



Binary nano-enhanced phase change materials (BNePCMs) integrated serpentine flow based photovoltaic thermal system: A new approach towards performance enhancement

Imtiaz Ali Laghari^a, A.K. Pandey^{b,c,*}, M. Samykano^d, Reji Kumar Rajamony^{e,f},
Yasir Ali Bhutto^{a,b}, Abdul Hameed Soomro^a, K. Kadirgama^d, V.V. Tyagi^g

^a Department of Electrical Engineering, University of Larkano, Larkana 77150, Sindh, Pakistan

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

^c CoE for Energy and Eco-Sustainability Research, Uttarakhand University, Dehradun, India

^d Faculty of Mechanical & Automotive Engineering Technology, University Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

^e Institute of Sustainable Energy, Universiti Tenaga Nasional (National Energy University), Jalan IKRAM-UNITEN, Kajang, Selangor, Malaysia

^f Faculty of Engineering and Technology, Parul University, Waghodia Road, Vadodara 391760 Gujarat, India

^g School of Energy Management, Shri Mata Vaishno Devi University, Katra 182320, Jammu & Kashmir, India

ARTICLE INFO

Keywords:

Photovoltaic thermal systems
Binary composite NePCM, thermal energy storage
Phase change materials
Electrical and thermal efficiency

ABSTRACT

Photovoltaic thermal systems (PVT) are widely acknowledged as solar technology that effectively produces both electrical and thermal energy. Nevertheless, the performance of photovoltaic (PV) systems is significantly affected by elevated temperatures of solar cells. Phase change materials (PCMs) are a class of substances that possess the ability to store and release latent heat. However, PCMs have inadequate thermo-physical characteristics, which may be altered via the incorporation of different nanoparticles. Herein, binary nanoparticles (Titanium oxide and Graphene) enhanced PCM (Paraffin Wax) is integrated with the PVT system to improve its thermal and electrical performance. The present study utilized a unique two side serpentine flow absorber to effectively extract heat energy. The effectiveness of the created PVT system was evaluated using three mass flow rates (0.3, 0.5, and 0.7 LPM). Further, as prepared BNePCM having thermal conductivity and latent heat of 179 % and 10 % higher than that of base PCM, respectively was integrated with PVT system. The energy analysis was used to assess the heat transfer and electrical power output. As per results, at optimum flow rate of 0.3 LPM; the overall energy efficiencies found were 80.49 %, 82.45 %, and 83.65 %, respectively for the PVT, PVT-PCM, and PVT-NePCM systems. Furthermore, the PVT-NePCM system exhibited an electrical output of 46.88 W, which is a significant rise of 10.6 W compared to PV system. Therefore, study will be useful for the applications in pre-heated water for low and medium temperature range, and cooling applications of electronic devices.

1. Introduction

Population expansion, technological improvements, and industry are driving up energy consumption, underscoring the necessity for renewable energy sources [1]. Renewable energy offers a viable alternative for addressing greenhouse gas emissions, environmental issues [2], and the current imbalance between energy demand and supply [3]. Solar energy is widely recognized as most prominent kind of renewable energy due to the substantial amount of irradiation received by the globe during a

single hour, which surpasses the total global energy consumption over the course of an entire year [4]. Photovoltaic (PV) systems are the most prominent technology extensively used over the last decade [5] and, consequently, it has emerged as one of the most influential and consistent sources of energy [6]. The leading limitations of PV is low energy conversion efficiency due to escalation in surface temperature [5], storage and effects of environmental conditions obstacles to the further development of this technology [7]. Increased temperature is shown to be a negative influence since it lowers the electrical performances of the PV panel, around 0.45 % to 0.56 % and conversion efficiency diminish

* Corresponding author at: Research Centre for Nanomaterials and Energy Technology (RCNMET), School of Engineering and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya 47500 Selangor Darul Ehsan, Malaysia.

E-mail address: adarsh.889@gmail.com (A.K. Pandey).

<https://doi.org/10.1016/j.tsep.2024.102704>

Received 13 February 2024; Received in revised form 6 June 2024; Accepted 15 June 2024

Available online 16 June 2024

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