Experimental Study of Multi Effect stages PV Panels Solar Still to Enhance the Productivity by Utilizing Water Heater and Cooling Fan.

Ali A. F. Al-Hamadani **Altaf Hameed Yaseen**

Mechanical Engineering Department, College of Engineering,Wassit University.

alirudhaengmec@gmail.com engaltaf1978@gmail.com

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Abstract

A deserted reign always suffers from lack of pure water in a large part of its area. In this area, valuable fresh water from swamps or ground water wells is salt water, and it is necessary purified or distillated. In the current experimental study, a new design is made to improve the yield of fresh water of a pyramid solar still by using an immersion type DC- water heater. It investigates the effect of an external fan to cool the glass surface. The Experiment was take placed in the summer season in Iraq conditions at latitude (33.2 ° N). A solar still with 32.5°glass slope angle is chosen in our work. As the productivity of a solar still is more for low water depths, the water level in the bottom basin maintained at 3 cm. The experimental outcomes observed that the yield of fresh water increased by a significant 370% when DC water heater each having 350 W capacities was used. During used the external cooling fan the productivity of fresh water was existed to decrease by (7%) and (15%) for wind speeds of (7 m/s) and (9 m/s) respectively. A good comparison takes placed with other experimental study was taken.

Keywords: Solar Still, Productivity Enhancement, Water Heater, Pyramid Charge, External Cooling Fan.

1. Introduction

Most of researchers are interested about the destination water due to the obvious lack of potable water in most countries of the world. Therefore; this paper is focusing to increase the productivity. Fresh pure water is necessary for our health and well-being. Just 3% of all the available water on the planet Earth is fresh, wherein only 1% is available for human use and the left is ice. With the ever increasing population, there is an urgent need to interest on the methods in which waste water can be used so as to satisfy the required of life of human requirements. One of method is Desalination of water which is used to get fresh water from brackish water. Using another option excepted nonrenewable energy sources will give us large space to develop desalination of water everywhere especially in the areas which are suffering from lack with pure water. Hence, there is a global attention to use solar and renewable energy to desalinate water. Solar distillation is considering the best option to provide the fresh water for the people who are living in the desert areas or nearby from salt water. The solar stills consider one of the devices which use solar energy to get fresh water. Many parameters are used to enhance the fresh water

Productivity such as glass slope angle, wind velocity, depth of water, solar radiation and ambient temperature. There were several investigations were taking place before utilizing various kinds of solar still. Mathematical modeling of a multistage stacked tray solar still was examined [1] to exam the performance of stable case for the still unit. They setup new design of multistage stacked try solar still by improving the heat and mass transfer relations when they utilized an immersed water heaters in the water and simulate the work [2] indoor simulation has been done by utilizing two water heater with resistance 75 Ω. Murugavel, et al. [3] investigated the increasing of fresh water productivity by utilizing the AC heater water with capacity 2 KW via conduct indoor experiments utilizing light cotton cloth, quartzite rock. etc. in order to simulate the condition of real radiation. To increase the yield of fresh water of solar still, several efforts were carried out by academics. An experimental investigate of solitary slope solar still was implemented by Abu-Hijleh and Rababa'h [4] who interest on putting sponge's cubes in the water of basin. The level of water was increased to the highest point of sponge cubes via the average of capillary forces therefore there will be increasing in the rate of evaporation. It observed that the productivity increased from (18%) to (73%) through utilizing the sponge cubes.

Rajvanshi [5] take place a single slope solar still experiments in order to investigate the influence of adding dyes like black methylamine, dark green and red carnosine. It was observed that the dye solution helped to increase the productivity with (29%). The best dye in their investigation was observed to be black napthylamine. The influence of applying various improvers such as sprinkler and asphalt was investigated by [6]. He found that an increase of 29% in yield of fresh water of still unit is gotten when asphalt was utilized. A further improvement in fresh water yield about 22% was found when sprinkler was mutual with asphalt. A mathematical investigate was made by [7]. The influence of temperature variance between the basin water and the surface of glass. It was found, the increasing in the temperature variance will escort increasing the yield of fresh water. [8] The researcher concluded experimentally the influence of the motion of air inside the solar still. He set up a fan inside the solar still and observed that there is increasing in yield of fresh water. Samee et.al, [9] examined a simple single solar still in Pakistan. The average yield of fresh water obtained was (1.7 litter/day), and the efficiency of the system was (30.65%). Algaim, et.al., [10]investigated the comparison between pyramid solar still and single basin solar still via two experiments took place in Basra city in Iraq, they found the productivity of pyramid solar still and single basin solar still were (7.36 and 5,57) litter /day respectively. Abdallah et.al. [11] They conducted experimenters and design a new step solar still coupled with heating coil and inclusion of PV power, for improving the performance of solar still and improved the productivity of distillate by up to 1089%.

