Journal of Thermal Analysis and Calorimetry (2024) 149:14643–14662
https://doi.org/10.1007/s10973-024-13845-7

Thermal analysis and thermal regulation of photovoltaic thermal system using serpentine tube absorber with modified multi-walled carbon nanotubes enhanced PCM

Reji Kumar Rajamony[1,2,11] · Johnny Koh Siaw Paw[1] · A. K. Pandey[3,4] · Subbarama Kousik Suraparaju[5,6] · A. G. N. Sofiah[1] · Yaw Chong Tak[1] · Jagadeesh Pasupuleti[1] · M. Samykano[7] · Azher M. Abed[8] · Tiong Sieh Kiong[1] · Manzoore Elahi M. Soudagar[9,10,12]

Received: 12 December 2023 / Accepted: 7 November 2024 / Published online: 3 December 2024

Abstract

The concept of photovoltaic thermal (PVT) systems holds the potential to reduce global energy consumption by simultaneously generating electricity and heat. However, the widespread adoption of these systems is impeded by technical challenges, particularly the rise in panel temperature and constraints on operation during night hours. The present research aims to explore the effect of coolant flow rate and solar radiation on the electrical output and thermal output of PV, PVT, salt hydrate integrated PVT system (PVT-SH), and modified multi-walled carbon nanotubes infused salt hydrate integrated PVT (PVT-SHMM) systems. Additionally, the study examines the heat transfer analysis of a fabricated PVT system incorporated serpentine flow thermal absorber and modified multi-walled carbon nanotubes infused salt hydrate phase change materials (PCMs). In this experiment, water was used as a cooling fluid, with a flow rate of 0.008 to 0.023 kg s^{-1} and irradiation of 400 to 800 W m^{-2}. The findings show that the thermophysical properties of formulated nanocomposite have significantly improved, and the thermal conductivity of nanocomposites improved up to 97.2% compared to pure salt hydrate. The pressure drops enhancement increases become more pronounced at the higher mass flow rate, primarily because of the outlet's elevated viscosity of the cooling fluid. As the water flow rate increases, the heat removal factor exhibited 1.06 times rise, with relatively lower values in turbulent flow regions than in laminar flow conditions. Furthermore, the investigation notes a substantial decrease in panel temperature, an increase in electrical power with higher flow rates, and a higher heat gain at

✉ Reji Kumar Rajamony
reji.kumar@uniten.edu.my

1 Institute of Sustainable Energy, Universiti Tenaga Nasional (The Energy University), 43000 Jalan Ikram-Uniten, Kajang, Selangor, Malaysia

2 Department of Physics, Saveetha School of Engineering, SIMATS, Chennai 602105, India

3 Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Engineering and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, 47500 Petaling Jaya, Selangor Darul Ehsan, Malaysia

4 CoE for Energy and Eco-Sustainability Research, Uttaranchal University, Dehradun, India

5 Centre for Research in Advanced Fluid and Process, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuhraya Tun Razak, Gambang, 26300 Kuantan, Pahang, Malaysia

6 Solar Energy Laboratory, Department of Mechanical Engineering, Sri Vasavi Engineering College (A), Tadepalligudem, Andhra Pradesh 534101, India

7 Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

8 College of Engineering and Technologies, Al-Mustaqbal University, Babylon 51001, Iraq

9 College of Engineering, Lishui University, Lishui, Zhejiang 323000, China

10 Division of Research and Development, Lovely Professional University, Phagwara, Punjab 144411, India

11 Centre of Research Impact and Outcome, Chitkara University, Rajpura, Punjab 140417, India

12 Department of Mechanical Engineering, Graphic Era (Deemed to be University), 248002 Dehradun, Uttarakhand, India