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Immersed fins influence on the double slope solar still production in south Algeria climatic condition

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ABSTRACT

This work presents a theoretical and experimental study of a double slope still with fins immersed in a basin. The influence of the speed of wind, distance between fins, height of fins, number of fins and thickness of the water layer in the basin, on the production of the still, is investigated. From the results obtained, it is noted that for a wind speed greater than 3.5 m/s, a decrease in the productivity is caused by the cooling of the outer walls, and this induces some heat losses, especially at the front and rear walls of the still. The distance between fins has no significant effect on the still productivity. Moreover, increasing the height of fins, from 2 to 5 cm, causes a raise in the productivity; however, when the height changes from 6 to 8 cm, the distillate production goes down. A larger number of fins lead to a rise in the amount of distilled water produced. Therefore, one should use the maximum number of fins, while taking into consideration the feasibility of the assembly. Increasing the mass of water in the basin makes the productivity to go down. The results obtained on June 11, 2016, show that the productivity of the proposed system was about 15 to 27 % higher than that of a simple one, under the following conditions, i.e. m_w = 42.61 kg, h_1 = 3.6 cm, V_v = 3.5 m/s, l_w = 5 cm and N_{fins} = 12.

Keywords: Solar Still, Distilled Water, Shadow, Immersed Fins, Radiative Flux.

1. INTRODUCTION

Fresh water represents only 3% of the total amount of water available on earth. Only 1 % of that quantity is in a usable form, as the rest is in the form of glaciers or is buried deep underground. Arid regions are characterized by droughts; they are poor in superficial water, which is generally saline. This is the case of some regions in southern Algeria, namely Bouda, Abadla, etc.

Using the solar desalination process could offer economic and environmental benefits for the drinking water supply system in these regions. Several research works have investigated, experimentally and theoretically, the parameters influencing the productivity of different configurations of a solar still.

