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Theoretical and Experimental Study of a PV/T Collector by Using TRNSYS Software in Mosul City

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ABSTRACT

The research included a practical and theoretical study on a PV/T collector to verify the validity of the results and data provided by the simulation program used in the research (TRNSYS). A practical PV/T collector was designed and implemented, followed by theoretical simulation using the (TRNSYS) program. Comparitive analyses of the practical and theoretical results of both closed cycle and open cycle systems was conducted under the atmospheric conditions of the Mosul, Iraq. The solar collector was faced the south, and comprehensive data form the practical setup were recorded after its operation. For the closed cycle, the results showed an error of 2.7% in the exit water temperatures from the solar collector and a 3.4% error in the tank water temperature. In the open cycle, an error of 2.8% was recorded the incident radiation intensity, with 3% error in the solar collector's thermal efficiency. The close difference of these results confirms the accuracy of the data provided by the TRNSYS program, indicating its reliability for developing and studying other theoretical systems, thereby saving time, effort and money.

Keywords:

Photovoltaic collector; Solar energy; Thermal collector; Thermal performance; collector.

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1. INTRODUCTION

The world suffers from an increased demand for energy in various aspects of commercial, service, and industrial life. This has prompted a global turn to additional energy sources to fill the shortage and relieve the pressure on electric power stations and fuel supplies. Furthermore, the shfit aims to reduce environmental pollution as a result of using fossil fuels which are harmful to the environment, the main cause of global warming, and reduction of the ozone layer.The high prices and the difficulty and cost of extracting fossil fuels have further prompted stakeholders to devise new ways to generate energy based on free, clean energy sources. Solar energy, one of the most prominent renewable energies sources, is increasingly relied upon in many applications to serve people.

Solar water heating is one of the most well-known solar thermal applications and is considered one of the systems with low energy costs and expenses over its total lifespan. Solar water heating technology has proven cost-effective for many domestic and industrial applications. These systems have been recognized for a long time and are currently being used in many commercial, service, and domestic sectors worldwide. Therefore, the solar water heating system is the most widely used and the fastest developed at the present time. In addition to the aforementioned reasons, the continuous rise in fuel prices, along with favorable climatic conditions in some countries, have made renewable energy sources, especially solar energy, increasingly attractive [1].

Man realised the benefits of using solar energy as far back as prehistoric times. The Greek historian Xenophon in his 'Memorabilia' records some of the teachings of the Greek Philosopher Socrates (470–399 BC) regarding the correct orientation of dwellings to ensure houses were cool in summer and warm in winter [2]., Solar energy is one of the most desirable types of energies for many applications due to the intensity of radiation falling on the globe. The Earth receives approximately 174 million kilowatts of radiation emitted from the sun at the upper layers of the atmosphere, and 30% of this radiation is reflected back into outer space.

The conversion of solar energy into thermal energy by a solar collector is considered the most common due to its impact on reducing people's consumption of electric energy and reducing the cost of bills, especially for domestic purposes. In addition, hot water is used for industrial and production processes, such as pasteurizing milk. This interest in alternative energy sources has led to the development and invention of many types of collectors and solutions to increase their efficiency. Merging more than one type to create a new collector with the advantages of both systems is an example of this innovation, as seen in photovoltaic thermal collectors (PV/T). This will be the focus of the research.

2. THERMAL SOLAR COLLECTOR SYSTEM

2.1. The working principle of the pv/t solar collector

The photovoltaic thermal collectors (PV/T) system is a combination of a flat plate solar collector and an electric power generation system. it consists of a photovoltaic solar panel placed above the thermal solar collector to produce electrical energy independently from the rest of the thermal system. This developed technology can produce both hot water and electrical energy simultaneously. The practical PV/T device, which is designed and built, is shown in Fig. 1.

2.2. Practical components used in the study

The device consists of a thermal solar collector that contains a tube in a zigzag shape, with a photovoltaic solar panel placed on top. The collector converts the radiation into heat stored in the water. Furthermore, the system includes a pump to circulate the water, a water tank, and a control panel for measuring the temperature.

The solar collector converts solar energy into thermal energy stored in the flowing fluid through the radiation falling on the surface of the collector. The intensity of the falling radiation varies according to the timeof the day, as well as vbb the months and seasons of the year. The solar collector also produces electrical energy through the radiation falling from the sun, which hits the solar panels. This leads to the flow of electrons that generate a potential difference, producing an electric field.

