IASJ المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Fabrication and study of a single Basin Double-slope solar distilled

Yaseen H. Mahmood , Ahmed A. Rajab

Department of Physics, College of Sciences, University of Tikrit, Tikrit, Iraq

https://doi.org/10.25130/tjps.v25i6.314

ARTICLE INFO.

Article history:

-Received: 26 / 7 / 2020

-Accepted: 30 / 8 / 2020

-Available online: / / 2020

Keywords: Renewable Energy, Solar radiation, Solar Still, Heat Transfer, single basin Double-slope solar stilled.

Corresponding Author:

Name: Yaseen H. Mahmood

E-mail: Yaseen H. Mahmood

D.yaseen.ph.sc@tu.edu.iq

ahmedamer9589@gmail.com

Tel:

ABSTRACT

Solar distillation is a simple, cheap technique for obtaining safe water where either solar radiation or heat is required as a source of energy for evaporation and condensation, in this research a solar distilled form of local materials with one basin and two miles, and the examination and measurement was conducted in the Door- Salahaddin area along a longline (43.798°) and latitude (34.46°), east of the Tigris River, the characteristics of the factory distilled and the heat transfer process were studied. The following results were obtained in March, the high temperature of water and glass over time, and the increase in efficiency over time to reach the highest efficiency by 40%. Distilled is a good choice for saving water, cheap and practical.

1. Introduction

Due to the lack of potable water in remote areas and the lack of access to electricity, many research has been conducted to provide water, A significant increase in the efficiency and productivity of a distilled with different absorbent material to improve water absorbency for solar radiation as the pelvis has a two-slope cover with an effective area of $3m^2$ [1] .The project was completed on the simple dual-slope solar distilled southern Algeria on the basis of partial shading for intermittent periods of one side of the glass cover to reduce its temperature and improve the performance of condensation. This work gave an improvement of 12% of the daily output [2]. A theoretical analysis of the mechanisms of heat and mass transmission within the solar distilled has been developed and the performance of distilled has been measured, compared with theoretical analysis, as results have shown increased distilled efficiency by increasing solar radiation and increasing the temperature of the nutrient water of the distilled basin [3].A bi-slope sun distilled is designed. And achieving the ideal angle of tilt of glass (25°,30°,35°,40°) and water depth (1,2,, and 3) cm in Saudi Arabia's weather conditions [4].Develop an efficient solar distilled with high-intensity caravan-saturated salicas for precipitation radiation. Install the distilled with the gel which absorbs a large range of precipitation with internal reflections, the pelvic productivity was 49% efficient compared to 30-35% without gel [5]. The test demonstrated the effectiveness of the vertical solar distilled with the release of evaporating water on the surface of sponge fabric and indicated that the rate of production is automatically doubled with climatic conditions, the temperature of the desert area, and the temperature of the glass cover. The study also showed that the productivity of such vertical distilled varies from 0.5 to 2.3 g/m^2 of sponge area [6].Two traditional, geometric-similar solar tracks, one of which painted white, were placed on the inside walls and tested field under the atmospheric conditions of Malawi city, where the daily rate of productivity and efficiency of the solar distilled was greater than the traditional distilled [7]. Single-slope solar trailers were studied at 15°,30°,45° angles compared to the Dongle model. The current model performance is found to be higher than the Dongle model, the maximum internal mass transfer of the condenser cover gets a 45° angle of pitch and a 15° angle of intensity cover [8]. Five sunrises with different angle angles were randomly selected (4,7°,10°,13°,15°) and solar radiation, temperature and water produced for eight days, found

