EARTH TUBE HEAT EXCHANGER (ETHE)

PROF.SANTOSH ALONE[1] CHETANA LANJEWAR[2], ANUJ MALEWAR[3], KULDIP KANEKAR[4],ABHIJIT ROKDE[5],
KAMLESH KHOBRAGADE[6]
PROFESSOR&STUDENTS
OF
MECHANICAL ENGINEERING DEPARTMENT
MADHUKAR RAO PANDAV COILLEGE OF ENGINEERING, BHILEWADA, BHANDARA, MAHARASHTRA, INDIA

Abstract

Earth tube heat exchanger systems can be used to cool the building in summer climate and heat the buildings in winter climate. In a developing country e.g. India, there is a huge difference in demand and supply of electricity and rising electricity prices have forced us to look for cheaper and cleaner alternative. Our objective can be met by the use of earth tube heat exchangers and the system is very simple which works by moving the heat from the house into the earth during hot weather and cold weather. Measurements show that the ground temperature below a certain depth remains relatively constant during the year.

Keywords - *EUT, ETHE, Earth Tube, Air.*

1.Introduction

Saving energy is one of the most important global challenges. A large portion of the global energy supply is used for electricity generation and space heating, having the major portion derived from fossil fuels. It is nonrenewable resources and their combustion is harmful to the surroundings, during the manufacture of greenhouse gases, which effects the climate change and additional pollutants. Fossil fuel exhaustion along with pollutant emissions and global warming are important factors for sustainable and environmentally benign energy systems. These concerns have motivated efforts to reduce society's dependence on nonrenewable assets, by dipping demand and substituting choice energy sources. First of all efforts are focused on producing electricity with higher efficiency.

ETHE can be used for providing a clean way in heating and cooling to the residential and commercial buildings. Normally using this source of energy is considered a renewable energy which is stored in the ground, being most efficient. ETHE is suitable for various types of buildings and environmentally impacts many projects. Heat collecting pipes in a loop, which pass air in tubes, are used for extracting stored energy from the ground. Hence to provide heating or cooling to the space, the simplicity, low operation and maintenance cost are the main advantages of this type of the system as well as it is environmentally friendly

The main idea of passing air through underground chambers or tubes to obtain a heating effect could be a pretty proposal. Up to date there are hundreds of systems which were constructed. In fact, the climates of the different locations are different and also the soil properties vary from one location to another. Therefore, practically it is imperfect to use the same design for different locations, because each location has particular specifications. Heating tubes are long and buried underground. Air is drawn in plastic pipes or different metal pipes. The good proposal for achieving heat from surrounding soil which can be done by the air routes through the pipes entering to the zone as a source of heating or cooling air. This will be available only if the soil soundings under the earth are by several degrees warmer than the ambient inlet air. In summer, if there is a suitable thermal design of the system, in the buildings the mechanical and air-conditioning units can be reduced in the capacity which leads to reduce the energy consumption and operation cost. A lot of experimental and theoretical studies have been implemented on the ETHE for air conditioning purposes and for different climatic conditions.

