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Study The Use Of Solar Energy For Heating Buildings In Baghdad City

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Abstract

The research is devoted of study the possibility of using solar energy for home heating system by using the absorption refrigeration system and solar collector design has the ability to provide the heating system, solar thermal energy intake in winter, and chosen for the study of building and an area of 100 m^2 and study the system for the winter months, December (12) and January (1) and February (2).

Was represented mathematically as the system is calculated solar energy falling on the rooftop solar energy absorbed and the energy collected and added energy by auxiliary heater in addition to water temperatures to different locations of the system and the thermal loss, efficiency of solar collector and heating load for all hours of operation of the system, and can raise the efficiency of the system in winter by using the system to heat water for residential uses in addition to heating the air.

Keywords; absorption refrigeration system, solar collecter design, heating system, solar collecter efficiency .

دراسة استخدام الطاقة الشمسية لأغراض تدفئة الابنية في مدينة بغداد

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الخلاصة :

تضمن البحث دراسة أمكانية استخدام الطاقة الشمسية لأغراض تدفئة المنازل باستخدام منظومة تثليج امتصاصية وتصميم مجمع شمسي له القدرة على تزويد منظومة التسخين الحرارية الشمسية بالطاقة الحرارية شتاء" ا ولأغراض الدراسة اختيرت بناية نموذجية مساحتها 100 m^2 ودراسة المنظومة للأشهر الشتوية كانون الأول (12) وكانون الثاني (1) وشباط (2).

تم تمثيل المنظومة رياضيا حيث تم حساب الطاقة الشمسية الساقطة على سطح المجمع الشمسي والطاقة الممتصة والمجمعة والطاقة المضافة من السخان المساعد بالإضافة إلى درجات حرارة الماء لمواقع مختلفة من المنظومة والخسائر الحرارية وكفاءة المجمع الشمسي وحمل التدفئة لكل ساعة من ساعات اشتغال المنظومة، ويمكن رفع كفاءة المنظومة شتاءا باستخدام المنظومة لتسخين الماء للاستعمالات المنزلية بالإضافة الى تدفئة الهواء.

Nomenclature

Symbols	Definition	Units
A_c	Area of solar collector	M^2
C_b	Welding thermal conductivity	W/m.°C
C_p	Specific heat of water	J/kg.°C
D	External diameter of tube	m
D_i	Internal diameter of tube	m
F	Fin efficiency	-
F_R	Factor of solar collector	-
F'	Efficiency factor of solar collector	-
G	Mass flow coefficient per unit area	$kg/sec.m^2$
h_w	Wind heat transfer coefficient	$W/m^2.°C$
h	Heat transfer coefficient between fluid and internal tube wall	$W/m^2.°C$
H	Rate of solar radiation incident on a horizontal surface	W/m^2
H_T	Total solar radiation rate falling on the surface of the solar collector	W/m^2
K	Coefficient of thermal conductivity (thermal conductivity)	W/m.°C
L	Length tube of solar collector	m
$\dot{m}$	Mass flow rate of water	kg/sec
$\dot{m}_c$	Mass flow rate of the water passing through the solar collector	kg/sec
$\dot{m}_L$	Average mass of water drawn from the thermal tank	kg/sec
m_s	Mass of water in the reservoir per unit area	kg/m^2
N	Number of riser	-
n	Number of glass covers	-
Q_{Coll}	Solar energy collected	W
Q_{Load}	Energy lost from the solar collector to the environment	W
Q_{CLoss}	Energy lost from the solar collector to the environment	W
Q_{Stor}	Energy stored in the tank	W
R	Percentage of total solar radiation incident on a sloping surface than that falling on a horizontal surface	-
S	Solar energy absorbed	W

s	Inclination angle of the solar collector	degree
t	Time	hr
T_a	Air temperature	°C
$T_{f,i}$	Inlet water temperature from solar collector	°C
$T_{f,o}$	Outlet water temperature from solar collector	°C
$T_{f,m}$	Mean external temperature from solar collector	°C
$T_{p,m}$	Absorbed plate mean temperature	°C
T_P	Temperature of absorbed plate	K
T_s	Water temperature of the tank	°C
T_{s1}	Water tank temperature at the beginning of time	°C
T_{s2}	Water temperature of the tank at the end of time	°C
$(UA)_s$	Overall heat transfer coefficient of thermal reservoir	W/°C
U_L	Coefficient of thermal losses from solar collector	$W/m^2.°C$
U_t, U_b, U_e	Coefficient of thermal losses from the upper and lower surface and behind solar collector	$W/m^2.°C$
V	Wind Speed	m/sec
V_{st}	Size of storage tank	M^3
W	Distance between centers of two tubes	m