2. Experiential Procedures

The (MESPVH) solar still facility as demonstrated in Figure (2) was structured, and Figure (3) demonstrates the Schematic diagram of (MESPVH) Solar still. It consists of four main parts as follows:

1. (MESPVH) solar still system unit.
2. PV panel (Photo voltage).
3. Pyramid glass cover.
4. Layer with PCM (Paraffin wax).

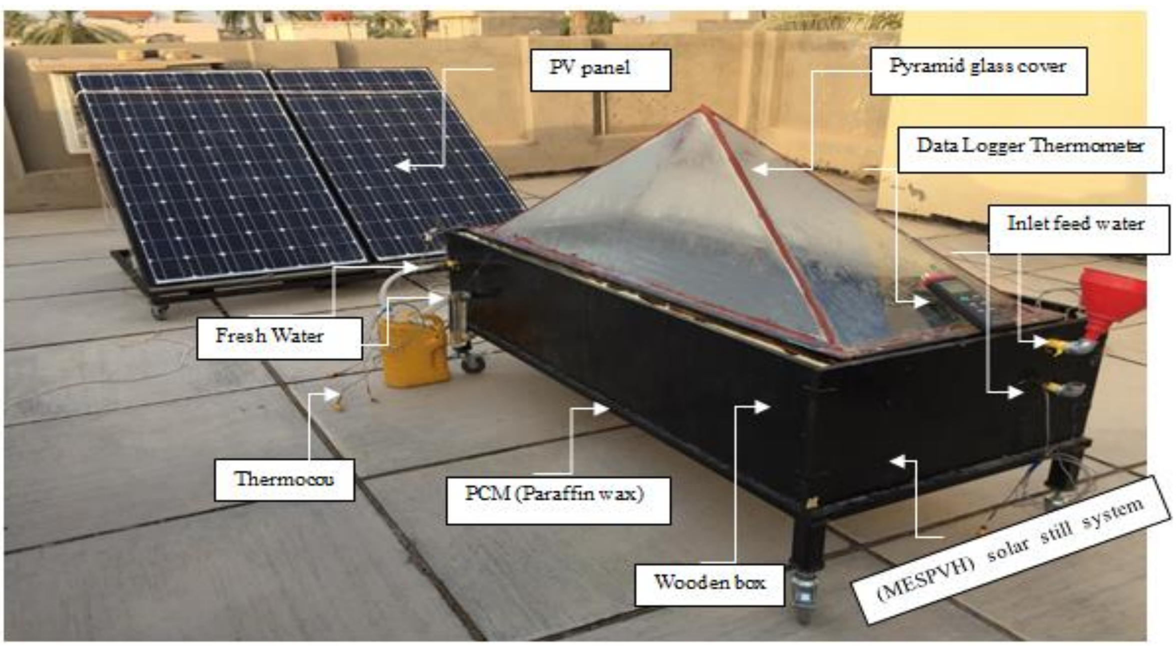

Fig. (1) Photography of (MESPVH) Solar Still System.

