Experimental Analy sis of Air Inlet Height Variation in a Solar Updraft Tower system Using Plate and Metal Foam Absorber

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Abstract

The experimental analysis was conducted under the Iraqi climate conditions to investigate the performance enhancement of a solar updraft tower system (SUTS) using porous copper foam as an absorber plate and a conventional absorber plate with an absorber inclination angle of 18°. In the present work, a semicircular collector was divided into two identical quarter thermal collectors to become two identical SUTS. One of the quarter circular thermal collectors contains the metal foam as an absorber plate, while the other quarter collector is on the conventional flat copper absorber plate. In this study, the air inlet height is changed at (3, 5, and 8) cm. The experimental tests were carried out in Baghdad city (latitude 33.3° N). Results showed that the air inlet height variation caused to enhance the solar updraft tower performance. The highest values were recorded when the air inlet height is 3 cm using a porous absorber compared to a flat absorber plate. Copper material foam as an endothermic surface causes a marked decrease in the average surface temperature of the plate. The maximum hourly thermal efficiency of the solar collector was increased to about 41.6 % and the maximum enhancement of the power output to about 45.2 % compared with the flat absorber plate.

Keywords: Tower Updraft System, Inlet Air Height, Porous Media, Copper Foam, Renewable Energy.

تحليل عملي لتغير ارتفاع مدخل الهواء في نظام برج الطاقة الشمسية باستخدام لوحة وامتصاص الرغوة المعدنية

سرمد عزيز عبد الحسين، محمد عبد الرؤوف نعمه

الخلاصة:

تم إجراء التحليل العملي في ظل الظروف المناخية العراقية للتحقق من تحسين أداء نظام برج الطاقة الشمسية باستخدام الرغوة النحاسية المسامية كلوحة امتصاص ولوحة امتصاص تقليدية بزاوية ميل امتصاص تبلغ ١٨ درجة. في العمل الحالي ينقسم المجمع نصف الدائري إلى مجمعين حراريين ذات ربعين متطابقين ليصبحا نظامي برجين متطابقين. يحتوي أحد المجمعات الحرارية على الرغوة المعدنية كلوحة ماصة، بينما يحتوي مجمع الربع الدائري الآخر على لوح امتصاص نحاس وهو يمثل المسطح التقليدي. في هذه الدراسة تم تغيير ارتفاع مدخل الهواء بمقدار (٣ ، ٥ ، ٨) سم. نفذت الاختبارات التجريبية في مدينة بغداد (خط عرض ٣٣,٣ درجة شمالا). أظهرت النتائج أن اختلاف ارتفاع مدخل الهواء أدى إلى تحسين أداء برج الطاقة الشمسية الصاعد. تم تسجيل أعلى القيم عندما كان ارتفاع مدخل الهواء ٣ سم باستخدام ممتص مسامي مقارنة بالصفيحة المسطحة. تسبب وجود لوحة امتصاص الرغوة المعدنية في انخفاض ملحوظ في متوسط درجة حرارة اللوح الماص. اقصى كفاءة حرارية لكل ساعة للمجمع وصلت إلى حوالي ٤١,٦٪ و أقصى إنتاج للطاقة إلى حوالي ٤٥,٢٪ مقارنة بلوح الامتصاص المسطح.

1. Introduction

The reason for the increasing need for renewable energies in the last years of this century is the change in the world climate, which leads to global warming. This crisis prompted scientists to find alternatives to energy [1-10]. One of these alternatives is to take advantage of solar energy as an environmentally friendly source [11-12]. Solar energy is one of the types of renewable energy that represents the fall of solar radiation on the surface of the earth. One of the solar energy applications is the solar updraft tower power plant SUTPP. The SUTTP relies on simple, powerful, and sustainable technologies, allowing them to generate electricity from solar radiation at a low maintenance cost and lack cooling water. They can save electricity for decades, even up to 100 years. The main objective of the use of SUTPP is to increase the power generated and thus increase the rate of production of electric power, this is either by improving the performance and increasing efficiency of the solar collector or through the modification of the solar updraft tower system [13]. The porous surface in general and mineral porous metal foam, in particular, is characterized by having a very large surface area (The ratio of the large surface area to the volume of the heat transfer process (500 ~ 10000 m^2 / m^3) that allows to increase the heat transfer largely from the absorber surface to the airflow within the solar collector and then increase of the air pumping towards the solar tower. Therefore, the metal foam is used as an absorber plate in the solar updraft tower system to increase the thermal efficiency of the collector as a result of the buoyancy force increases, so it will be reflected positively on the increase of the SUTS performance [14].

