Review on the types of solar stills

Mohammad Abd Al Amir Khadim , Wisam A. Abd AL-Awahid , Dhafer M.Hachim.

Mohammad Abd Al Amir Khadim , Al-Furat Al-Awsat Technical University , Najaf Technical College , E-mail address: ma4855552@gmail.com, mobile: 07723792206 .
Wisam A. Abd AL-Awahid , Al-Furat Al-Awsat Technical University , Najaf Technical College , E-mail address: wsm19782000@gmail.com, mobile: 07809247781.
Dhafer M.Hachim , Al-Furat Al-Awsat Technical University , Najaf Technical College , E-mail address: coj.dfr@atu.edu.iq, mobile: 07809787897.

Abstract

The Using of desalination technology to meet The demand for fresh water production and that is increasing day by day is due to the increase in world population and with industrial growth . Among technologies used for desalination, Solar stills are easy to design, easy to maintain and low cost compared to other water systems . the same time, it has low productivity , But its disadvantages are low productivity, The aim of this paper is to provide a detailed overview of the various types of solar stills, passive and active design features, single and multi-function designs. And different efficiency improvements, The reflectors used, fins, heat storage, condensers, collectors, Also to improve heat and mass transfers. New advances in phase-change materials and nano composites Are highly promising for further performance development, Subsequent studies in these and other areas needs to be carried out to improve productivity of the solar distillers and take advantage of solar energy in this and other fields .

1- Introduction

Shortage of water is a major global challenge. Until 2025, Water shortage is expected to impact 1/4 of the world's population, And two-thirds of the world ’s
population faces water-stressed conditions. With up to 31 percent of the population, African regions are currently under high stress from water. Asia, America and Europe were followed by 25 percent, 7 percent and 2 percent respectively. Sea and brackish water desalination methods are extensive, including Distillation by flash, Osmosis to the reverse, exchange of forward ions, deionisation capacitive, electro dialysis multi-effect distillation, membrane distillation, and greenhouse technology with seawater. The desalination energy can come from fossil fuels or from renewables For example, wind, geothermal energy, solar power, biomass or waste heat production. There are many different ways to desalinate solar energy and one of them is using solar distillers. Solar stills have many Benefits include ease of use, Low Price, Suitable for easy maintenance and No effect on the environment. And the disadvantage of solar still is low efficiency. Solar also typically acts on evaporation and condensation processes. Within the solar power the brine is still evaporated, and the condensate is stored as the distilled water output. Using multiple effects helps to maximize productivity along with cost losses associated with it. The use of active parts, such as pumps and fans, is another way to improve performance, but it also introduces penalties for costs and complexity. Today, efficiency and productivity will measure the solar production. Efficiency is defined as the ratio of the condensed water's latent heat energy to the total incident quantity of solar energy. Instant efficiency defines performance over a limited period of time (Usually just 15 minutes), whereas total efficiency for the entire day is defined. Productivity is still the water production per solar area per day. Productivity is still only about (2–5 L / m2. Day) for a simple passive solar; therefore, a minimum of 1 m2 of space is needed to meet one person's critical needs.[1]

2- General parameters affecting Solar Stills efficiency [1]

2.1. Climatic conditions: such as Solar radiation intensity, wind speed, ambient temperature.

2.2. Depth of Water.

3-Solar stills:

3.1. Advantage:

1- The simple in design and installation.

2- Small-size

3- Method works at a lower cost for providing pure water in houses and small communities, without used stationary accessories (vane, motors, etc.).
4-It is a friend of the environment where it requires renewable energy only and does not produce any pollution of the environment.

5-Does not require an operator with extensive knowledge of work or maintenance or any possible failure. [2]

3.2. Disadvantages:

1-This method requires large tracts of land that are prosperous with solar radiation for installation and work,

2-It can be affected by weather conditions,

3-Low efficiency and productivity [2]

3.3.Types of Solar Stills

Solar stills can be sub divided in to two kinds:

A. Passive solar stills: Still solar systems that use solar energy as their primary source of heat energy. And those that are combined with solar thermal energy are directly used to heat water and then produce the distillation effect. The low operating temperature and vapor pressure explain this development rate. [3]

B. active solar stills: Extra thermal energy of this form is combined with passive solar for faster evaporation and this extra thermal energy can be collected from a solar collector or any excess thermal energy generated from any industrial plant.[3]

Most reviews were written of solar stills, Especially with regard to design and development, wick type and modeling performance enhancement. Nevertheless, recent developments including new materials (such as Nano composite materials and phase change materials).

[4] They have selected the different angles of inclination of the condensing cover (15 °, 30, 30 °, 45 °) in winter and summer seasons. It was found that the passive solar with a 45 ° inclination also provides better efficiency in both season (winter and summer) in Delhi.as shown in Fig.1.

[5] conducted to the 15 inclination of the condensing cover has been observed to give maximum annual yield and distillation efficiency. In Climate conditions in New Delhi (Latitude: North 288370 and Longitude: East 778130).
Fig. 1. Photograph of experimental system of solar stills inclined from left to right at 15°, 30°, 30°, 45°.