Fig.1 photovoltaic thermal collector used in the current study.

2.3. Overview of trnsys software

TRNSYS, an acronym for Transient System Simulation, is a simulation program that manage data inputs and outputs. It simplifies projects development, saving effort, time, and money, while presenting information in a graphical and digital format that illustrate system behavior. Researchers have employed TRNSYS extensively as the pioneer tool in renewable energy studies. In this work, version 18 (V.18) of TRNSYS will be utilized, allowing for testing and analysis of its data, which will be compared with practical results. Additionally, TRNSYS includes a comprehensive library of global weather data, faciliating precise input parameters.

2.4. Theoretical components used in the simulation

The theoretical components correspond to the elements of the practical device in terms of operating conditions and the working principle, and they are arranged in the same order as the practical components for simulations purposes. Table 1 outlines the elements used in the simulation along with theircorresponding symbols and descriptions. Moreover, Table 2 displays parameters fixed during the manufacturing of the collector, while Table 3 presents factors that remain constant during the simulation. In this study, we used the PV/T collector component (Type 50a) due to its suitability the case under consideration.

Table 1: Elements used in the simulation.

Type Name	Symbol
Weather Data Processor	Type15-1
PV-Thermal Collector	Type 50a
Cylindrical Storage Tank	Type534-NoHX
Auxiliary Fluid Heater	Type138
Single Speed Pump	Type114
Time Dependent Forcing Function	Type14h
Quantity Integrator	Type24
Printer	Type25c
Online graphical plotter with output file	Type65c

Table 2: Fixed measurements for the design of the solar collector and its various parts.

parameters	value	units
The length of the solar collector	1.5	m
The solar collector width	1	m
The number of solar collectors	1	----
The number of layers of the board Clear plastic	1	----
The distance between the collector tubes	0.05	m
Solar collector tube diameter	0.007	m
The distance between the tubes and the transparent sheet	0.04	m
insulator thickness	0.04	m
The length of the serpentin pipe in the collector	10	m
Tank diameter	0.4	m
Tank length	0.8	m
Tank volume	100	L
Water flow rate	1	L /min
Specific heat of water	4.19	KJ/kg.K
viscosity of water	3.12	kg/m.hr
Water conductivity	2.14	kJ/hr.m.K
Solar panel length	0.32	m
Solar panel width	0.75	m

Table 3: Constants and factors used as inputs in the TRNSYS software.

parameters	Value	units
Collector Fin Efficiency Factor	0.96	-
Fluid Thermal Capacitance	4.19	kJ/kg.K
Collector plate absorptance	0.92	-
Collector loss coefficient	14	kJ/hr.m^2.K
Cover transmittance	0.89	-
Reference temperature for cell efficiency	25	C
Packing factor	0.16	-
Tank Volume	0.1	m^3
Tank Height	0.8	m
Fluid Specific Heat	4.19	kJ/kg.K
Fluid Density	1000	kg/m^3
Fluid Thermal Conductivity	2.14	kJ/hr.m.K
Fluid Viscosity	3.12	kg/m.hr
Maximum heating rate	5000	kJ/hr
Specific heat of fluid	4.19	kJ/kg.K
Efficiency of auxiliary heater	0.8	-
Set point temperature	60	C°
Slope of surface	55	Degrees
Azimuth of surface	0	Degrees
Reference efficiency of photo voltaic	0.25	-

2.5. Related works

Recent research has focused on producing energy and harnessing nature to serve humanity. Renewable energies have gained interest among researchers because they have existed since time immemorial and are freely available. Researchers have attempted to harness these energies and convert them into other forms of energy that benefit humanity worldwide.

Researchers in the field of renewable energy have shownincreasing interest and conducted many studies on the PV/T solar collector. These studiesfocus on measuring its efficiency, operating conditions, continuous improvement, and the potential for its commercial development and market introduction. The following is a review of the most prominent researches on this type of solar collectors.

Dadia et al. (2019) used the TRNSYS software to simulate the conversion of solar energy into thermal energy for heating water. They conducted this experiment on a solar collector with evacuated tubes and a second system a parabolic solar collector, both with the same surface area of 4.44 square meters. The liquid flow rate was 105.394 kg/hr. The experiment took place in the Ahmed Abad region of Pakistan to explore the feasibility of harnessing solar energy for heating purposes., They found that it is possible to achieve temperature of 200 °Cfor the liquid exiting the parabolic solar collector and 380 °Cfor the liquid exiting the evacuated tube collector of the same area and flow rate. Furthermore, they noticed that from the mid-November to January, the exit temperature of the liquid using the parabolic solar collector was 40-50 °C, while the temperature utilzing the evacuated tube solar collector was 40-150 °C. From April to mid-July, both types of solar collectors could achieve the highest liquid exit temperature during the summer season. The study concluded that the climate in the Ahmed Abad region can be effectively exploited through solar energy for heating purposes [3].

