EFFECTS OF PARAMETERS ON PERFORMANCE OF EARTH AIR HEAT EXCHANGER SYSTEM (EAHE): A REVIEW

Dheeraj Sardana[1], Rishi kumar[2], Snehal S Patel[3], Gaurav Saini[4]

[1, 2, 3] *Department Of Mechanical Engineering, SRPEC, Unjha, (India)*

[4]*Research Scholar, Department of Mechanical Engineering, YMCA, Faridabad (India)*

ABSTRACT

Earth air heat exchanger or earth tube heat exchanger is a device used to produce heating effects in winter and cooling effects in summer using the ground or soil as a source or sink. Till date many researchers have implemented numerous ideas, conducted experiments on EAHE with different parameters depending on the location and found optimum values of parameters for better performance. The present study reviews the previously conducted studies in terms of performance assessment with effects of various parameters like material of construction, depth from earth surface, velocity of air and length of pipe etc.

Keywords: Eahe-Earth Air Heat Exchanger

I. INTRODUCTION

It is found that the soil at some depth from earth surface has a property of remaining cold during summer and relatively hotter during winter days from the atmospheric temperature. This strikes the researchers to use the temperature gradient of soil for cooling in summer and heating in winter [1]. As we have limited source of energy it is important to find alternatives sources to save conventional fuel for future to save exergy of universe. These days air conditioning is widely employed in industries and for the comfort purpose in livestock buildings and hospitals etc. It is employed efficiently by vapour compression cycle in which we are using high grade electrical energy which also affects atmosphere by CFC so to reduce the use of high grade energy number of methods are explored[2,3]. EAHE is one of such techniques. It uses heat source from underground soil and heat is transferred to air through conduction and convection which results increased air temperature than that of ambient temperature at outlet of earth-air-pipes.and this outlet air directly can be used for space heating purposes [4].

Till date a lot of research work on EAHE has been carried out. Vikas Bansal et al. [2,3] developed the model inside the FLUENT simulation program and validated against experimental investigations on an experimental set-up in Ajmer (Western India) during summer, and found 23.42m long EAHE system gave cooling in the range of 8.0–12.7˚C for the flow velocities 2–5 m/s. M.K. Ghosal et al. [5] developed a simplified analytical model to study the year round effectiveness of a recirculation type EAHE coupled with a greenhouse located in IIT Delhi, India, and found Temperatures of greenhouse air to be on an average 6–7 ˚C more in winter and 3–4 ˚C less in summer than the same greenhouse when operating without EAHE. Fabrizio Ascione et al. [6] studied the energy performances achievable using an EAHE for an air-conditioned building for both winter and summer by means of dynamic building energy performance simulation codes, and analyzed the energy requirements of the systems for different Italian climates. . Trilok Singh Bisoniya et al. [4] presented experimental and analytical analysis of EAHE systems in India. Rohit Misra et al. [7] experimented transient analysis based on determination of derating factor for EAHE in summer. Joaquim Vaz et al. [8] conducted an experiment in southern Brazil in the city of Viamao, and its results were used to validate the computational modeling of EAHE, the variation of air temperature inside the ducts, to an annual cycle, was investigated. The numerical solution of the conservation equations of the problem is performed with a commercial code (FLUENT) which is based on the Finite Volume Method (FVM).

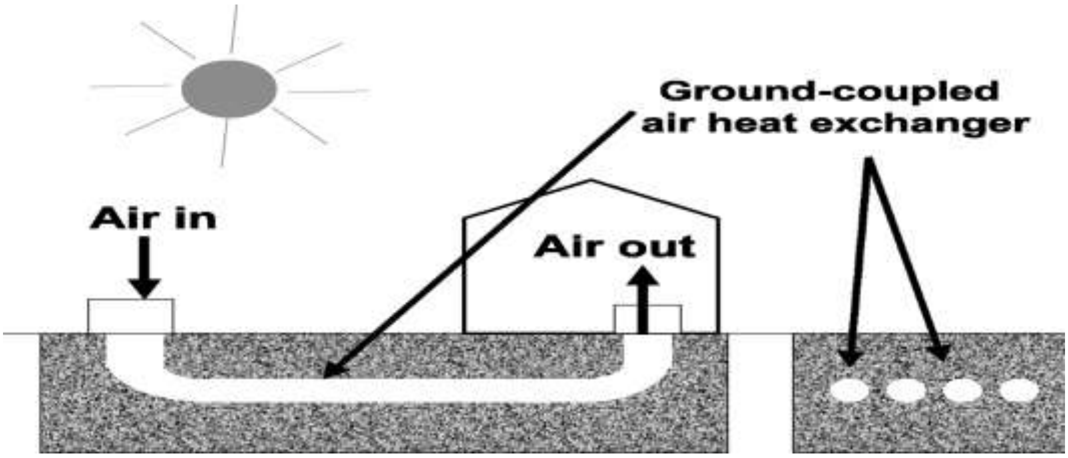

Fig.1 Ground Coupled Heat Exchanger [10]

