A LOW COST LINEAR PARABOLIC CONCENTRATOR SYSTEM– PHOTOREACTOR FOR PHOTOCATALYTIC PROCESSES THAT USES NATURAL SOLAR LIGHT

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Abstract

PdS/CdS based photocatalysts exhibit high efficiency in water splitting reaction. Due to the fact that the band gap value of CdS is 2.4 eV, the photocatalytic process may be performed using visible light at temperatures between 20 and 80°C. From our previous work we noticed that the yield of water splitting process, using this type of photocatalysts increases with the increase of temperature from 20 to 60°C. To increase the temperature of the photocatalystsuspension at higher values than the environment temperature, an irradiance greater than 1000 $W/m^2$is needed. In this paper we present the design and construction of an inexpensive solar collector –photoreactorassembly, by which the optimal temperature of photocatalystsuspension can be maintained,even in low solar irradiance conditions.

Introduction

Photocatalysisthat uses solar energy is utilized the most often todegrade the wastewater organic content into carbon dioxide and water and in the water splitting reaction [1]. For these processes the following types of photoreactors[2] are used: Inclined Plane Photoreactor, Double Skin Sheet Photoreactor and Parabolic trough Photoreactor. The first two types of photoreactors do not need the solar tracking devices. The Parabolic trough Photoreactor needs, at least one axis tracking system. The Inclined Plane Photoreactor and the Double Skin Sheet Photoreactor can utilize the direct and diffuse radiation. Due to the fact that they do not use concentrated solar light, these photoreactors cannot function at temperatures much higher than that of the environment. Also the functioning of these photoreactors during the winter is problematic. The Parabolic trough Photoreactor functions in concentrated light making the high temperature photocatalysis possible, also a fraction of the solar energy may be saved as heat [3]. In this study a low cost tubular photoreactor – linear parabolic concentrator assembly is presented. This system is utilized for the water splitting reaction with simultaneous heat recovery.

Experimental

In this paper we are presenting the design and construction of an inexpensive linear parabolic concentrator – photoreactor system, which can be utilized for photocatalytic processes that need natural solar light. The total price of the concentrator – photoreactorsystem is lower than 200 Euros.Due to the fact that the photocatalytic process is a discontinuous one(determined by the necessity of the photocatalyst periodic replacement) the photoreactor design has to fulfill at least some criteria, like: the photocatalytic process must take place in a visible range transparent flask apart from the photocatalystfueling tank, the separation and storage of the produced hydrogen and the simple and efficient delivery.In order to satisfy these necessities, the constructive solution of a tubular, glass photoreactor, equipped with a cooling mantle, positioned in the focus of a cylindrical parabolic concentrator, was chosen. This set-up is placed on a dual axis solar tracker device. The system has two recirculating fluid pumps, one dedicated to the photocatalyst suspension and the other to the cooling fluid.