In another study, Hamdoon et al. (2020) conducted numerical simulations to evaluate the thermal and electrical performance of a photovoltaic/solar thermal domestic hot water system (PV/T-SDHW) for a five-person house in Mosul- Iraq. Using TRNSYS software, they analyzed the effects of various factors on the energy output of the solar heater and the generation of electric power and hot water. The obtained results were validated against experimental and numerical fidings from two different studies, showing good agreement between them [4].

Johnsonet al. (2018) measured the performance of a solar water heating complex in the Zaria region in Nigeria, located at latitude 11.2 south and longitude 7.8 east. The system, with an inclination angle of 12 degrees and an area of 2.2 m^2, was designed to provide 100 L of hot water. The experimental results were verified using the Nash-Sutcliffe efficiency (NSE) and compared them with the simulation results from the TRNSYS software. The comparison showed that TRNSYS produces realistic values, and the simulation outputs closely matched the experimental findings [5].

Abdunnabiet al. (2014) conducted a practical comparison of the temperature difference resulting from a solar heater using the TRANSYS simulation program to test its accuracy. They employed a solar collector compsed of four evacuated tubes connected to a 200 L water tank, arranged in parallel and connected in series, with water circulation through the tubes in an open loop. The same system specifications, weather conditions, and operation were applied in the simulation to verify its validity and accuracy. The results indicated that the software provides satisfactory predictions compared to the experiment, with accuracy of 13.5% [6].

Fudholi et al. (2014) examined a PV/T water collector consisting of a compact PV unit and a heat absorption collector with spiral tubes. The efficiencies of the solar collector were measured under solar radiation between 400 to 800 W/m². The results indicated that at a radition level of 800 W/m² with a fluid flow rate of 0.041 kg/s, the spiral solar collector achieved an efficiency of approximately 65%, a PV/T efficiency of 13%, and a thermal efficiency of 52%. In addition, it demonstrated a primary energy saving efficiency between 79% and91% at flow rates ranging from from 0.01 to 0.041 kg/s. Their results also showed that the efficiency of the photovoltaic module increases as the temperature decreases, although the temperature decrease is not linear with the increase in the mass flow rate. However, a significant temperature drop occurs once the mass flow rate reaches 0.024 kg/s. Overall, it was found that the efficiency of PV/T water collectors increases with higher mass flow rates under varying levels of solar radiation. This is due to the enhanced cooling effect of the photovoltaic module cells with increasing mass flow rates, which indirectly contributes to a rise in the temperature of the solar collector [7].

3. THE PROPOSED METHODOLOGY

The current study was conducted in Iraq, specifically in the city of Mosul (36°N,43°E). Instantaneous weather conditions were measured using several instruments: a thermocouple (Fig. 2) for measuring atmospheric temperature , multi water temperature sensors calibrated by Senserion device (Fig. 3), and a radition meter (Fig. 4) for quantifying solar radiation intensity.The solar collector was positioned with its surface facingsouth at an inclination angle of 55 degrees. The system was evaluated under both closed loop(Fig.5) and open-loop configrations(Fig.6).

A comparison was made between the practical and theoretical results for various parameters: the input water temperature to the PV/T collector, the exit water temperature from PV/T collector, the water tank temperature, radiation levels, useful heat gain, thermal efficiency, and ambient temperature. This procedure was conducted separately for both closed -loop and opened -loop systems.

Readings were taken for the closed and open cycle from 9 a.m. until 2 p.m.. The for the comparison for the closed cycle was conducted on the 1st of November, while the comparision for the open cycle took place on the 14th of November. For the open cycle, cold water was added to the tank from the public network at a rate of 18 L/hr) and a temperature of 19°C.Similarly, hot water was drawn from the tank for domestic uses at a rate of 18 L/hr.

Fig.2 Thermocouple STC1000.

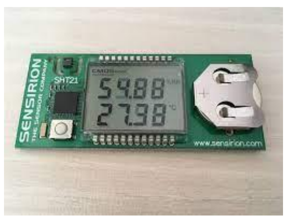

Fig.3 Senserion correction device.

