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EXPERIMENTAL INVESTIGATION OF USING THE GEOTHERMAL ENERGY FOR COOLING OF AIR SUPPLY INSTRUMENTS IN OIL FIELDS

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ABSTRACT

In This study an experimental investigation of a ground-air heat exchanger system for the cooling of air supply compressors in oil pipeline applications has been made. It's noteworthy that the air compressor holds significance as a vital component in the production process of oil and gas isolation stations. This equipment necessitates consistent and stable operating conditions for proper functionality. Any deviation from these conditions can result in the station coming to a halt, subsequently ceasing production. The primary aim of this study is to establish suitable operating conditions by generating ample cooling for this equipment. This system utilizes a 11.88-meter PVC pipe with a 2-inch diameter to transfer heat by passing air through it and which bured approximately 3.5 meters deep in the ground using the earth as a heat sink. The ground temperature formed relatively constant at around 30°C at a depth of 3 meters in Nassriyah city south of Iraq throughout the year. This consistency allows the ground to serve as an efficient heat sink, cooling the system during the summer and providing warmth in the winter. The results of the system, which was measured from the end of August 2023 to the end of September 2023, Clearly, in the early days of August, even with significantly elevated inlet temperatures in the system, the outlet temperatures persistently stay low. This is attributed to the soil temperature being 30°C, aiding in system cooling and consequent reduction of outlet temperatures, thereby ensuring efficient cooling performance, leading to an increased heat transfer rate. Remarkably, effective cooling is attained despite these challenging external conditions. This pattern highlights the system's effectiveness on hot days. Additionally, it was observed that the system consumed less electrical energy, emphasizing its energy efficiency.

Keywords: EAHE system, expermantel investigation, thermal of performance, parameters.

1. INTRODUCTION

Energy is widely acknowledged as the foundation of all human endeavors. From a broad perspective, energy plays a crucial role in fostering a nation's prosperity by actively contributing to the advancement of technology, industry, economy, and society as a whole. Lately, energy consumption levels have surpassed normal demand, necessitating careful attention through the adoption of energy-saving and management techniques. It has become imperative and urgent to explore alternative sources of energy, particularly clean energy, to replace conventional fuels and mitigate their adverse environmental effects.

Efforts to achieve indoor thermal comfort while minimizing energy consumption have become a significant concern and a formidable challenge for our society. Various passive measures are being employed to either replace or complement traditional air condition methods. One such alternative approach is the use of earth-air heat exchangers (EAHE). In an EAHE system, pipes are buried at a certain depth in the ground, allowing them to extract thermal energy from the soil for use in space air conditioning during both winter and summer seasons. The performance of EATHE systems has been subject to extensive research.

This study includes building experimental model for EAHE for purpose of cooling the mechanical equipment (compressor) within the Nasiriyah gas isolation station at Thi-Qar Oil Company. It is responsible for generating the required pressures using dry air. This is achieved by propelling air through a dedicated network of pipes towards the valves connected to various components, such as insulators, tanks, and pumps within the oil and gas isolation station. This system regulates the oil production process by ensuring that the equipment operates at the correct pressures, which is achieved automatically through signals transmitted by highly precise machinery devices The importance of this study lies in the vital role of air compressors and its needing for cooling in addition its location which lay far of electricity network, which make the providing of traditional cooling techniques very different, therefore using of this new technique will leads to saving the pumping components without consuming a lot of energy. It is important to highlight that the air compressor plays a crucial role in the production process of oil and gas isolation stations. This equipment relies on consistent and standardized operating conditions, and any deviation from these conditions can result in a halt in station operations, leading to a production shutdown. The primary objective of this study is to establish optimal operating conditions by implementing an innovative and environmentally friendly underground cooling system, known as EAHE. This system aims to generate effective cooling for the equipment, ensuring the continuous and efficient production process while minimizing costs.

Numerous academics have explored the integration of earth-to-air heat exchangers (EAHE) with buildings as an effective method for supplying passive energy to regulate the indoor environment within structures for different applications, such as:

A.A. Serageldin et al. (2016) [1] investigated the performance of an Earth-Air Heat Exchanger (EAHE) used for heating and cooling within the specific climate conditions of Egypt. Thier study encompasses experimental work to comprehend soil temperature profiles and the distribution of air temperature within a horizontal EAHE. In addition, it involves the development of a mathematical model based on one-dimensional, unsteady, and quasi-steady equations, which is then solved using MATLAB. Furthermore, a three-dimensional Computational Fluid Dynamics (CFD) ANSYS Fluent simulation model is created to predict both air and soil temperatures.

The research also conducts a thorough parametric analysis, exploring the influence of various factors such as pipe diameter, material, spacing, length, and fluid velocity on air temperature. The findings reveal that these parameters significantly impact the outlet air temperature, with alterations in pipe diameter, length, spacing, and material leading to diverse effects. Additionally, fluid velocity is identified as a factor causing fluctuations in outlet air temperature.

M. Khabbaza et al. (2016) [2] studied, both through numerical analysis and experimental investigation, explored a ground-to-air heat exchanger system implemented in an apartment building located in a predominantly hot city climate. This terrestrial heat exchanger configuration comprised three PVC pipes, each extending 72 meters in length and possessing a diameter of 15 centimeters. These pipes were strategically buried at varying depths within the ground, ranging from 2.2 to 3.2 meters.

During thier experimentation, it was observed that the incoming air temperature, when directed into the building, remained at approximately 25 degrees Celsius, despite the external temperature soaring to 40 degrees Celsius. The optimal pipe lengths for this setup were determined to be approximately 20 meters and 70 meters, respectively. These lengths were chosen to effectively moderate the annual and daily temperature fluctuations.

They utilization of TRNSYS Simulation in the analysis revealed that the Earth-Air Heat Exchanger (EAHX) system had the capability to reduce the maximum air temperatures to 19.5 degrees Celsius and 18.3 degrees Celsius in the respective scenarios.

M. I. Hasan and S. W. Noori (2018) [3] conducted a numerical investigation into several parameters, including the impact of wall thickness and pipe material on the Coefficient of Performance (COP) of the Earth-Air Heat Exchanger (EAHE) system. Thier study focused on two distinct materials, namely steel and PVC, and considered three different thicknesses: 2 mm, 3 mm, and 6 mm.

Upon successfully validating the model, the performance of the EAHE system was assessed using a standardized pipe length of 50 meters and a pipe diameter of 0.1016 meters. Various ranges of air velocity and inlet temperatures were examined as part of the analysis. They findings revealed that the thermal efficiency of the steel material was relatively low, rendering it insignificant when compared to other materials, especially in consideration of its cost-effectiveness

M. I. Hasan and S. W. Noori (2019) [4] Numerically investigated methods to decrease energy consumption in a building equipped with an Earth-Air Heat Exchanger (EAHE) system. Thier study examined three distinct systems:

The first system comprised a single EAHE layer buried at a depth of 3 meters in the house garden. The second system involved two EAHE layers buried at different depths, specifically 3 meters and 4 meters. The third system featured a single EAHE layer buried at a depth of 3 meters, covering the entire house area.

Thier research findings revealed that the second system, with its dual-layer configuration, yielded significant electricity cost savings over the course of a year, amounting to 376,329 Iraqi Dinars (equivalent to $301.11).

G. Mihalakakou. et al. (1992) [5] analysed encompasses seventy-four years' worth of ground temperature measurements conducted at different depths at the National Observatory of Athens. Precise yet straightforward models have been created to forecast the yearly fluctuations in surface ground temperature as well as temperature at various depths below the Earth's surface. Additionally, algorithms have been formulated to predict the daily temperature variations at the ground surface. They findings of this comprehensive analysis are then compared with corresponding data from other established datasets.

Thier comprehensive analysis proves valuable for predicting the performance of buildings directly in contact with the ground, as well as for estimating the efficiency of Earth-Air Heat Exchangers

A. Mathur et al. (2016) [6] performanced numerical simulations, thier research examined the Coefficient of Performance (COP) of the Earth-Air Tunnel Heat Exchanger (EATHE) system in Jaipur city during summer operations and assessed the extent of soil degradation. It was observed that a significant challenge in operating the EATHE system is the soil's low moisture content and high specific heat, which leads to the buildup of heat around the pipes. They study's findings indicated that soil reaching thermal saturation by the end of the summer season may result in unusual performance for the subsequent summer. The COP values for various operation modes, including summer with night purging, summer, winter, and night winter day, were recorded at 3.68, 4.23, 6.65, and 5.01, respectively

V. Bansal et al. (2009) [7] Numerically investigated the cooling load of buildings in Ajmer city, located in Western India, during the summer season using an Earth-Pipe-Air Heat Exchanger (EPAHE) system. Thier model was developed using the FLUENT program. studied examined the impact of key operating parameters, specifically air velocity and pipe material, on the thermal efficiency of the EPAHE system. They analysis was conducted over a length of 23.42 meters, resulting in a cooling range of 8.0 to 12.78 degrees Celsius. They findings demonstrated that the Coefficient of Performance (COP) of the EPAHE system varied between 1.9 and 2.9 as the air velocity ranged from 2.0 to 5.0 meters per second.

