Design and Testing of a Solar Still Coupled With a Solar Centeral Receiver

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Abstract

In this paper with the praise of **ALLAH** blessed be and high above all, a solar distillation system has been designed installed and tested under real conditions in the faculty of Engineering, Port Said, Suez Canal University, Egypt. The system consists of a solar still coupled with a solar central receiver (ssscr). The function of this arrangement is to heat the basin water in order to increase temperature and thus increase the solar still productivity. The thermal behavior of the system is investigated by two series of tests. First test is carried for the solar still unit only and second for the solar still coupled with the solar central receiver. The influence of coupling the solar still with the solar central receiver is reported, especially concerning distilled water productivity. A simple transient mathematical model is presented. The model is based on analytical solution of the energy-balance equations for different parts of the still. Numerical computations have been carried out for Port Said climatic conditions (31°17' N latitude, 32°12' E longitude). Good agreement between experimental and theoretical results is obtained. It is observed that the use of the proposed solar desalination system (ssscr) improves the accumulative productivity of the solar still by 91% when using 28 heliostats arranged in three circles around the central receiver.

Keywords: Solar energy - Solar Desalination – Solar Still – Central receiver .

Introduction

Drinking water of acceptable quality has become a scarce commodity. In many places of the world only saline or brackish water is available. This leads to an increasing interest in new desalination technologies. The standard thermal methods of water desalination such as multi-stage-flash-evaporation and multi-effect-evaporation, vapor compression and reverse osmosis are reliable in the capacity range of some 100 to 50,000 m^3 per day fresh water production. They are not used in regions with low infrastructure either for the supply in decontrols regions due to their permanent need of qualified maintenance and electricity supply. Here the use of solar desalination systems is desirable and makes economic sense [1,2]. Desalination is one of many processes available for water purification, and sunlight is one of several forms of energy that can be used to power the process.

Solar desalination systems can be small or large. They are designed either to serve the needs of single family, producing from 1 to 4 liters of drinking water a day on the average, or to produce much greater amounts for an entire neighborhood or village. In some parts of the world the scarcity of fresh water is partially overcome by covering shallow salt-water basins with glass in green house- like structures. These solar energy-distilling plants are relatively inexpensive, low technology systems, especially useful where the need for small plants exists [3].

Different designs of solar still have emerged. The single effect solar still is a relatively simple device to construct and operate. However, the low productivity of the solar still triggered the initiatives to look for ways to improve its productivity and efficiency. These may be classified into passive and active methods. Passive methods include the use of dye or charcoal to increase the solar absorptivity of water, applying good insulation, lowering the water depth in the basin to lower its thermal capacity, ensuring vapor tightness, using black gravel and rubber, using floating perforated black plate, and using reflective side walls [4-6]. Active methods include the use of solar collector or waste heat to heat the basin water, the use of internal] and external condensers or applying vacuum inside the solar still to enhance the evaporation/condensation processes, and cooling the glass cover to increase the temperature difference between the glass and the water in the basin and hence increase the rate of evaporation [7-10].

In this work a theoretical and experimental investigation on a new active solar distillation system (a solar still coupled with a solar central receiver) are carried out. The study includes design, construction and testing of the new system (Figs.1&2). The concepts of these two parts will be briefly explained below.

The Concept of Solar Still

The basin type solar still is basically a pan of water covered with transparent glass cover. The brine water is admitted into the basin where it is heated by absorption of solar energy. The base of the tray is blackened to facilitate this absorption. Since the water is substantially transparent to the short wave radiation from the sun, therefore the water liner always at a high temperature with respect to the basin water. As the water temperature increases, the motion of the water molecules become more vigorous and they are liberated from the surface in increasing number. Convection on the air above the water surface carries the vapor molecules away to the glass cover. As the glass cover temperature is always at a relatively lower temperature than the vapor temperature, therefore the vapor starts to condense on the lower side of the glass. The glass cover is adjusted with certain inclined angle to the horizontal to prevent the failing of the formed water droplet back to the basin, and allowed only to run down to the trough. The condensed water is discharged out the unit as fresh water. After vapor condenses on the glass, carrier air is now cooled due to releasing the latent heat of condensation to the atmosphere. Cooling air becomes heavier than hot air at the water free surface, thus convection current will continue to reach the thermodynamic balance inside solar still.

The Concept of Solar Central Receiver

Central receivers are one of the most promising applications in the utilization of solar energy to produce heat. Basically, reflecting surfaces called heliostats are laid around a central tower and used to reflect solar irradiance to a receiver on the top of the rower. Radiation absorbed by the receiver is then utilized to produce heat. The heliostat field consists of a number of flat or focusing mirrors (heliostats) distributed in a surround-field arrangement (360° arrangement). Each heliostat is continuously rotating around two axes to follow the sun so that solar ray is always reflected to the central receiver. This means that the tilt and the orientation angles of each heliostat are continuously adjusted. The reflected radiation from the heliostat field is absorbed by the receiver surface. Heat is then removed from the receiver by means of heat removal fluid. The overall dimensions and costs of a central receiver system depend on the design of the system. The designer of a central receiver system faces several problems and challenges to economically optimize his design. Among these challenges are: the selection of the heliostat type and its dimensions; the spacing between the heliostats in the field; the field dimensions; the tower height; the receiver geometry and type; the method of heat removal from the receiver, etc. The heliostat has either a flat (non-focusing) or a focusing surface. In most cases glass mirrors are used as the reflecting surface.

The mathematical equations required to determine the tilted angle and the orientation angle of a give n heliostat in a field were given by many workers [11]. The center of a heliostat is defined in terms of the radius r and the azimuth angle ψ_p , where r is the horizontal radial distance from the center of the tower, and ψ_p is the azimuth angle of the heliostat arrangement measured from the south direction as depicted in Fig.3. The center of the receiver is located at a height H above point O. Figure 4 depicts the heliostat tilt angle γ. The heliostat tilt angle is the angle between the unit vector N normal to the heliostat surface and the vertical direction. The heliostat azimuth angle (also called heliostat orientation angle) is the angle between the horizontal projection of the unit vector N and the south direction, with clockwise rotation as positive. The heliostat tilt angle "s" according to [11] is given by:

$$\cos\ s = \frac{\cos\theta_z\ +\ \cos\theta_r}{\left\{2 + 2[\cos\theta_z\ \cos\theta_r - \sin\theta_z\ \cos(\psi - \psi_p)\sin\theta_r]\ \right\}^{1/2}} \qquad (1)$$

Where θ_z and ψ are the solar zenith and azimuth angles], respectively and θ_r is the receiver altitude angle which is defined as follows:

$$\theta_r = \tan^{-1} r / H \qquad\qquad (2)$$

The heliostat azimuth angle γ (orientation angle) is given by:

$$\cos(\gamma - \psi_p) = \frac{\sin\theta_z \cos(\psi - \psi_p) - \sin\theta_r}{\left\{[\sin\theta_z \cos(\psi - \psi_p) - \sin\theta_r]^2 + [\sin\theta_z \cos(\psi - \psi_p)]^2\right\}^{1/2}} \qquad (3)$$

$$\sin(\gamma - \psi_p) = \frac{\sin\theta_z \sin(\psi - \psi_p)}{\left\{[\sin\theta_z \cos(\psi - \psi_p) - \sin\theta_r]^2 + [\sin\theta_z \cos(\psi - \psi_p)]^2\right\}^{1/2}} \qquad (4)$$

The heliostat angles s and γ given by the above equations are functions of the sun arrangement and the heliostat arrangement, i.e., they are functions of θ_z, ψ - ψ_p and r / H.

