Journal of Renewable Energy and Sustainable Development (RESD) Volume 10, Issue 2, December 2024 - ISSN 2356-8569
http://dx.doi.org/10.21622/RESD.2024.10.2.1015

Received on, 15 September 2024 Accepted on, 21 November 2024 Published on, 28 November 2024

A Practical Comparative Study of a Single-slope Solar Still with an Enhanced Design

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ABSTRACT

In this paper, an attempt was made to design and fabricate an improved single-slope solar still using a semicircular metal absorber plate. The proposed semicircular solar still (SSS) was tested alongside conventional solar still (CSS) made with the same materials and absorption plate area. The new design (SSS) allows for the best possible use of solar radiation by minimizing the shadow of the side walls of the structure on the metal absorber plate. The semicircular solar still (SSS) design allows using a range of additives, significantly enhancing the value of freshwater yield production. Practical results showed that semicircular solar energy still enhances the pure water yield by 22.08 to 37.21% compared to the traditional model. Using a semicircular solar still with an internal reflector and transversely perforated cylindrical fins with a grooved upper surface (SSS-RTCF) showed a maximum productivity enhancement of up to 104%. This increase in pure water production for (SSS), coupled with the stability in the cost of manufacturing the solar distillation device, led to a decrease in the cost of producing a liter of fresh water from about 0.0332 to 0.0166 dollars, that is, a reduction of up to 50% compared to (CSS).

Index-words: *Single-slope solar still with innovative design, Semicircular solar still, Cylindrical fins, Desalination system, Cost analysis.*

Nomenclature		Subscripts	
A	area (m^2)	a	ambient
cp	specific heat (J/kg K)	b	basin
h	heat transfer coefficient (W/m^2 K)	c	convection
I	solar radiation intensity (W/m^2)	d	daily
k	thermal conductivity (W/m K)	s	Sky
m	mass (kg)	e	evaporation
P	productivity (kg/m2)	g	glass
T	temperature (C^o)	ins	insulation
t	time (sec)	Greek	
U	heat loss coefficient (W/m^2 K)	τ	transmissivity
X	thickness (m)	ρ	density (kg/m^3)
α	absorptivity	σ	Stefan-Boltizmann's constant ($W/m^2 K^4$)
		ε	emissivity
		η	efficiency (%)
		θ	angle of inclination (Degree)

I. INTRODUCTION

Due to the increasing population mass around the world and the accompanying urban and industrial development, the share of fresh water per capita decreased by 27.27% during the period from 2000 onwards [1]. With the rise in global fuel prices, the increasing problems of pollution and global warming, and the weak infrastructure in many developing countries, all of this makes solar energy a successful and important solution for powering many applications, including water solar stills. The first conventional solar still was designed and used by Wilson in 1883 to provide fresh water to a factory [2]. Then came many improvements to the traditional form through many studies that are presented to improve performance and productivity [3-8]. Velmurugan et al. [9] present a pilot study to increase the productivity of a conventional solar still by about 75% using a finned absorption plate containing pieces of black rubber, sand, small pebbles, and sponge pieces. It includes a practical study presented by Hadj-Taieb et al. [10] on the use of a monoclinic solar still supported by trays filled with different types of sand layers, in addition to the use of internal reflectors.

The results show that the cumulative productivity increased by 105% compared to the traditional solar still. The results obtained from the experimental study presented by Davra et al. [11] show that the double-basin solar still achieves an increase in productivity of about 57.83% compared to the conventional solar still. A practical study presented by Davra et al. [12] involves the use of a stepped-type solar still reinforced with a layer of paraffin wax as the phase change material. The achieved results show that the increase in overall energy efficiency amounted to about 86.57% compared to the traditional model. Amiri [13] presents a practical study that includes the use of an enhanced passive condenser, which leads to an increase in daily productivity of about 30% to 150% compared to the traditional model. Ramnarayan and Aseem [14] present an experimental study involving a single-slope solar still using three different types of nano-solutions with a layer depth of 0.5 cm. Experimental results show that the use of the nanosolution increases the maximum efficiency to 17.06% compared to the conventional model. Abdullah et al. [15] present a practical study that includes testing a modified single-slope solar still that uses a copper coil to heat turbid water. The results obtained show that thermal productivity/efficiency increased by about 76% compared to the conventional model. A practical study is presented by Saha et al. [16] for the design, manufacture, and testing of a double slope vacuum solar still reinforced with a phase change material. The results obtained show that cumulative productivity increases by approximately 63% compared with traditional solar stills. The experimental study presented by Zhenyuan Xu et al. [17] concludes that using a multi-stage solar still increases productivity by about 75% compared to a traditional still. A literature review study presented by Singh et al. [18] shows the extent of the influence of weather conditions on the total productivity of the solar still. Dhivagar and Mohanraj [19] present an analytical study to determine the environmental and economic impact of using a single-slope solar still during its life span, which is estimated at ten years. The results show that relying on solar energy for water desalination contributes to reducing the volume of carbon dioxide generated by about 14.1 tons and saving $338.4 in energy allocations. Sourabh et al. [20] present a literature review study to clarify the extent to which the depth of turbid water present in the absorption basin of the solar still affects efficiency and overall productivity. The study concludes that efficiency and productivity are greater at the aquarium water depth (1-2 cm). Several literature review studies have been presented regarding the designs and improvements used to enhance the productivity and efficiency of different solar still designs [21-26].

