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Study of the impact of variable-phase materials (PCM) on the single basin two-slop solar distiller

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ABSTRACT
The potable water declined after the global climate crisis. Due to global warming. River levels have also decreased. Moreover, so much has become dependent on the water from the wells. Which are often salty. Purifying this water often requires many fossil fuels that cause damage to the environment. Therefore, the researchers turned to renewable energy sources, including solar energy. In this paper, we designed and made a solar distiller, a single sink with a double slope. It is used to desalinate water and remove salt from water using solar energy. This technique is the best solution for obtaining water in remote and desert areas where potable water is not available. The purpose of the research is to study variables that promote increased efficiency. Study the use of phase change materials (PCM) to enhance the productivity of solar distillers. Bitumen was used to store solar thermal energy in latent heat. It has increased efficiency by (15–25%). For the distiller using bitumen in the basin relative to the distiller to which it is not added.

Introduction
Due to higher fuel prices. The lack of potable water and the difficulty of providing it, especially in remote and remote areas, one solution is to use solar distillers. For ease of design and cheap price, researchers want to develop different types of distillers. Also, use variable phase materials to boost productivity and efficiency [1,2]. In addition, manufacture of distillation systems in Baghdad. To be treated solar distillers stopped working from 12 to 3 hours due to overheating. The new model increased productivity by 337.36% with cooling cover and increased productivity by (403%) when coupled with the old model [3]. Wax was mixed with (Al_2O_3) nanoparticles and placed in a basin in a water distillation experiment in a solar distiller. (Tw) water temperature was studied in the basin, and (Tg). Glass temperature. It also used a fuse in another experiment and found distilled water mass. The efficiency was also found for the distiller, and the productivity was (7.460 and 4.120 kg/m^2) day, respectively [4]. The addition of fins, absorption plates, nanoparticles, cotton fuses, and phase change materials was discussed, as the lowest depth of water in the distilled basin increases productivity. Increasing space increases productivity. Using porous materials like sponges and fins gives better results. This helps solar energy and provides a solution that can save drinking water [5]. Making three solar distillers with the same dimensions as the first did not put additives in the basin. The second puts something in the basin, and the third puts (paraffin as a variable-phase material) in the basin. Third, the development of a n-PCM (NPCMSS) variable nanomaterial Experiments in India showed that the addition of variable-phase substances improved water production by (51.22) for the Model II and the Model III by (67.07) [6]. A double slop solar distiller with one basin is used for practical checks with a parabolic trough concentrator to improve the distiller's performance. Wax is also used as a variable phase material (PCM). The center of the basin was directed to the south. The depth of the water in the distilled basin was (20 mm). An

increase in productivity was obtained using the parabolic trough, and productivity was increased by (37.3%) and (42%) respectively [7]. The addition of the energy matrix to the solar distiller has led to increased productivity and ease of use, efficient performance, and the addition of good performance nanoparticles and increased efficiency has led to the recommendation of using this technique [8]. Increase the productivity of solar water distillation systems using thermal energy storage materials and without the use of these materials in the distillation basin. These serve to store energy in the form of heat during the day. Moreover, use it during the night. To heat the basin water so that the system works at night with the application of PCM. The researchers used paraffin wax ($MgSO_4$-$7H_2O$) CH_3COONa K_2Cr2O_7) and steric acid. Where it improved and almost doubled productivity by 108% from the traditional distiller without using PCM materials [9]. A method of integrating variable-phase material under a water distiller basin to maintain excess solar energy. In addition, store them for use at night. The increase in productivity also raised the annual cost of distilled water [10].The temperature of the heat transfer liquid (HTF) in the solar collector tube is greatly affected by immediate solar radiation, which usually causes significant fluctuations in the temperature of HTF. To improve this performance, The suggestion of a solar assembly tube integrated with a layer of variable-phase material (PCM), and the thermal behavior of the 630 mm long tube and 20–70 mm in diameter inside and outside, was studied. As PCM, PCM (60 wt% $NaNO_3$ and 40% wt KNO_3) was added. Air was chosen as the HTF. Thermal inspection of solar assembly tubes was conducted experimentally under different solar radiation and airflow rates. The results proved that the temperature in the solar assembly tube with PCM was 65.45–128.75 C^o higher than the temperature without additives. [11]. Three solar desalination systems were used for water. The first is a conventional system, and the second is using phase change material (PCM) (TESU). The third is using natural-type dolomite (PCM). Experimentally obtained increased productivity for the second and third models compared to the first model by (10.15% and 17.75%), respectively. Energy and efficiency improved by (15.91% to 18.28%) [12]. In this research, they designed and manufactured a one-basin solar distiller and two sloped the study of its properties also studied the temperature of water and glass on a clear day. We found an increase in the temperature of water and glass was observed over time. It also studied the addition of bitumen in the basin and studied the efficiency before and after adding. It found that the use of bitumen increases the speed of evaporation and efficiency.