Chang et al. [15] investigated numerically the effect of changing the air inlet thickness using the porous silicon foam (SiC) solar receiver. Results showed that the bigger porosity was given the lower surface temperature and the higher the air temperature. The smaller thickness of the air inlet caused enhanced the convection heat transfer and fluid flow characteristics. The effects of absorber temperature and air inlet height on the solar tower performance were studied experimentally by Abdel Hamid et al. [16]. The study concluded that the maximum performance can be given when the air inlet height was minimum. Xinping [17] designed and built the solar chimney power plant in china. The temperature distribution in the system and the air temperature difference between the collector exits and the ambient were measured. The results showed that the air temperature increases with the increase of the intensity of the solar radiation and this caused to increase in an upward air flow pumping towards the chimney tube. Sabah and Miqdam [18] designed and manufactured a prototype of a solar tower in Baghdad in the autumn of 2009. Results showed that the weather in Iraq was appropriate for this system. Abdulcelil [19] investigated experimentally the temperature distribution in the solar tower system during designing and constructing the plant in Adıyaman. He studied the effect of air temperature, absorber temperature, and airflow velocity on the performance of the solar chimney plant. (Mehrdad et al. [20] studied experimentally the performance of the solar chimney by examining two effective parameters that included absorption materials and engineering variable parameter dimensions such as the chimney height and the collector diameter. the best parameters can be gotten by choosing the minimum air entrance height. Carl [21] investigated numerically and experimentally the effect of the pressure drop and exit swirl angle of the flow passing through the collector towards the chimney to allow the airflow into the turbine inlet guide vanes (IGV) installed at the chimney base. Bashir et al. [22] evaluated the performance of the solar tower system (STS) by developing the STS model from the calculations of the energy and the technical data of Manzanares solar power plants depending on the methodology of the hydraulic similitude design. The experimental model and Numerical simulations were presented by Haider [23] to enhance the performance of a solar chimney by using thermal energy storage materials. Phase change materials (PCMs) and sensitive energy storage materials have been introduced to increase the solar thermal storage system of the solar chimney model. The effect of using different thermal energy storage materials on the solar chimney performance was studied. Results showed the effect of the solar radiation amount that occurred on the solar collector to consider the best performance of the solar chimney that had been depended largely on the air temperature difference (ΔT) between the temperature of the collector exit and the ambient temperature. Aseel et al. [24] investigated experimentally and numerically the impact of collector reduction area on the solar chimney performance. The height of the glass cover to the absorbing plate had been changed to create a reduction in the area of (h1=3.8 cm, h2=2.6 cm, and h3=1.28 cm). The results showed that the third height (h3=1.28cm) has been given the best result because the decrease in the height of the glass cover to the absorbing plate lead to an increase in the airflow velocity and this caused to increase in the thermal efficiency of the solar chimney model. Mohammed et al. [25] investigated theoretically and experimentally the solar tower power plant performance under climate conditions of Karbala city. One of the parameters studied was changing the inlet height from 3 to 5 cm. The distribution of the temperature and the airflow velocity in the STPP was measured. The results showed that the collector inlet height was one of the important parameters that increased the output power to about 50% with 3 cm compared to 5cm collector inlet height. Ali [26] investigated experimentally and theoretically the collector design parameters on the performance of the SCPP in Holley Karbala city. The study included an examination of some of the parameters that affected directly the solar chimney performance such as collector roof angles, collector cover, and air inlet height. The results showed a good level of agreement between the analytical solutions and the experimental results for the prototype.

From the above review, numerous experimental and numerical studies exist in the literature that investigates the enhancement ways of the SUTS performance, but most of them are for the case of the conventional flat absorber plate. The objective of the present work is to investigate the performance enhancement of a solar tower system with porous metal foam as an absorber plate under Iraq climate conditions. So, this investigation is proposed to cover this shortage in the understanding of the performance of the solar updraft tower system. Also, studying the effect of changing the air inlet heights at (3, 5, and 8) cm on the SUTS performance utilized flat plate and metal foam absorber plate.

2. Experimental Apparatus and Procedure

The experimental apparatus consisted of two separate and identical SUTS. Two SUTS are manufactured; each one contains a quarter circular thermal collector and tower tube. The two identical SUTS were manufactured to achieve a real-time comparison between the porous and non-porous collectors and to evaluate the performance of the two identical SUTS under the same weather conditions. Fig. 1 shows the experimental apparatus schematically and Fig. 2 photographically.

2.1 Air solar collectors

Figs. 1 and 2 show the semi-circular structure manufactured with a diameter of 4 m to carry the solar air collector. The semi-circular structure was divided into two identical quarter shapes with a 2 m radius. Each quarter stands as the base structure of the SUTS and the two quarters were separated from each other by installing the separate wood panel (t=20 mm) was used to insulate and separate the two quarter circular thermal collectors completely. Two absorber plate samples (porous metal foam and flat plate) were manufactured and installed on quarter circular collectors to form the required quarter circular collector plate. The two quarter solar collectors were sloped with an angle of 18°. Two doors made of wood sheets (w = 2 m, t = 20 mm) were installed at the back for each quarter circular collector. the roofs of the two quarter circular thermal collectors that manufactured by using 7 square steel bars of length 220 cm with a tilt angle of 22.5° which can be divided into two pieces: a straight steel bar (170 cm length) and a curved junction that fabricated to have (r = 50 cm). The structure of each quarter circular collector roof was covered with a transmittance acrylic sheet (t=2.5 mm). To ensure that the solar radiation intensity incident on the two quarters circular collectors will be received equally, repositioning was done by means of a set of tires (d= 10 cm) that were used to adjust the solar tower position to ensure that the collector absorber plates in each quarter circular collector are facing the direct incident at each time increment during the acquiring of measured parameters.