From the studies presented, it can be said that solar stills are designed with well-known and specific geometric shapes (single-slope, double-slope, spherical, cylindrical, conical, and others), while most of the current studies works to add improvements to those shapes without changing the general geometric shape.

This research presents a practical study that includes the design and testing of a solar still with a completely new design. A single-slope, semicircular solar still is designed, implemented, and tested under the real climatic conditions of the Iraqi city of Najaf.

The solar still innovative semicircular design optimizes the utilization of available solar radiation by minimizing the shadow cast by the vertical walls on the metallic absorption part.

A. Experimental Setup

As seen in figure 1, the experimental configuration consists of a cork structure that is 7 cm thick with a single-slope semicircular geometry, an inner radius of 40 cm, and an inclination angle of 32.1°.

The solar still basin is designed with a semicircular plate with an area of 0.25 m2 and a thickness of 1 mm, is made of galvanized sheet, which is characterized by its cheap price and high conductivity, and is coated with a matte black lacquer to increase the absorption. To increase the surface contact area, twenty transversely perforated cylindrical fins with a height of 1 cm are used and welded to the bottom of the absorption basin. The metal basin is inserted into the cork structure so that it is completely adjacent to the base and internal walls of the structure.

The cork structure is covered from above with a glass cover with a thickness of 4 mm and an inclination angle of 32.1 degrees, which corresponds to the latitude of Najaf, Iraq.

A PVC collecting channel is installed at the lower end of the glass cover from the inside so that the water condensed on the inner surface of the glass is transported through the collecting channel to the yield flask outside the rig. The thermocouples are passed to measure the temperature of the absorption plate, turbid water layer, vapor content, and glass cover through a small side hole in the cork structure.

Using a mechanical float, the sea turbid water level is adjusted to a depth of 1 cm, while dust and salt deposits are removed through a control hole at the bottom of the black basin.

In exactly the same way and from the same materials as the semicircular solar still, a conventional solar still is made consisting of a square metal absorber with a side length of 0.5 m fixed inside a cork frame with a small front side height of 4 cm, while the upper face of the cork frame is covered with 4 mm-thick transparent glass with an inclination 32.1°.

Two thermocouples are installed at each of the basin plate, brackish water, steam, and glass cover, while these thermocouples are connected to a digital temperature reader type Hit-HT-9815. On a related note, the intensity of solar radiation is measured using a calibrated pyrometer type, the Metravi-207. The PCE-420 digital device is used to measure the wind speed.

