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ScienceDirect

Solar Energy 120 (2015) 100–103

SOLAR ENERGY

www.elsevier.com/locate/solener

Brief Note

An improved power free tracking system for box type solar cookers

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Received 24 May 2015; accepted 15 July 2015

Communicated by: Associate Editor Yanjun Dai

Abstract

An improved power free solar tracking system for box type solar cookers, suitable for up to six hours of cooking is being reported in this brief note. The requirement for solar tracking along the altitude has been eliminated by orienting a relatively larger booster mirror at a predetermined optimum angle for the day for a particular location. The requirement for tracking along the azimuth has been addressed by using the gravitational potential energy stored in a water container connected to a pair of springs. Discharge of water from the container at a constant predetermined rate drives a timing belt mounted wooden disc to rotate with the sun at a uniform rate. Experimental results indicate that the system faithfully tracks the sun for up to six hours, starting 3 h before solar noon and up to 3 h after it.

Keywords: Solar energy; Solar cooker; Box type solar cooker; Sun tracking

1. Introduction

One of the most effective ways of harnessing the solar energy is to use it for cooking, which accounts for up to one third of the total primary energy consumption in many countries (Muthusivagami et al., 2010). Use of solar cookers has the potential of not only reducing the overall energy demand, but may also lead to substantial reduction in greenhouse gas emission and deforestation.

The most popular and well known solar cooker is the box type, due to its ease of manufacture and lower costs (Tiwari and Yadav, 1986; Pande and Thanvi, 1987; Mullick et al., 1996). However, it suffers from a main disadvantage that it is required to regularly follow the sun along two directions – azimuth and altitude. This requirement leads to the manual readjustment of the box every 20–30 min, becoming a major hurdle in its wide scale adoption. Recently, a gravity based tracking system was proposed that can track the sun for up to six hours without using any external source of power (Farooqui, 2013). The system utilized a spring connected to a water container through a cord. The spring is constrained to stretch or contract inside a semicircular steel tube having a long slit. A vertical bolt extending outward from this slit can drag a base plate along a curved path as the spring stretches or contracts. The cooker placed over the base plate rotates along the sun if water is discharged at a matching rate from the water container, thereby un-stretching the spring. The scheme is illustrated in Fig. 1.

However, the average results of five tests of the system for six hours duration each, as shown in Fig. 2, reveal that the rate of rotation of the cooker is not perfectly linear with respect to time. The rate of rotation is relatively slower during the first three hours and faster during the next three hours. Therefore, this system can more properly track the sun for three hours loading at a time. This is because of

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http://dx.doi.org/10.1016/j.solener.2015.07.021
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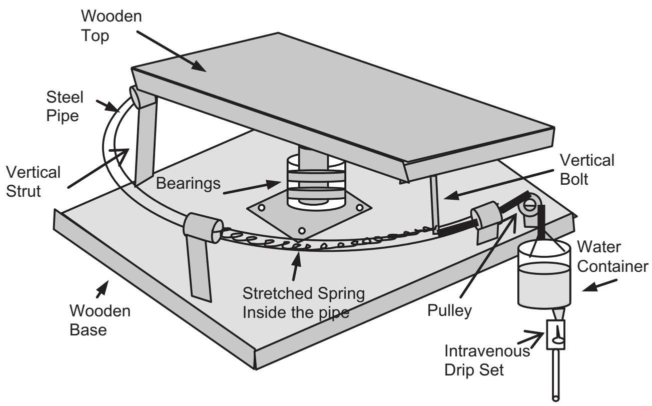

Fig. 1. The gravity based sun tracking system.

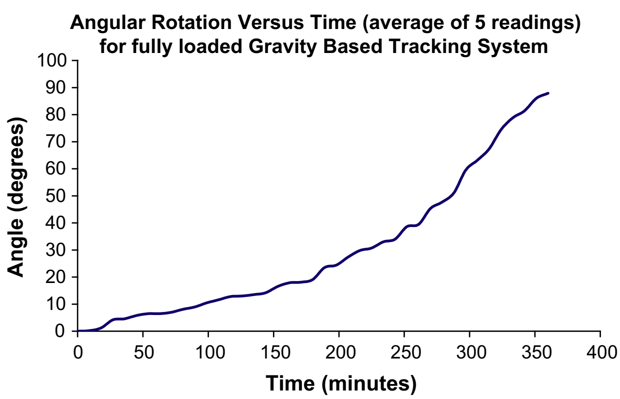

Fig. 2. Plot of the 6 h of angular rotation of the fully loaded gravity based sun tracking system for box type solar cookers, showing the average of five readings.

the curvature of the steel tube inside which the spring is constrained to stretch.

