International Journal for Research in Engineering Application & Management (IJREAM)
Special Issue – ICRTET-2018 ISSN : 2454-9150

CFD Analysis of Solar PhotovoltaicThermal System with air cooling.

[1]Ankit S. Gujrathi,[2]Sudhir U. Patil,[3]Sachin P. Ingale
[1]Assistant Professor,[2]Designation of 2nd Author,[3]Designation of 3rd Author
[1]Department of Mechanical Engineering,
[1]SNJB's K. B. Jain College of Engineering, Chandwad,India

Abstract: The paper presents the CFD analysis of Solar PV cell Panel by air cooling using Ansys Workbench Fluent model. The 3cm x 3cm Solar PV Cells are mounted on on a Wooden Panel Box 33 cm long and 21 cm wide with 3 cm spacing between two adjust PV cells. The modeling is done with air velocity of 0.5 m/s and temperature variation along the length is plotted. The inlet air temperature is taken 300^0K while average outlet temperature is found to be 312^0K. the modeling is done with Roseland Radiation Model using Solar Calculator for Nashik the 73^0E Longitude, 20^0N Latitude with the Direct Solar Irradiation 884.07 W/m^2. The temperature variation along the length and cross section is also discussed and the performance is evaluated. The thermal efficiency is found to be 11.73%.

***Index Terms*–Solar PV Thermal system.**

I. INTRODUCTION

Due to depleting fossil fuel, the renewable energy sources find a great importance to meet the world's future energy demand. Solar Energy is found to be one of the most prominent source to meet these demand as it is clean source of energy which is available freely in almost all parts of the world. Thus, electric generation using solar energy finds utmost importance in meeting the energy demand. The Solar Photovoltaic technology directly converts the incident solar energy into electricity and emerged as a promising technology today. But, the performance of the solar pv electricity generation decreases with increase in the temperature of pv cell surface. The solar PV thermal systems removes this heat energy from pv cell surface to cool it and improve its performance and simultaneously transfer this heat energy to fluid usually air which can be utilize in a particular application. A PVThermal collector is the collectorwhich produced electricity and hotwater or hot air at the same time andworking as solar cells and solar heaters.

Ahmed et al studied the performance of hybrid solar PVT system with water cooling and the effect of reflective mirror is also determined. The heat energy from the pv cell is removed using thermal heat exchanger placed at the lower part of the cells with different flow rates using using reflective mirror and glass cover. The existence of the reflectance mirrors lead to increase thetemperature of the solar cell, therefore, its value was (92.7 °C) when using lower and upper mirrors with a glass cover(76.1 °C) when using only a lower mirror, and (71.35 °C) without reflecting mirrors[1]. Ali el al reviewed and explained the current status and future aspects of the solar PV thermal technology.Research thus far has been successful in validating the importance of such studies in the effective adoption of PV/T as a reliable means of harnessing solar energy. However, the PV/T system is still under development and has many points and gaps that require intensive future studies[2].Akhsassi et al modeled and experimentally investigated the thermal behavior of solar pv module[3]. Khelifa et al modeled and studied hybrid solar PV thermal collector. In the study, the photovoltaic panel temperature significantly reduced by 15–20% due to the flow of water through the manifold to the rear of the PV panel[4].Good et al simulated and studied three alternative solar energy systems which are covered PV thermal , uncovered PV thermal, and only pv module.The results suggest that covered PV/T could give an increased output compared to solar thermal collectors. The system with uncovered PV/T modules holds up well in this comparison where electricity is favored, but the thermal output is small and of low temperature, which means that an auxiliary energy source is necessary also during summer[5] . Zaraket et al studied the performance of pv module under the influence of thermal stresses. Different levels of temperature were applied into the solar cell and C-V characteristics were measured. Experimental results concluded that increasing the temperature of pv cell decreases the efficiency, power and performance of the solar cell module. The paper contributes to the research on the adverse effect of temperature on the capacitance and normal functioning of the cells and solar module[6]. Rosa Clot et al studied the possibility of solar pv module submerged in water or simply covered by a water veil suggest the possibility to use this renewable energy source (RES) integrated with swimming pools or with decorative pools and fountains. Solar heating together with electrical energy production coming from PV effects can be naturally coupled to water basins such as swimming pools, fountains etc. The possibility to capture solar radiation efficiently to produce both electric power and heat is proved in several tests already done and documented in the scientific literature. The most interesting aspect however is the possibility to use already existing structures with a specific use (recreational or aesthetic) for producing power without any visible impact and without changing the basic function of the structures[7].