The heliostat layout configuration around the tower could be detrimental factor in the amount of energy collected by the receiver. Improper heliostat layout results in excessive losses in the energy reflected by the heliostat surface, in addition to the increase of the heliostat cost. Two configurations were used: a rectilinear layout configuration and a radial layout configuration. Radial staggered layout configuration is proved to be the best layout arrangement by many investigators in recent installations. The simplest criteria to primary layout the heliostat in the field is to minimize or to eliminate the losses due to the so-called shadowing and blocking. Shadowing means that the reflecting surface (or part of it) of one heliostat comes in the shade area of another heliostat, whereas blocking means that the reflected rays (or part of them) by one heliostat is blocked by the back surface of another heliostat.

Several research studies were carried out to recommend the radial and azimuth spacing between heliostats in a radial staggered field. A common feature between these works is to minimize or eliminate the losses due to shadowing and blocking. In many cases additional criteria were considered. Several researchers recommended the following constant azimuth spacing:

$$S_\psi / D = 2.1 \qquad (5)$$

On the contrary, several correlations were recommended in the literature for the radial spacing S_r,

$$S_r / D = 0.2 + r / H \qquad (6)$$

In this paper a theoretical and experimental investigation have been carried out on the active solar distillations system to determine the influence of this arrangement on the

solar still characteristics. The tests have been carried out for Port Said climatic conditions (31°17' N latitude, 32°12' E longitude).

Thermal Analysis

The assumptions considered in Ref. [12] are used in the present analytical analysis. These assumptions are:
1. The glass cover has the same area A_g as the water film A_w.
2. The water film and the glass cover are gray surfaces.
3. The water film is maintained at a constant temperature T_w.
4. The glass cover is taken at a constant temperature T_g.
5. There is constant and equal specific heat C for feed, brine, and distillate.
6. The sky can be considered as a black body.
7. The glass cover is exposed only to the sky.

With these assumptions an overall heat balance for the still gives:

$$q_f + \alpha_g H_s + \alpha_w \tau_g H_s = q_{ga} + q_b + C_s \left(\frac{dT_w}{dt} \right) \tag{7}$$

A heat balance for the glass cover gives:

$$q_{ga} = q_r + q_c + q_e + \alpha_g H_s \tag{8}$$

The heat transmitted by convection is given by:

$$q_c = 0.8831 \left[(T_w - T_g) + \left(\frac{P_w - P_{wg}}{0.265 - P_w} \right) (T_w + 273) \right]^{1/3} (T_w - T_g) \tag{9}$$

The heat transmitted by radiation is determined from the following equation:

$$q_r = F_{wg} \, \sigma \left[(T_w + 273)^4 - (T_g + 273)^4 \right] \tag{10}$$

The expression for F_{wg} is given as follows:

$$F_{wg} = \frac{1}{\frac{1}{\varepsilon_w} + \frac{1}{\varepsilon_w} - 1} \tag{11}$$

The heat transmitted by evaporation is given as follows:

$$q_e = 0.0061[(T_w - T_g) + (\frac{P_w - P_{wg}}{0.265 - P_w})(T_w + 273)]^{1/3} \cdot (P_w - P_{wg})L_w \qquad (12)$$

The value of q_b per unit area of the cover is determined as follows:

$$q_b = h_b(T_w - T_b) \qquad (13)$$

The value of q_f is simply given by:

$$q_f = mC_p(T_i - T_w) \qquad (14)$$

The cover temperature, T_g, is determined from Eqn. (8) after substituting of q_r, q_c and q_e from equation (9), (10) and (11), respectively, and substituting the following for q_{ga} :

$$q_{ga} = h_{ga}(T_g - T_a) + F_{g\,sky}\,\sigma[(T_g + 273)^4 - (T_a + 273)^4] \qquad (15)$$

The expression for F_{gsky} is given as follows:

$$F_{g\,sky} = \frac{1}{\frac{1 - \varepsilon_g}{\varepsilon_g} + \frac{1}{S_{gs}}} \qquad (16)$$

The view factor S_{gs} determined from the expression:

$$S_{gs} = \frac{1}{2}(1 + \cos s) \qquad (17)$$

The value of h_{ga} is determined from the following equation:

$$h_{ga} = a + b\,(v)^n \qquad (18)$$

The rate of distillate P_d produced by the still per unit area of the cover depends on the time of day. Its instantaneous is given as follows:

$$P_d = \frac{q_e}{L_{wg}}$$ (19)

The daily output of the still D is thus:

$$D = \sum P_d . \Delta t$$ (20)

Test Rig Description

A schematic diagram of the proposed active solar distillation system (ssscr) is shown in Figs 1&2. It consists of a basin type solar still coupled with a solar central receiver by means of a pump and a closed water cycle to transport the heat from the solar central receiver to the brine in the still to increase the evaporation rate. The still has an area of 1 m². The bottom and sides are insulated against heat loss to surroundings by means of glass wool insulation. The surface of the basin facing the sun is painted black for maximum absorption of solar radiation. A 0.025 m diameter single tube copper coil lays on the bottom of the still to perform a part of the heating closed circuit which transform heat from the central receiver to the brine in the still. The second part of the single tube copper coil lays on the absorber plate surface of the solar central receiver as shown in Fig.5. The still cover is made of 0.003 m thick ordinary window glass and has an inclination of 10°. The yield is collected in an Al. channel attached to the lower end of the glass cover and is taken outside using a water tap and measured directly by a measured jar. A PVC pipe is used for the supply of seawater. The whole system is almost vapor-tight; silicon rubber is used as a sealant because it remains elastic for quite long time. The still is coupled with the central receiver by means of a single tube copper coil and a water pump to form the active distillation system. The central receiver system consists of a 3 m tall steel structure tower with a 0.5m x 0.5m receiver on the tower top as shown in Fig.6. The receiver used in water heating is an insulated waterproof box containing dark four sides absorber plates under a transparent cover (0.003 m thick ordinary window glass). The box is made of galvanized iron sheet (0.003 m thick) formed by bending and assembled by soldering. The dark absorber (galvanized iron sheet 0.003 m thick.) catch up heat from sunlight that passes through the cover, and then gives the heat up to the fresh water flowing in a copper single tube coil past the absorber surface (see Fig.7). A 28 (05m x 0.5m) two axis tracking mirrors (heliostats) that redirect and focus solar radiation on receiver. The 28 heliostats are arranged around the steel tower in three circles. The first circle consists of 4 heliostats and has a 6m diameter. The second circle consists of 8 heliostats and has a 9 m diameter. The third circle consists of 16 heliostats and has a 12 m diameter. Experiments have been carried out outdoors during summer of 2001. The global solar radiation on a horizontal surface is measured using a silicon cell pyranometer model (3120). Calibrated NiCr-Ni thermocouples are used to measure the

temperatures of different pans of the basin still and solar central receiver, e.g. basin liner, basin seawater, enclosure vapor, the absorber plate and the inner and outer sides of the glass cover of the still. The ambient temperature and wind speeds have been also measured.

Results and Discussion

Experimental tests were carried out in four successive days during August 2002 to ensure the same climatic conditions for all sets. The thermal behavior of the system is investigated by two series of tests. First set of tests is carried for the solar still unit only and second is the solar still coupled with the solar central receiver in three arrangements.

