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DESIGNING AND TESTING A SOLAR COOKER FOR REMOTE AREAS

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ABSTRACT

The design philosophy, construction and thermal performance tests of a solar cooker for single and double glass cover with or without reflector are presented. A simple experimental box-type solar cooker is made of locally available materials. The absorber plate is made of 1 mm iron sheet in trapezoidal shape and painted with matt black paint. Commercially available (3 and 5 mm) thick glass is used as glazing material. The outer frame is made of soft wood and glass wool was inserted between the casing and the absorber for insulation. The plane reflector was made of a commercially available specular plane mirror. Provision is made for one cooking vessel, capable of holding up to 3 kg of water. The obtained results were employed to calculate the two figures of merit (F_1 and F_2), the overall and utilization thermal efficiencies (η and η_u) and the required time for cooking different types of food and boiling a known quantity of water. The absorber plate stagnation temperatures increased from 113°C to 133°C and from 132°C to 144°C without and with reflector for single and double glass cover, respectively. The required time for boiling water was reduced by using the reflector while steam condensation reduced by using the tight cooking pot. The values of (η_u) and F_2 increased when the load increased. Finally, the results illustrated that the cooker has a good reliability for cooking food and boiling water (limited quantities of food and water).

INTRODUCTION

Humanity is forced to look for renewable sources of energy such as solar energy, wind energy, hydrogen energy and tide energy. These energies come to a sharp focus in the present time because the most of these energies are available everywhere, inexhaustible, unlimited and clean sources.

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Cooking by the sun is one of the thermal solar applications that uses the sun as an alternative source of energy instead of using the traditional sources of energy. The history of the solar cooking goes back to dim recess of antiquity. The use of solar power to ignite altar fires has been mentioned. The first solar furnace was fabricated in France by the famed naturalist George Louis Leclere Buffon (1707 – 1788). However, the first reference relating to solar cooking was that of Nicholas-de-Saussure (1740 – 1799). There are over 60 major designs of solar cookers, some of which are patented, more than 69 variations and over 100 drawings of solar cookers. A new set of parameters is suggested for testing the solar cooker such as reflectors, and insulation material. **(Kundapur, 1998).** Cooking is an activity that must be carried out almost on a daily basis for the sustenance of life. An enormous amount of energy is thus expended regularly on cooking. In many of remote areas in Egypt, the traditional and most popular sources of energy for cooking are kerosene, firewood and coal, associated together in incomplete combustion. The emission of toxic gases like carbon monoxide which are suspected to be the main cause of respiratory diseases and conjunctivitis amongst women that cook daily with these fuels **(Ekechukwu and Ugwuoke, 2003)**. Fuelwood and coal if not properly handled can be very unhygienic for cooking. Consequently and under these conditions, solar-energy cookers appear increasingly attractive as supplements to conventional cookers. **(Ekechukwu and Ugwuoke, 2003)**. Egypt is blessed with abundant solar energy. Located between latitudes 31.29°N to 21.18°N and longitudes 25.31°E to 35.59°E, it lies within the high sunshine belt of the world. Annual solar radiation average on a horizontal surface of 20.05 MJ m^{-2} day^{-1} and maximum (during June) of 27.95 $MJm^{-2}day^{-1}$ **(Duffie and Beckman, 1991)**. In Egypt, the annual average of global solar radiation is 5.4 - 7.1 kWh m^{-2} day^{-1}, while the annual average of diffuse solar radiation is 1.8 - 2.2 kWh m^{-2} day^{-1}. The annual average of actual daily sunshine duration is 9.2 - 11 h day^{-1}. The annual average of solar radiation on full tracking system is 7.5 - 10.5 kWh m^{-2} day^{-1}. From these numbers it can be concluded that Egypt has a great potential of solar energy, which can be considered as a reliable energy resource all over the year **(Habib, 2002)**. The intermittent nature of solar energy is a major handicap towards the adoption of solar cookers as viable alternatives to the traditional techniques. However, the development and popularization of efficient solar cookers which can be employed when feasible would reduce substantially the resources expended on energy for cooking. The impact of solar cookers on the economies of developing countries and the global ecology has been well articulated **(Ekechukwu and Ugwuoke, 2003)**. The historical development of solar cookers and a comprehensive review of the various practically realized designs of solar-energy cookers have been documented. Two generic types of solar cookers can be identified, namely, the box-type and the solar concentrator-type. Box-type solar cookers are both cheaper and simpler to construct and operate than the concentrator types. For locations with high diffuse solar radiation ratios, the problem of tracking is avoided. The box-type cookers have often not achieved their expected performance due to base design. A major shortfall associated with solar box cookers is the steam condensation on the inside surfaces which reduces the transmissivity of the glazing and sometimes causes corrosion of the absorber surface. They are also characterized by long cooking times. Cooking times of between 2 and 3 h have been reported and at times the food item may fail to cook. There is also the problem of lack of homogeneity in the cooked food. The objectives of the present study are building a simplified box-type solar cooker, studying the effect of cooker shape on its performance and utilizing the solar energy as a clean renewable source in cooking instead of the traditional method especially in remote areas by using box-type solar cooker.

