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Experimental investigation of symmetrical double slope single basin solar stills productivity with different Insulation

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Abstract

Solar energy utilization in five symmetric double slope single basin solar stills with different insulation under actual field to find out the best insulating material in Basrah. From an economic point of view it is found that dry hay is the best material to be used for insulating the symmetrical solar stills.

Introduction

Water is the primary source of life and it is essential to life. Next to oxygen, fresh water is the most important substance for sustaining human life, and it's a key for life. Water shortage is a worldwide problem, where 40% of the world population is suffering from water scarcity [1].

Although 75 percent of the earth is covered with water, 97 % of Earth's water is too salty for us to use. 3% of Earth's water is fresh water; only one-third is accessible at the lakes and rivers [1,2].

The fact that 97% of the earth's surface is covered with saline water has been an important catalyst for developing water desalination technologies [3,4].

All desalination methods require fossil fuel or electrical energy but 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 [5].

Solar distillation process, which occurs in the still, is similar to natural evaporation of water from the sea, which creates clouds. The result is fresh water. Solar desalination could be one of the most successful applications of solar energy in most of the hot climate countries having limited resources of fresh water [6].

Distillation is the oldest and simple method to produce salt rather than drinking water. As early as the fourth century before Christ (B.C) [3], Aristotle described a method to evaporate impure water and then condense it to obtain potable water [2,5,7].

Solar distillation has been in practice for a long time. The earliest documented work is that of an Arab alchemist in the 15th century [3,8].

Although solar distillation at present cannot compete with oil-fired desalination in large central plants, it will surely become a viable technology within the next 100 years, when oil supplies will have approached its end. When that day arrives, the primary question will be, "which method of solar distillation is the best" [9].

Solar still is most simple device to get potable/fresh distilled water from impure water using solar energy as fuel. Solar stills can be easy to construct and maintain. Depending upon their size, they can provide water for many uses. A solar still is very useful in desert areas where, sunshine is plentiful and there isn't fresh water.

A solar still consists of a shallow basin of brine, coated with black paint to get good radiation absorbtivity, and covered by a transparent material as a glass or plastic. The optimum inclination of the glazing surface mainly depends on the location, glazing material and the season. It has been observed experimentally by various investigators that the minimum inclination of the glass cover should be at least 10^o, to avoid the drop back of the condensate [10,11].

A basin still consists of the following basic components: (1) a basin, (2) support structures, (3) glazing, (4) a distillate trough (channel), and (5) insulation. In addition to these, other components may include like: (a) Sealants, (b) piping and valves, (c) tank for storage**,** (d) an external cover to protect the other components from the weather and (e) a reflector to concentrate sunlight [9,12].

Solar stills are simple in operation and non-requirements of highly skilled for maintenance. The only maintenance required is the cleaning of the plant, especially of the glass cover. As such, it can be used at any place without many problems.

The solar distillation systems are classified into two groups; Passive and active solar stills, Fath [13] reviewed the various designs of solar stills and studied the suitability of solar stills for providing potable water.

In this paper the effect of different types of insulation materials on the productivity of the stills have been studied by using five solar stills with the same design but with different types of insulation under actual climatic conditions of Iraq at Basrah city (longitude 47^o45' 06.45"E, latitude 30^o33' 56.26"N). The objective of this paper is to find the best insulating material.

Experimental set-up

Five symmetric double slope basin-type solar stills (SS) were designed from locally available materials and locally manufactured components. The stills have the same dimensions and cover inclination angles, but they are insulated with five different insulating materials. The solar stills have been constructed in same steps for comparison purposes where; each one have a basin area of 0.5 m2 was made of 1.5 mm aluminum plates, and covered with 4 mm transparent glass which fixed on the iron frame. The supported structure of each still made from iron angel cross section of (1.25)". A rubber gasket has been placed between the upper and the lower iron frames to prevent leakage. The basins of the stills were painted with black paint, the bottom of the four stills were insulated from outside only with plywood of 4 mm thickness to minimize the heat loss with the surrounding. Whole assemblies of the stills are made air tight with the help of rubber gasket and rubber silicon. While the supported structure of the fifth still was made of glass thickness of 4 mm. The basins of the stills were insulated from outside with different types of insulation. Each still provided with four adjustment screws to rest it horizontally on the ground as shown in figure (1). The fifth

still has the same design but it is made of glass except the basin which it is made of aluminum plate.