The experimental work is carried out in order to study the thermal behavior of each unit and a quantitative as will qualitative comparison can be easily withdrawn. The tests have been carried out for the units that are shown in Fig.8.

Fig. 9 shows the measured wind speed variation on 17 August 2002. The average value of this speed needs as input parameter in the mathematical model. Typical measurements of hourly temperature variation of the solar still elements for different days of operation are presented graphically in Fig.10. Typical results of hourly variation of water, glass and ambient temperatures for solar still unit on 14 August 2002 are shown graphically in Fig.10a. It is shown that the temperature has increased with the hours of the day up to a maximum value close to 2 p.m. and then decreases. The measured hourly temperature variation of water, glass, ambient and inlet water to the brine from the central receiver for (ssscr) in arrangement 1 on 15 August 2002 are shown in Fig.10b. It can be seen from the figure that the measured values of the brine are higher than those of the solar still unit. This is due to the fact that the single tube copper coil heating closed circuit transfers heat from the central receiver to the brine in the still and this will lead to an increase in the brine temperature. Figs. 10c&10d show the hourly variation of water, glass and ambient temperatures for (ssscr) in arrangements 2&3 during 16 & 17 August 2002 respectively. The results show that the use of (ssscr) in arrangement 3 achieves the highest value of the brine temperature, as the number of heliostats in this arrangement is 28. These will results in an increase in the amount of solar intensity concentrated on the central receiver and hence increase amount of heat transfers by the single tube copper coil heating closed circuit to the solar still.

Figs. 11a to 11d show the hourly variation of daily productivity for the four sets of experiments. From the above curves it is shown that the daily productivity increase with hours of the day up to a maximum value at a time close to 2 p.m. and then decrease. This behavior is similar to the behavior of the brine temperature in the basin because the productivity of the still is a strong function in the brine temperature. It is also shown that the solar still unit productivity increases when it coupled with a solar central receiver (ssscr). Arrangement 3 achieves the highest value of the daily productivity, as the brine temperature in this arrangement has the highest measured values and thus a high rate of evaporation.

Fig.12 shows the typical measurements of solar radiation intensity on solar still unit during 17 of August 2002. It can be seen from the above curve that the maximum value of the solar radiation intensity is 1114 W/m^2. The measurements of solar radiation intensity on (ssscr) surface in arrangement 3.for the same day are presented in Fig.13. It can be seen from the above curve that the maximum value of the solar radiation intensity is 1400 W/ m^2.

A computer program is prepared for the solution of the energy balance equations for the proposed distillation system. The input parameters to the program include climatic, design and operational parameters. The climatic parameters are the ambient temperature, wind speed and solar intensity. The values of these parameters are taken from there measured values for Port Said (31°17' N latitude, 32°12' E longitude) during summer of 2002. The design parameters that are needed as input for the computer program are presented in table 1.

Table 1: Design parameters for the solar still and central receiver

Solar still parameters	Central receiver parameters	Site parameters
A_w= A= 1 m^2, d_w = 0.05 m	A_{cr}= 1 m^2 , C_w= 4190 J/kg ˚C	Latitude: 31°17' N
C_w= 4190 J/kg ˚C, α_w = 0.8	α_g = 0.1, τ_g = 0.89	Longitude: 32°12' E
α_g = 0.1, β_s = 15° , h_b = 5	F_{gs} = 0.9	
W/ m^2 ˚C, τ_g = 0.89	m_w= 400 kg/s	
C_s = 0.32 x 10^6 j/ m^2 ˚C		
F_{wg} = F_{gs}= 0.9		

The accumulative daily productivity of the solar still unit is presented in Fig. 14. It can be noticed from the figure that the measured daily accumulative productivity is 3.15 lit/m^2. Fig.15 shows the accumulative productivity for (ssscr) in arrangement 1. It can be seen from the figure that the measured daily accumulative productivity is 3.95 lit/m^2. Fig.16 shows the accumulative productivity for (ssscr) in arrangement 2. It is clear from the figure that the measured daily accumulative productivity is 4.5 lit/m^2. Fig.17 shows the accumulative productivity for (ssscr) in arrangement 3. It can be seen from the figure that the measured daily accumulative productivity is 6 lit/m^2. Comparisons between the four sets of experiments are presented in Fig.18. It can be seen from the above figure that the use of (ssscr) in the three proposed arrangements increases the daily productivity of the system. It is clear from the figure that the use of (ssscr) in arrangements 1, 2 and 3 increases the system productivity by 25 %, 43 % and 91 % respectively. The accumulative daily productivity of the solar still unit and for the solar still coupled with the solar central receiver in three arrangements are shown in Figs.14–18. These figures show the experimental results as well as the theoretical results obtained from the mathematical model presented in this work. For the three arrangements, the mathematical model gives higher values for the accumulative productivity than the values measured experimentally. The difference may be due to the large number of assumptions used in the mathematical model.

Conclusion

A new active solar distillation system was designed, constructed and tested in Port Said, Egypt. The system consists of a solar still coupled with solar central receiver (ssscr) and a number of heliostats arranged around it in three arrangements. The system seems to be suitable to provide drinking water for population or remote arid areas. Theoretical analyses of the thermal behavior of the still have been carried out. The experimental results obtained show the significant superiority of this proposed system over the conventional basin type. Good agreement between experimental and theoretical results is obtained. The experiment results show that:

1-The use of (ssscr) with 4 heliostats arranged around the central receiver in one circle, (arrangement 1) increases the daily productivity of the still by 25%.

2- The use of (ssscr) with 12 heliostats arranged around the central receiver in two circles, (arrangement 2) increases the daily productivity of the still by 43%.

3- The use of (ssscr) with 28 heliostats arranged around the central receiver in three circles, (arrangement 3) increases the daily productivity of the still by 91%.

Nomenclature

Ag	glass cover area
Aw	Basin area
b	constant
C_P	specific heat of water
C_s	thermal capacity of the still, water and ground, $J/C.m^2$
F_{gsky}	shape factor of diffuse radiation between cover and sky
F_{wg}	shape factor of diffuse radiation between water and cover
D	length of the side of a square heliostat
H	height of tower
H_s	incident solar flux, W/m^2
h_b	heat transfer coefficient between still and surroundings, $W/m^2.K$
h_{ga}	convective heat transfer coefficient between cover and ambient, $W/m^2.K$
L_{wg}	latent heat of water at saturation temperature equal to T_g, J/kg
m	water mass flow rate in the single tube copper coil,m/s
n	constant
P_w	saturation pressure of water at T_w, MN/m^2
P_{wg}	saturation pressure of water at T_g, MN/m^2
P_d	rate of distillate production, $kg/m^2.s$
q_b	rate of heat flux transferred from still to ambient and ground, W/m^2
q_f	rate of heat added to brine from central receiver, W/m^2
q_{ga}	rate of heat flux transferred from glass cover to ambient, W/m^2
q_e	rate of heat flux transferred by evaporation between water surface and still cover, W/m^2

q_c	rate of heat flux transferred by convection between water surface and still cover, W/m^2
q_e	rate of heat flux transferred by radiation between water surface and still cover, W/m^2
R	outer radius
r	radial distance of center of heliostat measured from base of tower
s	heliostat tilt angle with the ground plane
S_r	spacing of heliostats along the radial distance of the heliostat field
S_ψ	spacing of heliostat s along the azimuthal direction of the heliostat field
S_{gs}	view factor between the glass cover and the sky
T_a	ambient temperature, °C
T_b	the average temperature of the base at ambient side, °C
T_g	average temperature of the glass cover, °C
T_i	inlet water temperature to the basin from the central receiver, °C
T_w	average water temperature in the basin, °C
t	time, s
Δt	time intarvals, s
v	wind speed, mt/s
Z	distance, mt
α_g	absorptivity of the still glass cover
α_w	average absorptivity of water
ε_w	emissivity of the water-liner
ε_g	emissivity of the glass cover
θ_r	receiver altitude angle measured from center of heliostat
θ_z	solar zenith angle
σ	Stefen- Boltzman constant, $= 56.7 \times 10^{-9} \, W/m^2 K^4$
τ_g	transmissivity of the still cover
ψ	solar azimuth angle , measured from south in clockwise direction
ψ_p	heliostat arrangement angle, measured from south in clockwise direction