MATERIALS AND METHODS

1. Design of the experimental solar cooker

a) Selecting the necessary design materials (raw materials)

The experimental cooker is of a box-type. The desired characteristics of the construction materials are: local availability, low cost, easy handling during fabrication, lightness and non-toxic effects. Commercially available (1 mm) thick iron sheet was used as an absorber plate. The absorber plate was painted with matt black paint to improve its absorptivity. Commercially available (3-5 mm) thick glass is used as a glazing material. Glass wool was used for insulation. Commercially available 2.5 cm thick soft wood was used for the casing. The plane reflector was made of a commercially available specular plane mirror, which has the desired property of high optical reflectivity.

b) The essential features

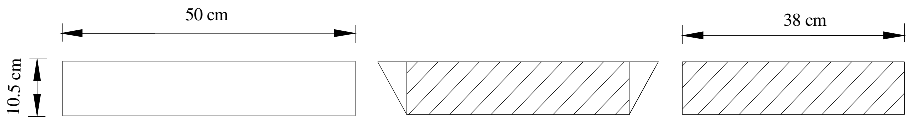
The following features were introduced to enhance the cooker performance over the traditional ones:

1. A specular plane mirror reflector is used to increase the amount of solar radiation flux incident on the cooker surface.
2. A trapezoidal absorber plate is used instead of the rectangular form.
3. A rubber gasket is used to reduce heat losses from the top.
4. The cooking vessel is cylindrical in form and have flat base to ensure good thermal contact with the absorber plate.

c) Size of cooker and volume of cooking chamber

Fig. (1) shows three different shapes of inner cooker box which are:

1- Cases 1 and 2 are similar in the top area.
2- Cases 2 and 3 are similar in the bottom area.
3- The three cases have the same depth.



Case (1) Case (2) Case (3)

Figure. (1) Different shapes of inner box

For selecting the shape, which achieves the best thermal efficiency, two important factors should be calculated:

1- R, the ratio between aperture area and absorber area:

$$R = \frac{top\ area}{bottom\ area + sides\ area}$$

Case (1) rectangular in shape with square top:

$$R_1 = \frac{a^2}{a^2 + 4ad} = 0.55$$

Case (2) trapezoidal in shape with square top:

$$R_2 = \frac{a^2}{b^2 + 4d[(a+b)/2]} = \mathbf{0.76}$$

Case (3) rectangular in shape with square top:

$$R_3 = \frac{b^2}{b^2 + 4bd} = \mathbf{0.48}$$

2- F, the effective volume factor ($m^2\ m^{-3}$):

$$F = \frac{aperture\ area}{volume\ of\ cooking\ chamber}$$

For case (1) $F_1 = \frac{a^2}{a^2 d} = \mathbf{0.096}\ m^2\ m^{-3}$

For case (2) $F_2 = \frac{a^2}{0.5d(a^2 + b^2)} = \mathbf{0.122}\ m^2\ m^{-3}$

For case (3) $F_3 = \frac{b^2}{b^2 d} = \mathbf{0.096}\ m^2\ m^{-3}$

Since $R_2 > R_1 > R_3$ and $F_2 > F_1$ and F_3, it can be concluded that:

1- Case 2 consumes minimum material as compared with case 1.

2- Case 2 absorbs the maximum solar radiation due to increasing R and less shade casting on the absorber.

d) Design parameters:

The design parameters are as follows: mass of water to be boiled (M) 1.5 kg, initial water temperature (T_i) 27°C, desired final temperature of water (T_f) 100°C, specific heat capacity of water at constant pressure (C_p), 4200 J kg^{-1} $°K^{-1}$, time desired for boiling of water (t) 2 h (7200 s), anticipated average total insolation (during the time t), (I_{av}) 700 Wm^{-2} assumed overall solar cooker efficiency (η) 35%, ambient air temperature (T_a) 30°C, anticipated absorber plate maximum temperature (T_p) 150°C, desired maximum heat loss rate through the cooker walls, (q_L) 7% of I_{av}, solar cooker surface area (A_s) 0.25 m^2 (calculated), thickness of wall insulation (x) 0.04 m (calculated). If $M_p\Delta T$ is the energy required to raise the temperature of the water from T_i to T_f (where $\Delta T = T_f - T_i$) and $I_{av}A_s$ is the amount of solar energy available to boil the water, then the cooker surface area is obtained as:

