Journal of Basrah Researches ((Sciences)) Vol. (42). No. (2) A (2016)

Available online at: http://www.basra-science-journal.org

ISSN –1817 –2695

Received 10-4-2016, Accepted 17-10-2016

STUDY THE EFFECT OF THE EXTERNAL REFLECTOR ON THE EFFICIENCY OF PYRAMIDAL SOLAR STILL (PSS) IN BASRA CITY - IRAQ

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ABSTRACT

This research a pyramidal solar still (PSS) has been manufactured in Basra city. The experimental investigation was carried out on solar still under the same conditions. The pyramidal solar still consists of a basin area of (0.25 m^2). Some additions have been made and examined in order to increase the performance of the still. external reflector (dish covered with aluminum paper) was used to concentrate the solar rays towards certain region of the solar still(constructed manually in our laboratory). The maximum efficiency has been got of the experimental still varies from (40% -70%) pyramidal solar still.

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

1. INTRODUCTION

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 [1-2]. Solar distillation is one of many processes that can be used to produce fresh water by using the heat of the sun directly in a simple equipment to purify water. The equipment, commonly called a solar still [3]. 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) [4-5]. Desalination processes require significant quantities of energy to achieve the separation of salts from seawater as shown in figure (1) [6]. In oil rich countries, about 95% of all freshwater is already supplied by desalination technologies using fossil fuels (oil or gas). In view of future oil shortages, desalination must, however, be driven with renewable energy [7].

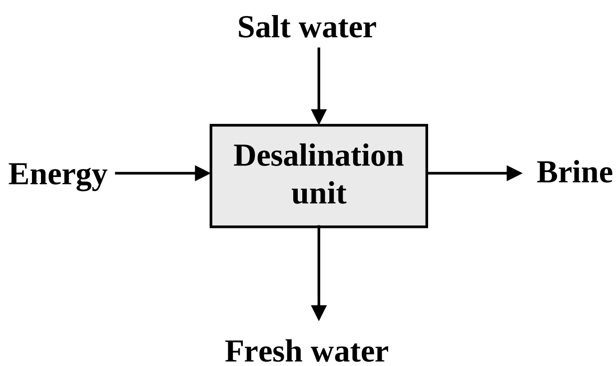

Figure 1: Diagram of desalination process

Solar still technology has a bright future because it offers an easy system to obtain quality water to use in innumerable purpose, especially as drinking water in the section of the world where the availability of potable water is lowest [8-9]. Solar stills are the 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 do not need other expensive energy sources such as fuel or electricity [10]. Huda R. M. Algaim et al. [11] studied the efficiency for the pyramidal solar still (PSS) in Basra city, Iraq, and get a maximum efficiency which is (66 %) for the pyramidal solar still. The general objective of this work is to design a pyramidal solar still and measure its efficiency with the external reflector .

2. EXPERIMENTATION

2.1 System Description

A pyramidal solar still has been constructed and it's performance has been evaluated under different weather conditions of Basra city (Iraq) (Latitude 30° 33' 56.55''N, Longitude 47° 45' 5.86''E). The pyramidal solar still (PSS) has been manufactured of transparent glass with a thickness (4 mm) and has the same dimensions of absorber plate which contains the Saline water. The glass cover length, width and height for the pyramidal solar still are 0.5 m, 0.5 m and 0.67 m respectively. The plate in still is made of aluminum with surface area (0.25 m2), the surface was coated to maximise radiant energy absorption and in some cases to minimize radiant emission, coated with black paint (Al-marjan black paint and Spray black paint). Paint the basin with a good mute black paint. The paint should be able to withstand continuous immersion and temperatures of 65-70 Co and should not fade or discolor under the influence of the sun's rays. In this research has not been a study of the absorption spectrum Paints, because the aim of the study is the effect of the external reflector on the efficiency of pyramidal solar still. The brackish water is fed to the still through the hollow screw (double ended screw pipe) of (8mm) diameter on the side glass at height 5 cm and join with rubber tube to the tank of saline water with capacity 30 liter. The condensed channel in still lies between the absorber plate and the glass cover with width 1cm and height 2cm. The absorber receives solar radiation from both sides. Flowing water gets heated and evaporation starts from absorber plate. The evaporated water was condensed on condensed channel, it has been developed by putting hollow screw (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). The base of the still is 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. figure (2) shows a photograph picture of the still, figure (3) shows the schematic diagram of the still. An external reflector (dish covered with aluminum paper) was used to reflect and concentrate sunlight onto the basin. The dish is moved manually depending on the rotation of the sunlight movement, to reflect the highest percentage of sunlight possible on the basin show in figure (4) [12]. The cost of the manufacturing a pyramidal solar still about (50,000) Iraqi dinars and the cost of the manufacturing of a solar still is matched with the production of distilled water.