Fig.4 Radiatin intensity meter.

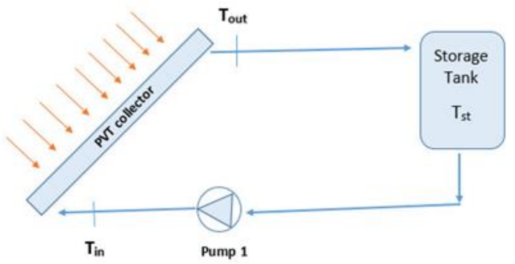

Fig.5 Closed-loop cycle system.

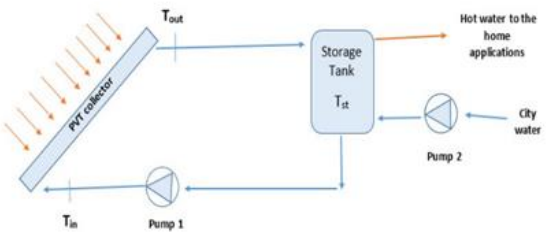

Fig. 6 Open-loop cycle system.

Table 4: Static specifications of the (STC 1000) thermocouple.

Temperature Measuring Range	-50 to 90°C
Control Temperature Range	-50 to 90°C (Adjustable)
Control Temperature Difference	0.3 to 10°C (Adjustable)
Relative Humidity	20 to 85%
Resolution	0.1°C
Accuracy	± 1°C
Sensor	NTC sensor
Sensor Cable Length	1m
Relay Output Capacity	Heating: 10A (max) 250 V Cooling: 10A (max) 250V
Shipping Weight	0.11 kg
Dimensions	10 × 10 × 5 cm

Table 5: Static specifications of radiation intensity meter.

Resolution	0.1W/M2, 0.1 BTU/(FT2-H)
Accuracy	±10W/M2 [±
Temperature Coefficient	±0.38W/M2 /°c
Range	0.1-399.9 W/M2, 1-3999 W/M2, 0.1-399.9 BTU/(FT2-H)

Table 6: Static specifications of Senserion thermometer.

Maximum Operating Temperature	+ 60 C
Minimum Operating Temperature	- 10 C
Product Type	Multiple Function Sensor Development Tools
Series	SHT40

3.1. Mathematical model

3.1.1. The amount of useful heat gained in the process

This is the energy gained from the sun in the form of heat by absorbing solar radiation falling on the solar collector and transferring it to the water as thermal energy. It is measured in watts (W) and is represented by the symbol (Qu_{theo}). Its value depends on the inlet and outlet water temperatures of the solar collector and is expressed mathematically in the following equation:

$$Qu = m' * Cp_w * (T_{in} - T_{out}) \quad .....(1)$$

Where:
m' : the water mass flow rate.
Cp_w : the specific heat of water.
T_{in} : inlet water temperature.
$T_{out,}$: outlet water temperature.

3.1.2. Thermal efficiency of the solar collector

The theoretical thermal efficiencyis calculated by inputing the theoretical variables into the equation. The thermal efficiency is , denoted by η_{theo}, and the theoretical thermal efficiency is represented by the following mathematical representation ,

$$\eta = \frac{Qu}{Rad * A_{coll}} \quad .....(2)$$

Where:
Qu : useful heat gain.
Rad: intensity of radiation.
A_{coll} : collector area.

3.2. Calculation of the uncertainty coefficient

The uncertainty factor for the temperature and radiation intensity sensors on the solar collector device was calculated using the following equation:

Table 7: Device Accuracy.

Instruments	Type of measuring	Max. value of reading	Device accuracy
Thermocouple 1	inlet solar collector temperature	63 °C	±0.02
Thermocouple 2	outlet solar collector temperature	69 °C	±0.02
Thermocouple 3	water tank temperature	61.4 °C	±0.02
Thermocouple 4	weathertemperature	31 °C	±0.01
Radiation meter	intencity of radiation	2730 kJ/hr.m^2	±4

$$\text{Uncertainty} = \frac{\text{Device accuracy}}{\text{maximum value of reading}} * 100 \quad .....(3)$$

Table 8: Instruments Uncertainty.