Greek Symbols

Symbols	Definition	Units
δ	Angular location of the sun at the time back to the level of the equator	Degree
η_{Coll}	Efficiency of solar collector	%
ε	Permeability coefficient	-
ϕ	Latitude angle	Degree
γ	Thickness of welding line	m
ω	Hour angle	Degree
ρ_r	Reflection coefficient	-
σ	Constant Stefan (10-8×5.66)	$W/m^2.K$
θ	Fall angle of solar radiation	Degree
τ	Emission factor	-

1. Introduction

With suitable technology, solar cooling can help alleviate the problem. The fact that peak cooling demand in summer is associated with high solar radiation offers an excellent opportunity to exploit solar thermal technologies that can match heat-driven cooling technologies. Of particular interest are urban areas where adverse outdoor conditions, as a result of higher outdoor pollution and the urban heat island effect, encourage the use of mechanical air-conditioning with a direct impact on peak electrical energy use [1].

Commercial application of solar energy for air conditioning purposes is relatively new. Lamp and Ziegler [2] give an overview of the European research on solar-assisted air conditioning up to 1996. Tsoutsos et al. [3] present a study of the economic feasibility of solar cooling technologies. Karagiorgas et al. [4] investigated the application of renewable technologies in the European tourism industry and identified a large number of solar thermal systems but only a few solar cooling systems. Different heat-driven cooling technologies are available on the market, particularly for systems of above 40kW, which can be used in combination with solar thermal collectors [5]. They consist of several main components **(Figure.(1)**[6], the solar air conditioning system;

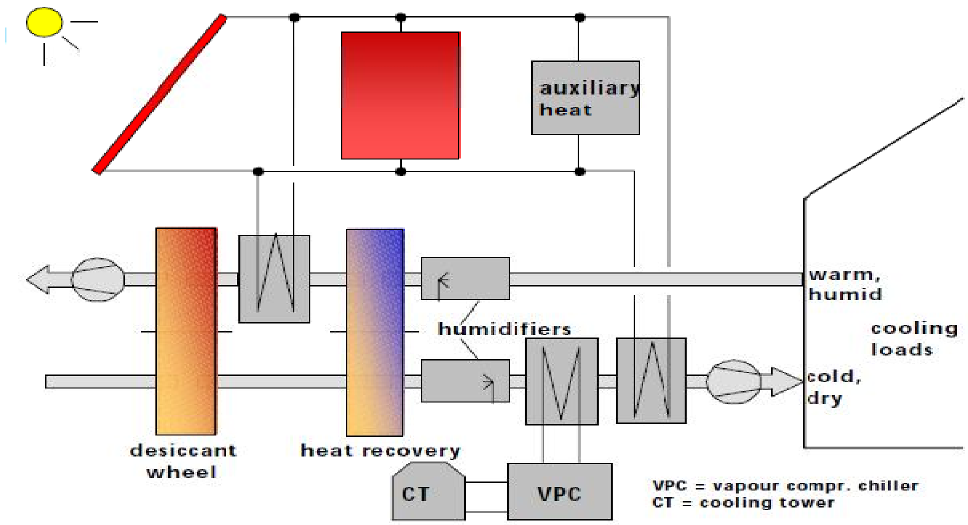

Fig. (1). Solar air conditioning system, [6].

The main obstacles for large scale application, beside the high first cost, are the lack of practical experience and acquaintance among architects, builders and planners with the design, control and operation of these systems. For smaller scale systems, there is no market available technology. Therefore, the development of low power cooling and air conditioning systems is of particular interest. Heat-driven cooling technologies include mainly closed cycles (absorption, adsorption) and open cycles (desiccant systems) [7, 8].

