A REVIEW ONPERFORMANCE ANALYSIS OF EARTH-AIR-HEAT-EXCHANGER (EAHE)

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A B S T R A C T

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. 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. This paper presents a review on EAHE systems as well as types of EAHE i.e. open loop and closed loops in detail.

Keywords: EAHE, open loop, close loop, assumptions

1. INTRODUCTION

Energy has been a most important factor for human beings since Stone Age. The use of energy in active cooling systems especially for HVACs in homes building and other recreations has been tremendous. The demand of energy for space cooling is growing day by day, as time goes by in India as well as in other countries of the world, driven by rising income, lowering cost of technology and natural preference of ambient human comfort level temperature. Sales of air conditioners have been increased to 20 percent, mostly in domestic area. In US now almost 87% owns air conditioners, as given by the latest data of the survey from EIA's residential energy consumption. A base case estimate usage of 42 terawatt-hours in 2010 for air conditioners. All that air conditioning does is to throwing the indoor heat out, warming up the outdoors, increasing the greenhouse effect.

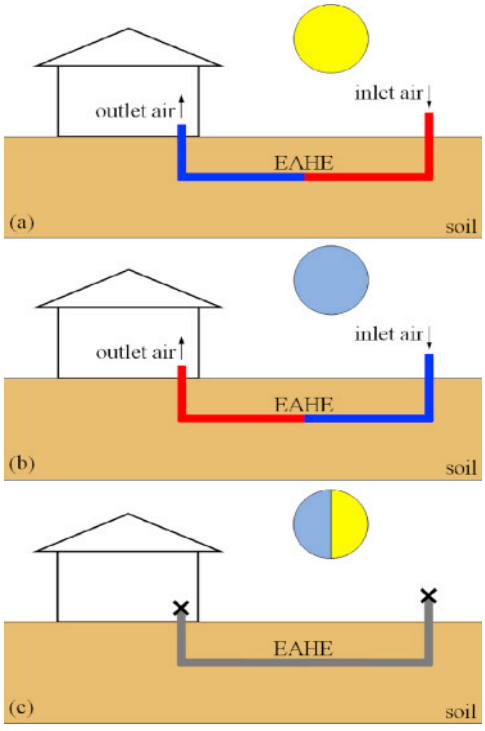

Figure 1. EAHE

Dependency of air conditioners onCFCs, HCFCs and others has increased the effect of global warming too by depletion in ozone layer. All these factslead to changing the source of cooling and most importantly the energy. Earth air tunnel heat exchanger (EATHE) isone such solution to all of the problems mentioned against air conditioners. EATHE is a pipematrix arrangement led underground, in which ambient air is passed. The temperature of soil being lesser than summer air along with the air in winter. This cooled air in summer or hot air in winter is then directed inthe houses or buildings. The temperature of the soil rests unchanged during the whole year after a certain depth, mostlyafter 2.5-3 meters depending upon the geological areas, climatic conditions and soil type.To attain thermal comfort condition several other techniques have been discovered. One of the most agreeing methods is earth-air heat exchanger (EAHE) that can come in use much efficiently to heat the air in winter as well as cooling the air in summer. Throughout the year the temperature of the earth remains constant inside the depth of 1.5 to 2 m (Bisoniya et al. 2013). The temperature of the earth which is not changing is known as earth's undisturbed temperature (EUT).

2. LITERATURE REVIEW

ŁukaszAmanowicz et al. (2018): In this paper the experimentally acquired flow features of multi-pipe earth-to-air heat exchangers (EAHEs) were used to validate the EAHE flow working ability numerical model set by means of CFD software Ansys Fluent.The meshing type resembling cut-cell along with the turbulence model having realizable k-ε equation comprised of coefficient value which is default and helps in advancement in the treatment of wall was utilized. The entire pressure is lost by each and every pipe of multi-pipe exchanger which is examined by both the ways experimentally and numerically.The outcome of each and every pipe of multi-pipe EAHE structure shows that the airflow in each pipe is not equal.For designing of multi-pipe EAHEs properly from the point of view of flow characteristics, the validated numerical model can be used for designing.

