A new design of a single slop double- basin solar still(SSDBS)

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ABSTRACT

A new type of a single slope double- basin solar still have been designed and manufactured; in order to compare its productivity with that of a single basin solar still, an experimental investigation was carried out on two single slope solar stills with different basin under actual field conditions; where the first still is conventional solar still with horizontal basin of $0.25m^2$ while the basin of the second still (the new design) has two partitions; horizontal basin of $0.1m^2$ and vertical basin of $0.15m^2$. From the experimental results, it has been observed that there is significant enhancement in daily output due to the basin deviation on a clear day. The main advantages of the vertical partition of the basin are that the latent heat of vapor condensing over the inner surface of the still is utilized in heating the water in the vertical partition of the basin which leads to store the hot water for the continuity of vapor at night , also the vertical partition of the basin helps to concentrate the sun ray on it by any type of external reflector to increase the productivity.

Keywords: Solar energy; Solar desalination; Solar distillation; Solar still;

INTRODUCTION

It is a well known fact that fresh water is necessary for the continuity of all life. It is also the key to the industrial and agricultural development of rural areas. In Iraq, the urgent need for fresh water is concentrated in the south regions Since the transportation of fresh water to these areas is difficult and not economic by the effect of the seawater, desalination plants are essential. Fortunately, Iraq is a sunshine country. The distillation is one of the important methods of getting clean water from brackish and seawater using the free energy supply from the sun.[1]. Solar distillation is one of the available methods to produce potable water. This process has the advantage of zero fuel cost, but requires more space (for collection) [2] So, solar distillation is a promising way of supplying these regions with fresh water.

Suggested to utilize the released latent heat, solar distillation of saline water has been practiced for centuries. Apart from common basin type solar stills, different designs have been studied such as the double basin still, the diffusion still, and the multiple effects still. The double basin still, the diffusion still, and the multiple effects still are of better performance than that of the traditional basin-type solar still. The weak point of the diffusion type was found to be its operational and maintenance problems and the difficulty to be adapted to the field application. Many experimental and theoretical studies have been done to study the performances of single and double basin [3-6], and several concepts such as tilted tray, tilted or vertical wick and some other designs have emerged [7-11]. Different design shapes and construction materials have been attempted to maximize the productivity of fresh water.

The development started from the simple conventional solar stills of high thermal capacity to the designs of systems of low thermal capacities such as tilted-wick still, multiple-ledge tilted still, cascade tilted still, and those that recycle heat such as multiple-effect diffusion still, multiple-effect tilted still and multiple- effect basin type still. In some of the still designs, evaporation and condensation take place in the same enclosure, in others evaporation and condensation occur in separate enclosures. Also, some of the stills recycle energy through the latent heat of condensation either in counter-current flow of an air-vapor mixture with the inlet feed or directly to another solar still, like in double-basin solar stills. Solar

stills that reject the heat of condensation to the atmosphere are termed as single-effect solar stills, but those that provide the reuse of latent heat of condensation to some or more extent, are termed as multiple-effect solar stills.[12].

From a practical point of view, it has now been realized that solar distillation cannot compete with other methods of desalination unless a major improvement is achieved. Among the different types of solar stills, the basin type was found to be preferable [13], this is because it is most economic, easily constructed and does not require any continuous attention or special experience. So continuous efforts have been expended to improve its coefficient of performance. Several authors [14-16] suggested a multiple level, double-basin still. The main advantage of this type is that the latent heat of vapor, condensing over the lower surface of the lower glass cover is utilized in heating the upper layer of water, rather than being wasted to the atmosphere [17].

In this paper a comparative study on a daily productivity between the conventional single slope single basin solar still (CSSSBS) and the new conventional single slope double basin solar still (CSSDBS) is reported.

EXPERIMENTAL SET-UP AND PROCEDURE

Two solar stills having similar basin areas were constructed and tested under field conditions at the testing field of the Physics Department in the Education College of the Basrah University (longitude $47^{o}45'$ 06.45"E, latitude $30^{o}33'$ 56.26"N).

The stills have the same dimensions and cover inclination angles, but they differ in the basin, The first type was a single-basin solar still (SBSS) with horizontal basin of 0.25 m^2 , while the basin of the second type (new still) was divided into two partitions ($0.1m^2$ horizontal basin and $0.15m^2$ vertical basin). Each still's inner dimensions were 0.54 m ×0.54 m, and hence the effective distillation area of each still was 0.25 m^2 . The cross-sectional side view of the single basin solar still and a new double basin solar still are shown in figure 1. Figure 2 shows a Photograph picture for the two stills.