Solar assisted cooling systems usually involve solar thermal collectors connected to thermally driven cooling devices. the solar collectors; a heat buffer storage; the heat distribution system; the heat-driven cooling device; an optional cold storage; the air conditioning system, including various forms of cold distribution; and auxiliary (backup) subsystem. The auxiliary subsystem may, in principle, be integrated at different places in the overall system: as an auxiliary heater parallel to the collector or the collector/storage, or as an auxiliary cooling device, or both.

2. Objective of Research

The research aims current to study the possibility of using solar energy in the process air heating using the system icing absorbency of type water-lithium bromide solar-powered source heat essential for the operation of the system through the construction of a mathematical model to simulate the system's work capacity, solar-powered model includes the following:

1. Design-type solar collector level to meet the requirements of the work of the system powered by solar as a primary heat source.
2. Calculation of energy collected from the solar collectors and the added energy from the heater Assistant, calculate the proportion of the contribution of solar energy in addition to the expense of efficiency solar collector and the efficiency of the system.
3. The principle of work of the cooling system absorbance solar-powered

4. System of Solar energy collector

One area of use of solar energy is converted into thermal energy and used for this purpose complexes solar absorbs solar radiation falling them directly and converted into thermal energy to raise the temperature fluid flowing through them, and specifications solar collector type level, which was chosen in the study case are shown in **Table (1).**

Table (1): Specifications of the solar collector.

No.	Part of Collector	Details
1.	Type of Glass	Glass Jerry : glass cover
		Permeability coefficient: 0.96
		Refractive index: 1.52
		The number of blankets: 2
		Thickness: 3 mm
2.	plate absorber	Metal Type: galvanized iron
		Coefficient of thermal °C conductivity: 66.99 W/m.
		Type of coating: black chrome
		Absorptivity coefficient: 0.95
		Emission factor: 0.1
		Inner tube diameter: 15 mm Outer tube diameter: 22 mm
		Inner tube diameter: 15 mm Outer tube diameter: 22 mm
		The distance between the centers of tubes: 114 mm
		The number of tubes per square meter: 8
3.	Thermal Insulation	Type of insulation : glass wool
		Coefficient of thermal C conductivity: 0.038 W/ m.
		Thickness of the insulating material (C): 8.9 mm
4.	structure of the solar collector	Metal Type: Stainless steel
		Shell thickness: 0.76 mm

For the purpose of implementing the measures under study following assumptions were used [7]:

1. A regular flow in the case of in vitro stability.
2. There is no energy stored in glass lids and absorbent surface.
3. Neglecting the temperature difference during the glass cover.
4. Static properties of the fluid.

5. The mathematical model

Composed system used in the current study and shown in Figure (1),[6] of the following parts: -

- The solar collector system and in turn consists of a solar collector and heat reservoir.
- The cooling system absorbance.
- Assistant Geyser.
- Pumps and control devices.
- Air handling unit or unit and fan.

Basic governing equations and used in the mathematical model to represent the system mathematically are:
incident solar energy can be represented as [7,8]:

$$Q_{Coll} = A_c F_R \left(S - U_L \left(T_{f,i} - T_a\right)\right) \quad ...(1)$$

Assuming there is no heat loss in pipes Delivery Thus, the energy all accrued transmitted to thermal reservoir and thus become balance equation for thermal tank as follows:

$$Q_{Coll} - Q_{Load} - Q_{SLoss} = m_s C_p \frac{dT_s}{dt} \qquad ...(2)$$

The compensation equation (1) in equation (2) we get the equation governing the solar heater and in the following form:

$$A_c F_R \left(S - U_L \left(T_{f,i} - T_a\right)\right) - Q_{Load}$$
$$- Q_{SLoss} = m_s C_p \frac{\mathrm{dT_s}}{\mathrm{dt}} \qquad ...(3)$$

Where is,

$$S = H\ R(ta)(1-d)(1-Z) \qquad ...(4)$$

$$R = K_b R_b + K_b \left(1 + \frac{\cos\ (s)}{2}\right) +$$
$$r_r \left(\frac{1 - \cos\ (s)}{2}\right) \qquad ...(5)$$

$$R_b = \frac{H_{bT}}{H_b} = \frac{H_n \cos q_T}{H_n \cos q_Z} = \frac{\cos q_T}{\cos q_Z}$$

$$\cos q_T = \cos(f - s)\cos d \cos w$$
$$+ \sin(f - s)\sin d$$
$$\cos q_Z = \sin d \sin f + \cos d \cos f \cos w$$

$$d = 23.45 \sin\left(360\left(\frac{284 + \tilde{n}}{365}\right)\right)$$

$$w_1 = w_2 + \frac{180}{12};\ w_2 = \frac{180}{12}(12 - I);$$
$$w = (w_1 + w_2)/2$$

