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Renewable Energy 28 (2003) 1629–1643

RENEWABLE ENERGY

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Modification of urea–sodium acetate trihydrate mixture for solar energy storage

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Received 5 September 2000; accepted 14 March 2002

Abstract

The system urea–sodium acetate trihydrate has been mentioned in the literature as an energy storage system. Due to its low melting point (30 °C), the system is not suitable for use in a hot climate. Modifying the system composition is shown in the present work through adding lead acetate trihydrate to the binary mixture in the ratio of 16.6% with the object of raising its melting point to a practical value. A melting point of 44.5 °C could be reached for the new system.

The mixtures of urea–sodium acetate trihydrate and urea–sodium acetate trihydrate–lead acetate trihydrate are tested in the present work as phase change storage mixtures and comparison between both mixtures was carried out.

The results showed that the system composed of urea–sodium acetate–lead acetate stored 286 kJ/kg of the storage mixture.

Keywords: Solar energy; Phase change materials (PCMs); Energy storage; Latent heat of fusion; Eutectic mixtures

1. Introduction

All forms of energy storage play an important role in energy conservation. The intermittent and dynamic nature of solar insolation and the need to utilize solar energy systems in a continuous and static load, make the use of storage systems essential in most of the potential uses of solar energy.

Amongst the various heat storage techniques of interest is latent heat storage. It is particularly attractive, due to its ability to provide a high-energy storage density.

0960-1481/03/$ - see front matter © 2003 Published by Elsevier Science Ltd.
doi:10.1016/S0960-1481(02)00052-6

Nomenclature

A_c	Collector aperture area m^2
H_m^A	Heat of fusion of constituent A in the mixture kJ/kg
H_m^B	Heat of fusion of constituent B in the mixture kJ/kg
Q_u	Amount of heat extracted during cooling of PC mixture kJ/kg
$Q_{u\ c}$	Useful energy of the collector W
S_t	Total solar radiation incident on the surface of the collector W/m^2
T_m^A	Melting point of constituent A °C
T_m^B	Melting point of constituent B °C
T_m^C	Melting point of constituent C °C
T_m^{eu}	Eutectic melting point of the mixture °C
U_L	Overall heat loss efficient W/m^2 °C
U_t	Top heat loss coefficient W/m^2 °C
U_b	Bottom heat loss coefficient W/m^2 °C
U_s	Side heat loss coefficient W/m^2 °C
W^A	Mass fraction of constituent A –
W^B	Mass fraction of constituent B –
ΔH_m^{eu}	Latent heat of fusion of eutectic mixture kJ/kg
ΔH_v	The enthalpy of latent heat of vaporization kJ/kg
ζ	Efficiency of the solar energy storage container –

The major problem is the selection of a suitable material or a system having suitable thermo-physical characteristics that fit the load requirements.

Studies of the thermal performance of latent heat thermal storage systems have been performed by many authors. [1–3] studied the use of phase change materials in solar passive systems. Nishina and Takakura [4] used phase change materials for solar heating of green houses. Chauarsia [5] found that a storage system based on a latent heat technique employing paraffin wax and other materials can be used as a storage system for solar water heating. Kaygusuz [6] conducted an experimental and theoretical study to determine the performance of phase-change-energy storage materials for solar water heating.

Different phase change materials were tested for use as phase change mixtures for storage of solar energy by Fathy [7].

The choice of the components of a system is determined according to the requirements, both with respect to the temperature and ambient energy delivery. Thus, the system urea–sodium acetate trihydrate has been adopted for modification so as to meet the requirements of relatively hot weather.