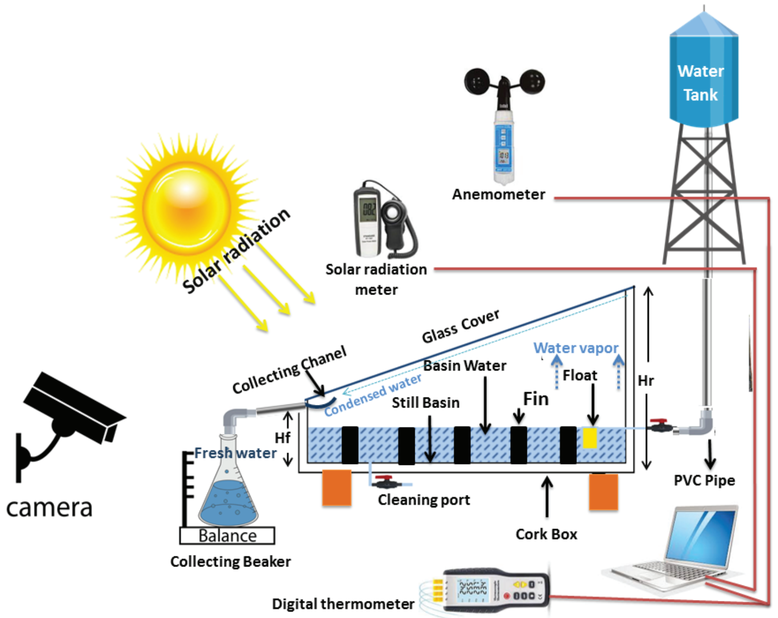

Fig. 1. The experimental setup schematic diagram

B. *Adjustment to the Type of Fins Used*

The fins act as an extended surface that raises the temperature of the turbid water, increasing the rate of distillate production. Therefore, in this work, three types of cylindrical fins manufactured from automotive iron scrap are tested to determine the best one. Twenty fins of each type are tested within three identical rigs of the semicircular solar still used in this experiment.

1. Solar Still with Solid Cylindrical Fins

The free area of the turbid water basin is 0.25 m^2. To enhance productivity, solid cylindrical iron fins with a height of 1 cm and a radius of 1 cm are also used, as shown in figure 2.a. These fins are painted black. While the turbid water reaches the surface of the fins. The use of fins increases the metal absorption surface exposed to solar radiation, as well as increasing the contact area between the sea turbid water layer and the metal absorption basin, which increases the ability to heat exchange and thus increases the temperature of the turbid water basin, which increases the difference between the temperature of the glass layer and the water layer, which causes high yield productivity.

2. Solar Still with Transversely Perforated Cylindrical Fins

Cylindrical fins are used that contain 3 transverse holes, each with a diameter of 3 mm, spaced apart from each other at an angle of 120 degrees, as in figure 2.b. Perforated fins are used transversely to contribute to increasing the heat exchange area as a result of water passing through the fin body, which increases crop productivity as a result of high saltwater temperatures.

3. Solar Still with Transversely Perforated Cylindrical Fins with a Grooved Upper Surface

Transversely perforated cylindrical fins were used with the same specifications as before, with the difference that their upper surface contains 1.5 mm-thick slits, as shown in figure 2.c, which leads to a broader improvement in the heat exchange process as a result of increasing the surface area for absorption and heat exchange, which leads to raising the temperature of the saltwater basin and increasing productivity.

C. *Use an Internal Reflector*

A semicircular reflector made of inexpensive aluminum foil is attached to the inner wall of the cork structure, as shown in figure 2.a. The reflector works to increase the concentration of solar radiation towards the black absorption plate, which raises the temperature of the water basin and thus increases yield production.

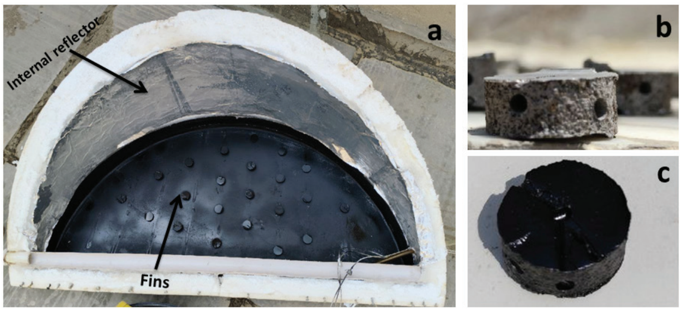

Fig. 2. (a) The internal reflector and the cylindrical fins arrangement used inside the absorption basin, (b) transversely perforated cylindrical fins, and (c) transversely perforated cylindrical fins with a grooved upper surface

D. *Methodology of Experimental*

Through a one-way bypass valve, raw water is passed from the side water tank to the solar still basin. To keep the raw water in the basin at a height of 1 cm, the end of this valve is attached to a mechanical float. As the incoming free solar radiation passes through the layers of glass and water and reaches the black absorption plate, which absorbs it, the temperature of the plate rises. This causes the temperature of the saltwater to progressively rise by conduction, which causes it to evaporate. The vapor condenses on the glass cover inner surface and moves along it in the direction of the PVC collecting tube. Using a clear plastic hose, the water collected in the collection channel is transferred to an external glass beaker.

