Experimental study of two basin type solar stills with energy storage

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***Abstract*— Many solutions are developed to cure and solve the lack of potable water problem such as : sea and brackish water desalination , which can be granted easily through the solar still as far as, it needs less high technologies, besides it is of low cost and while the energy is free. Solar distillation is one of the simplest processes of separation, in this study we are interested in the realization and the experimentation of the coupling of a still solar with a solar collector that primly will warm up the water constantly influencing the productive rate and the competent one. Naturally, some of the key characteristics of this distillation instrument are that the equipment is simple, easy to operate, needs no maintenance and produces high quality distilled water. The series of tests were carried out in summer 2014 in order to identify its various parameters. The daily output of the solar distiller is of 6 liters/day with pre-heating for an absorber surface of 1m^2.**

Keywords—Solar still, solar sensor, performance, efficacy, distillation.

I. Introduction

Lack of drinking water and its scarcity, caused both by drought and overexploitation of groundwater, becomes a big problem that threatens the lives of people in several regions. Search and produce potable water from other natural resources is of paramount importance. However, in the vicinity of several regions, missing drinking water sources exist brackish water containing a certain percentage of salt, except seawater. Address this critical problem, desalination of salt water and / or brackish water appears as one of the possible survival of humanity solutions. Among, and relatively low water needs the techniques used in this field, solar distillation can be a very interesting solution especially for arid and desert areas.

Solar distillation is a technology of a great story. The modern use of solar energy for distillation of salt or brackish water began in 1872, in northern Chile by installing a solar distiller types basin, which helped meet the needs of the community, for many years as disclosed by references [1 and 2].

Since 1954, the experiences have multiplied in particular under the auspices of the Office of Saline Water (OSW) Department within the United States and led to the construction of large installations cover glass and plastic DAYTONA BEACH, in Florida. These installations have been used for several years and the results have been published [3].

The objective of this work is the experimental study of the effect of several parameters (distillation time, global radiation and temperature difference *water- inside glass*) on production of distilled water for the solar still with square shape was chosen.

II. Description of the System

Our solar still greenhouse with energy storage which consists of two separate units: the sensors solar thermal planes representing the heat source and a distillation unit. The distillation unit is a tray of 1.20 m^2, filled with water to be treated, with a stagnant black surface coating asphalt to promote absorption of the solar rays. The tray is topped with an optimized height side walls and covered by a glass plate treated, inclined by 13 ° relative to the horizontal so as to optimize the transmission of solar radiation and facilitate the draining of water condensation. The volume of water to be desalinated is adjusted to occupy a thickness optimized (see Fig. 1). The mass of water to be treated is heated by the greenhouse effect in conjunction with a heat exchanger connected to a solar plan to accelerate the heating step during morning. Under the action of heat, the water evaporates. The evaporation capacity grows gradually as the temperature increases until the air reaches its saturation water vapor. The water vapor thus obtained is condensed under the glazing. Then the condensed water flow toward the lower part of the glazing in a channel leading to a storage tank for recovery of distillate, (The distiller consists of a covered with a black absorbing layer and a transparent pool cover glass) as well as sensors.

Moreover, the solar heat of the day is collected, transferred and stored in the mass of reinforced concrete plinth of the distiller. This heat gain is used to maintain the distiller production continues even after sunset and during the night [4].

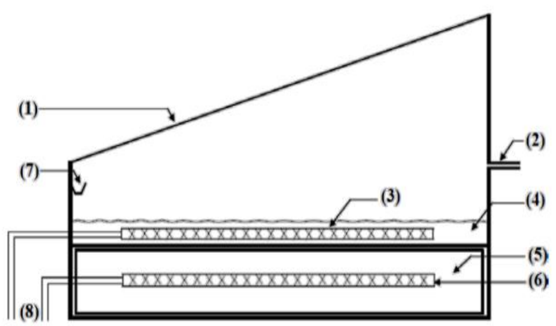

Fig. 1 Synoptic diagram of the solar still under controlled pressure and energy storage. (1) Glazing, (2) Control system pressure, (3) Heating system of distilled water, (4) raw water, (5) Concrete plinth, (6) heating system of concrete plinth, (7) collecting channel of distilled water, (8) Output heating to solar sensor.