2.2 Testes

The pyramidal 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. The experiments on the still was carried out during some days of (April 2014, May 2014) to study their

performance under different field conditions. In each experiment, the hourly amount of distilled water and the insulation are monitored for the still. The total daily amount of distillate water was recorded. The intensity of solar radiation was measured by the pyranometer device in the College of Agriculture - University of Basra.

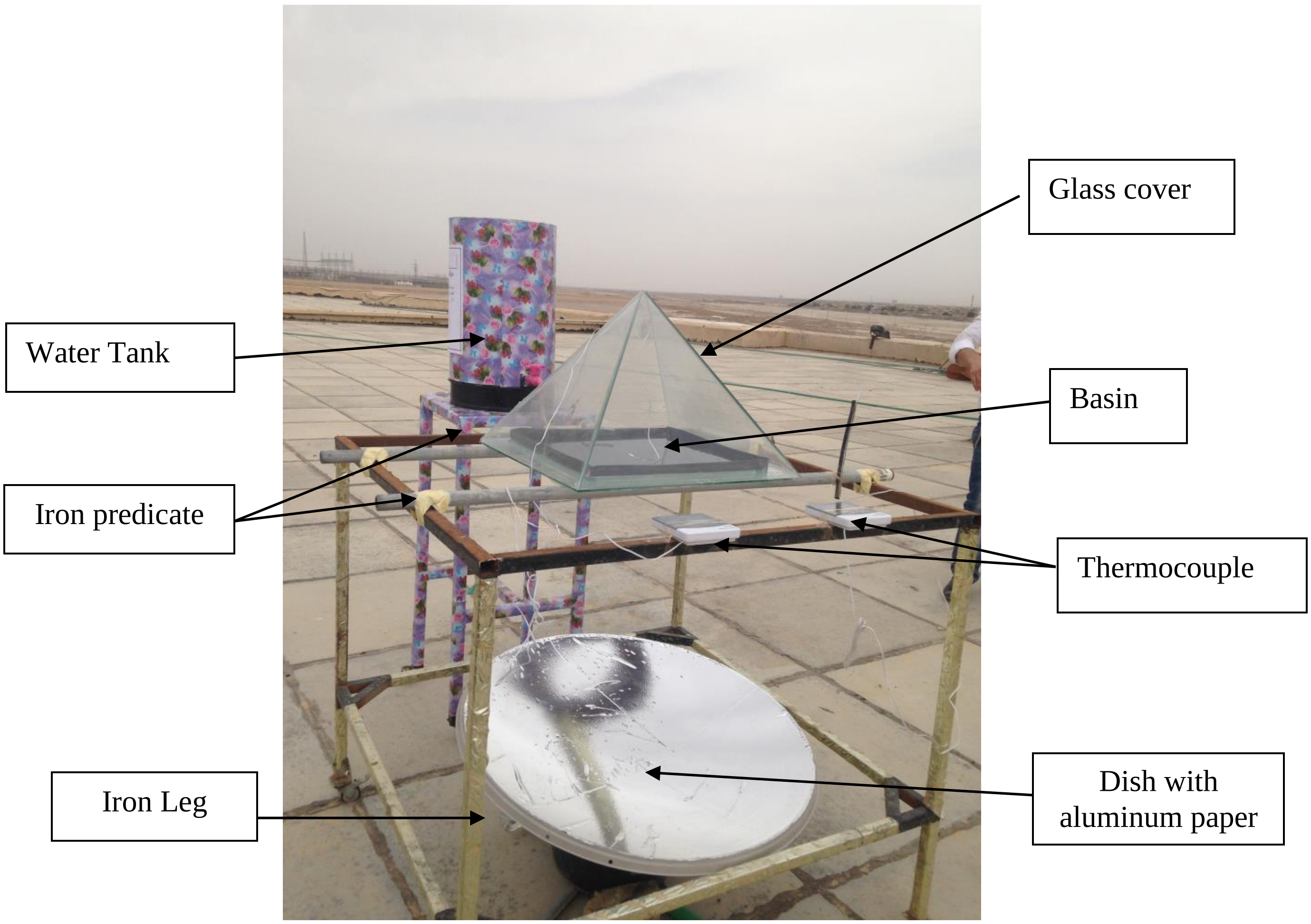

Figure 2: Photograph picture of the pyramidal solar still(PSS) with external reflector.

