International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 8, August-2018

Investigation on extraction of waste thermal energy from solar pv panels

Manoj Kumar Sharma[1], Dr. Sandeep M. Joshi[2]

[1] *M.E Thermal Engineering, Pillai College of Engineering*
[2] *Professor, Pillai College of Engineering*

Abstract - The temperature of PV modules increases when it absorbs solar radiation, causing decrease in its efficiency Because of negative temperature coefficient. The Efficiency drops with the rise in temperature, with a magnitude of approximately 0.5 % per °C. This present paper gives the possibilities of extraction of waste thermal energy from the solar panel to maintain its efficiency and to obtain hot water as byproduct. The extracted heat can be used for many domestic applications. Computational fluid dynamics (CFD) analysis using Ansys fluent was done .The outlet water temperature is observed with significant rise in temperature.

Keywords - PV modules, thermal energy, negative temperature coefficient, temperature rise.

I Introduction

Solar energy is most remarkable, vital, clean and environment affable renewable energy source. Now a day's solar photovoltaic (PV) is swift developing technology. The photovoltaic cell converts only 6% - 18 % of solar energy into electricity rest 88 – 85 % of the energy is wasted in the form of heat. During the operation heat is generated due to which temperature of the system increases, if the generated heat is not removed the efficiencies decreases because of its negative temperature coefficient. With increase in cell temperature efficiency of cell reduces with enormity about 0.5 %/°C. So to maintain the system at working temperature, generated heat in the system must be extracted for its efficient working. The extra generated thermal energy in the system can be used for many domestic applications.This thermal energy is mainly due to two factors. First, due to I^2 R, as denouement of the current (I) flowing through the resistance, R of the solar cell. Second, the thermal energy which represents the disparity between the absorbed photons and the output electrical energy generated due to electron–hole pairs. Cell temperature is vital parameter which affects performance of PV cells in a panel. Lot of work has been reported in this field of performance parameters, Temperature dependence and energy conversion in solar PV panels. Thus, it can be proclaimed that the panel thermal energy generation is more than electrical energy.

II Experimental setup

Monocrystalline Silicon 145 *145 mm solar cells used for the experiment. U bend aluminum elliptical tube of ½ inch and 40mm thick poly-isocyanurate foam for thermal insulation is used. Direct contact heat exchanger system was designed with the coolant being water to transfer heat from solar cells. Heat extraction system must be such that it should increase the solar cells efficiency and should not create any obstruction for incident solar radiation. back side of the cells will be suitable for extraction of heat energy. Water is continually circulated at 1 LPM with the help of 5W water pump. 5 liters water is used for the experimentation, K type thermocouple is used to measure the inlet and outlet water temperature with indicator.

Fig1 Experimental Setup

III Results and Discussion

Experiment was performed on 5th June 2018 at Pillai College of engineering, having closed water circulation system maintaining flow rate of 1LPM. Detailed result is plotted in fig 2 where inlet and outlet water temperature is plotted for every hour from 10.00am to 4.00 pm. It is clear from fig 2 that raise in water outlet temperature shows the potential to tap the thermal energy from the solar cells. Fig 3 shows the comparison between with and without heat extraction system rise in solar cell voltage shows that the efficiency of the system is improved with the waste heat extraction system. Computational fluid dynamics simulation was carried out to validate the result .