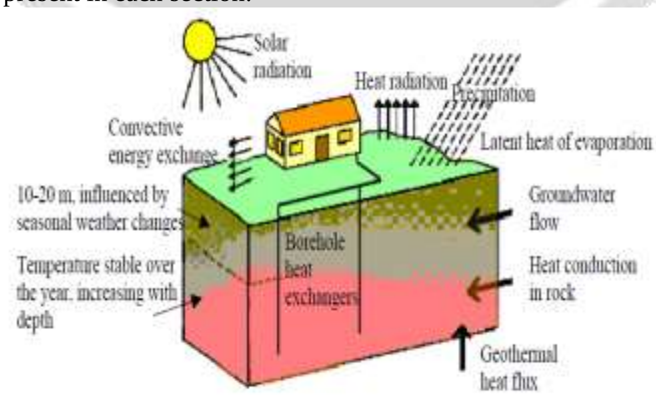
2.LITRETURE REVIEW

The most commonly used systems to obtain comfort in residential buildings, offices, etc. is the conventional air conditioning system. The working principle of air conditioning system is to condition the air, transport it and introduce it to conditioned space. Air conditioning system uses a large amount of energy and also causing depletion of ozone layer due to the emission of CFCs. The Kyoto Protocol given by United Nations Framework Convention on Climate Change (UNFCCC) emphasizes on the reduction the greenhouse gases emission.. In order to reduce the consumption of energy passive techniques are introduced in HVAC installations. One such passive technique is EAHE that uses earth as the heat sink. Air is the transfer medium for summer cooling and winter heating. When air flows through the pipes heat exchange between air and earth takes place. This concludes that the temperature at outlet is higher/lower than the ambient temperature.

Many ancient Greeks, Persians and Iranian Architects have used this technology indirectly. Wilkinson in the 19th century designed a Barn; in order to cool the barn during summer time he buried a 500ft underground passage. As mentioned earlier Iranian architects also used underground air tunnels and wind towers for passive cooling. For many decades ETHE system has been used as a conjunction with solar chimneys or with air conditioning system. ETHE system is probably the most growing alternative renewable energy in the world. With increasing demand for energy savings, places like Europe, Germany have grown its market widely in the recent years. A 10% increase has been seen in installations in about 30 countries over the last 10 years. Places like South Algeria where four fifth of the land is desert which has a dry desert climate, where during summer maximum temperature rises to 45°C and during winter temperature lower below 1°C, the ETHE system cannot be used all alone . Under this condition ETHE system is made conjunction with air conditioning system.

3. GROUND THERMAL BEHAVIOUR

The use of direct or indirect earth-coupling techniques for buildings and agricultural greenhouses requires knowledge of the ground temperature profile at the surface and at various depths. The ambient climatic conditions affect the temperature profile below the ground surface and need to be considered when designing a heat exchanger. Actually the ground temperature distribution is affected by the structure and physical properties of the ground, the ground surface cover (e.g. bare ground, lawn, snow etc.), the climate interaction (i.e. boundary conditions) determined by air temperature, wind, solar radiation, air humidity and rainfall. The temperature distribution at any depth below the earth's surface remains unchanged throughout the year with the temperature increasing with depth with an average gradient of about 30 °C/km. The geothermal gradient deviations from the average value are, in part, related to the type of rocks present in each section.



4. GROUND COUPLED HEAT EXCHANGER

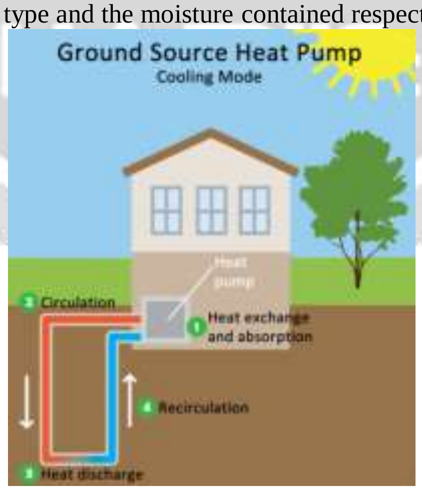
A ground coupled heat exchanger is an underground heat exchanger that can capture heat from and dissipate heat to the earth. They utilize the earths close to constant profound temperature to warm or cool air or other fluids for suburban,

Farming or manufacturing uses. They are also called earth tubes or earth-air heat exchangers or ground tube heat exchanger. Earth tubes are often a viable and economical alternative or supplement to conventional central heating or air conditioning systems since there are no compressors, chemicals, burners and only blowers are required to move the air. These are used for either partial or full cooling and their use can help building meet passive house standards.

