iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.77872

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

Computational Study of Photovoltaic Thermal System with Different Absorber Configuration – Review

Nixon Kocharekar[1], Kiran Thakur[2], Mahesh Tanpure[3], Rahul Tambat[4], Jitendra Satpute[5]
[1]*Department of Mechanical Engineering*
[2, 3] *Suman Ramesh Tulsiani Technical Campus Faculty of Engineering, Khamshet, Pune, Maharashtra*

Abstract: In Photovoltaic Thermal (PVT) systems, absorber configuration plays an important role in improving the overall performance of the system. A PVT system all together generates electrical and thermal energy by cooling the photovoltaic panel using a working fluid. The electrical efficiency of PV panels decreases with an increase in operating temperature. In the present work, a computational analysis of a water-based PVT system is carried out using different aluminum absorber configurations such as Spiral, Serpentine, and Wavy designs. The study is carried out using Computational Fluid Dynamics (CFD) simulation in ANSYS FLUENT to evaluate thermal and electrical performance. The results help identify the most efficient absorber configuration for improved heat transfer and overall energy conversion efficiency.
Keywords: PVT System; CFD; Absorber Configuration; Thermal Efficiency; Electrical Efficiency; ANSYS FLUENT

I. INTRODUCTION

The rapid increase in global energy demand and environmental issues caused by fossil fuels have encouraged the use of renewable energy sources. Solar energy is one of the most abundant and clean sources of energy. Solar energy can be converted into: Thermal energy (Solar Thermal Systems) and Electrical energy (Photovoltaic Systems). Photovoltaic (PV) panels directly convert solar radiation into electricity. However, only 15–20% of solar energy is converted into electricity, while the remaining energy is converted into heat.

This heat increases the temperature of the PV module, which results in low electrical efficiency. To overcome this limitation, Photovoltaic Thermal (PVT) systems are developed. A PVT system integrates a thermal collector at the backside of the PV panel. The circulating fluid absorbs excess heat, thereby reducing panel temperature and improving electrical performance while simultaneously producing useful thermal energy. The present study focuses on computational analysis of different absorber configurations in a water-based PVT system. This project focuses on evaluating such a hybrid system experimentally.

II. SYNTHESIS OF THE PVT SYSTEM

The The PVT system consists of the following components:

1) Photovoltaic panel
2) Aluminium thermal absorber
3) Water flow channel
4) Inlet and outlet piping system

In this project, three absorber configurations were designed: Spiral configuration, Serpentine configuration and Wavy configuration. The geometries were developed using CAD software. The computational analysis was performed using ANSYS FLUENT software.

The process includes:

a) Preparation of CAD geometry
b) Meshing of computational domain
c) Defining material properties (Water and Aluminium)
d) Applying boundary conditions (Heat flux, inlet mass flow rate)
e) Solving governing equations of fluid flow and heat transfer

III. NEEDS OF PHOTOVOLTAIC THERMAL SYSTEM

1) To reduce temperature of PV panels and improve electrical efficiency.
2) To utilize waste heat generated in photovoltaic panels.
3) To increase overall energy conversion efficiency.
4) To produce both electrical and thermal energy simultaneously.
5) To promote renewable energy systems for sustainable development.

IV. APPLICATION OF PVT SYSTEM

1) Residential water heating systems.
2) Industrial heating applications.
3) Solar drying systems.
4) Space heating applications.
5) Hybrid renewable energy systems.
6) Commercial buildings for combined power and heating.

V. LITERATURE SURVEY

Hamid Mortezapour et al. [1] investigated copper-based heat exchanger designs for PVT systems under various solar radiation levels and coolant flow rates. The study compared oscillating, spiral, and direct flow configurations. It is seen that spiral flow design maintained better temperature uniformity across the PV surface and improved electrical output compared to conventional direct flow systems.

Misha et al. [2] conducted a numerical and parametric analysis of a PVT system under hot climatic conditions using ANSYS software. The study evaluated the effect of radiation intensity and water flow rate on PV temperature distribution. The results indicated that increasing mass flow rate reduced PV cell temperature and improved thermal efficiency.

Long et al. [3] examined the performance of harp and grid roll-bond absorber configurations through numerical and experimental methods. The grid channel absorber achieved higher overall efficiency compared to harp design, but pressure drop was also higher. The study focuses the importance of balancing heat transfer enhancement with hydraulic losses.

Erkata Yandri et al. [4] developed a polymer-based thermal absorber for PVT applications. The experimental and numerical results showed significant improvement in cooling performance with thermal efficiency approaching 80%. The study highlighted that absorber material selection mainly influences PVT system effectiveness.

