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A NOVAL DEVELOPMENT OF EARTH AIR TUNNEL HEAT EXCHANGER

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ABSTRACT
A mono cause to move in a specified direction earth air tube heat exchanger was introduced to study the conductance of cooling as well as heating during summer and winter. A smaller diameter longer pipe buried at certain depth. And we observed the decrease of outlet air temperature of EATHE,it was resulted by containing lower air flow velocity. The EATHE is made of 24m long Galvanized Steel pipe-25mm nominal diameter and 1.5 mm wall thickness. Another EATHE system is made up of PVC with 36mm nominal diameter. The EATHE is buried under the earth surface about 2-3m deep. The ambient air of the room is sent through the pipe with the help of a 45W blower. Every day, the system was worked for 7hours during the day and shut down for the night. The test results are noted in summary for each month of conductance . From the test results it is concluded that the, EATHE experimental setup can decrease the temperature about 8-10 degrees of the room temperature.

1. INTRODUCTION
The Energy using up a resource of buildings for cooling and heating purpose has sufficiently great increased during these decades. In concerning all most people feel comfort and flexible, when the temperature is in the period separating 25C-35C.Air conditioning system was broadly appointed for the comfort occupancy and the industrial management involved in making. It can be successfully bought in such a manner as to achieve a desired result by compression machines but due to the reduction in the number of ozone layer and global warming by using CFCs and the must to minimize the high grade energy using up a resource. Various passive especial executions are now days introduced, one such technique is earth air tube heat exchanger. Also the system can be benefited in degrading the high electrical consumption. After one year, the measurements they reported on the soil between 2-3m depth had stable temperature command suitable for installation of EATHE.Longer pipes of conducting materials are utilized for drawing the effect of soil temperature near 2-3m depth from the surface. Heat transfer can be takes place between the air and soil which circulates in the pipe.

1.1 Modes of Energy Transfer
Heat, is defined as the vitality required for sustained physical transaction due to the

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slight difference in the condition of temperature. Whenever a temperature disparity exists, in a medium or in the period separating media, the heat will be flows as a result of the slight difference in the temperature difference. Unlike in nature inconsistent types of heat transition processes are called modes of heat. (These modes are shown in Figure 1.1.) When the temperature gradient exists in a stationary medium, in which either it may be a solid or a fluid, heat flows under the law of conduction heat transfer. On the other hand if the temperature increase or decrease in the magnitude of a property exists in the period separating a moving fluid and surface we use the term Convection

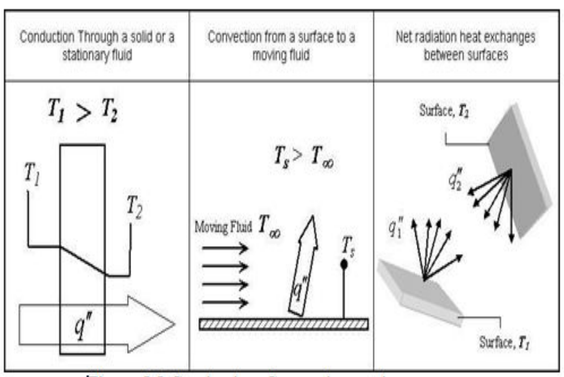

Figure 1.1 Conduction, Convection modes

1.1.1 Conduction

Conduction is the process of heat transfer, in which the vitality required for sustained physical strength is transported in the period separating the parts of a continuum by the transfer of kinetic energy between minute portions of matter. s at the atomic level. We should make up the abstract idea of atomic and molecular activity in gases; conduction is caused by the elasticity collision of molecules. Typically before making a decision a gas having a temperature gradient and assume that there is no bulk motion. The gas may be occupies the space between two surfaces which are maintained at different temperatures as shown in Figure 1.2.We relate the temperature at any point with the energy of gas molecules near the point. This energy is about to the random translational motion and also to the internal circular movement about an axis or centre and vibrational process of moving of the molecules

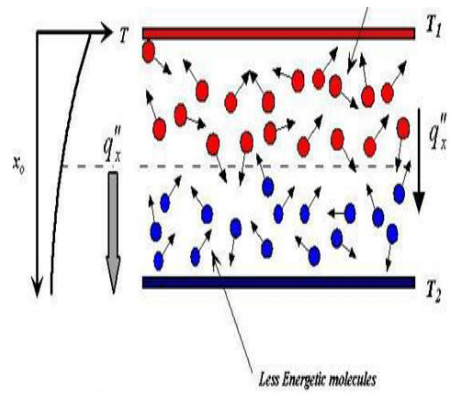

Figure 1.2 Conduction heat transfer as the spreading of something more widely of energy due to molecular pursuit.