the greater angle of 15° to be the ideal climate for the Makiri site in Nigeria [9]. The effect of the water temperature and condenser cap tilt angle on internal heat transfer and the productivity of a single slop distilled at (15°,30°,45°) found that at 15° inclination angle the greatest value of heat transfer coefficients for the condenser cap was obtained and the lowest value at 30° and that the temperature difference between the evaporation surface and the condensation surface The greatest of the cover was at a 45° angle and the lowest difference at 15° so the greatest production at a 45° angle of inclination[10]. A study to test the performance of three single-slope sun distilled under the same conditions at a different water depth. The results of distillation, temperature, solar intensity, glass and ocean cover and the calculation of heat losses and experimental and thermal efficiencies for the fresheners have been measured, the results show that the solar distilled performs higher at a lower depth of water [11]. A composite system for focusing solar energy by multiple block panels connected to a water pump and a solar basin where warm saltwater water accumulates in Nasiriya, Iraq. Properties are calculated using theoretical equations such as: Average temperature of water, glass, and basin; convection heat transfer coefficient, radii and evaporation inside the basin; distilled water radii-output; total thermal efficiency per hour. The average temperature of water and glass and the production of distilled water throughout the day with the third different levels of the basin. This work was confirmed by comparing the water produced with distilled to other research to be approximately consistent. The increase in the number of compounds should increase the production and efficiency of distilled water (0.6kg 2/m). 1 hour and 13 respectively)[12].Assess the performance of distilled using a combined box, results showed that the amount of distilled water increased as solar radiation temperature increased. The highest solar water distillation efficiency of 11.4% was obtained on a rainy day partly cloudy between 8 a.m. and 10 a.m., the second highest distillation efficiency of 5.15 was obtained on a sunny day between 10 a.m. and 12 p.m. Results showed that distilled water can be obtained even in very bad weather, solar radiation is very low, and the higher amount of distilled water is at higher values than solar radiation. Experimental results also showed high ambient temperature, reducing condensation and distilled water [13]. Analysis of performance of the solar water distilled type hybrid pyramid to purify water and salts, and comparison of performance after adding a center (CPC) discussing performance on condensation the condensation process can be increased either by lowering the temperature of the condensation cap or by increasing the water temperature the use of the center accelerated temperature increase and increase condensation[14]. The need for studies to look for alternative ways to water purification and economic analysis to be implemented worldwide[15].

2. Theoretical part

The process of heat transfer in the solar water distilled has been discussed in detail in many research [16-17] and the most important equations used in the calculation and results will be addressed here**.**

The partial vapor pressure is given by equation (1) [16]

$$\mathbf{P_w = exp\ [\ 25.317 - (\frac{5144}{T_w})\ ]\ .....(1)}$$

Where $\mathbf{P_w}$ is Partial vapor pressure at water temperature, N/m^2 and , $\boldsymbol{T_w}$ Water Temperature °C

The Partial vapor pressure calculate by equation (2):

$$\mathbf{P_g = exp\ [\ 25.317 - (\frac{5144}{T_g})\ ]\ ....(2)}$$

Where $\mathbf{P_g}$ Partial vapor pressure at glass temperature, N/m^2,and $\boldsymbol{T_g}$, Temperature of condensing cover, °C

The difference between water and glass temperature expressed in equation (3):

$$\boldsymbol{\Delta T^*} = [(\boldsymbol{T_W - T_g}) + \frac{(P_W - P_g)(T_W + 273.15)}{268.9\times10^3 - P_W}].....(3)$$

Convective heat transfer coefficient is given by equation(4)[17]:

$$\boldsymbol{h_{cw} = 0.0884(\Delta T)^{\frac{1}{3}}}\ .....(4)$$

$\boldsymbol{h_{cw}}$Convective heat transfer coefficient from water to condensing cover, W/m^2 °C

The Rate of Convective heat transfer is given by equation (5)[17]:

$$\boldsymbol{\dot{q}_{cw} = h_{cw}(T_W - T_g).....(5)}$$

$\boldsymbol{\dot{q}_{cw}}$ Rate of Convective heat transfer from water to glass cover, W/m^2