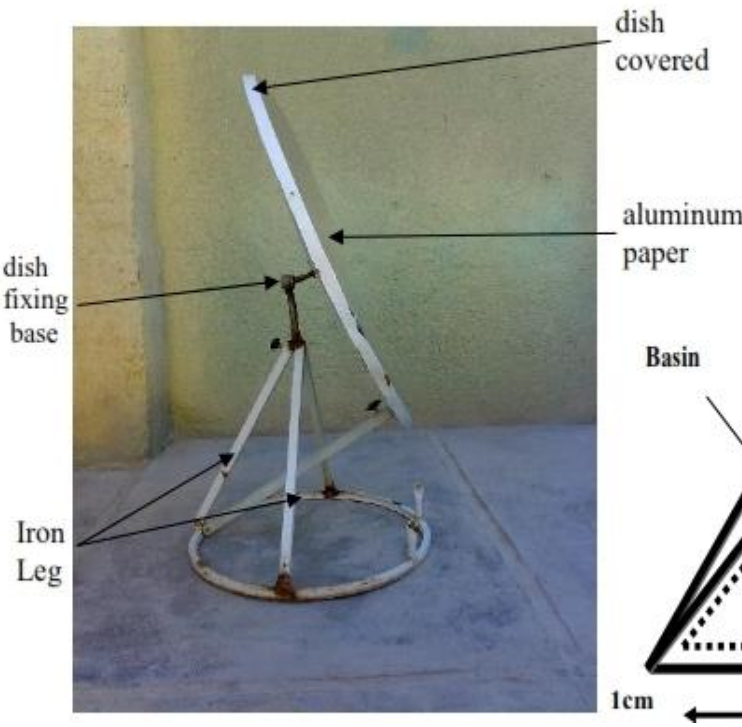

Figure 4: Schematic diagram of the dish covered with aluminum paper

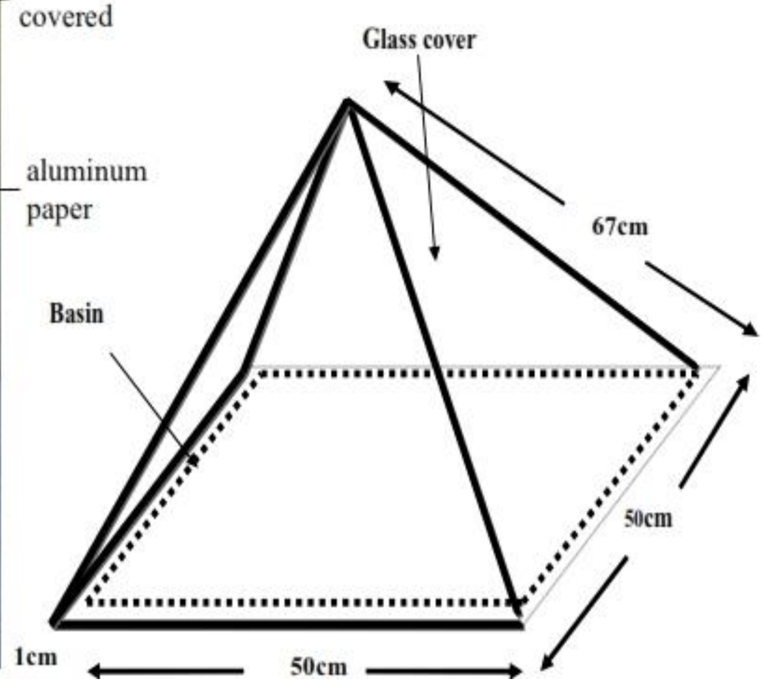

Figure 3: Schematic diagram of the pyramidal solar still(PSS).

3. RESULTS AND DISCUSSION

The product water is measured every hour by calibrated beaker of 1 liter volume. The productivity of the still with respect to the solar radiation has been studied. The results of the day 29 May 2014 (No. of day (149)), are shown in figure(5). It is clear from the figure that the productivity of the still 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. A maximum production is one at the first and the end day hours arrived to (1280 ml/m^2/h) of (PSS) with external reflector and a maximum solar radiation is one at the first and the end day hours arrived to (1836 w/m2/h), also at the first hours the inner surface of the pyramidal enhances to quick the condensation of the vapor which arises from the