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# Proportional Design of Earth Tube Heat Exchanger Materials For Cooling of Air

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***Abstract*— The earth–air heat exchanger (EAHE) is a promising technique which can effectively be used to reduce the heating/cooling load of a building by preheating the air in winter and vice versa in summer. In the last two decades, a lot of research has been done to develop analytical and numerical models for the analysis of EAHE systems. Many researchers have developed sophisticated equations and procedures but they cannot be easily recast into design equations and must be used by trial-and-error. In this paper, the author has developed a one-dimensional model of the EAHE systems using a set of simplified design equations. The method to calculate the earth's undisturbed temperature (EUT) and more recently developed correlations for friction factor and Nusselt number are used to ensure higher accuracy in the calculation of heat transfer. The developed equations enable designers to calculate heat transfer, convective heat transfer coefficient, pressure drop, and length of pipe of the EAHE system. A longer pipe of smaller diameter buried at a greater depth and having lower air flow velocity results in increase in performance of the EAHE system.**

***Keywords*— GCHE,GSHP, EAHE,Temperature.**

## I. INTRODUCTION

The way towards energy and environment Earth-air heat exchangers can be analyzed for performance with several software applications using weather gage data. These software applications include GAEA, AWADUKT Thermo, EnergyPlus, L-Autism, WKM, and others. However, numerous earth-air heat exchanger systems have been designed and constructed improperly, and failed to meet design expectations. Earth-air heat exchangers appear best suited for air pretreatment rather than for full heating or cooling. Pretreatment of air for an air-source heat pump or ground-source heat pump often provides the best economic return on investment, with simple payback often achieved within one year after installation.

Most systems are usually constructed from 100 to 600 mm (3.9 to 23.6 in) diameter, smooth-walled (so they do not easily trap condensation moisture and mold), rigid or semi-rigid plastic, plastic- coated metal pipes or plastic pipes coated with inner antimicrobial layers, buried 1.5 to 3 m (4.9 to 9.8 ft) underground where the ambient earth temperature is typically 10 to 23 °C (50 to 73 °F) all year round in the temperate latitudes where most humans live. Ground temperature becomes more stable with depth. Smaller diameter tubes require more energy to move the air and have less earth contact surface area. Larger tubes permit a slower airflow, which also yields more efficient energy transfer and permits much higher volumes to be transferred, permitting more air exchanges in a shorter time period, when, for example, you want to clear the building of objectionable odors or smoke but suffer from poorer heat transfer from the pipe wall to the air due to increased distances. interior temperature. In indirect system, the building interior is conditioned by air brought through the earth, such as in earth-to-air heat exchangers [2]. The isolated system uses earth temperatures to extend the potency of a setup by lenitive temperatures at the compressing coil. The energy setup is that the example of associate degree isolated system. This thesis can concentrate on indirect systems. Indirect systems, i.e. earth-to-air heat exchangers, generally referred to as ground tubes, or ground coupled air heat exchangers are a noteworthy and promising technology. Tubes are placed within the ground, through that air is drawn. owing to the high thermal inertia of the soil, the air temperature variations at the bottom surface exposed to the outside climate are damped deeper within the ground. any a wait happens between the temperature variations within the ground and at the surface. At a ample depth the bottom temperature is above the surface air temperature in winter and lower in summer. once recent air is drawn through the earth-to-air heat exchangers the air is therefore cooled in summer and heated in winter. together with alternative systems and smart thermal style of the building, the world to air device will be accustomed heat air in winter and avoid air-conditioning units in buildings in summer, which ends up in an exceedingly reduction in electricity consumption of abuilding.

Types of Eart Tube Heat Exchanger:

There are three types

1. Closed loop system
2. Open system
3. Combination system

***Closed loop system:***

Air from inside the home or structure is blown through a U-shaped loop of typically 30 to 150 m (98 to 492 ft) of tube(s) where it is moderated to near earth temperature before returning to be distributed via ductwork throughout the home or structure. The closed loop system can be more effective (during air temperature extremes) than an open system, since it cools and recools the same air.