Also Evaporative heat transfer coefficient is given by equation (6)

$$\boldsymbol{h_{ew} = 16.273 \times 10^3\ h_{cw}\frac{(p_w - p_g)}{(T_w - T_g)}}.....(6)$$

$\boldsymbol{h_{ew}}$ Evaporative heat transfer coefficient, W/m^2°C

The Rate of evaporative heat transfer is given by equation (7) [17]

$$\boldsymbol{\dot{q}_{ew} = h_{ew}\ (T_W - T_g)}\ .....(7)$$

$\boldsymbol{\dot{q}_{ew}}$ Rate of evaporative heat transfer from water to glass cover W/m^2

Also we can found the Rate of radiative from water to glass cover by equation (8,9,10)

$$\boldsymbol{\dot{q}_{rw} = h_{rw}(T_W - T_g)}....(8)$$

$\boldsymbol{\dot{q}_{rw}}$ Rate of radiative heat transfer from water to glass cover W/m^2.

$$\boldsymbol{\dot{q}_{rw} = \varepsilon_{eff}\sigma\ [(T_W + 273)^4 - (T_g + 273)^4]}\ ....(9)$$

$$\boldsymbol{\dot{q}_{rw} = \varepsilon_{eff}\sigma\ [(T_W + 273)^2 + (T_g + 273)^2][T_w + T_g + 546]}\ .....(10)$$

Where the $\boldsymbol{\sigma}$ Stefan Boltzmann constant (5.67 ×10^{-8} W/m^2 K^4)

$\boldsymbol{\varepsilon_{eff}}$ Effective emissivity of water and glass surface

Latent heat of vaporization calculated by the following equation [11]:

$$L = 2.4635 \times 10^{6}[\,1 - 9.4779 \times 10^{-4}T + 1.3132 \times 10^{-7}\,T^{2} - 4.7974 \times 10^{-9}\,T^{3}]. \quad (11)$$

L Latent heat of vaporization, J/kg

The Distillate Output can be expressed in equation (12) [11,17]

$$m_{ew} = \frac{q_{ew}}{L}\ 3600 \quad \ldots(12)$$

m_{ew} Distillate Output kg/m^2/h

The Efficiency(η) of solar stilled is given by equation (13) [19]**:**

$$\eta = \frac{q_{ew}}{I} \quad \ldots\ldots(13)$$

where (I)Solar radiation

3. Experimental procedure

3.1 Metal frame

Iron structure made in thickness of the (2mm)" is made to give a support to the water distilled and give it more protection, the iron is cut, to design the 3D structure with a length (1m), width (0.7m) and height (0.2m), after which the structure and the structure-tie were built by the New welder, After finishing the welding of the iron structure the structure was painted , shows the iron structure as shown in Figure (1).

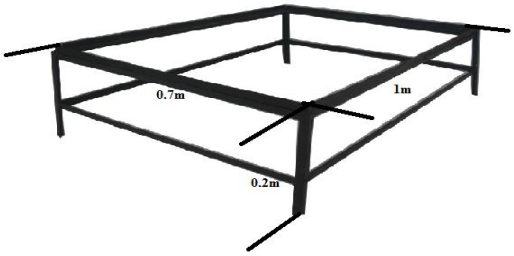

Fig. 1: Shows the metal structure of the fabricated diameter.

3.2 Distilled box:

Wood panels of length (2.20m) and width (1.10m) were used to make the thick wooden box of the distilled (0.015m) and were mounted on the chassis and of the same dimensions, rubber silicone were added to the contact points to prevent water leakage. The distilled was also black to increase the contact's contact light Figure (2) shows the distilled box.

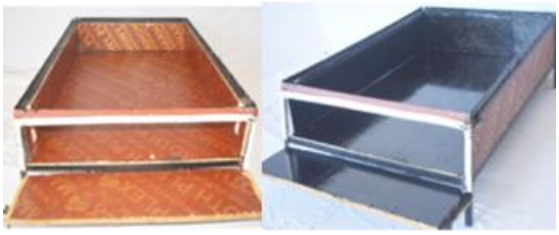

Fig. 2: Shows the box of the before and after painted.