horizontal basin on it because of its lower temperature figure (6) show the daily production of distilled water of the pyramidal solar still with the solar radiation through the months(April to May 2014), this figure shows that the daily production has a maximum value arrived to (8000 ml/m^2/day) for the No. of day (149) where the sky is clear (there is no dust), where the production of the solar still has been depend on the intensity of solar radiation, while the less value of production is (7640 ml/m^2 /day) for the No.

of day (100) where the sky is not clear but partly cloudy and the weather contains some dust storms. The temperature of water basin for (PSS), ambient air was recorded continuously for one hour at 10 April 2014 (No. of day (100)), show in Figure (7).

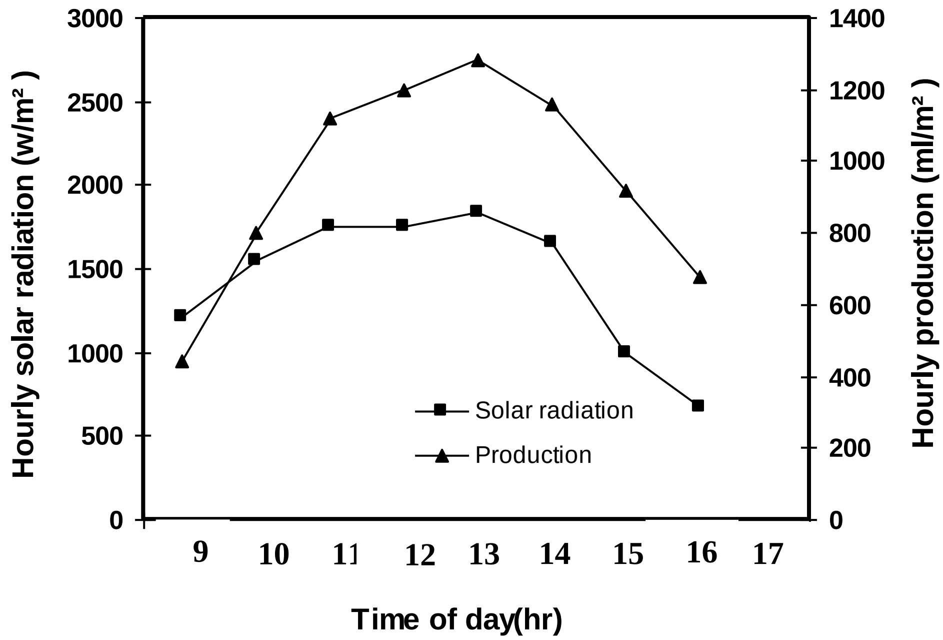

Figure 5: Hourly productivity of the pyramidal solar still with external reflector & solar radiation during the No. of day (149) .

