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A review of earth to air heat exchanger as a passive cooling and heating technique and the affecting parameters

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ABSTRACT

In the recent time the EAHE is widely used as a passive cooling and heating technique due to the mounting thermal potential of earth as and as a result of energy crisis. In the past years many researches published including studying this type of heat exchanger and using it in many applications and many locations with different climate conditions. Also, these researches investigated the most affecting parameters. In this paper a review is prepared to survey the published literature in this field to shed a light on the research.

1. Introduction:

The requirement to reduction a consumption in the energy for heating and cooling loads improved through past time. Energy saving can be reached by depend on the renewable energies for example solar, wind and geothermal energy. For heating and cooling buildings it can be reliant on the ground for example warmth source in the winter and as heat sink in the summer. The utilities of the geothermal energy in heating and cooling spaces can be consummate by using (EAHE) or moreover named earth heat exchanger Singh et al. [1].

Earth to air heat exchanger is a passive heating and cooling systems and it used in wide types of application for example heating and cooling greenhouse, industrial and inhabitation buildings. EAHE is usually involves of pipe or more -pipes that inside the earth vertically or level. First the end of the tube is linked to the supply end of the fan and the other of side is open for air. While the air of flows during the inhumed of tubes, the heat is transmission from air to the contiguous soil through a summer period and the opposite in a winter.

Abbreviations

DE	Dry heat exchanger	P.P	pumping power
COP	Coefficient of performance	WE	Wet heat exchanger
EAHE	Earth Air Heat Exchanger		

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2. Applications:

The earth to air heat exchanger used in many applications mainly in Yusof et al. [2]
1) Agricultural applications, 2) residential building Equations

2.1. Agricultural applications:

Okonkwo, W et al . [3] conducted an experimentally investigation the poultry house, with solar Trombe wall which is equipped in order to the provide the ventilation, cooling and heating to a poultry house. They noted that the EAHEs maintained the temperature in the range from 28°C -35°C, 586 is grams the average body weight, the rate of mortality is around 3%and the feed conversion ratio is 1.87% . Ahachad, M et al.[4] and Fawaz, H et al. [6] performed experimentally the influence of the heat stress phenomenon are offered with simulating and modeling on the poultry house and it the effect of all parameter on the performance of the building (shape , ventilation, orientation etc) in North of Morocco. From the results showed temperature will decrease per 2 air changes per hour by about 1.5°C, for 5 air changes per hour to 2.7 C° and for 10 air changes per hour 3.8 C°, the temperature of the inlet air reduction (up to 9 C°), and the production quality is enhancement. the ventilation lead to a full decrease of the cycle cooling capacity of 29.9 %. Choi, Salim et al. [5] studied the geothermal of heat pump for heating of poultry house, the geothermal of heat pump allows the lesser cost of heating, developed the production performance with decline amount of the gases discharges. Kapica, J,et al. [7] estimated the decrease of CO_2 by using the solar-wind hybrid system for heating the house of poultry hey discovered that the larger system provides a greater CO_2 drop ,however the energy utilization ratio reductions . Azzeddine L aknizi. [8]study plan and modeling of the earth to air HE for the typical poultry house to estimate the potential of cooling and heating. They results found that the outlet temperature is 15°C for cooling mode of summer and heating mode in winter was 21.8°C.. Azzeddine et al. [9] studied the thermal performance of the EAHEs through the parametrical to investigate the influences of the velocity of the air, the physical properties and the diameter of the pipe. The results displayed that a heat exchanger gives the coefficient of performance is higher with a upper efficiency and a system has the potential energy 146.38 M W h in heating and 104.3 M W h in cooling modes. Wasseemet al. [10] studied experimentally the thermal performance of EAHE in arid and humid soil in the Basra in the semi desert region for a poultry shed. They found results advances the overall heat exchange efficiency. The (COP) of the wetted exchanger with an average COP of 6.41, while the dry exchanger (DE) obtained the value of 5. 07. On average, the exit temperature from the wet exchanger (WE)was 37.35°C ,however in the dry exchanger it was 38.91°C in the warmest hours of the day. Also, the WHE warmed the air over than the dry exchanger system, throughout the night time.