II. A BRIEF OF HISTORICAL BACKGROUND EAHE SYSTEMS IN THE WORLD

If air from buildings is blown through the heat exchanger for heat recovery ventilation, they are called earth tubes (also known as earth cooling tubes or earth warming tubes) in Europe or earth–air heat exchangers (EAHE or EAHX) in North America. The idea of using earth as a heat sink was known in ancient times.[9] In about 3000 B.C., Iranian architects used wind towers and underground air tunnels for passive cooling.[10,11] EAHE is a passive climate control technique that has application in residential as well as agricultural building utilizes the underground soil temperature that stays fairly constant at a depth of about 2.5–3 m [6]. In agricultural facilities (animal buildings) and horticultural facilities (greenhouses) Earth–air heat exchangers have been used over the past several decades and have been used in conjunction with solar chimneys in hot arid areas for thousands of years, probably beginning in the Persian Empire Earth–air heat exchangers are one of the fastest growing applications of renewable energy in the world, with an annual increase in the number of installations with 10% in about 30 countries over the last 10 years [12]. With the exception of Sweden and Switzerland, the market penetration is still modest throughout Europe but is likely to grow with further improvements in the technology and the increasing need for energy savings. From the middle of the 20th century, a number of investigators have studied the cooling potential of buried pipes. South Algeria is typical of a dry desert climate with the highest air temperature being recorded in July and August with an afternoon average maximum of 45°C. Summer starts at the beginning of May and continues until the end of September, with a mean air temperature of 37 °C. In addition, the air is generally dry [11]. In winter, the weather is comfortably cool, generally mild, with a monthly mean temperature of 10°C, and a minimum temperature recorded being occasionally below 1°C. The EAHE system alone cannot maintain indoor thermal comfort, but it could be used to reduce energy demand in domestic building in south Algeria if used in conjunction with an air conditioning system.

III. METHODOLOGY

Earth air heat exchanger (EAHE) systems. EAHE systems are long metallic, plastic or concrete pipes that are laid underground and are connected to the air intake of buildings, particularly houses. From inlet the atmosphere air is forced by using blower in the pipe during the movement heat gets transferred from hot soil to cold air in winter and cold soil to hot air in summer and it changes the air temperature accordingly. The pipe outlet is given where the space needs to be air conditioned in industrial or livestock buildings etc. By taking benefits of this costless energy we can reduce our energy consumption for air conditioning of space hence a very useful technique it is.

3.1 Open Loop Systems and Closed Loop Systems

In an open loop system air is directly supplied to the building and this system provides the ventilation while closed loop circulates the interior air and is more efficient than open loop [9]

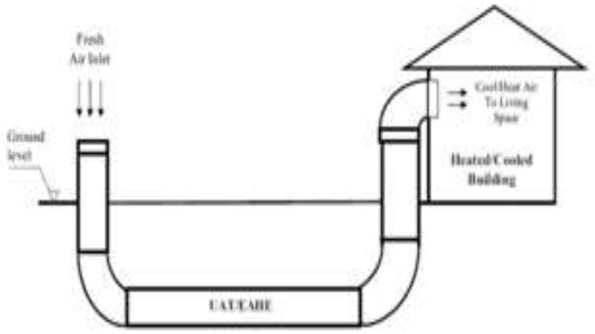

Fig.2 Open Loop for Space Heating/Cooling System [9]

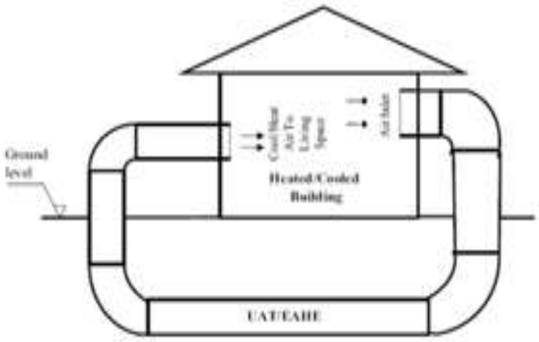

Fig.3 Closed Loop for Space Heating/Cooling System [9]

3.2 Effects of Various Parameters on ETHE

3.2.1 Effect of Material

Initially steel pipes were used for the construction of ETHE but then experiments were conducted for different materials. Researcher [2, 3] studied the effects and they found that PVC material also give the similar performance hence we can use cheaper material like PVC instead also there life is more. Though steel has higher conductivity than that of PVC yet the variation in temperature of the air at the outlet of pipe between steel and PVC is very small. Therefore, it can be concluded that in EAHE system, convective heat transfer plays a more important role than conductive heat transfer.

