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Research Article

Solar Stills Design and evaluation of: A Comprehensive Review

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ABSTRACT

Modifications to the Distiller in the water desalination in desert territories, a set of models was suggested (including simple solar panel with single-slope basin). The improvements were classified into two types. the first was to cool the condenser, and the second was to portray the process of heating the evaporator. Five experiments were carried out in the Ouargla region with a dry desert climate. The study, experimental and theoretical, supported the claim that when a heat pump evaporator was added, production of pure water was increased. It was followed by steam condensation and exposing the condenser to sunlight. This was best installation for the distiller. This improvement was then succeeded by the addition of a black sponge layer to the evaporator and then thin-thick glass application. A powder mix experiment showed that cooling air close to the outer face of the cover increased the quantity of distilled water. Lastly, the experiment with a two layer of glass, which is not a procedure, played a great role on increasing production. Summing up, the study under consideration can be defined as a process that includes condenser cooling and evaporator heating procedure. One of the advantages is the elimination of direct heat exchange between these two components and restriction of the heat exchange between these two components to the one in the distillation cell.

1. INTRODUCTION

The The rise in the standard of living and development in all areas has led to a significant increase in population, resulting in a shortage of drinking water resources and pollution resulting from industrial development. As a result of these dangerous phenomena, many countries around the world are trying to provide potable water by developing and improving water resources, rationalizing consumption, desalinating seawater, and purifying sewage and industrial water. Among the proposed solutions are renewable energy, as it is a means of spreading greater justice in the world between rich and poor countries [1]. Rather this does not only apply to the living today. Today's energy maximization will not leave no opportunity to future generations. Conversely, by using renewable sources of energy especially solar energy we shall make our children and grand children's future more secure [2]. That is the way German Environment Minister Sigmar Gabriel defined renewable energy in his speech at the third World Renewable Energy Forum in Bonn. Hydropower, organic energy, and other types of energy include solar energy and natural gas. Renewable energy is vital for the future, and it is hoped that it will provide energy and potable water on a continuous basis [3]. Natural energy is considered a "natural" energy. In addition, applying modern technologies to generate these types of energy will enable us to provide inexhaustible and non-polluting energy, purify and desalinate water more quickly and provide potable water in a greater and better way, as well as provide multiple job opportunities for young people. This was confirmed by the conference attendees, headed by the President of the World Renewable Energy Council, Hermann Scheer [4]. The conference president, Hermann Scheer, emphasized the importance of renewable energy, especially solar energy, for a long time, and considers it a source of water in the future. The table below explains that each country has a value of potable water from 1990 to 2025. [5]
Given the depletion of traditional energy sources such as oil and coal, and even efficient and highly efficient energy sources such as nuclear energy, it is necessary to search for sustainable energy sources or energy sources that can be renewed. Among these promising energies is solar energy, represented by photovoltaic action [6]. In this research, the thermal form of solar energy, represented by thermal radiation, and its electrical form, will be studied. The research will examine the

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thermal form of solar energy for the production of potable water. This water can be either completely pure (for distillation) or purified of some of the dissolved mineral salts. It is then treated to produce potable water [7].
Water purification technologies are essential and important for providing potable water for daily use in communities, especially if these technologies are simple and inexpensive. From this perspective, communities suffering from water scarcity can be supported by solar distillation devices with improvements to provide sufficient quantities of water, with sufficient solar radiation to operate these devices [8]. This study will address some improvements to basin distillation devices, and more details will be provided on this topic. Adding evaporator or condenser fittings to achieve the best installation, and the remaining chapters
This study focuses on solar stills, which rely on the thermal action resulting from solar radiation. It also aims to improve the efficiency of each still and determine the most efficient one [9]. This study was conducted on the theoretical side and the internal and external variables. It also included an experimental study to obtain experimental models and theoretical simulations of the variables involved in solar still operation [10].

