CFD Analysis of Experimental Result of Earth Tube Heat Exchanger Cooling of Air

Sanjay Sharma[1], Amit Kumar[2]

[1]M Tech Scholar ME Department PGOI

[2]Asst.Proff,ME Department PGOI Bhopal

Abstract - Earth tube heat exchanger systems can be used to cool the building in summer climate and heat the buildings in winter climate. In a developing country e.g. India, there is a huge difference in demand and supply of electricity and rising electricity prices have forced us to look for cheaper and cleaner alternative. Our objective can be met by the use of earth tube heat exchangers and the system is very simple which works by moving the heat from the house into the earth during hot weather and cold weather. Measurements show that the ground temperature below a certain depth remains relatively constant during the year. Experimental research were done on the experimental set up in Lakshmi Narayan College of Technology, Bhopal. Effects of the operating parameters i.e. air velocity and temperature on the thermal performance of horizontal ground heat exchanger are studied. For the pipe of 9m length and 0.05m diameter, temperature falling of 3.930C-12.60C in hot weather and temperature rising of 6oC-10oC in cold weather have been observed for the outlet flow velocity 11 m/sec. At higher outlet velocity and maximum temperature difference, the system is most efficient to be used.

Keywords - Heat, Exchanger, Earth Tube, Air.

1. INTRODUCTION

1.1 Background:

Saving energy is one of the most important global challenges. A large portion of the global energy supply is used for electricity generation and space heating, having the major portion derived from fossil fuels. It is non renewable resources and their combustion is harmful to the surroundings, during the manufacture of greenhouse gases, which effects the climate change and additional pollutants. Fossil fuel exhaustion along with pollutant emissions and global warming are important factors for sustainable and environmentally benign energy systems. These concerns have motivated efforts to reduce society’s dependence on non renewable assets, by dipping demand and substituting choice energy sources. First of all efforts are focused on producing electricity with higher efficiency. Old power plants are more rapidly phased out and substituted by new, more resourceful plants. Added efficient use of energy not only reduces the consumption of electricity, but also lowers the consumption of non renewable assets. Renewable energy assets are sought that are more environmentally benign and economic than conventional fossil fuels. Beyond fossil fuels, the earth’s crust stores an abundant amount of thermal energy [1]. Geothermal systems are relatively benign environmentally, with the emissions much lower than for conventional fossil fueled system. Geothermal energy is heat as of within the earth. Geothermal energy is produced in the earth’s core and core is made up of very hot magma (melted rock) surrounding a solid iron center. High temperatures are continuously produced inside the earth by the slow decay of radioactive materials and this process is natural in all rocks. The outer core is surrounded by the mantle, which is made of magma and rock. The outer layer of the earth, the land that forms the continents and ocean floors is called the shell. The shell is not a solid portion, like the crust of an egg, but it is out of order into pieces called plates. Molten rock comes seal to the earth outside near the edges of these plates. We can dig wells and pump the hot underground water to the surface. People use geothermal energy to heat their homes and to produce electricity. 1.2 Ground Coupled Heat Exchanger: A ground coupled heat exchanger is an underground heat exchanger that can capture heat from and dissipate heat to the earth. They utilize the earth’s close to constant profound temperature to warm or cool air or other fluids for suburban, farming or manufacturing uses. They are also called earth tubes or earth-air heat exchangers or ground tube heat exchanger. Earth tubes are often a viable and economical alternative or supplement to conventional central heating or air conditioning systems since there are no compressors, chemicals, burners and only blowers are required to move the air. These are used for either partial or full cooling and their use can help building meet passive house standards.