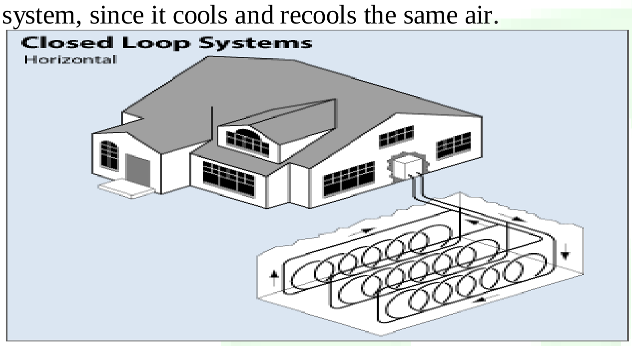


Fig No.1.1 :Earth tube Heat Exchanger (Closed Loop System)

## II. LITERATURE REVIEW

**Abbaspour-Fard et al. [30]** tested the performance of an **Balghouthi et al. [34]** studied experimentally thermal and moisture behavior of dry and wet soil heated by buried capillary plaits, on a prototype similar to an agricultural tunnel greenhouse. It was concluded that the surface temperature amplitude was superior in wet soil as compared to dry soil. **Li et al. [35]** constructed experimental setup at Herbin in China, for study of a ground sink direct cooling system in cold areas and concluded that there was substantial scope of energy conservation within a particular region. It was found that geographical and climatic conditions affect the performance level.Efficiency can be improved by reducing pipe diameter, mass flow rate of air, increasing pipe length, buried depth and buried pattern.

Goswami et al. [36] constructed an experimental setup at the energy research and education park at the university of Florida, which consisted of a 0.3 m diameter, 30.5 m long corrugated plastic pipe buried at a depth 2.75 m, a 0.2 kW blower, a 2½- ton heat pump, open loop. It was suggested that 0.3 m diameter for single pipe and 0.2–0.25 m diameter for multiple pipes in parallel could be suitable for achieving optimum performance but paper is silent on selection criteria for 0.3 m diameter pipe. It was observed that smaller diameter provided higher temperature drop, but consumed more fan power.

Bisoniya et al. [37] tested EAHE system for hot and dry summer conditions at Bhopal in India. The experimental set up had two cylindrical PVC pipes of 0.1016 m ID. The length of each cylindrical pipe was 9.114 m, connected in series. The total length of burial pipe assembly including elbows, connector pipe was 19.228 m, buried in black cotton soil at a depth of 2 m. For air flow velocities of 2 m/s, 3.5 m/s and 5 m/s, researchers concluded that decrease in air temperature was significant in initial length of pipe than in the remaining length of pipe. Maximum and minimum drops in air temperature were 12.9 1C, 11.3 1C observed at air flow velocities of 2 m/s and 5 m/s respectively. It was felt that lower air velocities would lead to higher temperature drop. A simulation model was developed on computational fluid dynamics (CFD) platform CFX 12.0 and simulation results validated satisfactorily with the experimental results.

Dubey et al. [38] tested EAHE system with pipes in parallel at Bhopal in India. Experimental setup had 3 GI pipes of 64 mm internal diameter (ID), 3 m each, connected in parallel to common intake and exhaust, buried at a depth of 1.5 m in a flat land with dry soil. Researchers found that temperature difference of air at the inlet section and exit section of the pipe at 1.5 m depth, varied from 8.6 to 4.18 1C in the air velocity range of 4.1–11.6 m/s and COP from 6.4 to 3.6. It was observed that lower air velocities resulted higher temperature drops and COPs. temperature at a depth of 1.5 m remained at about 30.4 1C. Paper does not provide selection criteria for serpentine pattern and comparison with others.

Woodson et al. [39] constructed experimental setup of EAHE system at the International Institute for Water and Environmental Engineering in Ouagadougou, Burkina Faso. It was a horizontal open-loop system used 25 m long, 125 mm diameter PVC pipe at a depth of 1.5 m. The EAHE system had two air inlets, located 15 m and 25 m away from the air outlet in the building. But this study was done only on 25 m long pipe which was laid down in serpentine pattern. It was found that 25 m long EAHE buried at a depth 1.5 m could reduce the temperature of air drawn from outside by more than 7.5 1C. While outdoor temperature varied from 25 1C to 43 1C and the soil.

Rodrigues et al. [40] experimented combination of EAHE with PCM as alternative of conventional air-conditioning. It was concluded that combined effect of EAHE with PCM conserved significant amount of energy as compared to conventional air conditioning system. It could enhance cooling up to 47%.

