Study the effect of the external reflector on the efficiency of one sided Vertical Solar Still

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Abstract

A vertical solar stills have been constructed under different atmospheric circumstances of Basra city(Iraq). An experimental investigation was carried out on two solar stills under the same conditions with one side evaporative. The still has consists from the basin total area of 0.125 m^2, covers the basin still with a piece of black cotton cloth wet with water to be distilled, and one still provided with external reflector for the purpose of direct sunlight to the absorber surface.We found in this experimental study that the efficiency without any improvement (VSS) is (17.6 %) and increases to (38.2 %) by using external reflector (VSSR).

Keywords :Water, Saline Water, Solar Still, Vertical Solar Still, Desalination.

Introduction

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) [Omar et.al 2007 - Omar 2007], and solar distillation is one of the techniques for water purification. Consists of production of fresh water through condensation of water vapor after evaporation of brine water[Pierre et.al 2004 - Boukar et.al 2004]. Distillation is an alternative way for supplying small communities in remote areas and islands with fresh water[Bachir 2002 - Soteris 2005].

Solar desalination is gaining more importance for obtaining potable water. The main advantage of this process is that it does not utilize costly conventional fossil fuels, which create pollution problem[Phadatare 2007 -Bachir 2003].

Although solar distillation at present can not compete with oil-fired desalination in large central plants, it will surely become

available technology within the next 100 years, when oil supplies will have approached its end, at that time[Gordes 1985].

Solar stills can be best suitable units to be used as low-capacity and self-reliance water supply systems, since they can produce pure water by using solar energy only, and does not need other expensive energy sources such as fuel or electricity [Tiwari 2007].

Studied M. Boukar et al. the effects of design parameters and preliminary experimental investigation of an indirect vertical solar still, the efficiency ranged from 47.69 to 57.85% [Boukar 2007].

Hiroshi Tanaka et al. Thy have studied designed simple solar still: a vertical multiple-effect diffusion-type solar still consisting of a flat-plate mirror and they predicted to produce 29.2 and 34.5 Kg/m^2 d in sunny spring [Hiroshi et.al 2005].

presented Hiroshi Tanaka et al, the results of outdoor experiments of the vertical diffusion solar still coupled with the flat plate reflector at Kurume, Japan (33.2EN latitude and 130.2EE longitude). The experimental results of daily productivity for such study in Oct.20 (4.39 kg/m^2.day) [Hiroshi 2009].

In this paper a comparative study on a daily productivity between the vertical solar still(VSS) and the vertical solar still with the external reflector (VSSR) at Basra city , Iraq , was discussed the results obtained from solar stills.

Materials & Methods:

A vertical solar still has been constructed and it's performance has been evaluated under different atmospheric circumstances of Basra city (Iraq) (Latitude 30° 33' 56.55"N, Longitude 47° 45' 5.86"E) .

Two vertical solar stills having been built of transparent glass with a thickness (4 mm) and have the same dimensions of the measurement of the walls and cover inclination angles. Consists of all stills from the vertical basin of (0.25 m^2)which is made of aluminium, the basin surfaces were coated with black paint to absorb the maximum amount of solar radiation incident on them, have been fixed pieces of clothes on the basin increase absorption of water. The brackish water is fed through the vertical absorbing for cloth from the top of the absorber. The absorber receives solar radiation from both sides. Flowing water gets heated and evaporation starts from wetted surface. The evaporated water was condensed on inner surface of both transparent

covers and trickles down into drainage available at the bottom of the glass cover. which is located at a distance of (0.01m).

Distance between the vertical basin and glass cover (1cm) was used to collect the distilled water, it has been developed by putting hollow screw (double ended screw pipe) of (8mm) diameter on the channel to get distilled water linking transparent rubber tube in this screw, goes to the distilled water

collecting flask, diameter of the plastic tube (1cm).Putting the hollow screw in the channel disposing of surplus water ,channel designed on depth of (3cm) and located in the bottom of the cloth also to wet the cloth from the bottom and climbing capillary tubes, linking transparent rubber tube in this screw goes to salt-water (brain) container.The base of the still are insulated with pieces of wood (wood block) of (1cm) thickness to avoid the thermal losses to the external ambient, proven the basin on the base by silicon rubber, and the solar still directed to the south geographic, the direction geographical advantage from solar radiation and to be the first side towards the sunrise and the other side heading towards the sunset. Fig. (1) shows the schematic diagram of the still. Fig. (2) shows a photograph picture of the still.

The experiments on the stills were carried out during some days of (March , April, May, June, and July 2012) to study their performance under different field conditions.

In each experiment, the hourly amount of distilled water and the insulation are monitored for both stills. The total daily amount of distillate water was recorded.