1.3 General Explanation Earth tubes are low technology, sustainable passive coolingheating systems utilized mostly to preheat a dwelling's air intake. Air is either cooled or heated by circulating underground in horizontally buried pipes at a specified depth. Specifically air is sucked by means of a fan or a passive system providing adequate pressure difference from the ambient which enters the building through the hidden pipes. Due to earth properties the air heat at the pipe outlet maintains moderate values all around the year. Temperature fluctuates with a time lag (from some days to a couple of months) mainly relative to the profundity careful. Hotness values stay usually in the comfort level range (15-27 °C). This technology is not recommended for cooling of hot humid climates due to moisture reaching dewpoint and often remaining in the tubes. However there are southern European coastal regions as in Greece where the climate remains hot and dry. In such locations these systems could have impressive results. 1.4 When should earth tubes be used? • Best in climates in extreme warmth and cold. The elevated difference among the ambient temperatures and the required indoor temperatures create the best opportunity for earth tubes to produce valuable results. • Need available land to accommodate the length of tubes. • Great occasion to position them below the building ground when constructing a new building. 1.5 Ground heat transfer mechanism: The temperature field in the ground is influenced by different quantities Absorption of the solar radiation depends on the ground cover and color, while the long wave radiant loss depends on soil surface temperature [3]. The net radiant balance between solar gain and long wave loss is usually positive in summer and unhelpful in winter. This causes warm to run down from the outside into the ground in the summer and upward to the surface through the winter. The grid radiant stability also determines the dealings between the averages of the earth surface and the ambient air temperatures. By shading the soil in summer while partially exposing it to the sky in winter, for example, with trees, it is possible to lower the ground temperature in summer to a greater extent while possibly increase the ground temperature in winter somehow. The performance of ground coupled air heat exchanger is directly related to the thermal properties of the position. The land has thermal properties that give it a elevated thermal inertia. The heat transfer mechanisms in soils are, in arrange of significance: conduction, convection and radiation. The temperature field in the ground depends on the soil type and the moisture contained respectively. 1.6 Types of Ground Coupled Heat Exchangers: There are two general types of ground heat exchangers: open and closed. In an open system, the ground may be used directly to heat or cool a medium that may itself be used for space heating or cooling. Also, the earth may be used ultimately with the aid of a heat carrier medium that is circulated in a closed system. 1.6.1 Open systems: In open systems, ambient air passes through tubes buried in the ground for preheating or pre-cooling and fresh fluid is circulated through the ground loop heat exchanger. This system provides ventilation while hopefully cooling or heating the building's interior. 1.6.2 Closed Systems: In closed systems, both the ends of the pipe are kept inside the control environment, which can be a room in case of air and a tank in case of water, the system is said to be closed loop because the same fluid is passed continuously over and over through the loop. Closed type ground heat exchangers can be either in parallel, straight up or tilted position and a heat carrier medium is circulated within the heat exchanger. 1.6.3 Vertical loops system: Vertical loops are generally more classy to install, but necessitate less piping than flat loops because the earth deeper down is cooler in summer and warmer in winter, compared to ambient temperature. Vertical type borehole heat exchangers can be classified into two basic types: (a) A pair of straight pipes having U-turn at the bottom side. (b) Coaxial or concentric pipe configuration in which one pipe is placed inside the pipe with bigger diameter. 1.7 Advantages and Disadvantages of Ground Heat Exchanger

2. LITERATURE REVIEW

The Heat transfer to and from Earth tube heatexchanger system has been the subject of many theoretical and experimental investigations. By having a review on previous research papers published by many authors we can have an idea on how it works.sehli *et al.* proposed a one-dimensional numerical model to check the performance of EAHEs installed at different depths. It was concluded that EAHE systems alone are not sufficient to create thermal comfort, but can be used to reduce the energy demand in buildings in South Algeria, if used in combination with conventional airconditioning system.

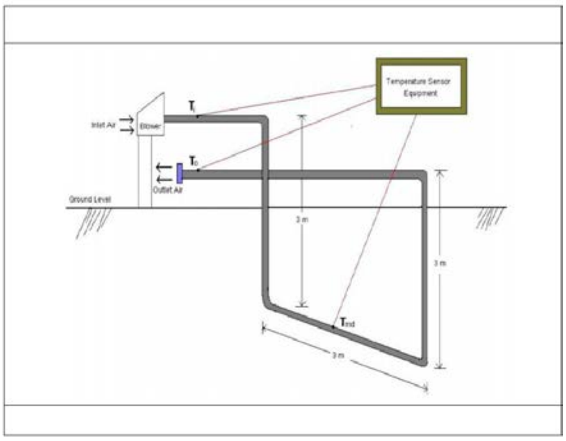
Ghosal *et al.* developed a simplified analytical model to study year around effectiveness of an EAHE coupled greenhouse located in New Delhi, India. They found the temperature of greenhouse air on average 6-7 °C more in winter and 3-4 °C less in summer than the same greenhouse when operating without EAHE.

Shukla *et al.* developed a thermal model for heating of greenhouse by using different combinations of inner thermal curtain, an earth-air heat exchanger, and geothermal heating.

Bansal *et al.* investigated the performance analysis of EAHE for summer cooling in Jaipur, India. They discussed 23.42 m long EAHE at cooling mode in the range of 8.0-12.7 °C and 2-5 m/s flow rate for steel and PVC pipes. They showed performance of system is not significantly affected by the material of buried pipe instead it is greatly affected by the velocity of air fluid. They observed COP variation 1.9-2.9 for increasing the velocity 2-5 m/s.