The experiments were conducted on April 13, 2024, from 7 a.m. to 10 p.m. Solar radiation intensity, wind speed, ambient air temperature, absorption basin temperature, water layer temperature, cover glass temperature, and distilled water productivity are measured hourly. The measuring devices used in this practical experiment are distributed and installed, as shown in Figure 3. Because sea water is used, the absorption plate is usually cleaned, and clay and salt deposits are removed periodically through a control valve located at the bottom of the basin.

The results obtained for the semicircular model are compared with the traditional model manufactured with the same specifications, as shown in figure 4.

The results obtained from the practical experiment of the proposed model are compared with the conventional solar still device made with the same absorption plate area, the same materials used, under the same weather conditions, and at the same test time.

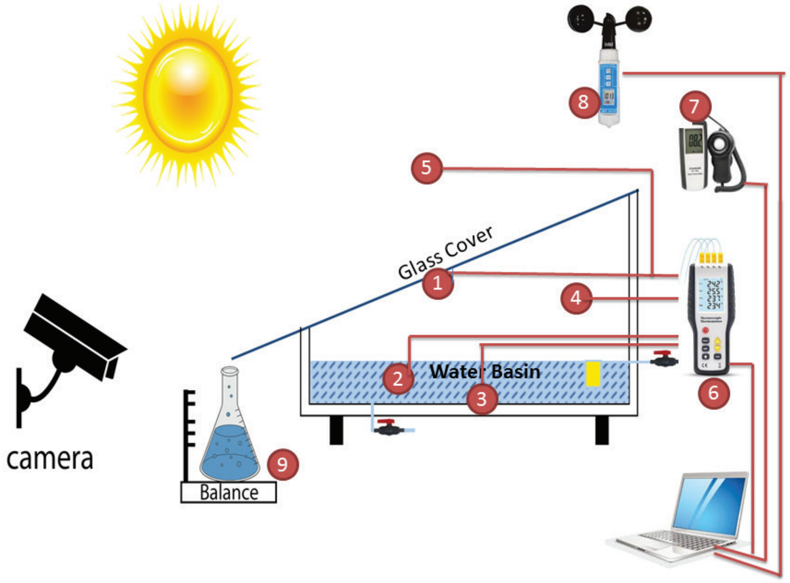

Fig. 3. Distribution of measuring devices used in the practical experiment. (1-5 thermocouples locations, 6-Thermometer Data Logger, 7-Solar irradiance meter, 8-Wind speed meter, and 9-Beaker for yield)

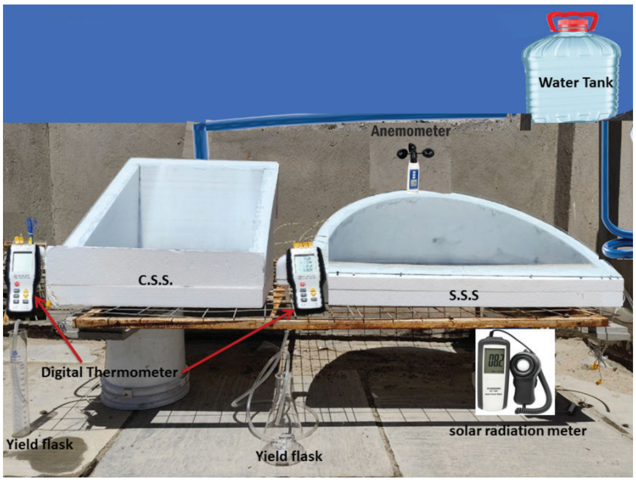

Fig. 4. A comparison between the semicircular solar still used in the practical experiment and the traditional solar still with all accessories and measuring devices

E. Mathematical Model

This theoretical analysis aims to know the temperature of the water basin, the temperature of the glass cover, and the evaporation rate at every moment.