2.2. Residential building:

Sodha et al. [11] investigated the EAHEs pipe length requisite in the cooling of the model with different earth surface dealings of Delhi (India) for compound climate. Observed from the result that for meeting the cooling load demand the dry sunny superficies requisite long tunnel, while, wet covered surface requisite the smallest length one. From the parametric of their research, saw that improvement for the temperature of the profiles in soil with great moisture of substances is faster than compared to the soil by little moisture substances. Sharan and Jadhav [12] used EAHEs to heating and cooling with modes was working in India ,Ahmedabad, with yearly the middle temperature varieties between (23◦C and 43◦C). They found that a system was capable to rise the temperature with nearly 14◦C in January and reduce the temperature in May with a same value. The performance coefficient (COP) for heating and cooling was 3.8and 3.3, correspondingly. F. Al-Ajmi et al.[13] improved a theoretically model to calculate the earth to air heat exchanger temperature of air outlet and the potential of this cooling apparatus in a warm and dry weather. The model for the classic home of Kuwait City. They found that the EAHEs had the ability to decrease home cooling energy request through the summer season by 30%. M.K. Ghosal and G.N.Tiwari .[14] in India, analytically model was advanced to study the efficiency of the earth thermal air heat exchanger combined greenhouse found in New Delhi. Their Results presented that the thermal performance was suitable and advance by using of EAHEs . M.K.Ghosal et al. [15] presented advanced numerical model of using the kept thermal energy of earth for space warming to investigate the potential with the advantage of (EAHE) systems with the greenhouses situated in the Delhi, India. Experimental. They found that the air temperature were discovered to be on the average from(7-8 C°) greater than a same greenhouse when operational minus EAHE. Cheletal et al [16] executed experimentally during winter season thermal analysis with EAHE systems for the building integrated. The dimensions of building air temperature showed that with using EAHE system is an increase by 5 – 15.8 ˚C in the temperature of air of building compared by ambient air temperature, consequently the concluded that the EAHE is appropriate to an axillary system for heating and cooling buildings . Transient Systems Simulation Software (TRNSYS) by Abdullahi Ahmed. et al. [17] estimated a thermal performance of the EAHEs for unlike shapes and work conditions in the UK. Their result showed major enhancement in potential and internal thermal conditions to decrease use of the energy concentrated conservative cooling system . Bansal et al. [18] and Vaz et al. [20] showed out a numerical studies by the help of FLUENT based on the computational fluid dynamics(CFD) surroundings for calculating the heating and cooling capability of earth to air-pipe heat exchanger (EAPHE) system . Mohammad Jia et al. [19] investigated experimentally the measurement the capacity of cooling the ETAHEs in Bangladesh.. They found that the COP and the capacity of Cooling increased with the increase of mass rate of flow ,the outlet temperature declined below ambient temperature as the inlet air. Khalajzadeh et al. [21] estimated the performance thermal of earth heat exchanger (GHE) and evaporative cooler hybrid systems of Tehran, Iran in summer climate. They [60] saw that the hybrid systems are able to change the conventional air conditioner efficiently and its cooling efficacy is higher than unity. Tudor et al. [22] analyzed and advanced the suitability of using the EAHEs as the passive method for heating and cooling of houses under the climate for five cities of South – Eastern Europe. They obtained that the exit air temperature from EAHEs noted during July and August month was the maximum monthly average, while in January month was the minimum. Moreover, they discussed, best the thermal performance and the high heat gain record with using pipe diameter of 100 mm instead of 200 and 300 mm &17 m pipe length instead of 10 and 5 m, 2.5 & 3.5 m burial depth in its place of 1 m .Ramirez-Davila et al [23] executed numerically study on the performance thermal of the (EATHE) system by changing climatic conditions for three cities in Mexico. Their results presented that use of EAHEs was suitable for extreme and enough temperature areas wherever the thermal inertia influence is greater in soil. Earth to air heat exchangers (EAHE) s with solar chimneys Haorong Li. et al. [24]. Experiments studied to estimate the performance the system in summer to investigates an innovative passive air conditioning system. They noted that EAHE full cooling aptitude in that Experimental was 3308 W, while the maximum cooling ability of coupled system EAHEs and solar chimneys was 2582 W, and they concluded that the increase in the exit air temperature . Trilok Singh Bisoniya et al.