Earth tubes are low technology, sustainable passive cooling heating systems utilized mostly to preheat a dwelling's air intake. Air is either cooled or heated by circulating underground in horizontally buried pipes at a specified depth. Specifically air is sucked by means of a fan or a passive system providing adequate pressure difference from the ambient which enters the building through the hidden pipes. Due to earth properties the air heat at the pipe outlet maintains moderate values all around the year. Temperature fluctuates with a time lag (from some days to a couple of months) mainly relative to the profundity careful. Hotness values stay usually in the comfort level range (15-27 °C). This technology is not recommended for cooling of hot humid climates due to moisture reaching dew point and often remaining in the tubes. However there are southern European Coastal regions as in Greece where the climate remains hot and dry. In such locations these systems could have impressive results.

5. GROUND HEAT TRANSFER MECHANISM

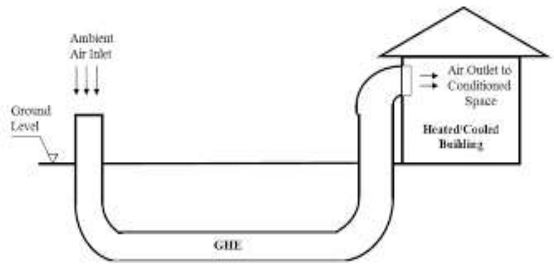
The temperature field in the ground is influenced by different quantities Absorption of the solar radiation depends on the ground cover and color, while the long wave radiant loss depends on soil surface temperature the net radiant balance between solar gain and long wave loss is usually positive in summer and unhelpful in winter. This causes warm to run down from the outside into the ground in the summer and upward to the surface through the winter. The grid radiant stability also determines the dealings between the averages of the earth surface and the ambient air temperatures. By shading the soil in summer while partially exposing it to the sky in winter, for example, with trees, it is possible to lower the ground temperature in summer to a greater extent while possibly increase the ground temperature in winter somehow. The performance of ground coupled air heat exchanger is directly related to the thermal properties of the position. The land has thermal properties that give it an elevated thermal inertia. The heat transfer mechanisms in soils are, in arrange of significance: conduction, convection and radiation. The temperature field in the ground depends on the soil type and the moisture contained respectively.



6. TYPES OF GROUND COUPLED HEAT EXCHANGERS

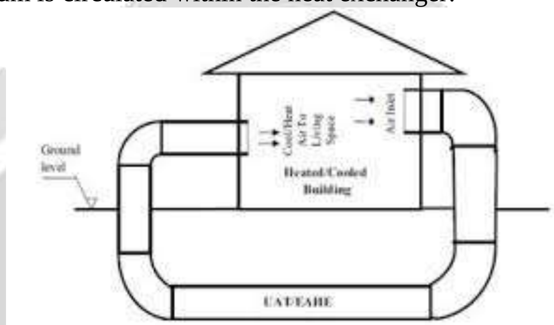
1. Open systems:

In open systems, ambient air passes through tubes buried in the ground for preheating or pre-cooling and fresh fluid is circulated through the ground loop heat exchanger. This system provides ventilation while hopefully cooling or heating the building's interior.



2. Closed Systems:

In closed systems, both the ends of the pipe are kept inside the control environment, which can be a room in case of air and a tank in case of water, the system is said to be closed loop because the same fluid is passed continuously over and over through the loop. Closed type ground heat exchangers can be either in parallel, straight up or tilted position and a heat carrier medium is circulated within the heat exchanger.



7. SELECTION OF MATERIAL

The tube is the main element of ETHE. There are certain properties we have to take into consideration while finalizing the tube material. Tube material must have good thermal conductivity, strength, corrosion resistance, durability, and the cost of the tube material. Various factors need to be considered while deciding upon the material of the pipe for this system. There can be many options while selecting the material of the pipe to be used with the system. As the pipe has to be buried underground, it is not easy to replace the pipe often. Hence the longevity of the pipe is of utmost importance while taking care of the heat transfer characteristics of the system. There was a wide range of materials available for the selection for use in our system.