The condenser surface of the still is made of 4 mm ordinary glass. The angle of inclination of the front glass cover (facing south) is 15° to the horizontal, while it is 90° for the back one (facing north) as shown in fig. 1(a). Collecting channels are used in each still to collect the distillate condensing on the inner surfaces of the glass covers and to pass the condensate to a collecting flask. The bottom sides of the stills are insulated with 50 mm glass wool. Plastic tub for overflow water outlet was used in each still to keep the brine depth at 20 mm at the beginning of each experiment. The basin surfaces were painted with black paint to absorb the maximum amount of solar radiation incident on them. The new basin of the second still was divided into two partition horizontal and vertical as shown in fig.1(b). The experiments on the stills were carried out during some days of (March , April, May, June, and July 2010) to study their performance under different field conditions. During each experiment, the hourly amount of extracted distilled water and the insolation were monitored for both stills. The total daily amount of distillate water was recorded.

An external reflector (dish covered with aluminum paper) [18]. was used to reflect and concentrate sunlight onto the vertical basin of the new double basin solar still. The dish is mounted on the vertical basin manually to reflect the highest percentage of sunlight possible onto the vertical basin.

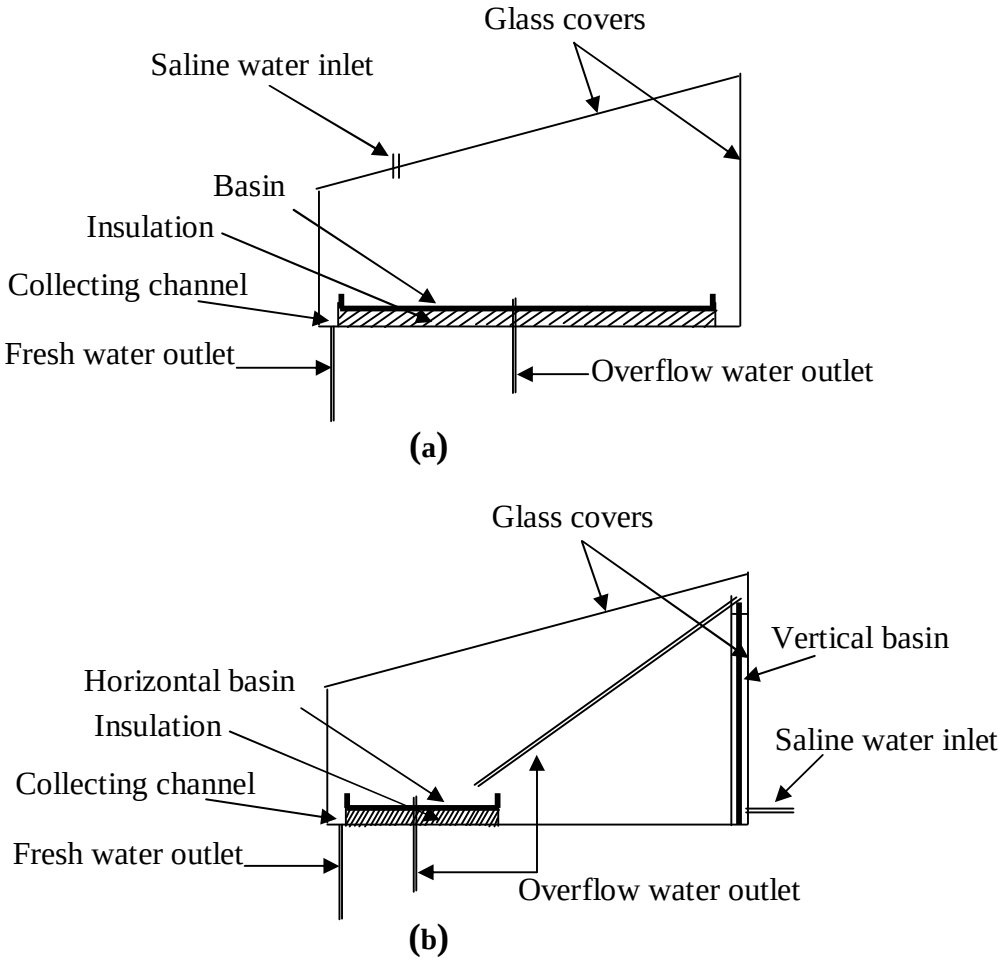

Fig. I. Cross-sectional side view of the solar still (a) single basin (b) double basin.