Instruments	Uncertainty Percentage
Thermocouple 1	0.03
Thermocouple 2	0.029
Thermocouple 3	0.033
Thermocouple 4	0.032
Radiation meter	0.15

$$\text{Total uncertainty} = \sum Devices\ uncertainty = 0.274\ \%$$

4. RESULTS AND DISCUSSIONS

A solar collector system was practically manufactured with the previously mentioned specifications. Digital sensors were installed to measure temperatures: water entering and leaving the solar collector, water in the storage tank, ambient atmosphere, solar radiation intensity, and energy obtained from the solar collector. This data will be collected and compared separately with the theoretical data generated using the TRNSYS software for both closed and open systems. The verification of these software results will also be illustrated in the following section, followed by a discussion to asses the software's reliability in meeting the design requirements for such systems.

The term "closed cycle" refers to the water flow within both the physical system and the theoretical system simulated in the software, where water circulats within the system without withdrawing hot water from the tank oradding cold water from the public network. This contrasts with the "open cycle". The program's accuracy is verified by comparing the practical results with those generated by the simulation, examining each characteristic separately to determine the compatibility of the readings.

Readings were taken for both the closed and open cycles from 9 a.m. until 2 p.m.. The closed cycle comparison was conducted on November 1st, while the open cycle comparison took place on November 14th. For the open cycle, cold water was added to the tank from the public network at a rate of 18 L/hr and a temperature of 19°C. Similarly, hot water was withdrawn from the tank at a rate of 18 L/hr for domestic use. The following section reviews the most important variables compared between the practical and theoretical parts to verify the accuracy of the program's results.

A. Water temperature leaving from the solar collector

The temperature of the water exiting the solar collector in the practical closed-circuit system was measured at 34.7°C at 9 a.m., gradually increasing to 65.8°C by 2 p.m. In comparison, the theoretical water temperature exiting the solar collector, as generated by the simulation program, was 36.4 °C in the morning, also rising gradually to a maximum at of 63.8° C by 2 p.m. Fig. 7 illustrates the accuracy of the simulation results.

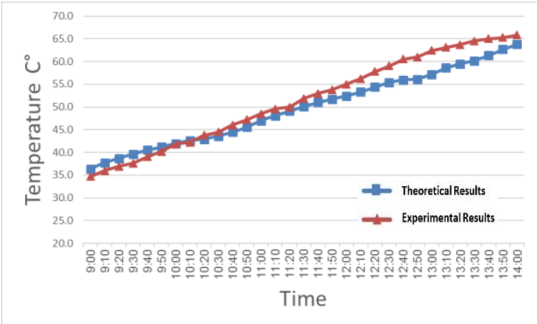

Fig.7 Theoretical and experimental results over time for the temperature of the water leaving the solar collector in the closed cycle.

The same experiment was repeated on the open circuit of the solar collector for the practical setup. It was observed that the temperature of the water exiting the solar collector was 38 °C at 9 a.m., increasing to to 68.5°C. The results obtained from the simulation of the theoretical system were. In the simulation of the theoretical system, the water exit temperature was 39.7 °C at nine o'clock in the morning, rising to 69 °C by eleven o'clock, as shown in Fig. 8. The comparison of the practical and theoretical results of the open and closed systems for both open and closed systems showed a strong agreement, with only slight differences.

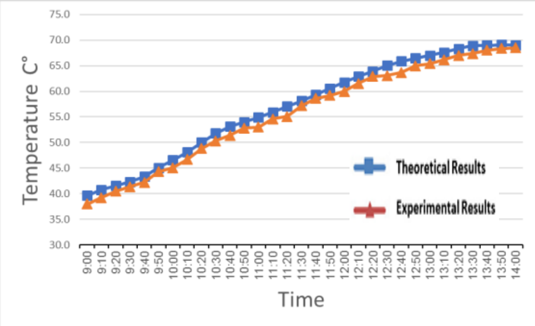

Fig.8 Theoretical and experimental results over time for the temperature of the water leaving the solar collector in the open cycle.

B. Water temperature inside the tank

The practical results of the closed cycle showed that the water temperature inside the tank was 31° C at nine o'clock in the morning, increasing to 61.4° C by two o'clock in the. The theoretical results indicated a temperature of 34.2 °C at the start of the experiment, reaching 58.3 °C by the end. These findings demonstrate a remarkable convergence between the practical and theoretical results for the closed cycle, as illustrated in Fig. 9.