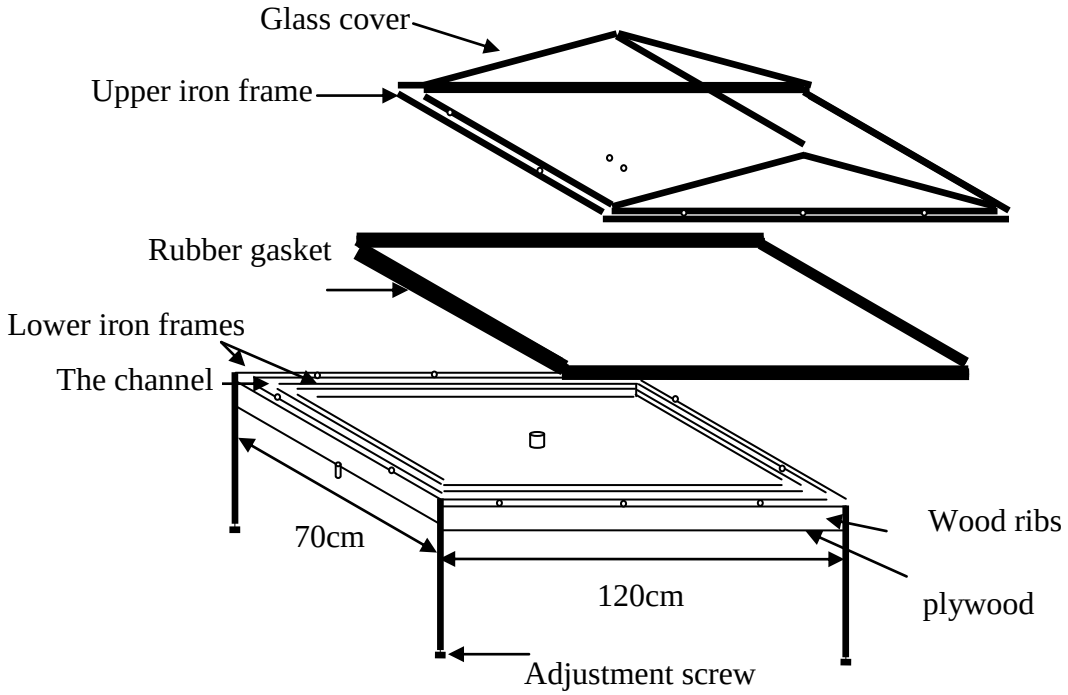

Fig.(1): Schematic diagram of the solar still

The solar stills glass covers were tilted at angles of 15°. The depth of water in the basin was maintained at 2 cm. The distillate yield was measured by scaled flask every day.

The stills were operating at the same time after putting equal quantities of brackish water in each of them, and under the same conditions after discarding from any leakage in each of them. Stills provided brackish water in the morning and leave for one day for measuring the daily production of each one, where: the basin of SS. No. 1 was left without any isolator, while the basins of SS Nos. 2-5 insulated by: only plywood, glass wool, hay and air gap respectively. Figure (2) shows a photographic of SS. Nos 1-5 where;

SS. No. 1

This still has been manufactured with the following specifications:
- It is as a rectangular shape of (120 x 70) cm^2.
- The area of the basin is 0.5 m^2 and made from aluminum plate with thickness of 1.5 mm.
- The glass cover has been inclined in a single slope of 15^o.
- The width of the incline glass cover is 112 cm.
- There isn't any insulation under the basin.

SS. No. 2

This still has been manufactured with the same specifications of SS.No.1 except:
- The basin insulated by only plywood.

SS. No. 3

This still has been manufactured with the same specifications of SS.No.1 except:
- The basin has been insulated with glasswool and plywood.

SS. No. 4

This still has been manufactured with the same specifications of SS.No.1 except:
- The basin has been insulated with 5 cm thickness of hay and plywood.

SS. No. 5

This still has been manufactured from glass 4 mm thickness while the bottom from glass with 6 mm thickness in the same specifications of solar still No.1 except :
- The basin has been insulated by 5cm thickness air gap between it and the glass bottom.

All stills operated under the same conditions in order to calibrate its productivity before they have been insulated to know the effect of the insulation.

Fig.(2): A photograph of setup the stills Nos.1-5.

Results and discussion

All stills operated under the same conditions for the period from 29 Jan. 2008 to 19 Feb. 2008 (from the day number 29 to 50) and the results are shown in the figure (3).