Material and Methods

A. Convection heat transfer

The rate at which the heat transfer the load q_{cw} from the surface of the water to the glass condensation cover is given by the equation (1):-

$q_{cw} = h_{cw}(T_w - T_g)$-------(1)

Where (T_w) The temperature of water, (T_g) The temperature of glass, **(**h_{cw}) The convective heat transfer coefficient.

$h_{cw} = 0.0884(\Delta T^*)^{\frac{1}{3}}$---------(2)

$\Delta T^* = \left[(T_w - T_g) + \frac{(Pw-P_g)(Tw+273.15)}{268.9\times10^3-Pw}\right]$-----(3)

Where, (Pw) and (Pg) are partial saturation pressures are given by the following equations (4,5):-

$P_g = exp\left[25.317 - \frac{5144}{(T_{gi}+273)}\right]$-----(4)

$P_w = exp\left[25.317 - \frac{5144}{(T_w+273)}\right]$-------(5)

B. Evaporative heat transfer

The rate of transfer of vaporizing heat q_{ew} from the surface of the water to the surface of the glass cover is given cover by equation (6):-

$q_{ew} = h_{ew}(T_w - T_g)$------(6)

The rate of evaporative heat transfer is given by equation (7):-

$h_{ew} = 16.273 \times 10^{-3} h_{cw} \frac{(P_w-P_g)}{(T_w-T_g)}$------(7)

B. Radiation heat transfer

The rate of irradiative heat transfer equation (8):-

$q_{rw} = h_{rw}(T_w - T_g)$------(8)

Where: h_{rw} is a radiation heat transfer coefficient from the water surface to the glass cover and is given by equation (9):-

$q_{rw} = \varepsilon_{eff}\sigma[(T_w + 273)^2 + (T_G + 273)^2][T_w + T_G + 546]$--------(9)

Where ε_{eff} is Effective water emission and glass surface, σ Stefan Boltzmann constant (5.67 × 10-8 W/m^2).

Where (L) is the latent evaporation heat of less than 70 C^o and is given by the equation (10) [13].

$L = 2.4935 \times 10^6[1 - 9.4779 \times 10^{-4}T + 1.3132 \times 10^{-7}T^2 - 4.7947 \times 10^{-9}T^3]$------(10)

The hourly distillation output per square meter can be obtained from the solar distiller by equation(11)[13].

$m_{ew} = \frac{q_{ew}}{L}3600$-------(11)

Evaporation heat is transferred from the water surface to the glass surface given by the equation (12).

$\mathrm{m_{ew}} = \frac{\mathrm{h_{ew}(T_w-T_g)}}{\mathrm{L}}3600$ kg / m^2 /h-----(12)

Efficiency Equation (13) [13,14].

$\eta_i = \frac{m_{ew}.L}{I(t)} = \frac{\{h_{ew}.(T_w-T_{ci})\}}{I(t)}$---- (13)

Experimental work

A. Distilled Box

The structure was made of a wooden box (Fig 1). With a thickness of 0.015m. The distilled has a length of (1 m), a width of (0.75 m), and a height of (0.2 m and a slop of 350). The sides of the distiller were designed as doors. With length (0.75 m) and height

(0.2 m), to insert and remove the basin of the distiller and add water.