1. The following assumptions are applied to solve the heat balance equations for the single-slope solar still [27-29]:

I. There is no leakage of steam mass outside the solar still.

II. All the flow inside will still be laminar.

2. Heat balance equations of still parts [30-33]:

The algebraic result of the summations of the energy gained through the black absorption plate, the energy lost by convection from the basin to the turbid water layer, and other collateral losses are called the absorption basin energy.

$$m_b c_{p,b}\left(\frac{dT_b}{dt}\right) = A_w[I\alpha_b - h_{cwb}(T_b - T_w) - U_b(T_b - T_a)] \quad (1)$$

The energy that the saline water in the still receives from the solar radiation and absorber plate is equal to the total of the energy that is lost through radiative heat transfer, evaporative heat transfer, and convective heat transfer between water and glass.

$$m_w c_{p,w}\left(\frac{dT_w}{dt}\right) = A_w[I\alpha_w + h_{cbw}(T_b - T_w)] \\ - A_w h_{wg}\left(T_w - T_g\right) - A_w U_{ins,w}(T_w - T_a) \tag{2}$$

The total amount of energy lost by radiative and convective heat transfer between glass and ambient is equal to the energy acquired by the glass cover (from the solar and convective, radiative, and evaporative heat transfer from raw water to the glass layer).

$$m_g c_{p,g}\left(\frac{dT_g}{dt}\right) = A_g \alpha_g I + A_w h_{wg}\left(T_w - T_g\right) \\ - A_g h_{rgs}\left(T_g - T_s\right) - A_g h_{cga}\left(T_g - T_a\right) \tag{3}$$

Hourly weather factors obtained from practical experience are used to solve the above equations through mathematics and obtain the total value of productivity or return obtained [34].

$$P_d = \frac{dm_e}{dt} = h_{e,w-g}\frac{[T_w - T_g]}{[h_{fg}]} \tag{4}$$

All factors required in the mathematical solution are listed in Table I [6]:

TABLE I
FACTORS REQUIRED TO SOLVE EQUATIONS MATHEMATICALLY.

Parameter	Value	Parameter	Value	Parameter	Value
ε_g	0.88	$k_{ins}(w/m.k)$	0.03	$x_b\ (m)$	0.001
τ_g	0.9	$cp_w\ (J/kg\ K)$	4190	$\rho_b\ (kg/m^3)$	7870
τ_w	0.95	$A_w(m^2)$	0.25	$\sigma(W/m^2K^4)$	5.669x10^{-8}
α_b	0.9	$x_g\ (m)$	0.004	$m_w(kg)$	2.5
α_g	0.05	$Cp\ b\ (J/kg\ K)$	460	$\theta(Degree)$	32.1
α_w	0.05	$k_b(W/m.K)$	73	$U_{ins,w}(\frac{w}{m^2 k})$	0.5
ε_w	0.96				

F. Comparing the Physical and Chemical Analysis of the Water Produced from Solar Stills with the Natural Sources of Water Available

A physical and chemical analysis of the water available and used within the geographic region of Najaf Governorate, Iraq (Najaf Sea water, well water, and Euphrates River water in Kufa) is conducted and compared with the water yield obtained from the solar still, and the results are as shown in Table II.

TABLE II
PHYSICAL AND CHEMICAL ANALYSIS OF THE WATER AVAILABLE IN NAJAF GOVERNORATE, IRAQ, AND THE WATER RESULTING FROM THE SOLAR STILL.

Parameters		Najaf Sea	Well	Kufa Euphrates River	Distilled water
PH		30	8	7.98	7.3
TDS (mg/l)		37500	2820	433	110
Negative Ions (PPM)	HCO_3	18000	206	240	59
	CI	84977	611	377	6
	SO_4	4081	1143	107	4
Positive Ions (PPM)	K	805	26	113	1
	Na	1045	372	218	8
	Mg	11344	131	70	2
	Ca	1763	332	148	15

From Table II, one notes that the quality of water resulting from solar still has physical and chemical properties that make it conform to the specifications approved by the World Health Organization and thus be suitable for human consumption.

G. *Analysis of Uncertainties*

The percentage of uncertainty (error) calculated for all measuring tools used in the practical experiment (thermocouples, digital temperature reader, solar radiation, anemometer, and collection flask) by using general equation as shown in Table III [40].

$$\partial f = \sqrt{\left(\frac{\partial f}{\partial x_1}\,\delta x_1\right)^2 + \left(\frac{\partial f}{\partial x_2}\,\delta x_2\right)^2 + \cdots + \left(\frac{\partial f}{\partial x_n}\,\delta x_n\right)^2} \quad (5)$$

TABLE III
MEASURING INSTRUMENTS USED IN PRACTICAL EXPERIMENT INTERMS OFACCURACY AND RANGE.