Thermal conductivity in metals happens, like electrical conduction, through the motion of free electrons. Thermal energy transfer places along the direction of decreasing temperature, at major role of the second law of thermodynamics. Examples of conduction heat transfer are huge. During the sunny day, the significant energy can be gained from the outside air to the room. This gain is chiefly due to conduction heat transfer by way of the wall that divides room air from outside air.It is possible to quantify heat transfer steps taken in terms of suitable rate equations. These equations possibly used to work out the amount of energy existence passed per unit time. For heat conduction, the rate of correspondence is known as Fourier's law. Fourier's law is a as distinct from that of the nature of being; that

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is elaborated to a specified degree from observed occurrence rather than being attained from first principles. The general rate equation is based on much experimental facts available of the body. For the one amplitude plane wall. Temperature dispensation T(x), the rate equation is shown as

$$q''_x = -k \frac{dT}{dx}$$

The heat flux q" (W/m2) is the heat transfer rate in the x guidance of someone per unit area perpendicular to the direction of transfer, and it is corresponding in size to the temperature gradient, dT/dx, in this direction. The proportionality constant k is a transport possession collectively known as the thermal conductivity (W/m. K) and is a characteristic of the wall material. The minus sign is a typically one that is unwelcome fact that heat is transferred in the direction of becoming smaller temperature.

1.1.2 Heat Convection

This mode of heat transfer include as a necessary energy transfer by fluid motion and molecular diffusion. Typically before making a decision heat transfer to a fluid flow over plane plate as in Figure 3.5. If the Reynolds number is large enough, three different flow having definable characteristics but not always fixed boundaries that exist.

Without any intervening time adjacent to the wall is a laminar sub layer where heat transfer occurs by thermal conduction, outside the laminar sub film is a transition region called the buffer film, where Convection heat transfer may be divided as stated by to the nature of the flow for free or normal convection the flow is induced by buoyancy forces, which arise from density variation caused by temperature variations in the fluid. Both eddy mixing and conduction effects are notable, beyond the buffer layer is the turbulent region, where the dominant mechanism of pass is eddy mixing.An example is the free convection heat transfer that happens from hot components on a vertical array of circuit boards in still air as shown. Air that made in contact with the components experiences an increment in temperature so that the density is reduced.For a forced convection; the flow is promoted by external cause, such a fan, a pump, or atmospheric gales. An example, the use of a fan to cause to happen forced convection air cooling of hot electrical vectors acting in different directions which on printed circuit boards as shown in Figure.

Turbulent region

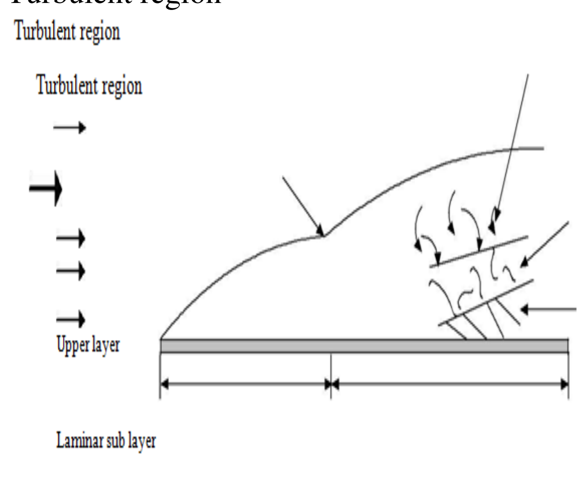

Figure 1.3 Boundary layer build up over flat plate

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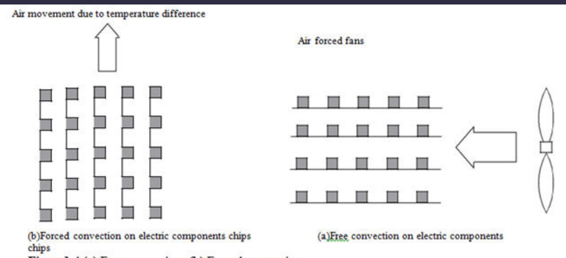