2.2 Metal foam sheets, construction and bonding

The dimensions of the copper foam sheets are (50*50) cm^2 area and thickness of 10 mm. A number of the porous sheets cover sufficiently a quarter of the circular structure, which has an area of 24040.6 cm^2. The porous copper sheets at the circumference were cut and shaped carefully using the steel saw machine to achieve the arc of the quarter circular structure and finally, all the sheets were put together to cover the entire area of the quarter circular structure. The porous copper sheets overlapped each other at a 1 cm distance to achieve a strong contact between the porous sheets as shown in Figs. 3 and 4. The thermally conductive adhesive was put in the porous plate overlap areas to increase the contact pressure between the porous metal sheets in those areas [See Fig. 3]. Fig. 5 shows the final form of the copper foam absorber plate.

2.3 Updraft solar tower tube

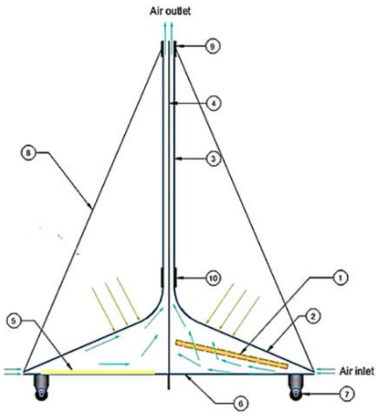
Figs. 1 and 2 show the solar tower tube manufactured from PVC tube with 5mm thickness and 14 cm diameter that divided into two identical diameters. A wood plate of 2 cm thickness has been placed along the middle of the tower tube. This wood plate was put into contact at the tower tube base with the separate wood panel at the middle of the semicircular structure to form a full separate air updraft passage from the air inlet to the air exit for each quarter circular collector [See Fig. 6]. Glass wool (k =0.46 W/m.K) was used to reduce the losses of the heat from the tower surface to the ambient. Four steel cables (d= 5 mm) are tightly connected from the top of the tower tube to the circumference of the semicircular collector structure to install the tower tube and to prevent its movement during any environmental conditions.

2.4 Height of Air Inlet (Periphery)

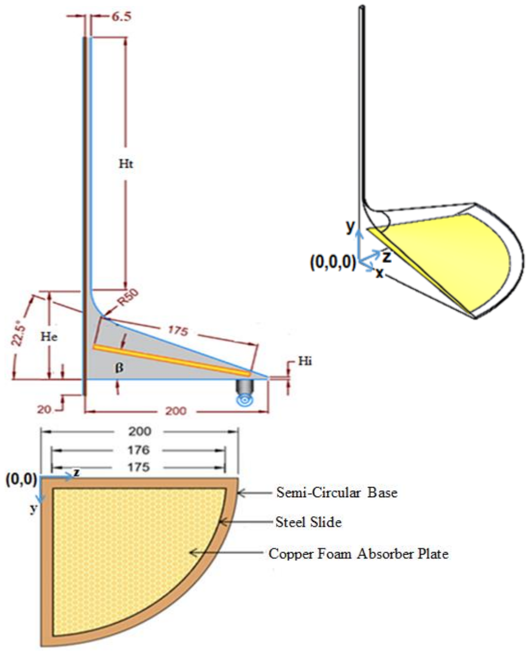
The parameter studied in the present work was the effect of varying the height of the air inlet (3, 5, and 8) cm on the performance of the SUTS with and without the presence of a copper foam absorber plate. The height of the air inlet was controlled using nuts and screws. Seven nuts are welded on the circumference of the semicircular structure base and distributed at equal distances. Each nut is provided with a screw (L = 20 cm and d = 22 mm) at which its end was put in contact with the roof structure arc. The height of the air inlet was adjusted by changing the height of these seven screws [See Figs. 7 and 8].

2.5 Experimental procedure

All experimental tests that were conducted started at 09:00 AM and ended at 03:00 PM. The data reading was recorded every hour. There are some measures that must be taken before each test:



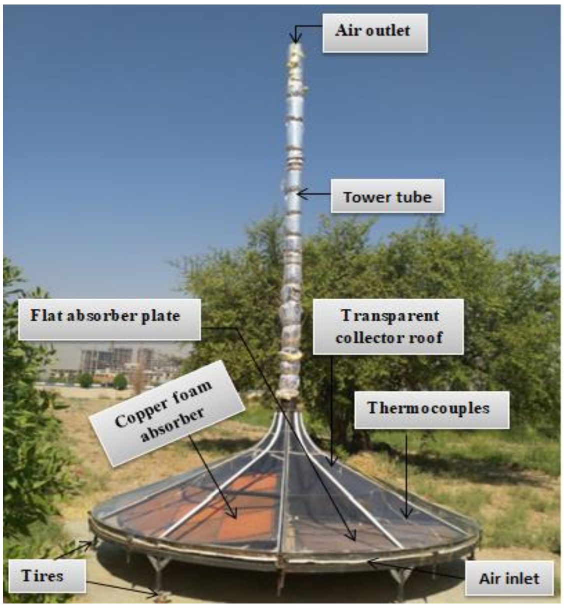
1	Metal foam absorber plate	6	MDF wood panel
2	Collector roof	7	Tire
3	PVC tower	8	Steel cable
4	Separate wood panel	9	PVC ring
5	Flat plate absorber	10	Steel ring