- **Mild Steel (MS)**
- **Copper**
- **Aluminum**
- **Poly-vinyl Chloride (PVC)**

Mild steel - Steel has one of the lowest thermal conductivity values of all metals, making it an ideal material to use in high-temperature environments such as vehicle or airplane engines. Thermal conductivity describes the rate at which thermal energy is transported through a material. This rate is measured in Watts per Meter per degrees Kelvin (W/(mK). A high thermal conductivity material can transport heat more quickly and efficiently than a material with low thermal conductivity.

8.CONSTRUCTION

Steel tube pipe

Steel has one of the lowest thermal conductivity values of all metals, making it an ideal material to use in high-temperature environments such as vehicle or airplane engines. Thermal conductivity describes the rate at which thermal energy is transported through a material. This rate is measured in Watts per Meter per degrees Kelvin (W/(mK). A high thermal conductivity material can transport heat more quickly and efficiently than a material with low thermal conductivity.

Poor thermal conductors, such as steel, carry heat very slowly and are ideal materials to use as insulators. Most metals display a high thermal conductivity and contain many fast-moving electrons, primarily responsible for conducting heat. The thermal conductivity of steel is measured at approximately 45 W/(mK), which is extremely low compared to copper and aluminum that exhibit a thermal conductivity value of 398 W/(mK) and 235 W/(mK) respectively.

Blowers:
Blowers can achieve much higher pressures than fans, as elevated as 1.20 kg/cm2. They are too used to manufacture negative pressures for industrial vacuum system. The centrifugal blower & the optimistic displacement blower are two main types of blowers, which are described below

Soil
Thermal conductivity ranged from 0.58 to 1.94 for sand, from 0.19 to 1.12 for sandy loam, from 0.29 to 0.76 for loam, and from 0.36 to 0.69 W/m K for clay loam at densities from 1.23 to 1.59 g cm(-3) and water contents from 1.4 to 21.2%.

The **thermal properties of soil** are a component of soil physics that has found important uses in engineering, climatology and agriculture. These properties influence how energy is partitioned in the soil profile. While related to soil temperature, it is more accurately associated with the transfer of energy (mostly in the form of heat) throughout the soil, by radiation, conduction and convection.

Table

We fabricate the table as a experimental setup . this table consist the blower assembly , soil , heat exchanger and house modal , this table is 5*3*2 ft in size

9.WORKING OF ETHE

The concept of earth tube heat exchanger (ETHE) is very simple as. The ambient air is drawn through the pipes of the ETHE buried at a particular depth, moderated to EUT, and gets heated in winter and vice versa in summer. In this way, the heating and cooling load of building can be reduced passively. We are using open loop system for our project. By using aluminum tube, blower, soil. The earth–air heat exchanger is one of these promising techniques which can effectively be used to preheat the air in winter and vice versa in summer. The temperature of earth at a depth of 1.5 to 2 m remains fairly constant throughout the year. This constant temperature is called earth's undisturbed temperature (EUT). The EUT remains higher than ambient air temperature in winter and lower than ambient air temperature in summer. The air will be supplied from the aluminum tube with the help of blower. The aluminum tube is dipped in soil. In one end we are connected the blower and other end are connected to home or structure.
In summer the atmospheric hot air from blower will be supplied to the aluminum tube. In summer earth is cool in depth so the hot air in the aluminum tube will be converted to cooled air with the help of earth cooling. As some in winter session the atmospheric cold air will be supplied from blower to the aluminum tube. In winter the earth are hot in depth so the cold air will be converted in hot air by using earth hotness.