D. Bechki 2010 [1],Studied the effect of shadow of an intermittent partial coverage on the efficiency of a single basin double slope solar still. The daily production in the first series was found equal to 6.01 (l/m2/day). This quantity was improved by 33.7% in the second series. The third one consisted of reducing the temperature of the transparent cover by means of shadows of the intermittent glass cover on the north side. This procedure allowed an additional 12% improvement in the daily production of distillate. A.E. Kabeel 2012 [2] Conducted an experimental and theoretical study on two types of solar stills, namely a conventional inclined solar still and a cascade solar still, which were tested simultaneously. They also examined the influence of the depth and width of the tank on the performance of the solar still. The cascade solar still was supplied with hot water coming from an evacuated tube solar collector. To increase the heat exchange surface, they used a wick on the vertical sides of the cascade distiller. In this case, the daily efficiencies, for one liter of distillate, for the cascade and conventional solar distillers were found to be approximately 53 and 33.5%, respectively. H. Al-Hinai September 2002 [3] Developed a mathematical model to predict the productivity of a simple solar still, under different climatic conditions in Oman. They found that the optimum design is obtained for a glazing with an inclination angle of 23°, and an insulation thickness equal to 0.1 m. With such a design, the distiller can produce 4.15 kg/m2 of water per day. Next, they improved their model based on a technical and economic study; they found that the unit cost for distilled water obtained from the solar still was $ 74/1000 gal. C. E. Okeke 1990 [4] Studied the effects of coal and charcoal on the performance of a solar still designed and manufactured with local and sustainable materials that are available on the market. Both kinds of coal can improve the performance of the distiller, as well as its daily productivity and efficiency, with an average of 1.12 l/m2 and 16.5%, respectively. P. I. Cooper 1969[5]Presented a theoretical study to predict the influence of characteristic parameters, such as water depth, wind speed, insulation of the distiller, double-glass cover, inclination of the glazing and climate conditions, on the productivity of the distiller. The simulation results indicate that the depth of water in the basin has little effect on productivity, and insulation improves the efficiency. Moreover, increasing the wind speed and decreasing the ambient temperature lead to a slight increase in productivity. It was also found that the double glazing significantly reduces the production of distillate. From an economic viewpoint, the use of the two glass covers and the increase in the inclination angle of glazing are not necessary. Besides, when the temperature of water in the basin of the distiller rises and that of glazing declines, the productivity of the solar still increases. P. Cooper 1969 [6]Developed a method for calculating the effective fraction of solar radiation incident on the still surface. The variables that influence the operation of the distiller are the day of the year, latitude, inclination angle of glazing, orientation of the distiller, fraction of the scattered radiation and solar radiation on the system. He discovered that the intermittent sunshine has a negligible effect on performance, and also the increase in the percent of daily diffuse radiation decreases absorption. Hassan E.S. Fath 2002 [7] Conducted a theoretical study on a single basin double slope solar still. The first cover glass, transparent and oriented towards the south, acts as an evaporator; the second one is tinted and oriented towards the north, and acts as a condenser. They added a black dye into the basin of the distiller in order to improve the absorption of the plate and to increase the evaporation surface. Then, they studied the influence of climate and geometric parameters on the productivity of the distiller. They also carried out frequent instantaneous cooling of the transparent cover, for example every hour. The efficiency was improved by 55% compared to that of a single basin still. K.Voropoulos 2004[8] Studied a hybrid solar desalination system consisting of a conventional solar still coupled to a field of solar collectors and a storage tank for hot water. Distilled water production of a coupled system is much higher than that of a non-coupled distiller. In addition, this system has the advantage of providing hot water from its storage tank. The experimental results obtained in the laboratory were found to be consistent with theory, with an accuracy of about ± 3%. The experimental results show that a draft of hot water with a volume equal to 1/4, 1/2 or 1 volume of the storage tank reduces the production of distilled water by 36, 57 or 75 %, respectively, with a simultaneous energy output of about 1900, 3300 and 5200 MJ. Eduardo Rubio 2004 [9]Conducted a theoretical study on the parameters that may have an impact on the production of distilled water in a double slope solar still. The maximum production of distilled water through the two transparent covers, oriented east and west, is 0.19 and 0.18 [kg/m²/h], respectively. Imad Al-Hayek a 2004[10] Studied two types of solar stills, one is simple with a vertical mirror, and the other is a double slope solar still. They found that the productivity of the distiller with a vertical mirror is 20 % greater than that of the double slope still. The temperature of water surface is closely related to the incident solar radiation. Decreasing the thickness of the water layer and adding the dye increase the amount of distilled water produced. Z. O. A.E. Kabeel 2014 [11]Proposed to add an external condenser to the distiller and to use Nano fluids in order to increase the productivity of distilled water by 53.2 and 116%, respectively. M. Mustapha Belhadj 2015[12] Suggested attaching a condensation cell to a double slope distiller in order to improve the productivity of the system by about 60 %, which is higher than that of a conventional distiller or a solar distiller with capillary film. M..Morad 2015[13] Proposed the periodic cooling of the glazing cover of the distiller. Benhammou M 2014[14] Studied the shadow effect of the reflector on the productivity of the distiller. Rahul Dev 2009[15], Tanaka et Nakatake 2005 [16],A.A El-Sebaii 2015, [17] Investigated the effect of height, thickness and number of fins on the production of an ordinary distiller; this caused the production of distilled water to increase by 13.7 %, compared to a simple distiller.

Purpose of the paper is studied theoretically and experimentally a double slope still with fins immersed in a basin. The wind speed, distance between fins, height of fins, number of fins and thickness of the water layer in the basin, influences on the solar still production, is investigated.

Our result describes for first time the geometrical and meteorological condition influence on the solar still production. Knowing that in ADRAR city, during the summer period the the solar radiation intensity reaches its maximum values, it can exceed 1200 W/m², as for as the day duration exceed 14 hours. Those conditions automatically favored the solar distiller production. For this reason, we propose the following experiment.

2. THEORETICAL STUDY THERMAL BALANCE

The mathematical model that describes the operation of a solar distiller is based on the thermal balances in each element of the distiller.