No.	Instrument	Accuracy	Range	%Error
1	K-type thermocouple	±1 ℃	0-100 ℃	0.25
2	Hit-HT-9815 thermometer	±2 ℃	-200-1350 ℃	0.5
3	Metravi-207 Solar meter	$\pm 1\,\frac{w}{m^2}$	0-5000 $\frac{w}{m^2}$	0.25
4	PCE-420 Anemometer	$\pm 0.1\,\frac{m}{s}$	0-25 $\frac{m}{s}$	10
5	Collection Flask	$\pm 10\ ml$	0-1000 ml	10

H. *Results and Discussion*

The newly designed semicircular solar still is reinforced with different-shaped cylindrical fins and an internal reflector to enhance its productivity. Table IV shows the values of the maximum and minimum temperatures for water and glass and the percentage improvement in productivity and efficiency for the various modifications applied in practice. The maximum increase in productivity was 104% when using a semicircular solar still with an internal reflector and transversely perforated cylindrical fins with a grooved upper surface. The practical performance of the semicircular solar still used in this experiment is compared with the traditional solar still.

The performance achieved from the practical experiment is compared with the different designs presented by previous researchers, as shown in Table V (Tables 1–6).

TABLE IV
THE MAXIMUM AND MINIMUM TEMPERATURES AND THE VALUE OF THE INCREASE IN PRODUCTIVITY FOR THE VARIOUS MODELS USED IN THE PRACTICAL EXPERIMENT.

No.	Modification	During high radiation (981 w/m^2)				During low radiation (220 w/m^2)			
		T_w (°C)	T_g (°C)	Productivity (ml)	%Increase in Productivity	T_w (°C)	T_g (°C)	Productivity (ml)	%Increase in Productivity
1	Conventional still (CSS)	59.2	43.1	77	Ref.	40.3	33.4	43	Ref.
2	Semicircular solar still (SSS)	69.5	44	94	22.08	49.1	35.2	59	37.21
3	Semicircular solar still with cylindrical fins (SSS- CF)	71.3	44.7	99	28.57	48.5	33.2	70	62.79
4	Semicircular solar still with transversely perforated cylindrical fins (SSS-TCF)	73.5	44.8	108	40.26	48.5	31.6	75	74.42
5	Semicircular solar still with internal reflector with transversely perforated cylindrical fins with a grooved upper surface (SSS-RTCF)	96.3	50.1	157	104	55.9	35.5	84	95.4

TABLE V
A COMPARISON BETWEEN THE PERFORMANCE OF THE SOLAR STILL USED IN THE PRACTICAL EXPERIMENT AND THE PERFORMANCE OF SOLAR STILLS WITH DIFFERENT SHAPES PRESENTED BY PREVIOUS RESEARCHERS.

No.	Title of the paper and Author	Geometric shape of the solar still	Types of feed water	%Increase in production	Ref.
1	Performance improvement of double slope solar still via combinations of low-cost materials integrated with glass cooling - Khaled Elmaadawy et al.	Double slope solar still	Fed with salt water	68%	[35]
2	Experimental study with thermal and economic analysis for some modifications on cylindrical sector and double slope, single basin solar still - El-Sebaey et al.	cylindrical sector solar still	Fed with salt water	40.67%	[36]
3	Comparative performance of spherical, hemispherical, and single-sloped solar distillers - A.E. Kabeel et al.	Spherical solar still	Fed with salt water	77.42%	[37]
4	Novel Design of Double Slope Solar Distiller with Prismatic Absorber Basin, Linen Wicks, and Dual Parallel Spraying Nozzles: Experimental Investigation and Energic–Exergic-Economic Analyses – M. E. Zaye.	Prismatic Absorber Basin	Fed with salt water	49.64%	[38]
5	Theoretical and experimental investigation on double basin double slope solar still -T. Rajaseenivasan and K. Kalidasa Murugavel	double basin double slope solar still	Fed with salt water	85%	[39]
6	In this work	Semi-circular solar still	It is fed by Najaf sea water	104%	—

From Table V, it is clear that the improvement in productivity achieved in this work as a result of using the solar still with a semicircular design is greater than what previous researchers achieved with the different designs presented, so that it increases by 20% over the highest design presented, which makes the semicircular-solar still that is presented in this study of great importance.