Misra et al. [41] made an experimental setup of EAHE system in hybrid with air conditioner (AC) at Ajmer in India. The experimental setup comprised of 60 m long, 0.10 m ID PVC pipe, buried at a depth of 3.7 m in a flat land with dry soil. There were four modes of test, in mode-I, alone AC supplied the conditioned air to the test room that was treated as base mode. In mode-II, AC and EAHE system both supplied their 100% conditioned air to the test room. In modeIII, AC supplied conditioned air to room and but 100% conditioned air from EAHE system was supplied to AC's condenser coils to cool them only. In mode-IV, AC supplied conditioned air to room and 50% conditioned air from EAHE system was supplied to AC's condenser coils to cool them and remaining 50% air was supplied to test room. Outcome of different combinations of EAHE system with conventional 1.5 TR AC is presented in Table 3.

It was concluded from experiment that suitable combination of EAHE system with conventional AC in mode-III could conserve significant amount of energy as given in Table 3.

Haghighi et al. [42] integrated EAHE system with solar chimney and concluded that 0.5 m diameter, 25 m length of EAHE system, 0.2 m air gap and outlet sizes of solar chimney could enhance the performance.

Tavakolinia [43] integrated EAHE system with wind catcher for cooling and natural ventilation for the single story spaces in Los Angeles area. It was concluded that integrated system could perform better than unity system.

Ralegaonkar et al.[44] tested EAHE system at Nagpur in India and concluded that geothermal cooling system i.e. EAHE could save up to 90% of electricity as compared to conventional air conditioning systems and 100% of water as consumed by evaporative cooling systems.

Chel et al. [45] made an experimental setup of EAHE system integrated with 2.32 kWp photovoltaic power system at solar energy park in New Delhi, India. This integration had estimated potential of up to 50% energy conservation.Appropriate modifications like cross ventilation, earth surface and soil–cement mixture treatment, wall configuration, etc. provide enhanced output.

## III. DESIGN PARAMETERS

When designing earth tubes, choosing the type of pipe is the first decision. There are a variety of materials to choose from, from baked clay tiles, to steel duct work, to common PVC or the most modern HDPE plastics with anti-microbial coatings. Perhaps I will eventually come back and put this in a table, but for now, I will just list some of the pros and cons to each.

Note that the thermal conduction properties of the material do affect the rate that heat conducts thru them, but it doesn't seem to affect the overall performance of the earth tubes. Partially, this may be because the total resistance to thermal conduction includes both the R value and the thickness.

## IV. EXPERIMENTAL SET UP

### 4.1 Description of Set-Up

For the experimental work we used MS pipe of 5 cm diameter and was buried at a depth of 3meters. A blower was used to drive the air through the pipe which was circulated throughout the pipe. A vane type anemometer and thermocouple was used to measure the velocity and temperature of the air respectively. The thermocouple was attached with the Temp. Sensor .Figure 4.1:

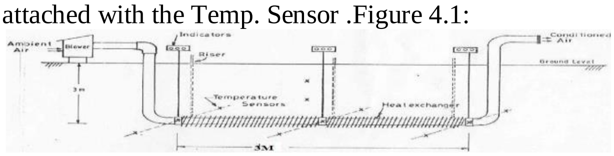


Figure 4.1: Schematic Representation of Experimental Set up

The experimental set-up in the figure 5.1 consists of the 5 cm diameter MS pipe buried below the ground level at a depth of 3 m. At a depth of 3 m, the pipe is spread horizontally for a length of 3m. The total length of the experimental set-up is 9 m. The outlet pipe is covered with a sheet which acts as a insulation and prevents any variation in the air coming through the outlet pipe and for L bends have been used in the experimental set up.

### 4.2 Procedure for Experimentation:

To start the experimentation, the blower was switched on and the air was let to pass through the pipe for some time till the steady state was achieved. The velocity at the inlet and outlet was calculated with the help of vane type anemometer. The thermocouple wire was attached at inlet portion middle portion and outlet portion. The Thermocouple wire is attached with temperature auto scanner which continuously displays the readings of thermocouple. The above procedure was repeated with different ambient conditions, this is achieved by conducting the experiment 3day of summer season (24, 25, 26MAY-2018) and 3day of winter season (2, 3, 4th Jan-2018). All the data thus obtained is compiled into a single table. The graphs are plotted for various sets of observations obtained from the experiment. The total cooling and heating has been calculated for flow velocities 11m/s by the following equation:

For Summer Climate

For winter climate

$Qc = mCp(T_{inlet} - T_{outlet})$

$Qc = mCp(T_{outlet} - T_{inlet})$

Where m= mass flow rate of air through thepipe Cp= specific heat capacity ofair

Tinlet= inlet temperature of air Toutlet= outlet temperature ofair.