An external reflector (dish covered with aluminum paper) , is used to reflect and concentrate sunlight onto the vertical basin . The dish was mounted on the vertical basin manually to reflect the highest percentage of sunlight possible onto the vertical basin . Fig (3) shows a photograph picture reflector (concave mirror) [Ahmed 2010].

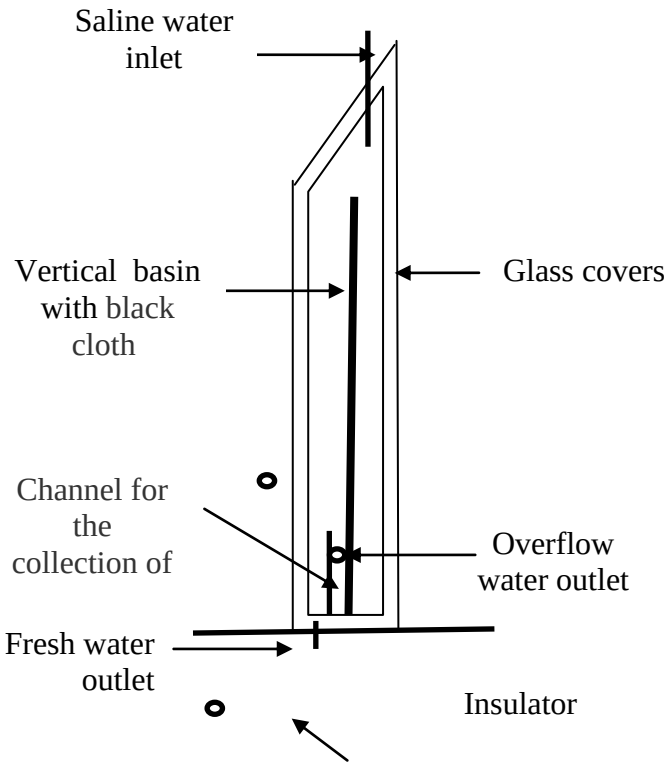

Fig. (1) A schematic diagram of the Vertical Solar Still (VSS)

Fig.(2) A photographic picture of the Vertical Solar Still (VSS)

Fig. (3) A photograph picture reflector (concave mirror) [Ahmed 2010].

Results and discussions:

Fig. (4) shows the daily production of the solar still for some days of (February to August 2012), and the solar radiation intensity values for the same days .It was seen from this figure that daily production of the maximum value arrived to (1710 ml/m^2) at (16 July 2012), where the sky is clear ,where the production of the solar still has been depending on the intensity of solar radiation, while the less value of production to (1040 ml/m^2)on the day of (22 February 2012) where the sky is not clear but partly cloudy. Fig. (5) shows the relation between the daily

production of the vertical solar still with the reflector (VSSR) and the vertical solar still with out reflector (VSS), solar radiation recorded every hour using the solar integrator device [Hassan 2010] .

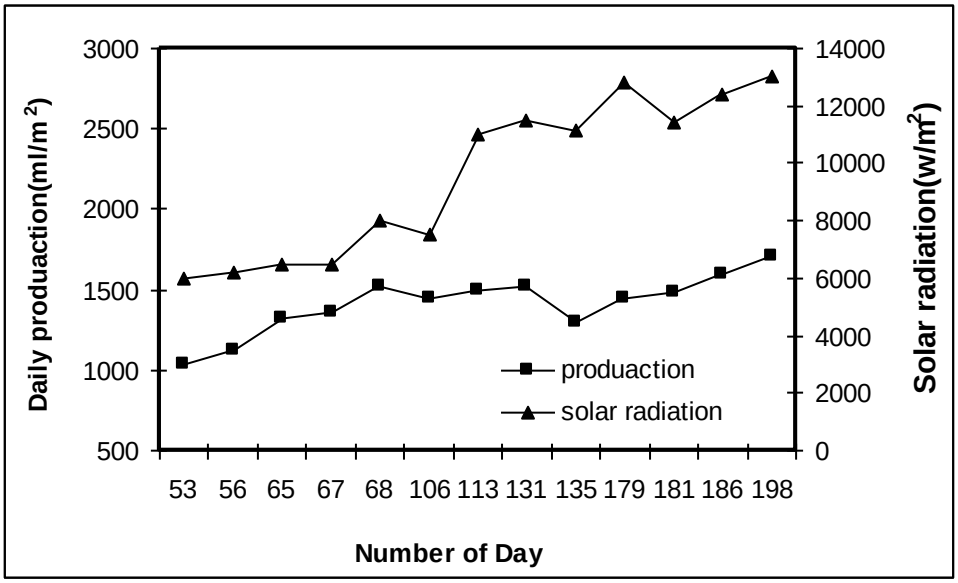

Fig. (4) Daily production of the solar still with the solar radiation from days of February to July 2012.

