© April 2019 | IJIRT | Volume 5 Issue 11 | ISSN: 2349-6002

A Review on Performance of Earth Tube Heat Exchanger

Piyush Pandey[1], Rajneesh Kumar[2]
[1]*Research Scholar, RKDF College of Technology, RGPV, Bhopal*
[2]*Assistant Professor, RKDF College of Technology, RGPV, Bhopal*

***Abstract*- Earth-air heat exchangers, likewise called ground tube heat exchangers, are an intriguing strategy to diminish vitality utilization in a structure. They can cool or heat the ventilation air, utilizing cold or heat gathered in the dirt. A few papers have been distributed in which a structure technique is depicted. The greater part of them depend on a discretisation of the one-dimensional heat move issue in the tube. Three-dimensional complex models, fathoming conduction and dampness transport in the dirt are additionally found. These strategies are of high unpredictability and regularly not prepared for use by planners. The temperature of earth at a specific profundity around 2 to 3m the temperature of ground remains almost consistent consistently. This consistent temperature is known as the undisturbed temperature of earth which stays higher than the outside temperature in winter and lower than the outside temperature in summer. At the point when surrounding air is drawn through covered funnels, the air is cooled in summer and heated in winter, before it is utilized for ventilation. The earth air heat exchanger can satisfy in both reason heating in winter and cooling in summer.**

With the help of ETHE we can reduce the energy consumption required for space. The ground temperature variation used in different researches is also reviewed in this paper as an important part of identifying potential ETHE implementations. Design and performance aspects of the ETHE are also reviewed. Finally, this paper summarizes the potential and benefit of ETHE implementation in the Indian climate for cooling and heating applications to reduce the energy used in buildings and greenhouse gas emission.

Index Terms- Earth Tube Heat Exchanger (ETHE), Renewable energy, Heating, Cooling, Ventilation.

I. INTRODUCTION

It is discovered that the soil at some profundity from earth surface has a property to stay cold amid summer what's more, moderately more blazing amid winter days from the air temperature. Because of constrained wellsprings of vitality, it is very basic to discover the elective wellsprings of vitality to spare the regular powers accessible in nature to spare vitality of universe. The vitality utilization of structures for heating and cooling reason has altogether expanded amid the decades. Vitality sparing is the real concern all over the place, especially challenge in desert atmospheres. The solace conditions for person are temperature between 200 to 260 and relative mugginess in the middle of 40% to 60%. This can be accomplished by molding air [4]. The framework utilized in now a days, air is gone through a covered pipe by fan. In summer the supply air to the structure is cooled because of the way that the ground temperature around the heat exchanger is lower than the surrounding temperature. Amid winter, when the encompassing temperature is lower than the ground temperature the procedure is turned around and the air gets preheated.

The earth air heat exchangers are considered as a successful swap for heating or cooling of structures. This is essentially metallic, plastic or solid funnels covered underground at a specific profundity. Through channels the new air go with the assistance of blower. As indicated by the temperature contrast the heat exchange happens between soil and air in channels. The proficient structure of the framework is important to guarantee great execution. In that agreement the cross segment region and kind of cross segment of pipe, speed of air and nature of soil assumes key job in effectiveness of framework. This uses green and clean vitality so as to limit contamination and to limit customary vitality consumption. There are two noteworthy sorts of Earth Air Heat Exchangers framework exist

A. Open loop earth tube heat exchanger

B. Closed loop earth tube heat exchanger

1.1 TYPES OF EARTH AIR HEAT EXCHANGER

1.1.1 CLOSED LOOP SYSTEM

In closed loop system, inside air from the home or structure is blown through a U-shaped loop of normally 30 to 150 m of tube where it is moderated to near earth temperature before returning to be distributed through ductwork throughout the home or structure. The closed loop system may be more efficient than an open system, since it recoils the air again.