 © 2018, IJREAM All Rights Reserved.

II. MODEL AND SIMULATION METHOD

The simulation of the Solar Photovoltaic Thermal System with air cooling is the aim of this study. For this, a Solar Photovoltaic Thermal System model is designed and modeled in ANSYS Workbench 15.0 software .The schematic model ofSolar Photovoltaic Thermal System as shown in fig.1 is made of a solar pv cells 3cm x 3cm in size mounted on the wooden panel box 33cm long and 21 cm wide. The thickness of the pv cells and wooden box is taken as 0.5 cm for the modeling.

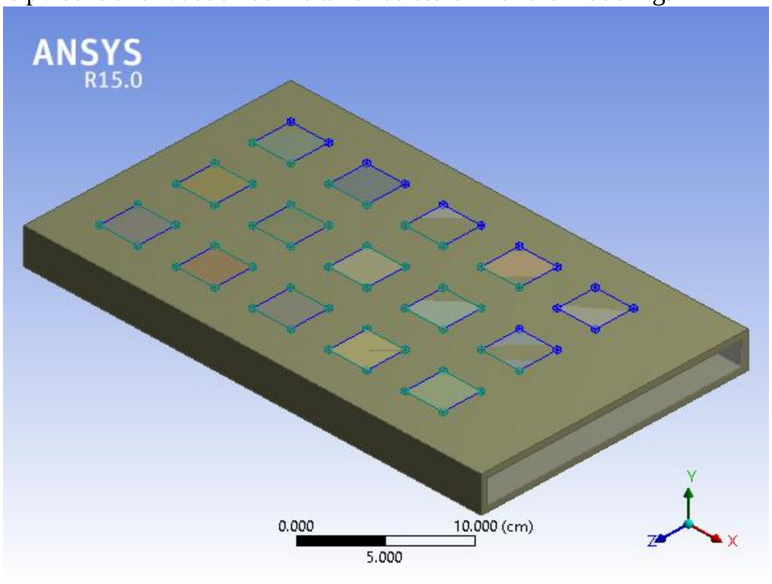

Fig. 1 Model of the Solar Photovoltaic Thermal system.

The meshing is an important step in the CFD modeling of the any simulation as the accuracy of the meshing determines the accuracy of the solution. The meshing of the Solar Photovoltaic Thermal model is as shown in fig.2 below

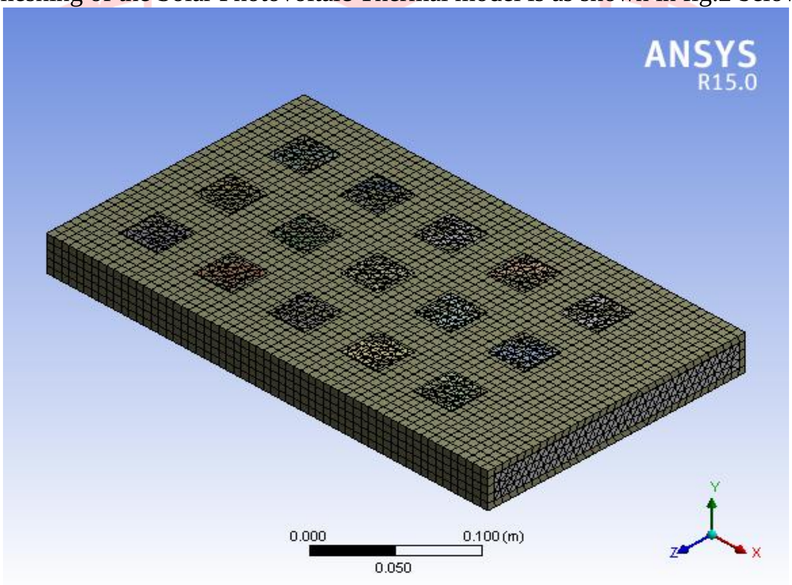

Fig. 2 Meshing of the Solar Photovoltaic Thermal model.