[25] discussed the decrease a cooling of energy demand of buildings experimentally in dry and hot climate Bhopal (Central India) .Observations of ; temperature was drop from 12.90 °C to11.30 °C and the gain energy of cooling of EAHEs improve 0.85 to 1.87 MJ h for the air flow of speeds of 2m/s to 5m/s . Trilok Singh Bisoniya et al. [26]discussed the efficiency of decreasing the heat of energy request of buildings in dry and cold winter climate conditions by using EAHE. Experimental results showed that heating potential various from 0.59 to 1.22MJ h for air of flow speeds of 2 to 5 m/s ,also correlation coefficient and root mean square of percentages deviance of 2.1% and 0.999. Nitish Shrestha et al. [27] Performance analysis of EAHE at different atmospheric conditions, Experimental that system consist of finned tube. Observed that in cooling mode the inlet temperature of the air drops with rise in the pipe length. The temperature reduction for a length of 1.2m differs from 1-3 C° at velocity 6.5m/sec. G.N. Tiwari et al. [28] experimentally estimate thermal conductivity of a soil, the EAHE system has been planned ,measurement of room with improved values of radius of pipe, length of pipe, number of air variations, and depth at which(HE) be fixed under the superficies of the ground. They observed that the outlet air temperature a reduction of(5 – 6 °C) in summer for a number of 5 air variations with 0.10 m and 21 m enhanced diameter and pipe length respectively. Sanjeev Jakhar. et al. [29] expected experimentally the thermal of performance of earth to air tunnel heat exchanger (EATHE) system linked by the solar air heating duct to develop the capacity of heating EATHE system. They noted that the capability of heating of EATHE system improved from 1217.625 to 1280.753 kWh after it was linked with the solar air heating duct with a significant rise of temperature of room by 1.1– 3.5 ◦C . the effect of a thermal performance of EAHE by its design parameters are planned numerically by Thakur et al.[30]. From result their displayed that the thermal performance improved with using finned pipe wherever the air temperature was recorded drop about 20.5 ˚C compared with 17.7 ˚C when the pipe is finless. Numerical study by Benhammou et al. [31] to estimate the thermal of performance of the (EAHE)system a passing one dimensional season below the climate conditions of Algerian Sahara. through summer . They found that the decline in the air temperature between inside and exit of the system is greater with high the inlet air temperature consequently by the tube length of 50 m, the drop in the air of temperature is 11 ˚C for the air inside temperature of 44 ˚C and is 5 C° for the air inside temperature of 29 ˚C. After observing their results they reached to that the thermal of performance of EAHEs developed at great air temperature through the summer season. Hiresh .et al. [32] performed an experimental operate to study the earth to Air Heat exchanger performance. They found that about 261.5 W was the maximum quantity of heat transfer from air to surrounding soil at 5 m/s the velocity of air. Also, they explained from the results that with temperature of inlet air changing from 32 ˚C to 40.3 ˚C the exit air temperature increased with 4.5 ˚C at 5 m/s. Anuj Mathur et al [33] showed an numerical the problematic of increase of heat nearby the tube during the summer period by soil having low moisture content and great specific heat. They obtained that the saturation of soil with heat hampers the performance of EAHEs and the heat can be enhanced in winter days with running the system. Sanjeev et al. [34] discuss experimentally and simulation typical with using TRNSYS 17 to evaluation the heating of potential of earth air heat exchanger with and without solar heat pipe (SHD). They establish through the simulation results and experimental results that the heating capacity and exit air of temperature of EAHEs enhanced by using solar heat duct.