Coefficient of performance (COP) of the system has been calculated from the following Expression:

For Summer Climate

$COP = mCp(T_{inlet} - T_{outlet}) / \text{Power Input}$ (1)

For winter climate

$COP = mCp(T_{outlet} - T_{inlet}) / \text{Power Input}$ (2)

### *4.3 Instruments Used:*

**Anemometer:**

An anemometer is a device used for measuring the speed of wind, and is also a common weather station instrument. The term is derived from the Greek word anemos, which means wind, and is used to describe any wind speed instrument used in meteorology. The first known description of an anemometer was given by Leon Battista Alberta in 1450Vane type anemometer was used for measuring the velocity of the air. A vane anemometer which uses a small fan is turned by air flowing over the vanes. The speed of the fan is measured by a revolutions counter and converted to a wind speed by an electronic chip. Hence, volumetric flow rate taken 0.0863 m3/s otherwise it may be calculated if the cross-sectional area is known.

 

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Figure 4.3: Vane type Anemomete

It has 13mm LCD display screen and temperature range is from 00C to 500C. It is extremely light weight instrument weighing 260 g and velocity range is from 0.40 m/s to 45 m/s with an accuracy of
±0.2% + 0.1 m/s.

**Temperature Auto Scanner:** It displays the temperature encountered bythe Thermocouple attached with the instrument.


Figure 4.4 Temprature Measuring Machine

**Specifications:**

| | |
|---|---|
| DISPLAY | 4-1/2 Digit, Segment; 0.56" Height; Red L.E.D |
| ACCURACY | 1% of full scale or ± 10 % 20C |
| RESOLUTION | 0.01oC up to 200oC |
| SENSOR BREAK PROTECTION | Display Starts Blinking |
| POWER SUPPLY | 180-230 V AC |
| NO. INPUT CHANNEL | 10 |
| DIMENSIONS | 96 x 96 x 130 mm |

Table 4.1: Specifications of Temperature Auto Scanner

**Thermocouple wire:**

Figure 4.5 Thermocouple wire

**Blower:**

Industrial fans and blowers are machines whose primary function is to provide and accommodate a large flow of air or gas to various parts of a building or other structures. This is achieved by rotating a number of blades, connected to a hub and shaft, and driven by a motor or turbine. The flow rates of these mechanical fans range from approximately 200 cubic feet (5.7 m3) to 2,000,000 cubic feet (57,000 m3) per minute. A blower is another name for a fan that operates where the resistance to the flow is primarily on the downstream side of the fan.

Figure 4.6: Blower

## V. EXPERIMENTAL RESULT FOR SUMMER AND WINTER SEASON

***5.1(a) Cooling Model Test (GI PIPE):***

The air velocity was 11 m/s. Velocity was measured by a portable, digital vane type anemometer The vane size is 66 x 132 x29.2 mm and velocity range 0.3 to 45 m/s. The anemometer measures mean air velocity. The volume flow rate of air was 0.0863 m3/s and mass flow rate 0.0269 kg/s. The ETHE system was operated for seven hours a 3days 24, 25&26 May-2018) for May Month. The tube air temperature at the inlet, middle and outlet, were noted at the interval of one hour. System was turned on at 10.00 AM and shut down at 5 PM. Tests in May were carried out on 24th, 25th, and 26th 2017). The ambient temperature on these three days was very similar. The results of the three days were therefore averaged. Table-5.1(a) shows the data, which is reading of three days and Table- 5.1(b) mean of the reading of three days. The ambient temperature started with 30.73oC at 10.00 AM and rise to a maximum of 40.13oC at 2 PM. The temperature of air at outlet was 26.8oC at when system started in 10am.. The outlet temperature was just above the basic soil temperature (26.6oC). The table also shows the COP values. The maximum COP Achieved at 2pm i.e2.702.