Figure 1: Shows the distiller box.

B. Basin

Using panels made of galvanized iron material with thickness (0.6mm) cut and bent in the shape of a rectangular basin with length (1m) and width (0.7m), after which the metal basin was painted black, so as to absorb as much solar radiation as possible, (Fig 2). shows the iron basin.

Fig. 2: Metal basin

C. Glasses cover

The one meter glass board, width (0.45m) and 4mm thickness was used to manufacture the sloped surface. The panels were fixed on top of the wood box at a sloped angle of (35^0). The other side of the box resembled the triangle was base length (0.6m) and height (0.25m) shown in (Fig 1).

The working method:

The Thermometers (type K) are distributed in the water in the basin and on the glass inside and outside the distiller (Fig 3). The water to be distilled (well water, river) is inserted into the basin. After that the closure of the distillation is set we record the amount of water collected every hour and the temperature measurement, as well as solar radiation. Without any pelvic additives. The experiment returns several times in a pure atmosphere. The experiment is also returned in similar circumstances after the bitumen has been added again.

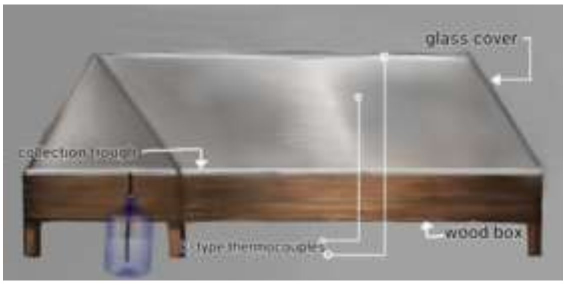

Fig. 3: solar distilled with distributed of (k-type) thermometer.

Result and discussion

The solar distiller was tested in several days in a clear day as in the (Fig 4). We studied the relationship between time and temperature of the ambient near the distiller as well as of glass and water from the distilled interior without additives. We found an increase in temperature over time from (9 am to 1 pm). Then it decreases slightly, and this is due to increased solar radiation with time that leads to warming in the atmosphere near the distiller and the heat rises inside the distillation due to total closure that raises the temperature of water and glass and is consistent with [15]. The experiment was also re-tried with the addition of bitumen in the basin. We also found that the water temperature in the basin is lower than the previous experiment when adding bitumen as a phase change material, plus its black color works to retain heat for longer which increases its heat, lowers the temperature of the basin, reduces the distillation speed and conforms to [12,15]. Through the experiment we note that the addition of bitumen in the basin. The heat in the basin decreased from morning at high temperatures due to its storage in bitumen, The temperature between the basin and the glass may weigh up to saturation and the evaporation stops. Until the glass temperature drops after water, the bitumen appears to release heat to the basin and warms more than the glass to increase evaporation in the afternoon, increasing heat and increasing distillation speed and conforming to [16,17].

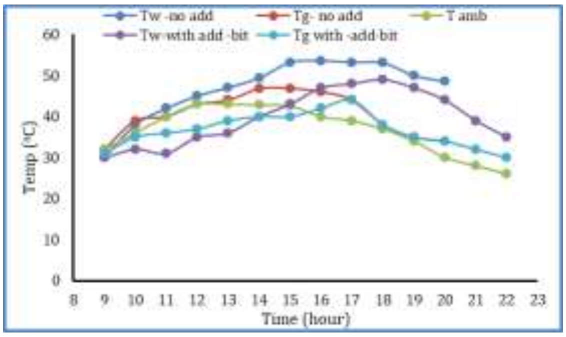

Fig. 4: Relation between time and temperature.

