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Performance evaluation of a solar water heater integrated with a PCM nanocomposite TES at various inclinations

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Abstract

The present work presents and analyzes the results acquired from outdoor experimental measurements of a flat plate solar collector integrated with built-in thermal energy storage. Paraffin wax as a PCM and a nanocomposite of paraffin wax with 1.0 wt% of 20-nm nano-Cu particles were tested as the energy storage medium for TES. Three cases have been investigated, namely without PCM, with PCM, and with the Cu-PCM nanocomposite, at 10°, 20°, and 30° inclination angles of each case. The system performance was evaluated for water heating. The process involved a total change of the 60-l water tank at 7:00 PM and 7:00 AM. The use of water circulation of 0.5 kg/min and setting the collector at a 10° inclination angle was found to be the best operational condition. The measurement result of the tank water temperature at 7:00 AM, after 24 h of operation, was 35.1 °C when the system operated without TES, while the operation with the PCM and with the Cu-PCM nanocomposite resulted in 40.1 °C and 40.7 °C tank water temperatures, respectively. The best performances analyzed were at 10°, with efficiencies of 47.6%, 51.1% and 52.0% for the cases without PCM, with PCM and with Cu-PCM nanocomposite, respectively. This indicates that the enhancement of the system using TES with paraffin wax is considerable, while further enhancement is not significant in the case of nanocomposite. Further measurements with various flow rates are recommended to investigate the performance of the developed solar-TES integrated system.

Keywords: PCM; Solar collector; Nanocomposite; TES

1. Introduction

The use of domestic water heating utilizing solar energy for residential and industrial consumption is increasing in demand due to awareness of renewable energy technologies and their beneficial impact on the environment. However, the drawback of using solar energy systems is the non-continuous operation due to the lack of solar irradiation during the night. As a solution, thermal energy storage (TES) techniques have been proposed and evaluated from the points of view of the storage materials, the storage design, and the integration methods with the solar collector.

1.1. Integrated solar-TES

The advantage of using TES as an energy storage method is the absorption of the extra heat at peak radiation hours that is released when the solar radiation is absent. The purpose of TES is to reduce the temperature fluctuations during the peak solar radiation hours. The

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