Santamouris *et al.* investigated the impact of different ground surface boundary conditions on the efficiency of a single and a multiple parallel earth-to-air heat exchanger system.

3.SYSTEM MODLING



4. PREVIOUS WORK

Till date the experimental data available of earth tube heat exchanger cooling of air in research datas but not found CFD Analysis data.

5. PROPOSED METHODOLOGY

I work to analyze the experimental data with the help of CFD Software.

6. CONCLUSION

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.

If cooling or heating rate is more achieve, then the length of pipe kept at least 100 m and blower some around 400 W.

REFERENCES

[1] Baxter D O (1992), "Energy Exchange and Related Temperature of an Earth-Tube Heat Exchanger in Heating Mode", Vol. 35, No. 1, pp. 275-285, Trans. ASAE.

[2] Baxter D O (1994), "Energy Exchange and Related Temperature of an Earth-Tube Heat Exchanger in Cooling Mode", Vol. 37, No. 1, pp. 257-267, Trans. ASAE.

[3] Capozza A, De Carli M and Zarrella A (2012), "Design of Borehole Heat Exchangers for Ground-Source Heat Pump: A Literature Review, Methodology Comparison and Analysis on the Penalty Temperature", *Energy and Buildings*, Vol. 55, No. 12, pp. 369-379.

[4] Esen H, Inalli M and Esen M (2007a), "Numerical and Experimental Analysis of a Horizontal Ground-Coupled Heat Pump System", *Building and Environment*, Vol. 42, pp. 1126-1134.

[5] Esen H, Inalli M, Esen M and Pihtili K (2007b), "Energy and Exergy Analysis of a Ground- Coupled Heat Pump System with Two Horizontal Ground Heat Exchangers", *Building and Environment*, Vol. 42, pp. 3606-3615.

[6] Hellström G (1991), "Ground Heat Storage, Thermal Analysis of Duct Storage Systems: Theory", Doctoral Thesis, Department of Mathematical Physics, University of Lund, Sweden.

[7] Kim S K, Bae G O, Lee K and Song Y (2010), "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.

[8] Nam Y, Ooka R and Hwang S (2008), "Development of a Numerical Model to Predict Heat Exchange Rates for a Ground-Source Heat Pump System", Energy and Buildings, Vol. 40, No. 12, pp. 2133-2140.

[9] Santamouris M, Mihalakaha G, Balaras C A, Argirioua Asimakopoulos D and Vallinaras M (1995), "Use of Buried Pipes for Energy Conservation in Cooling of Agricultural Greenhouse", *Solar Energy*, Vol. 35. pp. 111-124.

[10] Scott N R, Parsons R A and Kochler T A (1965), "Analysis and Performance of an Earth-Tube Heat Exchanger", ASAE Paper No. 65-840. St. Joseph, Michigan, ASAE.

[11] Sharan G and Jadhav R (2003), "Soil Temperature Regime at Ahmedabad", *Journal of Agricultural Engineering*, (forthcoming).

[12] Spengler R W and Stombaugh D P (1983), "Optimization of Earth-Tube Heat Exchanger for Winter Ventilation of Swine Housing", pp. 1186-1193, Trans. ASAE.

[13] Yavuzturk C, Spitler J D and Rees S J (1999), "A Transient Two-Dimensional Finite Volume Model for the Simulation of Vertical U-Tube Ground Heat Exchangers", ASHRAE Transactions, Vol. 105, No. 2, pp. 465-474.

[14] Zarrella A, Scarpa M and De Carli M (2011a), "Short Time-Step Performances of Coaxial and Double U-Tube Borehole Heat Exchangers: Modeling and Measurements", HVAC&R Research, Vol. 17, No. 6, pp. 959-976.

[15] Zarrella A, Scarpa M and De Carli M (2011b), "Short Time Step Analysis of Vertical Ground-Coupled Heat Exchangers: The Approach of CaRM", Renewable Energy, Vol. 36, No. 9, 2357-2367.

AUTHOR'S PROFILE

Sanjay Sharma has received his Bachelor of Engineering degree in Production Engineering from MIET Engineering College, Gondia Nagpur in the year 1995. At present he is pursuing M.Tech. with the specialization of Thermal Engineering in Sri patel college of science & Technology bhopal. His area of interest earth tube heat exchanger.

Amit Kumar has received his Bachelor of Engineering degree in Mechanical Engineering from AVIT Engineering College, Chenni in the year 2012.&Also he has received his Master of Technology degree in MANIT Bhopal in the year 2016 At present he is working as an Assistant Professor at Patel Group of institution Bhopal.His research area are stress& Vibration.