FOR SUMMER SEASON (MAY-2023)

Area = π x d2/4= π x 0.05 x0.05/4=0.00196 m2

Density of air = 1.225 kg/m3

Specific heat capacity of air,

Cp= 1007 J/kg K

Total cooling, Qc = mCp(Tinlet – Toutlet)

Coefficient of Performance, COP = = mCp(Tinlet – Toutlet)/Power Input

Mass flow rate, m = density x area x velocity=0.0269

Power Input = 125 W

1.Time:10:00

Inlet temperature, Tinlet: 30.730C Outlet temperature, Toutlet: 26.80C Velocity at outlet: 11 m/s

Qc = 106.45W COP = 0.851

2.Time:11:00

Inlet temperature, Tinlet: 34.33.20C Outlet temperature, Toutlet: 26.760C Velocity at outlet: 11 m/s

Qc = 205.05 W COP = 1.640

3.Time:12:00

Inlet temperature, Tinlet: 36.560C Outlet temperature, Toutlet: 27.130C Velocity at outlet: 11 m/s

Qc = 255.43 W COP = 2.043

4.Time:13:00

Inlet temperature, Tinlet: 37.630C Outlet temperature, Toutlet: 27.100C Velocity at outlet: 11 m/s

Qc = 285.23 W COP = 2.281

5Time:14:00

Inlet temperature, Tinlet: 40.130C Outlet temperature, Toutlet: 27.130C

Velocity at outlet: 11 m/s Qc = 348.62 W

COP = 2.817

Time:15:00

Inlet temperature, Tinlet: 400C Outlet temperature, Toutlet: 27.130C Velocity at outlet: 11 m/s

Qc = 341.30W COP = 2.788

 

7.Time:16:00
Inlet temperature, Tinlet: 39.80C Outlet temperature, Toutlet: 27.20C Velocity at outlet: 11 m/s
Qc = 337.78 W COP = 2.73
8.Time:17:00
Inlet temperature, Tinlet: 39.60C Outlet temperature, Toutlet: 27.130C Velocity at outlet: 11 m/s
Qc = 478.58 W COP = 2.70
5.1(a) EXPERIMENTAL RESULTS
(Graphical Representation)