III. RESULTS AND DISCUSSION

In this section, we will present the results of this experimental study for both stills (square and rectangular). The results are mainly concern the variation in production of distilled water as a function of distillation time, ambient temperature, global radiation, water temperature, temperature difference water- inside glass.

The calculations are made to the Unit Development Solar Equipment of Bou-smail whose the geographic coordinates are:

- Latitude of 36°38’33’’North ;
- Longitude of 2° 41’ 24’’East ;
- Altitude of 33 meters.

July 08th was chosen as the calculation date and the initial volume of distilled water (well water) was set at 25 litters.

Identify applicable funding agency here. If none, delete this text box.

The experimental results obtained in our study for the region of Bous-mail to normal weather conditions on July 8 show that the hourly production in both stills (square and rectangular) with a preheating system is almost zero for the first hours of the day (between 7am and 9am) during which the system must therefore ambient temperature reach its operating temperature. [5]. From this moment he appears a difference of production increases with the growth of solar radiation reaching a maximum at 13 hours when the hourly production of distiller square is 0.400 l/m².h,whereas the rectangular distiller reaches 0.380 l/m².h. Thereafter this difference decreases with the solar time (Fig. 2 and 3).

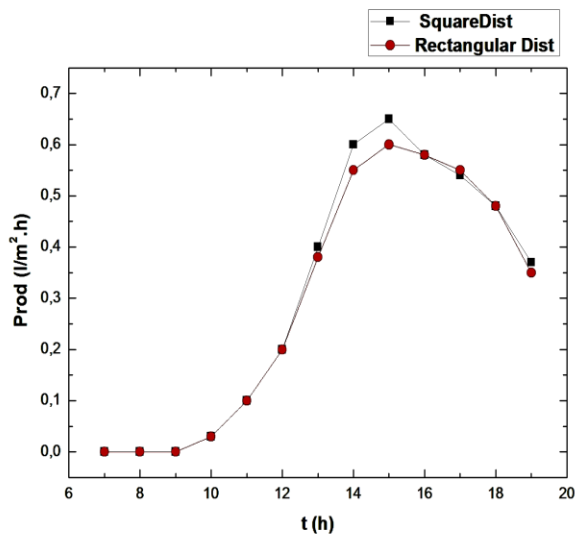

Fig. 2.Hourly production variation as a function of time.

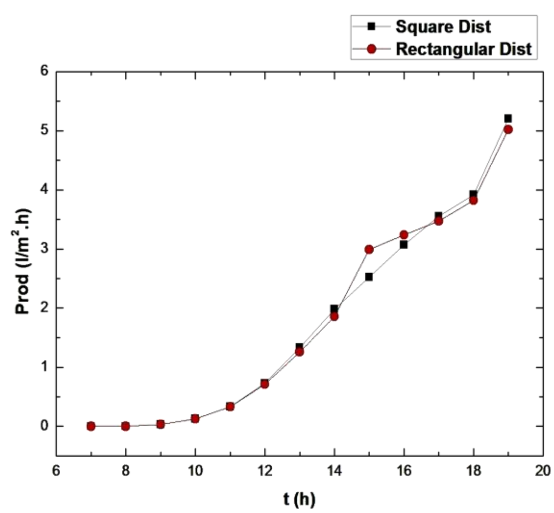

Fig. 3.Cumulative production variation as a function of time.

Fig. 4 summarizes the variation of the total production, daytime production and overnight production for the both distillers.

Square distiller:
Total production: 6.350 l;
Day time production: 5.200 l/day;
Overnight production: 1.150 l/night.
Rectangular distiller:
Total production: 6.100 l
Day time production: 5.020 l/day;
Overnight production: 0.930 l/night.

