Earth Air Heat Exchanger Performance in Summer Cooling For Various Supply Air Conditions — A Review

Ravi Ranjan Manjul[1*], Dr.V.N Bartaria[2]

[1*]Research Scholar, Department of Mechanical Engineering, LNCT, Bhopal, (MP), INDIA

[2]Professor & Head, Department of Mechanical Engineering, LNCT, Bhopal, (MP), INDIA

ABSTRACT: *There is a growing interest in heating and cooling systems based on renewable energy. This is the property of earth ground the below about 2.5 to 3 m, the temperature of ground remains nearly constant throughout the year. This constant temperature is called undisturbed temperature of earth. However, a good visualize the undisturbed ground temperature, for a correct interpretation of the geothermal heat exchanger. The undisturbed temperature is very important yourself, which remains higher than the outside temperature in winter and lower than the outside temperature in summer. The EAHEs are considered as an effective passive heating/cooling medium for buildings. It is basically a series of metallic, plastic or concrete pipes buried underground at a particular depth through which the fresh atmospheric air flows and gets heated in winter and supplied to the building if at sufficiently high temperature and vice versa in summer. Until now, many researchers have conducted a series of studies in the development, modelling and testing of systems of the earth. This paper reviews on the experimental, analytical studies and earth air heat exchanger performance in summer cooling for various supply air conditions of EAHE systems around the world.*

Keywords: *EAHE, Summer Cooling, Energy Saving, Earth's Undisturbed Temperature.*

1. INTRODUCTION

The idea of using earth as a heat sink was known in ancient times. In about 3000 B.C., IRANIAN ARCHITECTS used wind towers and underground air tunnels for passive cooling [1, 2]. Underground air tunnels (UAT) systems, nowadays also known as Earth to Air Heat Exchangers have been in use for years in developed countries due to their higher energy utilization efficiencies compared to the conventional heating and cooling system. Earth -air heat exchanger is a system of work that the thermal inertia of the earth for heating / cooling use of buildings, offices, residential, industrial, etc. or another word of earth-air heat exchangers are effective as emphatic substitute for these rated can be used for heating / cooling the building. This is a principally a series of metallic, plastic or concrete pipes immerse below the earth at a particular depth. Energy savings of great thought is everywhere a special challenge in the desert climate. The climate of the desert can be classified as hot and dry and such a condition exists in a number of areas around the world. In general, most people probably when the temperature is between 20 ° C and 26 ° C and a relative humidity is ranging from 40 to 60%.These conditions are often achieved by the use of air conditioners. Air conditioning is widely used for the comfort of the occupants and the industrial productions. It can be effectively achieved by vapour compression machines, but to minimize due to the depletion of ozone layer and global warming by chlorofluorocarbons and the need for high-grade energy consumption various passive techniques are now introduced a day, such a process is the earth-to-air heat exchanger. An earth-air heat exchanger consist in one or more pipe/tubes below the earth about 2.5 to 3 m in order to cool in summer climates and pre-heat in winter climates air to be supplied in a building. The physical phenomena of earth-air heat exchanger is simple the ground temperature or undisturbed temperature of earth generally higher than the outdoor air temperature in winter and lower in summer, so it makes the use of the earth suitable as warm or cold sink respectively. Both of the above uses of earth air heat exchanger can pass to reduction in energy consumption. Several researchers have described the earth-to-air heat exchangers (EAHE) coupled with buildings as an effective passive energy source for building space conditioning. An earth- to-air heat exchanger system suitably meets heating and cooling energy loads of a building. Its performance is based upon the seasonally varying inlet temperature, and out let temperature which further depends on the ground temperature or undisturbed temperature. The performance of the EAHE system depends on the temperature and humidity distribution in the soil, as well as to the surface conditions.

2. WORKING PRINCIPAL OF EARTH TUBE HEAT EXCHANGER

The principle of the basic inertia for heating and cooling using is not a new concept, but a modified concept that goes back to the ancients. This technology has been used throughout history by the ancient Greeks and Persians in the pre-Christian era until recent history (Santamouris and Asimakopoulos, 1996) [3,4,5]. For instance the Italians in the middle Ages used caves called colvoli, to precool /preheat the air before it entered the building. The system, which is currently used, consists of a matrix of on buried pipelines, through the air by a fan / blower. In summer, the supply of ambient air through the tubes to the buildings is due to the fact, cooled, that the undisturbed temperature is lower around the heat exchanger than the ambient temperature. Same as opposite rule of winter climates, the undisturbed temperature is the greater than the ambient temperature and the air gets preheated.