Also examined, the relationship between time and difference in water temperature and glass. for solar distillation from the inside, as well as solar radiation and through (Fig 5). found us in case of not only adding salty water in the basin, an increase in the difference between water temperature and glass over time due to the warming of the distiller from the inside and increased evaporation. As a result of increased solar radiation that raises water temperature and is the cause of increased evaporation speed and increased distillation efficiency. It is compatible with [3] as we note when adding bitumen the difference between water heat and glass in the early hours to retain this substance as heat PCM so it decreases slightly and the evaporation process delays and slows down. To return after the low heat in the pelvis to release absorbed heat to increase the speed of evaporation again as we note after (12 o'clock) at noon it has increased twice as much to retain the heat it absorbed for a larger period and for a long period consistent with [4,19].

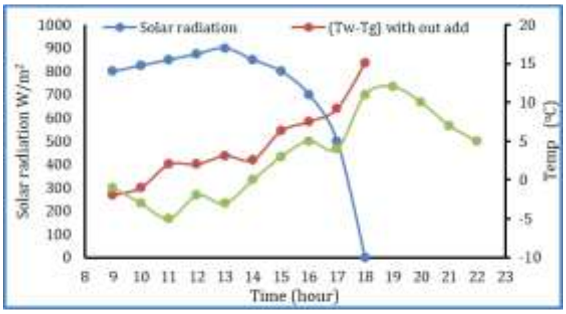

Fig. 5: Relation between time and temperature, and solar radiation.

It also examined the relation between time and solar distillation productivity over time. If one liter of salt water is added in the basin of distilled only. The experiment was also re-experimented with the addition of bitumen in the basin with salt water, as in (Fig 6). On a sunny day we notice, increased productivity over time for the two cases without additions to the basin. In addition, with the addition of bitumen. However, productivity increases more rapidly if not added. With the addition of bitumen as it lowers temperatures within the distillation basin and retains heat for longer, it returns to release heat in case of lower basin heat, which increases productivity, but over a longer period, which increases the productivity of the distillation as well as increases efficiency as a function of productivity and conforms to [19.20].

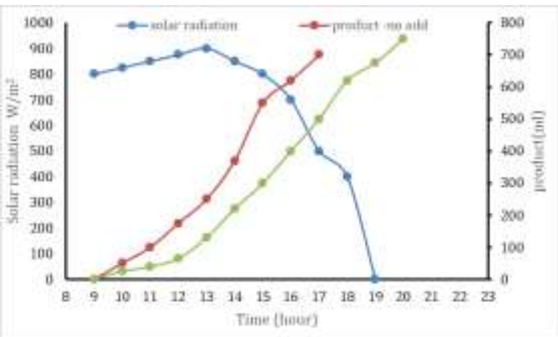

Fig. 6: Relation between time with Product, and solar radiation.

The measurements reached in practical experiments. In April the relation between water temperature and ambient temperature relative to solar radiation ((Tw-Ta)/Ia).In case no substances are added in the basin in (Fig 7). We note that the behavior approaches the linear behavior of numerous losses. In addition, these losses instruct a mass of salt deposition, in a bottom that reduces temperatures and thus reduces productivity and is consistent with [21].

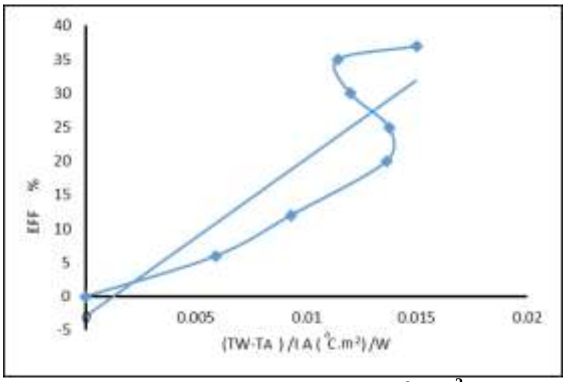

Fig. 7: Variations of the ((Tw-Ta)/Ia (°C.m²)/W) and efficiency without added.

When the bitumen is added, the behavior linear and positive. The increase in temperatures increases the productivity as it increases the efficiency (Fig 8). of the distiller and reduces the loss and is consistent with [21].