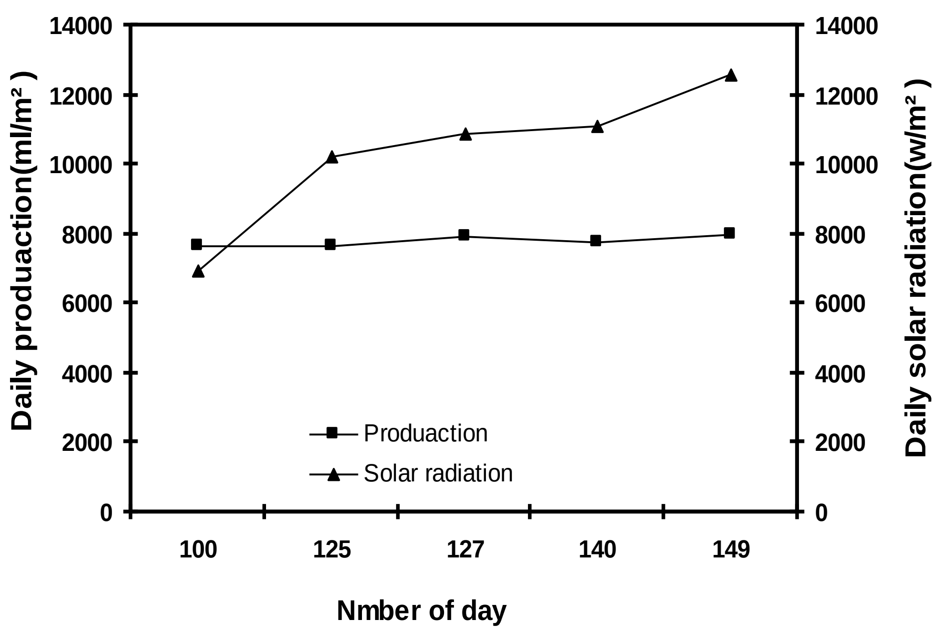

Figure 6: Daily production of the solar still with the solar radiation through days from months (April to May 2014)

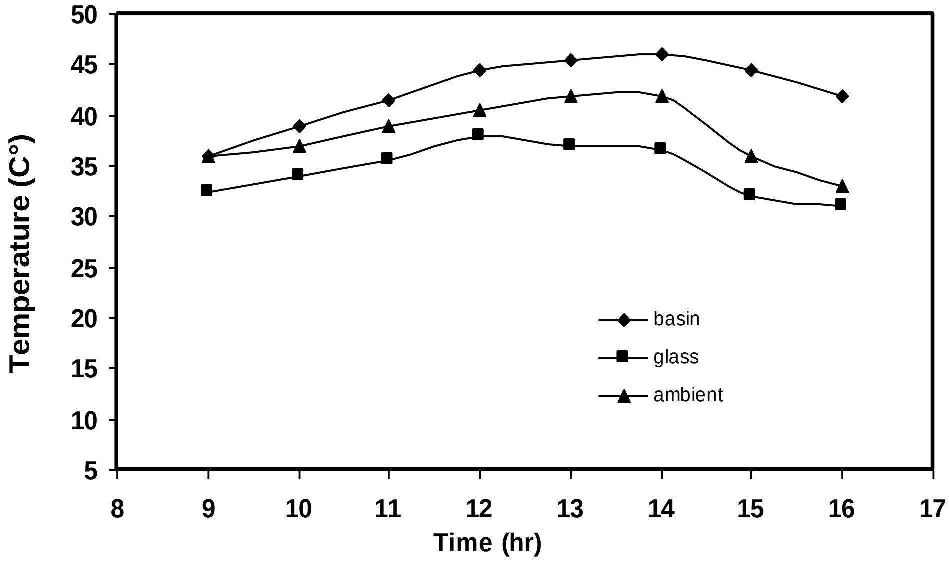

Figure 7: The change in the temperature of the water basin and glass and ambient along the daily hours at 10 April 2014.