A Solar PV Thermal hybrid system with air cooling is simulated using the Ansys Fluent Software with K-ε Realizable model. The solar calculator is set at the 73^{0}E Longitude, 20^{0}N Latitude which corresponds to Nashik at 05:30GMT. The solar photovoltaic cell is modeled with crystalline silicon material while the panel box is modeled with wood. The PV cells are 3cm x 3 cm in size which are 15 in number installed on wooden box. The spacing between the two pv cell is maintained as 3 centimeter.The size of the wooden box is 21 cm x 3 cm with 33 cm along the length and 0.5 cm in thickness. The air passage is 2cm x 20 cm which flow along the length.

III. RESULTS AND DISCUSSION

The simulation of the Solar PV Thermal system with air cooling is done during the study and the results obtained are discussed in the following section.. The figure 3. shows the temperature variation of air temperature during the flow from inlet to outlet. The average temperature of air at inlet is taken as 300^{0}K while the outlet air average temperature is found to be 312^{0}K.

 © 2018, IJREAM All Rights Reserved.

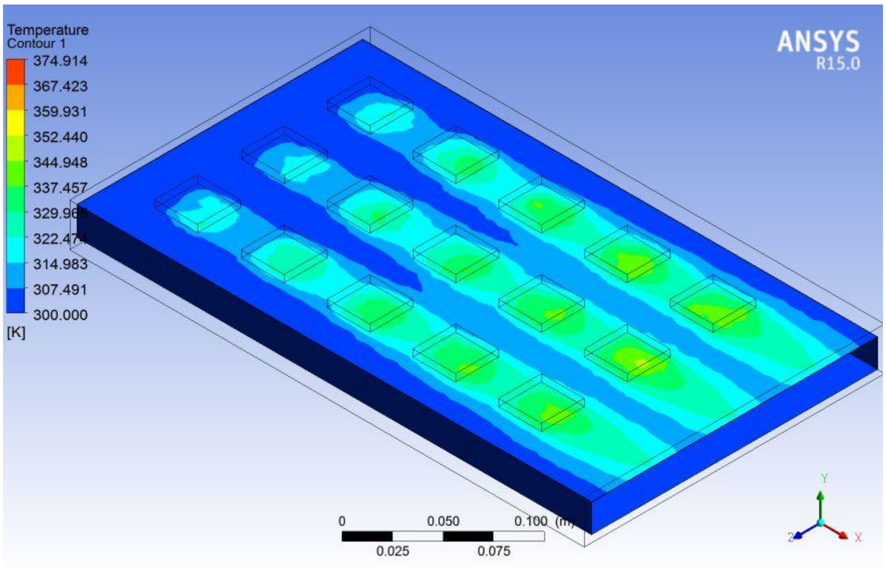

Fig. 3 Temperature profile of the air passage during the flow.

The figure 4 shows the temperature variation across the mid cross section along the length of the of the Solar PV thermal panel which gives an indication that the cooling of the PV panel takes place by flowing the air though the passage. The air temperature near the PV panel is almost near 340^0K.