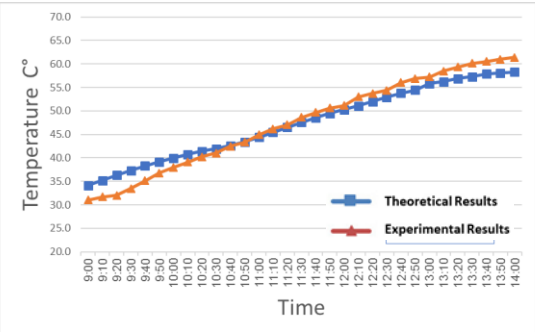

Fig.9 Theoretical and experimental results over time for the water temperature inside the tank in the closed cycle**.**

For the open cycle experiment, the results also showed a strong agreement between the practical and theoretical values. The theortical temperature at the beginning of the experiment was 35.6°C, rising to 58.8°C by the end, as depicted in Fig. 10.

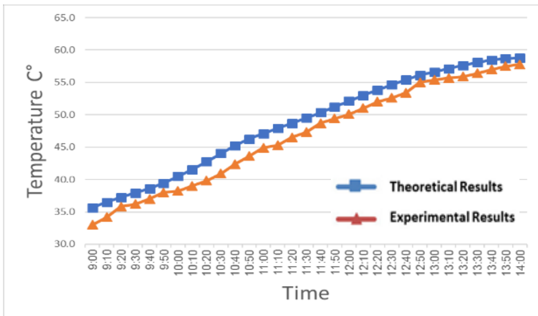

Fig.10 Theoretical and experimental results over time for the water temperature inside the tank in the open cycle**.**

C. Water temperature entering to the solar collector

The practical and theoretical results were very close for both the closed and open cycle systems. For the closed cycle, the temperature of the water entering the solar collector rig was 28 °C at the beginning of the experiment and 63°C upon completion. The theoretical results showed a temperature of 31.7°Cat the start and 60.6°C at the end of the experiment, as shown in Fig. 11.

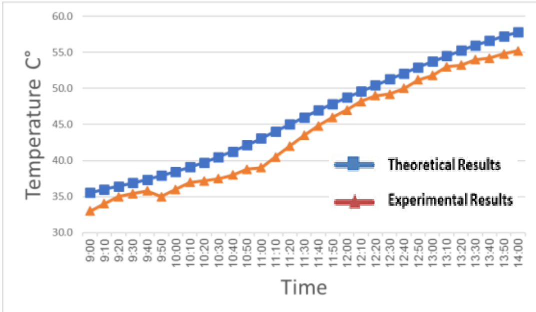

Fig.11. Theoretical and practical results over time for the temperature of the water entering the collector in the closed cycle**.**

When comparing the experimental and theoretical results of the open cycle, a high degree of proportionality and compatibility was observed. The temperature at the beginning of the experiment was recorded as 33°C, rising to 55.2°C by the end`. The theoretical results started at 35.5°C and increased to 57.8 °Cby the end of the experiment, as shown in Fig. 12.

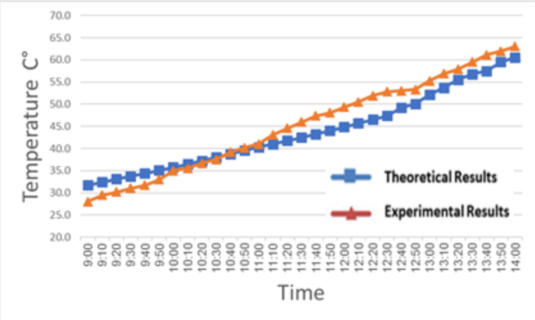

Fig. 12. Theoretical and experimental results over time for the temperature of the water entering to the collector in the open cycle.

D. Useful heat rate gained by the water

The useful heat gained by the water inside the solar collector is a critical parameter for researchers in the field of energy. An experiment was conducted on the constructed device, and the practical and theoretical results of the closed and open cycle were found to be closely aligned and validating the software's accuracy.

For the closed cycle, the practical results showed that the useful heat rate at the start of the experiment (9 a.m.) was 467.9 W. By the end of the experiment (2 p.m.) m this value decreased to 289 W, with the maximum heat rate recorded at 589W. In the theoretical simulation of the closed cycle, the useful heat rate was 325.4 W at the start and 273 W at the end, with a maximum value of 538 W, as shown in Fig. 13.