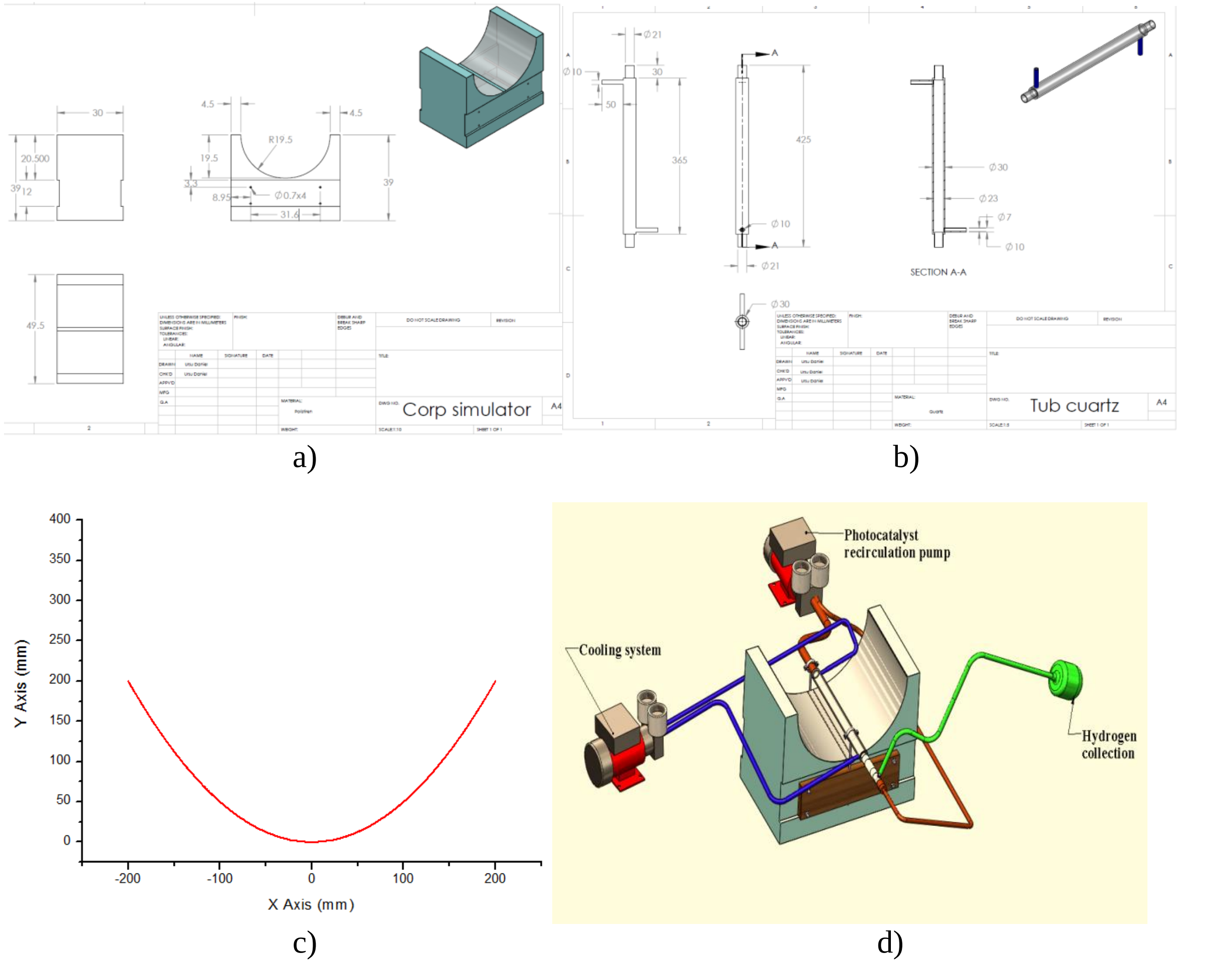
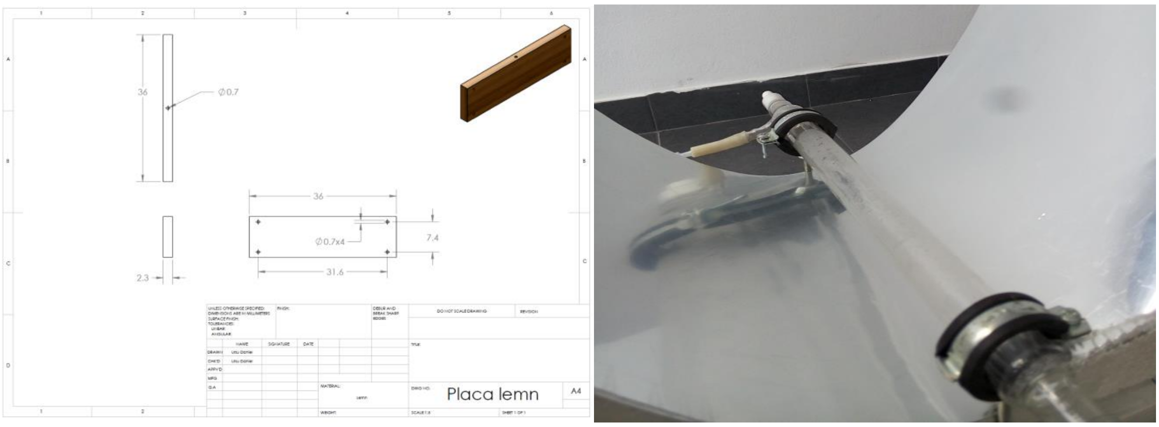


Fig. 1. Constructive sketches of the radiation caption body (a), the light collection tube (b), the details by which the parabolic body was cut (c) and of the 3D assembly (d)

The radiation collector tube (figure 1b) is made from borosilicate glass and has two entries and two exits for two recycling pumps mounting, one for the photocatalyst suspension and the second for the cooling water recycling. On the branch of cooling water recycling, the mounting of an air-water heat exchanger is necessary. A tank,having thermal buffer role,may be integrated in the system for avoiding the high temperature variations during its adjustment with the help of a PID controller.The linear parabolic body was cut in expanded polystyrene and covered with aluminum foil having 94% reflectance at a 500 nm wavelength. The parabolic concentrator has a 400 mm diameter and a depth of 200 mm. The focal axis is placed at a 50 mm distance from the bottom. The length of the linear parabolic body is 300 mm.



a) b)

Fig. 2. The construction sketch for the wooden boards (a) and parabolic concentrator – photoreactor overview

The glass photoreactor with cooling mantle is mounted with the help of two metallic rings through the medium of two threaded bars fixed in two wooden boards (figure 1d and 2a). These are attached on the sides of the polystyrene body, so as to the glass photoreactor can be lowered towards the bottom of the concentrator, into the focus.

Conclusions

In this paper, theconstruction sketches, for a linear parabolic concentrator system – photoreactor assembly, with a cost lower than 200 Euros, where presented. It can be employed in photocatalytic reactions that utilize the natural solar light. The body of the linear parabolic concentrator is manufactured out of expanded polystyrene, covered with a reflective aluminized mirror. The tubular photoreactor, made from glass is equipped with a cooling mantle and fixed through two threaded bars, as so being mobile in the plane which encompasses the bottom and the focal axis of the parabolic concentrator.

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