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An Analysis of Air Conditioner Using Earth Tube Heat Exchanger

Mansha kumari[1], Dr. A.S. Mohite[2]
[1] Assistant Professor, Mechanical Engineering Department, Vadodara Institute of Engineering College, Kotambi, Gujarat, India
[2] Associate Professor, Faculty of Engineering, Maharaja Sayajirao University, Vadodara, Gujarat, India

Abstract- **The objective of this research paperwork is to study the performance of air conditioner using earth air tunnel heat exchanger, as Power consumption is a major concern in Air Conditioner. The concept of experimentally study of air conditioner, using earth air tunnel heat exchanger (EATHE) can be done to evaluate the performance of the system [6]. The ground can be used as a heat sink for cooling in the summer and as a heat source for heating in the winter. The air thus cooled or heated can be used directly for the conditioned space. The EATHE's are considered as one of the most passive system due to its ability to provide both the effects; heating in cold months and cooling during warm months. The aim of this work is to investigate the possibility of reducing the operational energy of typical house without negatively affecting its embodied energy. This is done through consideration of different building materials coupled with the use of an earth to air heat exchanger (EAHE) for fresh air supply and cooling. A single pass earth-tube heat exchanger (ETHE) was installed to study its performance in cooling and heating mode. ETHE consists of a 10.36 m long ½ inches diameter Aluminium and Copper pipe with wall thickness of 3 mm respectively. Fins are made of thin GI plate placed over the pipe and then spot welded at several points. There are 25 fins per 0.5 m length of pipe. A 1 m wide, 3.19 m deep and 1 m long trench was first excavated by a bucket excavator Ambient air is pumped through it by a 400 w blower. Air velocity in the pipe is 11 m/s. Air temperature is measured at the inlet of the pipe, in the middle and at the outlet by thermistors placed inside the pipe. This arrangement can improve the Air Conditioning effect.**

Index Terms- **Earth tube heat exchanger, air tunnel, copper pipe, air conditioner.**

I. INTRODUCTION

The Energy consumption of buildings for heating and cooling purpose has significantly increased during the decades. Air conditioning system is widely employed for the comfort of occupant as well as the industrial productions. It can be achieved effectively by vapour compression machines, but due to the depletion of ozone layer and global warming by using chlorofluorocarbons and the need to minimize high grade energy consumption various passive techniques are now a day's introduced, one such method is earth air heat exchanger. An earth air heat exchanger consist in one or more tubes lied under the ground in order to cool in summer or pre-heat in winter air to be supplied in building.

II. WORKING PRINCIPAL OF EARTH TUBE HEAT EXCHANGER

In Earth Air Tunnel Heat Exchanger Earth acts a source or sink. High thermal inertia of soil results in air temperature fluctuations being dampened deeper in the ground. It Utilizes Solar Energy accumulated in the soil. Cooling/Heating takes place due to a temperature difference between the soil and the air. Performance of Earth Air Tunnel also impacted by the thermal conductivity of soil [4]. Soil temperature, at a depth of about 3 m or more, stays fairly constant throughout the year, and is approximately equal to the average annual ambient air temperature. The ground can, therefore, be used as a heat sink for cooling in the summer and as a heat source for heating in the winter [5]. A simple method of using this concept is to pass air through an underground air tunnel as shown in figure 1. The air thus cooled or heated can be used directly for the conditioned space or indirectly with air conditioners or heat pumps.

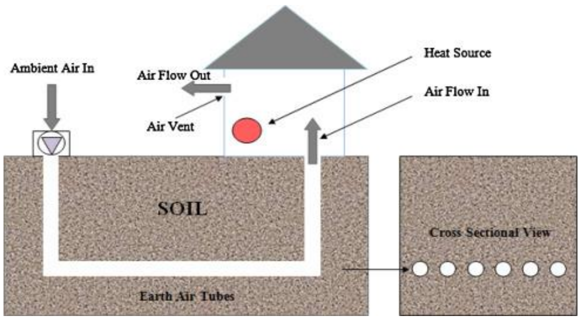

Fig -1: Earth tube heat exchanger [9]

III. TYPES OF EARTH TUBE HEAT EXCHANGER

A. Open type Earth tube heat exchanger: In open system ambient air passes through tubes buried in the ground for preheating or pre-cooling and then the air is heated or cooled by a conventional air conditioning unit before entering the building [1], [2] as shown in figure 2.