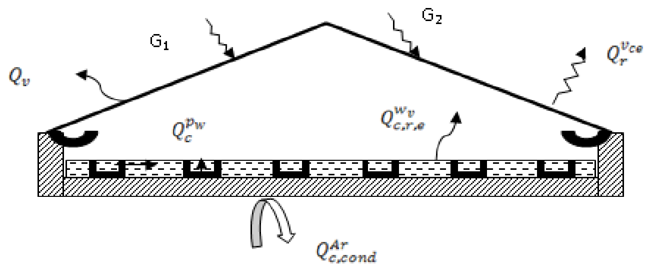

Figure 1. Distillation heat balance

The heat balance on the transparent cover of the distiller is given by the following equation:

$$m_g Cp_g \frac{dT_g}{dt} = (1-\tau_g)(G_1+G_2) + (h_c^{w\text{-}g} + h_e^{w} + h_r^{w\text{-}g})(T_w - T_g) - h_r^{g-ce}(T_g - T_{ce}) - h_v(T_g - T_a)$$

The thermal balance in water is expressed as follows:

$$m_w Cp_w \frac{dT_w}{dt} = \tau_v \alpha_w \left((G_1+G_2)\frac{A_{eff}}{A_p} + G_3\frac{A_{fin}}{A_p}\right) + h_c^{p_w}(T_w - T_g) - (h_c^{w_g} + h_e^{w} + h_r^{w_g})(T_w - T_g)$$

On the absorption plate, the balance is given by the following equation:

$$m_p Cp_p \frac{dT_p}{dt} = \tau_v(1-\alpha_w)\alpha_p \left((G_1+G_2)\frac{A_{eff}}{A_p} + G_3\frac{A_{fin}}{A_p}\right) - h_c^{p\text{-}w}(T_w - T_g) - \frac{\lambda_p}{e_p}(T_p - T_{ins})$$

With $A_{fin} = 2.N_{fins}.H.l$ and $A_p = l_w.l$

Calculation of the effective area depends on the determination of the shaded area of a rectangular vertical wall (Figure 2).

$$S_{\text{Shaded}} = l * l_{w0}$$
$$S_{\text{Shaded}} = l * \frac{H\ \cos(\gamma_p - \gamma_s)}{\tan h}$$
$$S_{\text{Shaded}} = \frac{S_f\ \cos(\gamma_p - \gamma_s)}{\tan h}$$

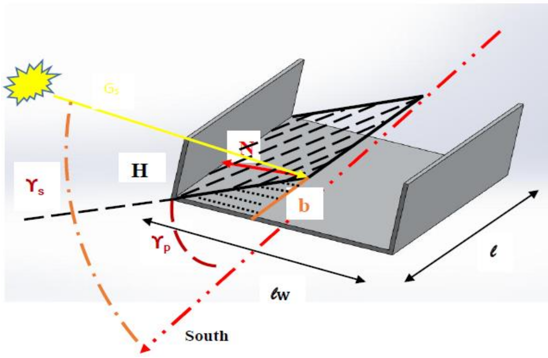

Figure 2. Representative scheme of the shaded area.

a) Calculation of the unshaded area

It is the absorption plate surface that is actually reached by the incident solar radiation (effective surface).

$$S_{\text{Not\_shaded}} = \frac{1}{2}\frac{H\ \sin(\gamma_p - \gamma_s)}{\tan h} * \frac{H\ \cos(\gamma_p - \gamma_s)}{\tan h}$$
$$S_{\text{Not shaded}} = \frac{1}{2}\frac{H^2}{\tan^2 h}\sin(\gamma_p - \gamma_s)\cos(\gamma_p - \gamma_s)$$
$$S_{\text{Not\_shaded}} = \frac{1}{4}\frac{H^2\ \sin 2(\gamma_p - \gamma_s)}{\tan^2 h}$$
$$A_{eff} = A_p - S_{\text{shaded}} + S_{\text{Not shaded}}$$
$$\frac{A_{eff}}{A_p} = 1 - \frac{S_{\text{Shaded}} - S_{\text{Not\_shaded}}}{A_p}$$

The thermal balance at the insulation level:

$$m_{ins}Cp_{ins}\frac{dT_{ins}}{dt} = \frac{\lambda_p}{e_p}(T_p - T_{ins}) - \left(\frac{1}{\left(\frac{1}{h_v}\right) + \left(\frac{e_{ins}}{k_{ins}}\right)}\right)(T_{ins} - T_a)$$

Calculation of heat transfer coefficients:

The heat exchange coefficient through convection between the transparent cover and the surrounding atmosphere is given by the Hottel and Woertz relation[14].

$$h_v = 5.7 + 3.8\,Vw$$

The radiative heat transfer coefficient between the glass cover and sky is given as follows:

$$h_r^{g\_ce} = \varepsilon\sigma(T_g^2 + T_{ce}^2)(T_g + T_{ce})$$
$$T_{ce} = T_a - 12$$