[6] They studies experimental Usage of two liner forms (asphalt and black paint) and Asphalt in the basin increased production by about 29%.

[7] To increase the total amount of solar radiation produced, they use external and internal reflectors, The research was performed on Constantine city, Algeria (36 0 70' N, 6 0 37' E) under climatic conditions days typical of winter, spring and summer. The results obtained show without question that the influence of the reflectors on the increase of the regular output of distillates over the winter period is very significant relative to the summer and spring. This rise in winter is about 72.8 percent.

[8] Two similar active solar systems are still being studied at the summit of Mount Tochal (35,6892 ° N, 51,3890 ° E) and Tehran (35,8842 ° N, 51,4199 ° E), at 13,005 ft., and 3871 ft. The system being proposed is a single-slope and single-basin solar created by photovoltaic (PV) panels still fitted with thermoelectric (TEM) modules. Overall production also at the summit is 42.5 per cent higher than Tehran.

Fig. 2. Experimental set in the city of Tehran
[9] Using an absorber plate (graphite) with high thermal conductivity to increase the efficiency of pyramid-shaped solar stills and to cool the glass cover. Additionally, the glass cover's exterior surface is cooled to raise the water vapor condensation rate and then improve the productivity of distillate water in Fig.4.

[10] The rate of evaporation and condensation is directly dependent the surface area in the solar also. The solar pyramid is still being examined with and without insulation, Water depth varying from 1 to 3.5 cm. The solar still with insulated is
better than the without non-insulated. For insulation, the daily productivity of solar still increased to approximately (28.5) percent, while the daily output for solar still without insulation is found to be 26.17 percent.

[11] Studies Modified single solar basin with permanent ferrite magnet, double slope (Reducing water's surface stress), Triangular prism made of metal (To reduce the length of a characteristic) And the black cotton cloth (Enhancing surface area) is still increased. (Latitude: 24°39’N) in India, In the regular distillate production of adjusted still, a rise of 60.24 per cent is observed.

[12] A solar basin style still with a flat plate external base reflector extending from the front wall of the still in addition to the internal reflector (two sides and back walls) is implemented and scientifically tested at 30 ° N latitude on three days (spring equinox and summer and winter solstices). We found the outer reflector would mirror Sunraysia to the liner at the basin, increasing the efficiency of the distillates. The total distillate quantity of the inner and outer bottom reflectors is predicted to be 41 percent higher, 25 percent higher and 62 percent higher than that of a standard form of basin still present in the spring equinox and summer and winter solstices.

[13] Studies Theoretical study of the solar basin type with internal and external reflectors, The increase in the average daily distillate quantity of a still with a full inclination external reflector in addition to an internal reflector throughout the year. If the inclination of the glass cover is 10, 30 or 50 and the outer reflector length is half the length of the still in Fig.5 compared to the typical form of the basin, 29 percent, 43 percent or 67 percent were still expected.
In this study three different types of local rocks were used, namely basalt rocks, concrete bricks and crashed rocks, to increase water efficiency by increasing the production time from the double-slope solar still. Results revealed a remarkable 42 per cent increase in basin productivity with concrete bricks, which was more than that of the basin's non-concrete productivity at 7 pm. in Fig.6., Fig.7.

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Fig. 5. Single basin single slope solar still with reflector

Fig. 6. Double-slope solar still with igneous rocks.
Experimental and computational studies of the condenser region's effect on the natural solar circulation system under standard Conditions for summer and for winter. This code is from the machine is used in the summer and winter conditions to predict the effect of still normal condenser area and wind speed on yield. The simulation shows that the NCL solar daily total production can still reach 4.73 L / m2.day and 2.71 L / m2.day respectively, under summer and winter conditions.

Investigates the efficiency of a semi-cylindrical solar still and compares it to a standard double solar pendulum single basin still. The transparent cover is made of glass in semi-cylindrical shape and still referred to as semi-cylindrical solar. One still is made as a normal single basin solar double slope still and checked under the same climatic conditions. The results show that in the semi-cylindrical solar the condensation rate is always higher even than in the traditional. The highest productivity of 2,87 and 1,985 kg / m2/d is provided in solar semi-cylindrical and double slope even, with mild steel sections in the basin respectively.

Still in the environment of Rajshahi, Bangladesh, An experimental research on a single solar slope is being performed. This study's main objective is to determine the effect of PCM (Phase Change Material) on a solar still. Therefore, Its productivity improved. Throughout this analysis, As a phase-changing material, bitumen was used to store thermal energy in the form of latent heat which provides high storage capacity per unit volume and unit mass and provides heat during the sunshine-off cycle. Solar distilleries with the presence of phase change materials have been shown to be better in productivity than those without phase change materials.
[18] They use a flat mica plate that is often embedded in traditional solar to increase the evaporation of water from the supply of saline water. To maximize the absorption of solar radiation, the flat plate absorber is mounted in such a way that the solar glass shield is always parallel to it. It was found that distillate production with a flat plate absorber increased by 25 percent compared to traditional still.