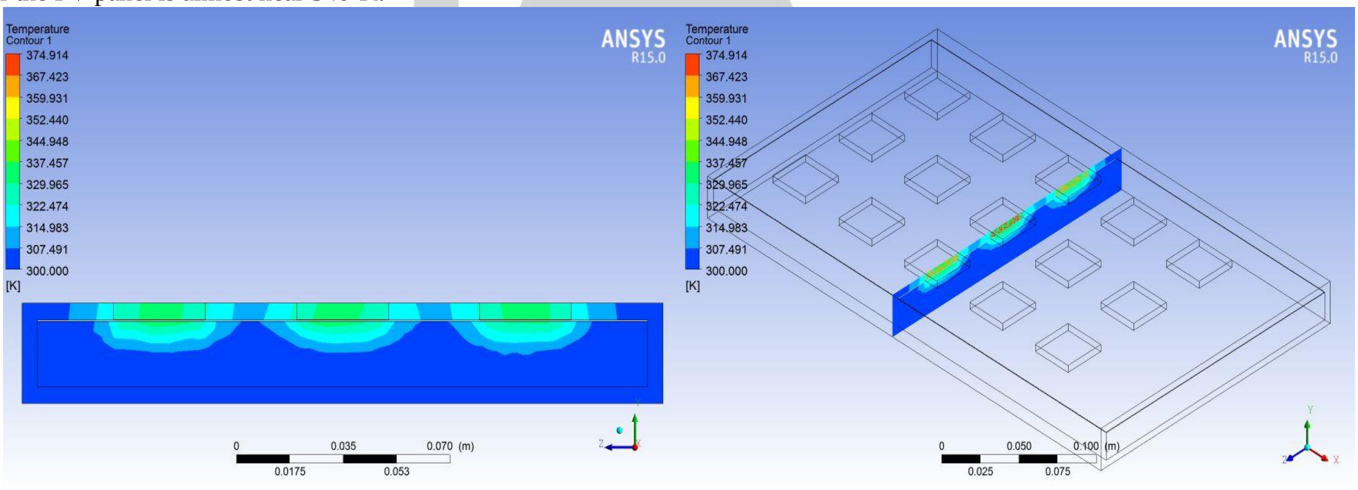

Fig. 4 Temperature Variation across the mid cross section of the PV Panel

The figure 5 shows the variation of the of temperature along the length of the PV panel which shows that the formation of thermal boundary layer along the length. The air temperature is found to increase in the direction of flow cooling the PV cells along the length.

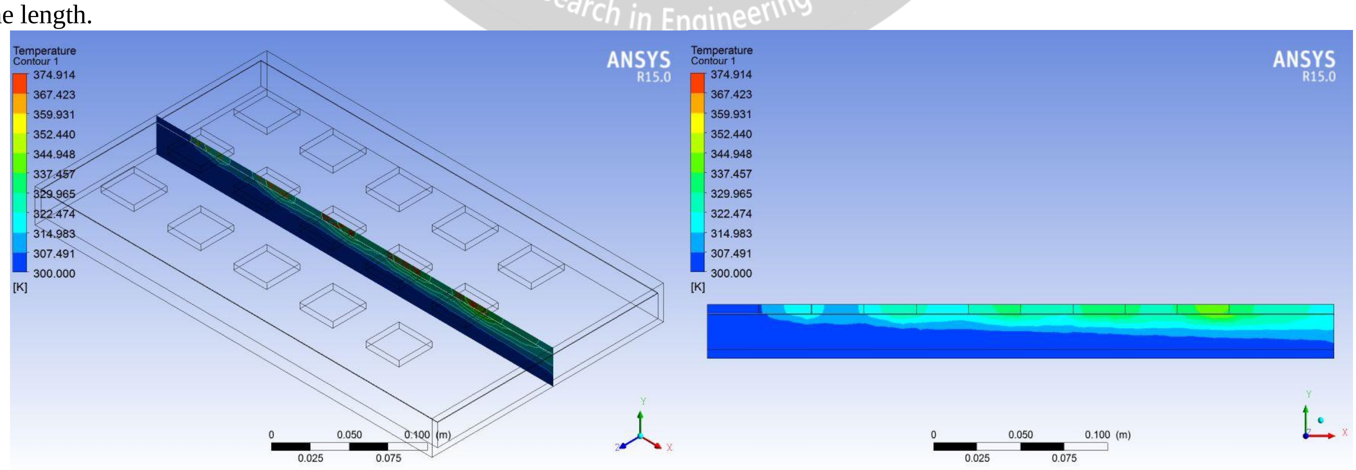

Fig. 5 Temperature Variation along the length of PV Panel

 © 2018, IJREAM All Rights Reserved.

The figure 6 shows the temperature variation of air at the outlet cross section of the PV Panel which shows the effective area of the temperature is considerably increased and also the thickness of the thermal boundary layer as compared to the mid-section in figure2.