3.3 Water collection channel:

The collection channel has the important function of receiving water from the drip-glass lid, assembling and transporting it out of the distilled into an external container for collecting distilled water, and as a base on which the glass cover of the solar sector is based. The cable-winged water collection channel has used the cable-wrapper (2m,0.015m) and height (0.01 m) which is made of plastic material

3.4 Glasses cover:

The glass is thick (4mm) and transparent and the dimensions of the two sides of the distilled are long (1m) and width (0.4m), the side of the triangle are in a triangle with a base (0.6m) and the height of the triangle head (0.25m), and the two sides of the distilled are chosen at an angle (35°). Figure (4) represents the installation of the glass.

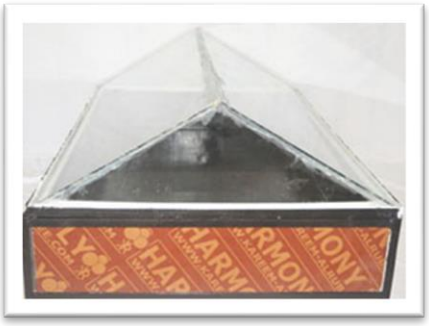

Fig. 4: Represents the glass panels used in the factory distilled.

4. Result and discussion

Direct solar radiation was studied in for month, and four different days were selected under generally different atmospheric conditions, On days when the weather was clear.

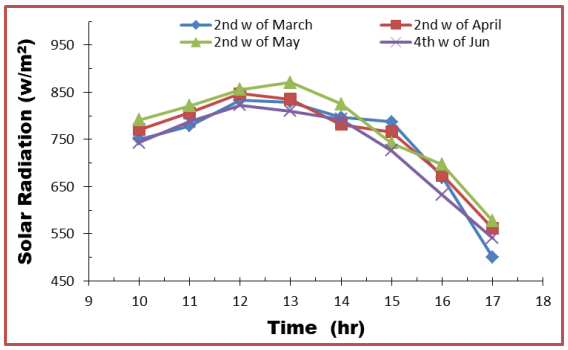

Fig. 5: Relation between solar radiation and time.

we note that solar radiation from sunrise until we reach midday, the highest possible and then solar radiation gradually decreases, until then Disappears at sunset. Through the figure (5) in the first day of, the solar radiation gradually increased until we reach about midday and then began to descend, and it is It is compatible with the state of solar radiation in the high atmosphere and the rest of the curves, fluctuating as a result of the passage of separate clouds and clouds that have caused the shielding and reduction of solar radiation and is generally consistent with. [18]. Also study the temperature surrounding the distilled, the temperature of the glass and water, of the locally-made solar distilled, was also studied in March, when the measurements of the experiment were taken at the beginning and end of the month ,The water inside the distilled was about (3cm) high at the beginning of the experiment.

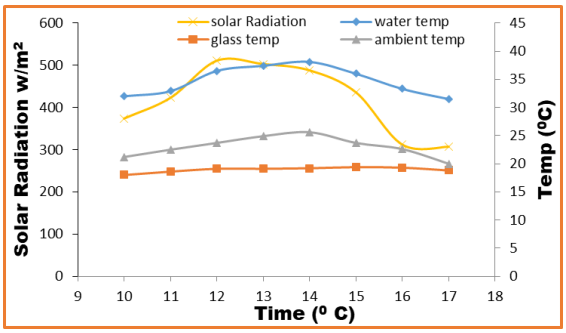

Fig. 6: The solar radiation beam and the temperature over time on the first March.