Esena Mehmet, Yukselb Tahsin (2013) [8] Thier research focuses on testing the effectiveness of biogas, solar energy, and ground energy for greenhouse heating in the specific climate conditions of Elazig, Turkey. To assess their viability, a greenhouse measuring 6m x 4m x 2.10m was constructed and its heating requirements were determined. studied involved designing and installing a greenhouse heating system called BSGSHPGHS, which utilized biogas, solar, and a ground source heat pump with a horizontal slinky ground heat exchanger. Their Experiments were carried out extensively from November 2009 to March 2010. Throughout thier experiments, the biogas system produced 2231.83 liters of gas. The growth of various plants in the greenhouse necessitated a temperature of 23°C, and thier systems effectively achieved this target. Consequently, thier research demonstrates the successful utilization of diverse energy sources for greenhouse heating.

The heating capacity of a single buried pipe using actual climatic data performed by **Mihalakakou G. (2003) [9]**. The adoption of buried pipes in buildings for both heating and cooling purposes has seen a growing trend in recent years. To calculate thier system's heating potential, a precise and dynamic deterministic numerical model was employed. Multi-year climatic data for both ambient air and soil conditions in Athens served as inputs for thier deterministic model, and the outcomes were compared. Additionally, a neural network approach was utilized to estimate the system's thermal performance for heating in Athens. Furthermore, thier study delves into the analysis of various climatic factors, such as ambient air temperature, ground temperature, and relative humidity, which were used as inputs to the neural model to assess their impact on system performance.

Zonghe Zheng, et al. (2011)) [10] addressed the issue of underground vertical U-tube heat exchangers within ground source heat pump systems at the Shenchi station of the Shuohuang railway. To tackle thier problem, a transient heat transfer physical and mathematical model for the soil and borehole temperature field is developed. MATLAB software is used to perform finite element numerical simulations. Through numerical simulations, thier research analyzes soil temperature, maps the distribution of isotherms around the pipes, and assesses the extent of heat transfer, providing a clear visual of the heat transfer performance around the pipes. Thier paper utilizes the model and numerical solutions to investigate changes in the temperature field in various scenarios, including geological conditions, operating modes, layout, pipe depth, and pipe coupling intervals. Thier findings offer valuable insights to aid in the engineering design of ground heat exchangers.

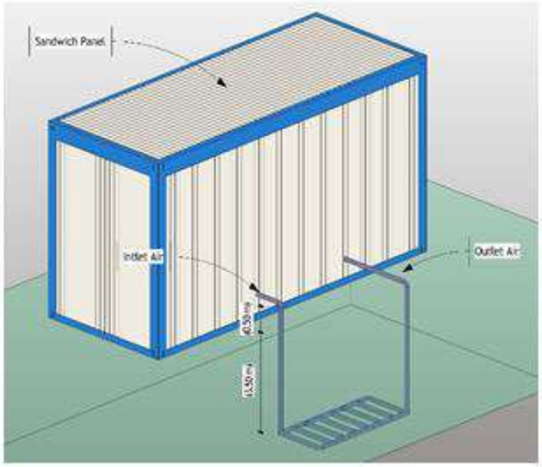
In this paper the EAHE technique will be investigated experimentally for cooling of air compressor in oil pipe lines which lay in arid regions far of electricity network.

2. Problem Description:

This paper employs an experimental approach to investigate the problem described below. The experiment involved utilizing the ground as a heat sink for. A novel design was implemented for EAHE based on specific soil properties, with the EAHE buried at a depth of 3.5 m, as illustrated in Figure (1). The EAHE consisted of an 11.88 m-long PVC pipe with a 2 in diameter, as depicted in Figure (2).

To facilitate the experiment, a test room was constructed with dimensions of 1.75 m in width, 2.40 m in length, and 0.8 m in height (W * L * H), as shown in Figure (3). The fan was connected to the ground-air heat exchanger, as indicated in Figure (4). Pressure gauges were installed at the inlet and outlet of the ground loop EAHE to measure the pressure. Thermocouples were affixed to the PVC pipe at the inlet and outlet of the EAHE. A flow meter was used to determine the air flow speed from the ground-air heat exchanger.

Inside the test room, a single thermocouple was employed to monitor the temperature, as displayed in Figure (5). The experimental setup's schematic diagram revealed ten sensors buried vertically in the ground to measure the earth's temperature. The sensors were positioned with a 30 cm spacing between them, as shown in Figure (6). The earth's temperature was measured and found to be constant after a depth of 3.5 m and was found to be 30 C°. All thermocouples readings were logged using a data logger, as depicted in Figure (7). The experiments were conducted during daytime hours (8:00 AM. to 2:00 PM.) on various days from late August 2023 to the end of September 2023.

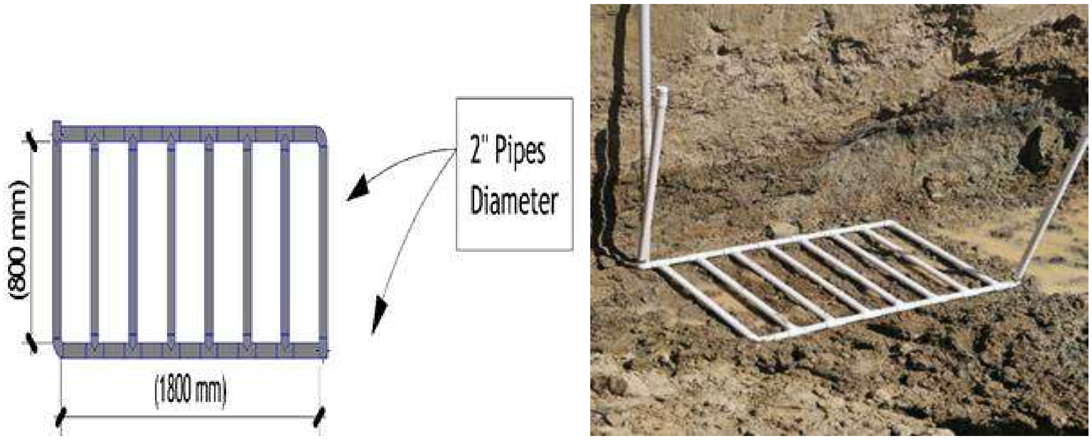


a. Schematic figure of the (EAHE).

b. Photo for test room.

c. Excavation work. **d.** Hall.

Fig. (1): Work of excavation in the ground at depth of 3.5 m.



a. Schematic for heat exchanger. **b.** Photo for heat exchanger.

Fig. (2): Design and Burial the EAHE System inside the hole with a diameter of 2 in.

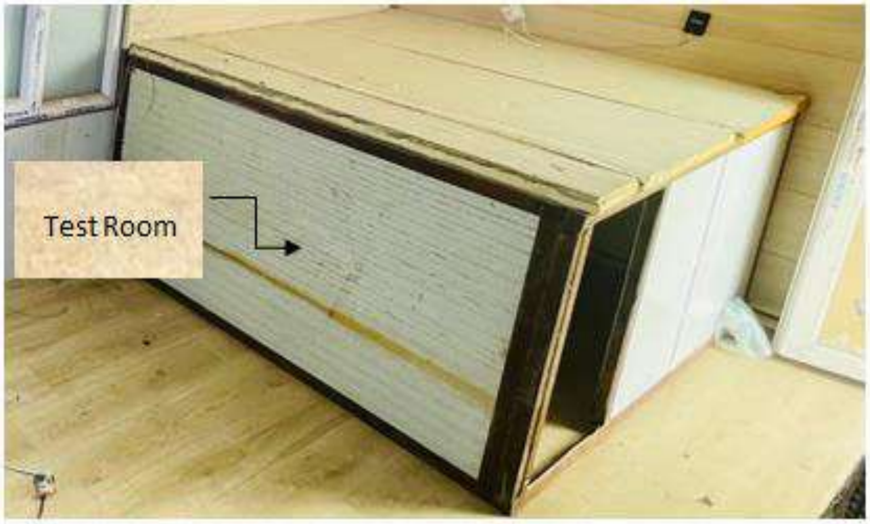


Fig. (3): Test Room built for experiments.

