and Fig. 6 illustrates the three dimensional view of the proposed contraption.

Contemplating the model, it consists of walls which are adiabatic in nature, excluding the glassy sheet. Summation of the heat amount which escapes the structure can possibly state as

$$Q_{out} = Q_{air} + Q_{conv-cond} \quad (2)$$

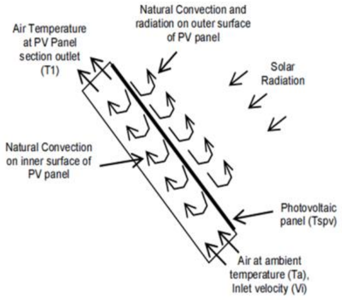

Fig. 5. Transfer of heat over the surface of the panel

Fig. 6. Three-dimensional view of the proposed contraption

The amount of heat absorbed by the air inside the channel or duct possibly provided as

$$Q_{air} = V_i \times A_{duct} \times \rho_i \times C_{p\,air} \times (T_o - T_i) \quad (3)$$

The amount of heat that lost on account of conduction and convection via the glassy sheet possibly indicated as

$$Q_{conv-cond} = \frac{\frac{T_i+T_o}{2} - T_i}{R_{conv-inside}+R_{cond}+R_{conv-outside}} \quad (4)$$

Convective thermal resistance inside the chimney duct

$$R_{conv-inside} = \frac{1}{h_i \times A_{absorber}} \quad (5)$$

Conductive thermal resistance for transparent sheet

$$R_{cond} = \frac{Thickness}{K \times A_{absorber}} \quad (6)$$

Convective thermal resistance provided to outside of the chimney is stated as

$$R_{conv-outside} = \frac{1}{h_o \times A_{absorber}} \quad (7)$$

Inside the chimney duct, if the heat is forced into the setup, that will increase the air warmth in it. Therefore, the total draft pressure generated over the chamber of absorption with the zenith of the vent can be developed as (Brinkworth 2000 [3]; Akbarzadeh, Johnson et al. 2009 [1])

$$\Delta P = (\rho_i - \rho_o) \times g \times H \quad (8)$$

Pressure fall athwart the system possibly stated by (Leenders et al., Bazilian [2]; Cengel,Turner et al. [4]; Ong [11])

$$P_{drop} = f \times \frac{1}{D_h} \times \frac{1}{2} \times \rho_i \times V_i^2 \quad (9)$$

Comparing these equations to invade the heat in the system and to escape the heat from the system, an equation has been developed with reference to the exit velocity. Likewise the equations for pressure and total draft pressure fall apart the setup, can be reorganized with reference of velocity at outlet. Resolving these equations altogether, the velocity at outlet and calefaction of the exhaust air can be predicted.

4. Conclusion

By using the effects of buoyancy in the chimney, the natural air draft can be attained and it can be also utilized as a apathetic cooling medium for photo-voltaic arrays. In the plan of the setup, simple modification was made and adding the section of absorber had helped to develop the induced natural draft of air as well as also as a consequence, aids to develop the competence concerning the photo-voltaic array. Elementary and overture investigation illustrates that in the process of coupling, an air passage channel and an absorber section with a photo-voltaic array and also possibly attain the appreciable conditioning system of air, of the photo-voltaic array as well as the potency of photo-voltaic array can possibly enhance.

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Ph.D. Kudithi Nageswara Rao
e-mail: nageswarak@hindustanuniv.ac.in

He is working as Assistant Professor in Department of Electrical & Electronics Engineering, Hindustan Institute Technology and Science, Padur, Chennai. He possesses 12+ years of experience from includes embedded technology industry, and rich teaching experience. He published more than 15 research articles including reputed conferences and he filed 1 patent in Intellectual property India, also he published a book. His area of interest is Renewable energy systems, Electric Vehicles and controller designs.

http://orcid.org/0000-0003-4490-0900

M.Sc. Rajkumar Ganesamoorthy
e-mail: raj06@ymail.com

He is a Research Scholar in Department of Electrical & Electronics Engineering, Hindustan Institute Technology and Science, Padur, Chennai. He possesses a decade of experience in the academic field, and in addition to one year of experience working as a Project Engineer in the EV industry. His professional background includes the successful publication of over 40 academic journals and completion of seven funded projects. He has received multiple national-level awards for my work.

http://orcid.org/0000-0002-6505-892X