2. SOLAR DISTILLATION

Solar distillation is a simpler and more economical technology than other available methods for water purification. The solar still contains impure water. Sunlight is passed through the glass cover to heat it, which then evaporates. The purified water vapor condenses on the inside of the still. As the water inside the still evaporates, all contaminants leave the inside of the glass [11]. This water is collected in a sealed container and destined for consumption, either as pure water for laboratory use or for drinking. There have been a great number of designs for solar distillation systems which have been constructed in many regions of the world over the years. This chapter in turn summarizes the technological advances of the various present-day solar distillation systems built by various researchers, including details such as the operating principle and nature of the conventional solar still without additives [12]. The review is also extended to thermal simulation of some existing solar distillation systems, comparing them with existing ones, and comparative studies of various solar distillers. Research and development are ongoing to this day.
Its production of pure water, and where Solar distillation systems are classified according to the improvements made to these devices, such as the degree of solar radiation, the degree of Many factors affect the performance of the distiller, such as the depth of the water in the tank, the tank material, the speed of the water, the ambient temperature, and the angle of inclination [13]. The production of each of the forms of solar energy will rely on the measure of temperature differences between the warm water in the tank from the inner surface of the glass cover [14]. In such a traditional distiller having not been im acted, sunlight is absorbed by that water stored in the cistern directly. Therefore evaporation will cause the tank since only solar radiation is used to raise the temperature of water and dimming the radiation which will consequently reduce production of the distiller [15]. That is the primary limitation of traditional solar distillers. In order to solve above problem, a number of solar distillers have been designed. Additional thermal energy must, therefore, be added to the tank to enhance its production or removing heat from the condenser [16]. This is the evaporation rate and through an external source for z. In special reviews (Kabeel et al. 1 and (2016) (Sampathkumar et al.) I have relied on both (2010 (Tiwari et al.) for improvements at the level of evaporators and condensers, respectively, and the classification is as follows (2008) Distillation by heating the evaporator at high temperatures - and hot water is fed into the basin from a solar collector [17]. Hot water is introduced into the basin at a flow rate of using preheating (Distillers operating) for night production - and hot water is fed into the basin once a day. 3) Distillers operating) 4) Low-temperature condenser-cooled distillation - In this type, the condenser is cooled by heat exchange with a source. The performance of the solar still is improved by some uncontrollable factors, such as radiation intensity. It cannot be predicted. However, there are some factors, such as water depth and the angle of the glass cover [18].

2.1. High-temperature distillation

It is known that water temperature increases by providing additional thermal energy. Therefore, solar radiation collectors for heating water can be used to improve the evaporation process in distillers at temperatures of (1-80) degrees Celsius. Figure (2-50) degrees Celsius to (70 - high temperature) The temperature can be raised from the range (20) [19].
summarizes all types that rely on this method.
Flat plate collector based solar energy: Distillers operating either in forced circulation mode (FPC Flat Plate Collector); solar Distillers coupled with a flat plate collector operate in natural circulation mode. When a forced circulation mode has been achieved, a pump is used to supply water. In natural circulation mode, water occurs because of density difference of water in accordance to the description of the researcher (2010) [20]. Solar distiller associated to a flatbed parallel with the evaporator having a flat plate collector. Experimental solar distiller attached to a flat plate collector, in parallel direction to the evaporator bed.
Demonstrates the details of the installation. The basic collector, in fact, involves a flat, parallel plate coupled to the evaporator (schematic in figure 1) with an air gap gap which represents the distillation cell. Water moved through the air

gap through absorbent fibers, and the distilled water is collected at the bottom of the distillation cell [21]. Solar still joined to flat plate parallel to the evaporator and its collector is flat plate: 1. Together with the team, he investigated the various effects of a vertical solar still when combined with the flat plate collector. (Kiatsiriroat et al., 1987). The distillation unit, comprises a vertical 'n' plate (3). The distillation unit consists of a flat solar still (see Figure (2)). The first plate is insulated on one of its sides, the last is exposed to the surrounding atmosphere [22].
On one side of each plate in the box there is a wet cloth. The cloth in extended upwards for feeding and downwards for recirculation. Untreated excess water can be pumped out to bottom of the plate without recirculation. The last plate is air or water cooled. The plate rate shows a slight increase up to the value of 5 when the plate number is above 5, increases by approximately 34 and 15% when the evaporation plate numbers are 1 and 2 respectively.