The coefficient of convective exchange between the absorption plate and water

$$h_c^{p\_w} = \left(h_c^{p1\_w}A_p + h_c^{p2\_w}A_{fin}\,\eta_{fin}\right)$$

The coefficient of convective exchange of the plate with brine

$$h_c^{p1\_w} = h_c^{p2\_w} = \frac{\lambda}{l}Nu$$
$$Nu = C.Ra^n$$

Table 1. Constants c and n

Geometry	Ra	C	N
Vertical	10^4-10^9	0.59	1/4
	10^9-10^{13}	0.13	1/3
Horizontal	10^5-10^7	0.54	1/4
	2.10^7- 3.10^{10}	0.14	1/3

The fin efficiency is calculated as follows:

$$\eta_{fin} = \frac{\tanh\left(\frac{2.h_c^{p2\_w}.H}{\lambda_{fin}.e_{fin}}\right)}{\left(\frac{2.h_c^{p2\_w}.H}{\lambda_{fin}.e_{fin}}\right)}$$

3. RESULTS

a) Theoretical results

This study was carried out under the climatic conditions of the town of Adrar, which is located at an altitude of 264 m, with a latitude of 27.53 ° east and a longitude of 0.17° west. Our objective is to determine the influence of the fins immersed in the basin on the operating performance of the distiller. The system of differential equations is solved using ODE45 under MATLAB.

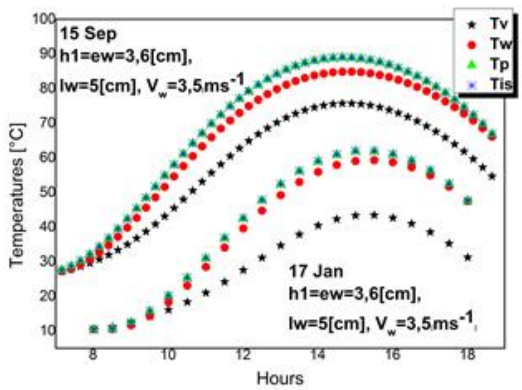

Figure 3. Temperatures of various components in the solar distiller.

Figure 3 shows the temperatures, calculated from the theoretical model, of different components of the solar distiller, namely T_g, T_{water}, T_p and T_{ins}, which are the glass, water, plate and insulation temperatures, respectively, for the days of September 15 and January 17. It is clearly observed that these temperatures are less intense during the winter season; this is due to the solar flux which is not as strong as it is in summer or spring.

Figure 4 illustrates the daily hourly production of distilled water for the days of September 15, June 11, January 17 and March 16. It is noted that despite the high intensity of the radiative flux and high temperatures during the summer season, the production in the month June is slightly higher than that in September. Also, the distiller has a lower production during the months of January and March. High temperatures during the summer period lead to a rise in the glass-brine temperature gradient, which causes an increase in the quantity of distilled water produced.

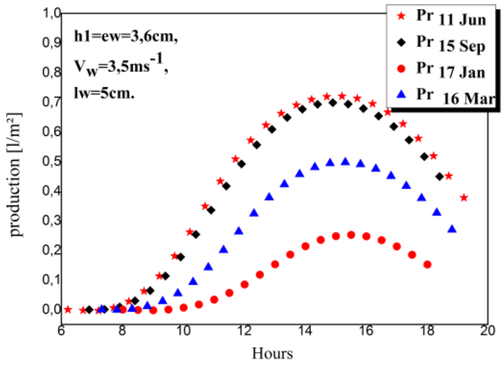

Figure 4. Daily hourly production

b) Experimental bench

Figure 5. Experimental bench

The present work intends to present an experimental study on a solar hot-box distiller, made of a mixture of glass wool and resin to ensure good thermal insulation. Polyurethane foam, 5 cm thick, was used to reduce thermal losses from rear and side walls. This was done in order to increase the productivity of the distiller and to extend its period of operation during the diurnal period, while taking advantage of the energy stored in the basin.

The temperatures were measured using thermocouples connected to a Fluke 2680 Series data acquisition system. The radiative intensity was measured using a Kipp & Zonen pyranometer.