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Appendix I

Table 2 : values of a,b and n to be used in Eq. 18

Nature of cover Surface	v < 18 km/hr			18 < v < 110 km/hr		
	a	b	n	a	b	n
Smooth	5.61	1.09	1	0	2.64	0.78
Rough	6.18	1.19	1	0	2.8	0.78
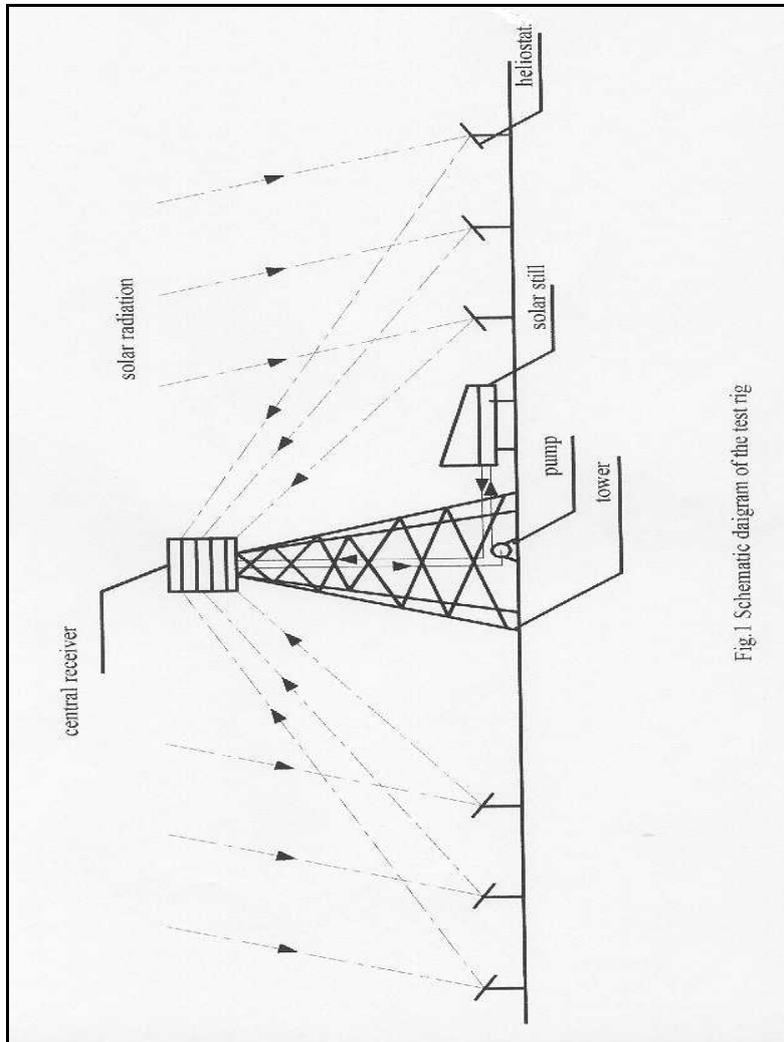
Fig.1 Schematic daigram of the test rig

Fig.2 Photo of the test rig with 28 heliostat (arrangement 1)
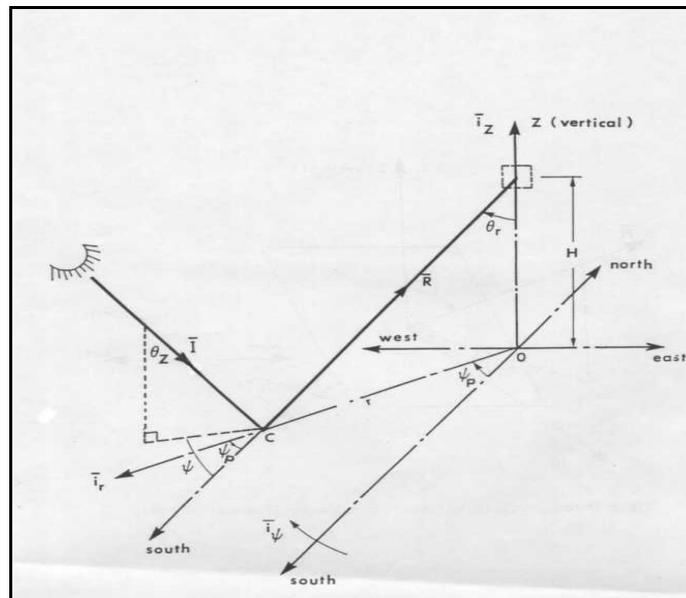
Fig.3 Geometry of position of heliostat with respect to tower and the reflection of a solar ray [11]
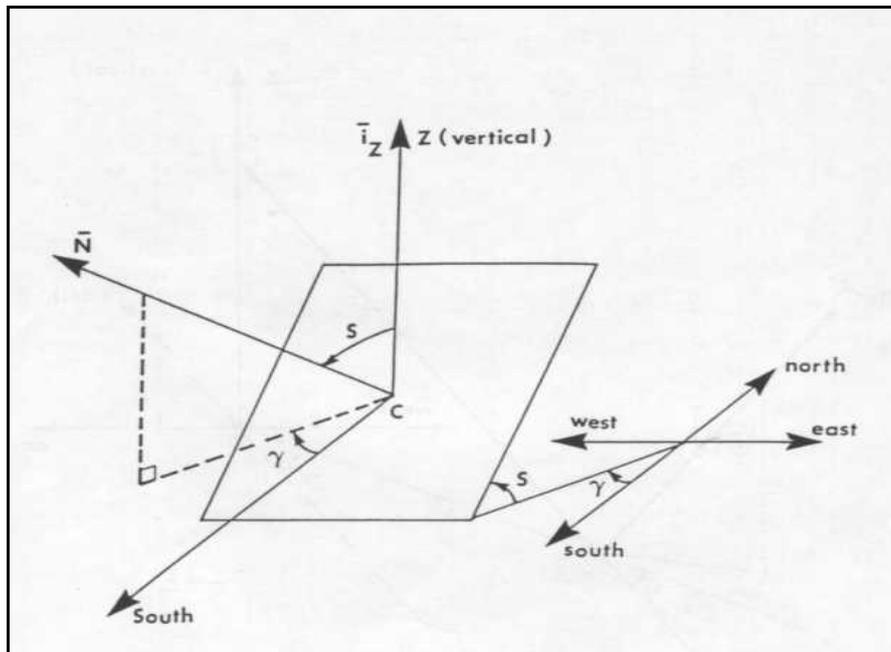
Fig.4 Definition of heliostat tilt and azimuth angles [11]

