# STUDY OF EARTH TUBE HEAT EXCHANGER USED FOR AMMONIA WATER VAPOUR ABSORPTION REFRIGERATION SYSTEM

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## ABSTRACT

A ground-coupled heat exchanger or Earth tube heat exchanger is a heat exchanger in which heat interactions takes place between working fluid and earth. They are the most economical and promising alternative to conventional Refrigeration systems. This Review paper presents a Specific literature that deal with Refrigeration purpose technologies using earth tube heat exchanger. Under the depth of 8 to 10 meters the ground temperature which is known as undisturbed temperature, is remains constant throughout the year because of high heat capacity and high insulation potential. The underground temperature at this depth is higher in winter and lower in summer than ambient temperature. In this review papers various design factors and performance parameters are shown. Simulation and Modeling is one of the very useful tools to predict the effect of the operating parameters of earth tube heat exchanger systems. Many study and research are taken in last 30 years on different models and performance parameters. The whole set up is installed at mechanical engineering department of RKDF University Bhopal Madhya Pradesh. This set up is totally eco friendly in nature

**KEY WORDS**: ***Geo Thermal Energy, Earth Tube Heat Exchanger (ETHX), Environment Friendly***.

## INTRODUCTION

Energy conservation is one of the important global challenges. A huge amount of the energy used for power generation and space heating and cooling which is coming from fossil fuels. Fossil fuels are not only non renewable resources of energy but their combustion also harmful for the environment, through the production of greenhouse gases and other pollutants. By using Refrigeration and air heaters for the human comfort, building such as Residential, Institutional or offices have major contribution in energy consumption which impact the environment because of use of CFC and results in global warming. Research and measurements reflect that the underground temperature remains constant at some depth throughout the year because of high thermal inertia of earth which results in no temperature fluctuations at some depth. Heating and cooling of a space can be done. Passive heating and cooling not only provide thermal conform but also consume less energy as compared with active systems. At a certain depth, the ground temperature is always higher than that of the outside atmospheric air in winter and is lower than that of the outside atmospheric air in summer. The temperature difference can be utilised for pre-heating in winter and for pre-cooling in summer by operating an earth tube heat exchanger. Also, a heat pump may be used in winter to extract heat from the relatively warm ground and pump it into the conditioned space. In summer, the process may be reversed and the heat pump may extract heat from the conditioned space and send it out to an earth tube heat exchanger. An earth tunnel heat exchanger is an heat exchanger installed under the earth at some depth that can exchange heat with the earth. Earth tube heat exchangers are often a viable and economical alternative to conventional heating or cooling systems since there is no use of compressors or chemicals. Earth tube heat exchanger uses only blowers to move the air.

## LITERATURE REVIEW

**Georgios Florides and Soteris Kalogirou [1**] had done literature review on earth tube heat exchangers and explained that the temperature distribution of earth is divided in three zones the ground, the first zone is surface zone up to a depth of approximately 1m, the second zone is shallow zone, ranging from 1m to 20 m and the third zone is the deep zone having constant temperature around the year. They suggested that for effective utilization of heat capacity of the earth we need to design a heat-exchanger system in which an array of pipes vertically buried in earth and running along the length of the building. Air or water can be used as circulating fluid to extract heat from earth during winter and summer respectively. Integration of heat pump to the system may also increase the efficiency of the system. In their literature, several calculation models are discussed for ground heat exchangers. One-dimensional models were devised in the first stages which during the nineties were replaced by two dimensional models and in the recent researches three-dimensional systems are considered. Earth tube heat exchangers are classified as open system and closed system.

**Arvind Chel et al [2]** investigated the performance evaluation of earth to air heat exchanger integrated with adobe building for New Delhi composite climate. The following conclusions were made from experiment: The adobe house has considerable energy saving potential for Indian climatic conditions. These adobe houses can be easily adopted for all locations, especially in hot and dry climatic regions of semi-urban and rural areas all over the world for achieving the thermal comfort. The total annual energy saving potential of adobe house for three conditions: (i) before renovation, (ii) after renovation and (iii) with Earth tube heat exchanger for six rooms for renovated adobe house was calculated as

4182kWh/year, 4876kWh/year and 10228kWh/year respectively..