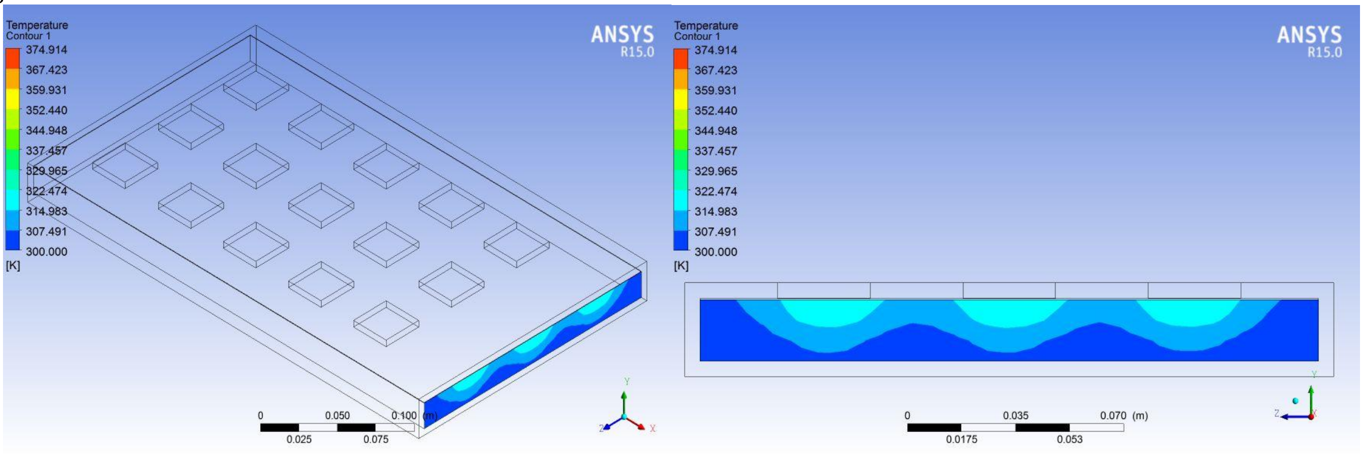

Fig. 6 Temperature Variation of air at the outlet Cross section PV Panel

The figure 7 shows the temperature variation of the solar PV cells along the length which shows the more rapid cooling takes place near the inlet side and temperature is found to be less near 340^0K while the temperature is found to increase along the length. Thus, effective cooling of the PV cell take place along the length of the PV panel which improves the performance of the pv cells.

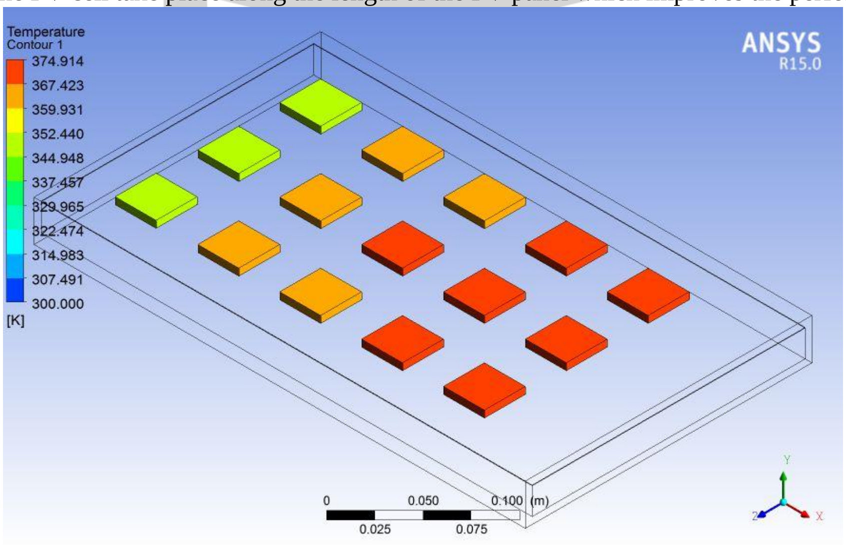

Fig.7 Temperature Variation of PV cells along the length

The figure 8 shows the variation of heat transfer co-efficient along the length of the solar PV panel. The average heat transfer co-efficient is found to be 18.9 W/m^{2}K near the PV cells region where air is in contact with pv cells. There is no heat transfer across the wooden panel box due to its insulating properties.