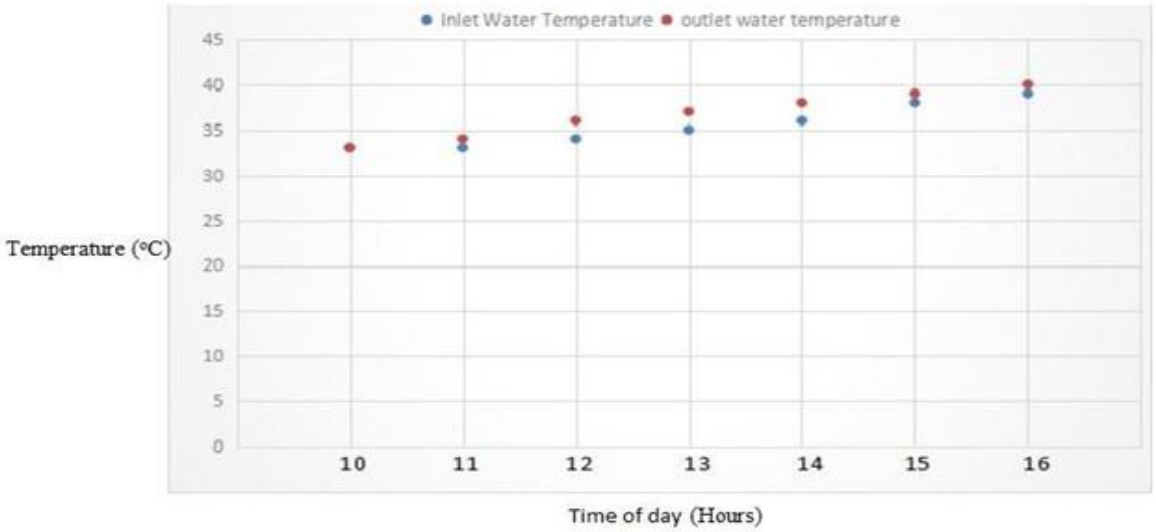

Fig 2 water inlet and outlet temperature

Its clear from fig 2 that system is successfully extracting significant amount of heat. their is 2C rise in output temperature at 13:00 and 14:00 hrs and water temperature at end of the experiment i.e at 16:00 hrs was recorded 40 C.

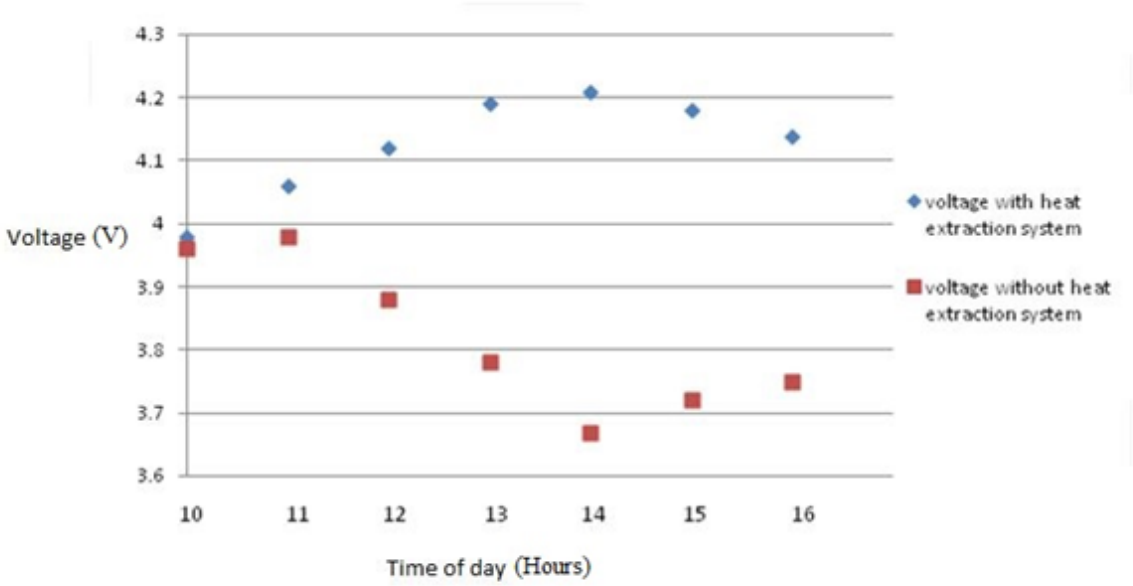

Fig3 comparison of cell performance with and without heat extraction system

It is evident from the fig 3 that Significant rise in voltage is achieved during the experimentation. At 14:00 hrs maximum voltage difference is seen. System efficiency is enhanced due to thermal energy extraction. thus system efficiency is increasing and generating hot water as by product.