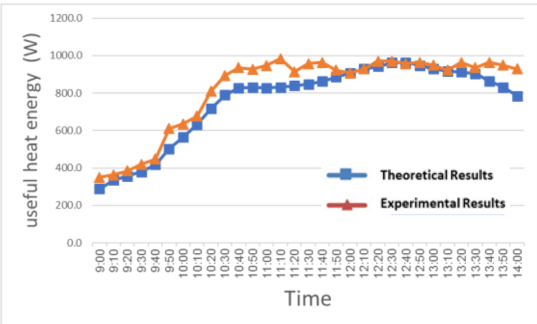

Fig. 13. Theoretical and practical results of the heat rate gained by the water in the solar collector over time for the closed cycle.

The experimental and theoretical results were conducted on the open cycle system. In practical experiment, the initial energy measurement was 249.2 W, increasing to 928.8 W by the end of the experiment, with a peak value of 970 W. The simulation results indicated 299.5 W at the beginning of the experiment, 785.1 W at the end, and a maximum of 963.6 W). These results demonstrated significant alignment between the practical and theoretical aspects of the open cycle, as illustrated in Fig. 14.

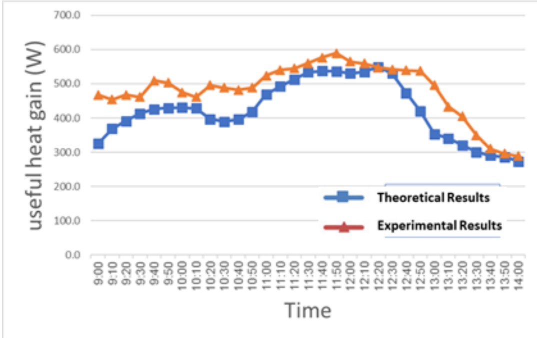

Fig.14. Theoretical and practical results of the heat rate gained by the water in the solar collector over time for the open cycle.

E. Thermal efficiency of the solar collector

Thermal Efficiency indicates the system's performance quality. Practical and theoretical experiment was conducted to determine the system's efficiency for both closed and open cycles. For the closed cycle, the practical results showed an initial efficiency of 0.17, which increased with the intensity of solar radiation, peaking at 0.23, and then decreased to 0.14 by the end of the experiment. The theoretical simulation results showed an initial efficiency of 0.14, peaking at 0.21, and then decreasing to 0.13 by the end. These results demonstrate a clear convergence between the experimental and theoretical findings for the closed cycle, as shown in Fig. 15.

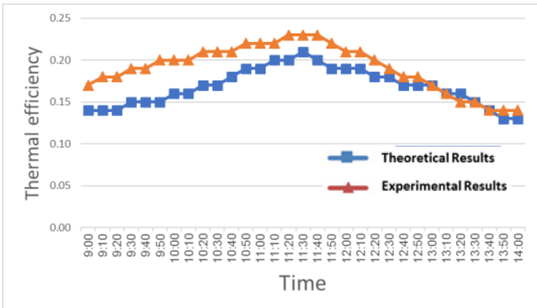

Fig.15. Theoretical and practical results of thermal efficiency with respect to time for the closed cycle.

Furthermore, a validation process was conducted on the open cycle system, with data recorded from the experimental. The thermal efficiency of the solar collector started at 0.19, peaked at 0.24, and then decreased to 0.16 by the end of the experiment. The theoretical resultsfrom the software indicated an initial efficiency of 0.14, a peak efficiency of 0.2, and gradual decrease to 0.15 by the end of the experiment. These results, shown in Fig.16, show a strong alignment between the experimental and theoretical results for the open cycle in the solar collector.

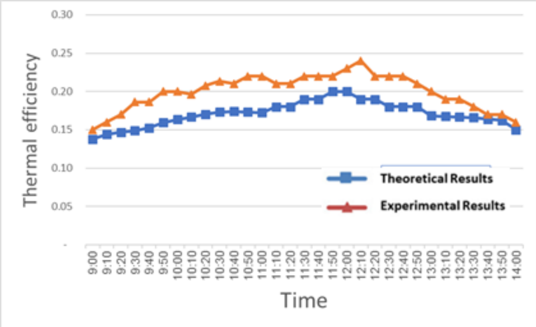

Fig.16. Theoretical and practical results of thermal efficiency with respect to time for the open cycle.

F. Intensity of the incident radiation

Solar radiation is an essential factor in both the experimental and theoretical results of the closed and open cycle system. The results indicated that as the intensity of solar radiation increased, the temperatures of the water leaving the solar collector increase.