Abdelkader Morsli et al. [5] analysed different absorber geometries including parallel, spiral, and square, and rectangular tube designs using MATLAB-based modelling. It was observed that rectangular cross-section absorbers provided better heat extraction due to increased surface contact area, resulting in improved thermal efficiency.

W. Mustafa et al. [6] evaluated the performance of a PVT system using a numerical and mathematical model considering different volume concentrations and flow parameters. The study concluded that lower volume concentration and optimized mass flow rate provide better overall electrical and thermal efficiencies. It was also observed that system performance is highly dependent on operating conditions.

K. Sopian, K. Sulaiman, and S. A. Kalogirou [7] investigated the electrical and thermal performance of a photovoltaic thermal (PVT) collector under various flow rates and absorber configurations. The study showed that growing mass flow rate significantly reduced PV cell temperature and increased electrical efficiency. It was also observed that optimized absorber design improves total energy output of the hybrid system.

T. T. Chow [8] presented a comprehensive review on photovoltaic thermal technology covering system classification, heat transfer enhancement techniques, and performance evaluation methods. The study concluded that water-based PVT collectors provide higher thermal efficiency compared to air-based systems due to better heat removal capability.

S. Dubey, G. N. Tiwari, and T. C. Bhattacharya [9] developed a mathematical model for combined photovoltaic thermal systems and studied their performance under different climatic conditions. The results indicated that proper integration of thermal absorber reduces PV surface temperature and increases overall system efficiency.

Ibrahim, M. Y. Othman, M. H. Ruslan, S. Mat, and K. Sopian [10] conducted an experimental study on a flat-plate photovoltaic thermal collector. The study showed that active cooling of PV panels enhances electrical efficiency while simultaneously generating useful thermal energy for domestic applications.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

H. A. Zondag [11] studied different photovoltaic thermal collector concepts including sheet-and-tube, channel, and free-flow designs. The study compared their efficiencies and concluded that properly designed water-based PVT collectors significantly enhance overall energy conversion efficiency compared to standalone PV modules.

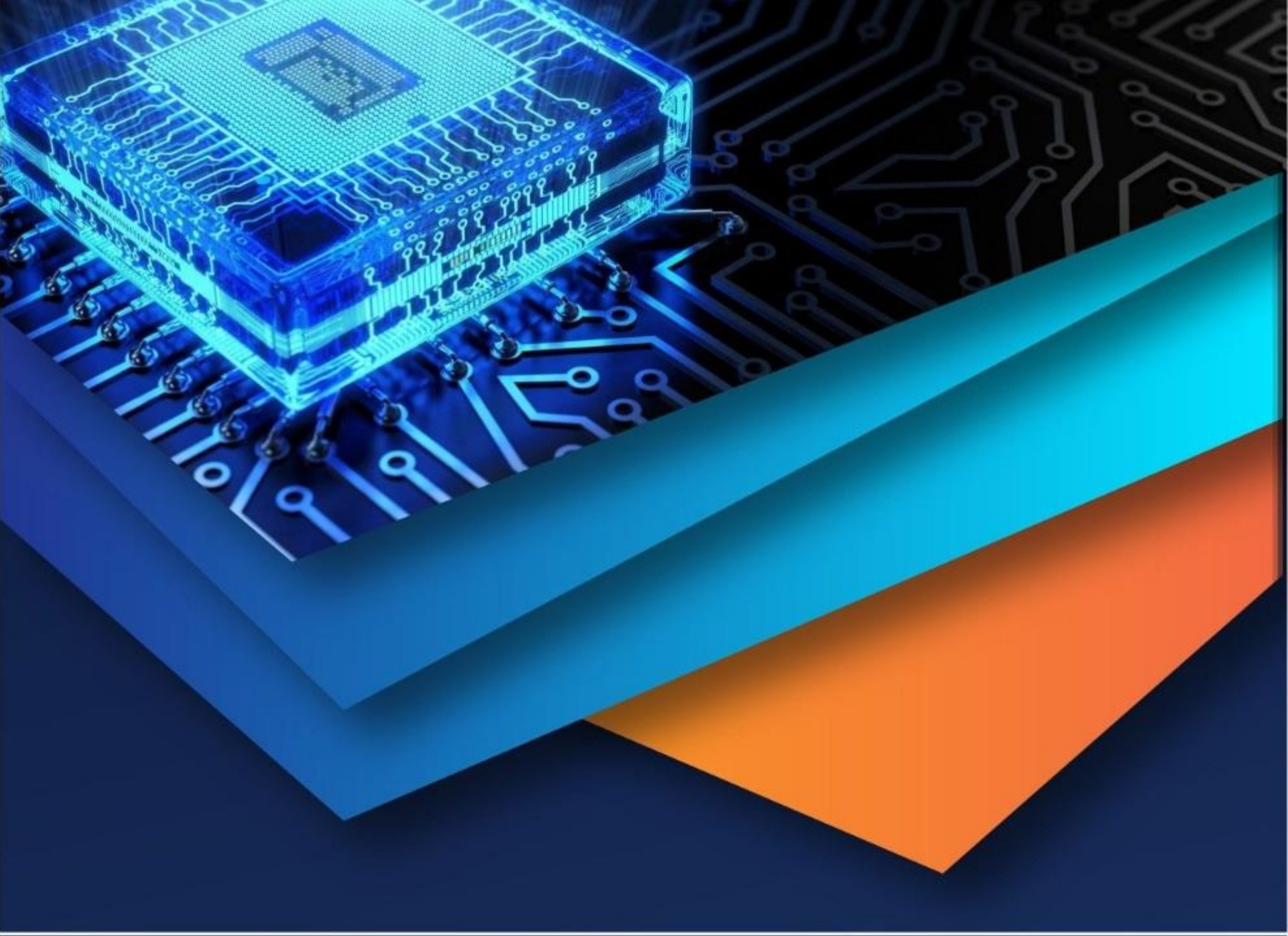
M. A. Hasan and K. Sumathy [12] reviewed recent developments in photovoltaic thermal systems with emphasis on absorber geometry, cooling techniques, and CFD-based optimization methods. The study highlighted that computational analysis plays a crucial role in improving next-generation PVT system performance.