Various series of tests were carried out during the period extending from March 04, 2015 to August 18, 2015. The temperatures, intensity of the radiative flux and quantity of distillate produced were evaluated. Two glasses of dimensions 57 cm x 131 cm, inclined at an angle of 15 °, and a basin of dimensions 93 cm x 125 cm were also used; this gives a surface area of 1.16m². The tests were carried out on the experimental platform of the *Research* Unit for Renewable Energies in the Saharan region (URERMS), in the town of ADRAR.

Figure 6 illustrates the evolution of ambient temperature and the intensity of the total horizontal radiative flux for the days of January 20 and July 15. It is noted that the ambient temperature follows the evolution of the solar radiation with a small offset at the maximum value.

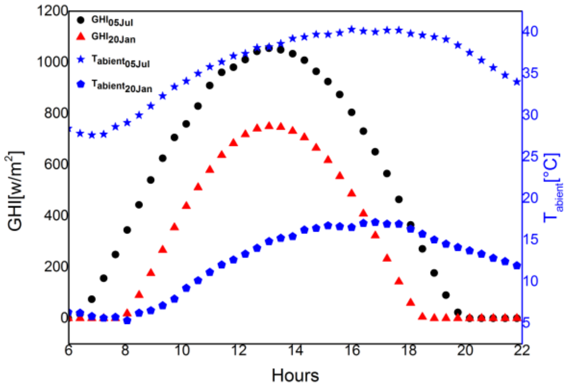

Figure 6. Ambient temperature and intensity of the overall horizontal radiative flux.

Figure 7 shows the variation in the temperatures T_2, T_3, T_4, T_5, T_6 and T_7 of the different components in the distiller, namely the temperatures of the basin, horizontal plate, vertical plate, water, inner and outer faces of glass, for the day of July 05. It can clearly be noted that the temperatures follow the evolution of the solar radiation and that the temperature of the plate and that of brine are very close; however, the temperatures of the inner and outer faces of the glazing are significantly lower than that of brine, by 10 to 20 °C. The temperature gradient between glass and brine has a considerable effect on the productivity of the distiller.

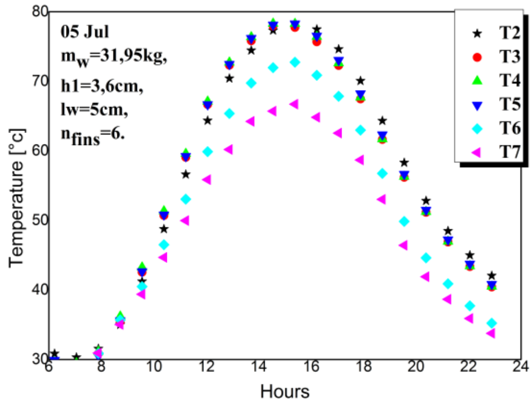

Figure 7. Temperatures of various distiller components

Figure 8 illustrates the measured values of the daily production of the distiller from the month of March to the month of August. It is found that the production of the distiller gradually increases to reach maximum values during the months of May, June and July and then begins to decrease after the month of August.

In addition, an average production of 6.6 liters, a maximum production of 8.6 liters and a minimum production of 2.64 liters were recorded. Similarly, Figure 8 shows the ratio of distilled water production to the daily global horizontal solar radiation (Pr/GHI [ml/Kwh/m²]. It was found that this ratio reaches an average value of 1000 [ml/Kwh/m²].

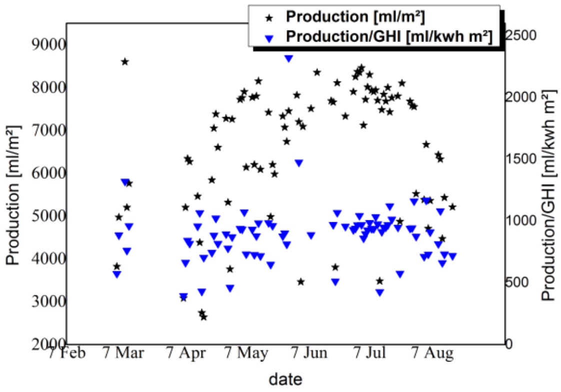

Figure 8. Daily production of the distiller.

It was found that the temperature of the cover glass coincides with the measured temperature of the inner face of this same cover. As for the temperature of brine, according to the results of Figure 9, it can be seen that from 8 a.m. to 1 p.m. the mathematical model describes very well the system, and the curves overlap. In the afternoon, the calculated values are slightly higher than those measured. This discrepancy may be explained by the simplifying assumptions made in the modeling of the system.