$$A_s = \frac{MC_p \Delta T}{I_{av} t \eta}$$ **(Ekechukwu and Ugwuoke, 2003)**

This gives a cooker surface area of 0.26 m^2. For ease of construction, cooker surface dimensions of 0.5 × 0.5 m are chosen. The cooker wall insulation thickness, x = 0.04 m is estimated from Fourier's law of conduction as,

$$X = \frac{kA_L \Delta T_p}{q_L}$$

where k is thermal conductivity of the fiber glass wool insulation (k = 0.04 Wm^1K^1) , A_L is the heat loss area (bottom + side walls, A_L= 0.327 m^2), ΔT_p is the temperature difference between the absorber plate and ambient, (T_p - T_a) = 120° C, q_L is the desired maximum rate of heat loss through the cooker walls (q_L = 7% of the incident insolation = 49 W). This gives The cooker wall insulation thickness 0.0334 m. For better wall insulation thickness 0.04 m is chosen.

2. Measuring Instruments.

Measurements of the cooker temperature, ambient and water temperatures, wind velocity and solar intensity were recorded. The instruments used in this research are data logger (Kaye instruments, 48 channels input), thermocouples type K (± 0.5 °C), pyranometer (resolution of 0.001Wm^{-2}), a digital balance (0.5 g accuracy), A digital voltmeter (0.1 mV accuracy), and a standard mercury thermometer (0-110 °C). Fig. (2) shows the thermocouples distribution and Fig. (3) reveals a schematic diagram of the experimental setup.

3. Experimental procedures:

The experimental tests were conducted at the Agricultural Engineering Research Institute, Dokki, Giza during June 2006 to February 2007. This site is located at 31° 13'E and 30° 02' N. The tests were run using different glazing thickness and numbers, with and without reflector, different quantities of water and cooking materials, and different tilt angles of the reflector.

Fig. (2) The box-type solar cooker and a cooking pot.

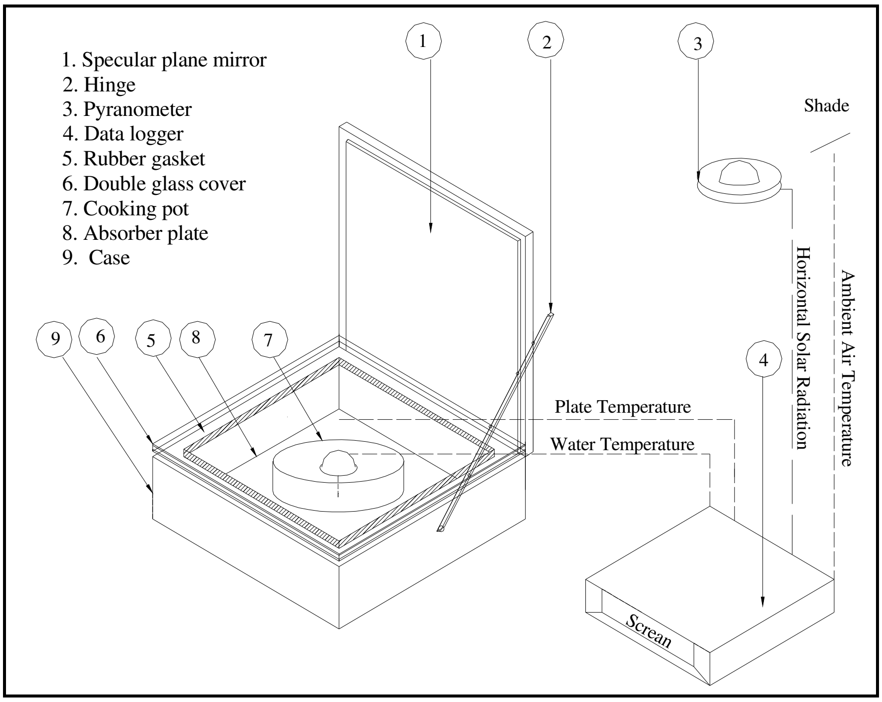


Fig. (3) Schematic diagram of the box-type solar cooker.