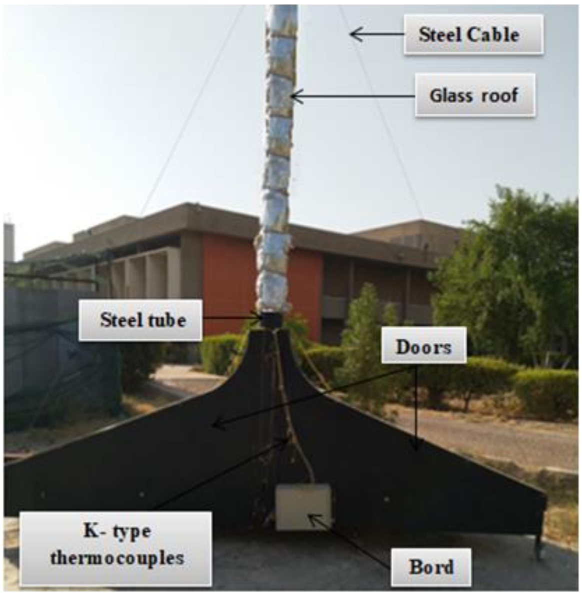


(a) Parts of the SUTS with Flat and MF Absorber Plate

(b) Dimensions of the SUTS with MF Absorber Plate (All Dimension in Centimeter)

Figure (1): Schematic Diagram of the Experimental Apparatus





(a) Photograph of the SUTS (Front View)

(b) Photograph of the SUTS (Back Side)

Figure (2): Photograph of the Experimental Apparatus

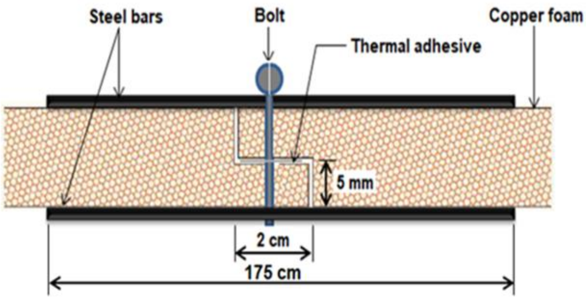


Figure (3): Schematic Drawing of Copper Foam Absorber Plate Overlap

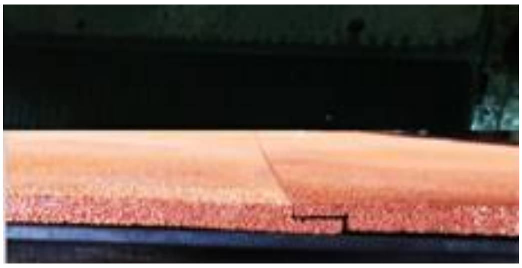


Figure (4): Overlapping Method of Copper Foam Absorber P[late

Figure (5): The Final Design of Copper Foam Absorber Plate

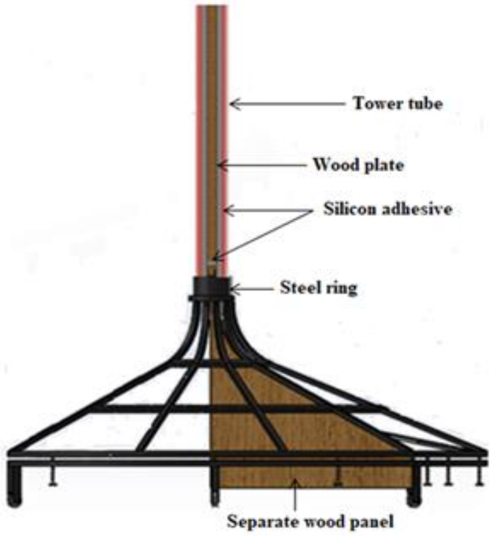


Figure (6): Schematic Drawing of Tower Tube Installing

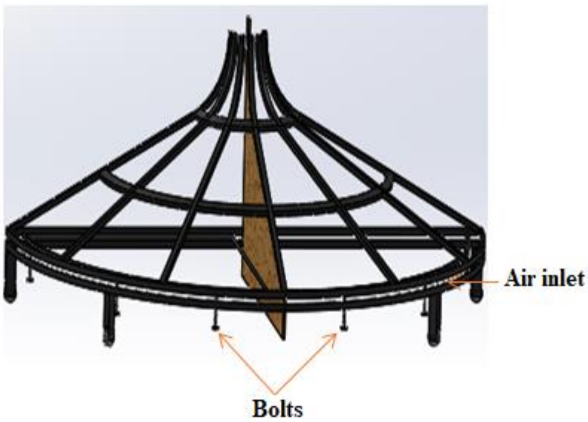


Figure (7): Controlling of the Air Inlet Height

Figure (8): Height of the Air Inlet

2.6 Error analysis

The experimental results accuracy can be affected by two factors; the measurements accuracy and device designing nature. Interval of the uncertainty (w) in a result can be written by the following correlation, Mélanie et al. [27]:

$$W_R = \left[\sum_{i=1}^{n}\left(\frac{\partial R}{\partial e_i} W_i\right)^2\right]^{1/2} \qquad (1)$$

Where R represents the result, e is an independent parameter and n is a summation of independent parameters. The experimental errors that may be happened in the independent parameters are given in the following table which is taken from measuring devices as follows:

Independent Parameter (e)	Uncertainty (W)
Temperature (T)	± 0.1 °C
Solar Radiation (I)	± 10 W/m²
Air Flow Velocity (v_t)	± 0.0004 m/s
Absorber Radius (r_c)	± 0.0005 m
Tower Hieght (H_t)	± 0.0005 m
Tower Radius (r_t)	± 0.0005 m
Air Inlet Height (H_i)	± 0.0005 m

2.7 Thermal analysis

Experimental calculation aimed to evaluate the performance of the SUTS utilized with flat and metal foam absorber plate.