From figure (7) we observe that the water temperature for the PSS has a highest value at mid day, this is because of the effect external reflector, also the maximum value of the temperature water basin arrived to (46 C^o)for the PSS with external reflector, while the maximum value of the temperature ambient arrived to (42 C^o). The thermal efficiency (E) of the still was calculated for the some days using the following equation [13] .

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

Where:

E_{bsn}: Thermal efficiency.

P: Daily output of distilled water (Liter).

L: Latent heat of water evaporation(MJ/ Liter).

I: Daily solar radiation (MJ / m²).

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

Table (1) shows the results of the thermal efficiency of the pyramidal solar still (PSS) with external reflector through the months (April to May 2014).

Table(1): Thermal efficiency of the pyramidal solar still (PSS) with external reflector.

Number of day	Production (ml/m^2/day)	Solar radiation(w/m^2)	Efficiency
100	7640	6950	70.2%
125	7660	10200	47.9%
127	7940	10900	46.5%
140	7760	11100	44.6%
149	7960	12400	40%

5. THE CHEMICAL ANALYSIS OF THE PRODUCT WATER

chemical analysis and the purity parameters of the distillate water which were collected from the stills are listed in table (2).

Table (2): shows the quality of the water source

water quality	PH	TDS(ppm)	Conductivity ($mS.cm^{-1}$)
Solar still water	**6.9**	**1**	**1**
Tap water	**8.5**	**240**	***Out of the rang of the device***
Mineral water(bought)	**7.3**	**36**	**16**
Brackish water	**7.9**	**650**	***Out of the rang of the device***

From the Table (2) it is clear that the solar still yields a good quality of water . Some treatment is necessary to the produced water. That can be achieved by passing the distillate over a calcium containing material or by adding salt tablets to the product water. If the produced water is being stored for longer periods, chlorine based chemicals to the system must be dosed.

where:

PH : power of hydrogen (An expression of the acidity of a solution; the negative logarithm of the hydrogen-ion concentration)

TDS : Total Dissolved Solids(ppm).

CONCLUSIONS:

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

Solar distillation is particularly useful to give drinking water to small and isolated villages. Solar distillation can partially support humanity's needs by fresh water with free energy, simple technology and a clean environment. 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. The day average of distillate production of the pyramidal solar still has the same behavior and the variation in its productivity from one day to another due to the variation in the solar radiation and the other meteorological factors like clouds. The maximum for the thermal efficiency arrived to(70.2 %) pyramidal solar still for the day (10/4/2014) (No. of day (100)). The distillate production can be increased when the temperature of the brackish water increases. The pyramidal solar still (PSS) is the best design appropriately in Basra region in this work. The hourly variation behavior of yield is similar to that of solar intensity and the distillate production can be increased when the temperature of the brackish water increases.

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دراسة تأثير العاكس الخارجي على كفاءة المقطر الشمسي الهرمي في مدينة البصرة ـ العراق.

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المستخلص:

في هذا البحث تم بناء مقطر شمسي هرمي تحت الظروف الجوية المختلفة لمدينة البصرة. يتكون المقطر الشمسي الهرمي من هيكل صنع من الزجاج وبسمك (4 mm). يتكون المقطر الشمسي الهرمي من حوض مساحته($0.25\ m^2$)، أجريت على هذا المقطر إضافات الغاية منها تحسين أداء المقطر الشمسي وزيادة كفاءته الإنتاجية إذ تم اختبار كفاءة المقطر تحت تأثير العاكس الخارجي والذي يعمل على تركيز أشعة الشمس نحو المقطر الشمسي الهرمي وعلى مناطق مختلفة منه (تم بنائه في المختبر العملي)، وكانت كفاءة المقطر الشمسي الهرمي التي تم الحصول عليها تتراوح بين (40 % – 70 %).