The temperature difference between the temperature of the surrounding from the beginning of the experiment is that 20°C and increasing slightly at midday to approach 25°C, and then fell, and is associated with the solar radiation that was about 350 w/m^2. It was then set at 10:00AM,and then it was rising at 12:00- 1:00 PM , to more than 500 w/m^2, then it was decreasing to disappear when the sun set. The temperature of the glass is almost constant, and the solar distillatory is exposed to light wind. The temperature of the water has increased, combined with solar radiation, and the accelerated absorption of the high-temperature base of the distilled, which moves heat into the water in the distilled figure (6) and is agreement with [4,18] .

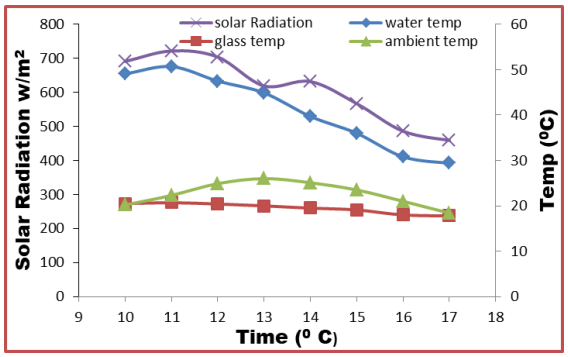

Fig 7: The Solar radiation beam and the temperature over time at 28. March.

On 28 March , figure (7) the solar radiation flutter occurred due to a sporadic clouds that reduced solar radiation from the beginning of the experiment, where solar radiation at a 700w/m^2 was on, then it fell slightly in the middle of the day and then began to gradually decrease until the sun set to fall with water from the water temperature 50 ^{0}C at the beginning of the experiment and up to 30 ^{0}C at the end, where low ambient temperature affected the result of the clouds and is consistent with [10,12]. In theory, the heat transfer of the locally-manufactured solar distilled was studied, using mathematical equations from (1-13)[17.18], for the first day of March, and according to weather conditions, solar radiation temperature , impactful winds, and other factors, and the table (1) was obtained.

Table 1: Represents the heat transfer variables of the solar distilled.

T_w °C	T_g °C	P_w	P_g	h_{cw}	h_{ew}	L	m_{ew}	q_{cw}	Q_{rw}
32	18	4681.74	2079.79	0.227	0.687	2417817	0.014331	3.18244	4597.06
32.9	18.6	4919.91	2156.83	0.229	0.721	2415675	0.015379	3.282084	46529.88
36.5	19.1	5982.80	2222.95	0.247	0.868	2407094	0.022606	4.298592	58202.18
37.4	19.1	6278.17	2222.95	0.251	0.907	2404944	0.024867	4.606772	61585.06
38.1	19.2	6516.70	2236.39	0.254	0.939	2403271	0.026596	4.606772	61585.06
36	19.4	5824.04	2263.48	0.243	0.848	2408287	0.021051	4.817634	63946.49
33.3	19.3	5029.15	2249.90	0.228	0.737	2414723	0.015394	4.034505	55448.28
31.5	18.8	4553.86	2183.07	0.220	0.668	2419007	0.012636	2.795031	40987.88
57.2	52.73	16959.1	13694.91	0.182	2.164	2357151	0.014777	0.814203	21113.16

In practice, the amount of distilled water produced daily after the addition of 3-liter of river water was calculated figure (8). The amount of water produced over time is represented by the hour we observe the increase in the amount of water over time per day from 10 a.m. the time of the trial to 5 p.m. the end of the experiment and for all days, and because of the increase in solar radiation that increases the temperature inside the distilled, The result of absorption is the base of the black distilled The fact that the water has been heated for a long time is well isolated, so it is kept in the heat of a long leash even after the solar radiation has been taken down after midday. We also note that the amount of water has increased over days to increase the temperature ,But there has sometimes been a oscillation as a result of clouds leading to decreased solar radiation and a decrease in solar radiation Heat is agreed with [17] .