The output power of the SUTS was depended on the several parameters which can be offered simply by the following equation, Jörg et al. [28];

$$P_{out} = \dot{Q}_{solar} * \eta_c * \eta_t * \eta_{turbine} \quad \text{... (2)}$$

In the present work there is no turbine, therefore the Eq. 1 become;

$$P_{out} = \dot{Q}_{solar} * \eta_c * \eta_t = \dot{Q}_{solar} * \eta_{plant} \quad \dots (3)$$

The input thermal solar radiation $\dot{Q}_{solar}$ into the collector can be calculated by the following equations:

$$\dot{Q}_{solar} = IA_c \quad \dots (4)$$

Where, A_c is the cross section area of each quarter circular thermal solar collector ($A_c = \frac{\pi}{16} D_c^2$) (m²).

The useful energy gain can be expressed;

$$\dot{Q}_u = \dot{m}c_p(T_{c,o} - T_{amb.}) \quad \dots (5)$$

The air mass flow rate moves towards the tower and can be written as;

$$\dot{m} = \rho_t v_t A_c \quad \dots (6)$$

The thermal efficiency for each quarter circular thermal solar collector can be calculated by the following equation;

$$\eta_c = \frac{\dot{Q}_u}{\dot{Q}_{solar}} \quad \dots (7)$$

The power output available to the tower inlet without turbine can be determined by multiplying the input of solar energy $\dot{Q}_{solar}$by the efficiencies of the collector and tower.

The tower efficiency can be found from the equation;

$$\eta_t = \frac{g.H_t}{C_p.T_{amb}} \quad \dots (8)$$

The pressure difference developed due to the air density difference between the collector exit (tower inlet) temperature and the ambient air temperature at the tower exit and can be written as;

$$\Delta p = g\int_0^{H_t}(\rho_{amb} - \rho_{c,o})dy \quad \dots (9)$$

The tower was insulated, therefore the heat was not added or rejected from the tower (adiabatic process), and thus the equation (9) becomes:

$$\Delta p = g(\rho_{amb} - \rho_{c,o})H_t \quad \dots (10)$$

The total power output is calculated from the following equation;

$$P_{out} = \eta_t \times \dot{Q}_u = \frac{g.H_t}{C_p.T_{amb}} \times \dot{Q}_u \quad \dots (11)$$

By substituting Eqs. 9 and 10 into Eq. 11, it becomes as follows;

$$P_{out} = \frac{\rho_t v_t A_c\, g.H_t\,(T_{c,o} - T_{amb})}{T_{amb}} \quad \dots (12)$$

Boussiuesq approximation gives a relation between the temperature and the density as follows;

$$\frac{T_{c,o} - T_{amb}}{T_{amb}} \cong \frac{\rho_{amb} - \rho_{c,o}}{\rho_{c,o}} \quad \dots (13)$$

Where, $(T_{c,o} - T_{amb})$ is the temperature difference between tower inflow (collector outlet) and the ambient temperature. Thus, the Eq. 13 can be simplified to become;

$$P_{out} = v_t A_c \Delta p \quad \dots (14)$$

3. Results and Discussion

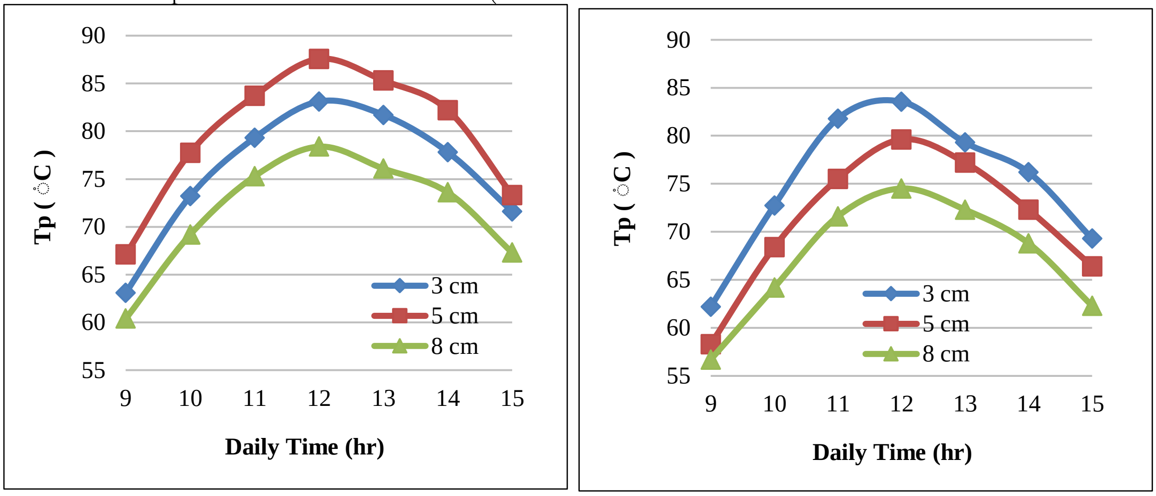
The experimental results presented and analyzed to investigate the effects of changing air inlet height on the SUTS performance using the copper foam as a heat absorber plate and compared to the conventional flat plate.

