# Expermental Evaluation of Earth Tube Heat Exchanger Cooling of Different Flow Rate of Air – A Review

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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.***

***The temperature of earth at a certain depth about 2 to 3m the temperature of ground remains nearly constant throughout the year. This constant temperature is called the undisturbed temperature of earth which remains higher than the outside temperature in winter and lower than the outside temperature in summer. When ambient air is drawn through buried pipes, the air is cooled in summer and heated in winter, before it is used for ventilation. The earth air heat exchanger can fulfil in both purpose heating in winter and cooling in summer. This paper investigates the experimental studies on earth air heat exchanger system in different flow rate of air.***

***Keywords - Earth Tube Heat Exchanger, Air, blower.***

## I. INTRODUCTION

The consumption of high-grade energy has increased considerably with growing needs to achieve thermal comfort conditions inside buildings, residential, greenhouses, livestock buildings, etc. It is desirable to minimize the use of high-grade energy consumption and to promote the use of renewable energy in order to save the earth from hazardous effects of global warming and ozone layer depletion. Numerous alternative techniques are being currently explored to achieve thermal comfort conditions inside buildings. 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 (Bisoniya et al. 2013). 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 concept of earth–air heat exchanger (EAHE) is very simple as shown in Fig. 1. The ambient air is drawn through the pipes of the EAHE 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.

In the last two decades, a lot of research has been done to develop analytical and numerical models for analysis of the EAHE systems (Mihalakakou et al. 1994; Bojic)et al. 1997; Gauthier et al. 1997; Hollmuller and Lachal 2001; Su et al. 2012; Sehli et al. 2012; Ozgener et al. 2013). The performance analysis of EAHE involved either the calculation of conductive heat transfer from the pipe to the ground mass or the calculation of convective heat transfer from the circulating air to the pipe and changes in the air temperature and humidity. A number of computer modeling tools are commercially available. EnergyPlus and TRNSYS have EAHE modules that work well; however, these are analysis tools and are not quickly used for design.

Presently, Computational Fluid Dynamics (CFD) is very popular among researchers for modeling and performance analysis of the EAHE systems. The CFD employs a very simple rule of discretization of whole system in small grids. Then, governing equations were applied on these discrete elements to get numerical solutions concerning flow parameters, pressure distribution, and temperature gradients in less time and at reasonable cost because of reduced required experimental work (Kanaris et al. 2006; Wang et al. 2007). For complete analysis of an EAHE system, the use of CFD is recommended, but it is limited to those who have a good command over it. For the initial design of an EAHE system, the use of basic heat transfer equations is more suitable to determine the geometrical dimensions of the system. Many researchers like De Paepe and Janssens (2003), Badescu and Isvoranu (2011), and T'Joen et al. (2012) have developed EAHE design equations and procedures. In this paper, the author has developed a one-dimensional model of the EAHE system. The method to calculate the EUT and the more recently developed correlations for friction factor and Nusselt number are used to ensure higher accuracy in calculation of heat transfer.

### 1.1 Analysis and modeling of EAHE

The development of the model of the EAHE system involves the use of basic heat transfer equations. The geometrical dimensions of the EAHE system are decided by taking into account the amount of heating or cooling load to be met for space conditioning of the building. The design procedure includes identifying the input parameters which are known to the user and the parameters affecting desired design output. Once the design output is fixed, the heat transfer equations are manipulated to meet the desired output in terms of input parameters. Therefore, depending on the nature of the design problem the mass flow rate of air, ṁ; inlet air temperature, Tin; desired outlet air temperature from EAHE, Tout; and EUT are considered as parameters of the sizing problem. Furthermore, it is considered that the location of installation of the EAHE system is known. So, ambient air temperature and soil properties are known. The EUT temperature is estimated as the annual average ambient air temperature of a particular location; therefore, it is also assumed as a known parameter. The mass flow rate of air and the outlet air temperature are set by the design requirements. The geometric sizing parameters of an EAHE include the diameter of the pipe, D; length of the pipe, L; and number of pipes in parallel, Np, in the heat exchanger.

## II. LITERATURE RIVIEW

The heating and cooling equipment involved in different domestic and business environments utilize electricity as a major source of energy which comes from the fossils fuels subsequently causing many global environmental problems. This large dependence on the conventional energy for the operation of different cooling equipment has caved in people to look for other cheaper and readily available energy sources. The refrigeration and air conditioning demand using conventional energy can now be reduced to some extent by

using solar energy, biogas, biomass, geothermal energy etc. Different authors have worked on economic and optimization analysis of different types of refrigeration system.