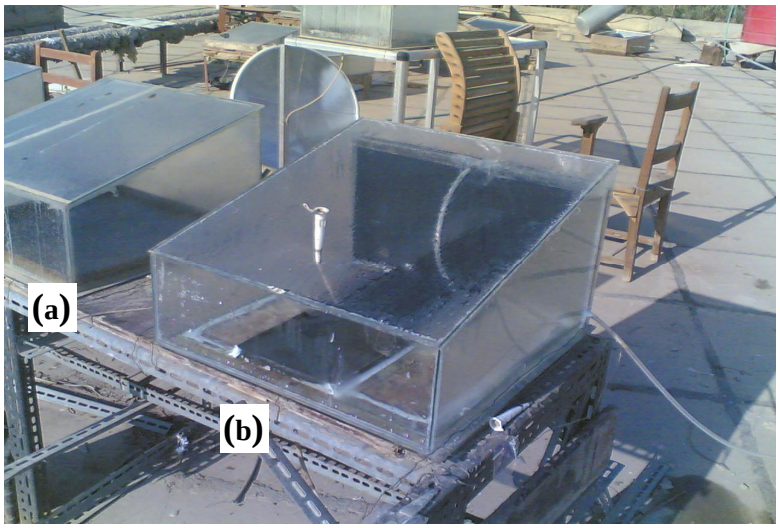

Fig. 2. A photograph for the two stills (a) single basin (b) double basin.

RESULTS AND DISCUSSION

Figure 3 shows a comparison between the daily production of distilled water of the two solar stills throughout some days of March 2010. This figure shows that the daily productivity of the new still is larger than the daily productivity of the single-basin solar still by 11% (where the average daily productivity of the single-basin solar still is 4082 ml/m^2 while it 4540 ml/m^2 for the new still at the operating days). .

Figure 4 shows a comparison between the daily production of distilled water of the stills throughout some days of March , April, May, June, and July 2010 after adding external reflector to the new still in order to concentrate the solar ray on the vertical basin. The graphs show that the new still unit gives the highest daily production throughout the operating months by 32 % as shown in table 1.

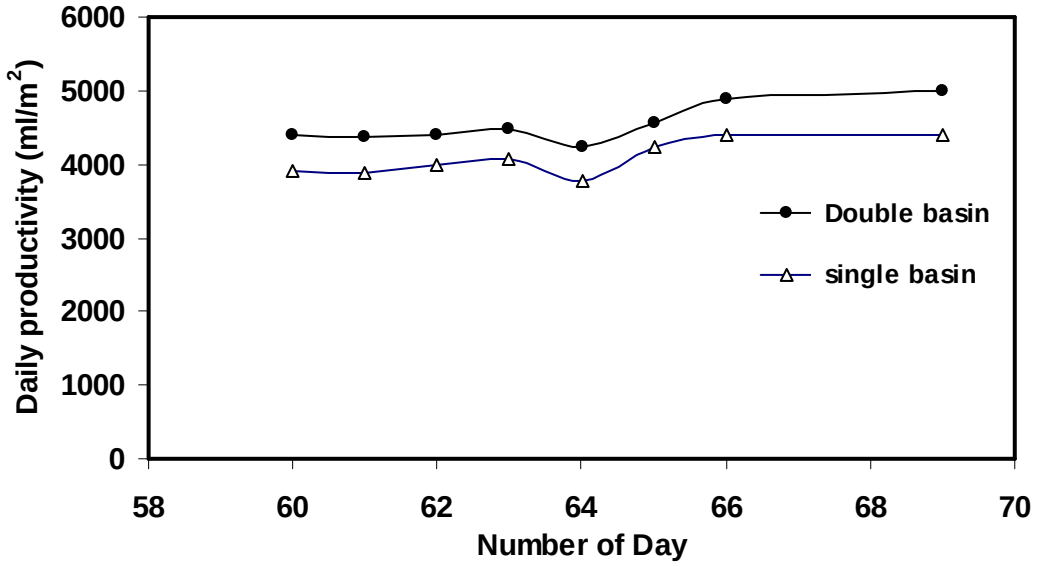

Figure 3: The daily productivity for the new design of double basin solar still &single solar still.