4. The thermal performance test of the solar cooker.

The procedures followed to evaluate the thermal performance of solar cookers consist of determining one of the following: (1) the stagnation plate temperature recorded in a test without load, (2) the time required for a sensible heating of a known quantity of water up to the boiling point, (3) cooking time for different food products. The first and second methods are better approaches because the third method involves uncertainties due to variation in the ingredients and judgment of the observer as to when exactly the food is completely cooked. (El-Sebaii and Ibrahim, 2005) used the second method to evaluate the solar cooker thermal performance by calculating the utilization thermal efficiency, η_u. During the experiments execution, the following measurements are measured and recorded:

a. The overall instantaneous insolation

$$I_T = I_b R_{br} + I_d F_{c-s} + I_r$$ **(Duffie and Beckman, 1991)**

where, I_b and I_d, are the beam and diffuse components of insolation impinging directly on the cooker glazing and I_r is the beam insolation reflected on the plane reflector surface to the cooker glazing. I_r is defined as follows:

$$I_r = \left[I_b R_{br} + \left(1 - F_{r-c} \frac{\rho_r A_r F_{r-c}}{A_c} \right) I_d \right]$$ **(Duffie and Beckman, 1991)**

where: ρ_r is the reflectivity of the mirror (given as 0.89), A_r is reflector area, A_c is top cooker surface area, R_{br} is the ratio between the beam radiation on a tilted surface and a horizontal surface, F_{r-c} is the view factor from reflector to collector, and F_{c-s} is the view factor from collector to sky.

b. Standardized cooking power (P_s)

$$P_i = \frac{(T_f - T_i) MC_v}{600}$$ **(ASAE Standards S580, 2003)**

where: P_i = cooking power (W), T_f = final water temperature (°C), T_i = initial water temperature (°C), and MC_v = water heat capacity (J K^{-1}).
Cooking power for each interval shall be corrected to a standard insolation of 700 Wm^{-2}.

$$P_s = P_i \frac{700}{I_i}$$ **(ASAE Standards S580, 2003)**

where: I_i = interval solar insolation, Wm^{-2}

c. The overall cooker thermal efficiency (η)

$$\eta = \frac{Q_T - Q_L}{Q_T}$$ **(Duffie and Beckman, 1991)**

where: Q_T = total energy (W) and Q_L = total energy loss (W)

$Q_T = \tau_g A_C I$ (for single glass cover) **(Habib, 2002)**

$Q_T = \tau_g^2 A_C I$ (for double glass cover) **(Habib, 2002)**

$Q_L = Q_t + Q_b + Q_s$

Where: A_c= collector top area (m^2), I = solar radiation on a horizontal surface ($W\ m^{-2}$), τ_g = transmissivity of the glass cover, Q_t = energy loss from top, Q_b = energy loss from bottom, Q_s = energy loss from sides**.**

1. Figures of Merit.

Mullick et al. (1996) proposed a standard test procedure for box-type solar cookers. In this procedure, two figures of merit F_1 ($^{\circ}C\ m^2\ W^{-1}$) and F_2 have to be determined by conducting the stagnation temperature test (without load) and by heating a known mass of water, respectively.

First Figure of Merit "F_1".

The first figure of merit, F_1 of a box-type solar cooker is defined as the ratio of optical efficiency to overall heat loss coefficient and is given as

$$F_1 = \frac{F'\eta_o}{F'U_L} = \frac{T_{ps} - T_{as}}{H_s}$$ **(Kumar, 2005)**

where: $F'\eta_o$ and $F'U_L$ are the optical efficiency and overall heat loss coefficient of the cooker, respectively, H_s and T_{as} are, respectively, the insolation and ambient air temperature at the time when the plate stagnation temperature T_{ps} is reached.

Second Figure of Merit "F_2".

The second figure of merit, F_2 of a box-type solar cooker is defined by Buddhi et al. (1999) as:

$$F_2 = F'\eta_o = \frac{F_1 (MC)_w}{A(t_2 - t_1)} \ln \left[\frac{1 - \frac{1}{F_1}\frac{(T_{w1} - T_a)}{I}}{1 - \frac{1}{F_1}\frac{(T_{w2} - T_a)}{I}} \right]$$

Where: M_w is mass of water (kg), C_w is specific heat of the water ($J\ kg^{-1}\ {}^{\circ}C^{-1}$), I is average solar radiation over time period ($W\ m^{-2}$), A is aperture area of the cooker (m^2), T_{w1} is lower value of water temperature (°C), T_{w2} is upper value of water temperature (°C), (t_2-t_1) is time taken for heating from T_{w1} to T_{w2} (seconds) and T_a is average air temperature over time period (°C). First figure of merit "F_1" tells about the ratio of the optical efficiency ($\alpha\tau$) and heat loss (U_L) factor in the box type solar cooker. Second figure of merit "F_2" tells about the product of the heat exchange efficiency factor (F') and optical efficiency ($\eta_o = \alpha\tau$). For the solar cooker, a high optical efficiency ($\eta_o=\alpha\tau$) and high heat exchange efficiency factor (F') with low heat loss factor (U_L) are desirable.