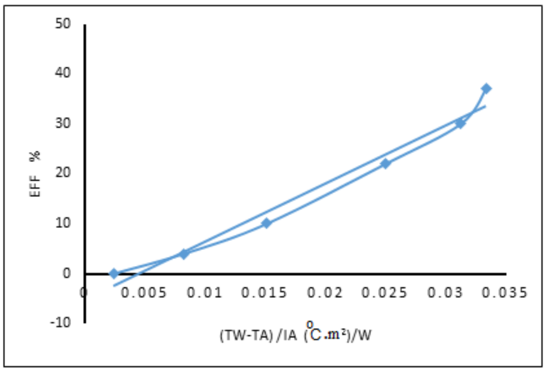

Fig. 8: Variations of the ((Tw-Ta)/Ia (°C.m²)/W) and efficiency, when added bitumen.

Conclusion

For one basin, a two-slope solar distiller manufactured and experimented with local materials. To be used to distill salt water for wells and used for drinking. Through practical experiments, it has been observed that the temperature of water and glass is affected by solar radiation. The distillation closure provisions increase the speed of evaporation and increase productivity and efficiency. Increasing the deposition of salts in wading reduces productivity. Using variable-phase materials such as bitumen, distiller can work in case of solar radiation decrease and by adding PCM material to raise distilled productivity by 15-25%. Nevertheless, longer.

References

[1] Khanlari, A. (2020). THE EFFECT OF UTILIZING Al2O3-SiO2/DEIONIZED WATER HYBRID NANOFLUID IN A TUBE-TYPE HEAT EXCHANGER. *Heat Transfer Research*, **51(11)**:991-1005.

[2] Güngör, A.; Sözen, A. and Khanlari, A. (2022). NUMERICAL INVESTIGATION OF THERMAL PERFORMANCE ENHANCEMENT POTENTIAL OF USING Al2O3-TiO2/WATER HYBRID NANOFLUID IN SHELL AND HELICALLY COILED HEAT EXCHANGERS. *Heat Transfer Research*, **53(12)**:37-54.

[3] Chaichan, M. T. and Kazem, H. A. (2015). Water solar distiller productivity enhancement using concentrating solar water heater and phase change material (PCM). *Case Studies in Thermal Engineering*, **5**:151-159.

[4] Shanmugan, S.; Palani, S. and Janarthanan, B. (2018). Productivity enhancement of solar still by PCM and Nanoparticles miscellaneous basin absorbing materials. *Desalination*, **433**:186-198.

[5] Bachchan, A. A.; Nakshbandi, S. M. I.; Nandan, G.; Kumar, S, A.; Dwivedi, G.; and Kumar Singh, A. (2021). Productivity enhancement of solar still with phase change materials and water-absorbing material. *Materials Today: Proceedings*, **38**:438-443.

[6] Manoj Kumar, P.; Sudarvizhi, D.; Prakash, K.; Anupradeepa, A.; Boomiha Raj, S.; Shanmathi, S.; Sumithra, K. and Surya, S. (2021). Investigating a single slope solar still with a nano-phase change material. *Materials Today: Proceedings*, **45**:7922-7925.

[7] Jassim, J.H.; Rishak, A.Q. and Abed, A.Q. (2021). Using PCM, an Experimental Study on Solar Stills Coupled with and without a Parabolic Trough Solar Collector. *Basrah Journal of Engineering Science*, **21(2)**:45-52.

[8] Kumar, S.A. et al. (2022). Study of analytical observations on energy matrix for solar stills. *Materials Today: Proceedings*, **49**:320-325.

[9] Behura, A. and Gupta, H. K. (2021). Use of nanoparticle-embedded phase change material in solar still for productivity enhancement. *Materials Today: Proceedings*, **45**:3904-3907.

[10] Wang, H. and Xie, S. (2022). The effect of annular phase-change material layer on the thermal behavior of solar collector tube. *Journal of Energy Storage*, **52**:104948.