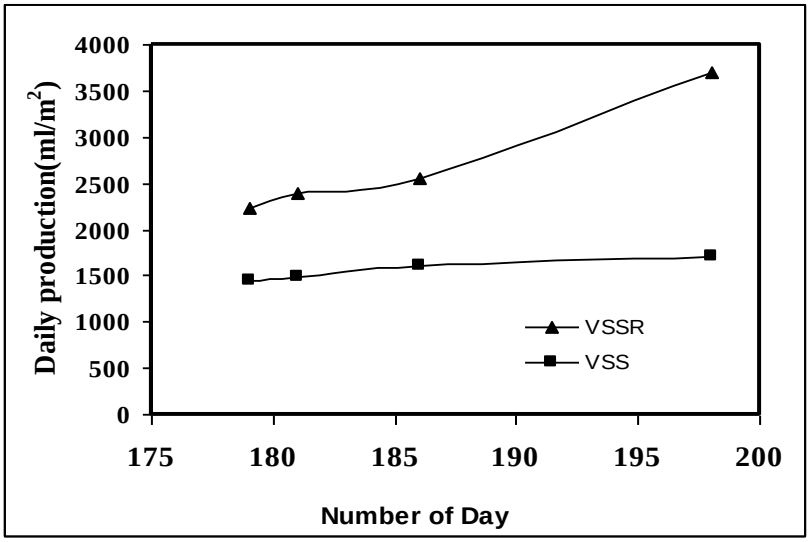

Fig. (5) the relation between the daily production of (VSSR) and (VSS) .

The results shown in Fig.(5) indicate that still has the same behaviour and the variation in its productivity from one month to another due to the variation in the solar radiation intensity and the other metrological factors like clouds, wind and the dust. The high daily production of vertical solar still with the reflector (VSSR) has been arrived (3700 ml/m^2) in July while the high daily production for the vertical solar still (VSS) has been arrived to (1710 ml/m^2) for the same month (July).These differences between

the daily production for the vertical solar still with the external reflector (VSSR) and the daily production for the vertical solar still (VSS) come from the improvements that were added to the stills reflector which is working to increase the temperature of the water basin solar still, lead to increase the difference between the temperature of the basin solar still and temperature of the cover condensation glass cover which is an important factor in increasing the productivity of solar still, while the less daily production for (VSSR) has been in the month (June) arrived to (2240 ml/m^2)in July. For (VSS) the productivity has been arrived to(1440 ml/m^2) in July where the productivity of the solar still has been depending on the intensity of solar radiation.

Table (1) concludes the percentage increase in the daily productivity for the daily productivity of(VSS) and (VSSR) .

Table (1): The percentage increase in Daily productivity of (VSSR) and (VSS)

Number of day	Daily productivity for (VSSR) (ml/m^2)	Daily productivity for (VSS) (ml/m^2)	Percentage increase %
179	2240	1440	55.5
181	2400	1480	62
186	2560	1600	60
198	3700	1710	116

Fig. (6) shows the results of experimental hourly productivity of VSSR and VSS at 16 July 2012 and the solar radiation intensity .

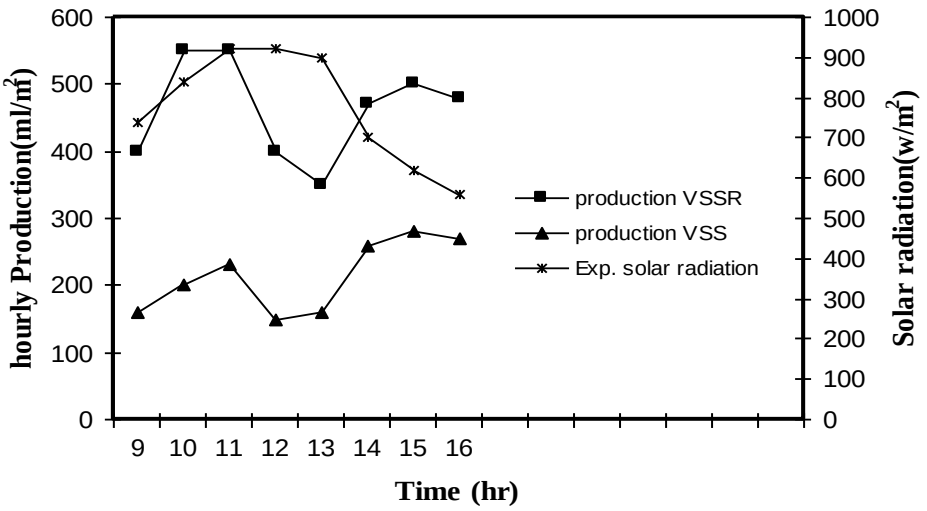

Fig. (6) Experimental hourly productivity of VSSR and VSS and the solar radiation intensity at 16 July 2012.