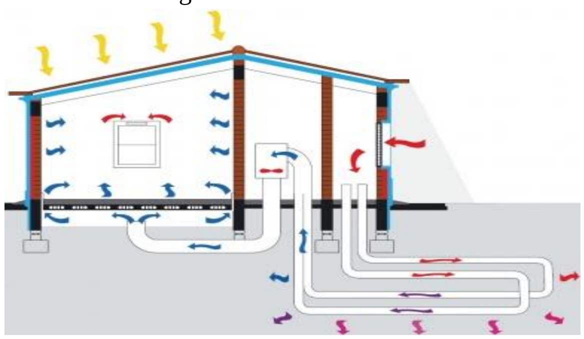
Fig 2: Open type earth tube heat exchanger [8]

B. Closed type Earth tube heat exchanger : In this case heat exchangers are located underground, either in horizontal, vertical or oblique position, and a heat carrier medium is circulated within the heat exchanger [3], transferring the heat from the ground to a heat pump or vice versa as shown in figure 3.

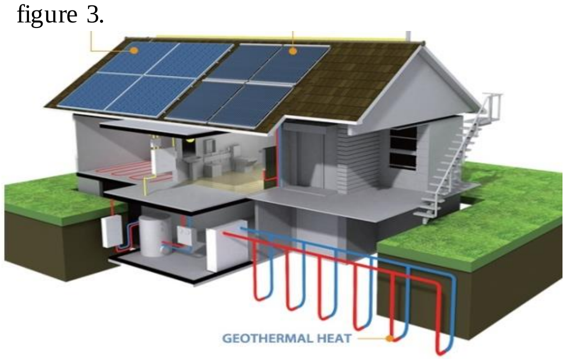

Fig 3: Closed type earth tube heat exchanger [10]

IV. DETAIL DESIGN OF EARTH TUBE HEAT EXCHANGER

ETHE consists of a 10.36 m long ½ inches diameter Aluminium and Copper pipe with wall thickness of 3 mm respectively as shown in figure 4. Fins are made of thin GI plate placed over the pipe and then spot welded at several points [11]. There are 25 fins per 0.5 m length of pipe. Fins are 3 mm wide, 2 mm thick. A 1 m wide, 3.19 m deep and 1 m long trench was first excavated by a bucket excavator which as be shown in figure 5. Trench floor was properly leveled and a 15 cm thick bed of sand placed on it. ETHE was then placed on it and covered with sand up to about 15 cm above it. After that trench was back-filled with the original soil. The inlet and outlet of the ETHE rise 0.5 m above ground. There are 4 temperature sensors are placed on the tube. The temperature sensors consist of a 0.20 m, 3.5 m, 3.43 m and 0.20 m long, 20 mm diameter PVC tube on which sensors are mounted respectively on inlet, middle and outlet of the pipe. Sensors are put through a hole on the tube and protrude outside about 5 mm. Probe has sensors (RTDs - PT 100) [7]. The ambient air sensor is shaded to protect it from the direct sun. Sensors are connected to a common digital indicator with a selector switch. Calculation for aluminum and copper pipe has shown in table 1 and 2 respectively.