**1. TIME &INLET TEMP. (MAY-2023)**

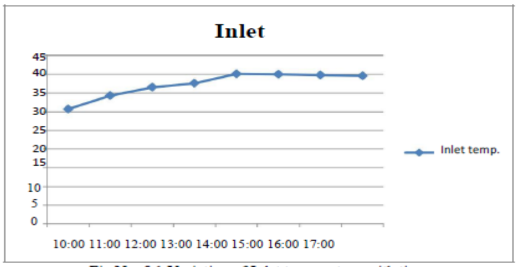


Fig.No. 5.1 Variation of Inlet temperature with time

**1. TIME & OUTLET TEMP (MAY-2023)**

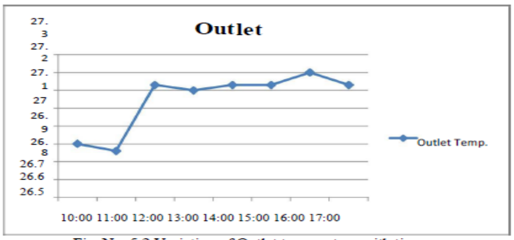


Fig. No. 5.2 Variation of Outlet temperature with time

**3. TIME & COP (MAY-2023)**

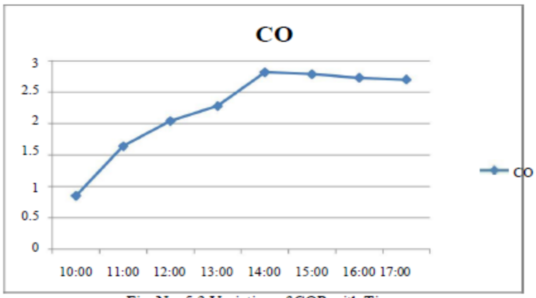


Fig. No. 5.3 Variation of COP with Time

4. TIME, INLET, OUTLET TEMP & COP (MAY-2023)

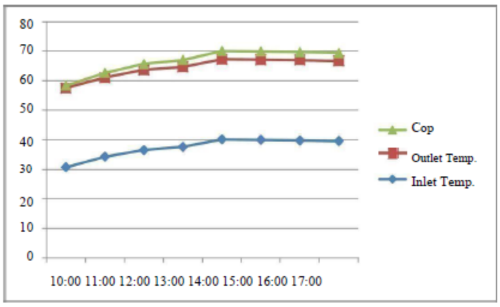


Fig. No. 5.4 Variation of Inlet, Outlet Temp. & COP with Time

***5.1(b) Cooling Model Test (COPPER PIPE)***

The air velocity was 11 m/s. Velocity was measured by a portable, digital vane type anemometer The vane size is 66 x 132 x29.2 mm and velocity range 0.3 to 45 m/s. The anemometer measures mean air velocity. The volume flow rate of air was 0.0863 m3/s and mass flow rate 0.0269 kg/s. TheETHE system was operated for seven hours a 3days 24, 25&26 May-2012) for May Month. The tube air temperature at the inlet, middle and outlet, were noted at the interval of one hour. System was turned on at 10.00 AM and shut down at 5 PM. Tests in May were carried out on 24th, 25th, and 26th may 2012). The ambient temperature on these three days was very similar. The results of the three days were therefore averaged. Table-1(c) shows the data, which is reading of three days and Table- 1(d) mean of the reading of three days. The ambient temperature started with 30.73oC at 10.00 AM and rise to a maximum of 40.13oC at 2 PM. The temperature of air at outlet was 23.63oC at when system started in 10am.. The outlet temperature was just above the basic soil temperature (26.6oC). The table also shows the COP values. The maximum COP Achieved at 2pm i.e3.6

FOR SUMMER SEASON (MAY-2023)
Area = π x d2/4= π x 0.05 x0.05/4=0.00196 m2
Density of air = 1.225 kg/m3
Specific heat capacity of air,
Cp= 1007 J/kg K
Total cooling, Qc = mCp(Tinlet – Toutlet)
Coefficient of Performance, COP = = mCp(Tinlet – Toutlet)/Power Input
Mass flow rate, m = density x area x velocity=0.0269
Power Input = 125 W
1.Time:10:00
Inlet temperature, Tinlet: 30.730C Outlet temperature, Toutlet: 23.630C Velocity at outlet: 11 m/s
Qc = 192.32.45W COP = 1.53
2.Time:11:00
Inlet temperature, Tinlet: 34.33.20C Outlet temperature, Toutlet: 23.070C Velocity at outlet: 11 m/s
Qc = 305.01 W COP = 2.44
3.Time:12:00
Inlet temperature, Tinlet: 36.560C Outlet temperature, Toutlet: 23.130C Velocity at outlet: 11 m/s
Qc = 363.79 W COP = 2.91
4.Time:13:00
Inlet temperature, Tinlet: 37.630C Outlet temperature, Toutlet: 23.000C Velocity at outlet: 11 m/s
Qc = 396.29 W COP = 3.17
5Time:14:00
Inlet temperature, Tinlet: 40.130C Outlet temperature, Toutlet: 23.130C Velocity at outlet: 11 m/s
Qc = 460.49 W COP = 3.68
**6.Time:15:00**
Inlet temperature, Tinlet: 400C Outlet temperature, Toutlet: 23.130C Velocity at outlet: 11 m/s
Qc = 456.17W COP = 3.65
**7.Time:16:00**
Inlet temperature, Tinlet: 39.80C Outlet temperature, Toutlet: 23.010C Velocity at outlet: 11 m/s
Qc = 454.80 W COP = 3.63

 

8.Time:17:00
Inlet temperature, Tinlet: 39.60C Outlet temperature, Toutlet: 23.160C Velocity at outlet: 11 m/s
Qc = 445.32 W COP = 3.56

**5.1(b) EXPERIMENTAL RESULTS (Graphical Representation)**

**1. TIME &INLET TEMP. (MAY-2023)**

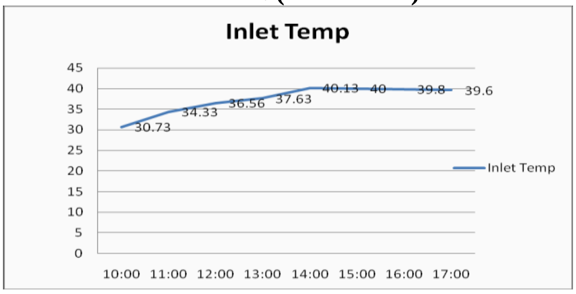


Fig.No. 5.5 Variation of Inlet temperature with time

2.TIME &OUTLET TEMP. (MAY-2023)