Where d coefficient takes into account the effect of dust on the glass cover, Z factor takes into account the effect of the edges of solar collector on the board absorber, K_b and K_d representing direct radiation to the total radiation and the proportion of radiation scatter to total radiation respectively and dependent values on the circumstances of Chaptera year where in the summer be K_b = 80%, K_d = 20% and in winter K_b = 70%, K_d = 30%.

To calculate the emission factor is, [8]:

$$ta = (t_1 \times t_2 \times .... t_n) \times a_P \times (IAM) \quad ...(6)$$

Since the IAM correction factor for the angle of incidence and depends on the number of glass lids and the type of paint used and its value is equal to (0.935) [8].
For the purpose of calculating the overall heat loss coefficient of the solar collector is used the following equation:

$$U_L = U_t + U_b + U_e \quad ...(7)$$

To calculate the coefficient heat loss from the upper surface of the solar collector is using the following formula:

$$U_t(s) = (1 - (s - 45)(0.00259 - 0.00144\, e_P)) \\ U_t(45) \quad ...(8)$$

Where is,

$$U_t = \left(\frac{N}{(344/T_P)[(T_P - T_a)/(N + f)]^{0.31}} + \frac{1}{h_w} \right)^{-1} + \frac{s\,(T_P + T_a)(T_P^2 + T_a^2)}{[e_P + 0.0425\, N(1 - e_P)]^{-1} + [(2N + f - 1)/e_g] - N} \quad ....(9)$$

Where is,

$$f = (1.0 - 0.04\, h_w + 5.0 \times 10^{-4}\, h_w^2)(1 + 0.058\, N)$$

$$h_w = 5.7 + 3.8V$$

To calculate the coefficient of thermal losses from the lower surface and sides of solar collector, as the sides of solar collector isolated the same material, U_b, U_e becomes as:

$$U_b = \frac{K}{L} \quad ...(10)$$

$$\left.\begin{aligned} U_{edge} &= \frac{K}{L} \\ U_e &= \frac{KA_e}{A_C} \end{aligned}\right\} \qquad ...(11)$$

To calculate the energy drawn from the tank and thermal heat losses from the tank warming are using the following equations, respectively:

$$Q_{Load} = \dot{m}_L C_p \left(\frac{T_{s1} + T_{s2}}{2} - T_r \right) \qquad ...(12)$$

$$Q_{SLoss} = (UA)_s \left(\frac{T_{s1} + T_{s2}}{2} - T_a \right) \qquad ...(13)$$

To calculate the solar energy collected, where starts solar collectors from eight o'clock in the morning until seven o'clock ten and is represented mathematically as follows:

$$Q_{Coll} = TF\, \dot{m}_c C_p \left(T_{f,o} - T_s\right) \qquad ...(14)$$

Where TF represents a conversion function to control the temperature and equal to one of the eight in the morning until seven o'clock ten and zero for the rest of the hours.

Compensation equations (12) and (13) and (14) in equation (2) we get the following equation:

$$m_s C_p \frac{dT_s}{dt} = \dot{m}_c C_p \left(T_{f,o} - T_s\right) + \dot{m} C_p \left(T_R - T_s\right) + (UA)_s \left(T_a - T_s\right) \qquad ...(15)$$

Where is,

$$T_s = \frac{T_{s1} + T_{s2}}{2} \qquad \frac{dT_s}{dt} = \left(\frac{\dot{m}_c C_p}{mC_p} T_{co} + \frac{\dot{m}_L}{mC_p} T_r + \frac{(UA)_s}{mC_p} T_a \right) - \left(\frac{\dot{m}_c C_p}{mC_p} + \frac{\dot{m}_L}{mC_p} + \frac{(UA)_s}{mC_p} \right) \left(\frac{T_{s1} + T_{s2}}{2} \right) \qquad ...(16)$$

To determine the temperature of water tank in the end of hour (Ts_2), the solution of equation above by used (Runge-Kutta) method [9].