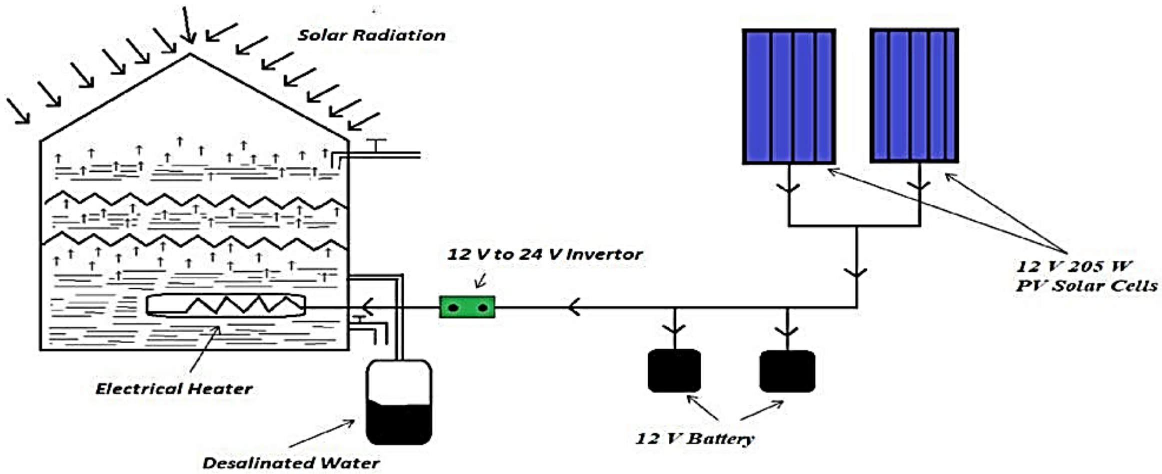

Fig. (2) Schematic diagram of (MESPVH) Solar still

The basin front side is facing to the south and is inclined at an angle of (32.5°). It is made from Galvanized Iron (GI) and painted black to improve absorption of the solar energy. The thickness of (GI) steel is (1 mm), and the basin has been made with dimensions (1.5 Length x 0.5 width x 0.3 high) m. The basin also contain on two stacked trays are made of Galvanized Iron (GI) and painted red to prevent the Iron rust, its thickness of (1 mm), and are folded into corrugated shape (isosceles right triangle) with right side length of 4 cm. The number of the stacked tray is two for this solar still. The V-shape troughs downside the stacked trays are used to collect the freshwater condensed on the lower surface of the stacked trays. The surroundings of the solar still are insulated with glass wool (5 cm) thickness, and wooden box (3cm) thickness to reduce heat loss. The average height between the water surface and the lower surface of the stacked trays is (8 cm), and the condensation area of the corrugated shape stacked tray is ($0.96 m^2$). For the bottom stacked tray, the seawater storage capacity is about (20 kg), while for other stacked trays the capacity is about (20 kg). So, the total seawater capacity of the solar still is about (40 kg). Valve (1) is linked with a water tank. The water first goes through this pipe and then goes into the top stacked tray, and the valve (2) goes to fill out the second and bottom basin at the same time. The over flow water does not circulate during the experiment. Figure (1) Photography of (MESPVH) Solar Still System, and Fig. (2) Schematic diagram of (MESPVH) Solar still. For the designed (MESPVH) Solar Still System. PV panels (Photo voltage) the solar power system in this work consisted of a (350 Watt) alternating current (DC) water heater, which was electrically powered by two PV modules with peak power output of (205 Watt) each. Each PV module had an area of (1.6 m × 0.8 m). The maximum power output from these two PV modules was (410 Watt). The power of the PV modules was regulated using a 30A charge regulator figure (4). A total of (2 × 12) Volt batteries each with capacity of (160 Ah) were charged by the two PV modules. The batteries were connected in series to each other. The DC power from the batteries was converted to DC power by the use of a (2 KW) inverter, enough to supply electricity to the heater. The specifications of alternating current (DC) water heater, solar charge regulator, PV modules, and batteries used in the experiments are shown in Table (1).

Table (1) Specifications of DC water heater, solar charge controller, photovoltaic modules, and batteries

Parameters	DC water heater	Solar charge regulator	Photovoltaic modules	Batteries
Maximum power voltage (Vpmax)	24 V	24 V	40.7 V	12 V
Maximum power output (Pmax)	350 W	720 W	205 W	1.800 WH
Maximum current power (Ipmax)	14.58 A	30 A	5.05 A	150 Ah
Open circuit voltage (Voc)	NA	NA	50.3 V	NA
Short circuit current (Isc)	NA	NA	5.54 A	NA