**Enrico Fabrizio, et al. [4]** suggested an integrated system for space cooling and domestic water heating. The study focusses on designing and operation of integrated HVAC and domestic hot water (DHW) production systems. The study includes biomass based HVAC and DHW production systems, solar assisted heat pump (SAHP) systems, typical zeolite/water gas system coupled with a gas condensing boiler with solar supported heating in thermal driven Adsorption heat pumps, Reversible system, Variable refrigerant flow (VRF) system and so on.

**F. Khalid, et al [5]** studied different HVAC systems like natural gas operated HVAC systems, PV system on the basis of efficiencies. In these systems when compared, the energy inputs are the solar and wind energy driven systems are superior to the solar and photovoltaic system, due to the better efficiencies of wind compared to photovoltaic systems. Energy and exergy analyses are performed to assess the performance of heating, cooling and overall systems. FarahKojok, et al. [6] proposed and investigated numerous systems combining different cooling processes. A properly selected hybrid cooling system offers a great reduction in energy consumption and a coefficient of performance improvement

**S.A. El-Agouz, et al. [20]** mentioned about a study regarding novel desiccant air-conditioning system, consisting of a desiccant wheel, fans, evaporative cooler, heat exchangers, electric heater unit to simulate the refrigeration unit and solar energy. The author concluded that by proper implementation of solar energy the coefficient of performance (COP) between 50% and 120%. It also showed that the efficiency is maximum at optimum value of regeneration temperature and rotational speed of the desiccant cooling cycle based on the design condition of the cooling cycle.

A study based on the review of various thermodynamic and economic parameters.

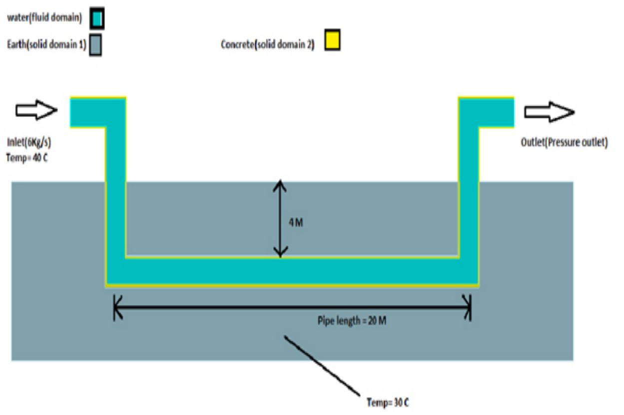
**Conducted by A. Gupta, et al. [1]** suggested that the variation in the evaporator temperature from -3 °C to3 °C decreases the power consumption of compressor by 32.9% due to the decrease in specific volume of refrigerant at the inlet of compressor. An improvement of 0.648 from 0.612 in the overall COP was shown to be achieved with an increment of 6 °C in evaporator temperature.

**Arne Speerforck et al. [2],** stated the study of a combination of indirect evaporative cooling coil and a ground circuit consisting of four bore heat exchangers (BHXs) was done, it showed that the combined system was more efficient than the indirect evaporative cooling coil alone.

However, the focus of this review is to study Geothermal as a source of energy in improving COP and reducing power consumption.

## III. DESIGN AND PERFORMANCE

The GHE is a simple heat exchanger system which requires a pipe or several pipes buried at a certain depth below the ground surface to transfer heat from the air to the ground. One end of the pipe acts as an inlet for the outdoor ambient air and the other end acts as an outlet which releases the air into the conditioned spaces. Outdoor ambient air is drawn into the pipe through the inlet end and travels along the pipe which exchanging the heat with the pipe walls.




The pipe is contacting with the surrounding underground environment makes the temperature of the pipe surface is almost or similar as temperature of the ground at particular depth. This temperature is usually lower than ambient temperature. In this way, heat is transferred to the surrounding soil by means of convection in the air tunnel to the pipe wall and conduction from the pipe wall to the surrounding soil.

The GHE can be designed with both an open-loop and a closed-loop system as shown by Figure 1 and Figure 2 [26, 29]. These systems can be single pipes or several pipes buried below the ground surface. The open-loop design of the GHE has been reported by [29]. The design is simple and there is no complex equipment attached. The closed-loop multi-pipe GHE was reported by [43] for a hot and arid area of India for agricultural application. The system consisted of two tiers with four parallel pipes 20 cm in diameter and 20 m long, each placed at depths of 2 m and 3 m respectively. Paepe and Jenssons [28] designed a GHE based on the definition of heat exchanger effectiveness. Several parameters were studied such as pipe diameter, pipe length, and number of pipes. They also established design maps of the GHE from which proper selection of the design parameters could be made. Other design parameters of the GHE.

## IV. PREVIOUS WORK

Till date the earth tube heat exchanger cooling of air data is available but the various flow rate of air is not available.

## V. PROPOSED WORK

The main focous of my research to find out COP of the system with variable flow rate of air.

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