1. Impact of Solar Radiation on Yield

The practical experiments were conducted on April 13, 2024, under real weather conditions in the city of Najaf, Iraq. Considering semicircular solar still with internal reflector with transversely perforated cylindrical fins with a grooved upper surface (SSS-RTCF), the results obtained show that increasing the maximum amount of solar radiation from 917w/m^2 to 981w/m^2 to an increase in productivity from 91ml to 158ml as shown in figure 5. It is clear that the increase in the heat capacity of the basin is due to the increased concentration of solar radiation on the absorption basin as a result of the use of the internal reflector and the increase in the absorption surface area as a result of the installation of the cylindrical fins.

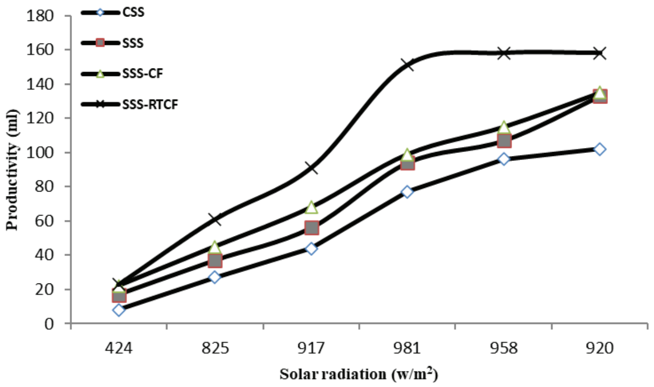

Fig. 5. The effect of changing the value of solar radiation on the amount of distilled water production

2. The impact of Wind Speed on Yield

By fixing the value of solar radiation at 917 watts, data for different days of the practical experiment with different air speeds for all rigs are selected and represented in figure 6. Considering the (SSS-RTCF) rig, increasing the wind speed from 4 to 8 m/s leads to a change in productivity from 91 ml to 83 ml. This means that increasing wind speed leads to an increase in the amount of heat lost by convection from the glass cover to the external environment.

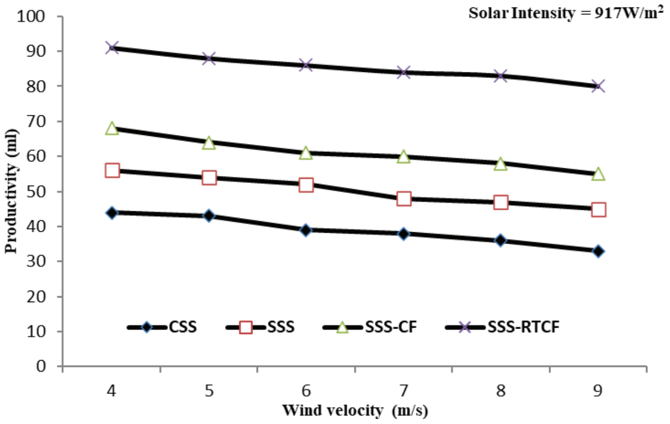

Fig. 6. The effect of changing the value of wind speed on the amount of distilled water production

3. Comparison of Practical and Theoretical Performance of the Semi-circular Solar Still

An analytical comparison between the practical and theoretical results of the solar stills used in the practical experiment (for the traditional solar still and the semicircular solar still) using the Matlab 2020 program. A comparison between theoretical and experimental results for conventional and semicircular solar stills reinforced with transversely perforated cylindrical fins and an internal reflector is shown in Figure 7. While the maximum deviation between the experimental and theoretical productivity results is about 9%, at a relevant level, Figure 8 shows the weather conditions based on the values of solar radiation, wind speed, and air temperature during the experiment time.