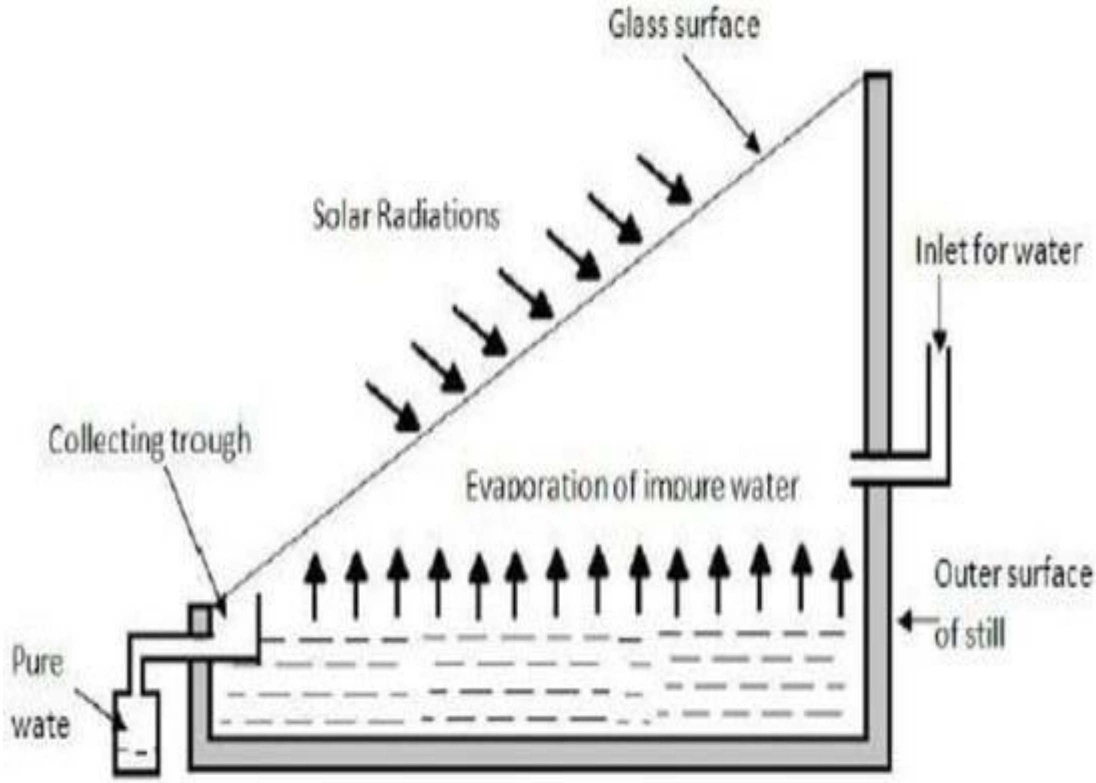

Fig. 1. Solar distillation

2.2. Solar Basin Distillers

Saltwater can be purified and made potable either thermally by evaporating and re-condensing it, or by pressing it through filters that allow only water molecules to pass through, a process known as reverse osmosis [24].
A large number of designs have been studied that rely on solar energy to evaporate water and re-condense it, thus making it potable [25]. A number of these designs will be reviewed below:

2.2.1. Basin Water Distiller

Figure 2 shows the simplest, most common, and most studied design of solar water distillers. This design consists of a basin with a volume of water at its bottom. The basin's bottom is coated with a solar-absorbing material, which heats the water and causes it to evaporate. The vapor condenses on the transparent, tilted basin cover, and the water droplets slide down to a dedicated channel that leads them out of the basin [26]. The resulting distilled water yield depends on several factors, including the intensity of solar radiation, the temperature of the external environment, the angle of inclination of the glass cover, and the depth of the water at the bottom of the basin. Numerous studies have been conducted on the effect of these factors on the resulting distilled water yield [27]. It has been shown that the yield of a basin water distiller in its simplest form is approximately 20%, and can increase to approximately 46% if improvements are made to increase solar absorption, such as adding colorants to the water or increasing the evaporation surface, such as using capillary materials on a wavy surface [28].