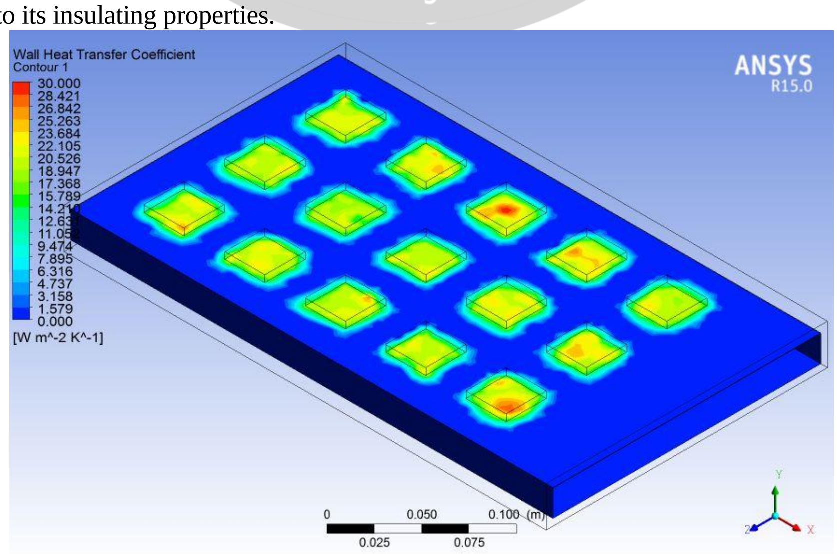

Fig.8 Heat Transfer Co-efficient variation along the length

 © 2018, IJREAM All Rights Reserved.

The Incident heat on the solar pv panel is found to be 89.5W while the heat absorbed by air from the pv cells is found to be 10.5W with the thermal efficiency of 11.73 % for the Solar Pv Thermal System with air as cooling medium.

CONCLUSION

The simulation of the Solar PV Thermal system with air as a cooling medium is studied in the proposed work to calculate the its effectiveness. The air temperature is found to increase and the growth of the thermal boundary layer takes place along the length of the hybrid pv panel. The air average temperature is found to be 312^0K at outlet. The average heat transfer Co-efficient is found to be 18.9 W/m^2K near the solar pv cells surface in contact with air. The Incident heat on the solar pv panel is found to be 89.5W while the heat absorbed by air from the pv cells is found to be 10.5W with the thermal efficiency of 11.73 % for the Solar Pv Thermal System with air as cooling medium. Thus, it can be concluded that the use of Hybrid solar PV thermal system cools the PV panel and increase its performance but also preheat the air which can be used in some specified applications.

REFERENCES

[1]. B. Praveen kumara, D. Prince Winston, P. Pounraj, A. Muthu Manokar, Ravishankar Sathyamurthy, A.E.Kabeel,2018. Experimental investigation on hybrid PV/T active solar still with effective heating and cover cooling method, Energy for Sustainable Development :235–246.

[2]. Ali H.A. Al-Waeli, K. Sopian, Hussein A. Kazem, Miqdam T. Chaichan, 2017. Photovoltaic/Thermal (PV/T) systems: Status and future prospects, Renewable and Sustainable Energy Reviews 77: 109–130

[3]. M. Akhsassi, A. El Fathi, N. Erraissi, N. Aarich, A. Bennouna, M. Raoufi, A. Outzourhit, 2017. Experimental investigation and modeling of the thermal behavior of a solar PV module, Solar Energy Materials and Solar Cells.

[4]. A. Khelifa, K. Touafek, H. Ben Moussa, I. Tabet, 2016. Modeling and detailed study of hybrid photovoltaic thermal (PV/T) solar collector, Solar Energy 135 :169–176

[5]. Clara Good , Inger Andresen, Anne Grete Hestnes, 2015. Solar energy for net zero energy buildings – A comparison between solar thermal, PV and photovoltaic–thermal (PV/T) systems, Solar Energy 122 : 986–996.

[6]. Jean Zaraket, Michel Aillerie, Chafic Salame, 2017. Capacitance Evolution of PV solar modules under thermal stresses, Energy Procedia 119: 702-708.

[7]. Marco Rosa Clo, Paolo Rosa-Clo and Giuseppe Marco Tina, 2017. Submerged PV Solar Panel for Swimming Pools: SP3, 9th International Conference on Sustainability in Energy and Buildings: 567-576.

International Journal for Research in Engineering Application & Management
IJREAM

 © 2018, IJREAM All Rights Reserved.