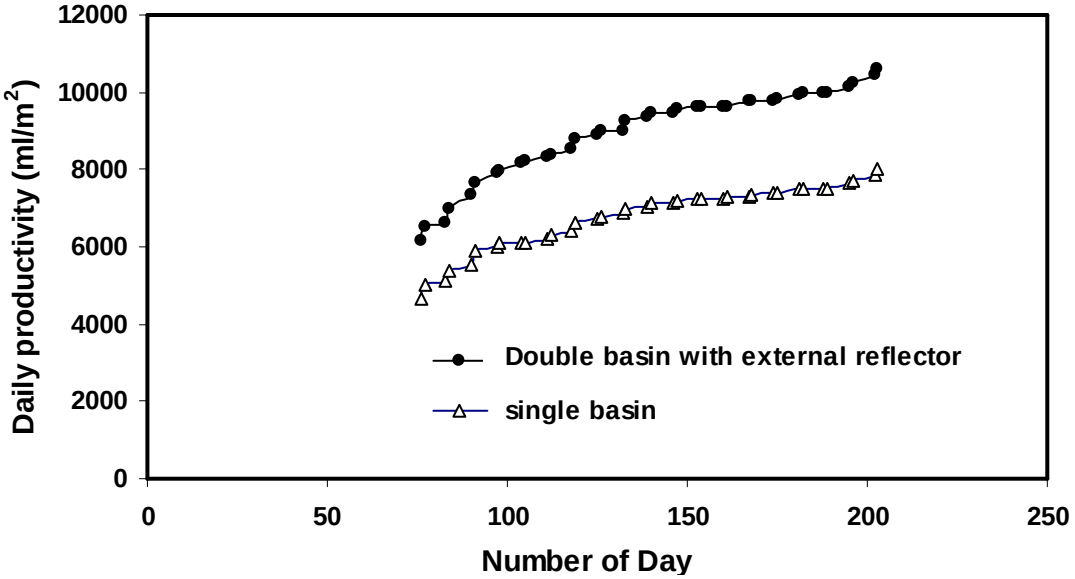

Figure 4: The daily productivity for the new design of double basin solar still with external reflector &single solar still.

Table 1: The percentage increase in the average productivity for the new solar still with respect to the single basin solar still (SBSS).

Solar still type	Average daily productivity (ml/m^2)	Percentage increase %
Single-basin solar still (SBSS).	4082	
New solar still without external reflector	4540	11
Single-basin solar still (SBSS).	6802.051	
New solar still with external reflector	9008.205	32

Solar radiation recorded every hour using the solar integrator device[19]. The product water is measured every hour by calibrated beaker of 1 liter volume. The productivity of the two stills with respect to the solar radiation has been studied. The results of the day 10 March 2010 are shown in figure (5). It is clear from the figure that the productivity of the two stills has the same behavior with the solar radiation. A maximum production is at midday while a lower one is at the first and the end day hours, but there is a significant increase in the productivity of the new design of the double basin solar still at the later hours of the day through the effect of the latent heat which is stored at the vertical basin, also at the first hours the inner surface of the vertical basin enhances to quick the condensation of the vapor which arises from the horizontal basin on it because of its lower temperature.

On the vertical basin the solar radiation has been concentrated by using a dish coverd with aluminum paper [18]. The results of the day 12 May 2010 are shown in figure (6). It is clear from the figure that the productivity of the two stills have the same behavior with the solar radiation, but there is a significant increase in the productivity of the new design of the double basin solar still due to the effect of the external reflector on the vertical partition of the basin.

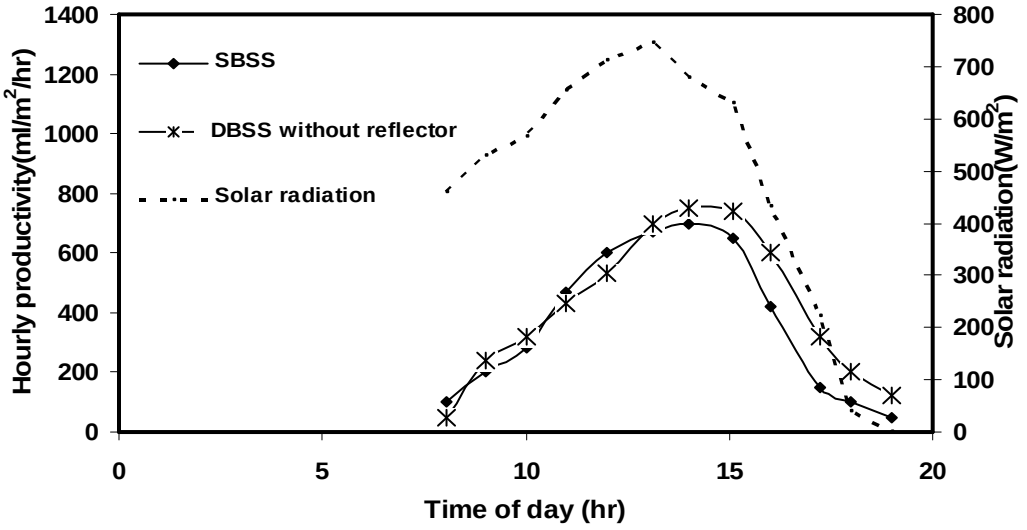

Figure 5: The hourly productivity of the new design of double basin solar still &single solar still during the day of 10 March 2010