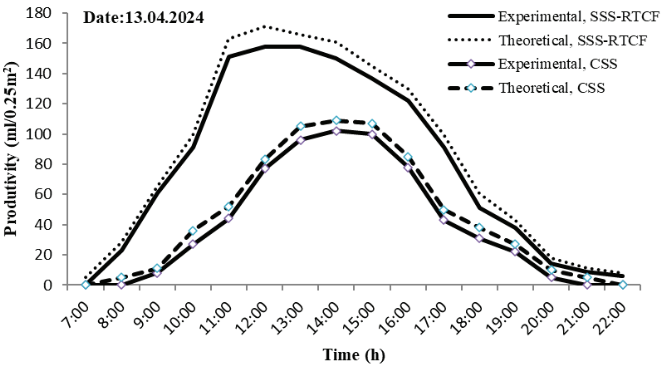

Fig. 7. Comparison between experimental and theoretical performance of a semicircular solar still with an internal reflector and transversely perforated cylindrical fins with a grooved upper surface (SSS-RTCF) and a conventional solar still (CSS)

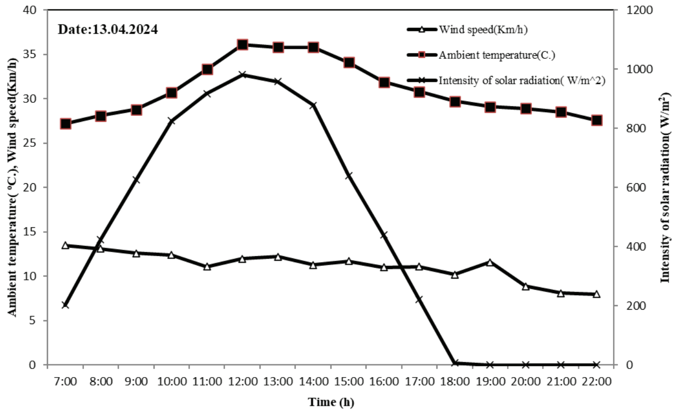

Fig. 8. Weather conditions during the time of the practical experiment

II. ECONOMIC ANALYSIS

The costs required to manufacture the semicircular solar still used in the current experiment (C) are analyzed using the following equations [40],and[41]:

$$C = \text{Fixed Cost } (F) + \text{Variable Cost } (V) \quad (1)$$

$$V = n \times 0.2 \times F \quad (2)$$

Where;

n= *The expected lifespan of the solar unit is approximately 10 years.*

The total cost of the solar still is calculated using the data shown in Table VI, as following:

$$C=21+(10\times0.2\times21)=63\$$$

The total daily yield of the conventional solar still and semicircular solar still is approximately 633ml/0.25m^2 and 1260 ml/0.25 m^2, respectively. If one assumes that the total working days of the device per year are 300 days, this means that the total production rate of the device during its life span (10 years) will be 1899L/0.25 m^2 and 3780L/0.25m^2 for CSS and SSS-RTCF, respectively.

From here, the total cost of producing one liter of fresh water can be calculated as follows:

For (CSS) 62.5/1899 = 0.033 for each L/0.25m^2.

For (SSS-RTCF) 63/3780 = 0.0166 $ for each L/0.25m^2.

TABLE IV
MATERIALS AND THEIR COSTS TO MANUFACTURE THE NEW_DESIGN SOLAR STILL.

No.	Material type	Specifications	Cost ($)
1	Cork structure.	0.1m^3	6.5
2	Glass cover with a 4mm thick.	0.33m^2	3
3	Basin made of iron plate 0.1mm thick.	0.2916m^2	7
4	Strips of aluminum foil, 0.2 mm thick	0.4m^2	0.5
5	Heat-resistant matte black dye.	1 spray piece.	1
6	Heat-resistant silicone adhesive.	1 piece.	1
7	Plastic collection and connection pipes.	3 pieces.	2
	Total Cost .		21

III. CONCLUSION

The semi-circular design of the single-slope solar still reduces the shadow of the sidewalls reflecting on the absorber plate, making the most of available solar energy. Salty sea water is used as feed. To enhance the productivity of the newly designed semicircular solar still, it is modified using an internal reflector and transversely perforated cylindrical fins that have a grooved surface. The productivity of highly saline Najaf Sea water is lower than that of low- or medium-salinity water. It is also shown that the yield productivity of the solar still is directly proportional to the value of the solar radiation intensity and inversely proportional to the wind speed. The practical results also converge closely with the theoretical results. The practical results show that semicircular solar still (SSS) design improves productivity by about 22.08 to 37.21% compared to conventional still. At the same time, the total output of the modern semicircular solar still with internal reflector with transversely perforated cylindrical fins with a grooved upper surface (SSS-RTCF) is 1260 ml/day, while the total output of the conventional solar still (CSS) is 633 ml/day. Compared to the traditional model, the enhancement of the total and maximum productivity of the semicircular solar still type (SSS-RTCF) exceeds 99% and 104%.

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