To calculate the rate of stored energy is used the following equation:

$$q_{Stor} = m_s C_p (T_{s2} - T_{s1}) \quad ......(17)$$

The rate of heat loss from the solar collector is calculated from the following equation:

$$q_{CLoss} = U_L (T_{s1} - T_a) \quad ...(18)$$

The temperature of the water outside from solar collector is calculated from following equation:

$$T_{f,o} = T_{f,i} + \left(\frac{F_R A_c}{\dot{m}_c C_p}\right)(S - U_L (T_{f,i} - T_a)) \quad ...(19)$$

the mean fluid temperature can be found by:

$$T_{f,m} = T_{s1} + \frac{Q_{Coll} A_c}{U_L F_R}\left(1 - \frac{F_R}{F'}\right) \quad ...(20)$$

The collector heat removal factor is:

$$F_R = \frac{GC_p}{U_L}\left(1 - e^{-(U_L F'/GC_p)}\right) \quad ...(21)$$

Mass flow coefficient per unit area is calculated from the following equation:

$$G = \frac{\dot{m}_c}{A_C}$$

Coefficient of efficiency solar collector is calculated from the following equation:

$$F' = \frac{1/U_L}{W\left[\frac{1}{U_L (D + (W - D)F)} + \frac{1}{C_b} + \frac{1}{p D_i h_{f,i}}\right]} \quad ...(22)$$

Where $h_{f,i}$ heat transfer coefficient between fluid and the internal wall for the tube, it is equal to 300 $W/m^2\ C^\circ$ or 1500 $W/m^2.C^\circ$ [7].

But the conductivity of welding (C_b) is calculated from this equation,

$$C_b = \frac{K_b b}{g} \qquad ...(23)$$

Where (b) welding line thickness, (K_b) heating conductivity coefficient for the welding material and is equal 400 W/m^2. C° [7].

Average temperature of the absorber plate is calculated from the following equation:

$$T_{p,m} = T_{f,m} + Q_{Coll} R_{p\_f} \qquad ..(24)$$

Where is,

$$R_{p\_f} = \frac{1}{pD_i nLh_{f,i}}$$

Solar collector efficiency gives the collector performance, which is the ratio of the useful energy gain to the incident solar energy and is expressed as [7]:

$$h_{Coll} = \frac{Q_{Coll}}{HRA_c} \qquad ...(25)$$

5.1 The size of storage tank

To find the size of the storage tank roughly must know the stored energy after a solar collector and using the following equation for this purpose [10], [11]:

$$V_{st} = \frac{HRh_{coll} A_C (1 - h_{loss}) - Q_L}{rC_p (T_{send} - T_{sfirst})} \qquad ...(26)$$

Where is, η_{loss} the thermal losses from tank and tube (%), T_{send} water heat temperature of the tank in the end of collected period (C^o), T_{sfirst} water heat temperature of the tank in the first of collected period (C^o), ρ water density (kg/m^3).

5.2 Thermal loading

Thermal loads are divided into the following:

1) External sources and include heat transmitted through the ceilings and walls, heat transmitted through the glass transition temperature as a result ventilation and heat transition as a result of leakage from the doors and windows.

2) Internal sources and is divided into: People, hardware service and other sources. For the purpose of getting at the details of this method and equations for calculating cooling loads can review the source [12], [13].

6. Results and Discussion

Figures (2) and **(3)** and **(4)** change solar energy combined solar collector area of 60 m^2 and note that the month of January is less energy assembled and it conditions the month of January the foundation in the design of system heating and overload heating required and also note that the energy collected be a few in the early hours due to the lack of solar radiation and low air temperature of air, but in the middle of the day increases energy collected so as to increase solar energy falling on the surface of the solar collector and the high temperature air and reduced carrying heating to high temperature air. **Figure (5)** shows the added energy from Geyser Assistant within hours of operation of the system and because of the low solar radiation and low air temperature and thus is required to start the heater Assistant to raise the temperature of water tank, but in the middle of the day where increasing energy collected, thereby reducing the added energy from Geyser Assistant gradually and reaches a minimum value (zero) and at the end of the day down energy collected and thus will Geyser Assistant again to raise the temperature of the water tank. Show **Figures (6)** And **(7)** losses thermal solar collector and the tank warming in the cases of the use of methods, in the case of using the first method losses are thermal bigger and efficient solar collector is less compared with the second method because the water temperature in the first case to be higher and thus the difference between water temperature reservoir and the temperature of the air a great atmosphere. **Figures (8)** and **(9)** and **(10)** change the temperature of water tank and water outside of the solar collector and the water reflux of pregnancy, where we note increasing water temperature reservoir with an increased rate of solar energy collected and be the highest value at 16 during the day and then then fall because of low solar energy collected, and increasing water temperature outside of combining solar with increasing energy collected up to the highest value at 15 during the day, while the temperature of the water yield it less than the temperature of the water supplier by carrying heating and be the difference significant the first and last hours of the operation of the system due to the high heating pregnancy. **Figure (11)** shows the change of the efficiency of solar collector, ranging efficiency solar collector between 51% and 53% and the highest value of 53%.