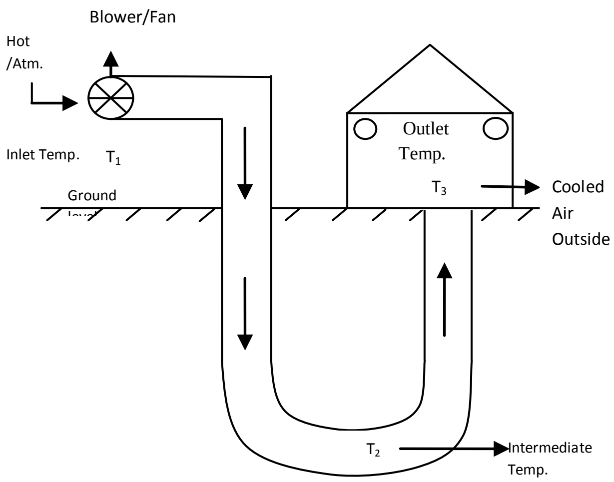

Figure: Earth Air Tube Heat Exchanger System:

3. TYPES OF EARTH TUBE HEAT EXCHANGER

There are two types of heat exchanger

A. Closed type Earth tube heat exchanger
B. Open type Earth tube heat exchanger

A. CLOSED SYSTEM

Air from inside the home or structure is a U-shaped loop of typically 30 to 150 m (100 to 500 ft) blown from tubes, where it will be hosted near ground temperature before over in the house or the structure distribute air ducts returns. The closed loop system may be more effective (while the air temperature extremes) as an open system, as it cools and cools again, the same air. In this case, heat exchangers are arranged underground, either vertical or oblique position, and a heat transfer medium in the heat exchanger circulates in horizontal to transfer the heat from the soil to a heat pump, or vice versa.

- Increases efficiency.
- Reduce moisture problems inside tube condenses.
- Domestic air circulates through the heat exchanger Earth air tube.

B. OPEN SYSTEM

Outside air is drawn from a filtered air inlet. The cooling tubes are typically 30 m (100 ft) long straight pipes in the home. An open system with energy recovery ventilation is combined, can be almost as effective (80-95%) as a closed loop and ensures that fresh air enters, is filtered and tempered. In open systems environment air passes through pipes 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.

- Outside air is drawn into the tubes and air handling units (AHUs) or directly supplied to the inside of the building.
- Hopefully ventilation ensures under cooling or the building interior heating.
- Improves indoor air quality (IAQ).

3. COMBINATION SYSTEM

This can be constructed with dampers, either closed or open to allow operation, depending on the fresh air ventilation requirements. Such a design could also drag in a closed loop, a lot of fresh air, when a drop in air pressure created by a solar chimney dryer, fireplace, kitchen or bathroom exhausts vents. It is better to draw outside air into the air as in the filtered passive cooling pipe.

4. HYBRID SYSTEM

Earth air tube heat exchanger system coupled with another heating / cooling system that can air conditioning, evaporative cooling system or solar air heating. Hybrid systems are being preferred over unitary system due to higher efficiency. Hybrid system could reduce significant amount of power consumption.

5. LITERATURE REVIEW

The heat transfer to and from Earth tube heat exchanger system has been the subject of many theoretical and experimental analysis. By having a review on previous research papers published by many authors we can have an idea on how it works.