Figure1.4 (a) Free convection, (b) Forced convection

The heat transfer by convection is given as a detailed account by the Newton's law of cooling

$q = hA(T_w - T_\infty)$ h = Heat transfer rate (w)

Where:

h = Heat transfer coefficient (W/m^2.K)

T_w= Wall temperature (K)

T_∞= Free stream fluid temperature (K)

The rough span of convection heat- transfer coefficients are point outed in Table 3.1 for free and physical power convection

PROCESS	h (W/m^2.K)free convection
-gases	2-25
-liquids	55-1,000
Forced convection	
-gases	30-250
-liquids	60-20,000
Convections with two phases	
-boiling or condensation	2,600-1,00,000

1.2 Combined Modes of Heat Transfer

Under investigations, most of the concerned with the actual doing cases, heat is transferred by more than one mode; as for examples heat may be passed by merged to form convection and radiation, merged to form convection and conduction, etc.

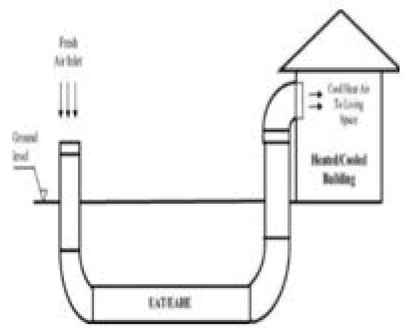
1.3 Combined Convection and Conduction

This combination is likely to take place with the use of expanded surfaces where the initial surface having an act of giving one thing and receiving another kinds in return heat by convection to the adjacent fluid flow and by conduction through the expanded surfaces. This cause may be taken in having a resemblance in appearance manner as the above, but here the problem doesn't need more work as the conduction thermal refusal to accept is predefined.

2. TYPES OF EATHE

2.1 Open Loop

Open loop consists of tube arrangement buried in soil at predetermined depth. One end of tube is connected to target room where cooling is required and other end is left to atmosphere from where the ambient fresh air is sucked by blower and sent into tube arrangement. Open loop maintains air quality as air is sucked from atmosphere and simple in construction. But the performance obtained is low because every time, fresh air at high ambient temperature has to be cooled.



2.2 Closed Loop

Closed loop consists of tube arrangement buried in soil at predetermined depth. Both ends of tube arrangement is connected to target room on either side of target room where cooling is required. At one end, air sucked from room and from other end, the cool air is sent to target room using a blower or fan. The main advantage with this system is that, the same quantity of air is being cooled in no. of stages repeatedly, hence

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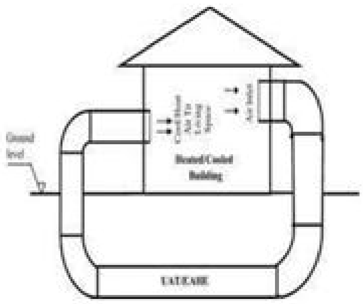
performance of the setup increases.But, drawback with this system is poor air quality because the same quantity of air is used hence air conditioning is required.



2.3 DESIGN GUIDELINES:

Design Parameters that impact the Performance of the EATHE.

A) TUBE LENGTH

The length of the material the energy must flow through can affect the rate at which it flows. The shorter the length, the faster it will flow. As the thermal conductance increases the heat transfer increases. Also, as the length of the tube increases the area of contact between tube and soil increases.

B) TUBE DEPTH

Thermal inertia: the degree of slowness with which the temperature of a bod y approaches that of its surroundings and which is dependent upon its absorptivity, its specific heat, its thermal conductivity. After years of study it was concluded that as the depth of the soil increases from the surface. For this reason, high depth is preferred for installing Earth Air Tube Heat Exchanger.

