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Solar distillation between a simple and double-glazing

La distillation solaire entre un simple et un double vitrage

***Abderrahmane KHECHEKHOUCHE*[a,b,c*]*, Boubaker BENHAOUA*[a,b]*, Zied DRISS*[c]

[a] *Laboratory of valorisation and technology of sahara resources technologies (VTRS), El-Oued University, ALGERIA*

[b] *Renewable Energy development unite in Arid Zones (UDERZA), El-Oued University, ALGERIA*

[c] *Laboratory of Electromechanical Systems (LASEM), ENIS, University of Sfax, TUNISIA*

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ABSTRACT

The south-east region of Algeria suffers from a great socio-economic problem that affects a large population. Faced with the unavailability of drinking water, solar distillation; which appears to be a suitable and inexpensive solution; was adopted by local researchers. Improving the productivity of a solar greenhouse distiller is the subject of several researches in the world. As it is well known, distiller with simple glazing is wildly studied but unfortunately has feeble efficiency. Double glazing is a method that increases the efficiency of a flat solar collector. The idea is to use the same technique on a single-slope solar distiller (50 x 50 cm). Two glass plates separated by 1 cm between them air is trapped. Experience shows that this technique has a negative effect on the productivity of the distiller with a rate of 88.63%; it means 9 times. So double glazing is not recommended in the single slope solar distiller.

RÉSUMÉ

Le sud-est de L'Algérie souffre d'un grand problème socio-économique qui touche une large population. Face à l'indisponibilité de l'eau potable, les chercheurs locaux adoptent la distillation solaire qui apparaît comme une solution convenable et non coûteuse. L'amélioration de la productivité d'un distillateur solaire à effet de serre et l'objet de plusieurs recherches dans le monde. Le double vitrage est une méthode qui augmente le rendement d'un capteur solaire plan. L'idée est d'utiliser la même technique sur un distillateur solaire à simple pente de (50 x 50 cm) et de le couvrir avec deux plaques de verre séparées de 1 cm, c'est-à-dire que l'air est emprisonné entre les deux verres. L'expérience montre que cette technique à un effet négatif sur la productivité du distillateur qui se voit diminuer jusqu'à 9 fois par rapport au distillateur avec un simple vitrage. Donc le double vitrage est déconseillé dans le distillateur solaire à simple pente.

1 Introduction

The lack of drinking water has become a huge global problem. Algeria, like the countries of the Great Maghreb, is not immune to this problem and has adopted two types of distillation (membrane processes and solar distillation processes). Solar distillation is the simplest and most economical of all techniques. Despite its low efficiency compared to other

* *Corresponding author. Tel.: +213 696555300.*
E-mail address: abder03@hotmail.com

technologies in which a membrane distillation or multi-effect distillation were used. The solar distillation has a great advantage due to the use of free solar radiation [1, 2] without another source of energy. As well known any variation in radiation, during the different seasons, influences the productivity of distillation. So there is a great relationship between the productivity and radiation. During the summer season, the productivity of a solar distiller was 1127 mL /day, whereas the same distiller gave only 119 mL /day in the period of the winter [3]. Then this technique is done outdoors; meteorological factors also have an influence on distillation. For instance, the wind has an influence on the glass cover. It forces the convection and causes an increase of the productivity. The output of a solar distiller increases from 2.75 to 3.25 L/m^2 when the wind speed increases from 1 to 3 m/s [4, 5]. Geometric factors affect productivity in a rather remarkable way. The angle inclination and thickness of the glazing influence the procedure of the distillation. The best angles are between 10-20°C, but if the thickness of the glass increases, the resistance to heat flow increases too. This resistance is inversely proportional to productivity [6, 7]. The improvement of this technique is the object of several researchers, especially in developing countries. Use of preheating by a solar collector or a solar concentrator and new forms of distiller have been developed recently [8]. Using CFD Fluent, the simulation was made for a transient state to validate the results experience for known climatic conditions [9]. Finally, in the developed laboratories, the use of nano fluid as a potential heat transfer fluid with superior thermo physical properties is an effective method for improving the thermal performance of the solar distiller [10-13].

This work is based on the fact that a double glazing in a flat solar collector increases the yield. The question that may be asked: does this parameter have the same effect on a single pitch slope solar distiller? This article aims to give an answer to this question.

2 Method and Experience

2.1 Treatment data

The experiments were done at the Renewable Energy Laboratory of El Oued University. Two distillers are used in the experiment, one of them was used as a reference distiller and the other constituted the object of our study. The latter was designed with two glasses superposed with a gap of 1 cm and isolated from the quads side by polyester rods. The two distillers have worked side-by-side in the same meteorological conditions and they have the same geometric parameters except at the glazing, as shown in Figure (1a, 1b).

