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Exergy analysis of a flat plate solar collector with latent heat storage by phase change material for water heating applications at low temperature

* Angie Rincon Ortega[1], Mauricio Carmona[2]
[1, 2] Mechanical Engineering Department, Universidad del Norte, Barranquilla, Colombia

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ABSTRACT
An exergy analysis has been performed to determine the potential for useful work in a latent heat storage system with phase change material (PCM) for a flat-plate solar collector. Commercial paraffin wax is used as PCM to store and release energy in the solid-liquid transformation; this material is located in metal containers under the absorber plate on the bottom insulation of the collector. The exergy analysis is performed in outdoor conditions for days of low, medium and high radiation taken from October 2016 to March 2017 at Barranquilla city (latitude: 10° 59' 16" N, longitude: 74° 47' 20" O, Colombia). The system is evaluated throughout charge and discharge periods. The energy and exergy balance equations based on the first and second law of thermodynamics is formulated and solved for each element of the collector system as well as for the PCM. Results obtained show the energy distribution and energetic destruction for each system component and its variation as a time function. It was observed that the average energy and energetic efficiency are 28.7 %, 13.2 % for of low radiation days. 26.9%, 20.56% for of medium radiation days, and 23.2%, 18.6% for of high radiation days, respectively. Results of the analysis are shown in detail in the present paper.
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1. Introduction

In recent years there is a grown interest in the use of renewable energy due to the scarcity of fossil energy reserves and the environmental impact caused by their management. Among renewable energy sources solar energy has been great attention due to the ease of obtaining and high potentiality in the generation of electricity and heat, the use of solar heating systems has increased on the basis of reasonable initial costs and structure relatively simple (Jafarkazemi,and Ahmadifard, 2013). For any application with solar thermal systems solar collectors constitute an important component, their operation is based on the capture of the radiation coming from the sun, converting it to heat and the transfer of this heat to a circulating fluid through the collector . The collected energy is carried by the fluid directly to a process requiring heat or to a thermal energy storage system and subsequently withdrawn for use (Kalogirou, 2004). There are different forms of storing thermal energy, among them are the storage by sensible heat, by the thermochemical reaction and by latent heat (Oliver et al., 2010).

***Corresponding Author:**
Mechanical Engineering Department, Universidad del Norte, Barranquilla, Colombia
E-mail address: anggier@uninorte.edu.co