**Kujawa et al. [3]** studied the case of deep geothermal heat plants. These plants operate with one or two-hole systems. A computational model is presented which estimates the temperature of the geothermal water extracted to the earth's surface as well as the temperature of the water injected into a deposit level. The predicted characteristics do not take into account specific working conditions of the systems

**Fabrizio Ascione et al [4]** the energy performances using an earth-to-air heat exchanger for an air conditioned building have been evaluated for both winter and summer season. By means of dynamic building energy performance simulation codes, the energy requirements of the systems have been analyzed for different Italian climates, as a function of the main boundary conditions (such as the typology of soil, tube material, tube length and depth, velocity of the air crossing the tube, ventilation airflow rates, control modes). The earth-to-air heat exchanger has shown the highest efficiency for cold climates both in winter and summer seasons.

**Kyoungbin Lim et al [5]** performed the experiment to measure the thermal performance of ground heat exchanger. Thermal response test using a vertical borehole heat exchanger at two different locations was done. The property of the rock at two regions was same but the value of thermal conductivity and thermal resistance was different, the reason for this was due to the groundwater flow, difference of borehole length and the weather variation during the measured period. Study also concluded that ground temperature remains stable over the borehole depth of 5m.

**Sunil Kumar Khandelwal et. al.[6]** shows the design of earth tube heat exchanger system for an institute library had developed a simple Excel based mathematical model to design the Earth tube heat exchanger system for library of the MNIT Jaipur. Their model helps in determining characteristic dimensions, air flow rate, number of pipes, selection of blower and economic investments in an ETHE system. They also conducted a thermal comfort survey to find the thermal comfort inside the library of MNIT, which is approx 28.6 Degree Centigrade ,quiet near to the temperature obtained through this system. They concluded that ETHE system has huge potential of saving electricity (32-50%) and it can also maintain indoor temperature around 29.5-32 Degree Centigrade The smaller diameter pipes enhance performance of ETHE as compared to large diameter pipes. Mass flow rate of air in the pipe should be around 2-5 m/s. Also in case of multiple pipe arrangement distance between pipes must be around 5 times the diameter of pipe. They also concluded that sandy **wet clay loam** has higher cooling potential than **dry sandy soil**. Pipe material has very little effect on thermal performance.

**Manoj kumar Dubey et. al [7]** perform experiments on earth air heat exchanger system and investigates the results for parallel connection in the summer climate. Their experimental result indicates that temperature difference between inlet and outlet of the pipe at a depth of 1.5 m varies from 8.6 to 4.18 °C at a velocity of 4.1 to 11.6 m/s. They also found that the COP in the parallel connection varies from 5.7 to 2.6 for velocity of 4.16 to 11.2 m/s respectively.

**G.N. Tiwari et. al. [8]** designed an Earth Air Heat Exchanger (EAHE) for Climatic Condition of Chennai, India. In their design the temperature of ground has been validated for climatic condition of Sriperumbudur near Chennai, India to evaluate thermal conductivity and thermal diffusivity of the soil. After the evaluation of thermal conductivity of the soil, they had designed an EAHE for a given dimension of room with optimized values of mass flow rate of air, pipe length, radius of pipe and depth at which heat exchanger to be installed below the surface of the earth. They observed decrease of 5 – 6 Degree Centigrade in the outlet air temperature in summer for different mass flow rate of air, 0.10 m optimized diameter and 21 m optimized length of pipe.

**Fabrizio Ascione et al [9]** conducted experiments at three different cities of **Italy** and evaluate the performance for ground heat exchanger in both summer and winter seasons. They concluded that the ground heat exchanger placed in the wet soil gave the better results than the other two. They use different materials like PVC, metal and concrete for tube construction and concluded that material type has no effect on the performance of the ground heat exchanger. Different mass flow rate of air is used in ground heat exchangers and found that low speed of 8 m/s gives better results as it decreases the pressure drop inside the tubes and energy requirements.