It is clear from Fig. (6) that the hourly production of the two stills have the same behavior but differ for the solar radiation behavior because the solar radiation measured to the inclined surface ,and there is a significant increase in the productivity of (VSSR) due to the effect of the external reflector on the vertical basin. A maximum production is one at the first and the end day hours arrived to (550 ml/m2/h) of (VSSR), and (280 ml/m2/h) of (VSS), while the lower at mid-day to (350ml/m2/h) of (VSSR), and (150 ml/m2/h) of (VSS), because the solar radiation is vertical at midday.The temperature of water basin for (VSSR) and (VSS), ambient air was recorded continuously for one hour at 16July 2012 show in Fig. (7).

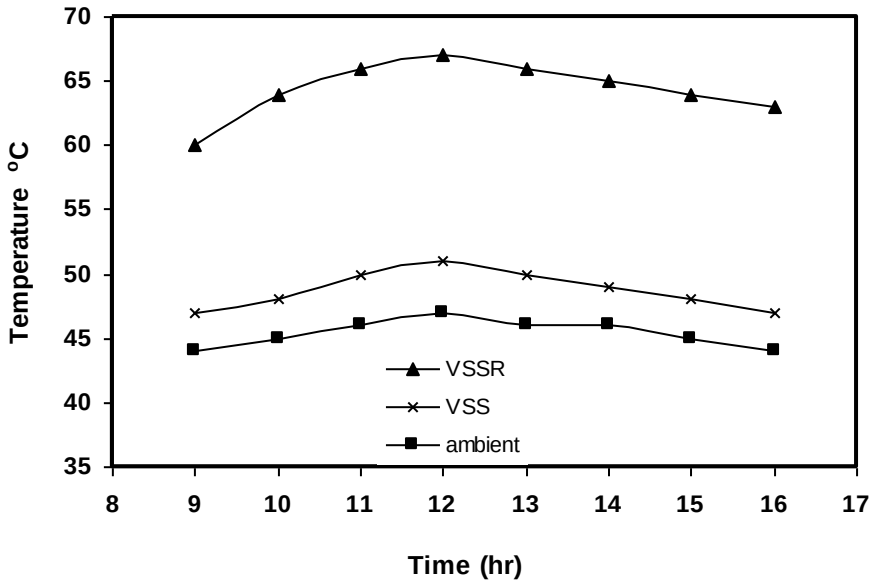

Fig. (7): The change in the temperature of the water basin along the daily hours at 16 July 2012.

From Fig.(7), we observe that the water temperature for the VSSR has a highest value at mid day ,this is because of the effect of external reflector on the vertical basin, also the maximum value of the temperature water basin arrived to (67^o)for the VSSR.

The thermal efficiency (E) of the stills was calculated for the same day (16 July 2012) using the following equation [Hussain 2001]:

$$E = \frac{P \times \mathrm{L}}{\mathrm{I} \times \mathrm{A_b}}$$

Where:

E: Thermal efficiency.

P: Daily output of distilled water.

L: Latent heat of water evaporation (KJ / Kg).

I: Daily solar radiation (W / m². Day).

A_b: Area of the solar still (m^2).

Table (2) shows the results of the thermal efficiency of the solar stills.

(Table 2) shows the thermal efficiency of the solar stills.

The still's	Production ($ml/m^2/day$)	Solar radiation (w/m^2)	Thermal efficiency%
VSS	**1710**	**6200**	**17.6**
VSSR	**3700**	**6200**	**38.2**

conclusions:

The main observations and conclusions that can be drawn from the results of this work are the following:

1. The largest part of distillate production was seen to take place between noon and sunset, where the productivity was increased with the increase of solar radiation.
2. The high distillate production of the a vertical solar stills occurred in July, which was related to the high incident radiation.
3. The influence of the vertical basin for the (VSSR) is significant on water production, especially with the external reflector.
4. The distillate production can be increased when the temperature of the brackish water increases.
5. The thermal efficiency arrived to (38.2 %) for VSSR and (17.6 %) for VSS.

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دراسة تأثير العاكس الخارجي على كفاءة المقطر الشمسي العمودي ذو الجانب المنفرد

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المستخلص:

في هذا البحث تم بناء مقطرين شمسيين عموديين تحت الظروف الجوية لمدينة البصرة (العراق) ، تم التحقق التجريبي لمقطرين شمسيين بالمواصفات نفسها وذو جانب واحد، يتكون كل مقطر من حوض مساحته ($0.125\ m^2$)، ويغطى حوض المقطر بقطعة قماش قطني اسود مبلله بالماء المراد تقطيره، احد المقطرين تم تزويده بعاكس خارجي لغرض توجيه أشعة الشمس نحو السطح الماص ، وقد أظهرت نتائجنا العملية بأن كفاءة السخان الشمسي بدون إضافة هي (17.6%) بينما ازدادت كفاءة السخان الشمسي عند وضع العاكس الخارجي بمقدار (38.2%) .