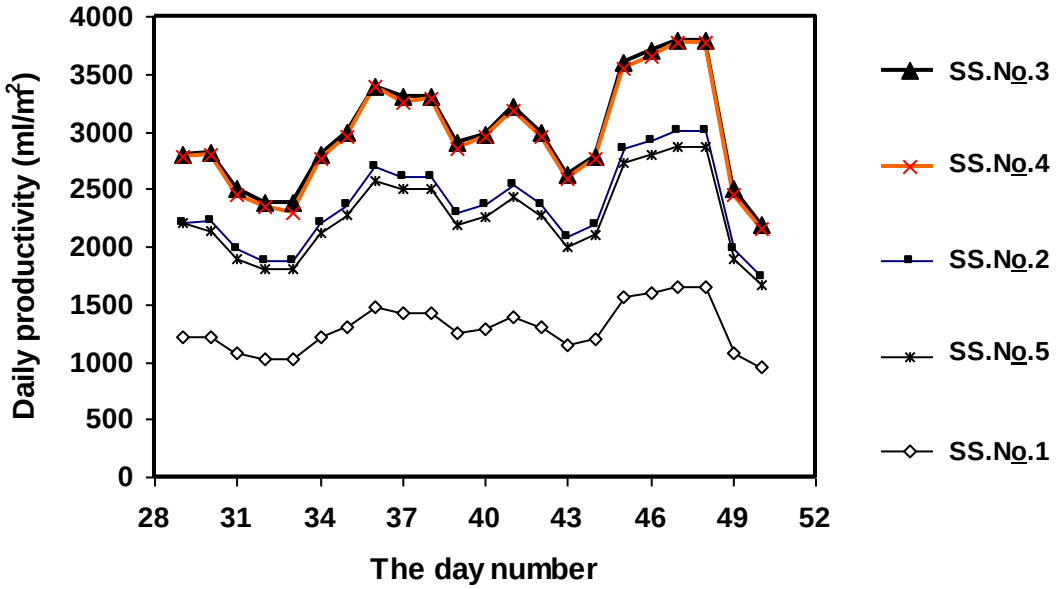

Fig. (3): The daily productivity with various insulations materials.

The results shown in figure (3) indicate that all stills have 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 metrological factors like clouds, wind and the dust. However, it is clear from the figure (3) that the daily productivity of the still No. 3, (which its basin insulated with glass

wool) is better than the productivity of the still No.1, (which its basin is non-insulated) by 130% , than still No.5, (which is made from glass and it basin isolated by 5 cm of air gap) by 32% , than still No.2, (which its basin isolated only by plywood with thickness of 4mm) by 26% and than still No. 4, (which It basin was insulated by hay with thickness of 5cm) by 12%. In other words, the productivity incensement in comparison with SS.No.1 is about 74% by air gap, 82% by plywood, 126% by hay and 130% by glass wool, table (1) shows the percentage increase in productivity for various insulations at the date from 29 Jan. 2008 until 19 Feb. 2008.

Table (1): The effect of insulation type on still productivity.

Insulation type	***Average productivity (ml/m^2)***	***Percentage productivity increase %***
without	1308.819	
air gap	2283.187	74
plywood	2385.697	82
Hay	2954.545	126
glasswool	3015.263	130

It is clear that the still which its basin without an insulation give low productivity. It means that the insulation is very important factor on the productivity of still because it will prevent heat loss from the basin.

Figure (3) and table (1) shows that there is no significant difference in the productivity of the stills Nos. 3,4 although the insulators are with different types, but there is a small difference, so, Hay insulator will be chosen because it is a cheapest one and available in the local market. In conclusion,

Conclusion

Solar stills are useful due to their simplicity, ability to supply fresh water to remote areas where no fresh water is available, and its environmental friendliness makes it attractive technology in future. The results in the present study indicated that Percentage productivity increase by 4% with glasswool insulation than it with hay insulation but in relative with the cost using the hay as insulation is more economic.

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التحقق التجريبي لإنتاجية المقطرات الشمسية ذات الحوض المنفرد والغطاء المتماثل الانحدار بالعزل المختلف

المستخلص

استخدمت الطاقة الشمسية بخمسة مقطرات متماثلة الانحدار ذات الحوض المنفرد بمادة عازلة لكل منها وتحت ظروف مناخية متشابهة لغرض الحصول على أفضل وارخص مادة عازلة للمقطر الشمسي في مدينة البصرة . ووجد أن مادة التبن الجاف هي أفضل مادة من الناحية الاقتصادية من بين المواد العازلة التي تم تجريبها في هذا البحث.