[19] In an attempt to enhance the efficiency of solar still, the use of graphite and copper oxide micro-flakes with different amounts was tested experimentally, different water depths in the basin, and different flow rates for film cooling. The results obtained show that, relative to traditional solar still (without micro-flakes), using copper oxide and graphite micro flakes respectively, the solar still improves productivity by around 44.91 percent and 53.95 percent. in Fig.8.

![Experimental setup](image)

**Fig.8.** Photograph of experimental setup

[20] They were experimentally tested under real weather conditions, two types of solar stills, triangular and tubular. The tests were performed over 7 average winter days and Examined the effects of ambient temperatures and solar radiation on water efficiency and overall still performance; Numerically, the fluid flow was measured using computational fluid dynamics. Local entropy output values in the chamber were measured using the fluid flow definitions. The findings showed that the tubular value was still 20 percent higher compared with the triangular one. The numerical simulation results have shown that the higher intensity of the recirculating zones and
the lower entropy generation are the main reasons why the tubular still produces better water.

[21] They used Tubular Solar Still (TSS) to allow the measurement of diurnal temperature variations, moisture relative humidity and water vapor density, and to estimate the hourly flux of condensation in addition to water levels, trough and cover. And the amount of evaporation by the hour. The Application of the experimental field findings obtained in 2008 in Fukui, Japan and Muscat, Oman. It is concluded that the proposed model can predict the TSS daily and hourly performance accurately.

[22] They use nanotechnology (ZnO nano-rod form) in the tubular solar still which increases productivity and efficiency by 30% and 38% respectively.

[23] The designed two types of a Tubular Solar Still (TSS) and comparison between them. The first type was conceived as a transparent tubular cover using a sheet of vinyl chloride. They designed a second type to improve assembly, quality and 1st level maintenance. A polythene film was used in second form as a cover.
[24] They use various gas media, namely air, oxygen, helium, and carbon dioxide. Through the tests, specific gas media were used to obtain for every measured point inside the unit, the water output rate and temperature values. The results show that if the temperature of the heating is 85 °C and the level of the gas is oxygen, the water production rate will surpass 0.58 kg•h^-1 Relative to the average if the gas medium is air, it will increase by 31.82 per cent.

[25] They used a new solar system but with a hemispheric top cover to desalinate water with and without water running over the cover. The performance was 34 percent, and the top cover cooling impact increased to 42 percent.

[26] They designed and fabricated hemispherical solar still, The daily distilled water production still varied between 2.8 and 5.7 l / m2 day. And its efficiency under the Dhahran climate conditions was experimentally evaluated outdoors.

[27] They also designed of hemisphere solar. Hemisphere solar also has hemisphere head that can absorb solar radiation from anywhere, Therefore the use of solar tracking system is not required. The water temperature and distillate production were in good accordance with the actual results of the experiment. Study shows that ANSYS CFD is both a very efficient and an important design tool.

[28] They used a model of mathematics to estimate spherical solar thermal efficiency. The analysis is based on Dunkle’s relationship between heat and mass transfer (1961), This was empirically updated to endorse Menguy et al's experimental
findings. (1980). Numerical measurements were also made for the analysis of the effect of the absorption of the basin liner on the still distillate yield.

[29] They used various modifications including the use of a reflector and experimented with external condensers. The goal of this investigation is to find out various techniques for improving the productivity of spherical solar still.

[30] Analyzes the thermal efficiency of a solar style "V" while using a charcoal absorber and estimates the production distilled collection of water. This analyzes internal heat transfer modes and external heat transfer modes. Even the output is measured in four ways. The average performance is still 24.47 percent with no charcoal, 30.05 percent with charcoal, 11.92 percent with boosting mirror and 14.11 percent with boosting mirror and charcoal, respectively. The key benefit of the "V" solar form is the accumulation of the core, and all condensation is easily directed towards the outlet.

[31] An experimental study was presented to improve the solar still productivity of passing air at varying velocities on still cover. A wire panel mesh mounted in still basin was also used, in addition to air velocity. The experimental results show that the productivity increased by 22.8% when the air velocity increased from 0.9 m/s to 4 m/s, and also when using wire screen mesh with air velocity of 2.5 m/s would achieve a productivity increase of up to 36.6%.

Conclusions:

In this paper, several types of solar stills were studied such as (single slope single basin solar stills, double slope single basin solar stills, tubular Solar Still, spherical solar stills, hemispherical solar stills, tringular solar stills, Pyramid-Shaped Solar Stills, Semi-Cylindrical solar stills, ‘V’-Type solar stills). And their converting salt water to fresh water. TSS solar has always achieved optimum efficiency. Hence from the above mentioned researches, From the above-mentioned research it was found that the wind speed, the intensity of the solar radiation and the Water depth: have an impact on freshwater output quantities. and the different design solar stills yielded different results.

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