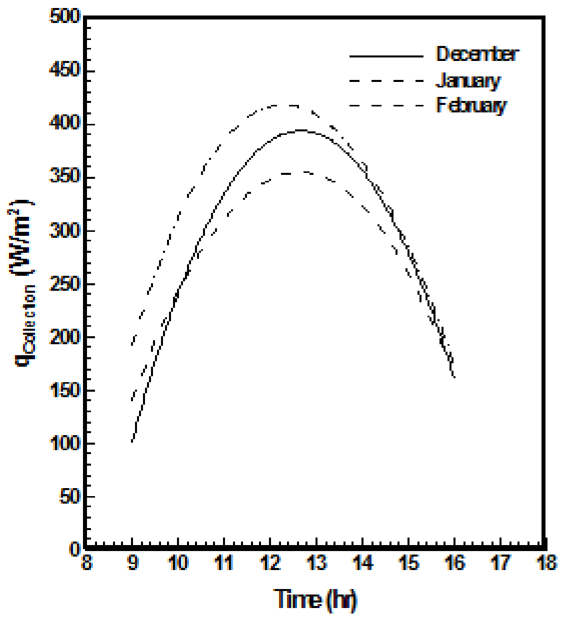

Fig. (2) shows change solar energy combined with lighting hours.

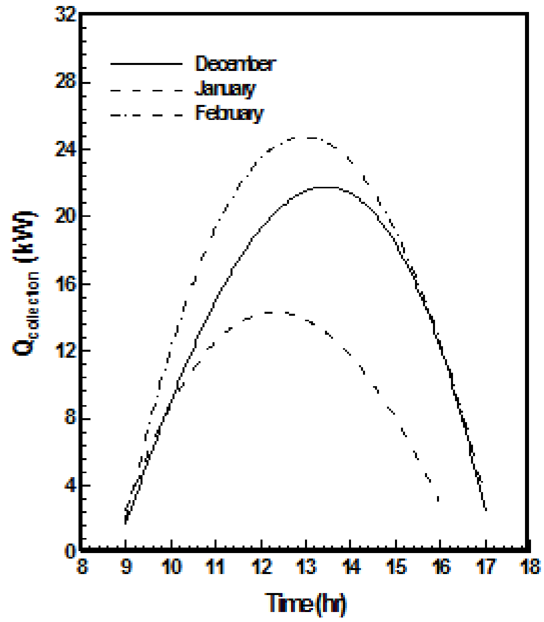

Fig. (3) shows change solar energy combined with lighting hours for solar collector area of 60 m^2.

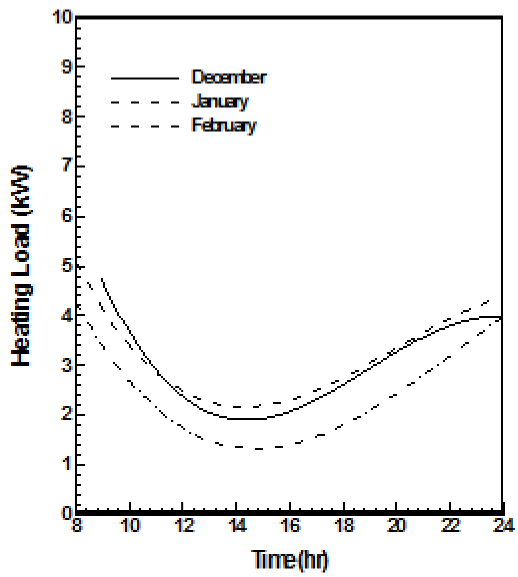

Fig. (4) shows the change of heating load within hours of operation of the system.