The triangular pyramid glass covers solar still regarding to the cheap price of glass and it is easy to get it from the market, we utilized it as a main part in (MESPVH) solar still. The thickness of the utilized glass is (0.004) m, and inclination angle is (32.5°). There are another advantages to utilize a glass as a cover for the unit because it has better thermal conductivity and allows good transmission of visible and non-transparent infrared rays. As for the material which is utilized to connect between the glass itself and the edge of basin marital, it's utilized a heat-resistant gum called (silicon) to reduce the heat losses. The basin is covered by a pyramid glass cover includes four triangles each corresponding two triangles is equal. The condensate slips on the internal surface of glass and then falling into the try attached which is inclined to the internal glass and ended in collecting tube, and then it is withdrawn as fresh water. The freshwater that generated could drip because the flow distance of the condensed water on the Pyramid glass surface is large and the inclination of the condensation surface is large for four triangles. The productivity of fresh water increased with utilizing Triangular Pyramid glass with higher temperature. PCM layer (paraffin wax) with mass (13 kg) which is placed on the down of basin solar still, this part of facility was added to improve the productivity of an existing desalination unit. Therefore, in the charging cycle on the daytime, the basin is heated the water by two ways: first by the absorption the energy from solar in the basin water and by receiving the heat from the DC water heater. Therefore, as a result of increasing water basin temperature, PCM melted and stored some of the energy absorbed as latent and sensible heat. As a result of heating the water in the basin, evaporation takes place. The rises vapor to the top and condenses on the internal surface glass of the glass cover. Additionally, the productivity was improved by a discharge cycle at night, where basin water temperature decreased and PCM froze and gave the latent heat to the system. So the basin water temperatures were in the range of evaporation. Table (2) lists the utilized paraffin wax Thermophysical characteristics all these characteristics were tested and at chemical engineering department laboratories – UOT –Baghdad.

Table (2) Thermophysical characteristics for the Iraqi paraffin wax that utilized in the current research

Material property	Range
Melting temperature (°C)	45
Latent heat of fusion (kJ/kg)	190
Solid liquid density (kg/m2)	930/830
Thermal conductivity (W/m°C)	0.21
Solid specific heat ðcpws Þ (J/kg°C)	2.384
Liquid specific heat cpwl (kJ/kg°C)	2.49

The produced fresh water salinity was tested by measuring total dissolve solid meter (TDS) which was found to be in the range of 10-16 ppm.

3. Instrumentation

Varied temperature measurements conducted by means of thermocouples type K, and it was used to measure the temperature of glass (Tg) and water (Tw) in the basin. The ambient temperature (Ta) was recorded using a digital thermometer (0–120) C° the measured temperatures recorded at regular intervals of time (every hour starting at sunrise). These thermocouples were calibrated using a calibrated mercury thermometer in the laboratory. The gathered distilled water volume measured by means of a cylindrical vessel of 5 liters' capacity. The solar power meter device (TES-1333R) W/m² is used to measure the intensity of solar radiation. The salinity of the fresh water produced was tested by measuring total dissolve solid meter (TDS) which was found to be in the range of 10-16 ppm.

4. Experimental Results

4.1 The influence t of External Cooling Fan.

The influence of external cooling fan. It's found there is a very little reduced in the glass and basin water temperatures when the wind speed was increased. It can be noted in Fig. (4) shows that when external cooling fan is used to rise the wind speed to (7 and ٩) m/s, there is a decreasing in the glass temperature from (53C° to 48C° and 46C°), respectively. The outer glass cover is cooled by forced convection thus reducing the inner glass temperature Figure (3). It can be remarked that the glass temperature is already low in sunset, and any further cooling of glass surface will make it cooler because of which the rate of heat transfers from water to glass surface increases. Subsequently, a reduced in water temperature was observed as can be noted in Figure (5) which will result in decreasing the evaporation rate of water. This will ultimately decrease the productivity of the still. Figure (6) shows that the productivity of solar still decreases with wind speed. It can be spotted that the daily in the fresh water productivities of solar still without cooling fan is (7.5 litter/day) and there was reduced with wind speed (٧and 9) m/s are (7 litter/day) and (6.5 litter/day), respectively. There is a decrease by about (7%) when the wind speed is increased to (7 m/s). A decrease in fresh water productivity by (15 %) was observed when the speed was increased to (9 m/s). The fresh water productivity decreases because the wind speed increases the top loss from the still [12]. This result is in agreement to the results gotten by [13], [14] who found the fresh water productivity to decrease with increase in wind speed. Therefore, this parameter is canceled because of the negative effect on the productivity of fresh water.

Fig. (3) External cooling fan

4.2 Effect Water heater.

Influence of Water Heater. Figure (5.1) shows Temperature Profile for (MES) solar still system with and without water heater on two clear days 0n July 2018, when water heater is immersed in the down basin of (MES) solar still system. There is one water heater having (350W) capacities were used to increase the evaporation rate. The level of water for the system was (10, 10, 12) Litters for top, second and down basin respectively. The maximum temperature attained by the down basin water, second and top staked trays due to the immersed water heater is (72 C° ,43C° and 54C°) respectively. The peak values basin water, second and top staked trays temperature for the still without the heater were found to be (31.7C°, 30C° and 46C°) respectively. The temperature is noted to rise gradually with the use of water heater. It can be observed that the peak value for the down basin with the heater is obtained at (1:00 p.m), while for the still without the heater; it is delayed by one hour. This delay could be because of low ambient temperatures during the morning which delays the warming up of the still as well as there is no another thermal source. The water heater in the down basin of the (MES) solar still increases the water temperature quite significantly. This high increasing in water temperature is observed very early around (1–3) hour after the experiment is started and it reaches a steady value in the down basin only. After that, the fluctuations in the water temperature throughout the day are resulting from the changes in the ambient conditions like solar radiation, wind velocity and dusty.