Simulation result of experimental model in Ansys Fluent –

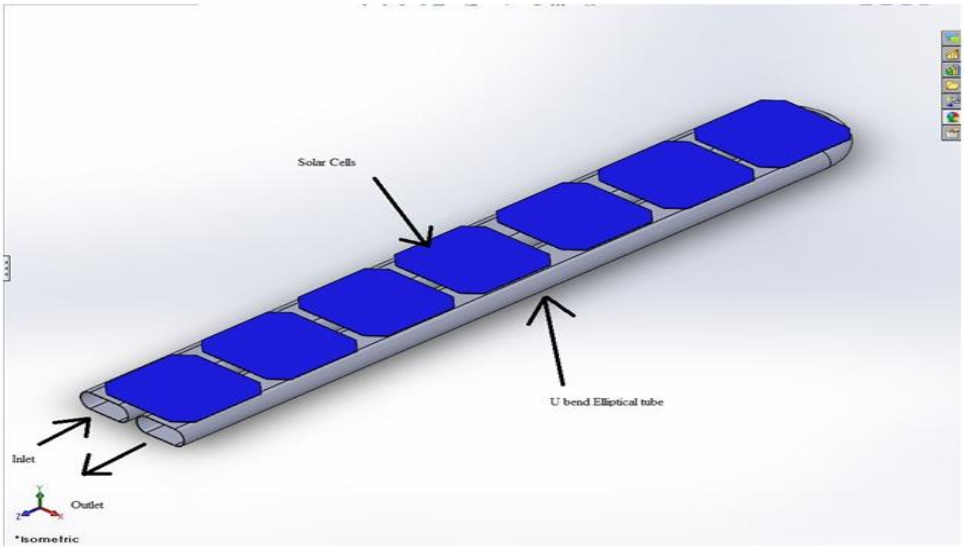

Figure 4 Experiment model in solid works

Experimental model was created in Solid works software and simulated with the help of Ansys fluent software. The simulation was carried out in three phases' first pre processing then processing and third post processing.

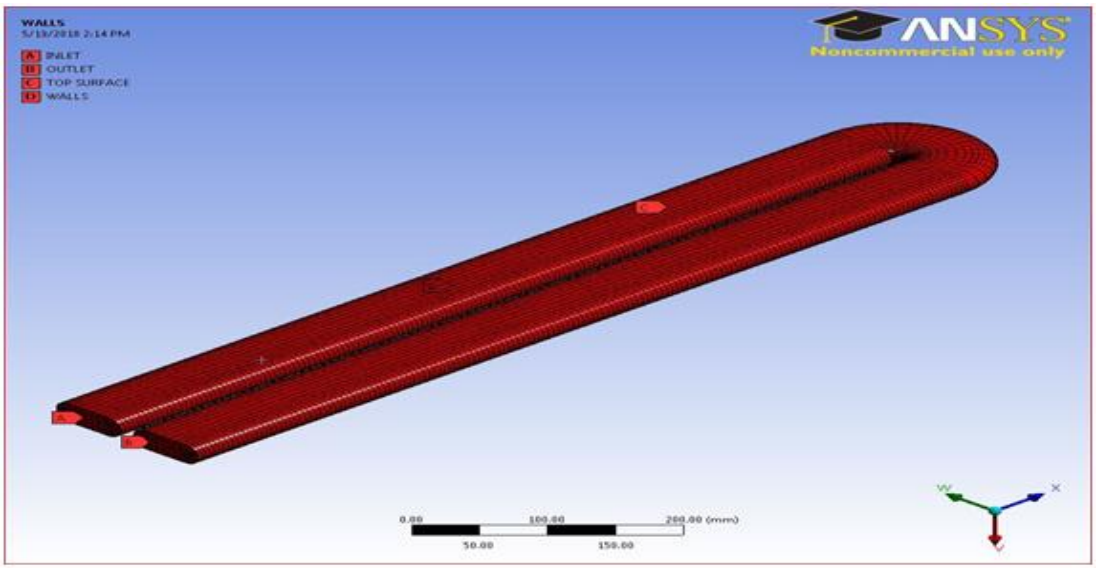

Figure 5 Mesh created on Aluminium tube with fluid domain (water)

Figure 5 shows the mesh created on the model with all the named section inlet, outlet, top surface and walls.default settings were used for the meshing.Fluid domain was created inside the tube hollow section and water was selected from the fluent database . Laminar flow model was selected in modelling. And following boundary condition were used.