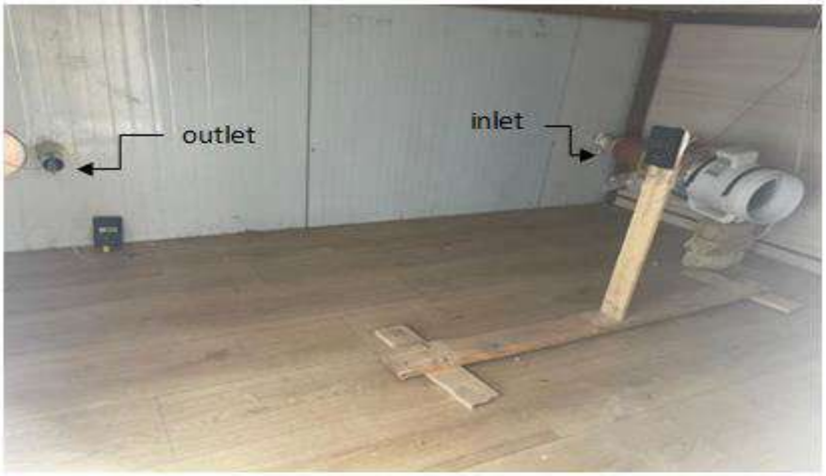


Fig. (4): The fan connected to the ground-air heat exchanger.

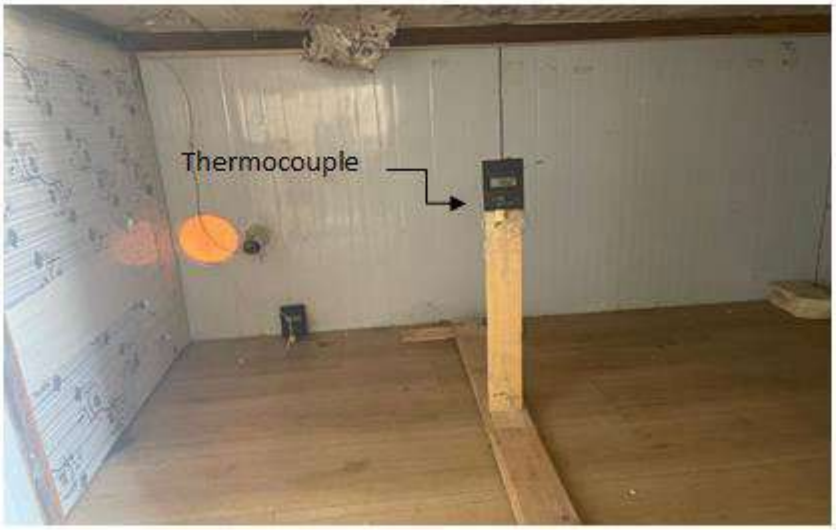
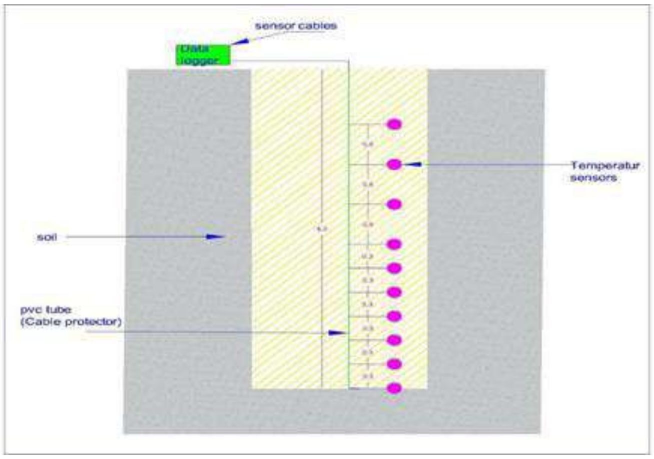


Fig. (5): a single thermocouple employed to monitor the inside temperature.



a. schematic for Thermocouple.

b. Thermocouple installation.

Fig. (6): Schematic diagram revealed ten sensors buried vertically in the ground to measure the earth's temperature.

Fig. (7): The data logger used in the experiment

3. Experimental Procedure and Equipment's:

The following of the equipment's are used in the experiments:

1. **Test Room:** This is a scaled-down model constructed from Sandwich panel material, known for its excellent heat-insulating properties. The room dimensions (2.40 * 1.75 * 0.8) m and includes a small door.

2. **PVC Pipes:** These pipes, with a length of approximately 11.88 m and a 2-in diameter, were buried underground.

3. **Thermocouples:** K-type thermocouples were employed for temperature measurements. There was a single thermocouple located in the middle of the test room, while another set of thermocouples were used to measure the temperature at the inlet and outlet of the PVC pipes.

4. **Data Logger:** An electronic device equipped with eight channels was utilized to record temperatures. The model used was S220-T8 and a temperature range of (-200 C° to +1800 C°). This device was used to measure temperature gradients in the earth.

5. **Flow Meter:** This instrument served to measure the airflow speed from the fan and at the outlet of the PVC pipes.
6. **Pressure Gauges:** These gauges were deployed to assess the pressure within the Earth Air Heat Exchanger (EAHE), both at the inlet and outlet of the ground-air heat exchanger.

3. Mathematical Modeling:

The subsequent equations are employed to assess the performance parameters of used systems. The calculation of heat transfer for the air delivered to the space is carried out in the following manner:

air flow area of the air PVC pipe supply opening (m^2) can be calculated for:

$$A= (\pi/4) (D)^2 \qquad \text{------ (1)}$$

D : is the diameter of PVC pipe

$$\dot{m}_{air} = \rho AV \qquad \text{------ (2)}$$

where: ρ is density of the air (kg/m^3).

V is velocity of the air (m/s)

Heat absorbed by EAHE calculated by:

$$Q_{air} = \dot{m}_{air} CP_{air} (Tin – To) \qquad \text{------ (3)}$$

where:

Tin is the inlet temperature to the EAHE.

To is the temperature outlet from EAHE.

The following factor (COP) will be used to measure the overall performance of EAHE.

$$COP = Q / P.P \qquad \text{----- (4)}$$

Where:

P.P is the pumping power and calculated from:

$$P.P = \Delta P \dot{V} \qquad \text{------ (5)}$$

To compute the pressure drop using the following equation:

$$\Delta P = Pin - Pout \qquad \text{------ (6)}$$

To compute the volumetric flow rate $\dot{V}$ is:

$$\dot{V} = AV \qquad \text{------ (7)}$$

5. RESULT AND DISCUSSION:

5.1 Verification:

To assess the reliability of the experimental model, has been conducted a comparison between the numerical findings and the experimental data, illustrated in **Figure 8. Figure 8** presents the contrast between the experimental and numerical outcomes for the outlet air temperature and changing air velocity, while maintaining a constant entry temperature using the ANSYS System. This figure clearly demonstrates a close alignment between the results, with a average percentage error of (7) %, indicating their acceptability.

Figures 9 and 10 depict the temperature variations (ambient temperature, outlet air temperature from the EAHE system and air temperature difference (ΔT=Ti-To)) over several days, spanning from August 20, 2023, to September 30, 2023. Readings were recorded on different days during this time frame. It's evident from the figures that the outlet temperature and difference temperature remains relatively constant throughout this period, with minimal day-to-day fluctuations.

Furthermore, the outlet air temperatures from the system are consistently lower than the ambient temperature and the temperature different ($\Delta T=Ti-To$) is hight. This is a result of the cooling process, which effectively dissipates heat from the room. Notably, the test room is exposed to direct sunlight, leading to rapid heat exchange. In areas where there is a substantial temperature differential between the air and the room, the efficiency of the EAHE system is notably improved. By leveraging the ground for cooling, this system provides a more comfortable indoor environment, ultimately resulting in lower room temperatures.

Figures 11 and 12 illustrate the fluctuation in outlet air temperatures achieved from the HAHE system from August 20, 2023, to September 30, 2023 and temperature different for same velocity (V= 4.52 m/s). It is evident from **Fig. 11** that temperatures vary day by day, with an initial rise during the hottest days due ambient temperature is high. The highest recorded outlet air temperature, occurring on August 21, 2023, is 36.1 C°, while the lowest is observed on September 30, 2023, at 33.1 C°. Additionally, the figure demonstrates the impact of inlet air temperatures on the outlet air temperature throughout these days. It is apparent that, as the days progress, the outlet air temperature gradually cools, benefiting from the decreasing the ambient temperature as a results decreasing the space temperature. While **Fig. 12** reveals the correlation between temperature variations on different days in August and September. On August 20th, a significant temperature difference is observed during the day, primarily due to a high initial temperature. Subsequently, on August 21 and 22, the temperature difference decreases, becoming lower than that of August 20. However, starting on August 23, the temperature differences begin to increase, eventually reaching their peak for the entire months of August and September. This upward trend reverses, leading to a decline in temperature variations until they reach their lowest point on August 31st. This decline is driven by the entry temperature decreasing and the exit temperature being influenced by exchanges through the pipe and soil by the end of August. The temperature variations then resume alternating between rising and falling, driven by differences in air temperature and the resulting heat exchange between the pipe and soil, which aids in cooling the air leaving the system.