SaniAliyu et. al. (2018) For the ventilation under the surface for pre cooling and pre heating through exploring the soil temperature a system has been developed which is known as Earth air heat exchanger (EAHX). The work ability is completely dependent upon the climatic condition and condition of the soil of an earth air heat exchanger. An Earth air heat exchanger (EAHX) has been designed first after that was constructed and later on, it has been installed for the evaluation of its actual working ability has been described in this paper.The outcome of the earth air heat exchanger has recommended that it not adequate on its own for creating the thermal comfort, but it can surely help in the important portion for heating the load.In the cold of Hamadan, when the average was taken for the coefficient of performance (COP) the outcome was 3.2.During the season of winter, the earth air heat exchanger has the ability to increase the cold atmospheric air by 3.40C.

D Darius et. al. (2017) It is very crucial to attain the thermal comfort and ensure it that the thermal work ability of earth air heat exchanger can be study through the parameters whose working has been effected by the materials of the pipe, length and diameter of the pipe , the length of the pipe is buried and soils which are different.From last few decades, to develop the numerical model for analyzing the EAHE framework, many researches has been performed by the researchers.During 1990s, the numerical models has been replaced by the two-dimensional models and recently the analysis system has been more advanced for the three dimensional models and most probably for the simulation of computational Fluid Dynamics (CFD) and its analysis through the help of earth and heat exchanger framework.Many earlier models have been analyzed by the earth and air heat exchanger framework reviewed by this paper and the limits of work which are being affected through the EAHE and its thermal performance as of February 2017.Through earlier search it has been found that the performance of earthy and air heat exchanger has been affected by the parameters which has been already discussed and presented.It is concluded that with the advent of CFD methods, the work of investigation has been increased through simulation and modeling because it helps in saving time and is also does not cost much.

Nitish Shrestha et al(2016): Thefins provided on the tubes are responsible for heat transfer effectively and results in cooling effect. This improves the thermal performance of finned tubes. The outcome obtained by the experiment is compared by the simulation of work done in experiment.The state of the atmosphere is achieved by the state of the experiments which are simulated in ANSYS. Soil diffusivity of $\mathbf{0.84{-}2.36\times10{-}6}\boldsymbol{m2/s}$ at depth of 5ft with 17 fins.It has been perceived that if the length of the pipe is increased by its length that it will help in decreasing the temperature in the cooling mode of the inlet air. The reduction of the temperatureoccurs at the length of 1.2m which keeps differing from 1-3 °C at velocity 6.5m/sec.

Mayank Bhardwaj et al (2016) To achieve a linear EATHE frame work , the four configuration, design and the operating parameters that are the pipe length, inlet air velocity and inlet air temperature have been considered at four different levels in Taguchi method. This method is used to achieve air temperature at maximum drop and heat transfer rate.

JyotirmayMathuret. al. (2015) On the work ability of the earth air tunnel heat exchanger the effect of thermo-physical feature of the soil has been presented through this paper. An evaluation has been done through the usage of 3-dimension, transient numerical model for the three soils which are different from each other.The governing equations, depending on the model ofk–ε as well as equation of energy were utilized to determine the transfer of heat as well as process of turbulence and were calibrated by the means of finite volume method.After completing the operation which was of 12 hours and operating it continuously many more comparison has been done in terms of temperature drop, heat transfer rate and COP of the EATHE system.It has been known from the studies that after the period is over of being continuously operated the each and every soil exhibits different rate of heat dissipation and thermal saturation which is affected by the work ability of EATHE.

3. TYPE OF EARTH-AIR-HEAT EXCHANGER (EAHE)

In many EAHE system loops are either open orclosed. In an open loop EAHE system, moderate air is passed through the pipes which are concealed in the ground to supplyas per the cooling /heating needs of the building. As for closed loop EAHE systems, warm air is passed through concealed pipes of the building by which the cool air is supplied in the building. The open loop EAHE system is considered over closed loop EAHE system because closed loop does not fulfil the requirement of building as stated in various studies. The subcategories will explain both types of the EAHE system.