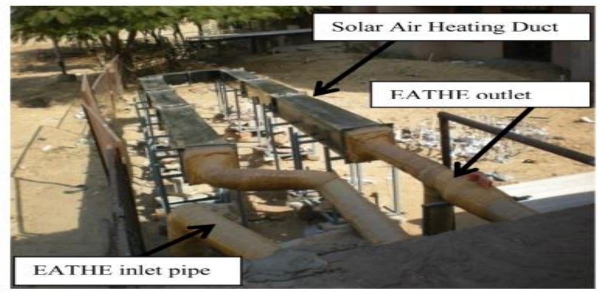

Figure 1: Experimental set-up of EATHE coupled with solar air heating duct.

Moreover, in the winter season they found that the exit air of temperature improved by reduced air velocity. Badgaiyan P et al. [35]. evaluated the performance of EAHE with several operating parameters was studied experimentally and numerically. They proved that thermal performance enhanced with increasing the length of pipe, wherever the outlet temperature reduced. Additionally, they concluded that for three velocity of air flow (4, 5, and 6 m/s). the less outside temperature found with 4 m/s air velocity .Omar Hamdi et al. [36] study the performance of the earth -to-air heat exchanger (EAHEs) and discovery out the usefulness of the cooling of buildings in the hot region in the south east of the Algeria at Biskra University. From result observed The air temperature at the outside of the exchanger is about 24 °C at the starting of May to reach nearly 32 C° in early September. Nasreddine Sakhri1 et al. [37] experimentally study is showed on the performance of a combined system :EAHEs and the solar chimney. as an arid region in the North-west of the city of Bechar, Algeria. They showed results of the capacity of the system to rise the outlet air temperature exit the system by 14 °C and produce the heating mode. The inside temperature increased ,then, the system travelled to a cooling mode by decreasing this temperature of air by 11.6 °C (from 36.2 °C at the inside to 24.6 °C at the outside). Three dimensional EAHEs combined with a house building by Mushtaq I. Hasan and Sajad W. Noori [38] discussed a numerical the potential for drop in energy consumption for heating and cooling loads by using the EAHE system in southern Iraq in the weather of Nasiriya city .They results showed that thermal performance and the outlet air temperature improved with length and the pipe of number of the EAHE system. So, The EAHEs is higher appropriate for work through winter month , wherever , the drop in energy saving and heating capacity are great compared with the decrease in energy saving and cooling capacity in summer months.

2.3.Study the earth to air heat exchanger performance with solar chimney:

Also, they used MATLAB software with CFD modeling by. Salman H et al. [39] studied to the investigating the influence of tube length , the air of speed , and tube diameter on a performance of the air thermal HE system in Basrah, used (EAHE) collected with Solar chimney (SC) .The results have shown that the temperature at outlet from the buried pipe declines with rising the pipe length , declining pipe diameter, declining mass flow rates of flowing air in the tube and rising depths up to 4m.

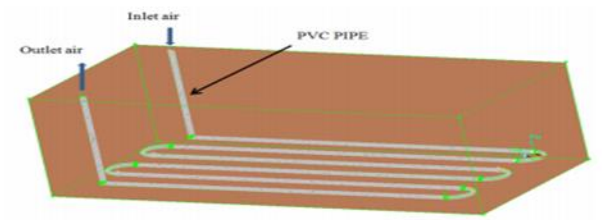

Figure 2: the Earth–tube–air heat exchanger system.

Earth to -air heat exchangers (EAHEs) with solar chimneys by Haorong Li. et al. [24]. Experiments studied to evaluate the performance the system in summer to investigates an innovative passive air conditioning system. They noted that EAHE maximum cooling capacity during that Experimental was 3308 W, while the full cooling capability of coupled system EAHEs and solar chimneys was 2582 W, and they saw that the rise in the outside air temperature . Nasreddine Sakhri1. et al. [40] an experimental investigation is showed on the performance of a combined system: earth-to-air heat exchanger and a solar chimney, as an arid region in the North-west of the city of Bechar, Algeria. They showed results the capacity of the system to rise the outlet air temperature exit the system with 14 °C and produce a heating mode. The inside temperature increased ,then, a system travelled to the cooling mode by decreasing this temperature of air with 11.6 °C (from 36.2 °C at the inside to 24.6 °C at the exit).

2.4.E ffect of soil type and moisture content on EAHEs:

After the parametric study by Puri. [40] Saw that advance of temperature profiles is quicker in soil by great humidity substances than to soil by little humidity contents. Their result improvement of the temperature with soil moisture contents.. Sodha et al. [11] studied the earth air HE pipe length requisite in the cooling of the model with different earth surface dealings of Delhi (India) for compound climate. Observed from the result that for meeting the cooling load demand the dry sunny surface requisite long tunnel, while, wet shaded superficies requisite the smallest length one. And , improvement of the temperature of the profiles in soil by great moisture of contents is faster than compared to the soil with little moisture substances. Santamouris et al. [41] studied the effect of different earth superficies the boundary of conditions on the of a multiple and a single parallel EAHEs They provide efficiency is high by using EAHE.. Clara et al. [42] Presented the influence of soil shield, soil composition and climate, on the performance of the EAHE systems. They reached that the bare surface for heating develops the performance of the EAHE, while the surface humid for the cooling object is better. They additionally ,showed that the higher water contented and a carefully packed soil nearby the tubes of EAHEs develop EAHE system performance. Mathur et al. [43-44-45] evaluated that the soil temperature about of the tube depends on the thermal conductivity of soil wherever the soil by a lesser thermal conductivity will saturate at the quicker than to the soil with the greater thermal conductivity. Mushtaq I. Hasan and Sajad W. Noori .[46] explained an numerical the influence of some plan and environmental factors (the material of pipe and the thickness of pipe wall, moist content of soil,) on the overall performance of an EAHE systems. They showed that the saturated soil shows the greatest general performance of EAHEs compared with further soils, also the wall thickness and tube material no significant influence on the overall performance. Agrawal. et al. [47] discuss experimentally the influence sub-soil moisture content in hot and arid climate to enhance soil thermal properties and its influence on EATHE the pipe of length and thermal performance requisite for selected temperature declined for the summer cooling. They noted that COP and the average heat transfer rate improved by 24.0% and 24.1% correspondingly for 20% moisture contented at 30 m EATHEs the pipe of length than to the dry system. Kamal Kumar A et al. [48] studied the moisture contented and its effect on the pipe of length and the performance of thermal necessary for selected temperature increase in the winter season. They saw that the coefficient of performance and the average heat transfer rise up to 26.1% and 26.0% correspondingly, for 15% the moisture contented at 30 m length pipe of EAPHE system as than to the arid climate.