Figures 13 and 14 reveal the variation in outlet temperatures and temperature difference at different hours of the day throughout August and September. Readings were taken at three-hours intervals, starting from 9:00 AM and concluding at 1:00 PM. Notably from **Fig. 13** the highest outlet temperature occurred on August 23, persisting throughout the entire day, while the lowest outlet temperature was registered on September 30. This temperature pattern corresponds to the hours of the day, as August 23 experienced extremely high ambient temperatures, reaching 51.6 C°, which subsequently resulted in an inlet temperature of 50.9 C°. Consequently, the outlet temperature was limited in cooling and remained at 35.4 C° due to the elevated inlet temperature, reduces efficient heat exchange between the pipe and the soil. Conversely, on September 30, the ambient temperature was 42.8 C°, and the inlet temperature was 40.7 C°, making it lower than August 23. As a result, the heat exchange system's outlet air temperature reached its lowest point at 33.1 C° during the months of August and September, primarily due to the lower inlet temperature. This temperature trend is distinctly observable from August 23 onwards.

It's evident that on August 23 and 24, the daytime temperatures reach their peak, while on the subsequent days, there's a gradual decrease in heat. However, by 1:00 PM, we observe a minimal temperature change across all days, mainly because of the persistently warm ambient temperatures during the afternoon. and **Fig. 14** depicting temperature difference variations over time, specifically between the months of August and September, has been observed changes occurring every two hours from 9:00 AM to 1:00 PM. The most significant temperature difference was recorded on August 23, during the daylight hours from 9:00 AM to 1:00 PM. It steadily increased during this timeframe, peaking at 1:00 PM, primarily due to the elevated initial temperature during the day.

Subsequently, a decline in temperature differences was witnessed at the 9th hour for all days, hitting its lowest point on September 29. However, from September 30 onwards, there was a resurgence in temperature differences.

This can be attributed to the lower entry temperature and heat exchange between the pipe and the soil, which contributed to reducing the exit temperature and, consequently, the air temperature difference.

Notably, at 11:00 PM and 1:00 PM, there were alternating temperature differences, though these values were higher compared to those at 9:00 AM. This can be attributed to the sun's high temperatures, which led to an increase in ambient temperatures and, subsequently, the entry temperature. This rise inhibited effective heat exchange between the pipe and the soil, making it challenging to cool the exit temperature during these hours.

Figure 15 unveils the relationship between heat transfer rates with various days throughout August and September. On August 20th, a substantial heat transfer rate is evident during the day, primarily due to a notable temperature difference. This rate of heat transfer is solely influenced by the entry and exit temperatures of the heat exchanger system, thanks to a consistent airspeed.

Subsequently, on August 21 and 22, the heat transfer rate declines, falling below the levels observed on August 20. However, on August 23 day, the heat transfer rate embarks on an ascending trajectory, reaching its zenith in 23 day. This upward trend subsequently reverses, resulting in a reduction in heat transfer rates until they reach their lowest point on August 31st.

This decline can be attributed to the diminishing entry temperature, with the exit temperature affected by interactions within the pipe and soil. This leads to a diminished temperature difference by the conclusion of August. The heat transfer rates then resume an oscillating pattern, characterized by fluctuations between increases and decreases. These fluctuations are driven by disparities in air temperature and the resulting heat exchange between the pipe and soil, contributing to the cooling of the air as it exits the system.

Figure 16 illustrates the relation between the heat transfer rate at three-hours intervals from 9:00 AM. to 1:00 PM. on different days in August and September. Notably, on August 23, the heat transfer rate remains consistently high throughout all these hours, peaking at 0.18 KW. This peak is primarily attributed to the substantial temperature differential, which hinders heat dissipation. The exchange of heat between the pipe and the soil is minimal during this time. On the remaining days, at 9 AM., the heat transfer rate is relatively low, which is advantageous for the heat exchanger system. This is due to the limited heat release within the system, particularly noticeable on September 29, when it reaches a low of 0.013 KW. In contrast, at 11 AM. and 1 PM., the heat transfer rate is significantly compared to 9 AM. This is mainly due to the elevated afternoon temperatures, which the rate of heat transfer through the system.

Figures 17and 18 it has been becomed apparent that from August 20th to August 23rd, the pressure drop pumping power remains minimal. This is because these days experience exceptionally high temperatures, resulting in a lower internal pressure and the pumping power remains consistently low, primarily attributable to a minimal pressure drop. The pumping power is notably influenced by both air velocity and pressure drop, with air velocity remaining constant, and changes in pumping power primarily arising from fluctuations in pressure within the system. It's important to note that the relationship between pressure and temperature is inversely proportional during this period (P=mRT) from a geographical standpoint, the hotter the weather, the lower the pressure due to the separation of air molecules. Subsequently, the pressure drop and pumping power begins to ascend until it reaches its peak on August 28th. Following this peak, it stabilizes, maintaining relatively consistent levels until approximately September 14th, with the highest recorded pressure drop value at (203 Pa). Afterward, there is a slight decrease in the pressure drop and pumping power, which is then followed by another increase, reaching its highest point by September 30th.

Figures 19 and 20 discern fluctuations in pressure and pumping power on different days in the months of August and September, specifically during selected hours of the day. The pressure drop and pumping power are measured at three-hours intervals, starting from 9:00 AM to 1:00 PM on each day. On August 23 and 24, it becomes evident that the pressure drop and pumping power are relatively modest when compared to the other days, except for 1:00 PM on the 24th, when the pressure drop is considerably higher due to the elevated daytime temperatures.

Consequently, the pressure drop within the system remains low during these two days. In contrast, the pumping power is low because it depends on the pressure drop. then the pressure drop and pumping power during the remaining days registers as higher during these specific hours, with the highest pressure drop observed at 9:00 PM all the days. This is primarily due to the cooler daytime temperatures at that hour.

Figure 21 illustrates the variation of performance factor of the ground heat exchanger system for individual days in the months of August and September. It's noteworthy that the pattern of this diagram closely mirrors that of the heat transfer rate showed in Fig. 15, This is because the performance factor and the rate of heat transfer have a direct relationship. The peak performance factor is observed on August 23, which can be attributed to the significantly high air temperature of the entering the system, even though the air temperature of the leaving the system remains favorable. Subsequently, the performance factor gradually decreases, reaching its nadir on August 31, as a consequence of the low air temperature of the entering the system and a substantial pressure drop.

Figure 22 presents the performance factor data for various hours of the day, covering the months of August and September. Measurements are taken every two hours, commencing at 9:00 AM and extending until 1:00 PM. It's evident from this chart that on August 23, the performance factor consistently reaches its peak across all hours of the day, with its highest value registered at 1:00 PM. Additionally, has been observed on August 24 that the performance factor starts at a low point at 9:00 AM, gradually rises at 11:00 AM, and then declines at 1:00 PM. This fluctuation can be attributed to the elevated temperature at 11:00 AM and the subsequent drop in pressure.

For the remaining days, the performance factor exhibits a gradual ebb and flow, with minor fluctuations throughout the day. Notably, the lowest performance factor is consistently observed at 9:00 AM on September 29. This can be linked to the cold inlet temperature into the system and a concurrent high-pressure drop, with 9:00 AM emerging as the consistent time for the lowest performance factor across nearly all days.

6. CONCLUSIONS:

In this paper, a prototype of a compact geothermal air exchanger was developed to serve as a cooling system for an air supply compressors. The experimentation was conducted within of the Thi - Qar Oil Company in southern Iraq, yielding the subsequent findings:

1. Here the focus is on the performance of the heat exchanger, represented by the outlet temperature and heat transfer increasing as the ambient temperature increases. Thus, the performance is directly proportional to the need for cooling, which makes it a suitable solution for cooling compressors in hot weather.
2. In early August, despite elevated inlet temperatures, the outlet temperatures in the system remained low. This was attributed to the soil temperature of 30°C, effectively cooling the system and sustaining favorable outlet temperatures throughout August and September. This condition facilitated efficient cooling of compressed air during this period
3. The Heat Transfer rate of the heat exchanger shows initial days with significantly elevated ambient temperatures, the system's inlet temp is correspondingly high, resulting in a heightened Heat Transfer rate. Surprisingly, effective cooling is still achieved despite these extreme external conditions. However, on the subsequent days, as the ambient temp decreases, the system attains even more efficient cooling capabilities
4. As the ambient temperature rises, it consequently elevates the system's inlet temperature, resulting in a minimal pressure drop during the initial days of August. Conversely, as the ambient temperature gradually decreases in the subsequent days of the two months, it causes a rise in pressure within the system.
5. In early August, there is a surge in heat transfer rate and a decrease in pressure drop, leading to an increased performance factor. However, in the following days of August and September, as the heat transfer rate decreases and pressure drop increases, the performance factor slightly reduces. This trend highlights the system's effectiveness on days with elevated temperatures.