10.CALCULATION

The coefficient of performance (COP):
Coefficient of performance is one of the measures of heat exchanger efficiency. It is defined :
COP = Q/Win

Q = ma Cp (Ti –To)
cp = Specific heat of air (J / kgC)
Qout = Rate at which heat is exchanged between hot air and cooler soil
Wi = Rate of energy input into the heat exchanger(energy used by blower)
ma = Mass flow rate of (kg / s)
Ti = Temperature of air entering the tube (oC)
To =Temperature of air at the outlet (oC)

For Summer Season
Qc = mCp(Tinlet – Toutlet)
For winter Season
Qc = mCp(Toutlet –Tinlet)
where m= mass flow rate of air through the pipe
Cp= specific heat capacity of air

Tinlet= inlet temperature of air
Toutlet= outlet temperature of air
Coefficient of performance (COP) of the system has been calculated from the following expression:
For Summer Season

COP = mCp(Tinlet – Toutlet)/ Power Input

For winter Season

COP= mCp(Toutlet –Tinlet)/ Power Input

11.FUTURE SCOPE

• The blower with variable running speed should be used.
• Theoretical model should be developed to predict the temperature of soil per meter depth of soil and effect of moisture content in the soil.
• This system will be tested for different length and different diameter of pipe.
• For further study humidity 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.

12.ADVANTAGE AND DISADVANTAGES

ADVANTEGES

1. The ground heat exchangers are very simple to use and easy to maintain.
2. In the long run, the low maintenance cost and the electricity cost saving make up for the initial investment.
3. Ground heat exchangers uses only the energy stored in the earth and have no harmful impact on the environment.

DISADVANTEGES

1. High initial investment cost.
2. Use of ground heat exchangers is recommended in new houses which has excellent insulation and air-tightness.
3. Space requirement is the major hindrance to the adoption of ground heat exchangers.
4. The design and installation of an effective ground heat exchange depends on the local geology and the heating or cooling requirements of the building and to get the benefit of a well-intended system, one desires to ask an expert installer which increases the cost of the system.

13.REFRANCE

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Devika Padwal 1, Tejaskumar Kharva2, Jaiminkumar Bhatt3
1,2Bachlor of Mechanical Engineering *at ITM* Vocational University, Vadodara-391760, Gujarat, India
Assistant professor in Mechanical Engineering Department at ITM Vocational University, Vadodara-391760, Gujarat, India.

7. Design and Development of Earth Tube Heat Exchanger for Room Conditioning
NiyuktiSogale1, Swati Thombare2, Ivy Lopes3, Ashwathi Nair4
Department of Mechanical Engineering
Vidyavardhini's College of Engineering and Technology, Vasai, India
8. Comprative Study Of Earth TubeHeat Exchanger Materials For Cooling Of Air
Shivam Jaiswal1, Omshankar Jhariya2, Anil Verma3, G.R. Selokar41research Scholar, Department Of Mechanical Engineering, School Of Engineering, Sssutms, Sehore2assistant Professor, Department Of Mechanical Engineering, School Of Engineering, Sssutms, Sehore3head Of The Department Of Mechanical Engineering, School Of Engineering, Sssutms, Sehore4registrtar, Sssutms, Sehore
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A. Janssens, Department of Architecture and Urbanism, Ghent University, Belgium M. De Paepe Department of Flow, Heat and Combustion Mechanics, Ghent University, Belgium
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Mr. Nilesh S. Shelar11ME Student,
Prof. S. B. Patil3Associate Professor,
Prof. N. C. Ghuge2 Associate Professor,
Mechanical Engineering Department,
Matoshri College ff Engineering & Research Center
Nasik, Maharashtra India

11. Design And Development Of An Earth Air Tube Heat Exchanger
Kunj M. Chauhan1, Jaykumar G. Prajapati2, Nikunjgiri Y. Goswami3,Sunny N. Patel4 And Krunal N. Patel , 123Bechlor of Mechanical Engineering at Institute of Technology and Management Universe, Vadodara-390510, Gujarat, India
4Masters of Engineering in Metallurgy at The Maharaja Sayajirao University of Baroda,Vadodara-390002, Gujarat, India
Assistant professor in Mechanical Engineering Department at Institute of Technology and Management Universe, Vadodara-390510, Gujarat, India