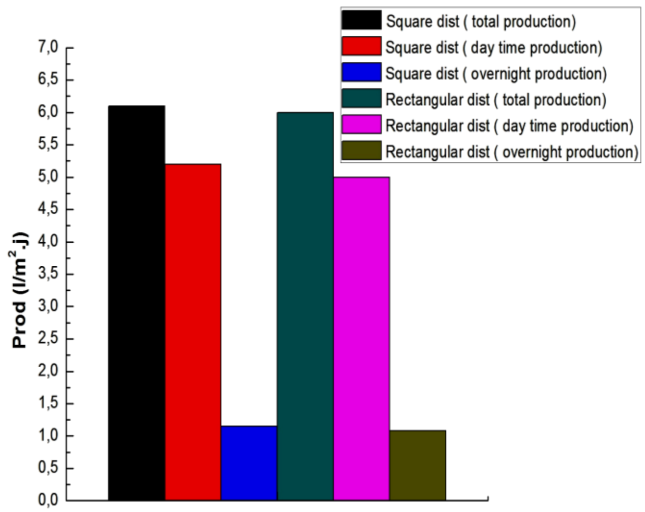

Fig. 4.Total production, daytime production and overnight production variation.

The results show that the effect of the geometry increases the rate of production of 5% in the case of the square distiller for the same evaporation and condensation surface.

The same applies for the day time production of the both distillers is very important that the night production.

Solar radiation is the most parameter affecting the system operation. It would be interesting to study its effect on these characteristics. Figures 5 and 6 shows the temporal production evolution in distilled water and the global solar radiation (G) received by square meter of horizontal flat surface. It may be noted that the power peaked between 1200 and 1300.

Distilled water production increases with global radiation. Note that the production increases when the radiation increases.

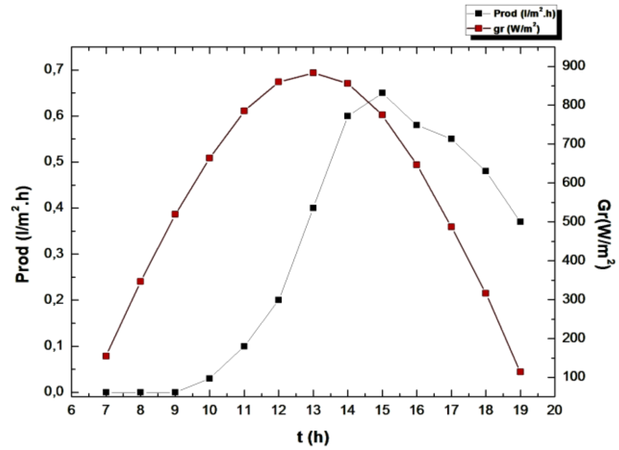

Fig. 5 Day time production variation as a function of the global radiation for the square distiller.

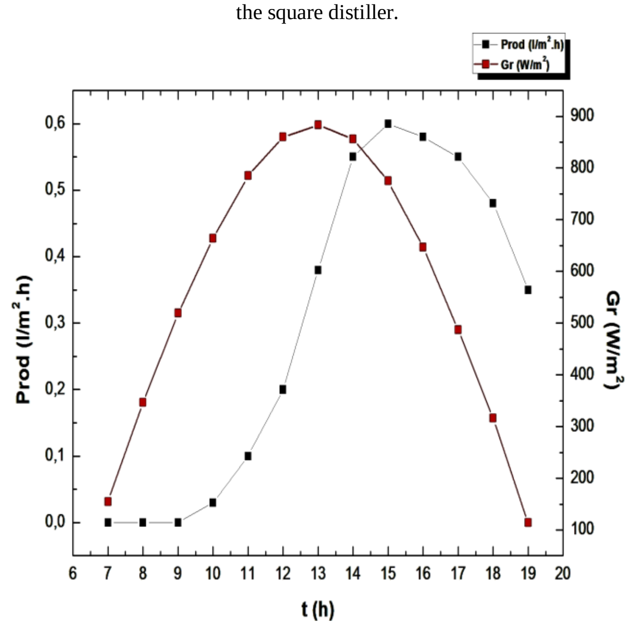

Fig. 6. Day time production variation as a function of the global radiation for the rectangular distiller.