1.1.2 OPEN LOOP SYSTEM

In open loop system, outside air is drawn from a clean air intake. The cooling tubes are usually 30 m long straight tubes into the home. An open system joint with energy recovery ventilation can be nearly as efficient (80-95%) as a closed loop, and make sure that entering fresh air is filtered and tempered.

1.2 WORKING PRINCIPLE OF EARTH AIR HEAT EXCHANGER

Earth air heat exchanger exchanges heat between air and ground by the process of convection and by conduction it transfers heat to the tube wall.

SUMMER CONDITIONS

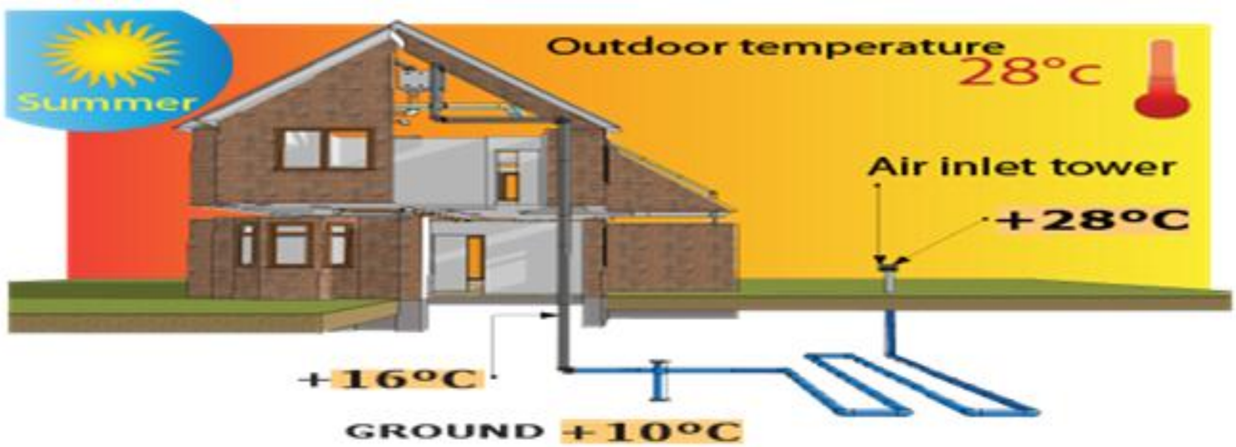

Fig 1 Working of EAHE in summer condition

- Hot air enters into the tube
- Air loses heat to the ground
- Cool air enters into the house

WINTER CONDITIONS

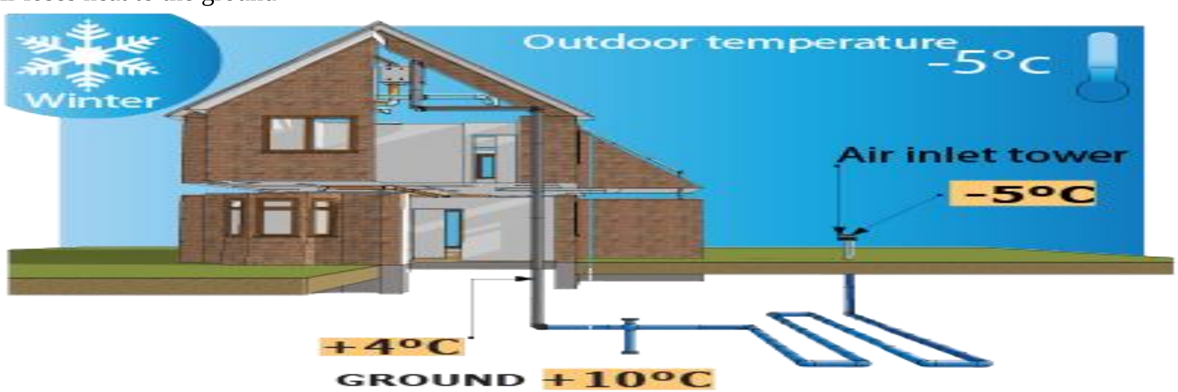

Fig 2 Working of EAHE in winter condition

- Cool air enters into the tube
- Air gains heat from the ground
- Hot air enters into the house

1.3 DESIGN PARAMETERS OF EARTH AIR HEAT EXCHANGER

1.3.1 LOCATION

If the purpose of the system is to heat, then it must be located in the sunny area. If the purpose of the system is to cool, then it should be located near shaded area of a lake or river.

