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ScienceDirect

Procedia Manufacturing 12 (2017) 1 – 6

Procedia MANUFACTURING

International Conference on Sustainable and Intelligent Manufacturing, RESIM 2016, 14-17 December 2016, Leiria, Portugal

Highly efficient collectors of solar energy using nanocarbon coatings based on vegetable raw materials

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Abstract

In this work we present the results of a study of model samples of solar collectors with an absorption material based on carbonized vegetable raw materials from apricot stones, rice husks and their combination with carbon nanotubes. These studies have shown the possibility and prospects of the use of carbon structures based on carbonized vegetable raw materials for the absorbing layers of solar collectors. Experimentally, on the basis of a comparative study of the absorption capacity of the coatings from carbonized rice husk, apricot stones, and their combination with the carbon nanotubes, it was found that the maximum absorption capacity was observed for a coating based on carbonized rice husks.

Peer-review under responsibility of the scientific committee of the International Conference on Sustainable and Intelligent Manufacturing

Keywords: collector of solar energy; carbonized carbon material; absorber.

1. Introduction

As is well known, the solar collector efficiency is largely determined by the losses associated with the reflection of solar energy from the glass tubes (to 7.5 %), the absorber (to 6.3 %), and the loss of radiation of heat energy in the infrared range (up to 4.4 %). At present, the efficiency of vacuum solar collectors is in the range of 70-80 %. By

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Peer-review under responsibility of the scientific committee of the International Conference on Sustainable and Intelligent Manufacturing
doi:10.1016/j.promfg.2017.08.001

using, an absorbent material with an efficiency of 98 % and the absence of reflections from it and with the maximum heat insulation in the infrared range is possible to increase the efficiency of the solar collector to a value above 80 %.

A number of teams have developed different methods to improve the efficiency of absorption by solar energy collectors. For example, a known collector with a selective highly absorbent coating, but weakly emitting in a certain area of spectrum, which correspond to certain semiconductors [1, 2]. However, currently used semiconductors exhibit a low mechanical strength and low thermal conductivity together with a high cost, which makes them less suitable for the manufacture of a total solar radiation receiver. To compensate for these negative properties of semiconductors, we can apply a thin layer on a metal substrate, which has toughness, good thermal conductivity, but low absorption capacity [3].

The use of carbon composite materials based on carbon nanotubes is a new direction in terms of increasing the absorption efficiency of solar collectors. It is known that carbon nanotubes behave like an ideal black body, absorbing a wide spectral range of more than 98 % of the energy of incident sunlight [3-5]. Carbon nanotubes have high strength, flexibility and high thermal conductivity and can be fabricated in to continuous tape with an extended submicron thickness, which can be wound onto the solar receiver with any configuration made of any material [6, 7].

The development of new materials for solar absorbers is quite a challenge. The purpose of such searches is to obtain coatings with a higher coefficient of absorption of solar energy at the lowest loss to radiation in the infrared range in combination with the low cost of their production. One of the new directions in the field of new materials for coating solar collectors, is the use of the carbonized material from vegetable raw materials and their combination with various additives as an absorber for a solar collector.

1.1. Experimental

Glass tubes were coated with a layer of sodium silicate mixed with a powder of carbonized vegetable raw material from apricot pits (AP) or rice husk (RH). The coating thickness does not exceed 0.8 mm. Samples were prepared in duplicate. A second instance was coated with 10 layers of films from carbon nanotubes (CNTs). Synthesis of a CNTs "forest" was carried out in the NanoTech Institute, University of Texas at Dallas (USA) headed by Professor A.A. Zakhidov, who is a foreign partner for the implementation of this work. The height of the synthesized CNT "forest" is an average of 300-350 μm and with CNT diameters ranging from 18 to 30 nm. A general view of the model solar collector tubes and the method of coating of CNTs are shown in Fig. 1.

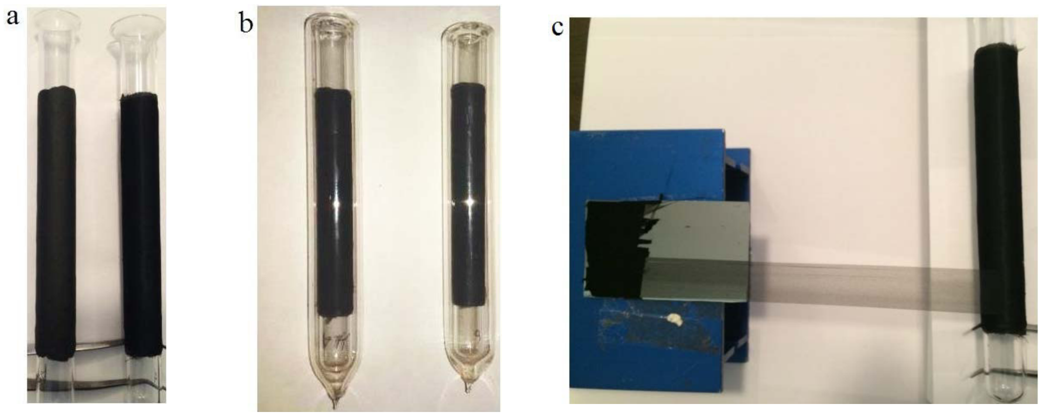

Fig. 1. General view of the collector tubes with coating (a, b) and the method of coatings of CNTs on the tube with a pre-coated RH or AP (c)

The coated tube was placed inside a tube of larger diameter and hermetically heat sealed. This assembly was evacuated to a pressure of $5x10^{-3}$ Pa and sealed. A general view of the finished evacuated tube of the solar collector model is shown in Fig. 1 (b).