Nomenclature

A	The air flow area of the PVC pipe (m^2)
$m^{\cdot}$	air Flow Rate of the air (m^3 /s)
ρ	Density of the air (m^3 /kg)
V	The air velocity is directly measured by the air flow meter (m/s)
Q_{air}	Heat transfer rate of air (KW)
Cp_{air}	constant specific heat of the air (J/kg. K)
Tin	The inlet temperature to the EAHE system (K°)
To	The outlet temperature inside the EAHE system (K°)
T_{room}	The air temperature inside the test room (K°)
Δp	The pressure drop of the EAHE system
COP	Performance factor for the ground air heat exchanger (EAHE).

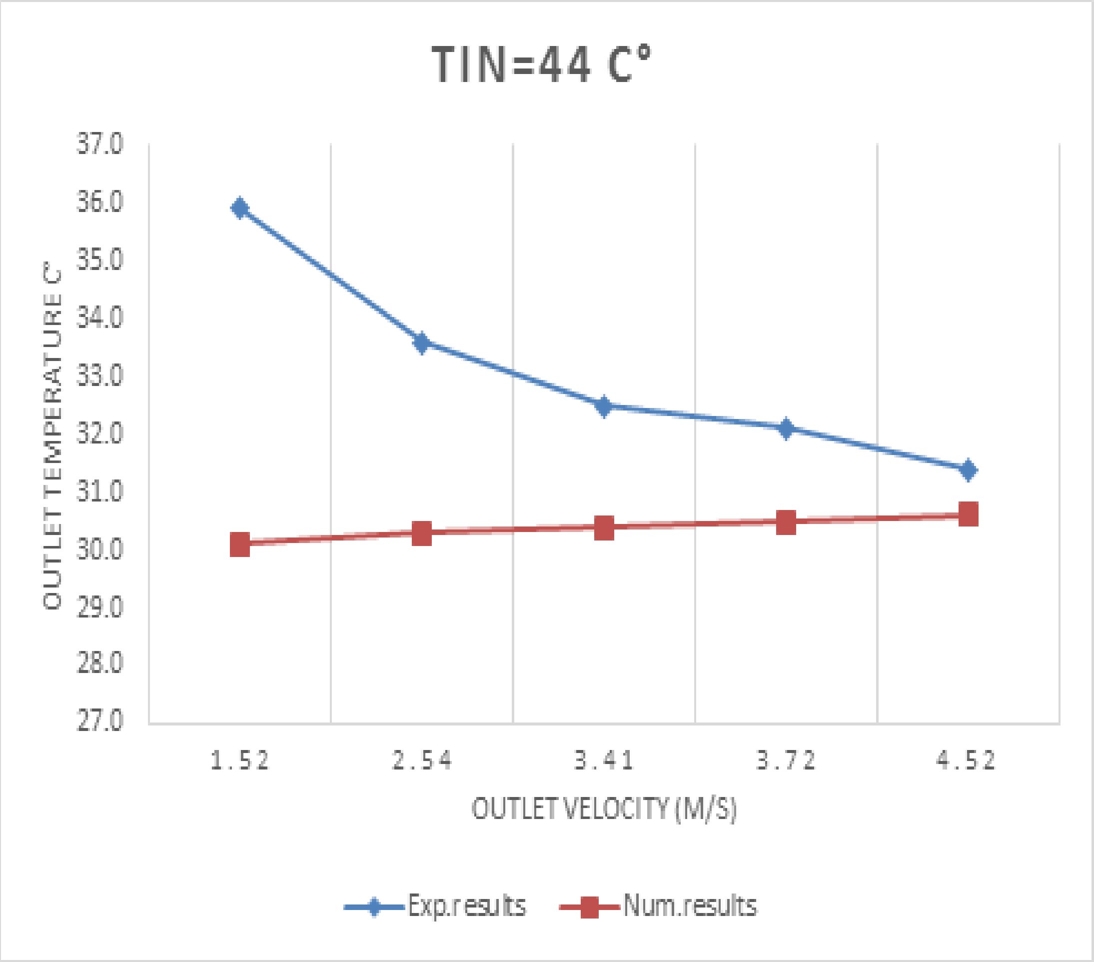


Fig. 8: variation of Outlet Temperature with Outlet Velocity at 27/8/2023.

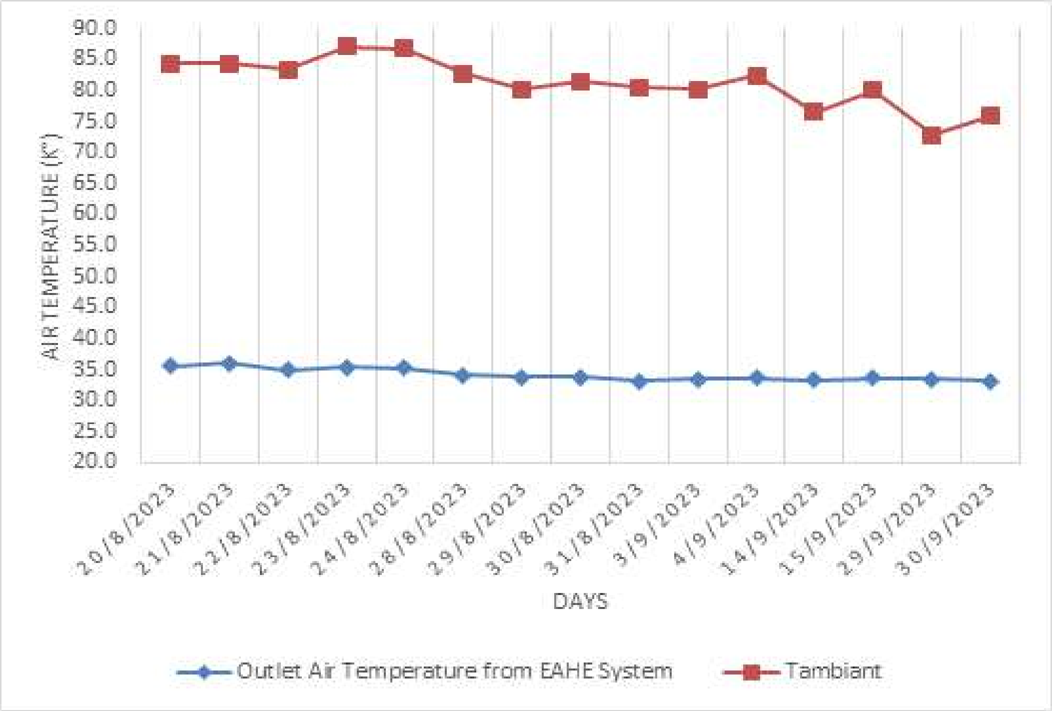


Fig. 9: variation of Outlet Air Temperature and ambient temperature with Days for EAHE system.

