



Research Paper

Heat transfer and energy performance analysis of photovoltaic thermal system using functionalized carbon nanotubes enhanced phase change material

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ABSTRACT

The photovoltaic thermal system (PVT) is an emerging technology that simultaneously generates both electrical and thermal energy from solar energy, aiming to improve solar energy utilization. However, significant technological issues with these systems obstruct their large-scale operation. The major drawback of the cooling fluid-based PVT systems lies in operation during sun-shine hours only. To address this issue, the present research endeavors a comparative study on with and without nano-enhanced phase change materials (NePCM) integrated PVT system. In this study, the performance evaluation of four configurations was analyzed with a flow rate varying from 0.4 to 0.8 liter per minute. From this, the experimental analysis was performed on two systems, including a photovoltaic and a PVT system. The simulation was performed using TRNSYS simulation on the phase change materials integrated photovoltaic thermal system, and NePCM integrated photovoltaic thermal system. The results indicate that increasing the flow rate by 2.2 times leads to a 4.9-fold increase in pressure drop, while the friction factor decreases with rising mass flow rate. Notably, the NePCM-integrated PVT system exhibited a substantial reduction in cell temperature and increased electrical power output at higher flow rates. At a flow rate of 0.4 liter per minute, a significant heat gain was achieved with an impressive energy-saving efficiency of 75.67%. Furthermore, the total efficiency of the PVT system, phase change materials integrated PVT system, and NePCM integrated PVT system were determined to be 81.9%, 84.5%, and 85.05%, respectively. These findings underscore the potential of NePCM-integrated PVT systems for enhancing performance and expanding their practical application.

1. Introduction

The energy demand worldwide is augmenting significantly due to technological developments, population growth and industrialization in the past few decades [1]. Most of the energy produced in the globe is from fossil resources like (coal, oil, natural gas etc.). Few studies [2,3] have confirmed that the depletion of fossil sources has been inexorable

70–100 years due to their large consumption in the past two centuries. Also, burning fossil fuels causes pollution and damage to the environment, which triggers an increase in carbon levels in the atmosphere, global warming, and consequential changes in climate, have significant problems [4,5]. Among these difficulties, the globe is looking to change towards renewable, most sustainable, and eco-friendly source of energy. Solar energy is the most predominant energy source than other renewable energies like wind, hydro, tidal, ocean, bioenergy etc., due to its

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