3.1 Surface absorber plate temperature

Figs. 9 (a and b) show the average temperature variation of the absorber plate for flat plate and copper foam with time for different heights of the air inlet (3, 5, and 8) cm respectively of the same solar intensity From the figures can be noted that the average absorber plate temperature for flat plate is higher than metal foam absorber plate due to the surface area of the flat absorber plate is small relative to the surface area of the porous absorber plate that caused an increased in the induced airflow. Also, it's noted that the average absorber plate temperature decreases with the increased air inlet height to reach the minimum value of 8 cm height. This can be attributed to the fact that when the air inlet height increased the gap between the solar roof and floor of the collector will increase, causing a difference in the thermal balance between the collector and the tower, and this affects on the heat transfer enhancement between the heat absorbent surface and the working fluid.

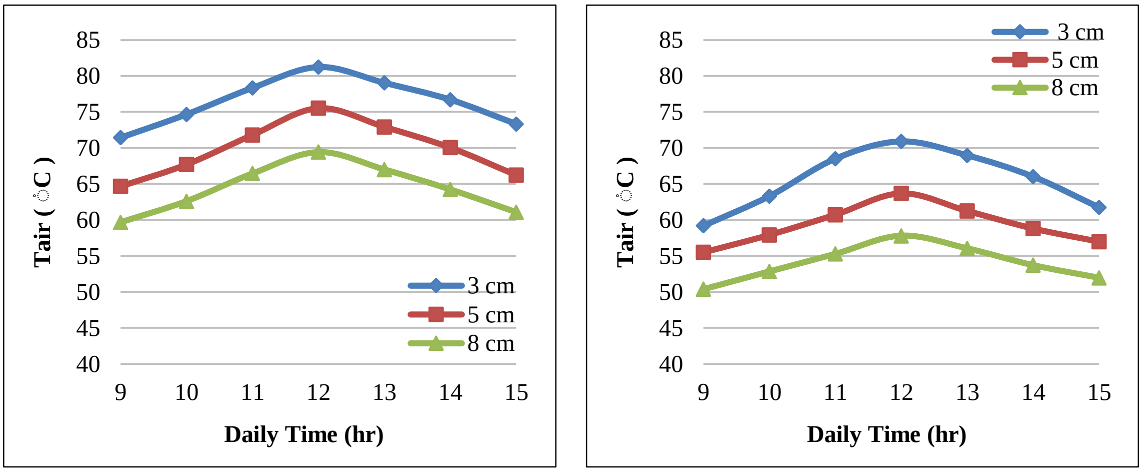
3.2 Air flow temperature distribution

Figure 10 shows the average air temperature inside the collector with copper foam absorber plate versus time for different heights of the air inlet (3, 5, and 8) cm respectively of the same solar intensity. The figure shows that the average air temperature at the upper and lower of the surface metal foam was decreased with an increase in the air inlet height due to the increased height between the roof and floor of the collector. The maximum reduction of the average air temperature at the upper and lower of the metal foam absorber plate was recorded at about (10.6% and 9.3%) respectively when the height of the air inlet was increased from 3 cm to 8 cm.



(a): With Copper Foam Absorber Plate **(b):** With Copper Flat Absorber Plate

Figure (9): Average Surface Temperature of the Absorber Plate with the Time at Different Air Inlet Heights



(a) **(b)**

Figure (10): Variation of Average Air Temperature from (a) Upper & (b) Lower of Copper Foam Absorber with Time for Different Air Inlet Height

3.3 Collector air temperature rise (ΔT)

Rising air temperature refers to the amount of thermal energy that was gained when the air passes through the solar collector and represents the difference between the ambient temperature and the air outlet temperature of the collector. The air temperature difference (ΔT) increases with the use of the metal foam absorber plate compared to the conventional flat absorber plate as shown in Fig. 11. It can be seen that the air temperature difference was increased to reach the maximum value during the period between 11:00 AM to 01:00 PM as the intensity of the solar radiation is increased to cause an increase of the buoyancy force. Thus, the induced air flow increases as a result of the increase in the air temperature difference (ΔT) and this enhances the SUTS performance as the power output increased.