For the closed cycle, the initial intensity of radiation was 1150 KJ/hr.m^2, rising to 1900 KJ/hr.m^{2}by the end of measuring period. The peak intensity was 2480 KJ/hr.m^2 at 12:30. In the theoretical model. the radiation intensity started at 1334 KJ/hr.m^2 and ended at2170 KJ/hr.m^2, witha peak of 2670 KJ/hr.m^2 at 12:30, as shown in Fig. 17.

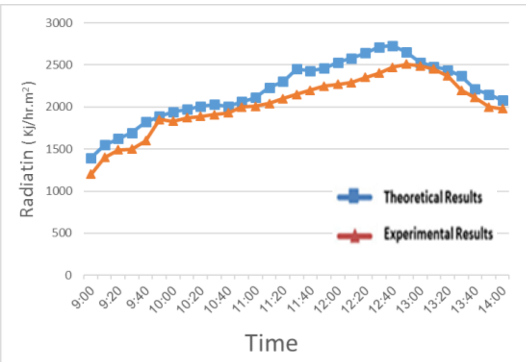

Fig.17. Theoretical and experimental results of incident radiation with respect to time for the closed cycle.

The experiment was repeated for the open cycle, and both experimental and theoretical results showed an excellent agreement. Initially, the radiation intensity in the programwas 1200 KJ/hr.m^2, which increased to 2510 KJ/hr.m^2 by the end of the readings, as illustrated in Fig. 18.

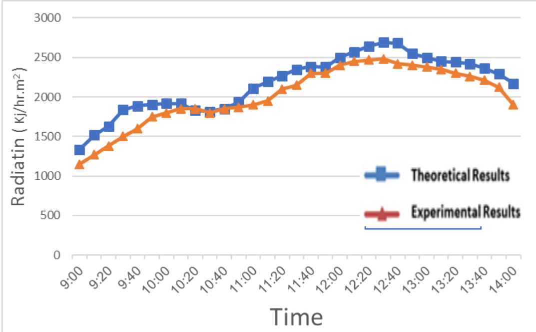

Fig.18. Theoretical and experimental results of incident radiation over time for the open cycle

5.CONCLUSION

The study of the closed cycle of the solar collector (PV/T) revealed a significant agreement between theoretical predictions and experimental results across various comparisons, including temperatures, radiation intensity, the energy output. Similarly, the open cycle of the solar collector showed a clear aligment between theoretical predictions from the TRNSYS software and the experimental results. The presented study confirms that the accuracy of the TRNSYS program data with an acceptable margin of error. It highlights how the software benefits researchers in renewable energy fieldby offering dependable analysis and simulation tools to design and optimize systems, thus saving time, effort and cost**.**

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دراسة عملية و نظرية لمجمع شمسي كهروضوئي حراري باستخدام برنامج TRNSYS في مدينة الموصل

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الملخص

تضمن البحث دراسة عملية ونظرية على مجمع شمسي كهروضوئي هجين للتحقق من صحة النتائج و المعطيات التي يوفرها برنامج المحاكاة المستخدم في البحث (TRNSYS) حيث تم تصميم و تنفيذ جهاز مجمع شمسي هجين عملي و محاكاته نظريا باستخدام برنامج (TRNSYS) و أجريت عملية مقارنة النتائج العملية و النظرية لكلا نظامي الدورة المغلقة و الدورة المفتوحة في أجواء مدينة الموصل في العراق حيث تم توجيه المجمع الشمسي باتجاه الجنوب و سجلت كافة البيانات للجهاز العملي بعد تشغيله و أظهرت النتائج للدورة المغلقة قيمة خطا بلغت 2.7% لدرجات حرارة خروج الماء من المجمع الشمسي و نسبة خطا 3.4 % لدرجة حرارة الماء داخل الخزان و كذلك نسبة خطا 4.3% لدرجة حرارة دخول الماء للمجمع الشمسي , اما بالنسبة للدورة المفتوحة فقد سجلت هامش خطا 2.8% بالنسبة لشدة الاشعاع الساقط و مقدار الخطا للكفاءة الحرارية للمجمع الشمسي بلغت 3% حيث لوحظ تقارب واضح للنتائج مما يؤكد على دقة المعطيات التي يوفرها البرنامج و إمكانية الاستناد الى معطياته في بناء منظومات نظرية أخرى و دراستها مما يوفر الوقت و الجهد و المال .

الكلمات الداله :

المجمع الشمسي الكهروضوئي، الطاقة الشمسية ، المجمع الشمسي الحراري ، الأداء الحراري ، المجمع الشمسي الهجين .