2. The utilization thermal efficiency (η_u).

$$\eta_u = \frac{M_w C_w \Delta T_w}{I_{avg} A_c \Delta t}$$ **(El-Sebaii and Ibrahim, 2005)**

Where: M_w, C_w are the mass (kg) and specific heat (J kg^{-1} K^{-1}) of water, ΔT_w is the temperature difference between the maximum temperature of water and the mean ambient air temperature during the interval (T_a), I_{av} is the solar intensity (Wm^{-2}) during the time interval and A_c is the aperture area (m^2) of the cooker.

RESULTS AND DISCUSSIONS

1. Effect of glass cover thickness on the cooker temperatures

Two tests were carried out on 5/6/2006 and 11/6/2006 without reflector and without load in order to determine the effect of using 3 and 5 mm thick of glass cover on the variations of the cooker temperatures. It evidently revealed that, the plate temperature was higher when using glass cover of 3 mm thick. In addition, the temperature of the cover top surface was higher as compared with that of 5 mm thick cover. Fig. (4) illustrates the variation in the cooker temperature and the solar radiation during the daytime of the tests.

3. Effect of plane reflector tilt angle on the cooker temperatures

Two tests were carried out on 18/6/2006 and 20/6/2006 to study the effect of reflector tilt angle on the cooker temperatures. The tilt angle was adjusted to 90° throughout daylight. The obtained results showed that the absorber plate reached to 129°C at noon. In the second day, the reflector angle was set to 80° at 10 am and increased by 10° every 2 hours. It is noticeable that the plate temperature was higher from morning to 11 am and from 2 pm to the end of the day as compared with the fixed tilt angle in the previous day.

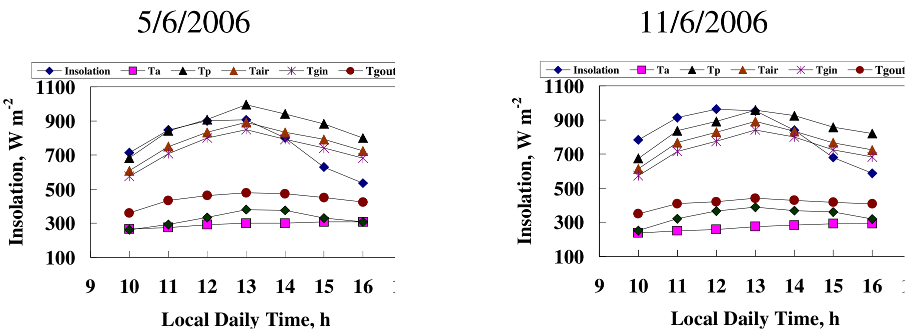


Fig. (4) Relationship between daytime , insolation, and cooker temperatures.

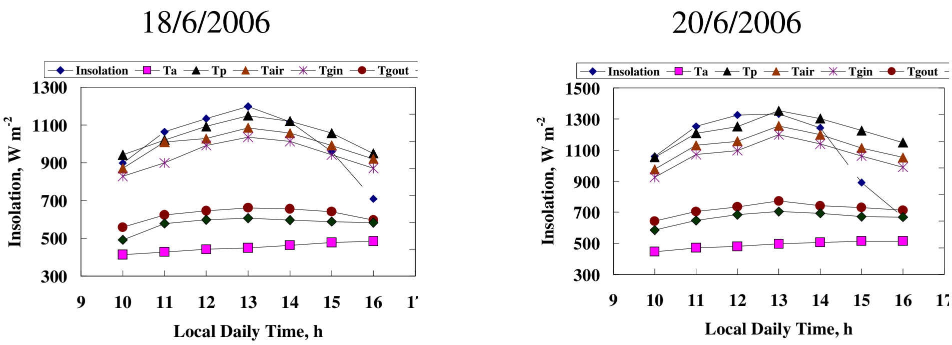


Fig. (5) Effect of reflector tilt angle on cooker temperatures without load.

4- Effect of condensed steam on the cooker temperatures and the required time to boil water

Two tests were conducted on 13/6/2006 and 15/6/2006 to examine the effect of condensed steam on the glass cover on the required time to boil 1 kg of water. The obtained data illustrated that the time decreased when the cooking chamber was tight enough. Also the amount of condensed steam on the glass cover was very low with tight cooking chamber. Fig. (6) shows the variation in the cooker temperature and the solar radiation during the execution of the tests.