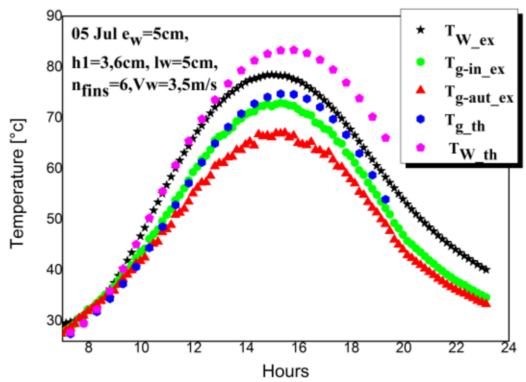

Figure 9. Comparison of theoretical and experimental results.

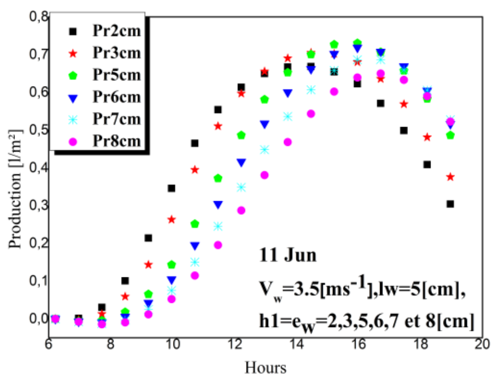

Figure 10. Production of the distiller for different brine depth.

Figure 10 illustrates the production of the distiller for brine depth equal to 2, 3, 5, 6, 7 and 8 cm, corresponding to briny water masses in the basin of 21.3, 31.95, 42.61, 53.26, 63.92, 74.57 and 85.22 kg, respectively. It was found that increasing the water mass in the basin, from 21.3 to 53.26 kg, causes an increase in the productivity of the distiller. Beyond the mass of 53.26 kg, the opposite effect occurs, i.e. the production decreases.

Moreover, an increase in the wind speed beyond 3.5 m/s leads a decrease in the production of the distiller. This may be explained by the cooling of the system (Figure 11).

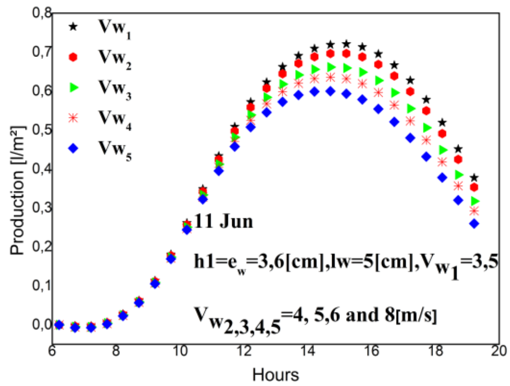

Figure 11. Influence of wind speed on production

Figure 12 depicts the production of the distiller for a distance between fins of 5 and 8 cm. In both cases, the brine depth varied from 3.6 to 5 cm, for the day of June 11. It was found that the distance between fins does not have a significant effect on the productivity of the distiller.

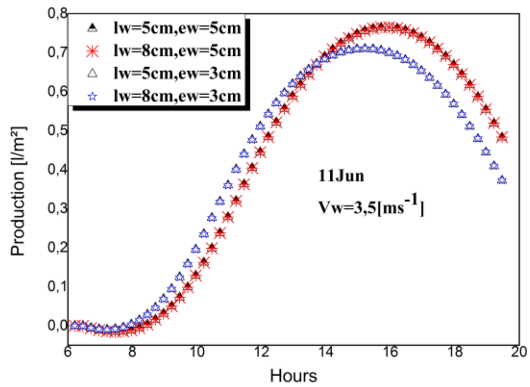

Figure 12. Influence of the distance between fins on production.

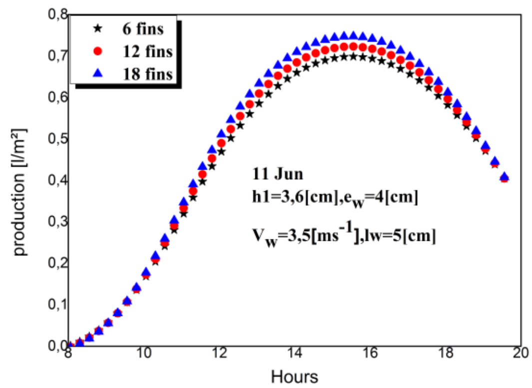

Figure 13. Influence of the number of fins on production.