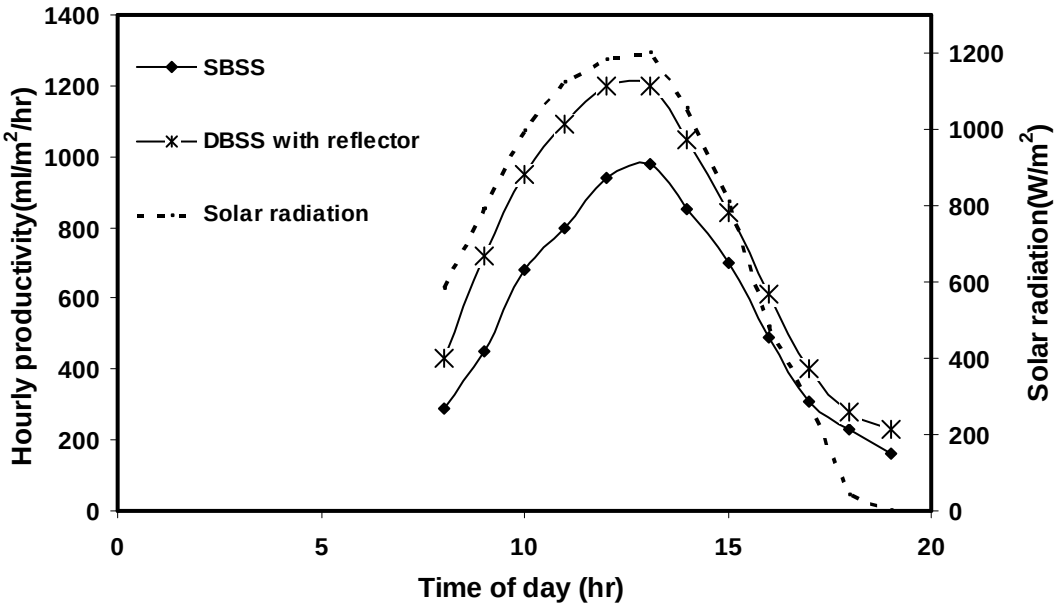

Figure 6: The hourly productivity of the new design of double basin solar still with external reflector &single solar still during the day of 12 May 2010

CONCLUSIONS

Based on the experimental results of the five months experimentation (March– July 2010), the following observations were found:

1. The highest distillate production for both single and double basin solar stills occurred in July, which is attributed to the high incident radiation (higher than 1100 W/m2).
2. The influence of the vertical basin of the new double basin solar still is significant on water production, especially with the external reflector.
3. The monthly average of daily distillate production of the new double-basin still is higher than the average distillate production of the single-basin still. Therefore, the new design of the double

basin still is recommended for use in this region.

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الخلاصة

تم تصميم وتصنيع نوع جديد من المقطرات الشمسية ذات الحوضين ، ولغرض مقارنة إنتاجيته مع إنتاجية المقطر ذو الحوض المنفرد : تم التحقق التجريبي لمقطرين شمسيين بالمواصفات نفسها عدا اختلاف الحوض، حيث المقطر الشمسي الأول تقليدي ذو حوض منفرد أفقي مساحته ٠.٢٥ م^{٢} بينما المقطر الجديد ذو مساحة الحوض الاول ذاتها إلا انه مجزأ إلى جزأين احدهما أفقي بمساحة ٠.١ م^{٢} والآخر عمودي بمساحة ٠.١٥ م^{٢} . ومن النتائج التجريبية لوحظ بأن هناك تحسيناً في الإنتاجية اليومية للمقطر الجديد . ومن الفوائد الرئيسة للجزء العمودي من الحوض هي إن الطاقة الكامنة للتبخر داخل المقطر تفيد في تسخين الماء الموجود في الجزء العمودي ويتم تخزين الحرارة فيه لاستمرار عملية التبخر بعد غياب الشمس، وكذلك الجزء العمودي من الحوض يسهل عملية تركيز أشعة الشمس عليه باستخدام أي عاكس خارجي لغرض زيادة الإنتاجية.