It can also be explained from Figure (5.2) the temperature profile for PCM and glass which also increase along with increasing water temperature because water heater is immersed in the down basin of (MES) system. It’s observed that the various temperature of water and condensing surfaces of solar still because the heat gained by the multi stages surfaces and glass surface from the evaporated water vapor which condenses on the condensing surfaces. This behavior is quite normal for any solar still. Moreover, the temperature variance between the water surfaces and the condensing surfaces also increased which results in high productivity.

Figure (5.٣) demonstrates the significant increment in the overall solar still productivity if the heater of water was utilized in the down basin. The solar still productivity for (MESPVH) that has an immersed heater of water was about (12.35 Litter/day) in comparison to (4.62 litter/day) found for the still without the heater because approximately there is no productivity in down and second basin water. The productivity was found to improve significantly about (167%). Therefore, the utilizing of heater water in the down basin of the solar still works out efficiently to improve the solar still productivity for (MESPVH).

Figure (12) demonstrates a comparison between the current work and experimental work utilizing water heater with solar still system. Abdallah, et.al, utilized three DC water heater (24 volt) and single PV panels (30.2) nominal volt and nominal current (8.11 A) [11]. The result of yield fresh water was (11 litters /day). The present work is sued one DC water heat and 2 PV panels and the productivity was (12.35 Litter/day). The fresh water productivity was utilized as main factor for comparison of these investigation. The recent investigation gives the peak productivity comparison with other studies since the new structure (MESPVH) Solar still (corrugated shape stacked trays) helped (1) the generated freshwater can quickly drip because the flow distance of the condensed water on the condensation surface is short and the inclination of the condensation surface is large;(2) the condensation resistance of the water vapor is reduced due to the thin liquid film; and (3) the area of the condensation surface is increased, which can enhance the heat transfer efficiency of the water vapor.

5. Conclusions

The following conclusions can be made based on the results presented in this paper as follows:

1. The use of water heater in the base tank of a solar still boosts the water temperature rapidly and enhances the productivity significantly by around (167%).
2. Wind speed has a decreasing effect on the productivity of solar still.
3. External cooling fan used for cooling the glass surface of the solar still decreases the productivity by 7% and 15% for wind speeds (7 m/s) and (9 m/s) respectively.
4. The PCM kind (paraffin wax) used to increase the efficiency and productivity of the system. The PV panel system is a sustainable design due to the use of solar energy to heat basins water, and electricity production using photovoltaic modules and storing it using batteries to ensure (12 hr) operation of the system.

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

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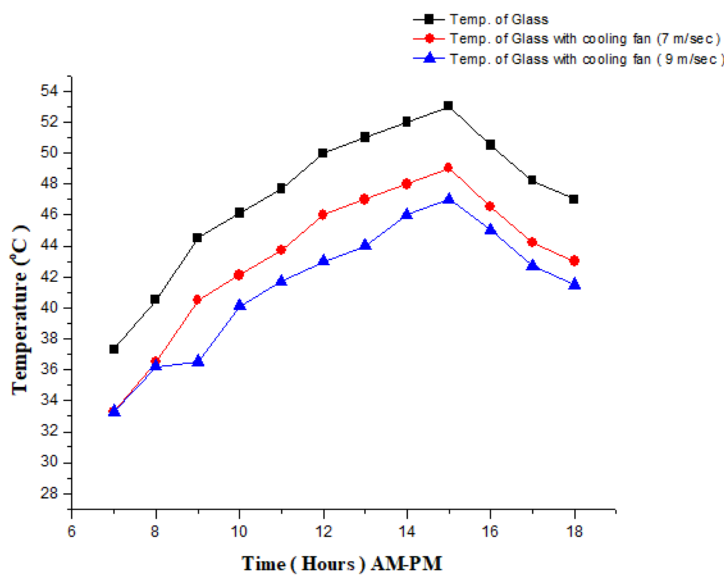