3.1. Open-loop system

Surface water and water from well is used in this type of system as a heat exchange fluid which is passed straight through the ground heat pump (GHP) system. After the water is beingcirculated it comes back to the ground through a recharge well, or surface discharge. This procedure can be done only where there is appropriate amount of clean water is availableand all the regional protocols and rules to be fulfilled in the context of utilizing the discharge from ground water.The main usage of this system was for larger installations. Figure 2 below shows an open-loop system.

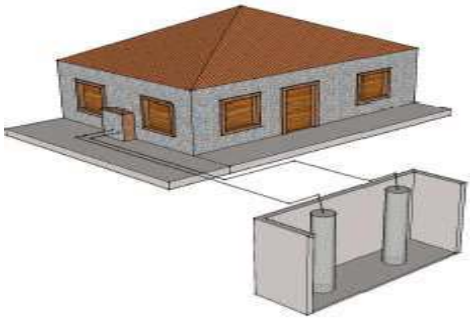

Figure 2: Open loop system

3.2. Closed-loop system

This kind of system use heat exchangers which are situated under the ground, either in horizontal or vertical position and in a closed loop the heat medium is circulated inside the heat exchanger. it helps in transferring the heat through the ground to heat the pump. For the horizontal type ground heat exchanger, there are three types of horizontal ground which are different from the way are connected with the pipe, some are in series, or parallel or else in spiral connections.. Figure 3 below shows the closed loop system in an EAHE system.

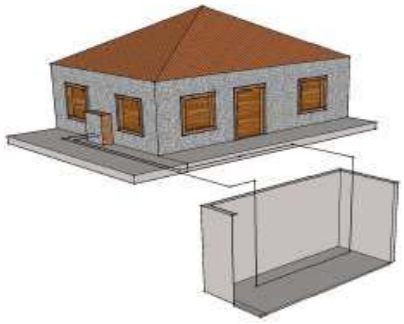

Figure 3: Closed Loop system

4. ASSUMPTIONS CONSIDERED ON EAHE SYSTEMS

The general assumptions which are considered for modelling as well as the thermal performance related with the analysis of EAHE associated systems utilized for either heating or cooling applications of buildings which are as follows.

(i) The pipe which are utilized in EAHE system is generally of uniform kind of cross section.

(ii) The structure of the thermal resistance of pipe material is almost nil (usually the thickness of pipe is extreme small).

(iii) The soil which is surrounding the outer pipe is isotropic, in the midst of homogenous thermal conductivity in all ground stratum.

(iv) There is no evaporation or freezing in soil; vapor and air in the pore space are assumed to be ideal gases

(v) The effect of moisture condensation on the cooling capacity of EAHE can be ignored especially when the dew point temperature of air at inlet of EAHE is higher than the lowest temperature of air along the pipe system (generally the lowest temperature occurs at the pipe outlet)

(vi) Pressure in the soil is considered to be atmospheric

(vii) The ground temperature of the surface can be approximated to the kind of ambient air temperature, which generates the inlet air temperature.

(viii)The degree of heat in the pipe vicinity is not affected by the existence of the pipe. As a conclusion, the pipe surface temperature is uniform in the axial way of direction

(ix) The framework of the Solar radiation is usually assumed to be constant

(x) Possible latent heat exchanges are not accounted for, which means that no water infiltration is at work and that the air temperature is supposed to remain above its dew point.

5. CONCLUSION

The present paper shows a review study on EATHE systems used for cooling purposes. Different types of EAHE systems namely, open loop and closed loop systems are discussed in detail. The variation in the performance in the working of EAHE systems is mainly dependent on depth of pipe buried inside the earth as well as the diameter of pipe used in the system. The structure of pipe is also an important factor which determines the performance of EAHE systems. The paper also includes assumptions related with the EAHE systems undertaken while its applications.

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