**Vikas Bansal et al [10]** investigated the performance of earth heat exchanger with horizontal pipe for space heating during winter and effect of mass flow rate of air and pipe material are evaluated. A mathematical model was developed to predict the performance of the earth heat exchanger. The 23.42 m long earth tube was used. The heating is in the range of 4.1-4.8 Degree Centigrade for mass flow rate of air of 2-5 m/s. They concluded that the pipe material does not affect the performance of the earth pipe air heat exchanger system so therefore a cheaper material can be used for making the pipe.

**Trilok Singh Bisoniya et. al. [11]** developed a quasi-steady state, 3-dimensional model, based on computational fluid dynamics to evaluate the cooling potential of earth tunnel heat exchanger system. They developed the simulation model in CFD platform CFX 12.0 and they validate the results against experimental observations of set-up installed in Bhopal (Central India). They use air flow velocities of 2m/s, 3.5m/s and 5m/s for the simulation and experimental. They found that the maximum drop in air temperature of 12.9 Degree Centigrade occurred at air flow velocities of 2m/s and minimum drop in air temperature of 11.3 Degree Centigrade occurred at air flow velocities of 5m/s. They built the experimental set-up of EAHE with PVC pipe of length 19.228m and 0.1016m in diameter buried at 2m depth. They finally concluded that EAHE system can be used effectively to reduce cooling load of buildings in hot and dry summer weather conditions.

**Arpit Thakur et. al.[12]** conducted analysis with the help of computational fluid dynamics modeling and simulation considering weather conditions to be hot and dry with ambient temperature of $319^0$K. They analysed the Effect of finned model and finless model on thermal performance. They developed a model having length 60m and diameter 100 mm buried in soil of thermal conductivity of 4 W m-1K-1, consisting 239 fins i.e. pitch of 250mm. They found a temperature drop of 20.5 Degree Centigrade in finned model and a temperature drop of 17.7$^o$C in finless mode.

**W.H.Leong et al [13]** investigate the effect of soil type and moisture content on the performance of ground heat exchanger and found that ground heat exchanger performance depended on the moisture content and the soil type. By varying soil moisture content from 12.5% of saturation to complete dry decreased the ground heat exchanger performance. With the application of a genetic algorithm.

**Rakesh Kumar et al [14]** designed and optimized earth heat exchanger and found the impact of humidity, ambient air temperature, earth surface temperature and earth temperature at depth on the outlet temperature of earth exchanger was investigated through detailed analysis. They concluded that outlet temperature was affected ambient air temperature and earth temperature at depth.

**METHODOLOGY**

The experimental set up is installed at mechanical engineering department in RKDF University Bhopal Madhya Pradesh. This Set Up is made with two parts, One part is Eath Tube Heat Exchanger made with two Iron Pipe Of Diameter 10 Inches and 10 meters inside the earth are used for water heating purpose and second part of single stage Ammonia Water vapour absorption refrigeration system run by boiled water is coming from earth tube heat exchanger. Two Thermocouples are connected at inlet and outlet of the pipes and temperatures of both inlet and outlet side is connected with digital display for taking reading. The Experimental Set Up shown in Figure 1(a),(b)(c) and (d) for taking reading purpose in different season of the two and three years.

**(a)** **(b)**

**(c)** **(d)**

**Fig1. Experimental Set Up of Earth Tube Heat Exchanger (ETHX) Installed at RKDF University (a),(b) (c) (d)**

## CONCLUSION

Various types of earth tube heat exchangers are studied and describe in this review paper.

(1) Earth tube heat exchangers are used to utilize the heat capacity of the soil efficiency and for increasing their efficiency they are coupled to heat pump.

(2) Different models such as one, two and three-dimensional can be found in the paper that simulate the heat transfer process. Mathematical models or Simulation may be used for analysis of system and predicts the performance of earth tube heat exchangers.

(3) It can be concluded that pipe material doesn't affect the performance of Earth Tube Heat Exchanger much whereas the air flow rate and ambient air temperature affects the performance of earth tube heat exchanger greatly.

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