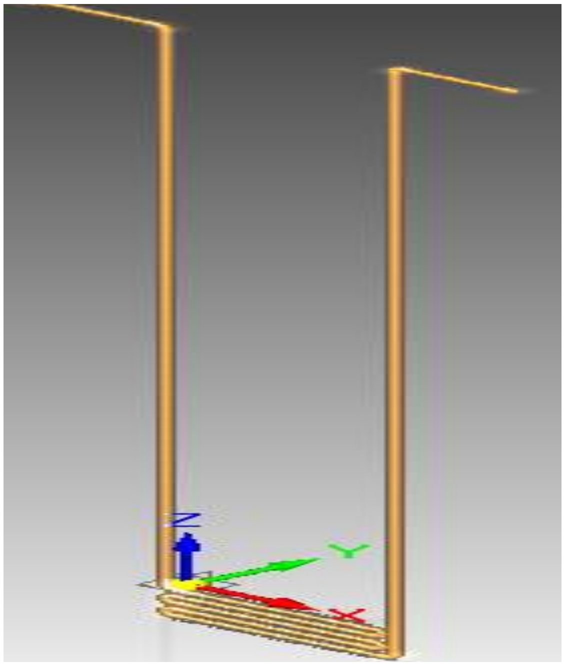

Fig 4: Experimental earth tube heat exchanger

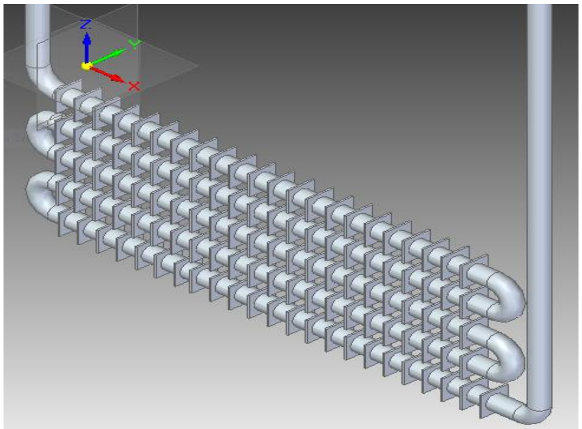

Fig 5: Fins at the ETHE

Heat loss due to conduction from the pipes are given by the equation

$$Q = \frac{K.A.\Delta T}{L}$$

Where,

K=thermal conductivity of pipe material A= Cross sectional area L= length of the pipe buried in the soil

ΔT = Temperature difference between ambient and inside soil temperature.

By performing the calculation with temperature difference, thermal conductivity, length of the pipe buried inside the soil, cross sectional area, we found the heat loss from the copper as well as aluminium pipe.

Diameter of pipe (d) =0.012m, Length of the pipe= 2.68 m, then area of the pipe is given by the following:

Area of the pipe A = pi * d * L = 3.147 x 0.012 x 2.68 = 0.1009824 m^2

$$Q = \frac{K.A.\Delta T}{L}$$

$$Q = \frac{205 * 0.1009824 * 1}{2.68} = 7.7244 \text{ W}$$

Sr. No	ΔT (℃)	K (W/ m k)	L (m)	A (m^2)	Q (W)
1	1	205	2.68	0.1009824	7.7244
2	2	205	2.68	0.1009824	15.4488
3	3	205	2.68	0.1009824	23.1732
4	4	205	2.68	0.1009824	30.8976
5	5	205	2.68	0.1009824	38.622
6	6	205	2.68	0.1009824	46.3464
7	7	205	2.68	0.1009824	54.0708
8	8	205	2.68	0.1009824	61.7952
9	9	205	2.68	0.1009824	69.5196
10	10	205	2.68	0.1009824	77.244

Table 1: Heat loss for Aluminium Pipe.

Similarly for Copper pipe, Sample Calculation is given by following formulas:

Diameter of pipe (d) =0.012m, Length of the pipe= 2.68 m, then area of the pipe is given by the following:

Area of the pipe A = pi * d * L = 3.147 x 0.012 x 2.68 = 0.1009824 m^2

$$Q = \frac{K.A.\Delta T}{L}$$

$$Q = \frac{401 * 0.1009824 * 1}{2.68} = 15.10968 \text{ W}$$

Sr. No	ΔT (℃)	K(W/m k)	L (m)	A (m^2)	Q (W)
1	1	401	2.68	0.1009824	15.10968
2	2	401	2.68	0.1009824	30.21936
3	3	401	2.68	0.1009824	45.32904
4	4	401	2.68	0.1009824	60.43872
5	5	401	2.68	0.1009824	75.5484
6	6	401	2.68	0.1009824	90.65808
7	7	401	2.68	0.1009824	105.76776
8	8	401	2.68	0.1009824	120.87744
9	9	401	2.68	0.1009824	135.98712
10	10	401	2.68	0.1009824	151.0968

Table 2: Heat loss for Copper pipe.

V. CONCLUSIONS

In this paper the performance of earth air heat exchanger system was investigated. If the length of the pipe is so small and the blower with high flow rate then the system is useless because the temperature difference between inlet and out let is very less. The material of pipe is not affected in the output result. If cooling or heating rate is more achieve, then the length of pipe kept at least 100 m and blower some around 400W. Based on the results it can be stated that ETHE holds considerable promise as a means for cooling or heating ambient air for a variety of applications such as the livestock buildings and green houses. By comparing aluminium and copper pipe for heating and cooling it has been observed that copper pipe is more suitable for cooling rather than aluminium pipe.

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