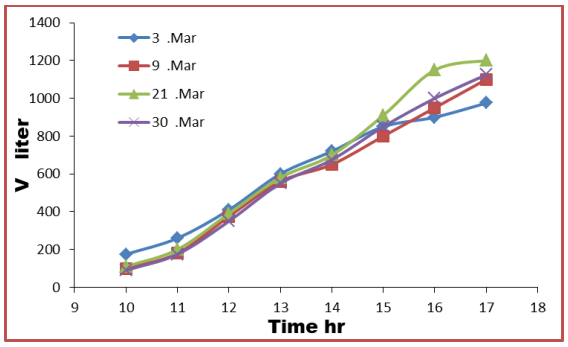

Fig. 8: Hourly water production on 11th of March.

In figure (8), the practical efficiency of the distilled is related to the amount of distilled water produced, and the loss of distilled is low because of its good isolation, so efficiency gradually increased from the beginning to the end of the experiment, related to the

quantity of water produced and for different days, and is consistent with [19] .

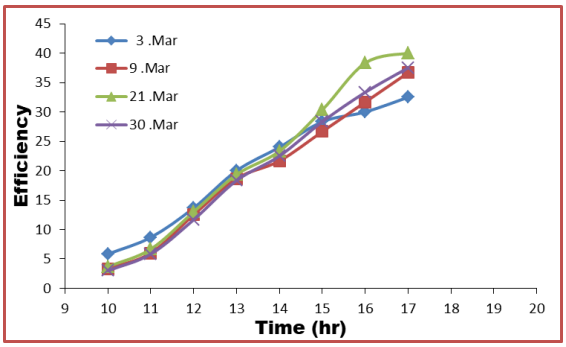

Fig. 9: Relation between efficiency and time.

5. Conclusions

A practical model of a double-slope, single basin solar distilled was built after the model was tried in different conditions of solar heat and radiation and other atmospheric variables, which have a bearing on the overall productivity of the distilled. The local system has proven to increase efficiency as solar radiation increases, which increases the temperature of the basin's water, exploits the heat of the reservoir to increase siltation and condensation, and improves the low rise of water from siltation . Experimental data show that distilled predict thermal behavior accurately and can be shown to be The expected results of this system are well-designed, isolated and parameter, also small scale low cost. analysis to overcome difficulties in building solar systems such systems can be used in remote areas where there is no clean water.

References

[1] Nijmeh, S.; Odeh, S. and Akash, B.(2005). Experimental and theoretical study of a single- basin solar still in Jordan. *International Communications in Heat and Mass Transfe*,**32(2005)** :565-572.

[2] Bechki, D. et al.(2010). Effect of partial intermittent shading on the performance of a simple basin solar still in south Algeria. *Desalination*, **260(1-3)**: 65–69.

[3] Medugu, D. W. and Ndatuwong, L. G. (2009). Theoretical Analysis of Water Distillation Using Solar Still. *International Journal of Physical Sciences* , **4(11)** :705-712.

[4] Al- Garni, A. Z.; Kassem, A. H.; Saeed,F. and Ahmed, F.(2011). Effect of glass slope angle and water depth on productivity of double slope solar still. *Journal of scientific and Industrial Research*, **70** : 884-890.

[5] Prasad, P. R.; Pujitha, P.; Rajeev, B.G.V. and Vikky, K. (2011). Energy efficient Solar Water Still . *International Journal of ChemTech Research*, **3(4)** : 1781- 1787.

[6] Harmim, A.; Merzouk, M. Boukar, M. Amar, M. (2012). Mathematical modeling of a box type solar cooker employing an asymmetric compound parabolic concentrator. *Solar Energy*, **86(6)** :1673–1682 .

[7] Tenthani, C.; Madhlopa, A. and Kimambo, C.Z. (2012). Improved Solar Still for Water Purification . *Journal of Sustainable Energy & Environment*, **3(2012)**: 111-113.