Fig. (4) Effect of External Cooling Fan of Glass temperature (MESPVH) solar on July 2018, (m down =20 kg)

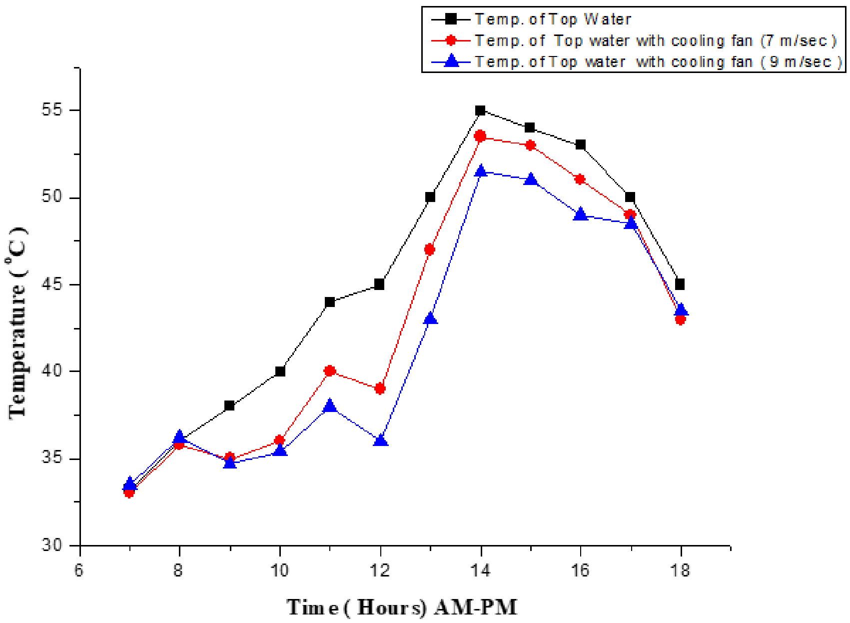

Fig. (5) Water temperature of (MESPVH) Solar still for various fan speed on July 2018, (m down =20 kg)

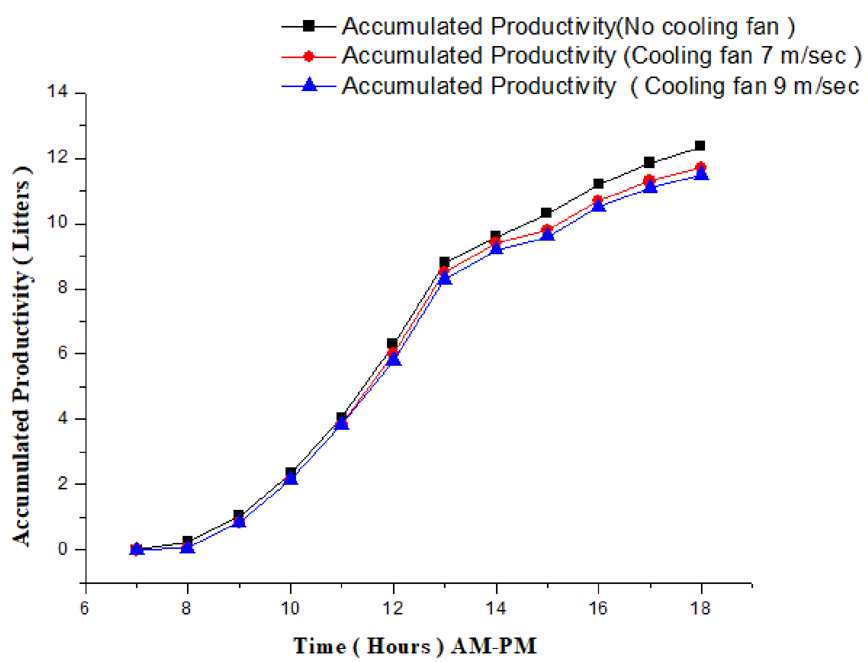

Fig. (6) Productivity of (MESPVH) Solar still for various fan speed on July 2018, (m down =20 kg)