1.3.2 DEPTH OF PIPE

Pipe should be buried as deep as possible but favourable depth can vary from 1.5 m to 3 m. A system designed for cooling requires more depth of pipe than a system designed for heating in same location.

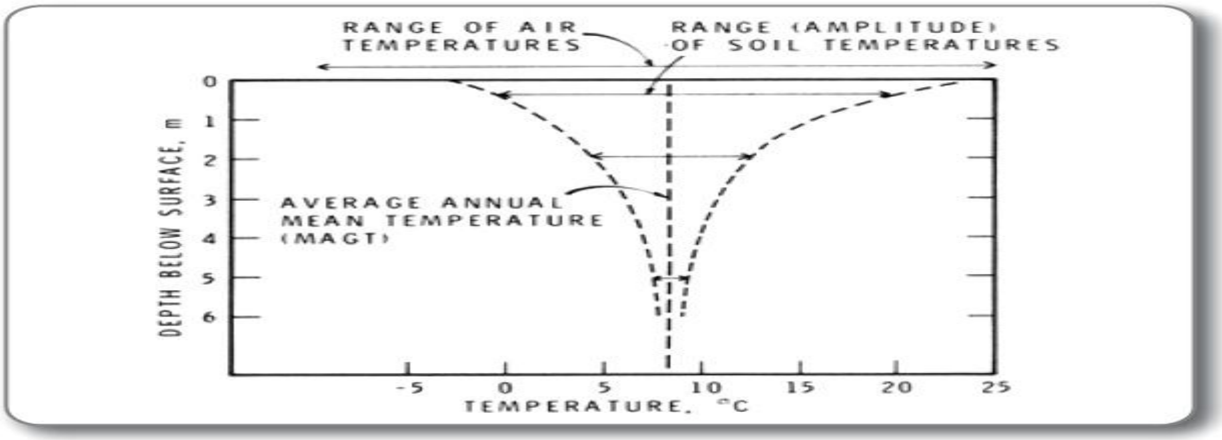

Fig 3 Temperature v/s Depth

1.3.3 SOIL CONDUCTIVITY

For conducting heat to or from the pipe, moist and compact clay is better than dry sand.

1.3.4 PIPE MATERIAL

Pipe can be made of plastics, metals or concrete-made with or without fins.

- Most conductive materials at the lowest cost
- Least air flow resistance
- Corrosion resistance

1.3.5 PIPE RADIUS AND LENGHT

As the radius of pipe increases, inlet air temperature also increases because with the increase of pipe radius, convective heat transfer coefficient on the inner surface of pipe decreases due to which overall heat transfer coefficient of the earth tube system deceases. For better performance smaller diameter pipe should be used.

1.3.6 AIR VELOCITY

With the increase in air flow rate, mass flow rate increases and inlet air temperature also increases. For a given tube diameter, increase in airflow rate results in: Increase in film coefficient, Increase in total heat transfer, Increase in outlet temperature, High flow rates desirable for closed systems.

For open systems airflow rate must be selected by considering: Outlet temperature and Total cooling or heating capacity.

II LITERATURE REVIEW

The temperature of soil is constant at 2 to 3 m depth. At 2 to 3 m depth the temperature is usually approximately equal to the mean annual air temperature. This temperature is called earth's undisturbed temperature. This undisturbed temperature is lower than the atmospheric temperature in summer. In winter the undisturbed temperature is greater than atmospheric temperature.