[11] Agrawal, R. and Singh, K. D. P. (2021). A review on productivity enhancement of solar still by application of PCM and nano enhanced PCM. *MATERIALS, MECHANICS & MODELING (NCMMM-2020).*

[12] Selimefendigil, F.; Şirin, C. and Öztop, H. F. (2022). Experimental Performance Analysis of a Solar Desalination System Modified with Natural Dolomite Powder Integrated Latent Heat Thermal Storage Unit. *Sustainability*, **14(5)**:2650.

[13] Patel, R. V. P. and Kumar, A. (2017). Experimental Investigation of Double Slope Solar Still for the Climatic Condition of Sultanpur. *International Journal of Engineering and Technology*, **9(6)**:4019-4033.

[14] Karimi, E.M.; Ahsan, A.; Feilizadeh, M.; Jafarpur, K.; Ashrafmansouri, S.-S. and Feilizadeh, M.(2016). Theoretical and experimental investigation on internal reflectors in a single-slope solar still. *Applied Energy*, **165**:537-547.

[15] Islam, A.; Sharma, A. and Kumar Singh, P. (2021). Performance study on customized solar still by optimum fins for production of distilled water. *Materials Today: Proceedings*, **45**:3517-3520.

[16] Nian, Y.-L.; Huo, Y.-K. and Cheng, W.-L. (2021). Study on annual performance of the solar still using shape-stabilized phase change materials with economic analysis. *Solar Energy Materials and Solar Cells*, **230**:111263.

[17] Mevada, D. et al. (2022). Investigation and performance analysis of solar still with energy storage materials: An energy- exergy efficiency analysis. *Case Studies in Thermal Engineering*, **29**:101687.

[18] Yadav, A.; Khalid, M. S.; Saini, P. and Kumar, A. (2021). Improvement of solar still productivity by using PCM and other enhancement technique- A review. *International Journal of Engineering, Science and Technology*, **13(1)**:98-104.

[19] Layek, A. (2017). Exergetic efficiency of basin type solar still. *AIP Conference Proceedings*.

[20] Safaei, M. R.; Goshayeshi, H. R. and Chaer, I. (2019). Solar Still Efficiency Enhancement by Using Graphene Oxide/Paraffin Nano-PCM. *Energies*, **12(10)**:2002.

[21] Aburideh, H.; Deliou, A.; Abbad, B.; Alaoui, F.; Tassalit, D. and Tigrine, Z. (2012). An Experimental Study of a Solar Still: Application on the sea water desalination of Fouka. *Procedia Engineering*, **33**:475-484.

دراسة تأثير مواد الطور المتغير (PCM) على المقطر الشمسي أحادي الحوض ثنائي الميل

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الملخص

انخفضت مياه الشرب بعد أزمة المناخ العالمية. بسبب الاحتباس الحراري كما انخفضت مستويات الأنهار. علاوة على ذلك، أصبح الكثير يعتمد على المياه من الآبار. وغالبًا ما يتطلب تنقية هذه المياه العديد من أنواع الوقود الأحفوري التي تسبب أضرارًا للبيئة. لذلك تحول الباحثون إلى مصادر الطاقة المتجددة، بما في ذلك الطاقة الشمسية. في هذه الورقة، صممنا وصنعنا مقطرًا شمسيًا، ذو حوضٍ واحدًا وبميل مزدوج ، يستخدم لتحلية المياه وإزالة الملح من المياه باستخدام الطاقة الشمسية. هذه التقنية هي أفضل حل للحصول على المياه في المناطق النائية والصحراوية حيث لا تتوفر المياه الصالحة للشرب. الغرض من البحث هو دراسة المتغيرات التي تعزز زيادة الكفاءة. مثل دراسة استخدام مواد الطور المتغير (PCM) لتعزيز إنتاجية المقطرات الشمسية. حيث تم استخدام القار لتخزين الطاقة الشمسية الحرارية على شكل حرارة كامنة. وقد زادت الكفاءة بنسبة (15-25٪). بالنسبة للمقطر الذي اضيف اليه القار في الحوض بالنسبة إلى المقطر الذي لم يُضف إليه.