3. Affecting parameters:

3.1. The effect of flow velocity:

Bansal et al. [50] numerical study carried out on the ETHE systems through the winter period .From their results they proved that 23.4 m of long the earth air thermal heat exchanger system can increase air of temperature for the flow of speeds of 2–5 m/s in the range from 4.1–4.8 C°. Vikas et al [51, 54] ,Sanjeev et al. [34] showed experimentally and numerically the influence of the air speed on the performance of earth to air heat exchanger system . Their result found experimentally and numerically during summer and winter seasons that the exit air temperature improved with rising the air of speed. Vikas Bansal. et al. [53] presented experimentally the effect of the operative parameters (air of velocity, the pipe materials) on a performance of thermal of EPAHE systems to reduction the cooling capacity of the buildings in summer period. They found the air temperature reduce with rise the velocity, and the performance of coefficient of the system differs from 1.9 to 2.9 for rise in speed from 2.0 to 5.0 m/s. V. Bansal et al.[52-56] performed the numerical simulation of cooling capacity and thermal performance of an EAHEs in the hot and dry conditions. They have saw that the velocity of air during a pipe buried has been noted significantly influenced the performance of the earth to air heat exchanger . Mohammad Hossein et al. [55] Carried out experimentally treatments on the influence of important parameters, counting pipe material and burial pipe (pipe of length, depth, air velocity)and on the performance of EAHE systems .They obtained that 5.5 of COP of the system for cooling type was greater than 3.5 for heating COP of material which is higher for steel than PVC. Also, the differential temperatures were 14.4 C° and 9.4 C° for cooling and heating modes .

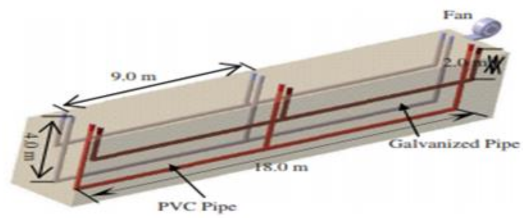

Figure 3: Schematic of the EAHE piping design.

Misra et al. [57] Estimate the variant of derating element of the EAHEs because of the influence of the parameters. They results displayed that the rise in the flow of velocity it causes decline in thermal performance of EAHEs. Nitish Shrestha1. et al. [28] performance analysis of EAHE at different atmospheric conditions observed that in cooling type the inlet temperature of the air drops with rise in the pipe length. The temperature reduction for a length of 1.2m differs from 1-3 C° at velocity 6.5m/sec. Salman H et al. [39]. studied to show the effect of the tube of length, air speed , and pipe diameter on the performance of the air thermal HE system in Basrah . The result have presented that the potential of Earth Tube is providing lesser exit temperature of air inside to the area. They discover that the temperature at outlet from the buried pipe declines with rising the length of pipe, declining pipe diameter, declining mass flow rates of flowing air in the tube and rising depths above to 4.m .Experimental and theoretical study have been by Mohammed Benhammou and Belkacem Draoui [58] to show the impact of dynamical and geometrical parameters on the thermal performance of EAHEs the thermal performance of (EAHEs) to the summer cooling in the Algerian Sahara. Their result obtained that the air exit temperature declines with rising the length of pipe but it rises with rising the velocity of air and pipe cross section , also experimental that COP declined quickly with increasing the velocity of air. numerical study by Benhammou et al. [31] to estimate the thermal of performance of earth to air heat exchanger system a passing one dimensional season below the climate conditions of Algerian Sahara. through summer . They noted from the results that the air temperature in outlet from the system with pipe length of 30 m is less by 2 ˚C compared with 10 m pipe length. Also, they observed that the air temperature in outlet decrease by 1.8 and 1.2 with using 10 cm pipe diameter 30 cm and 1 m/s the air of velocity in place of 3 m/s. Similarly with the found of Krarti et al. [49]. Ahmed et al [59].discussed numerical and an experimental investigation about the thermal performance EAHE systems with diverse parameters (pipe of length, pipe space ,pipe diameter and pipe material) in Egyptian weather conditions. The results showed by using computational fluid dynamic saw that the air temperature at exit increases with reduced diameter, increasing pipe length and decreasing the flow rate. Sanjeev J et al. [34] showed experiment was through winter season for the influence of diverse inside flow velocities, concluded that the best rise in EAHE exit temperature at the speed 5m/s compared with velocity at 2.5m/s and 3.5m/s. While, Jahkar et al [60] studied the parametric were done to analyses the influence of mass flow rate, radius of buried pipe , length of tube and the material of pipe on the performance study of a EWHE system. They obtained that by an rise in mass flow rate, the temperature in the outlet of EHWE rise .