Krarti and kreider (1996) investigate the simplified analytical model to determine energy performance for earth air tunnel. The model is analysis for heat transfer between the soil and air tunnel. This model can also determine daily mean and amplitude of total cooling/ heating effect of tunnel and this model is valid only when the condensation does not occur (relative humidity of pipe does not reach 100%).

Bojic et al. (1999) investigate the mathematical model for heat exchange from earth to air through two pips and this model design for two material steel poly venial chlorides (PVC). The pipe length 50 m and inner and outer diameter 140 mm and 150 mm respectively at 1.5 m depth in soil.

Kabashnikov et al. (2002) investigate the analytic and numerical model for investigation of soil to air heat exchanger. The model is based on representation of temperature in the form of Fortier integral. The mathematical model which issue analysis gives the result on the basis of number of tube which is valid for 2m depth.

M.K. Ghosal and G.N. Tiwari (2006) investigate the modeling and parametric studies for thermal performance of an earth to air heat exchanger integrated with a greenhouse. The thermal model has been developed to investigate potential of using stored thermal energy of ground for greenhouse heating and the cooling with the help of an earth air heat exchanger system integrated with greenhouse located in premises of IIT, Delhi, India. The temperature is rise up to7–8 0C and 5–6 0C reduction of temperatures for greenhouse air for winter and for summer period, respectively, due to incorporation of EAHE as compared to temperatures without the EAHE.

Kumar et al. (2008) Investigate design optimization tool of earth-to-air heat exchanger using a genetic algorithm. This paper presents design tool to optimize the input variables of earth-to-air heat exchanger. To determine heating and the cooling potential of two models of EATHE, The GA designed model incorporates greater accuracy than the previous models. The proposed model accounts for humidity variations of the circulating air natural thermal stratification of ground, the latent and sensible heal transfer, and the ground surface conditions, etc. The results show a very good agreement with the experimental data and other model predictions. Impact of four parameters like humidity of air, ambient temperature, ground surface temperature and the ground temperature at burial depth on outlet temperature of EATHE was studied through the sensitivity analysis.

Su et. al. (2012) Investigate a numerical model of a deeply buried air-earth tunnel heat exchanger. A numerical simulating model was developed for the deeply buried earth air tunnel heat exchanger, which includes an implicit the one dimensional transient convection-diffusion sub-model for air temperature and the moisture content computation and an explicit one dimensional transient heat conduction sub-model for rock temperature computation. This method has been verified by the comparisons between numerical results and test data. The maximum error of air temperature is 1.4°C and maximum error of relative humidity is 10% in most cases.

O. P Jakhar and RajendraKukana (2014) investigate the transient thermal analysis of earth air tunnel heat exchanger using CFD for Summer Season. The analysis of majorly available soil in the Bikaner region, have been considered are Sandy Loam Soil and Sandy Soil. The cooling effect of 13.85 and 9.22°C is obtained for the Sandy Loam Soil at inlet air velocity 9 m/sec for the temperature 47.6 and 39.3°C, respectively, as difference of the inlet temperature (higher) and the outlet temperature (lower). For the Sandy soil this difference of the inlet to outlet temperature of EATHE is 17.85 and 10.42°C for the temperature 47.6 and 39.3°C.The cooling effect is more for the Sandy soil as compared to the sandy Loam Soil. Hence Cooling is affected by the properties of soil considered.

Mihalakakou et al. (2016), investigated the heating potential of a single ground to air heat exchanger and also multiple parallel tube system. An accurate numerical model was used to investigate the dynamic thermal performance of the system during the winter period in Dublin

. The model has been successfully validate against an extensive set of experimental data. The results showed that the heating potential of the system during winter is significantly important. To obtained results showed that that the effectiveness of the ground to air earth air heat exchanger increases with an increase in pipe length (checked rang 30-70 m). Also, there is increase in effectiveness when the pipe is buried in greater depths (3 m instead of 1.2 m). By increasing the pipe diameter from 100 to 150 mm, the heating capacity of the system was reduced. This is due to a reduction in convective heat transfer coefficient and an increase in the pipe surface, therefore, providing a lower temperature at the pipe outlet. Finally a higher velocity in the pipe (range 5-15 m/s) leads to a reduction of the system hearting capacity, mainly because of the increased mass flow rate inside the pipe.