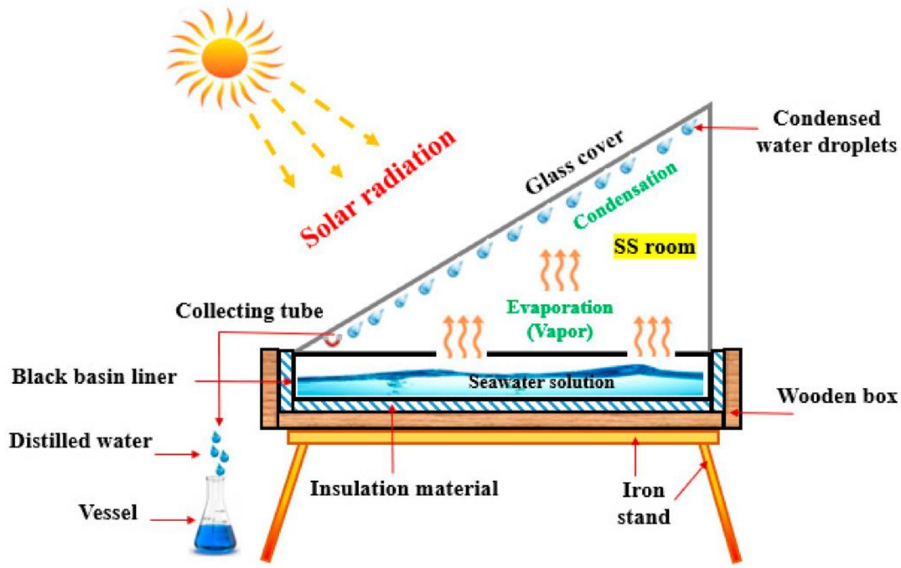

Fig. 2. Basin Water Distiller

2.2.2. Inclined water still with an absorbent material (wick).

Figure 3 shows a diagram of an inclined still with an absorbent material. It differs from a basin still in that it is inclined and contains a capillary material at the bottom [29]. This material distributes the salt water by capillary action (black wick) across the entire lower surface of the basin. This method ensures the absence of dry spots on the surface (capillary effect), which contributes to improved yield. The inclined still with a capillary action is characterized by a much lower amount of salt water inside the basin compared to a horizontal basin still. This results in a faster temperature rise, which in turn leads to improved yield. This yield reached 53% (Wick) [30].

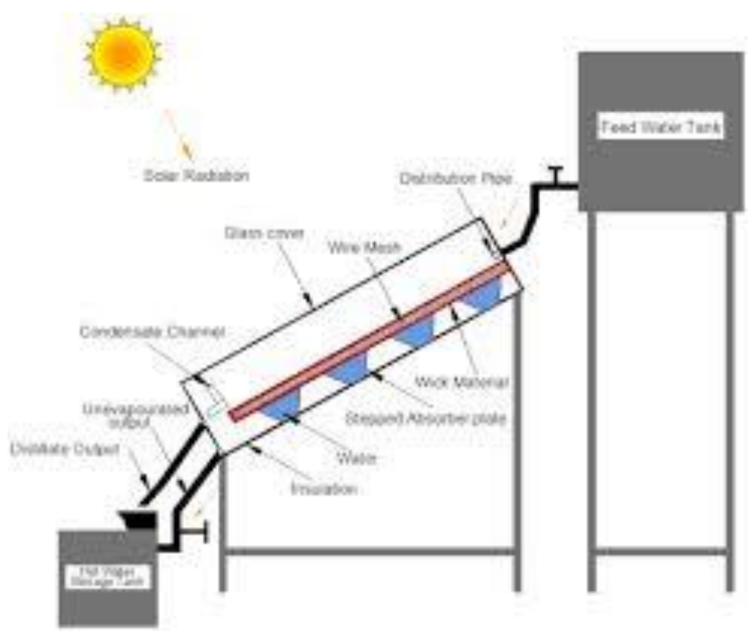

Fig. 3. Inclined water still with an absorbent material (wick)

2.2.3. Double-effect basin still

Figure 4 shows a diagram of a double-effect basin still, divided into two sections, similar to a conventional still (Figure 4). The second section (first effect) is located above the first section and uses the heat generated (second effect) [31] by the condensation of water in the first section to heat the water, increasing the yield by up to 50%.