Increasing the number of fins resulted in a rise in the production of the distiller, and this can be explained by the increase in the heat exchange surface since the absorption plate receives a greater amount of solar energy compared to the case without fins (Figure 13).

4. CONCLUSION

The present work presents a theoretical and experimental study of a double slope solar distiller, with fins immersed in the basin.

The influence of wind speed, distance between fins, height of fins, the number of fins and the mass of water in the basin, on the production of the distiller was investigated. The results obtained show that when the wind speed is more than 3.5 m/s, the productivity of the distiller drops, as the outer walls of the distiller cool more quickly, and this increases the heat losses from the back and front walls of the distiller. It was found that the distance between fins does not have a significant influence on the productivity of the distiller. Concerning the height of fins, it was established that an increase in the height of fins:

- from 2 to 5 cm, induces an increase in productivity,
- from 6 to 8 cm, induces the opposite effect.

An increase in the number of fins causes an increase in the quantity of distillate. Therefore, it is possible to install the highest number of fins while taking into account the feasibility of the system. The increase in water mass in the basin causes a decrease in productivity. For the day of June 11, and under conditions where h_1 = 3.6 cm, V_{wind} = 3.5 m/s, l_{water} = 5 cm, N_{fins} = 12 and for a mass of water of m_{water} = 21.3, 31.95, 42.61, 53.26, 85.22 kg, the production of the distiller, with immersed fins, increased by 21, 25, 27, 27 and 15%, respectively, compared to that of a conventional distiller.

The best available estimate of the measured values of the daily distiller production from the month of March to August is fond that the average = 6,616 Kg.the variance of the values due to random variations is; variance = 2.311 Kg^2. The experimental standard deviation; standard deviation = 1.52 Kg. The experimental standard deviation of the mean; variance of mean = 0.027 Kg^2. In addition, a standard uncertainty = 0.165 Kg. And the relative standard uncertainty = 0.025.

Table 2. Measurements accuracy range

No.	Instrument	Accuracy	Range
1.	Thermocouple J	±0.0102 °C	-30-150 °C
2.	Kipp-Zonen solarimeter	±0.05 W/m²	0-5000 W/m²
3.	Measuring beaker	±0.05 ml	0-3000 ml
4.	acquisition Fluke 2680	±0.2mV	300mV0°c to 60°c

Table 3. Comparison with previous researcher's works

Author	Enhancement method	Production [kg/m²/day]
V. Velmurugan et all[18].	Single basin with fin	2.81
A.A. El-Sebaii et all [17]	Single basin with fin	5.377
In this work	Double slope with fin	8.6

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REFERENCES

[1] Shukla S.K. (2007). Computer modeling of double slope solar still by using inner glass cover temperature, *ISES Sol. World Congr.*, ISES 2007, Vol. 3, pp. 2189-2200. DOI: 10.1007/978-3-540-75997-3_443

[2] Kabeel A.E., Khalil A., Omara Z.M., Younes M.M. (2012). Theoretical and experimental parametric study of modified stepped solar still, *Desalination*, Vol. 289, pp. 12-20. DOI: 10.1016/j.desal.2011.12.023

[3] Abu-Arabi M., Zurigat Y., Al-Hinai H., Al-Hiddabi S. (2002). Modeling and performance analysis of a solar desalination unit with double-glass cover cooling, *Desalination*, Vol. 143, No. 2, pp. 173-182. DOI: 10.1016/s0011-9164(02)00238-2

[4] Okeke C.E., Egarievwe S.U., Animalu A.O.E. (1990). Effects of coal and charcoal on solar-still performance, *Energy*, Vol. 15, No. 11, pp. 1071-1073. DOI: 10.1016/0360-5442(90)90035-z

[5] Cooper P.I. (1973). The maximum efficiency of single-effect solar stills, *Sol. Energy*, Vol. 15, No. 3, pp. 205-217. DOI: 10.1016/0038-092x(73)90085-6