Vikas Bansal et.al. (2017s), have worked on Performance evaluation and economic analysis of integrated earth air tunnel heat exchanger evaporative cooling system by applying implicit model based on CFD. For use of ETHE system integrated with evaporative cooling to be determine for evaluating the energy saving obtained. Four base cases of existing systems, i.e. electric heater and air-conditioner. Moreover, three different types of blower (i.e. standard blower, energy efficient blower and inefficient blower) are considered for evaluating the financial viability and energy saving of the proposed system.

So from the literature review we found that if we reduce velocity, checking for different material and make some appropriate changes in geometry, there will be a chance to improve the performance of earth tube air heat exchanger.

III. CONCLUSIONS

In this paper the performance of earth air heat exchanger system was investigated and we have observed the following.

1. If the length of the pipe is so small and the blower is high voltage then the system is useless because the temperature difference between inlet and out let is very less.
2. The material of pipe is not affected in the output result.
3. If cooling or heating rate is more achieve, then the length of pipe kept at least 100 m and blower some around 400 W.
4. More velocity of air which can reduces the temperature difference between outlet and inlet, so velocity in between 2- 5m/s more suitable.
5. At a depth of 1.5 m EUT is becomes stable so depth taken should be more than that 2m is sufficient to get required effect. Air quickly reached to the soil temperature so larger tube diameter is not needed.

REFERENCES

[1] D. J. Beebe, “Akshaykhot, analysis of various designing parameters for earth air tunnel heat exchanger system [IAEME] [ISSN 0976-6340][VOL. 5 issue DEC 2014 PP 118-125]

[2] Trilok Singh Bisoniya et al ,Parametric Analysis of Earth-Air Heat Exchanger System Based on CFD Modelling [IRACC,ISSN 2434,JULY 12-15,2010,PP 1-8]

[3] DheerajSardana et al, Effects of parameters on performance of earth air heat exchanger system (EAHE): a review,[IJATES],[ISSN 2348-7550,Vol. 3special issue no. 02,February 2015]

[4] Ashish Kumar Chaturvedi et al, performance of earth tube heat exchanger cooling of air—a review [IJMERR],[ISSN 2278-0149 VOL.4 NO.1,January 2015]

[5] RohitMisra et al, parametric study of derating factor for Earth Air Tunnel Heat Exchanger.” Applied Energy 103 (2013): 266–277

[6] Capozza A et al (2012), “Design of Borehole Heat Exchangers for Ground-Source Heat Pump: A Literature Review, Methodology Comparison and Analysis on the Penalty Temperature [IJMERC],[AUG. 2013]

[7] N.K. Bansal et al, Evaluation of an earth–air tunnel system for cooling/heating of a hospital complex, Building and Environment [IJATES][VOL NO 06 MAR 2013]

[8] Kim S K et al, “Field-Scale Evaluation of the Design of Borehole Heat Exchangers for the Use of Shallow Geothermal Energy”, Energy, [Vol. 35, No. 2, pp. 491-500](2010).

[9] Bisoniya TS et al, (2014) Cooling potential evaluation of earth–air heat exchanger system for summer season. [Int J Eng Tech Res 2(4)]:309–316]

[10] Thankur, A., Sharma,(2015) A., CFD Analysis of Earth- Air Heat Exchanger to Evaluate the Effect of Parameters on Its Performance IOSR-JMCE, [e-ISSN: 2278-1684, p- ISSN: 2320-334X].,PP 14-19

[11] P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited [Edition 2014].

[12] M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India.[Edition 2012].