The warming of the water to be distilled is even higher than the solar radiation received is more important, the resulting high temperatures leading to an improvement in the process of evaporation and consequently in a better production. The experimental work of O. O.Badran, Haal-Tahaineh [4] also reached the similar conclusions.

It should be noted however, that the coupling of a plan distiller with a sensor involves an additional surface to capture sunlight but only if the value of the solar irradiation is sufficient to achieve the warm saline water.

It can be seen through Figures 7 and 8, as the production increases as the temperature difference between the water layer and the inside glass surface increases.

Similar experimental results found by Voropoulos,Mathioulakis and Belessiotis [7], who found an increase in production with an increase Twater-Tinsude glass.

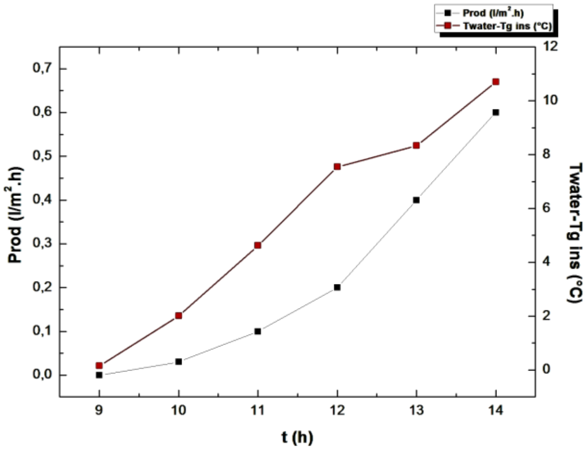

Fig. 7 Hourly production variation as a function of the temperature difference water- inside glass for the square distiller.

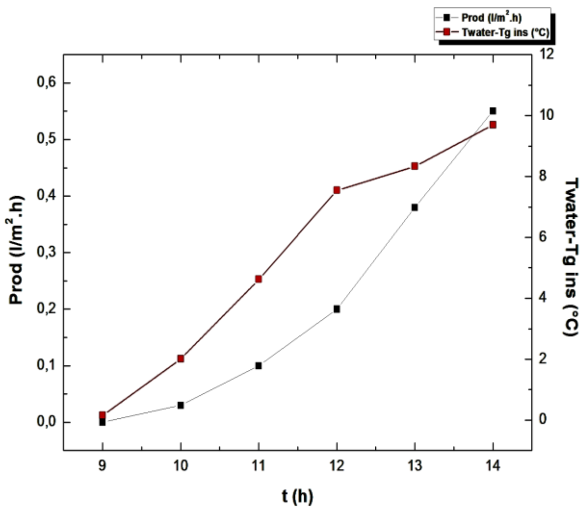

Fig. 8. Hourly production variation as a function of the temperature difference *water- inside glass* for the rectangular distiller.

R.Tripathi, GNTiwari explains that the preheating of the water in the sensor increases the difference between the water temperature and the inside glass temperature in the distiller, which has a direct effect on the increase of evaporation. This results in an improvement of the total distillate production. [8].

IV. Conclusion

This work concerns the experimental study of two solar stills planes (square and rectangular) with energy storage (preheating provided by a solar sensor).

The results highlight the influence of external and internal parameters on the characteristics of the solar still including production.

The solar radiation that remains the most influential parameter on these characteristics, and that the latter is at the same pace that the time variation of the solar radiation and the increase of the ambient temperature lead to an increased production.

Through the obtained results, it was found that there also must maintain a large temperature difference between the evaporation surface and the condensation surface.

Furthermore, the use of a preheating system which causes pre-heating of the desalted water (increase of the temperature difference between the evaporation and condensation surface), which improves production.

V. References

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