[8] Singh, N.(2013). Performance Analysis of Single Slope Solar Stills at Different Inclination Angles: an Indoor Simulation. *International Journal of Current Engineering and Technology*, **3(2):**677-784.

[9] Okibe, E. A. and Fadoo, U.(2013). Investigation of the Effect of Cover Thickness on the Yield of a Single Basin Solar Still under Makurdi Climate .The *International Journal of Engineering and Science* **,4 (1)** : 1-8.

[10] Singh, N.; Gaikwad, A. and Rai, A. K.(2013). Effect of Inclination on Internal Heat Transfer Coefficient and Productivity of Single Slope Solar Still: an Indoor Simulation. *International Journal of Scientific Research*,**2(7)**:141-146.

[11] Haruna, I. U.; Yerima, M .Pukuma, A. D. and Sambo, I. I.(2014). Experimental Investigation Of The Performance Of Basin Type Single-Slope Solar Still, *International journal of scientific & technology research* ,**3(3)**:169-174.

[12]Hannun, M.R. Khalaf, H.M.(2015).Effect of collector area and forced circulation on the solar still system at Nasiriya city. First Conference for Engineering Sciences and technology October 2015.

[13] Farge, T.; Suitan, K.; Ahmed, A. (2017). Experimental study of the performance water distillation device by using solar energy, *Engineering and Technology Journal* , **35(6)**: 653-689.

[14] Krishnan, G.S .; and S.B. Nithyananth, B.S. (2018). An Experimental Analysis of Hybrid - Pyramid type Solar Desalination with Concentric Parabolic Collector (CPC).International journal of advance research in science and engineering, **7(2)**: 664-668.

[15] Singh, S. and Inambao, L.F. (2019). Solar desalination: a critical review. *International Journal of Mechanical Engineering and Technology* , **10(8)**: 244-270.

[16] Hamdan, M .A.Musa, A.M. And Jubran, B.A. (1999). Performance of solar still under Jordanian climate. *Energy Conversion & Management*, **40 (1999)**:495-503.

[17] Prasad, P.R. and Kumar, A. (2018). Experimental Investigation of Double Slope Solar Still for the Climatic Condition of Sultanpur. *International Journal of Engineering and Technology*, **9(6)**:4119 -4133.

[18] Mahmood, H.Y and Al-Salih, Y.R.(2018). Experimental Study of Two Different Types of Solar Dish Characteristics and its Efficiency Based on Tikrit, Iraq Weather Conditions .The Sixth Scientific Conference "Renewable Energy and its Applications"

IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 1032.
[19] Ayav, I. and Atagündüz, G. (2007). Theoretical and experimental investigations on solar distillation of IZTECH campus area seawater. *Desalination*, **208 (2007)**: 169–180.

تصنيع ودراسة مقطر شمسي ذو حوض واحد وميلين

ياسين حميد محمود ، احمد عامر رجب

قسم الفيزياء ، كلية العلوم ، جامعة تكريت ، تكريت ، العراق

الملخص

تقنية التقطير الشمسي تقنية بسيطة ورخيصة للحصول على المياه الامنة حيث يتطلب اما الاشعاع الشمسي او الحرارة كمصدر للطاقة للحصول على عملية التبخر والتكثف, في هذا البحث تم تصميم مقطر شمسي من مواد محلية ذو حوض واحد وميلين, وتم اجراء الفحص والقياس في منطقة الدور– صلاح الدين على خط طول (43.798) وخط عرض (34.460), شرق نهر دجلة, وتم دراسة خصائص المقطر المصنع وعملية نقل الحرارة. وتم الحصول على النتائج التالية في الشهر الثالث ,ارتفاع درجة حرارة الماء والزجاج مع الزمن ,كذلك ارتفاع الكفاءة مع الزمن لتصل الى اعلى كفاءة بحدود 40 %. المقطر خيار جيد لتوفير المياه ورخيص وعملي.