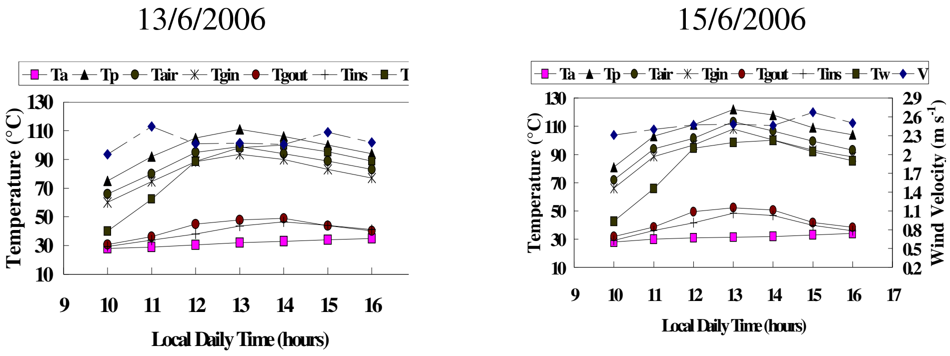


Fig. (6) The effect of cooking pot tightness and wind velocity on cooker temperatures.

5. Cooking time

The most important parameter which determining the effectiveness of the cooker is the time taken for cooking process. The cooking time differs for each material that is to be cooked, and depends on the initial temperature of the food. Four cooking tests with different cooking raw materials were conducted for determining cooking time. The materials were peanut, potato, meat and cake mixtures. The cooking materials were put in the cooker at 10 am. Fig. (7) reveals the cooking time taken during the cooking process for the different four materials.

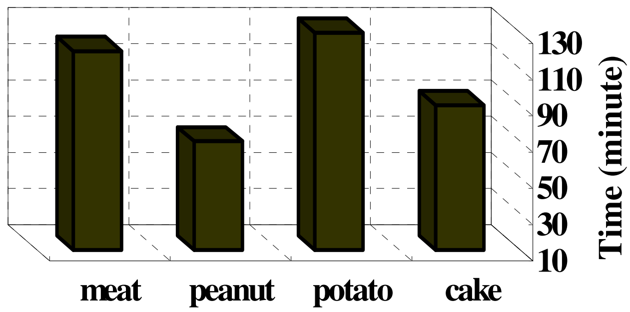


Fig. (7) The cooking time for different cooking materials.

5. The thermal performance of the cooker

5.1. Effect of glass cover numbers on the thermal performance of the cooker

Two tests were conducted on 20/6/2006 and 3/7/2006 with single and double glass cover, respectively. (with reflector tilt angle 80° with horizontal from 9 am to 11 am, changed to 90° at 11 am to 12 noon, changed to 100° at 12 pm to 1 pm, then changed to 120° tilt angle, to the end of the day) and without load in order to determine the effect of glass cover numbers on the variations of the cooker temperatures. It is noticed that the plate temperature was higher and the energy losses from the top reduced when using double glass cover. Fig. (8) illustrates the variations in the cooker efficiency (η %), the total energy gained (Q_t) and the total energy loss (Q_L) during the daytime of the test for single and double glass cover. This phenomenon could be attributed to the decrease in energy losses due to using double glazing.

20/6/2006 3/7/2006

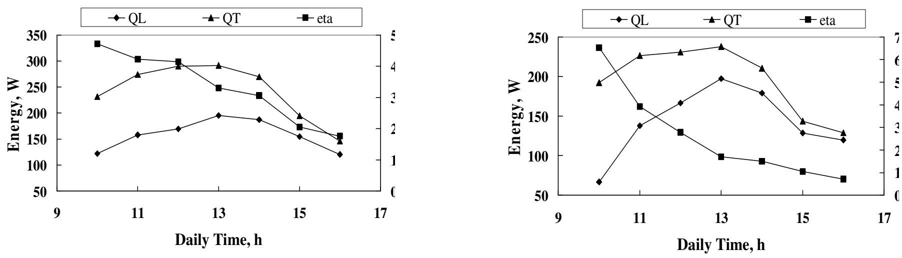


Fig. (8) Effect of glazing number on cooker thermal performance.