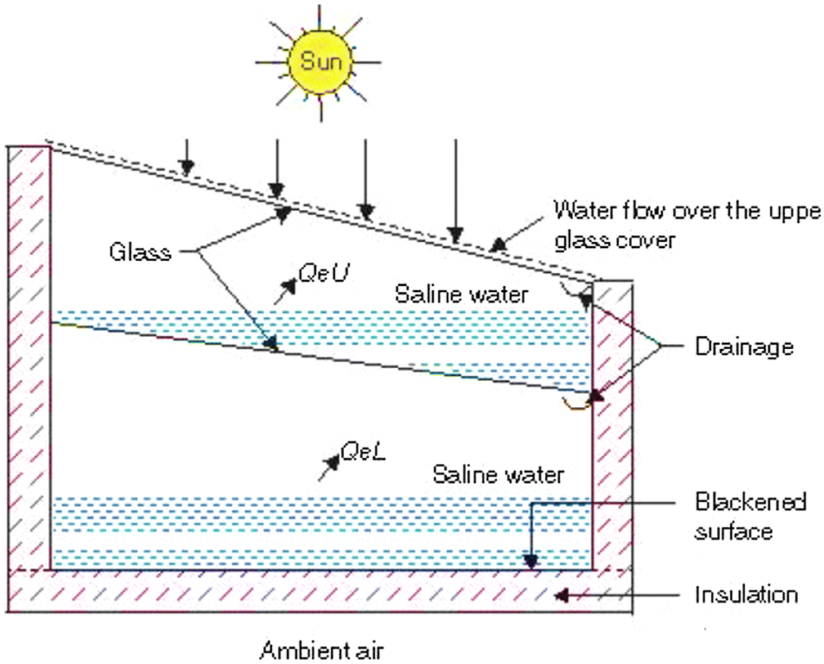

Fig. 4. Double-effect basin still

2.2.4. Solar still with a concave wick evaporative surface

In this design, the surface of the tank was shaped concave, creating a large evaporative surface area. This surface was covered with a capillary material. The glass cover of the tank was pyramid-shaped, creating a large condensation surface area [32]. Experimental results showed that the average yield of distilled water was 4 liters per square meter per day, while the energy efficiency was 38%. [Figure 5].

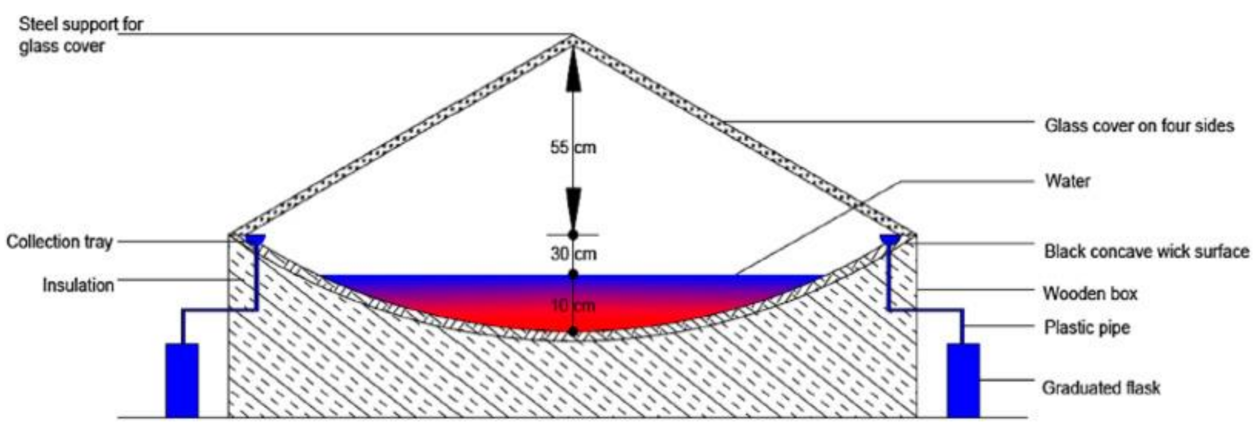

Fig. 5. Double-effect basin still

3. TESTING OF SOLAR DISTILLATION

Two series of experiments, each lasting three days, were conducted. The first series measured the thermal and production yield of distilled water over three consecutive days, from July 9 to August 23, 2024, without the fabric barriers. The second series of experiments was conducted from September 3 to September 22, 2024, but with the fabric barriers. The experiments began at 8:30 a.m., with 5 liters of non-potable water placed in the distillation tank. The glass cover was cleaned of dust from the previous day. Then, from 9:00 a.m. to 4:00 p.m., the solar radiation intensity perpendicular to the glass cover and the amount of distilled water produced per hour were measured. Weather conditions during both experimental periods were similar in terms of temperature and wind speed, allowing for an assessment of the effect of the fabric barriers on yield.

4. CONCLUSION

The simple, single-slope solar still is a good, simple, and inexpensive method. This study relied on using a heat pump through a set of experiments to improve the performance of the simple solar still. The experiments consisted of two groups (groups one and two), each differing from the other in the method of connecting the heat pump evaporator to the distillation cell. The principle used in these experiments was as follows: Two solar stills were used with the same dimensions and type of manufactured materials and under the same atmospheric conditions. However, the difference was in leaving the first solar still without any additions and the second solar still with additions, represented by connecting the pump parts to the solar still. The thermal experiments resulted in a set of results that will serve as an important reference for future studies. There were some drawbacks after conducting the experiments.

Conflicts Of Interest

The author's paper explicitly states that there are no conflicts of interest to be disclosed.

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