This note presents another and even simpler scheme through which an almost perfectly linear relationship between rotation and time is achieved. The curved steel pipe is replaced with a circular wooden disc mounted with a timing belt. The disc is attached to the top wooden board shown in Fig. 3 from below. An aluminum U-channel supported by two horizontal and two vertical axis bearings is connected to a pair of springs allowed to stretch linearly in the air. A section of timing belt is pasted along the back side of the U-channel. The whole spring – U-channel assembly dragging the wooden disc with it, moves along a straight line, producing a uniform rate of rotation throughout, if the rate of discharge of water from the container is held constant.

The requirement of tracking along the second direction, that is, along the changing solar altitude is eliminated by increasing the height of the booster mirror, as in the previous scheme (Farooqui, 2013). This optimum height for six hours of intended cooking time is found to be equal to twice the width of the solar cooker. The booster mirror is held at a constant angle for a particular day of the year, during this period. Hence the cooker is optimized for the cooking process without any human intervention for up to 6 h. The proposed mechanism is power free, reliable, innovative, simple, low cost, easy to handle and almost maintenance free. The new scheme and its experimental results are presented below.

2. The power free linear sun tracking system

The basic concept of the proposed mechanism is explained in Figs. 3 and 4. A rectangular wooden board having one side length equal to the length L_{SC} of the solar cooker and the other side length equal to 2.5 L_{SC} is selected as the base of the tracking system. Another rectangular wooden board having dimensions same as that of the base of the solar cooker is selected as the top of the tracking system. A small pipe section containing two bearings is fixed at the center of the rectangular board at one third distance from the left side, as shown in Fig. 3. Another small pipe section having outer diameter equal to the inner diameter of the bearings is fixed at the center of the top wooden board. A circular wooden disc mounted with a timing belt and having an internal and an external diameter, as shown in Fig. 4 is attached to the wooden top from below, matching its center to that of the bearing assembly. Now, the pipe section of the top of the tracking system is inserted into the

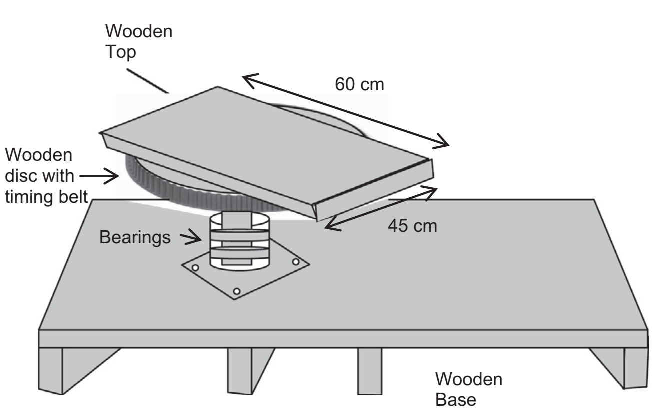

Fig. 3. Timing belt mounted wooden disc attached to the wooden top from below. Assembly is fitted on an extended wooden base.

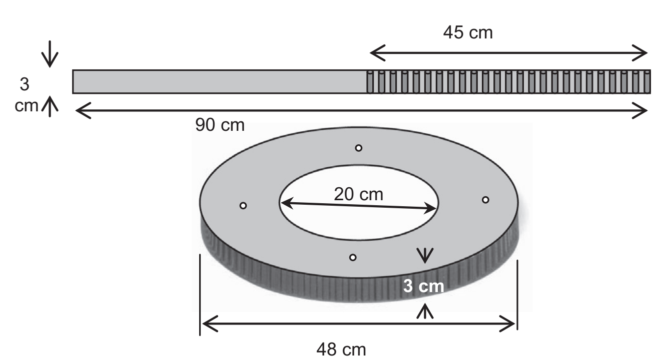

Fig. 4. Timing belt mounted wooden disc having an internal and an external diameter, and the aluminum U-channel pasted with a section of the timing belt on its back.