Fig.5 Solar still with single tube copper coil on the bottom

Fig.6 The central receiver with the steel construction tower

Fig.7 Central receiver with single tube copper coil on the absorber surface

The Thermal Test Behavior

Solar still unit

Solar still unit coupled with solar central receiver

Arrangement 1

Arrangement 2

Arrangement 3

4 heliostats arranged around the central receiver in a circle of 6m diameter

12 heliostats arranged around the central receiver in two circles as follows:

28 heliostats arranged around the central receiver in three circles as follows:

4 heliostats arranged around the central receiver in a circle of 6m diameter

4 heliostats arranged around the central receiver in a circle of 6m diameter

8 heliostats arranged around the central receiver in a circle of 9m diameter

8 heliostats arranged around the central receiver in a circle of 9 m diameter

12 heliostats arranged around the central receiver in a circle of 12 m diameter

Fig.8 The thermal test behavior

Fig.9 Typical measurements of wind speed (17th August 2002)
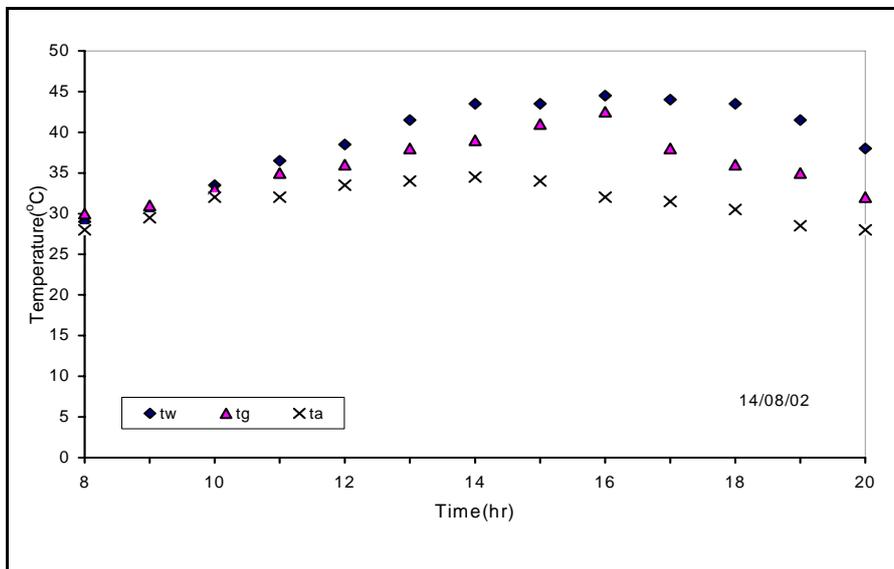