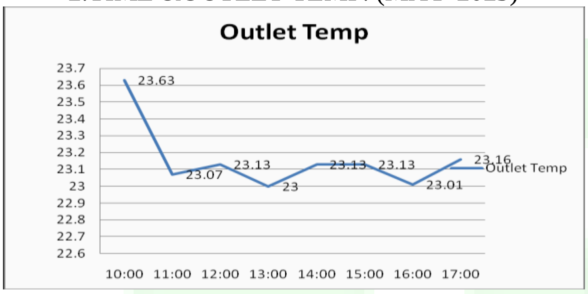


Fig. No. 5.6 Variation of Outlet temperature with time

3.TIME &COP. (MAY-2023)

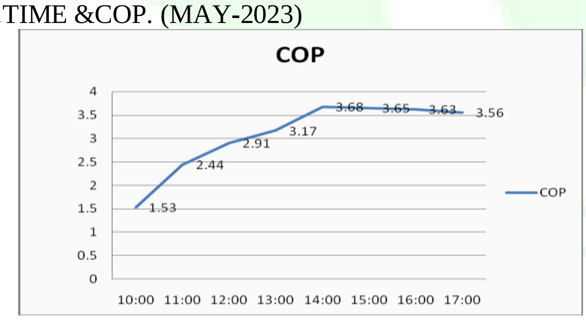


Fig. No. 5.7 Variation of COP with Time

4.TIME ,INLET,OUTLET,&COP. (MAY-2023)

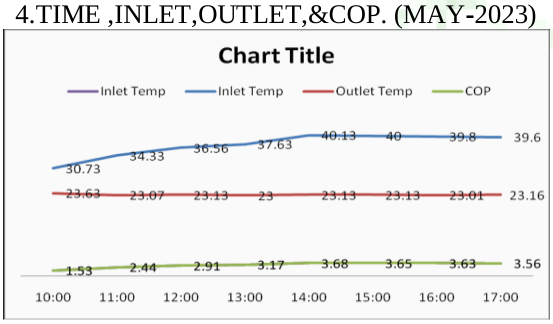


Fig. No. 5.8 Variation of Inlet, Outlet Temp. & COP with Time

**5.1(c) Cooling Model Test (COPPER PIPE)**

The air velocity was 11 m/s. Velocity was measured by a portable, digital vane type anemometer

The vane size is 66 x 132 x29.2 mm and velocity range 0.3 to 45 m/s. The anemometer measures mean air velocity. The volume flow rate of air was 0.0863 m3/s and mass flow rate 0.0269 kg/s. TheETHE system was operated for seven hours a 3days 24, 25&26 May-2023) for May Month. The tube air temperature at the inlet, middle and outlet, were noted at the interval of one hour. System was turned on at 10.00 AM and shut down at 5 PM. Tests in May were carried out on 24th, 25th, and 26th may 2023). The ambient temperature on these three days was very similar. The results of the three days were therefore averaged. Table-1(c) shows the data, which is reading of three days and Table- 1(d) mean of the reading of three days. The ambient temperature started with 30.73oC at 10.00 AM and rise to a maximum of 40.13oC at 2 PM. The temperature of air at outlet was 23.63oC at when system started in 10am.. The outlet temperature was just above the basic soil temperature (26.6oC). The table also shows the COP values. The maximum COP Achieved at 2pm i.e3.6

## VI. CONCLUSION AND FUTURE WORK

After done the calculation in the previous chapter, we can see that the results are quite encouraging. The results are summarized under the following points:

• IN GI Pipe For the pipe of 9 m length and 0.05 m diameter, temperature rise of 3.230C-6.10C has been observed for the outlet flow velocity 11m/s

• IN COPPER Pipe For the pipe of 9 m length and 0.05 m diameter, temperature rise of 8.330C- 10.10C has been observed for the outlet flow velocity 11m/s

• IN GI Pipe The maximum COP obtained in summer season is 2.817 at time 14:00 and the maximum COP obtained in winter season is 2.25 at time 17:00

• IN COPPER Pipe The maximum COP obtained in summer Season is 3.68 at time 14:00 and the maximum COP obtained in winter Season is 2.39 at time 17:00 m/s. ow velocity 11m/s

• IN GI Pipe The COP of the system varies from 0.85 – 2.70 in summer season and 1.41-2.25 in winter season in outlet velocity 11m/s.