C) TUBE MATERIAL

The high thermal conductivity material is preferred for high heat transfer between the tube and the soil. Also, the material with higher thermal conductivity results in low thermal inertia.

D) TUBE DIAMETER

The tube diameter should be nominal to avoid the decrease of rate of heat transfer between the air present in the pipe and the pipe when diameter is increased, also to avoid the decrease of rate of heat transfer between the soil and pipe when the diameter is decreased.

E) AIR FLOW RATE

According to the EATHE principle maintaining low air flow rate result in larger heat transfer between air and pipe as air flowing with a low flow velocity has sufficient time to be in contact with pipe resulting in sufficient time for heat transfer to take place.

3. EXPERIMENTAL PROCEDURES

This chapter outlines the experimental techniques used for this research project to evaluate the effect of PVC and GI pipe systems, were measured via temperature of outlet air.

3.1 Material selection

In this we use 3 types of polyethylene of measurements of 75mm diameter and 30m long. These 3 pipes are buried individually at depths of 0.5m, 1.5m. Mainly the Fan blowers are placed at each means of entry of the pipes, which are having air velocity of 5.6 m/s. A consequence resulted the best less in amount of temperature. It is of up to 6.4°C on the wet season. And 6.9°C while the dry and hot season. It is on while the pipes were buried at 1m depth in underground. Meanwhile, PVC pipes of 30m were also hidden underground at 0.5m, 1.0m and 1.5m depth underground in a way that results from chance despite being very unlikely at same time. However, the PVC pipes at below 0.6m were resulted to be broken just before taking the measurement.

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This is the cause reasoned by the increasing weight of the soil as it goes deep underground. It concluded that the PVC pipes are having low life time as compared to PE pipes.

Table.1 Summary of studies on EATHE system materials

Researcher	Location	Material	Temp. Reduction °C
Gowami & Biseli,1993	Florida, USA.	Plastic (PVC)	4 - 6
Sharan & Jadhav, 2002 & 2003	Ahmedabad, India. Thor, Ahmedabad.	Mild steel	8 - 10 14
Bansal et al., 2009 & 2010	Ajmer, India	Steel	4 - 5 (Heating) 8 - 13 (Cooling)
Onyango, 2012	Florida, USA.	Polyethylene (PE)	3 - 9
Sanusi, et.al. 2013	Selangor, Malaysia.	Polyethylene (PE)	6 - 7

From above information the best suited material for the system is PVC, which has more durability. And after PVC pipe material galvanized steel pipe materials are best suited, which has low cost and more thermal conductivity.

3.2 Fundamental truth of the earth to air heat exchanger (EAHE)

The fundamental truth of the EAHE shows that a pipe or some pipes are buried in underground, the initial end of the pipe with interconnected network (the inlet) exists as the entrance for outside ambient air, similarly the end next to the inlet of the interconnected network (the outlet) results air to the situated on of a building. Surroundings related air is sent into the inlet pipe, the air passing through the pipe by exchanging heat with the pipe walls where they are in physical touching with the underground a particular geographical area in surrounded to it. Likewise, heat is passed from the surrounding soil by using conduction through the pipe wall and convection with the tunnel air, the air is tempering as it flows through the pipe.

3.3 System Design

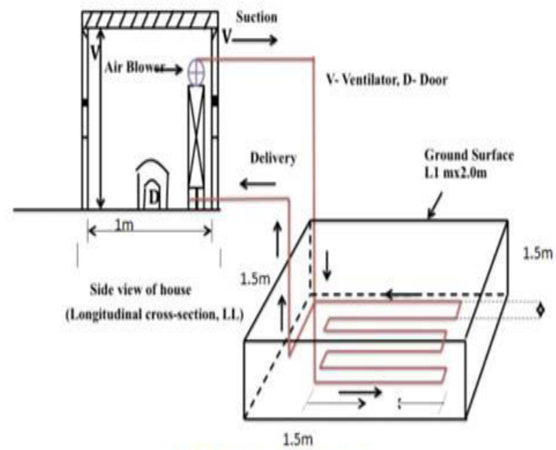

Figure 3.1 system design

3.4 Working Procedure

· Digging of hole is done as per required dimensions 4x6x6fts.