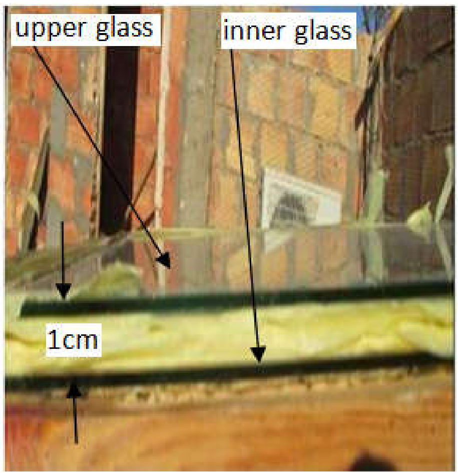

Fig. 1a- Distiller with Double glazing

Fig. 1b- Solar distillers in action

2.2 Description of the solar distiller

Figure 2 shows the solar distiller. The system is constituted of:

1. a wooden box of size 50 x 50 cm. The thickness of the wood is 2.5 cm;
2. The cover is made of commercial glass having 0.4 cm thick (playing the role of the condenser);
3. The collector of distilled water (in which the glass is emerged) having 3 cm in diameter and 0.55 cm in length;
4. Tank for distilled water.

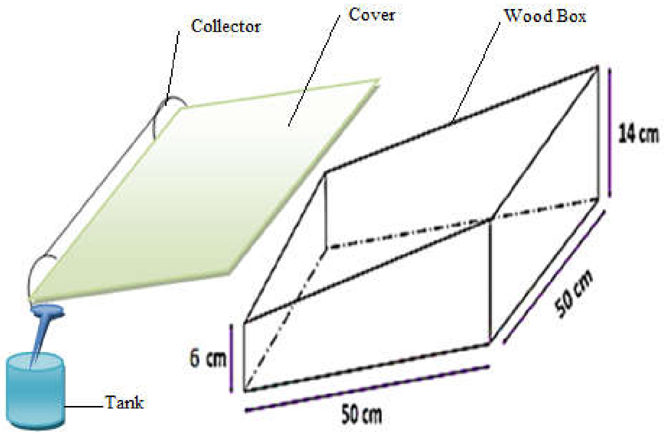

Fig. 2 – A single-slope solar distiller description

2.3 Location of thermocouples

Figure 3 shows the thermocouples location. Temperature samples are taken each hour by type K1 thermocouples. Apart the thermocouple 2, the other ones are used to control the temperature at different places as shown in figure 3. The latter are linked to controller (Arduino card) whereas the thermocouple 2 is used to control the hot water vapor so in this soft work we neglect the temperature measurements of this thermocouple.

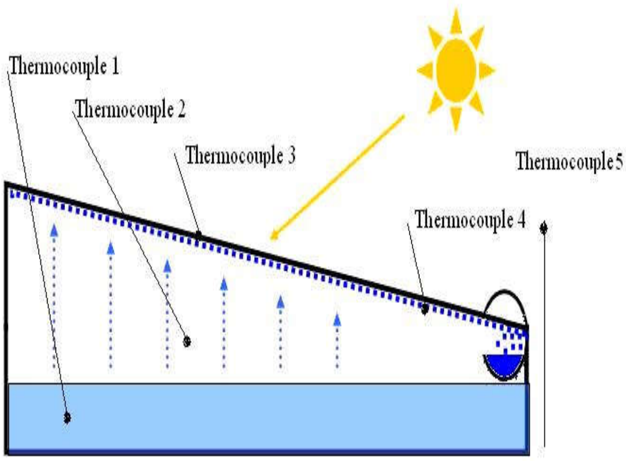

Fig. 3 – Thermocouple location [3]

The experience was proceeding on May 5th, 2017. Table 1 shows the meteorological conditions of the experiments.

Table 1 – Experience conditions

Meteorological conditions on May 2017	
Sunrise	**05:41 am**
Sunset	**07:19 pm**
Ambient temperature	**26-35°C**
Atmospheric pressure	**1013 mb**

2.4 Principle of operation

The operating principle is based on the greenhouse effect:

- The sun's rays enter the distiller via the glass cover;
- The water begins to warm up and evaporate;
- The hot water vapor comes back to the glass;
- The hot water vapor condenses (formation of droplets on the inner side of the glass);
- The droplets slip into the collector and finally driven in the tank.

3 Result and discussion

The experiment was made in the region of El Oued south-east of Algeria in May 2017 dealing with two distillers. The latter are exposed to the sun. The distiller D2 is the object of our study and it has double glazing and the distiller D1 is the reference (the witness). The temperature samples are taken every hour. Feature of their curves are represented in the figures 4 and 5 which interpreted the found results.