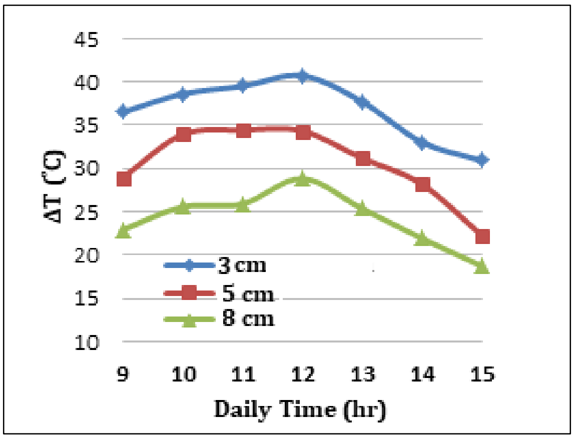


Figure (11): Collector Air Temperature Difference with the Time for copper foam Absorber Plate

3.4 Air velocity at tower inlet

The effect of changing the air inlet heights (3, 5, and 8) cm respectively with using a copper foam absorber plate on the variation of the air velocity at the tower inlet versus time can be presented in Fig. 12 of the same solar intensity. The maximum air velocity was decreased by about 29.1% with the increase of the air inlet height from 3 to 8 cm. This is attributed to the fact that the collector flow area will be increased by raising the collector roof which affected the balance between the solar collector and the tower and causes air turbulence which cools some regions in the system as a result increase of the pressure in those regions.

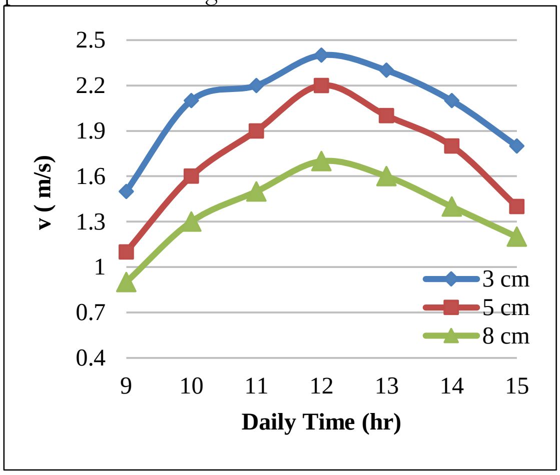


Figure (12): Variation of Air Velocity at the Tower Inlet for copper foam Absorber Plate with the time at Different Air Inlet Heights

3.5 Solar collector thermal efficiency

The effect of changing the air inlet heights (3, 5, and 8) cm respectively with using a copper foam absorber plate on the hourly performance of the collector thermal efficiency can be presented in Fig. 13. The maximum performance of the collector thermal efficiency is decreased about 48.3% with the increase of the air inlet height from 3 to 8 cm.

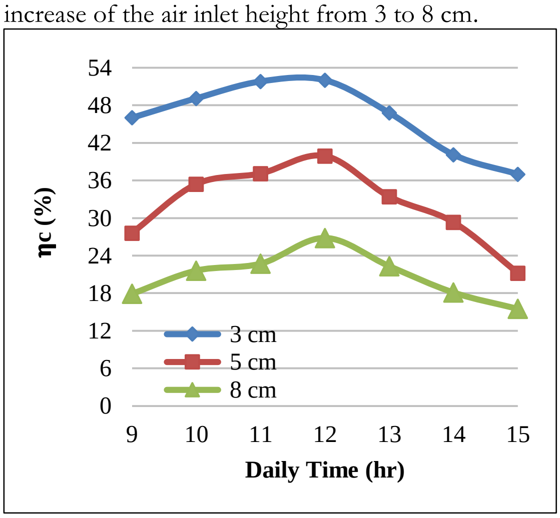


Figure (13): Variation of Collector Thermal Efficiency for Copper Foam Absorber Plate with the Time at Different Air Inlet Heights

3.6 Pressure difference (ΔP)

Fig. 14 shows the effect of changing the air inlet heights (3, 5, and 8) cm respectively by using a copper foam absorber plate on the variation of the pressure difference between the tower and the ambient. The maximum reduction of the pressure difference to about 22.4% with the increase of the air inlet height from (3 to 8) cm. This is attributed to the fact that the gap between the roof and the floor of the collector increases which affects the buoyancy effect as a function of the collector air temperature rise. The general behavior of the figure indicates that the presence of metal foam as an absorber plate increases the variation of the pressure difference produced between the tower base and the ambient significantly. This increase will be affected largely by the SUTS performance as a result of an increase of the buoyancy force.

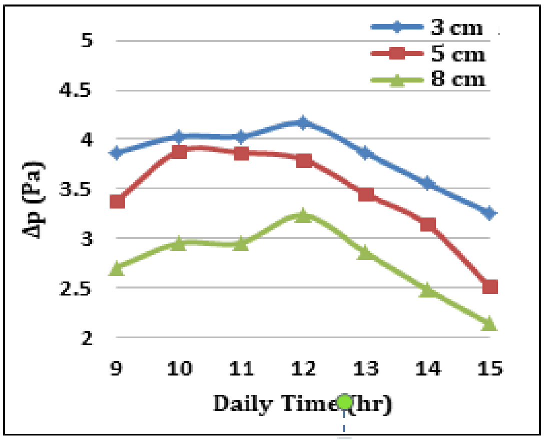


Figure (14): Hourly Variation of the Pressure Difference through the Tower with for copper foam Absorber Plate at Different Air Inlet Heights

3.7 Power contained in the air flow (Power output)

The effect of changing the air inlet heights (3, 5, and 8) cm respectively with using a copper foam absorber plate on the power output can be presented in Fig. 15. The maximum power output was decreased by about 45.1% with the increase of the air inlet height from 3 to 8 cm.