5.1. Figures of merit

First figure of merit (stagnation temperature test):

To determine the first figure of merit F_1, solar cooker without load was exposed to the solar radiation at about 10 am. Solar radiation on horizontal surface, plate temperature and ambient temperature were recorded each 60-minute interval simultaneously until the stagnation condition occurred. Tests were carried out on 11/6/2006 and 4/7/2007 to calculate the first figure of merit and the results showed that the value of F_1 was 0.086 °C m^{-2} W^{-1} at stagnation plate temperature of 113 °C, ambient air temperature of 31 °C and insolation on a horizontal surface of 953.6 W m^{-2}, respectively. For double glass cover, F_1 without reflector was 0.104 at stagnation plate temperature of 133 °C, ambient air temperature of 33 °C and insolation on a horizontal surface of 962.1 Wm^{-2}.

Second figure of merit (Heat up condition test):

To assess the second figure of merit F_2, the solar cooker with reflector was loaded with a known amount of water. Solar radiation, ambient air temperature and water temperature were recorded at an interval of 60 minutes until the water temperature exceeded 95 °C. To calculate F_2, initial and final water temperatures were chosen between 50 to 55 and 90 to 95 °C, respectively**.** Experiments were conducted with 1.0, 1.5, 2.0 and 2.5 kg loads of water. F_2 was calculated for each load. The data given in table (1) show the variation of F_2 at different loads.

Table(1): Variations of the second F_2 with quantity of water

Date	M_W^*, kg	T_{w1}, °C	T_{w2}, °C	$(t_2 – t_1)$, s	T_{avg}, °C	I_{avg}^{**}, Wm^{-2}	F_2
22/6/2006	1.0	55	95	5100	30.0	1148	0.263
29/6/2006	1.5	55	95	7728	32.0	1109	0.276
2/7/2006	2.0	55	95	9003	32.9	1112	0.296
1/7/2006	2.5	55	95	10200	32.5	1141	0.311

* The mass of the water was not measured at the end of the experiments.
** Values are obtained with reflector in place.

From table (1), it was observed that the value of F_2 depends on the quantity of water loaded in the solar cooker. The results showed that the values of F_2 increased when the load increased and these results agreed with the pervious works presented by **(Mullik et al., 1996)**, **(Kumar, 2005) and (El-Sebaii and Ibrahim, 2005)**

5.2. The utilization efficiency (η_u)

To determine (η_u), the solar cooker with reflector was loaded with a known amount of water. Solar radiation, ambient air temperature and initial and final water temperatures were recorded each 60-minute interval until the water temperature reached the maximum possible temperature.

Table(2): Utilization efficiency for the cooker in different days

Date	M_w*, kg	$T_{wmax,}$ °C	$T_{avg,}$ °C	ΔT, °C	Δt, s	I_{avg}, Wm^{-2}	η_u , %
15/6/2006	1.0	100.0	30.50	69.50	14400	864.0	9.36
22/6/2006	1.0	100.0	30.75	69.25	10800	1112.3	9.29
29/6/2006	1.5	100.0	32.60	67.40	14400	1095.7	10.76
2/7/2006	2.0	100.0	33.20	66.80	14400	1027.2	15.17
20/2/2007	1.0	72.4	20.75	51.65	10800	474.5	16.93
21/2/2007	1.0	94.6	23.00	71.60	14400	710.8	11.75

*The mass of the water was not measured at the end of the experiments.

Experiments were conducted with 1.0, 1.5 and 2.0 kg load of water and (η_u) was calculated for each load of water. From Table (2), it was observed that the value of (η_u) depends on the quantity of load in the solar cooker. The results showed that the values of (η_u) increased when the load increased and these results agreed with the pervious works presented by **(El-Sebaii and Ibrahim, 2005).**

5.3. The cooking power

Cooking power (P_i) and adjusted cooking power (P_s) are calculated for 60-minute intervals and plotted against the difference between water temperature and ambient temperature (T_d), as shown in Fig. (9). A linear regression was used to examine the relationship between cooking power and temperature difference. Fig. (9) shows that the adjusted cooking power (P_s) has opposite relation with the temperature difference. The regression equation is:

$$P_s = 59.2 - 0.859T_d$$

The value of the coefficient of determination (R^2) of the equation is 0.931.

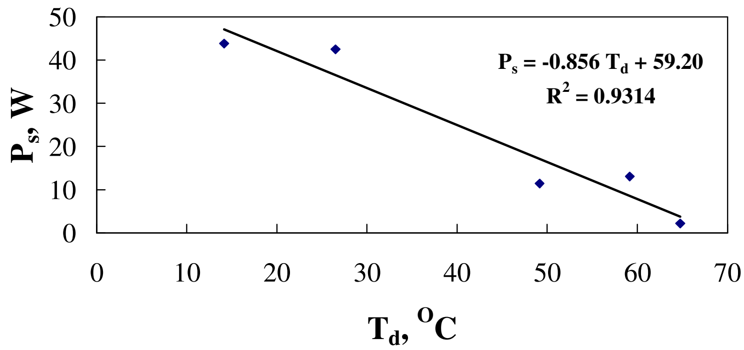


Fig.(9) Adjusted cooking power as a function of temperature difference (1.5 kg water, 29th June, 2006)

CONCLUSION

It could be concluded from this study that:

- The solar cooker temperatures was increased with using 3 mm glass thickness without reflector but with using reflector, it could be broken.
- The solar cooker performance was improved greatly with the plane

reflector in place.