Figure 4 shows the evolution of solar radiation (in Wh/m^2) during the day. An electronic radiation meter, by which every hour the solar radiation is taken, is placed next to the solar distiller. The curve has a normal shape as it was found in literature and having its maximum radiation between 11:00 and 14:00 which is the most important factor in solar distillation.

Figure 5 illustrates the variation of the ambient temperature in °C as a function of time. The temperature starts to vary between 23°C at launch and reaches a maximum of about 32°C between 12:00 and 18:00. The day was hot.

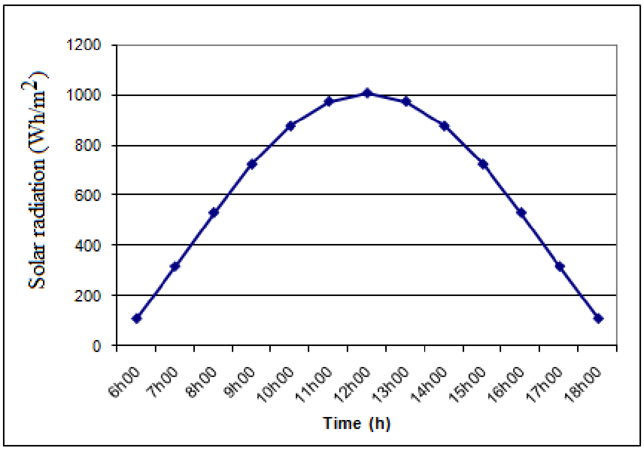

Fig. 4 – Evolution of solar radiation

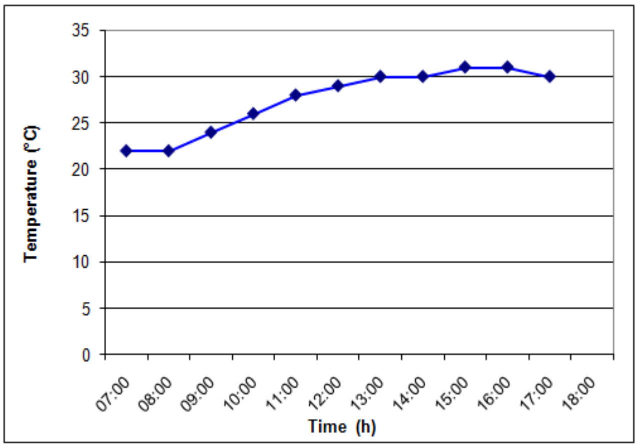

Fig. 5 – Evolution of ambient temperature

The heat transfer in the distiller D1 is done through a single wall (glass) so the glass cover receives heat by convection than by conduction then it releases heat to the outside by convection. Whereas in the case of D2 the heat transfer is done through inner glazing, as in D1, and stopped by a thin film of air between the two glazing which plays a role of the insulator to the heat.

Figure 6 shows the temperature evolution at inner face glass D2 and its change in the basin water. It is worth noting that there is almost no difference in the average temperature between the inner face glass D2 and the one of the water (ΔT= 0.5°C). The temperature of the water sometimes is higher than the glass one during the whole day. As it was known condensation needs a considerable difference of temperature to produce distilled water (*i.e* gradient of temperature). This feeble difference in temperature will be followed by feeble productivity during the day and leads to a weak efficiency of D2 distiller.

Figure 7 shows the temperature evolution at inner face glass D1 and its change in the basin water. It should be noted that there is considerable difference in the average temperature (ΔT= 4.2°C) between the inner face glass D1 and the one of the water. As can be seen the temperature of the water is higher than the glass one during the whole day and leads to a considerable gradient of temperature. This temperature gradient will be followed by great productivity during the day and leads to a strong efficiency of D1 distiller. So the productivity of the distilled water is directly related to the temperature gradient. Whenever this gradient is large, the productivity is interesting as it was meted in the case of the D1 distiller. Whereas, in the case of D2, this gradient is very low and the productivity of the D2 distiller of water is low also.

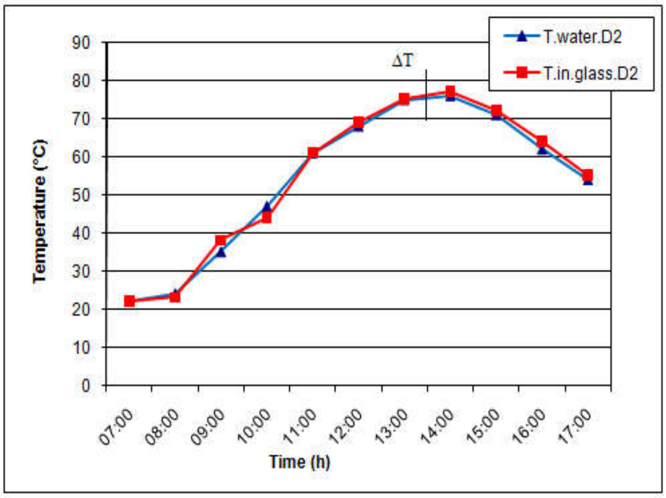

Fig. 6 – The glass inner face and the basin water temperatures evolution of the distiller D1