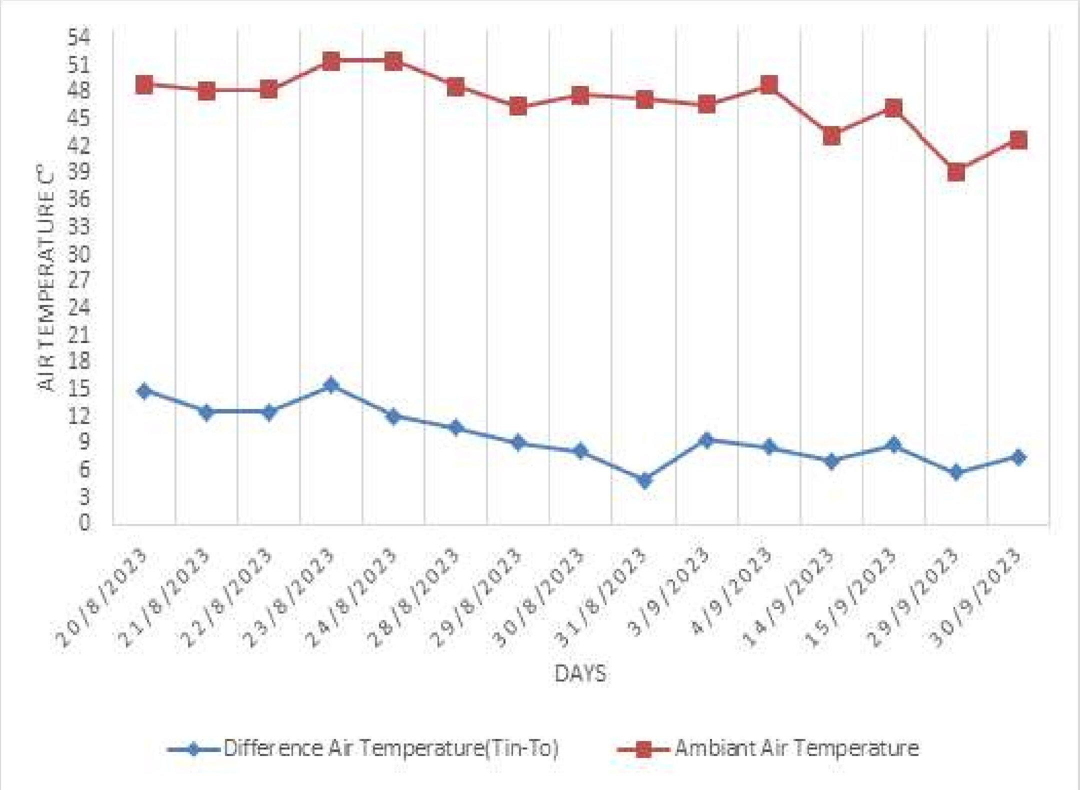


Fig. 10: variation of Difference Air Temperature and ambient temperature with Days for EAHE system.

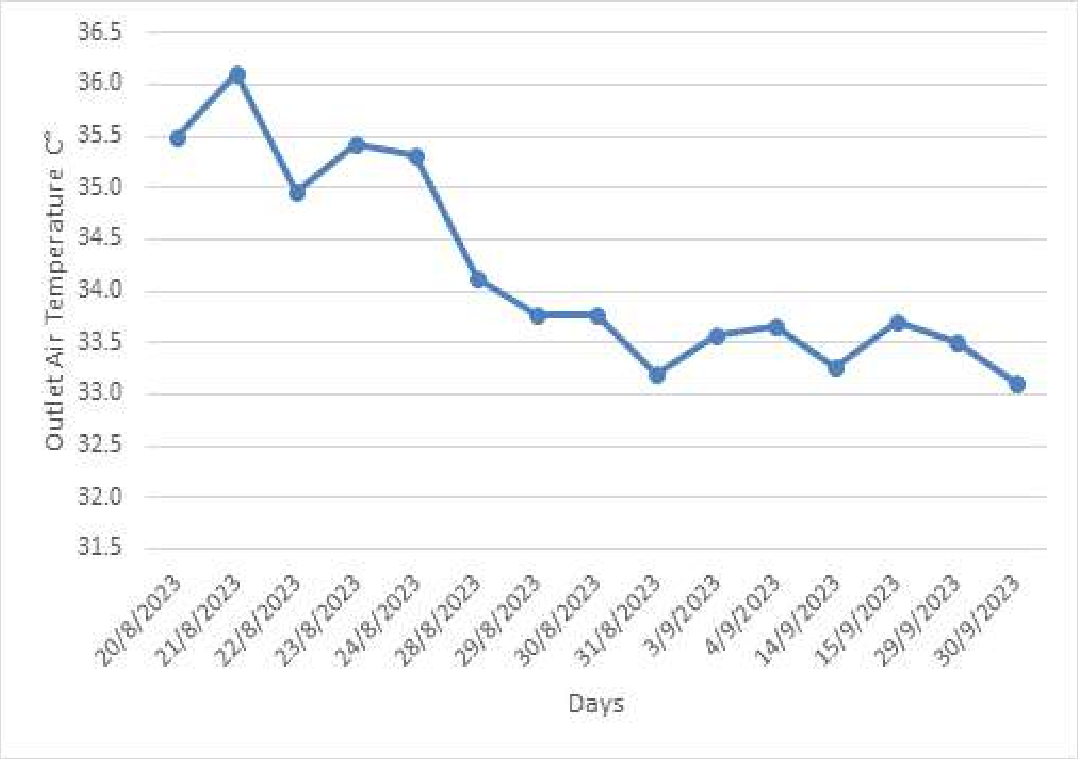


Fig. 11: variation of Outlet Air Temperature C° with selected Days for EAHE system.

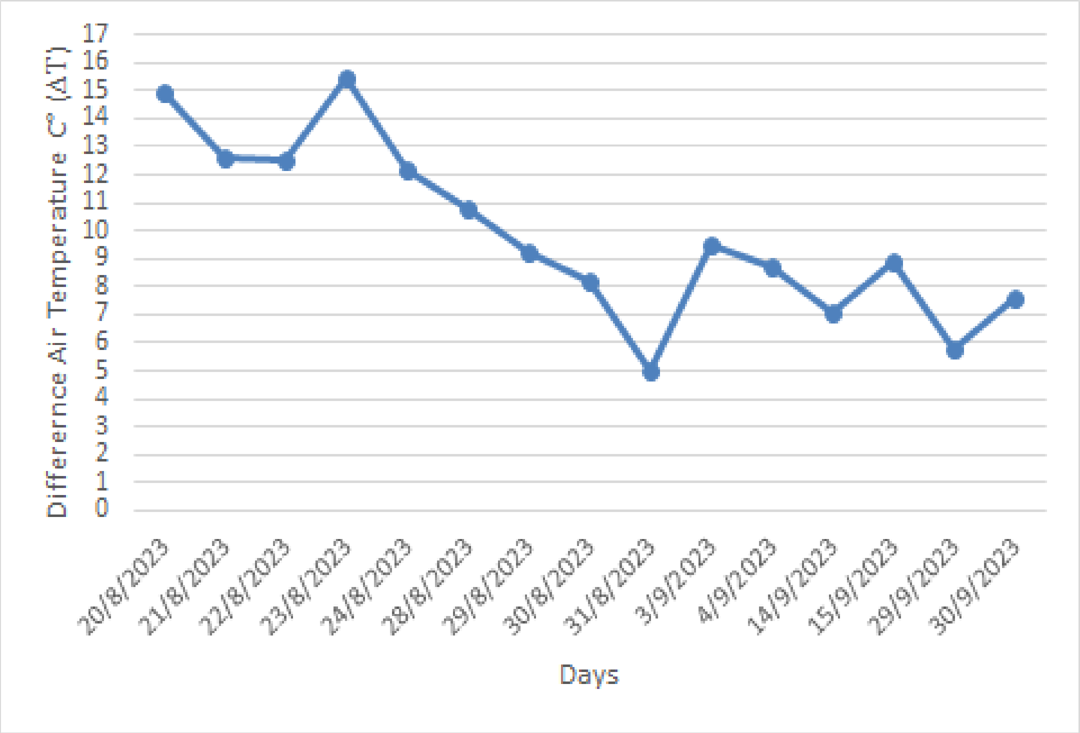


Fig. 12: variation of Difference Air Temperature (C°) with The Days for EAHE system.

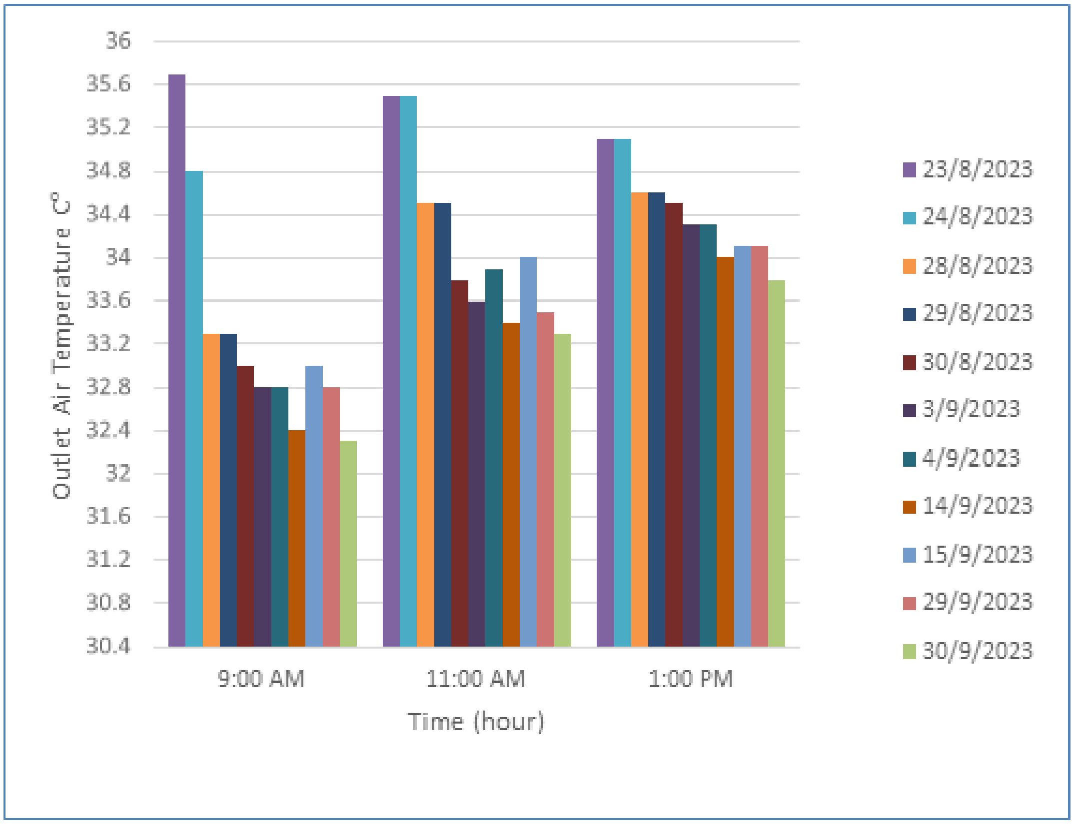


Fig. 13: variation of Outlet Air Temperature (C°) with The Time (hour) for EAHE system.