· GI pipes are brought and its connections are made.

· Air blower brought of 40 watts

· Cutting of GI pipes as per design

·Fixing the elbows

· Finally we made all the connections as per system design

·We need to fix the insulation properly and run the system.

3.5 Materials Required

Air blower : 1 number.

GI pipes : 24 m length.

Reducer : connection between the blower and GI pipe.

Elbows : required for connection of pipes in system design. Insulation : for the GI pipes to reduce heat losses.

Thermocouple : for measuring the inlet and outlet temperature.

3.6 Experimental setup details

The installation is at mechanical engineering laboratory of Kakatiyauniversity college of

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engineering and technology. The soil was tested at site and was found to be (sand 43%, silt 41%, clay 16%)sandy-silt. At the time of excavation, the moisture content was 10.61% (db). Experimental implimentation consists of an EATHE, fan house, temperature sensors. The setup of the EATHE with different views at mechanical engineering laboratory of Kakatiya university college of engineering and technology is shown in figure.

Figure 3.2 Design of Galvanized steel pipe system

Figure 3.3 Design of PVC pipe system.

Figure 3.4 Blower.

Figure 3.5 Insulation for Galvanized steel pipes

4. RESULTS AND CONCLUSIONS

4.1 Results

Cooling mode tests were carried out during the month of March onwards. The system turned on at 10am and worked for 7hours continuously till 4pm. Temperature readings were noted for consecutive hours like (10,12am etc)

Table 4.1 Observation table of Earth Air Tunnel Heat Exchanger (OBSERVATION TABLE)-U-PVC

S.no	DATE	TIME	INLET TEMP(HOT AIR)	OUTLET TEMP(COOL AIR)	TEMP DROP	EFFECTIVE NESS
1	02-03-2019	10.30 AM	37	32	5	0.41
2	02-03-2019	1.00 PM	39	33	6	0.42
3	02-03-2019	3.30 PM	38	33	5	0.38
4	07-03-2019	11.00 AM	37	34	3	0.25
5	07-03-2019	3.30 PM	38	34	4	0.31
6	11-03-2019	10.30 AM	39	34	5	0.35
7	11-03-2019	3.45 PM	36	32	4	0.36
8	14-03-2019	11.30 AM	37	30	7	0.58
9	14-03-2019	2.30 PM	39	31	8	0.57
10	19-03-2019	11.00 AM	37	31	6	0.50
11	19-03-2019	2.45 PM	39	32	7	0.50
12	20-03-2019	10.30 AM	38	30	8	0.61
13	20-03-2019	4.00 PM	39	33	6	0.42
14	21-03-2019	10.30 AM	37	30	7	0.46
15	21-03-2019	2.30 PM	39	31	8	0.50
16	25-03-2019	10.30 AM	37	31	6	0.50
17	25-03-2019	2.30 PM	39	32	7	0.52
18	27-03-2019	11.00 AM	37	31	6	0.50
19	27-03-2019	3.00 PM	40	32	8	0.53
20	29-03-2019	12.00 PM	38	29	9	0.60
21	29-03-2019	3.00 PM	40	38	8	0.66
22	02-04-2019	1.00 PM	38	30	8	0.61
23	03-04-2019	11.30 AM	38	30	8	0.61
24	11-04-2019	2.00 PM	40	31	9	0.60
25	16-04-2019	3.30 PM	41	30	11	0.73
26	2-05-2019	10.30 AM	38	32	6	0.46
27	6-05-2019	1.00 PM	40	28	12	0.80
28	07-05-2019	11.00 AM	40	29	11	0.73