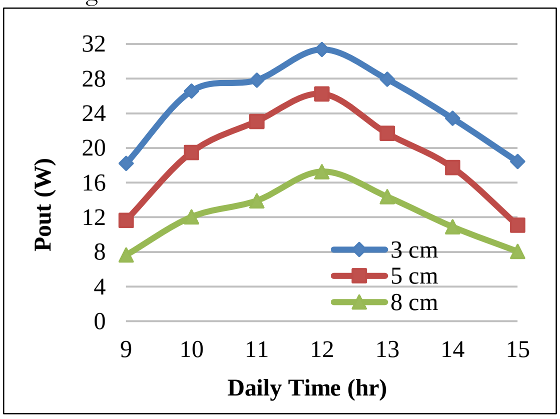
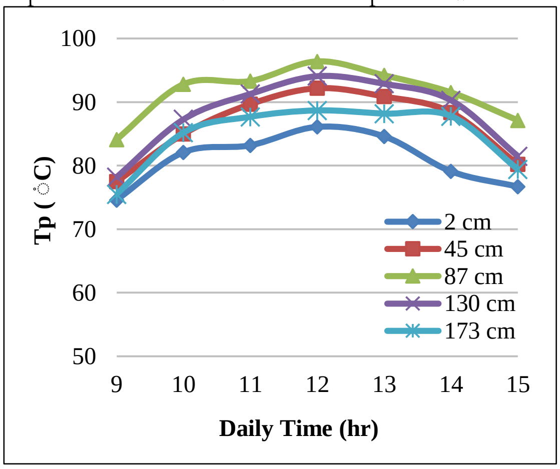


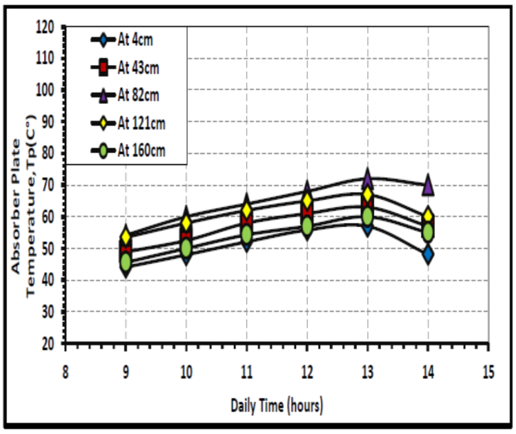
Figure (15): Variation of the Power Output for copper foam Absorber Plate with the time at Different Air Inlet Heights

3.8 Comparison with the previous experimental works

The published experimental researches are rare for the case of using the metal foam as a collector absorber plate inside the SUTS especially in Iraq (33.34° latitude, 44.42° longitude), Kasaeian et al. [29]. So, the comparison between the present experimental results and the other researchers will be depended on the general behavior for some parameters that studied the performance of the SUTS. For the SUTS without a metal foam collector absorber plate, Maryam [30] studied the performance of the SUTS with conventional flat absorber plate active solar air collector under Iraq weather conditions in May 2015. Fig. 16 presents the surface temperature distribution along the middle line of the collector absorber plate versus time. The general behavior of the surface temperature of the absorber plate is similar to the experimental result obtained in the present work.



(a): Present Work



(b): Maryam [30]

Figure (16): Comparison of Surface Temperature Distribution of Collector Absorber Plate with Time

4. Conclusions

The experimental present work aims to study the effect of changing the heights of the air inlet (3, 5, and 8) cm on the SUTS performance utilized plate and copper foam absorber plate. The experimental research was carried out under Iraqi climate conditions with an inclination angle of cover glass collector and porous absorber plate at 22.5°, and 18° respectively. The tower height was 3.5 m and the solar intensity changed from 500 to 900 W approximately. The presence of metal foam produced the following effects:

1. The average surface temperature of the absorber plate was reduced. The maximum reduction of surface plate temperature obtained experimentally with a copper foam absorber plate was about 6.3% respectively compared to the conventional absorber plate.

2. An increment in the values of collector air temperature rise (ΔT). The highest increase in the air temperature that obtained through the present experiment with Flat and metal foam absorber plates of 32.54 and 39.96 ℃ respectively.

3. The air velocity recorded a maximum enhancement at tower inlet using copper foam absorber plate to about 40.4% respectively compared to the flat plate.

4. The air velocity at the tower inlet is decreased with the increase of the air inlet heights. The percentage reduction in the air velocity from 3 to 8 cm with porous metal foam absorber plate to about 29.1% respectively.

5. The thermal efficiency of the solar collector was increased by using copper foam as an absorbent plate which recorded maximum values after 12:00 – 1:00 PM. The maximum enhancement of collector thermal efficiency was recorded with flat and copper metal foam absorber plates to about 20.4% and 41.6% respectively.

6. The maximum power output with porous metal foam is recorded at about 45.2 %, while with the conventional flat absorber plate about 31.5%.

The conclusions of experimental data analysis show that changing the air inlet height causes a marked increase in the SUTS performance, especially with copper material foam absorber plate. This gives evidence that using a metal foam absorber plate as an absorbent heat plate with a 3 cm air inlet height will be caused to increase the SUTS performance.

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