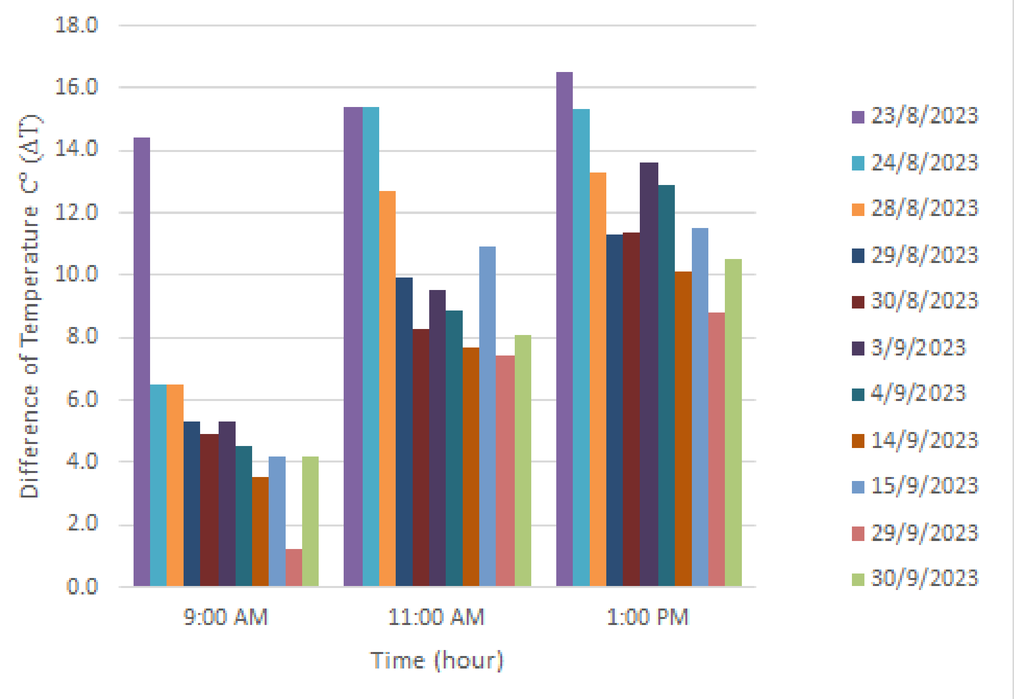


Fig 14: variation of Difference Air Temperature (C°) with The Time (hour) for EAHE system.

Fig. 15: variation of Heat Transfer Rate (KW) with The Days for EAHE system.

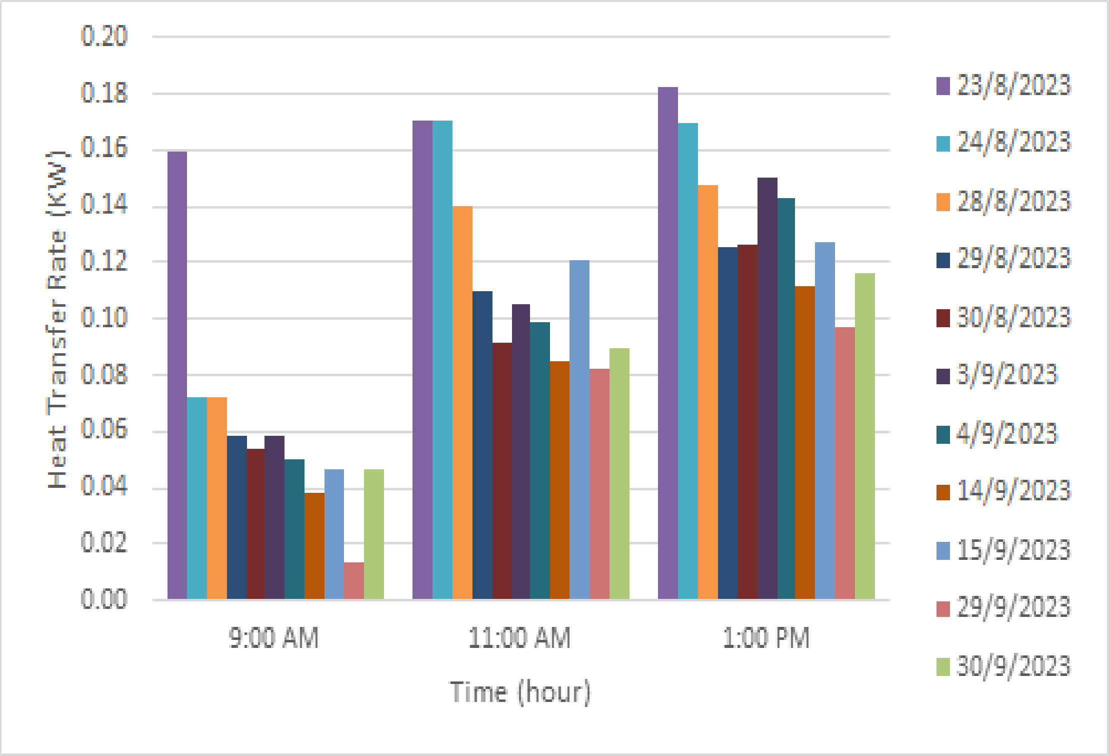


Fig. 16: variation of Heat Transfer Rate (KW) with The Time (hour) for EAHE system.

Fig. 17: variation of Pressure Drop (pa) with The Days for EAHE system.

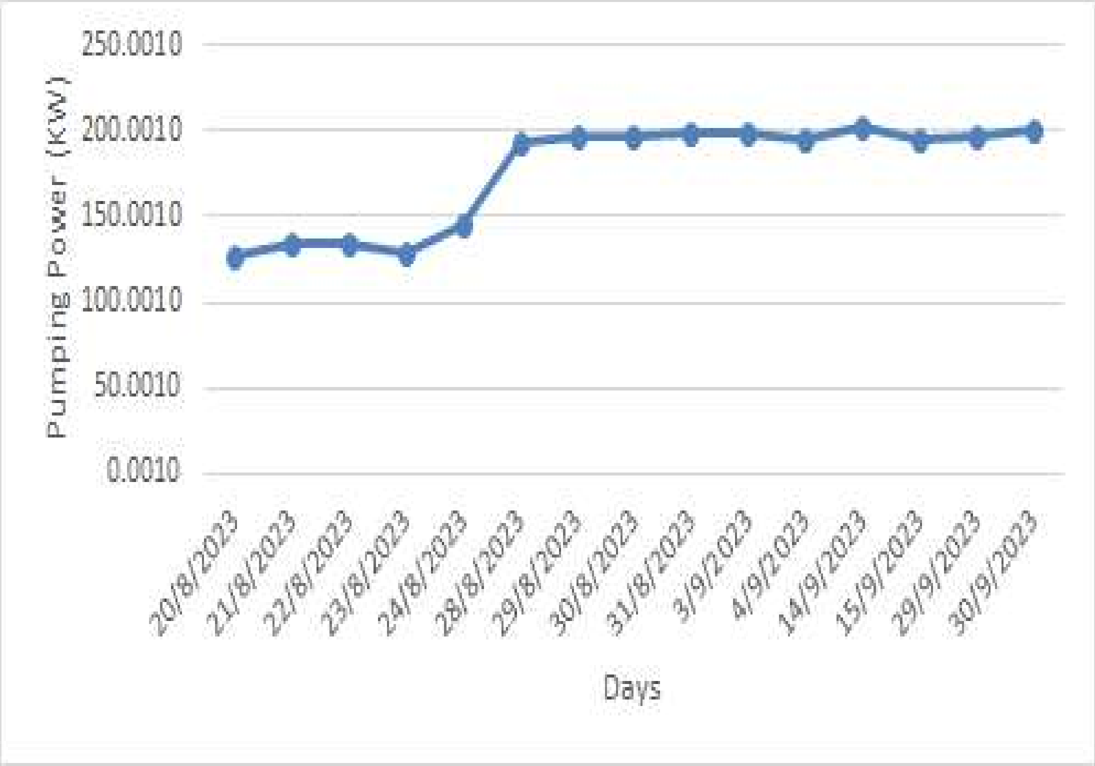


Fig. 18: variation of Pumping Power (KW) with The Days for EAHE system.