Fig.10a The hourly temperature variation of the solar still unit
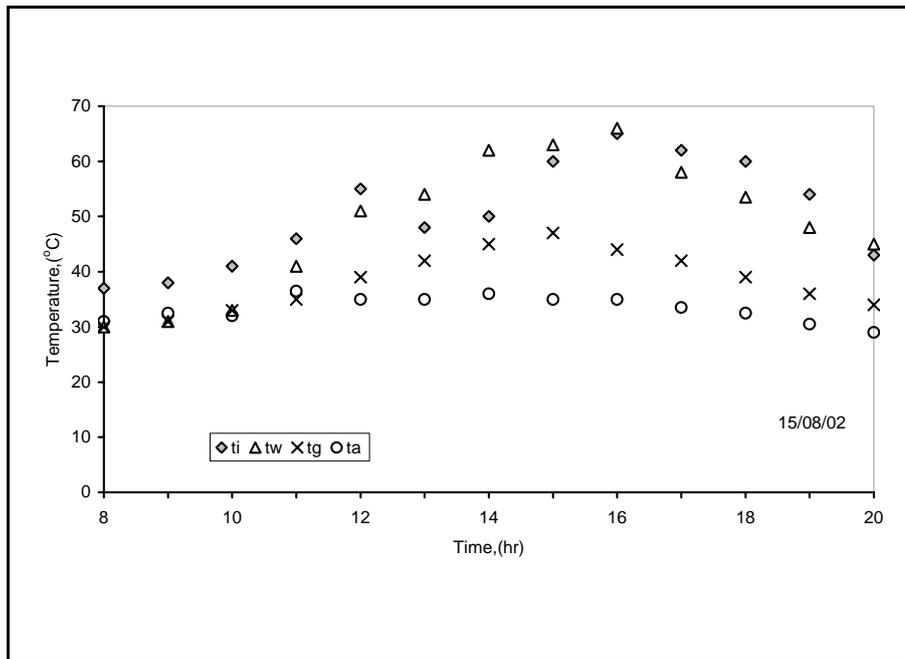
Fig.10 b The hourly temperature variation of (ssscr), arrangement 1
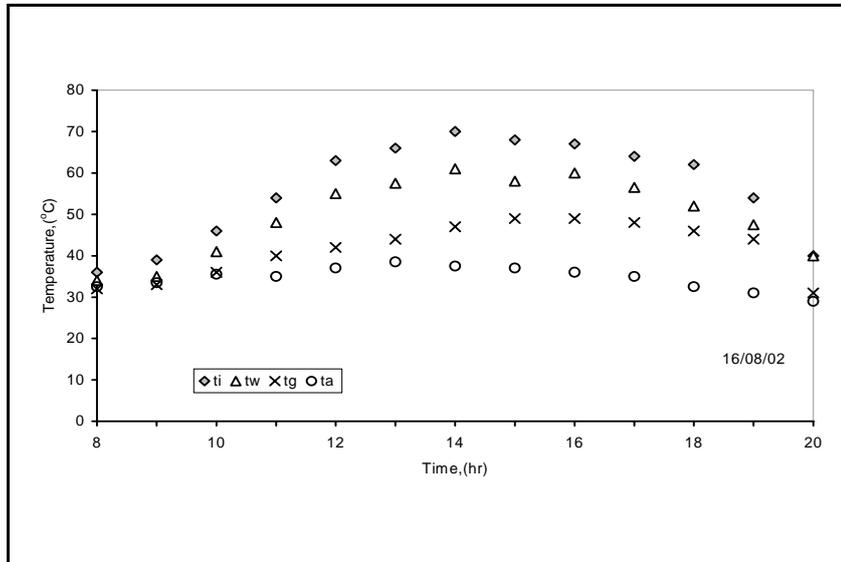
Fig.10 c The hourly temperature variation of (ssscr), arrangement 2
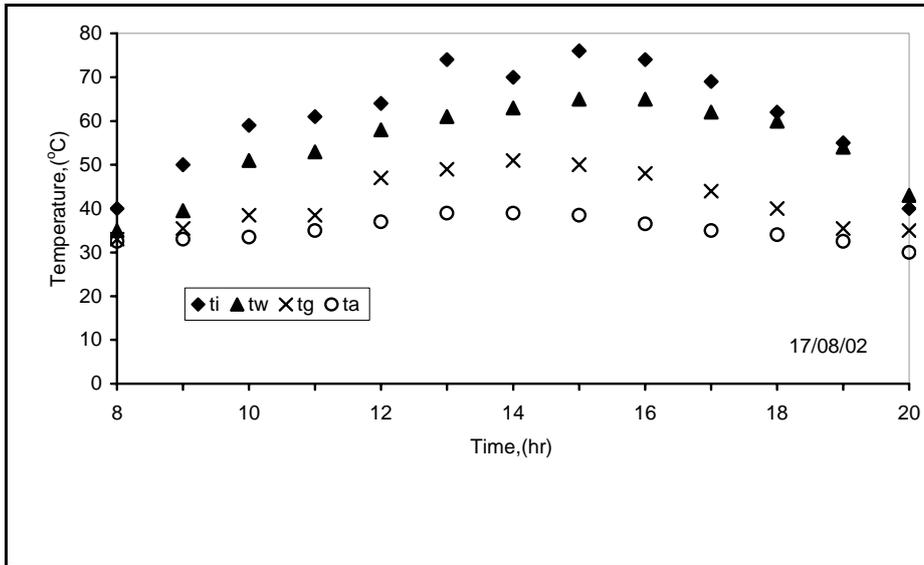
Fig.10 d The hourly temperature variation of (ssscr), arrangement 3
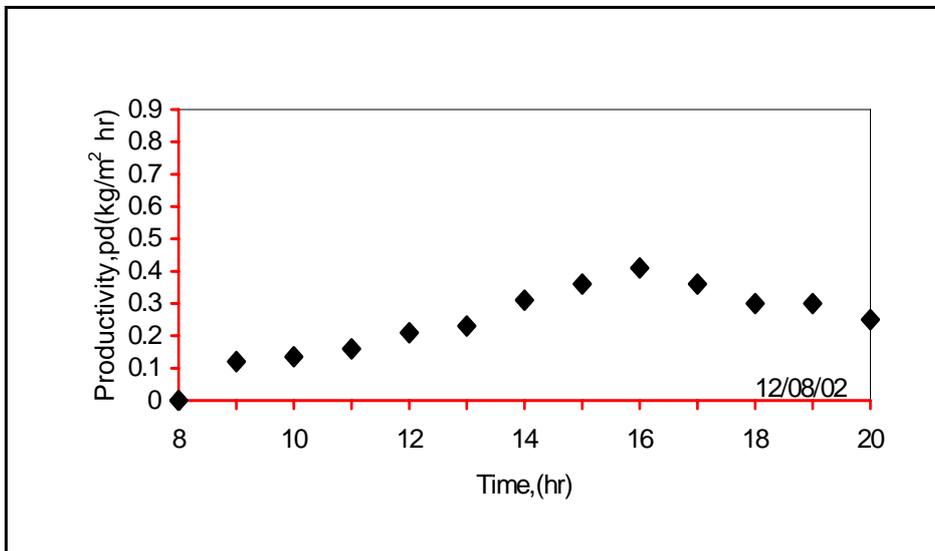
Fg.11 a The daily productivity of the solar still unit
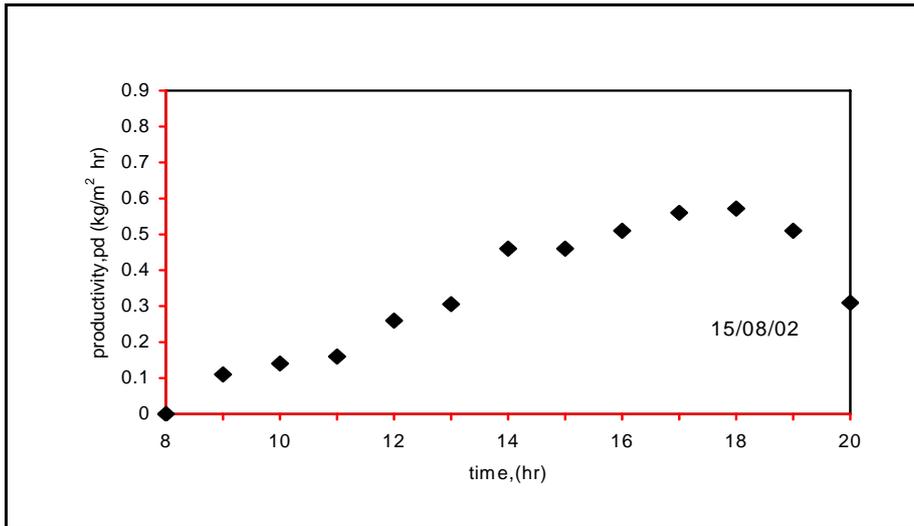
Fig.11 b The daily productivity of the (ssscr), arrangement 1
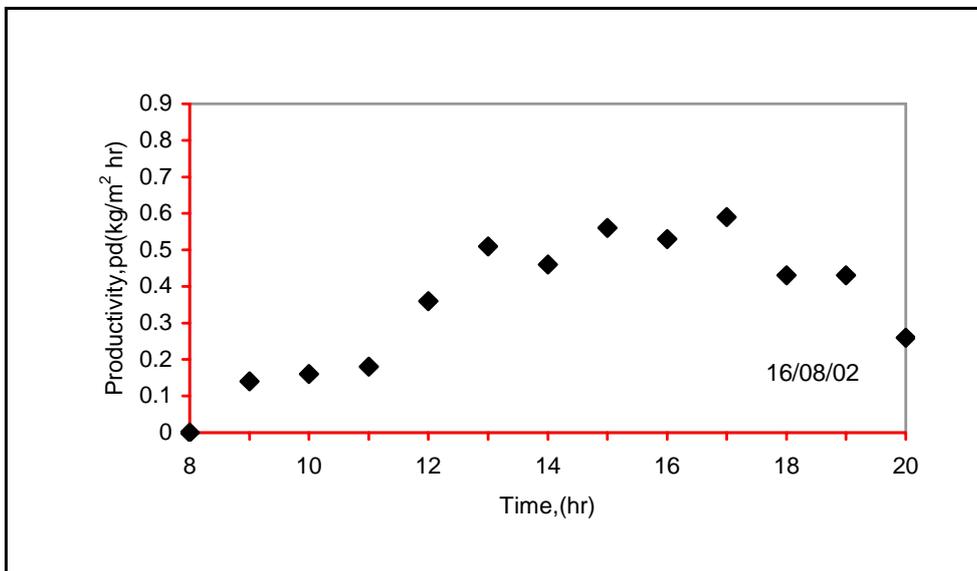
Fig.11 c The daily productivity of the (ssscr), arrangement 2
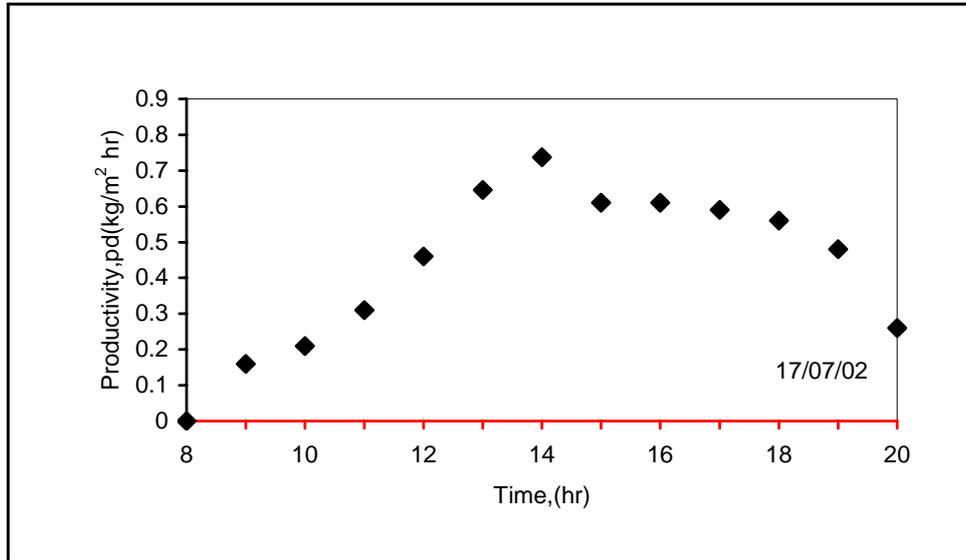
Fig.11 d The daily productivity of the (ssscr), arrangement 3
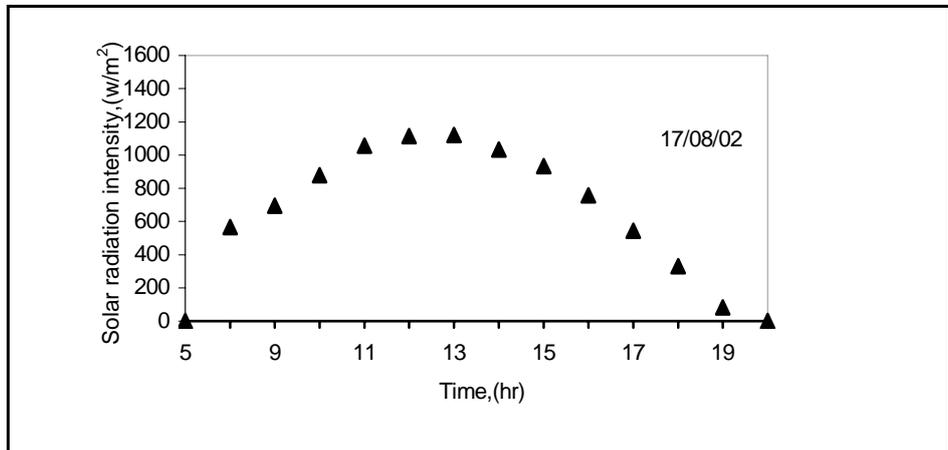
ig.12 Typical variation of solar intensity on solar still unit
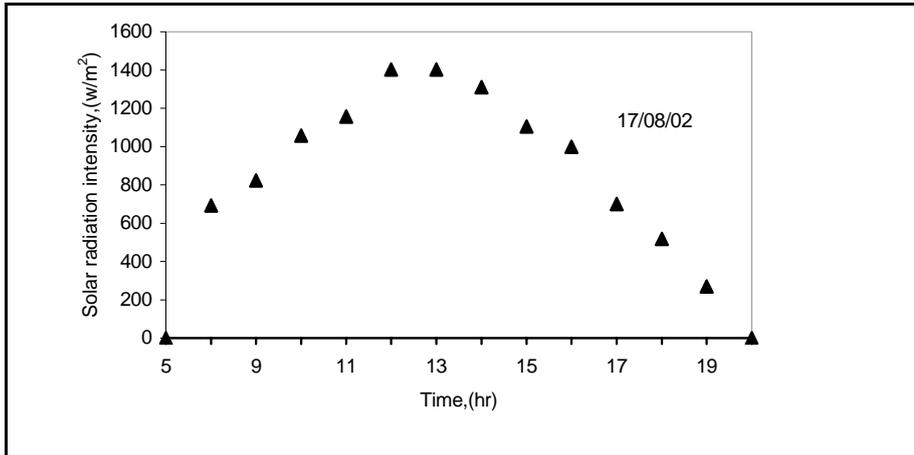
Fig. 13 Typical measurements of solar intensity on central receiver, arrangement 3
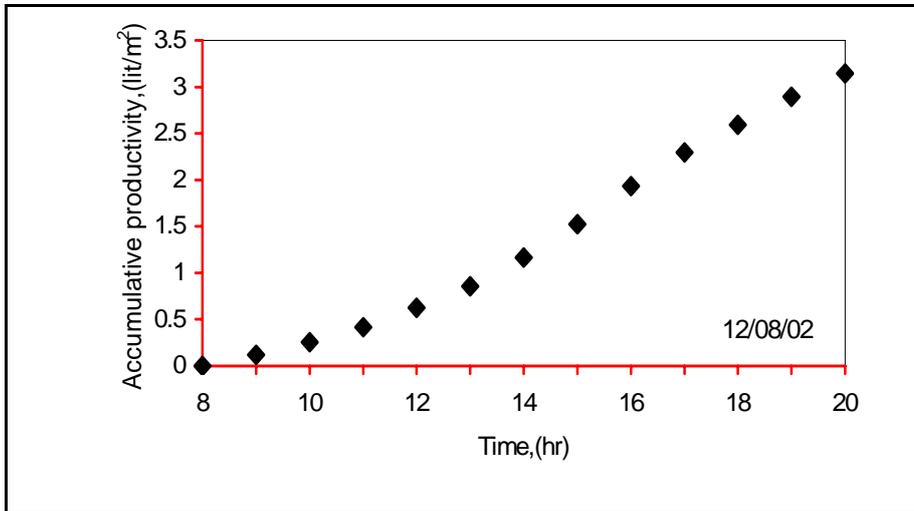
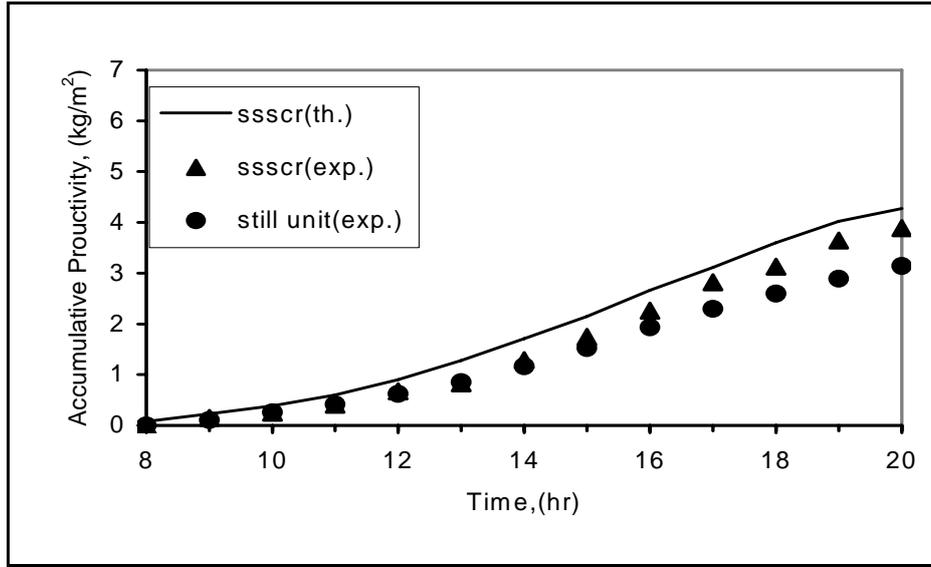Fig14 The accumulative productivity of the solar still unit