• IN COPPER The COP of the system varies from 1.53 – 3.68 in summer Season and 1.75-2.39 in winter Season in outlet velocity 11

• The results also show that conduction plays very important role in the cooling of air, it is evident from the fact that temperature remains constant where the insulation is done.

• If the blower speed is high and the length of pipe is less than the temperature difference inlet and outlet is very small.

This work can be used as a design tool for the design of such systems depending upon the requirements and environmental variables. The work can aid in designing of such systems with flexibility to choose different types of pipes, different dimensions of pipes, different materials and for different ambient conditions. So this provides option of analyzing wide range of combinations before finally deciding upon the best alternative in terms of the dimension of the pipe, material ofthe pipe, type of fluid to be used.

**Future Scope:**

• The blower with variable running speed should be used.

 

• Theoretical model should be developed to predict the temperature of soil per meter depthofsoil and affect of moisture content in the soil.
• This system will be tested for different length and different diameter pipe.
• For further studyhumidity control mechanism should be incorporated for winter and summer season.
• The fluid dynamics studies should be conducted to minimize the flow losses in the pipe and effect of moisture to be studied.

**References**

[1] Omer AM. Energy, environment and sustainable development. Renew Sustain Energy Rev 2008;12(9):2265–300.
[2] Mardiana A, Riffat SB. Review on heat recovery technologies for building applications. Renew Sustain Energy Rev 2012;16:1241–55.
[3] Zuo J, Zhao Z. Green building research-current status and future agenda: a review. Renew Sustain Energy Rev 2014;30:271–81.
[4] Mihalakakou G, Santamouris M, Asimakopoulos DN. Modelling the earth temperature using multiyear measurements. Energy Build 1992;19:1–9.
[5] Mihalakakou G. On the heating potential of a single buried pipe using deterministic and intelligent techniques. Renew Energy 2003;28:917–27.
[6] Chandrasekharam D, Chandrasekhar V. Geothermal energy resources, India: Country update. In: Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, vol. 7; 2010. p.1–11.
[7] Bansal NK, Sodha MS, Bharadwaj SS. Performance of earth-air tunnel system. Energy Res 1983;7(4):333–41.
[8] Ozger L. A review on the experimental and analytical analysis of earth to air heat exchanger (EAHE) systems in turkey. Renew Sustain Energy Rev 2012;15(9):4483–90.
[9] Yang H, Cui P, Fang Z. Vertical-borehole ground-coupled heat pumps: a review of models and systems. Appl Energy 2010;87:16–27.
[10] Florides G, Kalogirou S. Ground heat exchangers – a review of systems, models and applications. Renew Energy 2007;32(15):2461–78.
[11] Gazes J, Mixson D. Geothermal heating and air conditioning system. U. S. Patent 4 920 757, May 1, 1990.
[12] Wiggs BR. Direct exchange geothermal heating/cooling system sub-surface tubing installation with supplemental sub-surface tubing configuration. U. S. Patent 7 856 839, Dec 28, 2010.
[13] Omer AM. Ground-source heat pumps system and applications. Renew Sustain Energy Rev 2008;12:344–71.
[14] Anandarajah A. Mechanism controlling permeability changes in clays due to changes in pore fluids. J Geotech Geoenviron Eng 2003;129(2):163–72.
[15] Omer AM. Review-Direct expansion ground source heat pumps for heating and cooling. Int Res J Eng 2013;1(2):27–48.
[16] Bojic M, Papadakis G, Kytitsis S. Energy from two-pipe, earth-to-air heat exchanger. Energy 1999;24:519–23.
[17] Peretti C, Zarrella A, Carli MC, Zecchin R. The design and environment evaluation of earth-to-air heat exchangers (EAHE): a review. Renew Sustain Energy Rev 2013;28:107–16.
[18] Bisoniya TS, Kumar A, Baredar P. Study on calculation models of earth-air heat exchanger systems. J Energy 2014;2014:1-15.
[19] Ajmi FAI, Loveday DL, Hanby V. The cooling potential of earth–air heat exchanger for domestic buildings in a desert climate. Build Environ 2006;41:235–44.
[20] Petrov RJ, Rowe RK, Quigley RM. Selected factors influencing GCL hydraulic conductivity. J Geotech Geoenviron Eng 1997;123(8):683–95.

 