3.2.2 Effect of Velocity of Air inside Pipe

Researchers studied [2,3] the effects and concluded the reduction in temperature of the air at the exit of pipe due to increment in air velocity occurs because when the air velocity is increased from 2.0 to 5.0 m/s, the convective heat transfer coefficient is increased by 2.3 times, while the duration to which the air remains in contact with the ground is reduced by a factor of 2.5. Thus the later effect is dominant and therefore, less rise in temperature is obtained at air velocity 5.0 m/s than the 2.0 m/s. At high speeds due to reduction in time of contact the performance gets reduce.

3.2.3 Effect of Tube Length

It can be concluded that up to some extent length matters after a certain length no improvement in the performance is found however large its length may be. It can be inferred that, for all the considered climates, lengths of about 10 m are unsatisfactory, while significant advantages do not occur for lengths over 70 m, according to *Lee KH, Strand RK[13]*.

3.2.4 Effect of Tube Depth

The ground temperature is affected by the external climate and soil composition its thermal properties and water content. The temperature of soil fluctuates but become stable after some depth. This temperature remains same throughout the year. And it is concluded that after a depth of 1.5 meters this temperature becomes stable so the depth taken should be more than that. According to the (EREC2002) more than 3.5 meters depth is also not justifiable [15].

3.2.5 Effects of Tube Length, Diameter and Air Flow Rate

Cooling capacity depends on the overall surface area which is a keyway in designing it. This can be affected in two ways by changing length and diameter of the pipe. On increasing the diameter the mass flow rate gets reduced and more length increases pressure drop and increases the blower input. According to (EPEC2002) the optimum solution is the parallel tube of proper length and diameter are used. The air quickly reached the soil temperature so larger tubes are not needed. Generally 150 to 450 mm tubes are used. (IEA1999)

REFERENCE

[1] M. Santamouris, A. Argiriou, M. Vallindras, Design and operation of a low energy consumption passive solar agricultural greenhouse, Solar Energy 52 (1994) 371–378

[2] BansalVikas,Misra Rohit, Agrawal Ghanshyam Das,Mathur Jyotirmay. Performance analysis of earth–pipe air heat exchanger for winter heating. Energy andBuildings2009; 41:1151–4.

[3] BansalVikas, MisraRohit, AgrawalGhanshyamDas,MathurJyotirmay. Performance analysis of earth pipe air heat exchanger for summer cooling. Energy and Buildings 2010;42:645

[4] Trilok Singh Bisoniya, Anil Kumar, Prashant Baredar. Experimental and analytical studies of earth–air heat exchanger (EAHE) systems in India: A review. Renewable and Sustainable Energy Reviews 19 (2013) 238–246.

[5] M.K. Ghosal, G.N. Tiwari, N.S.L. Srivastava. Thermal modeling of a greenhouse with an integrated earth to air heat exchanger: an experimental validation. Energy and Buildings 36 (2004) 219–227.

[6] Fabrizio Ascione, Laura Bellia, Francesco Minichiello. Earth-to-air heat exchangers for Italian climates. Renewable Energy 36 (2011) 2177-2188

[7] Rohit Misra, Vikas Bansal, Ghanshyam Das Agrawal, Jyotirmay Mathura, Tarun Aseric. Transient analysis based determination of derating factor for Earth Air Tunnel Heat Ex

[8] Joaquim Vaza, Miguel A. Sattler, Elizaldo D. dos Santosa, Liércio A. Isoldi. Experimental and numerical analysis of an earth–air heat exchanger. Energy and Buildings 43 (2011) 2476–2482.changer in winter. Energy and Buildings 58 (2013) 76–85.

[9] Leyla Ozgener. A review on the experimental and analytical analysis of earth to air heat exchanger (EAHE) systems in Turkey. Renewable and Sustainable Energy Reviews 15 (2011) 4483– 4490

[10] M. De Paepe, A. Jannsens. Thermo-hydraulic design earth-air heat exchangers. Energy and Buildings 35 (2003) 389-397

[11] Abdelkrim.Sehli, Abdelhafid.Hasni, Mohammed. Tamali. The potential of earth-air heat exchangers for low energy cooling of buildings in South Algeria. Energy Procedia 18 (2012) 496 – 506.

[12] Sanner B.Current status of ground source heat pumps in Europe, Futurstock, Warsaw, 2003.

[13] Lee KH, Strand RK. The cooling and heating potential of an earth tube system in buildings. Energy and Buildings 2008;40:486e94

[14] Environmental Protection Agency. (2009). Heat and Cool Efficiently. Washington DC: Energy Star. Available at http://www.energystar.gov/index. cfm?c=heat_cool. pr_hvac [Accessed on 18 Feb 2009].

[15] EREC, reference brief 'Earth cooling tubes' US Department of Energy 2002.