INTERNATIONAL JOURNAL OF HYDROGEN ENERGY XXX (2017) 1–7

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Experimental study of the effect of soil type on global warming using laboratory thermal collector

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ARTICLE INFO

Article history:
Received 18 February 2017
Received in revised form
16 May 2017
Accepted 18 May 2017
Available online xxx

Keywords component:
Application of flat plate solar collector
Solar energy
Soil nature

ABSTRACT

Among the causes of global warming, figure the modification of the nature of the soil. This paper presents an experimental study of the effect of soil type on global warming using a laboratory thermal collector. This paper shows also another application of this experimental apparatus used generally for parametric study in order to improve its efficiency. The experimental device (ET200) used in this study consists of a thermal collector and water reservoir. The thermal collector receives solar energy from a halogen lamp (which simulates solar radiation) on its glass surface. The same amount of the following materials is spread over the receptive surface of the thermal collector; agricultural soil, local regional soil (soil of the region where these experiments were performed), cement and plaster. The same experimental conditions are kept up for each material used as receptive surface cover.

The incident heat flux is influenced by the nature of the receptive surface coverage. Indeed, the receptive surface covered by agricultural soil and local soil receives the same incident flux. This flux is reduced by 4% in case of cement and 8% in case of plaster (i.e; relative to flux received by agricultural soil and local soil). The reception glass covered with agricultural soil transmits better the energy received from the lamp to the heating medium (heat transfer fluid); this energy is lessened by 9% in the case of local soil, by 27% in the case of plaster and 18% in the case of cement. So, the incident solar radiation is well reflected by the plaster, it is less reflected by the cement and it is the least reflected in the case of agricultural soil and local soil. So, the thermal collector demonstrates that air temperature is affected by the nature of the soil. It is recommended to preserve agricultural lands and do not transforming them into urban areas in order to reduce the effect of global warming.

Introduction

As known, December is a cold month in the countries of northern hemisphere; However, December of the year 2015 was not cold. It recorded an average temperature above the normal in addition to a lack of precipitations. This is a consequence of climate change [1–3] that people begin to feel without any measuring instrument (global warming). Global

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http://dx.doi.org/10.1016/j.ijhydene.2017.05.244
0360-3199/

warming means an increase in average global temperatures [4]. Human activities (emission of greenhouse gases) are among the major causes that led to increase in the average temperature of Earth's atmosphere and oceans (Environmental impact) [5–8].

The greenhouse effect is a natural phenomenon of the lower atmosphere (troposphere), which helps to trap some of the solar heat on the Earth's surface, through the absorbing power of certain gases such as, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.

The return to clean energies is the main solution to the problem of increasing greenhouse emission in order to preserve life on Earth. Solar energy is the energy coming from the sun. It is an important source of renewable and clean energy. A solar thermal collector is a device that catches solar radiation and turns it to thermal energy which is a part of internal energy of a heat transfer fluid (air, water, oil) [8]. Flat plate collectors (FCP), developed by Hottel and Whiller in the 1950s [9], are a simple and widely used type of collectors to intercept solar radiation and produce low temperatures [10–12]. Indeed, they are composed of three main parts: firstly, absorber plate having high absorptivity, which absorbs solar radiation and transfers it to the heat transfer fluid, flowing through the heating tubes attached or welded to the absorber plate, secondly, transparent top cover which lets short wave radiation to pass and hinders them from exiting and thirdly, insulation which acts to prevent heat losses, from the back and the sides of the collector to the environment [13]. In flat plate solar collector, solar energy is absorbed to heat up the absorber plate. The heat thus gained is then transferred to a heat transfer fluid flowing through the collector [13–16]. Solar collectors can be used for applications needing moderate temperature ($T < 100$ °C) such as domestic hot water, space heating, air conditioning and industrial process heat [17–19].

Large agricultural area in Algeria has been transformed into urban areas covered with cement, changing, thus the nature of the soil.

The most existing studies in literature, dealing with climate change, are based on meteorological data analysis [2,3,20,21]. This paper treats one of climate change causes, which is not due to greenhouse effect but attributed to man's activity (changing sol's nature) using a solar thermal collector. Solar collectors have been widely studied to improve their performance [6,10,13,22–24]. This investigation shows another application of solar thermal collector used generally for parametric study in order to improve its efficiency. This document presents an experimental study of the effect of soil type namely: agricultural soil, local regional soil and plaster as well as cement on the amount of received radiation (Soil reflectivity.

Experimental methodology

This study was achieved in laboratory, using a device for heating domestic water ET 200, illustrated in Fig. 1.

The laboratory solar collector aimed for heating domestic water as shown in Fig. 1, consists of the following parts: a flat plate solar collector (1), a halogen lamp (2), a control box (3) and water storage tank (4).

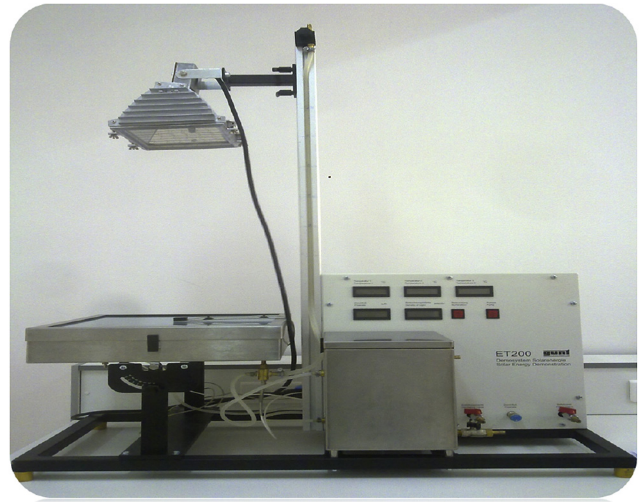

Fig. 1 – Laboratory solar thermal collector. (1) A flat plate solar collector, (2) A halogen lamp, (3) A control box, (4) Water storage tank.

The thermal collector is an insulated housing on its five sides except of its upper surface which is covered by glass (receptive surface) (see again Fig. 1). A heat exchanger in which circulates water (heat transfer fluid) is inside the manifold, this latter (the heat exchanger) is glued to a black surface called absorber, placed above it. The heat source used in these tests is a halogen lamp of 1000 W maximum. The solar collector ET 200 operates as follows:

The solar radiation emitted by the halogen lamp passes through the glass surface and reaches the absorber plate which heats up and transfers its energy to water flowing through tubes attached to the back of the black plate (absorber). The heated water circulates in a closed circuit composed of two heat exchangers; one placed under the absorber plate in the solar collector (heat receiver) and the other in the form of a coil in water tank (heat rejection). Water flows through the closed circuit by mean of a circulating pump. The water in this case acts as a heat transfer fluid that transports heat from the collector to the tank water in order to heat it.

The heat flux intercepted by the glass surface is measured using a heliometer sensor ((5) see Fig. 1), placed in the middle of the collector glass cover.

On the control box (component (3) in Fig. 1), one can directly read the following measures: the temperatures expressed in °C at the inlet and outlet of the absorber; T_1 and T_2 respectively, temperature of water in the reservoir T_3 in °C, water flow rate in l/h and illuminance (Incident flux by collector glass surface) in W/m^2.

The same amount of the following materials is spread over the glass receptive surface of the thermal collector; agricultural soil, local regional soil (soil of the region where these experiments were performed), cement and plaster.

It should be noted that the agricultural soil used in this study is taken from a region that is located at 35 km from test laboratory. Local soil is another agricultural land on which is built the laboratory in which the tests were done.