Boundary conditions used for the simulation –

1. Top surface heat flux = 1000W/m^2
2. All other surfaces = free convection
3. Inlet fluid – water at 30 C
4. Fluid inlet velocity – 0.023m/s {1 LPM}
5. Fluid outlet – pressure outlet

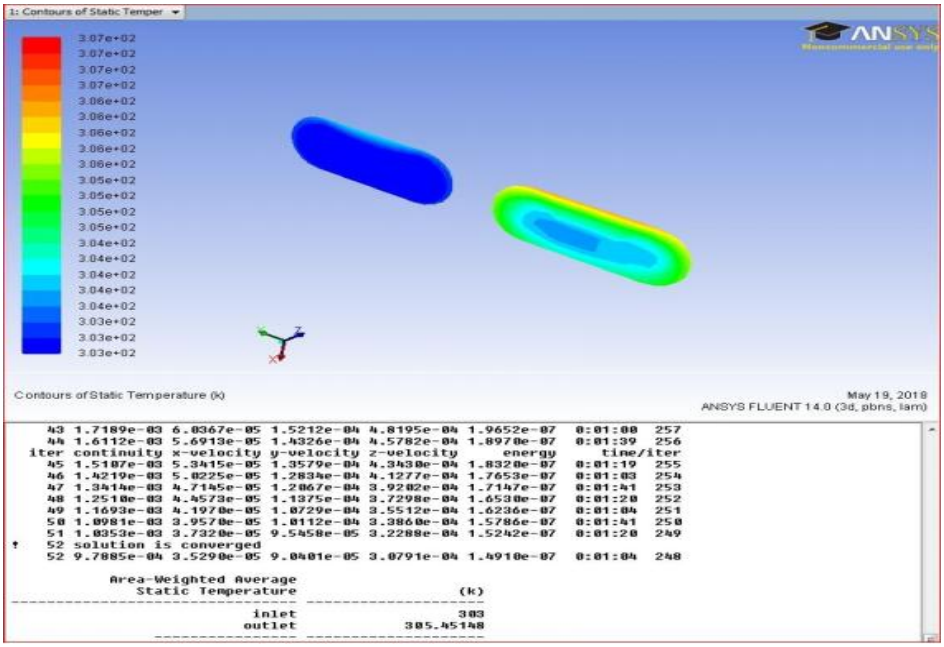

Figure 6 Contours of static temperature showing inlet and outlet

Figure 6 and figure 7 depicts the temperature rise at outlet . temperature range recorded was from 30 C to 34 C .velocity of water is low i.e 0.023 m/s .Its is indicated from the simulation result data that outlet water temperature is raised by almost 2.45 oC which is very close to experimental result data. Contours of static temperature at inlet and outlet are indicated in figure 6.