Table 4.2 Earth Air Tunnel Heat Exchanger (observation table) by GIpipe

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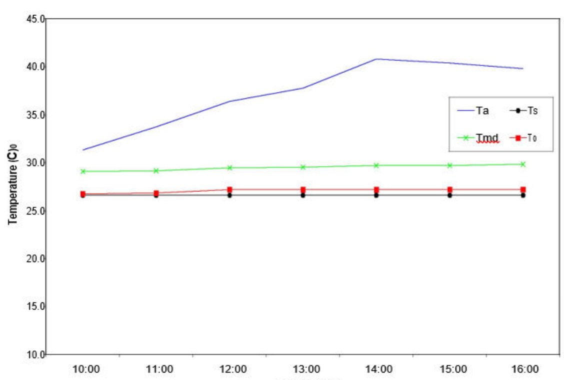
S.NO	DATE	TIME	INLET TEMP (HOT AIR)	OUTLET TEMP(COOL AIR)	TEMP DROP	EFFECTIVENES S S
1	02-03-2019	10.30 AM	37	32	5	0.41
2	02-03-2019	1.00 PM	39	33	6	0.42
3	02-03-2019	3.30 PM	38	33	5	0.38
4	07-03-2019	11.00 AM	37	34	3	0.25
5	07-03-2019	3.30 PM	38	34	4	0.30
6	11-03-2019	10.30 AM	39	34	5	0.35
7	11-03-2019	3.45 PM	36	32	4	0.36
8	14-03-2019	11.30 AM	38	32	6	0.38
9	14-03-2019	2.30 PM	39	32	7	0.46
10	19-03-2019	11.00 AM	39	33	6	0.48
11	19-03-2019	2.45 PM	38	32	6	0.49
12	27-03-2019	3.00 PM	39	32	7	0.51
13	29-03-2019	12.00 PM	38	30	8	0.57
14	29-03-2019	3.00 PM	39	32	7	0.55
15	02-04-2019	1.00 PM	38	30	8	0.61
16	03-04-2019	11.30 AM	38	30	8	0.61
17	11-04-2019	2.00 PM	39	31	8	0.60
18	16-04-2019	3.30 PM	39	32	7	0.58
19	2-05-2019	10.30 AM	38	32	6	0.46
20	6-05-2019	1.00 PM	40	32	8	0.62
21	07-05-2019	11.00 AM	40	33	7	0.60

The ambient temperature started at 28 degrees, rises up to 41 degrees at 2pm (peak temperature) but with the help of EATHE we can maintain room temperature as 28 degrees. The system performance is determined by temperature drop and effectiveness of heat exchanger.



Graph.1 Air temperature inside EATHE and soil temperature

4.2 Conclusion

1. The earth air heat exchangers are intended result passive cooling/heating technique for buildings, industries etc. The effect of four parameters pipe length, pipe radius, air flow velocity and depth of burial on the performance of eathe was studied. The eathe system has higher potential for summer cooling compared to winter heating. Therefore, the parametric analysis was carried out only for summer cooling and following conclusions were made.

·As we concluded that the U-PVC pipes having high effectiveness compared to the Galvanized iron (GI) pipe.

2. As the pipe length increases, the decrease in outlet air temperature can be observed from EATHE. Here the air temperature decrease was sharp for initial 10 meters (pipe length) and then became average in amount. So, promoting the pipe length to above20-30m was not because any notable rise in working and promotions began to be steady. These indicated values could be optimal design values. And these values for the dry and hot atmospheric levels.

3. And as the pipe diameter increases, through which air temperature of EATHE also increases. Because the convective heat transfer coefficient at inner surface of pipe decreases as well as overall heat transfer coefficient at earth pipe meet and interact also decreases at higher pipe diameters as usually.

4. As the increase in the depth of pipe burial, outlet air temperature of EAHE interconnecting network decreases. So, pipes of EAHE system used to indicate what are probables are installed as deeply as possible. But it increases excavation cost. So, it is informed to place pipe depth burial about 2m. It is of in order to limit the initial/installation orcost to start of EAHE system.

5. With increase in air flow velocity, the outlet air temperature of EAHE system increased. This is because of, the time of

ground to air contact is reduces as the air flow velocity is increased. The performance of EAHE cannot be increased only by decreasing the air flow velocity because the cooling capacity of EAHE system depends both on air flow velocity and temperature things are dissimilar. So, both air flow velocity and temperature things are dissimilar should be thought about carefully at the same time.

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