- The best performance of the cooker was achieved with the largest load and with tight cooking pot (less condensed steam).
- the values of (η_u) increased when the load increased.
- The cooker has a good reliability for cooking food and boiling water.
- For the solar cooker, a high optical efficiency ($\eta_o = \alpha\tau$) and high heat exchange efficiency factor (F') with low heat loss factor (U_L) are desirable.

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الملخص العربى

تصميم واختبار طباخ شمسى مناسب للمناطق النائية

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الهدف الرئيسى لهذا البحث هو تصميم واختبار طباخ شمسى من النوع الصندوقى لاستخدامه فى عمليات طبخ أنواع مختلفة من الأغذية كبديل عن أنظمة الطبخ الأخرى والتي تعتمد على استخدام مصادر طاقة تقليدية. وقد تم عمل النموذج بأدوات الورشة العادية دون الحاجة إلى أدوات معقدة مع استخدام مواد خام متاحة ومتوفرة محلياً وتم دراسة بعض العوامل المؤثرة على الأداء الحرارى للطباخ.

أوضحت النتائج التي أجريت على النموذج ما يأتى:

1- استخدام غطاء بسمك 3 مم أدى إلى زيادة درجات الحرارة داخل الطباخ بينما استخدام غطاء بسمك 5 مم أدى إلى انخفاض الفقد الحرارى.

2- زادت درجات الحرارة داخل الطباخ باستخدام غطاء زجاجى مزدوج بسمك 5 مم لكل غطاء وذلك نتيجة انخفاض الفقد الحرارى.

3- زادت درجات الحرارة داخل الطباخ زيادة ملحوظة مع استخدام العاكس حيث زادت كمية الطاقة المجمعة وقل الزمن اللازم لوصول 1 كجم من الماء إلى درجة الغليان مع ثباتها عند درجة الغليان (100° م) لفترة أطول.

4- زادت درجات الحرارة داخل الطباخ عند استخدام العاكس على زاوية ضبط 80° على الأفقى فى بداية الاختبار و 120° بعد الظهيرة وحتى نهاية اليوم. على الرغم من ذلك لم يلاحظ فروق كبيرة عند استخدام العاكس على زوايا ضبط مختلفة عنه عند استخدام العاكس على زاوية ضبط واحدة (90°) طوال اليوم.

5- زادت درجات الحرارة داخل الطباخ زيادة ملحوظة عند استخدام إناء للطبخ محكم الغلق لا يسمح بتسريب البخار بسهولة مما ترتب عليه تقليل الزمن اللازم لوصول الماء إلى درجة الغليان وإتمام عملية طبخ الطعام فى اقل وقت ممكن.

6- تم استخدام البيانات المسجلة لحساب عدة معاملات للحكم على كفاءة الطباخ تتمثل فى:

معامل الأداء الأول (F_1)

وصل معامل الأداء الأول بدون حمل أو عاكس إلى (0.086) درجة مئوية / م^2. وات مع غطاء واحد بسمك (5) مم بينما وصل إلى (0.103) درجة مئوية / م^2. وات مع الغطاء المزدوج.

معامل الأداء الثانى (F_2)

وصل معامل الأداء الثانى إلى (0.263، 0.276، 0.296، 0.311) مع حمل (1، 1.5، 2، 2.5) كجم ماء على الترتيب مع وجود العاكس.

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كفاءة الاستخدام (η_u)

أوضحت النتائج زيادة كفاءة الاستخدام مع زيادة الحمل وهذه النتائج تتفق مع الأعمال السابقة (السباعى وإبراهيم/ 2005)

قدرة الطبخ (P_s)

زادت قدرة الطبخ مع زيادة الحمل كما وجدت علاقة ارتباط خطى قوى بين الفرق فى درجتى حرارة الماء داخل الإناء والهواء الخارجى وقدرة الطبخ.

الكفاءة الحرارية الكلية (η)

زادت الكفاءة الحرارية الكلية مع استخدام غطاء زجاجى بسمك 5 مم عن الغطاء بسمك 3 مم كذلك قل الفقد الحرارى باستخدام غطاء مزدوج.