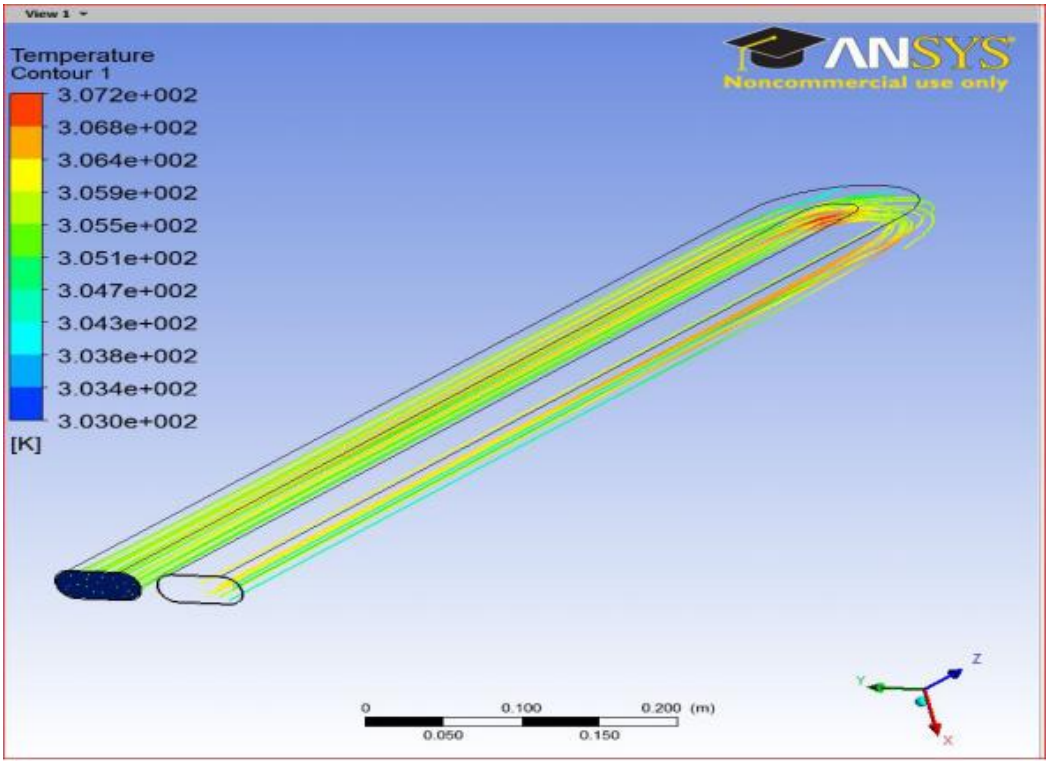

Figure 7 Temperature contour

IV Conclusion

1. It is clear from the experimental result data and simulation data that the significant amount of heat can be absorbed from the back side of the solar cells with increase in Efficiency. Thus the combined solar PV water heater system generates electricity with hot water as by-product.
2. The hot water at the outlet indicates that there is a potential to tap the thermal energy.
3. With low flow rate of 1 LPM solar cell temperature can be effectively controlled by transferring heat from the back side of the solar cells.
4. Efficiency of solar cells increased as we are controlling the operating temperature of the panel.
5. With reduced flow velocity we can achieve higher outlet water temperature. The high temperature water can be used for domestic purposes.

Reference

Patents –

Gustafson Gary R., inventor; 2014-02-18. Solar panels that generate electricity and extract heat: system and method. United States patent US8650877B1

Papers -

[1] Hiren D. Raval , SubarnaMaiti, and Ashish Mittal Computational fluid dynamics analysis and experimental validation of improvement in overall energy efficiency of a solar photovoltaic panel by thermal energy recovery, Journal Of Renewable And Sustainable Energy 6, 033138 (2014),pg. 033138 -1 -033138-12

[2] K.A. Moharram , M.S. Abd-Elhady , H.A. Kandil , H. El-Sherif Enhancing the performance of photovoltaic panels bywater cooling,Ain Shams Engineering Journal (2013) 4, 869–877

[3] MohdEhtishaan,MD RIZWAN SAIFEE Simulation Based Intelligent Water Cooling System for Improvement the Efficiency of Photovoltaic Module, International, Journal of Computer Science and Mobile Computing, Vol.5 Issue.7, July- (2016)pg. 535-544

[4] E.M.G. Rodrigues , R. Melício, V.M.F. Mendes and J.P.S. CatalãoSimulation of a Solar Cell considering Single-Diode Equivalent Circuit Model,International conference on renewable energies and power quality, Vol.1, No.9, May 2011

[5] Y.M.Irwan Comparison of solar panel cooling system by using dc brushless fan and dc water, Journal of Physics: Conference Series 622 (2015) *Ser.* 622012001

[6] FilipGrubišić-Čabo Photovoltaic Panels: A Review of the Cooling Techniques, TRANSACTIONS OF FAMENA XL - Special issue 1 (2016)