[6] Cooper P.I. (1969). Digital simulation of transient solar still processes, *Sol. Energy*, Vol. 12, No. 3, pp. 313-331. DOI: 10.1016/0038-092x(69)90046-2

[7] Fath H.E.S., Hosny H.M. (2002). Thermal performance of a single-sloped basin still with an inherent built-in additional condenser, *Desalination*, Vol. 142, No. 1, pp. 19-27. DOI: 10.1016/s0011-9164(01)00422-2

[8] Voropoulos K., Mathioulakis E., Belessiotis V. (2004). A hybrid solar desalination and water heating system, *Desalination*, Vol. 164, No. 2, pp. 189-195. DOI: 10.1016/s0011-9164(04)00177-8

[9] Rubio E., Fernández J.L., Porta-Gándara M.A. (2004). Modeling thermal asymmetries in double slope solar stills, *Renew. Energy*, Vol. 29, No. 6, pp. 895-906.

[10] Al-Hayeka I., Badran O.O. (2004). The effect of using different designs of solar stills on water distillation, *Desalination*, Vol. 169, No. 2, pp. 121-127.

[11] Kabeel A.E., Omara Z.M., Essa F.A. (2014). Enhancement of modified solar still integrated with external condenser using nanofluids: An experimental approach, *Energy Convers. Manag.*, Vol. 78, pp. 493-498.

[12] Belhadj M.M., Bouguettaia H., Marif Y., Zerrouki M. (2015). Numerical study of a double-slope solar still coupled with capillary film condenser in south Algeria, *Energy Convers. Manag.*, Vol. 94, pp. 245-252.

[13] Morad M.M., El-Maghawry H.A.M., Wasfy K.I. (2015). Improving the double slope solar still performance by using flat-plate solar collector and cooling glass cover, *Desalination*, Vol. 373, pp. 1-9.

[14] Mohammed B., Houcine M. (2013). Revue Internationale D'héliotechnique, Effet Des Parametres Geometriques D'Un Reflecteur Plan Vertical Sur Les Performances D'Un Distillateur So Laire Mono-

Incline Couple A Un Condenseur Separe, Vol. 45, pp. 14-20.
[15] Dev R., Tiwari G.N. (2009). Characteristic equation of a passive solar still, *Desalination*, Vol. 245, No. 1-3, pp. 246-265.
[16] Tanaka H., Nakatake Y. (2005). A simple and highly productive solar still: A vertical multiple-effect diffusion-type solar still coupled with a flat-plate mirror, *Desalination*, Vol. 173, No. 3, pp. 287-300.
[17] El-Sebaii A.A. (2000). Effect of wind speed on some designs of solar stills, *Energy Convers. Manag*., Vol. 41, No. 6, pp. 523-538.
[18] Moungar, H., Azzi, A., Sahli, Y., Mediani, A. & Haida, A. (2016). Physicochemical parameter influences on distilled water production for a simple and modified hot box solar still, *Int. J. Sci. Eng. Res*., Vol. 7, No. 6, pp. 846-850.
[19] Sathyamurthy R., Nagarajan P.K., Edwin M., Madhu B., El-Agouz S.A., Ahsan A., Mageshbabu D. (2016). Experimental investigations on conventional solar still with sand heat energy storage, *International Journal of Heat and Technology*, Vol. 34, No. 4, pp. 597-603. DOI: 10.18280/ijht.340407
[20] Mesmoudi K., Meguellati K., Bournet P.E. (2017). Thermal analysis of greenhouses installed under semi arid climate, *International Journal of Heat and Technology*, Vol. 35, No. 1, pp. 474-486. DOI: 10.18280/ijht.350304

NOMENCLATURE

Υ_p	Azimuthal angle of the plane
Υ_s	Solar azimuth
G1	Radiation received by a 15 ° inclined plane facing the south
G2	Radiation received by a 15 ° inclined plane facing the north
G3	Radiation received by a vertical plane
m_w	Mass of water
lw	Fin width
l_{w0}	Length of the normal to shaded surface
l	Length of fins
H	Height of fins
N_{fins}	Number of fins
Ap	Flat plat surface
T	Temperature
A_{fin}	Fins surface

Subscripts

w	Water
g	Glass
p	Plate
s	Saline
ins	Insolation
c	Convective
r	Radiative
e	Evaporation
Vw	Wind speed
ce	Sky