Author developed an Enhancement of gas turbine power output using earth to air heat exchanger (EAHE) cooling system. In this work, it is presented new inlet air-cooling system for gas turbine which using EAHE system of passive cooling, for applying this system, at first it should be examined the soil behaviour by predicting the underground soil temperature at different depth along the year and determine the optimum depth for high performance And low economical cost. Longer earth tube and deeply placed with smaller diameter and lower inlet air velocity lead to reducing the outlet air temperature [6]. Author developed the Ground coupled heat exchangers. The use of ground coupled heat exchanger (GCHE) systems is increasing worldwide. They are mainly used for space conditioning, water heating, agricultural drying, bathing, swimming, etc. They reduce cooling load in summer and heating load in winter. GCHE systems make available excellent scope to conserve significant amount of primary energy and thus mitigating the impact on environment through emission reduction. EAHE and GSHP systems are drawing attention of the researchers and designers as they are efficient, economic, environmental friendly and renewable in nature [7]. A developed an Analysis of various designing parameters for earth air tunnel heat exchanger system, EATHE evaporating cooling hybrid system can be used in summer for better result With increasing pipe length decreasing pipe diameter decreasing mass flow rate of flowing air inside buried pipe and increasing depth of ground up to 4m performance of EATHE becomes better [8]. Author developed the Hybrid ground coupled heat exchanger systems for space heating/cooling applications. Hybrid GCHE systems are being preferred over unitary system due to higher efficiency. Review of hybrid GCHE systems concluded that hybrid of EAHE with evaporative cooler could increase cooling effect by 69% and reduce length of buried pipe up to 93.5%. Hybrid system could reduce significant amount of power consumption. DX-GSHP with conventional air conditioning system could reduce power consumption by 15.5% [9]. Author developed an Earth Air Heat Exchanger in Parallel Connection and The experimental results indicates the temperature difference of the inlet section and exit section of the pipe at a of 1.5 m depth in parallel connection and find the maximum temperature difference varies from 8.6 to 4.18 °C at a velocity of varies from 4.1 to 11.6 m/s. Cop in the parallel connection and its value is varies from 5.7 to 2.6 for increase in velocity from 4.16 to 11.2 m/s. ETHE based systems cause no toxic emission and therefore, are not detrimental to environmental and ETHE based systems for cooling do not need water a feature valuable in arid areas like Kutch. It is this feature that motivated our work on ETHE development [10].Author a developed the influence of different ground covers on the heating potential of earth-to-air heat exchangers, an increase in the buried pipes radius leads to a reduction in the convective heat transfer coefficient. This leads to a lower air temperature at the pipe outlet and thus reduces the system′s heating capacity. Moreover, reduced outlet air temperature is associated with increased pipe surface, as the pipe radius increases and Pipe length an increase in the buried pipes length causes outlet air temperature to rise, which means that the systems potential heating capacity may also increase and typical diameters are 10cm to 30cm but may be as large as 1m for commercial buildings [11]. Author developed the Simple and accurate model for the ground heat exchanger of a passive house, the pipe material has little influence on summer and winter performance [12]. Author developed the ground coupled air system, low energy cooling-technology selection. If parallel pipe systems are used, pipes should be kept approximately 1m from each other in order to minimize thermal interaction. Greater spacing was not found to bring any extra benefit [13]. Author developed the earth to air heat exchangers for Italian climates. It is closely related to building use. The most convenient solution for office buildings is to use EAHE through- out the day. Thus, a 15-h day is the best solution and the system should be by past when the outside temperature enters a certain range (for example15–22 1C); the system can be con- trolled by ground temperature or by external air temperature [14]. Author developed the experimental and analytical analysis of earth to air heat exchanger (EAHE) systems. EAHE systems contain buried pipes in various combinations, in open loop as well as in closed loop. Air is blown through buried pipes using a properly sized blower fan installed at the entry or exit [15]. Author developed the Modelling and comparative thermal performance of ground air collector and earth heat exchanger for heating of green house. Tested and developed a model to investigate the thermal performance of an EAHE system coupled with a green house at Indian Institute of Technology, New Delhi, India. It was concluded that green house air temperature increased in winter with reducing pipe diameter and mass flow rate of air, increasing pipe length and depth of buried pipe up to 4m. A fair agreement was found between measured values and predicted values of green house air temperature in terms of statistical analysis i.e. root mean square of percentage deviation and correlation coefficient [16]. Author Developed a Performance analysis of earth– pipe–air heat exchanger for summer cooling and winter heating. an experimental setup of EAHE system in Ajmer in India, which had two horizontal cylindrical tubes of 0.15 m internal diameter, 23.42m buried length of each consisting of polyvinyl chloride (PVC) and Steel, at a depth of

2.7 m buried in flat land with dry soil. It has been found from the experiment that the power of each System was not affected by the material of the buried pipe for winter and summer cooling /heating. Temperature dropped more initial length of underground pipe. Then cost and durability would be the deciding factor for selection of material of pipe. It was suggested that plastic pipes extreme care when filling methods require the pipes against mechanical damage to avoid that as galvanized steel tubes come from mechanical injury, but raise the cost by 25-30% of project. It was also found that it was a fair agreement between the simulated and experimental results [17, 18]

6. CONCLUSION

In this paper the performance of earth air tube heat exchanger system find out and we have observed the following

- The increasing of pipe length, decreasing pipe diameter and decreasing mass flow rate of flowing air inside the buried pipe and earth below the depth up to 4 m then the performance of EATHE becomes better.
- EATHE can be used as replacement for the conventional air conditioning system.
- EATHE is the better result of summer.
- The design of earth air tube heat exchanger mainly depends on the heating / cooling load requirement of a building to be conditioned.
- After calculation of heating /cooling load, the design of the earth air tube heat exchanger only depends on the geometrical constraints and cost analysis.
- The pipe length, diameter of pipe and number of pipes are the main of parameters to be investigated.
- With an increase of pipe length then pressure drop and thermal performance increase.

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