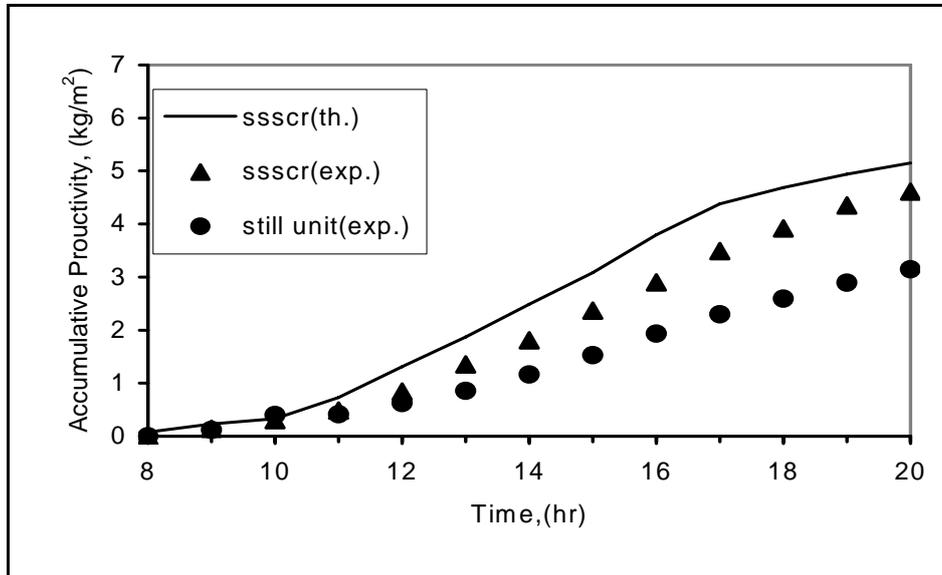Fig.15 The accumulative productivity of (ssscr), arrangement 1