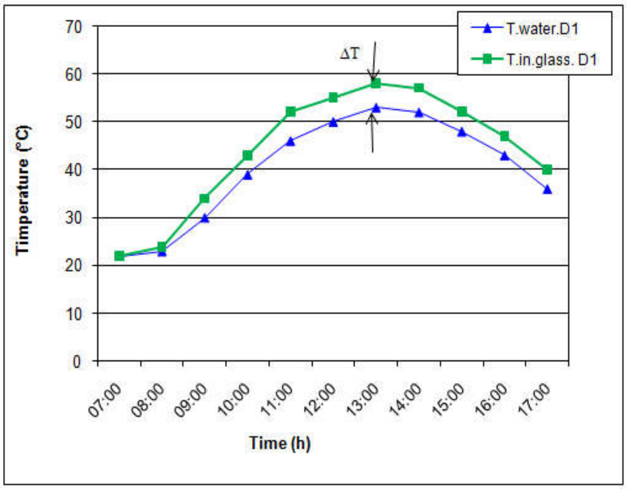

Fig. 7 – The glass inner face and the basin water temperatures evolution of the distiller D2

Figure 8 shows the productivity evolution of distilled water (in mL/hour) during the whole day. It is noted that the productivity of the distiller with the double glazing D2 is infinitely neglected compared to the productivity of the control distiller D1. The maximum value of D2 did not exceed 20 mL while the maximum value of D1 exceeded 100 mL. The average value of D1 productivity exceeded 60 mL/hour whereas for the distiller D2 did not exceed 07 mL/hour. The quantities of distilled water are related to the temperature gradient between the water basin and the inner face of the glass. Any increase in this temperature gradient will be followed by an increase in productivity of the distilled water. The maximum productivity was reached between 12:00 and 14:00 h PM for D1 whereas this maximum was reached early for D2 and the quantities are 108.6 and 19 mL for D1 and D2, respectively.

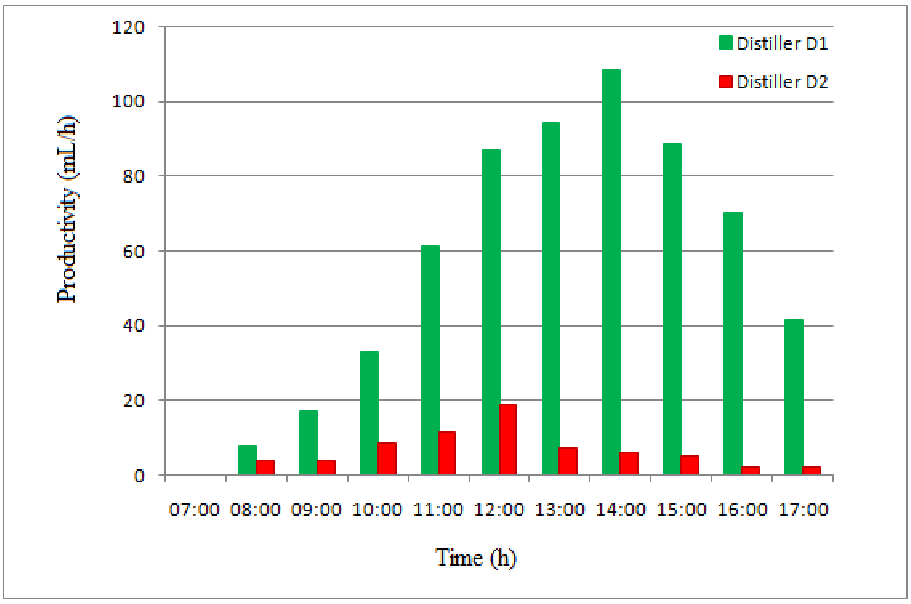

Fig. 8 – Productivity of distilled water

4 Conclusion

The gradient of temperature between the basin water and the inner side of the glass has a primordial role in the productivity of distilled water. If it is close to zero, the production of distilled water becomes weak. It is the case of the distiller with double glazing D2 in which the productivity was about 69.3 mL/day. When the gradient of temperature is greater, as in the case of D1, the productivity was about 609.6 mL/day. So the double glazing with 1 cm apart, blocks the distillation at an order of 9 times lower than the one of single glazing. So double glazing is not recommended in a single-slope solar distiller.

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