Available online at www.sciencedirect.com

ScienceDirect

Solar Energy 119 (2015) 100–113

SOLAR ENERGY

www.elsevier.com/locate/solener

Theoretical and experimental investigation of the thermal performance of a double exposure flat-plate solar collector

N. Nikolić, N. Lukić *

Faculty of Engineering, University of Kragujevac, Sestre Janjić 6, 34000 Kragujevac, Serbia

Received 24 March 2015; received in revised form 30 May 2015; accepted 2 June 2015

Communicated by: Associate Editor Brian Norton

Abstract

This paper presents the results of a theoretical and experimental investigation of a double exposure, flat-plate solar collector with a flat-plate reflective surface. The main role of the reflector, which is placed below and parallel to the collector, is the reflection of solar radiation on the lower absorber surface. To enable absorption from the lower absorber surface, it is necessary for the insulation mounted on the lower part of the collector box to be removed and the lower box surface replaced by a glass cover. In order to determine the feasibility of the proposed concept, theoretical and experimental investigations of a double exposure and conventional flat-plate solar collectors were carried out. The experimental tests verified the developed mathematical models of the thermal behaviour of the mentioned solar collectors. The main advantages of the proposed collector–reflector system in relation to the previously investigated are: parallelism between the reflector and the collector, mirror reflective surface and mobility of the reflector in all three possible orthogonal directions. The proposed system is simpler because it consists of only one reflector. The experimental and theoretical results show that performance of a double exposure, flat-plate solar collector can be significantly higher than a conventional solar collector. The experimentally obtained relative difference of thermal power of these collectors is in the range of 41.79–66.44%, the highest achieved value of this difference in the reviewed literature is 48%.

Keywords: Double exposure solar collector; Flat-plate reflector; Thermal performance; Experiment

1. Introduction

The increasing need for renewable energy sources, specifically solar energy, requires more complex research to be conducted to improve the efficiency of systems that transform solar energy. The most common solar systems are flat-plate (water) solar collectors (FPCs). The mentioned collectors transform solar energy into heat energy through an absorber plate with high thermal conductivity (copper, aluminium) placed in an insulated box with a flat glass cover. The main carrier of heat energy is a working fluid (water or antifreeze liquid) that passes through the absorber or absorber tubes integrated or attached to the same.

Conventional flat-plate collectors receive a relatively low solar flux and have an average efficiency, especially at lower level of solar radiation. Many investigations have been carried out to improve a performance of flat-plate collectors by concentrating solar radiation using reflector. A small part of those investigations has focused on a system of the flat-plate solar collector and flat-plate reflector (McDaniels et al., 1975; Larson, 1979, 1980; Hussein et al., 1999; Taha and Eldighidy, 1980; Tanaka, 2011, 2015; Ekechukwu and Ugwuoke, 2003; Farooqui, 2015; Grassie and Sheridan, 1977; Bollentin and Wilk, 1995;

* Corresponding author. Fax: +381 34 357 884.
E-mail address: lukic@kg.ac.rs (N. Lukić).

http://dx.doi.org/10.1016/j.solener.2015.06.038
0038-092X/