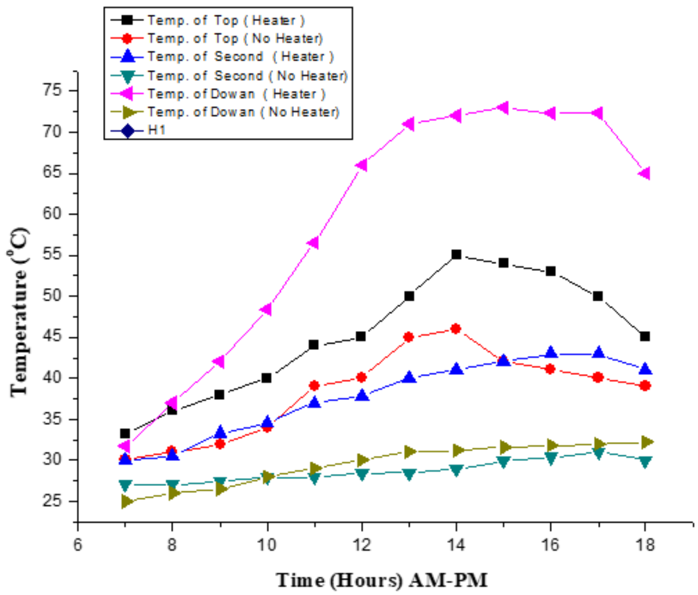

Fig. (7) Temperature Profile on July 2018 for solar still system with and without water heater

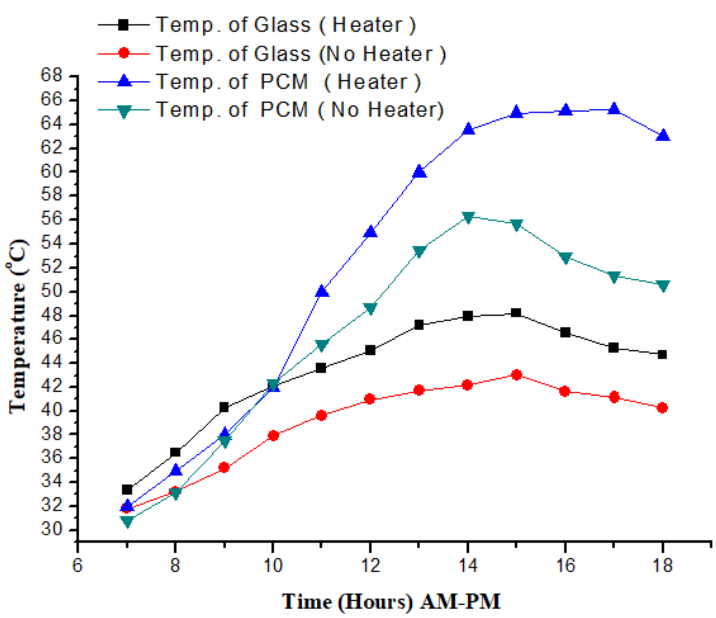

Fig. (8) Profile for PCM and glass temperature on July 2018 for (MES) Solar Still System with and without water heater.

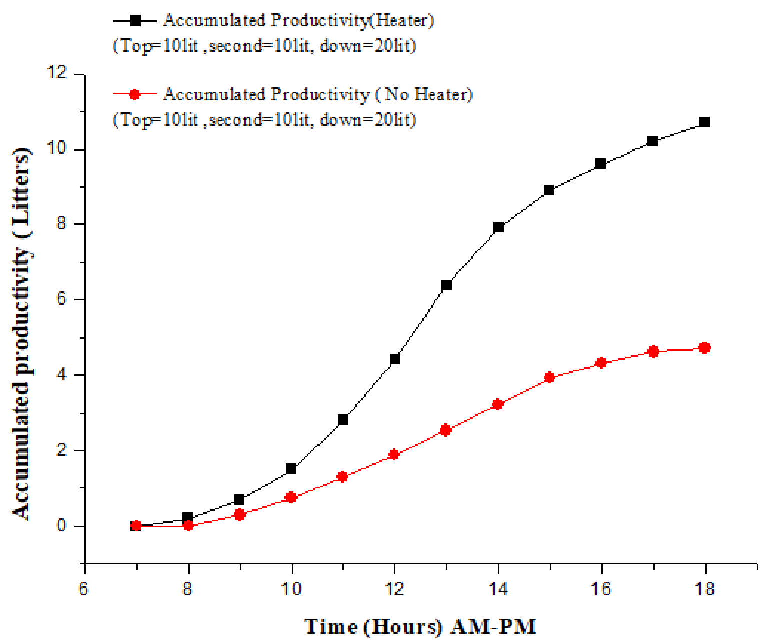

Fig. (9) Accumulated Productivity of (MES) Solar Still System with and without water heater.