VI. CONCLUSIONS

Based on the reviewed studies from different authors, it is observed that absorber geometry, material selection, and coolant flow configuration significantly influence overall system performance. Proper cooling of PV panels reduces surface temperature, which directly enhances electrical efficiency while simultaneously improving thermal output. It is also concluded that optimized absorber geometry and controlled flow parameters are key factors in enhancing the performance of photovoltaic thermal systems.

REFERENCES

[1] H. Mortezapour, M. Ghalambaz, and A. Chamkha, "Performance evaluation of copper-based heat exchanger designs in photovoltaic thermal systems under variable solar radiation," Solar Energy, vol. 195, pp. 84–96, 2020.
[2] S. Misha, N. Tamaldin, T. M. I. Mahlia, and M. A. M. Rosli, "Numerical investigation of photovoltaic thermal (PVT) system under tropical climate conditions," Energy Conversion and Management, vol. 180, pp. 326–339, 2019.
[3] P. Long, Y. Wang, and H. Li, "Experimental and numerical comparison of harp and grid roll-bond absorbers for photovoltaic thermal collectors," Applied Thermal Engineering, vol. 150, pp. 1204–1215, 2019.
[4] E. Yandri, H. Kurniawan, and I. D. Prakoso, "Development of polymer-based absorber for photovoltaic thermal applications," Renewable Energy, vol. 147, pp. 1786–1795, 2020.
[5] A. Morsli, K. Draoui, and M. S. Abdallah, "Modeling and performance analysis of different absorber geometries in photovoltaic thermal collectors," Energy Reports, vol. 6, pp. 1940–1950, 2020.
[6] W. Mustafa, A. Al-Douri, and S. A. Kalogirou, "Mathematical modeling and performance optimization of photovoltaic thermal systems," Sustainable Energy Technologies and Assessments, vol. 37, 100608, 2020.
[7] K. Sopian, K. Sulaiman, and S. A. Kalogirou, "Performance analysis of photovoltaic thermal collectors under varying operating conditions," Renewable Energy, vol. 34, pp. 234–240, 2009.
[8] T. T. Chow, "A review on photovoltaic/thermal hybrid solar technology," Applied Energy, vol. 87, pp. 365–379, 2010.
[9] S. Dubey, G. N. Tiwari, and T. C. Bhattacharya, "Thermal modeling of combined photovoltaic thermal solar systems," Solar Energy, vol. 82, pp. 602–612, 2008.
[10] A. Ibrahim, M. Y. Othman, M. H. Ruslan, S. Mat, and K. Sopian, "Recent advances in flat plate photovoltaic thermal collectors," Energy Conversion and Management, vol. 52, pp. 3189–3198, 2011.
[11] H. A. Zondag, "Flat-plate PV-Thermal collectors and systems: A review," Renewable and Sustainable Energy Reviews, vol. 12, pp. 891–959, 2008.
[12] M. A. Hasan and K. Sumathy, "Photovoltaic thermal module concepts and their performance analysis: A review," Renewable and Sustainable Energy Reviews, vol. 14, pp. 1845–1859, 2010.



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

SJIFactor IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY