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Impact of natural charcoal blocks on the solar still output

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Abstract

Solar energy is abundant energy in the earth globe. Solar distillation is one of the techniques that use this energy to obtain portable water from ground or saltwater. The purpose of our experimental study is to show that the blocks of natural carbon, that is to say, the remains of a fire, can serve as an element for improving the performance of a solar still. For this, two similar solar stills were used, one is taken as reference SSR and the other modified still SSM contains carbon block. The results show that there is an improvement rate of 8%.

Keywords: Solar energy, Solar distillation, Pure water, Glass cover, Groundwater

1. Introduction

Energy is a very important element in the development of human beings. Energy costs money and it also brings in money, but having free energy is even better. Renewable energies are almost free energies, especially solar energy, they have become the objective of several countries. Solar energy like fossil energy is not distributed evenly over the globe, so each zone has its solar radiation [1-3].

Solar energy is used in several energy devices [4, 5], it is also used in the distillation of polluted groundwater and affected by fluorine as in the case of a lot of counties and also in the southeast of Algeria [6-8]. The solar still is the main device of solar distillation in its construction is very simple and easy [9]. The goal of research laboratories around the world is to improve the performance of solar stills. one of the easiest ways is to use either external or internal refractors to multiply solar radiation [10-12]. Other research has used complementary devices, they have integrated a solar collector [13], a concentrator [14], a Fresnel mirror [15], or others in order to increase the output of solar stills.

The glass cover of the solar still is a very important element, which is why several studies have focused on this component. Glass cover thickness optimization experiments have been done to find out the best thickness that a solar still should have [16,17]. The focus of other researchers has been the angle of the glass cover relative to the horizontal and any variation in this angle directly affects the performance of the solar still [18]. An investigation has been studied the effect of an air chamber composed of two glass covers. The results obtained show a strong decrease in the output of the still. The same research group studied heat flow through a still covert. The conclusion of his studies shows that any increase in the thickness of the covert glass leads to a decrease in the performance of the still [19,20].

Another very important element in this area is the temperature of the water to be treated. Many researchers have tried to raise this temperature using different materials. Experimental works have used local materials in the water basin such as copper, stainless steel, mica, iron, sand, black zinc metal plate, or others in order to have a better performance compared to a reference distiller without modification [21-25]. The PCM phase change material and the nano-fluid technique have been used as an effective way to increase the temperature of the water. The rate of improvement of different materials depends on their thermal nature and their concentrations in the case of nano-fluids [26-29].

Our work is purely experimental and it consists of using similar solar stills under the same weather conditions in order to show the influence of natural charcoal blocks on the performance of the solar still.

2. Material and methods

An experiment with two similar single slope solar stills (0.5 x 0.5 m) was made at the University of El Oued, southeastern Algeria in the month of May 2021. The water level in both stills is the same 1 cm. The thermocouples are placed on either side of the glass cover, in the water and the last is placed in the open air to measure the ambient temperature. One solar still is used as the SSR reference still and the other is the modified solar still SSM i.e., a distiller which contains coal blocks in its water basin as shown in Figure 1. In this way, we can compare the results obtained with the reference solar still SSR. Measurements of the temperature and the pure water quantity are made every hour throughout the experiment.

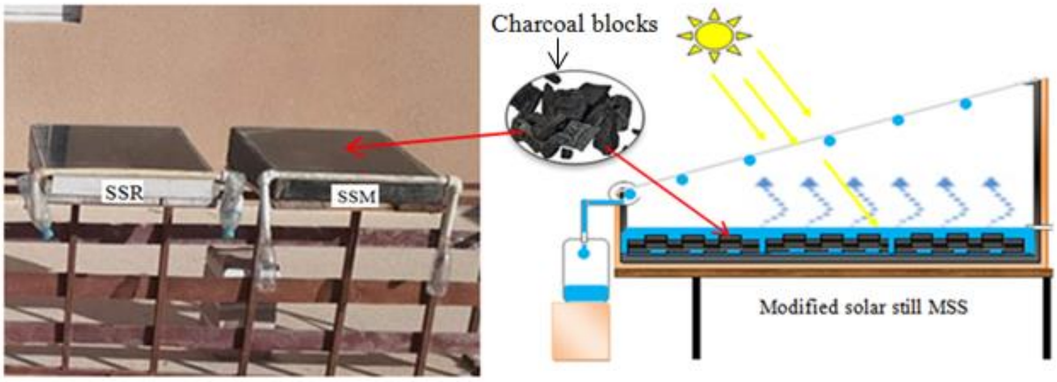

Figure 1. Experiment setup

3. Results and discussion

3.1. Solar radiation and ambient temperature

Solar radiation is one of the most important factors in solar distillation. Figure 2 represents the evolution of this radiation and the ambient temperature with respect to the experiment in real-time. The solar radiation begins to increase between 8:00h and 12:00h to reach its maximum 1009 W/m^2. Then it decreases until the end of the experiment with a value of 535 W/m^2 at 16:00h. The ambient temperature also increases with the radiation until it reaches a maximum of 36 °C at 14:00h and we notice stability between 14:00h and 16:00h.

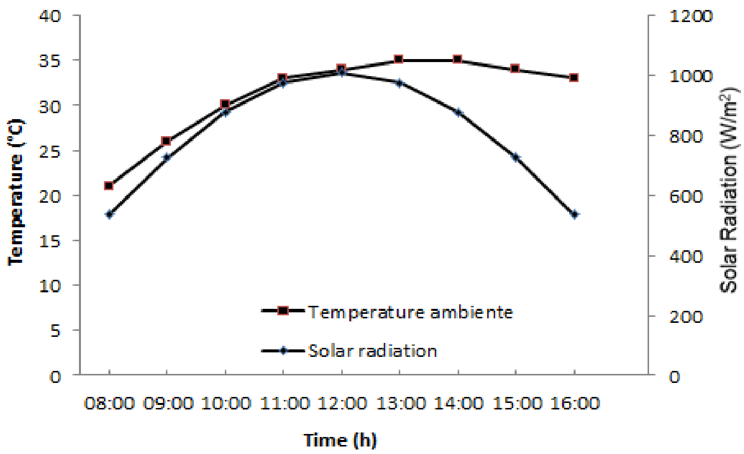

Figure 2. Evolution of solar radiation and ambient temperature

3.2. Internal glass temperature evolution

Figure 3 shows the inside glass cover temperature as a function of time. The evolution of the temperature of the glasses (inner face) along the experiment is almost the same as a slight advance of the SSM distiller. We note that the maximum values at 14:00h of SSR and SSM are 41°C and 42°C respectively.

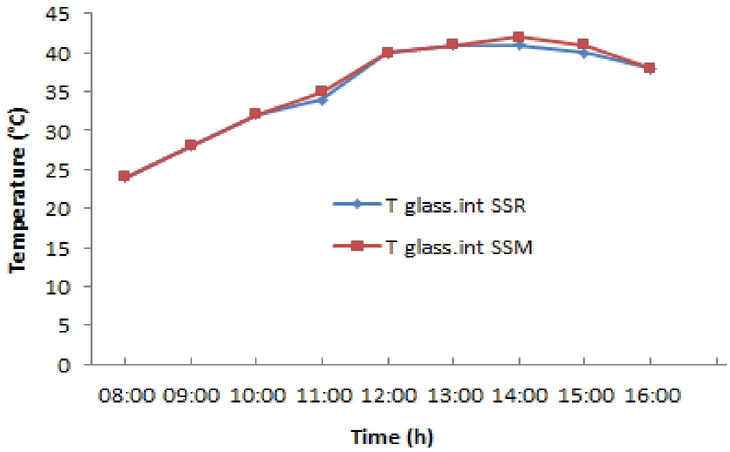

Figure 3. Internal glass temperature evolution

3.3. Water temperature evolution

Figure 4 shows the water temperature variation of the two solar stills via a real-time view of the experiment. It is noted that the water temperature in the SSM is much higher than the water temperature in the SSR. This difference is of course due to the only difference between the two distillers, it is the presence of the coal block. We also note that the maximum values of MSS (54°C) are greater than SSR (49°C) between 13:00h and 14:00h.

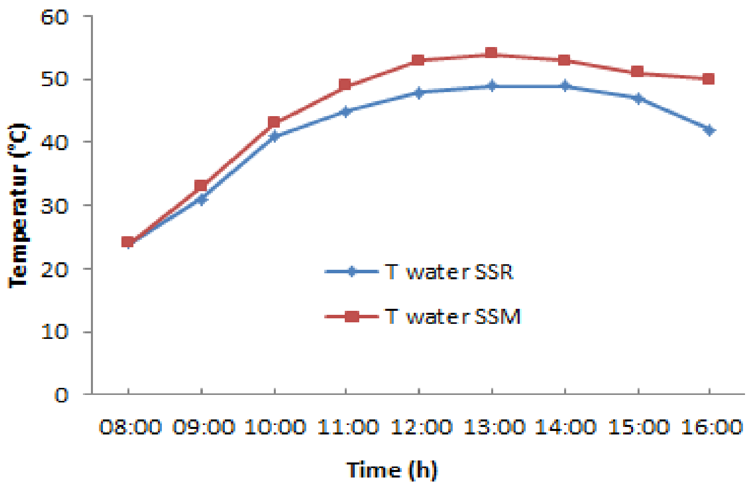

Figure 4. Water temperature evolution

3.4. Temperature gradient

Figure 5 represents the temperature difference between the water to be treated and the glass cover (inner side). This difference is very important in solar distillation because any increase in this temperature gradient causes an increase in output from the still [19, 20]. From the beginning of the experiment, we notice that the temperature gradient of SSM is greater than the temperature gradient of SSR and this gives an idea of the output of the two stills. It also gives an idea of the influence of the presence of the charcoal blocks in the SSM still.

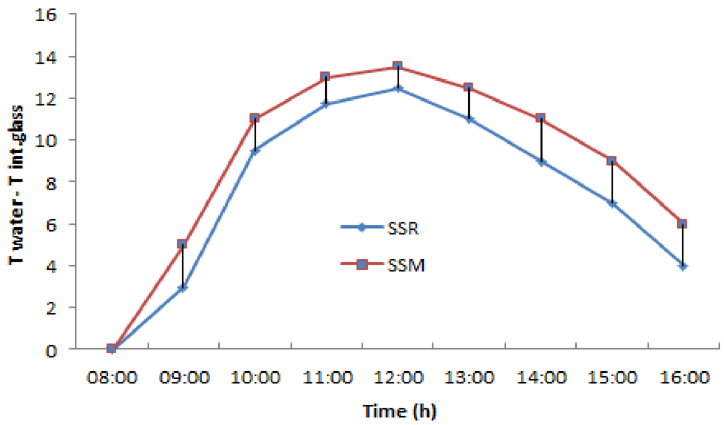

Figure 5. Temperature difference between the water and the glass cover (inner side)

3.5. Accumulation output of pure water

Figure 6 represents the variation of pure water accumulation from the two solar stills. Note that the total amount of pure water collected by the SSM distiller is 3209 ml and the SSR distiller is 2972 ml during 8 hours of the experiment. So, with a difference of 237 milliliters. This difference is because the SSM distiller has coal blocks in its water basin. The hourly output of pure water from the two solar stills is shown in Figure 7. It depicts the variation in productivity over the course of each hour. At 14:00h, the greatest value is 0.18 ml.

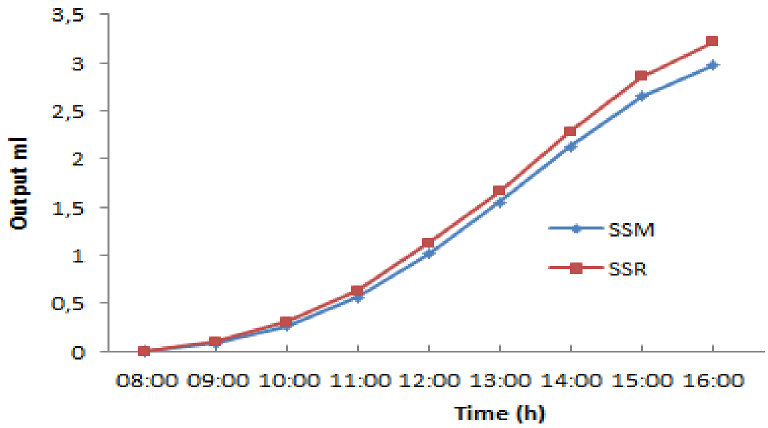

Figure 6. Accumulation output of pure water

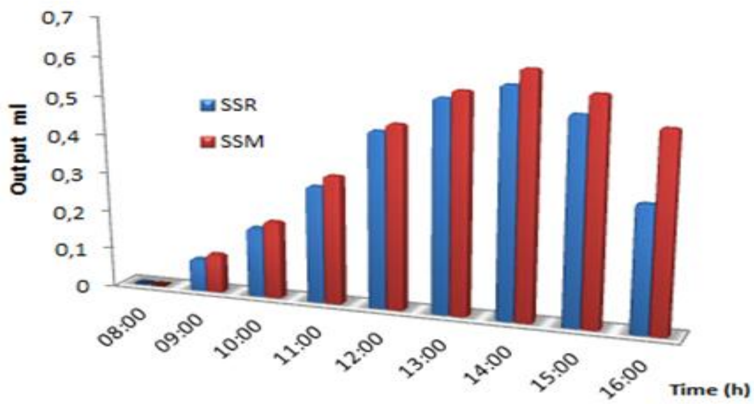

Figure 7. Hourly output of pure water

4. Conclusions

Two conventional solar stills of the same dimensions are tested under the same weather conditions in order to see the influence of the charcoal blocks on the output of the modified solar still SSM. The result shows that the output of the SSR reference still is 2972 ml and the SSM still is 3209 ml. The only difference between the two distillers is the presence of the charcoal block in SSM. An improvement rate of 8 % has been recorded, so we can take the charcoal blocks as an improvement material.

Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

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