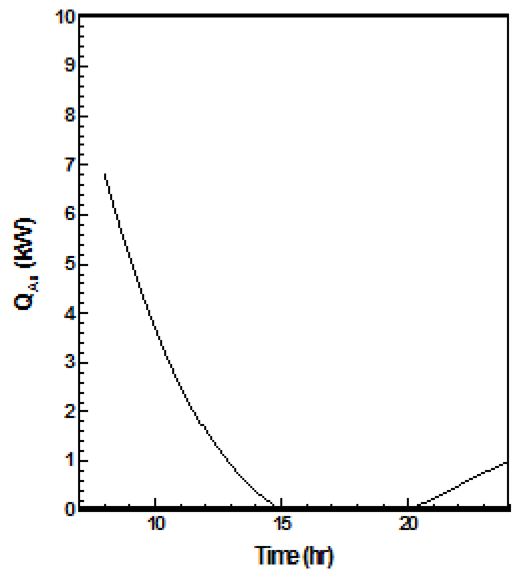

Fig. (5) shows the added energy from Geyser Assistant within hours of operation of the system for the month of January.

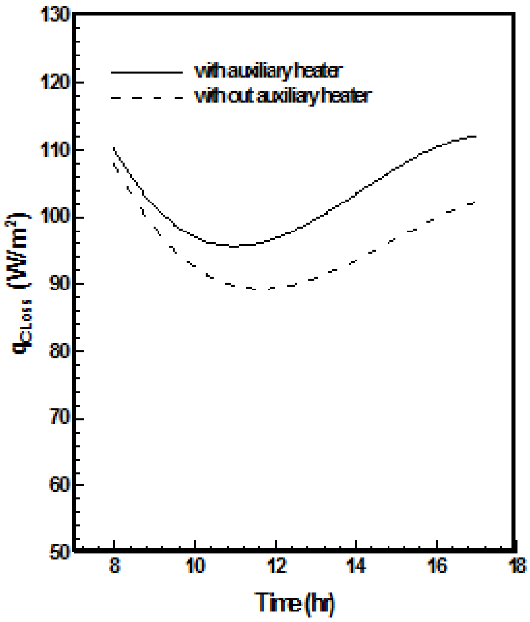

Fig. (6) shows change the losses thermal from solar collector within operating system hours for the month of January

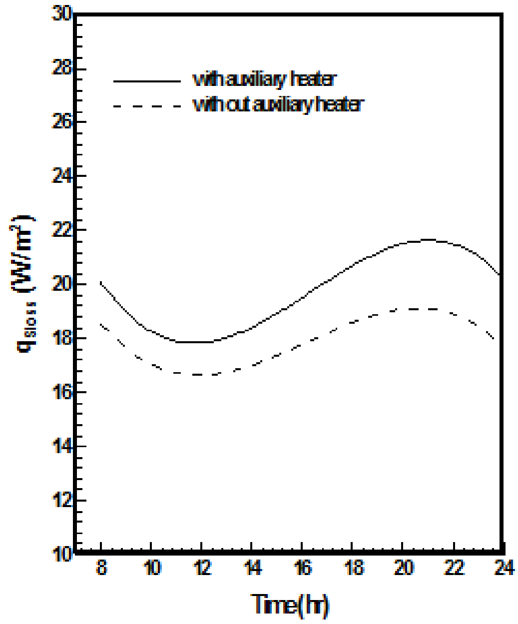

Fig. (7) shows change the losses thermal from the tank warming within operating system hours for the month of January

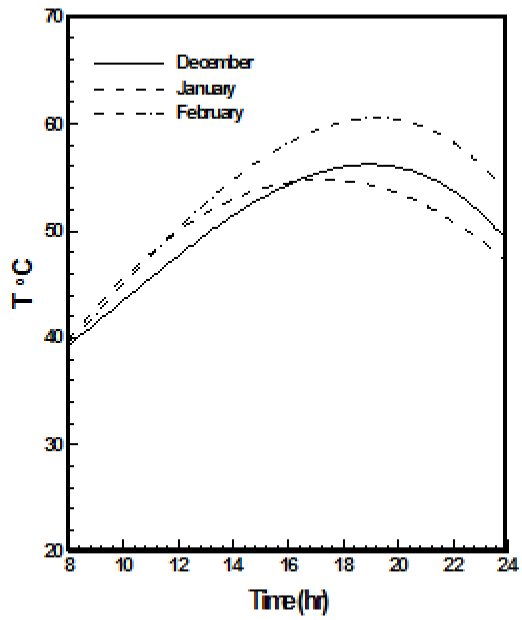

Fig.(8) shows change the temperature of water tank within operating system hours.