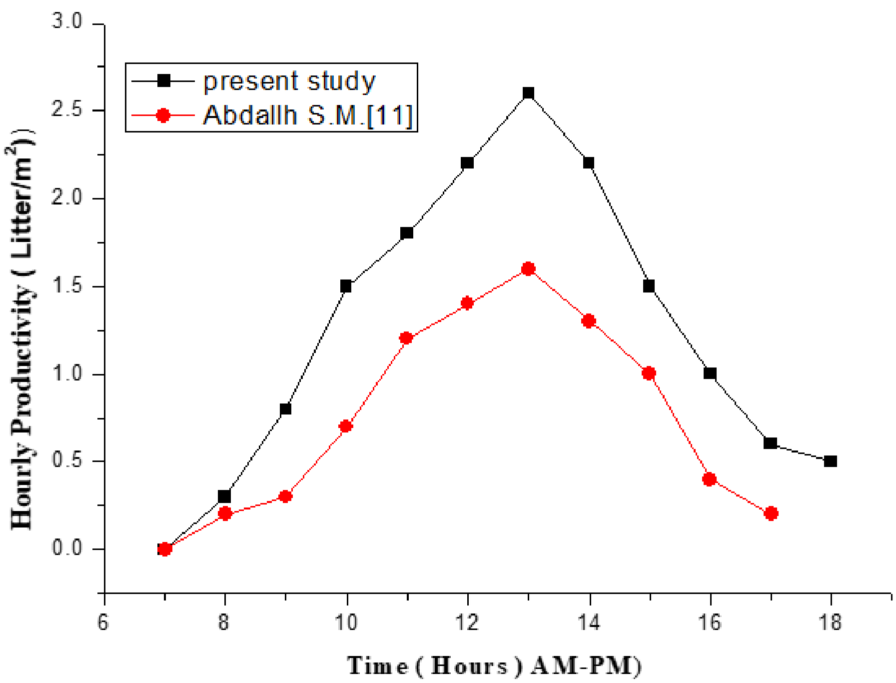

Fig (10) Comparison with other experimental study

دراسة تجريبية لمراحل التأثير المتعددة للألواح الكهروضوئية التي تعمل بالطاقة الشمسية لتعزيز الإنتاجية من خلال استخدام سخان المياه ومروحة التبريد.

علي عبد الرضا الحمداني **الطاف حميد ياسين**

قسم الهندسة الميكانيكية، كلية الهندسة، جامعة واسط

alirudhaengmec@gmail.com engaltaf1978@gmail.com

الخلاصة

دائما ما تعاني المناطق الصحراوية من نقص المياه النقية في أجزء كبير منها. وفي هذه المناطق، تكون المياه العذبة نادرة جدا حيث أن المياه التي يتم الحصول عليها من المستنقعات أو آبار المياه الجوفية هي مياه مالحة، ومن الضروري تنقيتها أو تقطيرها. وفي الدراسة التجريبية الحالية، تم إنشاء تصميم جديد لتحسين إنتاجية المياه العذبة لهرم التقطير الشمسي باستخدام السخان مغمور من نوع DC. إنه يبحث في تأثير المروحة الخارجية لتبريد سطح الزجاج. تم إجراء التجربة في فصل الصيف في ظروف العراق عند خط العرض (٣٣,٢ درجة شمالاً). يتم اختيار هرم التقطير الشمسي الزجاجي ذا زاوية ميل ٣٢,٥ درجة في هذا البيحث. نظرًا لأن التقطير الشمسي لا يزال يستخدم بصورة أكبر بالنسبة لأعماق المياه المنخفضة، لذلك فإن مستوى المياه في الحوض السفلي يبقى عند ارتفاع ٣ سم. لوحظ من النتائج التجريبية أن انتاج المياه العذبة زادت بنسبة كبيرة قدرها ٣٧٠ ٪ عندما تم استخدام سخان المياه DC لكل قدرة ٣٥٠ واط. أثناء استخدام مروحة التبريد الخارجية، كانت إنتاجية المياه العذبة تتناقص بنسبة (٧٪) و (١٥٪) لسرعات الرياح البالغة (٧ م / ث) و (٩ م / ث) على التوالي.

الكلمات الداله: – الطاقة الشمسية الثابتة، تحسين الإنتاجية، سخان المياه، رسوم الهرم، مروحة التبريد الخارجية.