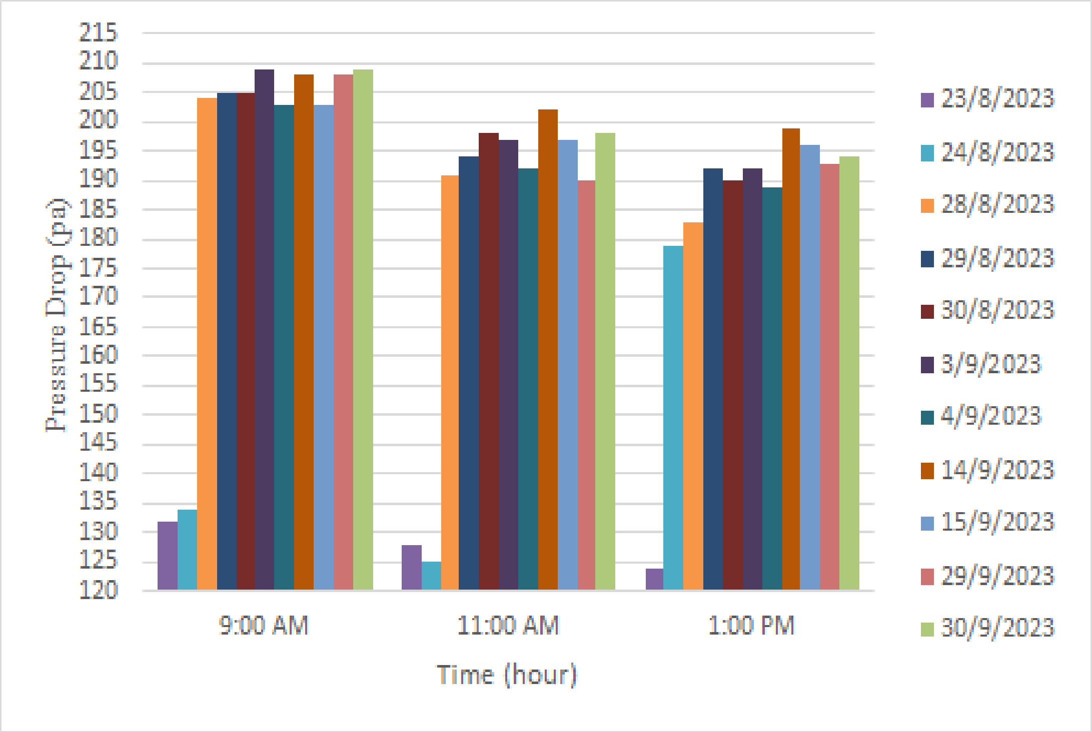


Fig. 19: variation of Pressure Drop (pa) with The Time (hour) for EAHE system.

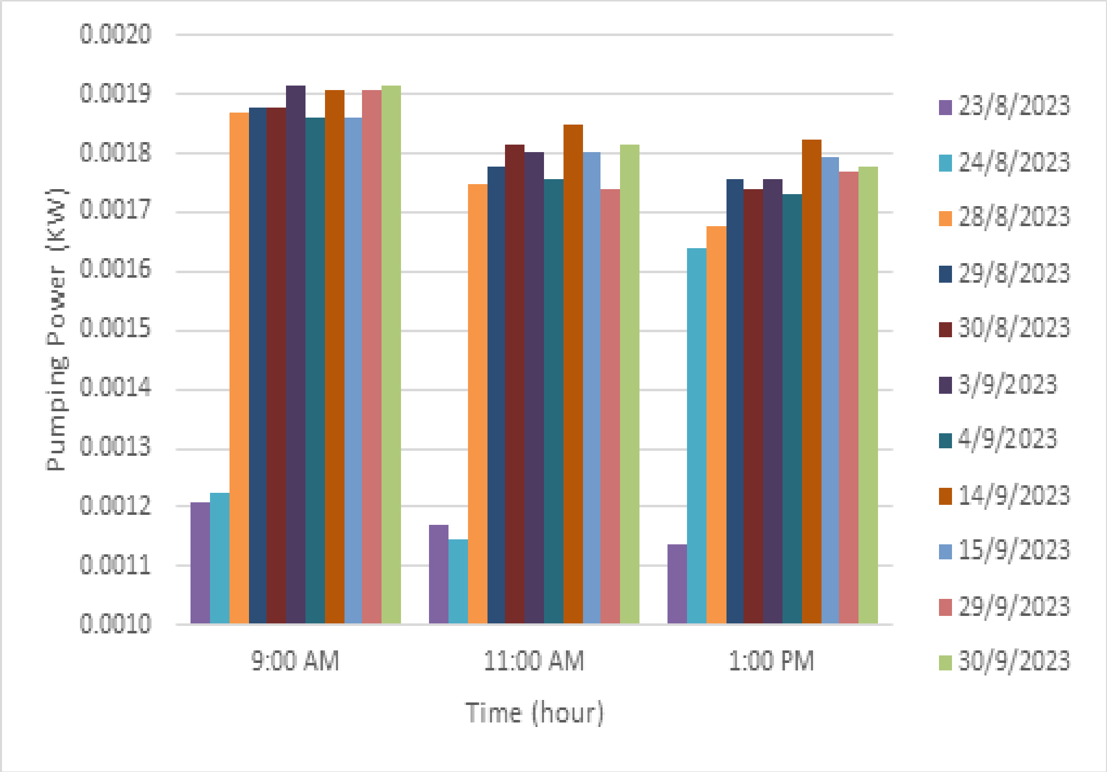


Fig. 20: variation of Pumping Power (KW) with The Time (hour) for EAHE system.

Fig. 21: variation of Performance Factor with The Days for EAHE system.

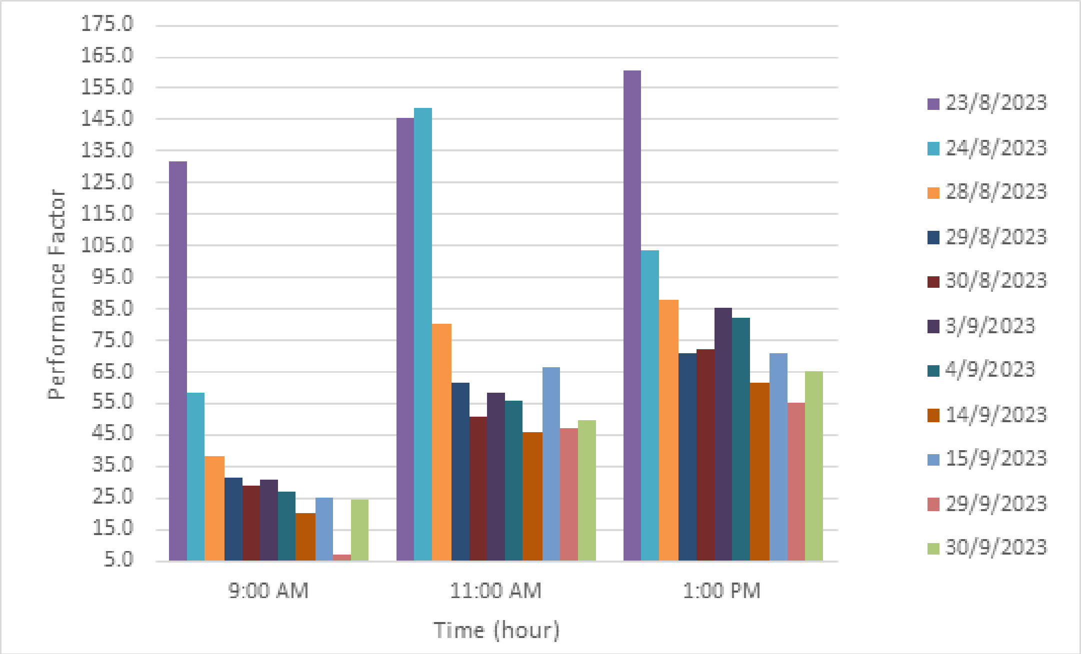


Fig. 22: variation of Performance Factor with The Time (hour) for EAHE system.

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