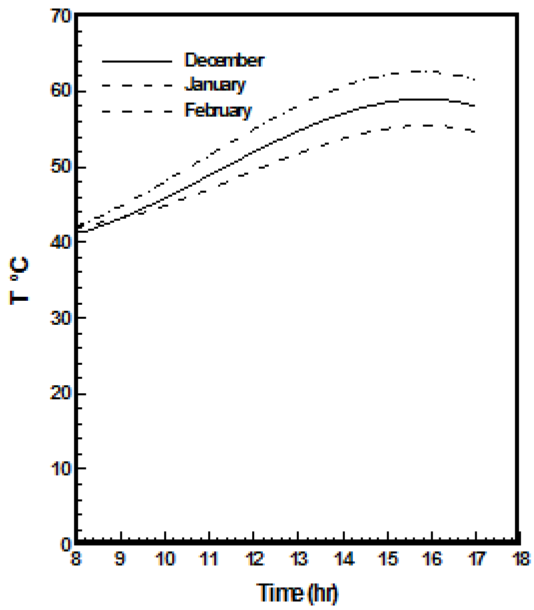

Fig. (9) shows change the temperature of water outside of the solar collector within operating system hours.

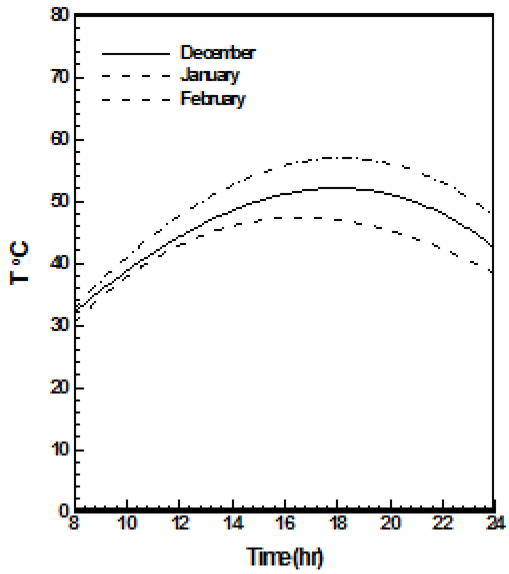

Fig. (10) shows change the temperature of water reflux of pregnancy within operating system hours.

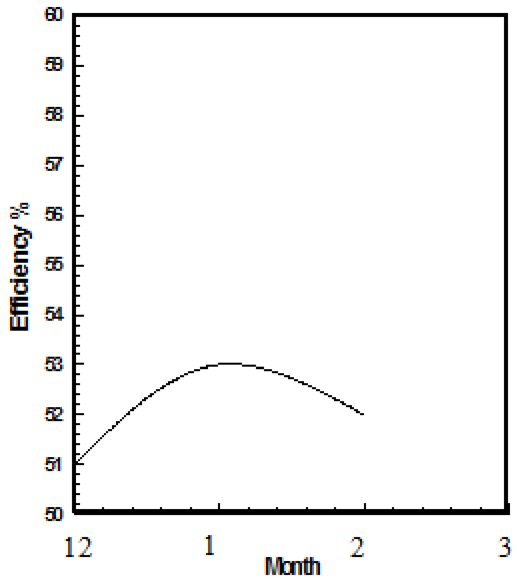

Fig. (11) shows change the efficiency of solar collector within winter months.

7. Conclusions

Through the findings of the study of the performance of the system that depend on the absorbance of solar energy show us that the use of solar collector with space (60 m^2) and the approved specifications in the table (1) meets the requirements of the work of the system absorbance. It also found that the use of these systems contribute to the rationalization of energy consumption including rate (70%) of the energy required to run the system if the system was used conditioning funky, addition been identified space solar collector who takes every ton cooling, which were up (20 m^2) .

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