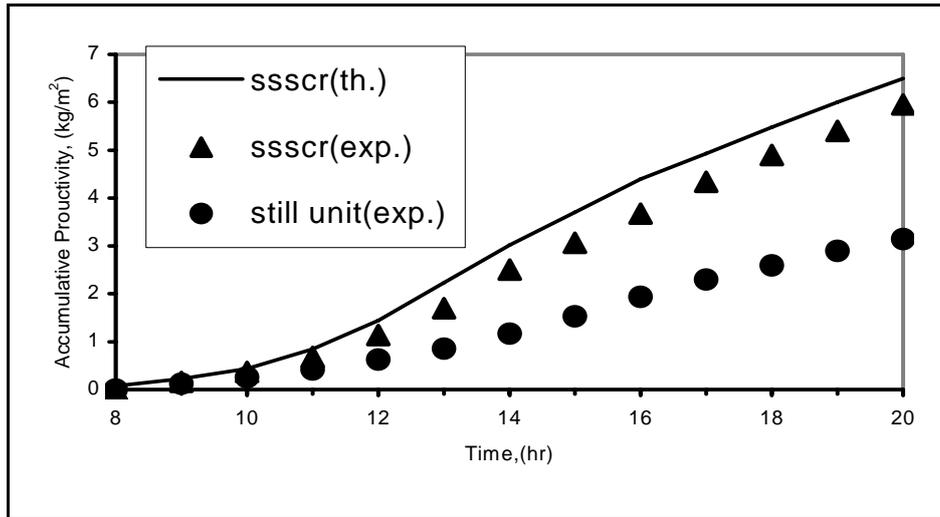Fig.16 The accumulative productivity(ssscr), arrangement 2

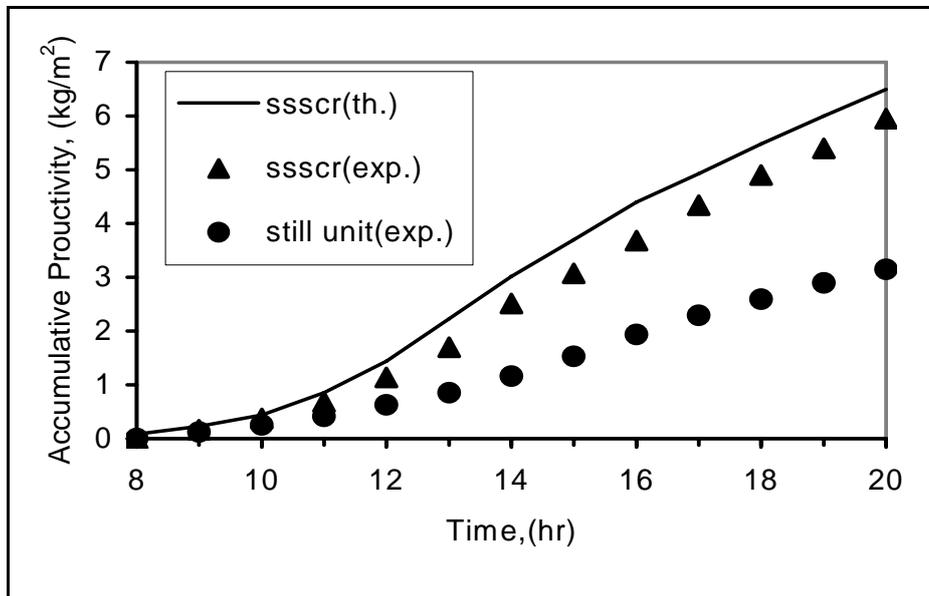Fig.17 The accumulative productivity of (ssscr), arrangement 3

Fig.18 Comparison between the experimental accumulative productivity of the four sets of tests

تصميم واختبار مقطر شمسي متصل بمستقبل شمسي مركزي

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تم بحمد الله تبارك وتعالي في هذا البحث تصميم وتصنيع واختبار نظام تقطير مياه شمسي متصل بمــستقبل شمسي مركزي للاستخدام في المناطق الصحراوية (بهدف تنميتها بشريا) في الهواء الطلق بمعمل الطاقــة الشمـــسية بكلية الهندسة ببور سعيد – جامعة قناة السويس– مصر.

الهدف من توصيل مقطر المياه الشمسي بالمستقبل الشمسي المركزي هو رفع درجة حرارة الماء المالح المـــراد تحليته داخل المقطر وبالتالي زيادة إنتاجية المقطر اليومية من الماء المحلي.

تم اختبار السلوك الحراري للنظام بواسطة مجموعتين من الاختبارات. المجموعـــة الأولي مـــن الاختبــارات أجريت علي المقطر الشمسي منفردا أما المجموعة الثانية من الاختبارات فقد أجريت علي المقطر الشمــسي بعـــد توصيله بالمستقبل الشمسي المركزي. كذلك تم في هذا البحث دراسة تأثير هذا الاتصال علي العوامل المختلفة الـــتي تؤثر علي إنتاجية المقطر اليومية من الماء المحلي. تم أيضا بناء نموذج رياضي استخدمت فيه إمكانيات الحاســـب الآلي العددية لبيان مدي تأثير تلك العوامل علي إنتاجية المقطر اليومية من الماء المحلي.

تم مقارنة النتائج المستخرجة من برنامج الحاسب الآلي مع تلك المقاسة عمليا ووجد أن هناك تطابقا جيـــدا بينهما. كذلك تم ملاحظة أن النظام المقترح يحسن إنتاجية المقطر اليومية من الماء المحلي بنسبة ممتازة قد تـــصل إلي 91% في حالة استخدام 28 هليوستات (مرآة) موزعين في ثلاث دوائر متحدة المركز حول المستقبل الشمسي.