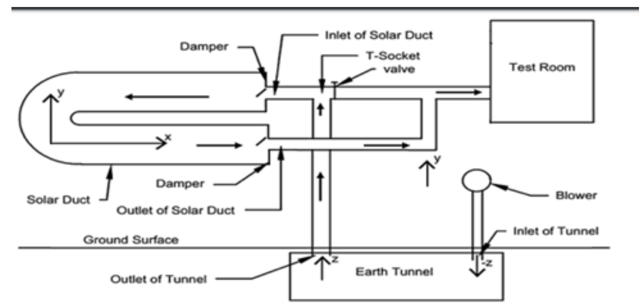

Figure 4: schematic diagram of the experimental setup.

Badgaiyan P et al. [35] estimated the performance of EAHEs with several operating parameters was studied. . They proved that thermal performance enhanced with increasing the length of pipe, wherever the outlet temperature reduced. Additionally, they concluded that for three velocity of air flow (4, 5, and 6 m/s). the less outlet temperature found with 4 m/s air velocity. Mushtaq I. Hasan and Sajad W. Noori [61] study a numerically the overall performance of the EAHE by five forms of the EAHEs channel. They discover that the outlet air temperature reduced through the summer and increased through the winter season period, with increasing pipe of length or declining the air of speed, so, they showed that there is the circular form gives the greatest general performance since it has the smallest pressure drop than by further figures.

3.2. Effect of length of pipe:

Mihalakakou et al. (1995) [62] discuss the parametrical model in which changing parameters were tube radius ,pipe length, speed of the air inlet the pipe and the buried of depth pipe under the earth superficies. conclude with increase the velocity the temperature is enhance. Bansal et al. [50] numerical study carried out on the earth air HE systems through the winter periods .From their results they proved that 23.4 m of long the earth air thermal HE systems can increase the air of temperature for a flow of velocities of 2–5 m/s in the range from 4.1–4.8 °C,. Maerefat and Haghighi [63] ,Pohstiri et al., [65] have advanced a mathematically typical based on energy conservation equations and resolved by iterative way to find out the ability of the solar chimney and EAHE system. pipe lengths of EAHE must be used to afford a best thermal security condition less than 35m .They results showed of the influence of EAHEs tube radius on the system performance exposes that the rise of the EAHEs diameter up to 0.5m does not rise the room air temperature. Ascione et al.[64].evaluated the energy of performance of the air to conditioned building joined by ground heat exchanger (GHE) in the Italian weather. From their result obtained for a 50 m length of ground heat exchanger pipe was about 14.2 kWh/m2 is the maximum major energy that saving . Mohammad Hossein et al. [55] Carried out experimentally treatments on the influence of important parameters, counting pipe material and burial pipe (pipe of length, depth, air velocities)and on the performance of an EAHE systems .They obtained that 5.5 of COP of the system for cooling style was greater than 3.5 for heating COP of material which is higher for steel than PVC. Also, the differential temperatures were 14.4◦C and 9.4◦C for cooling and heating modes . academics[66-67] have discovered that the system provide best the thermal of performance with rising the tube length burying, the pipe at a depth above to 3 m, expanding the superficies of a pipe, decreasing the tube radius and the air flow rate inlet the tube. Nitish Shrestha1. et al. [28] performance analysis of EAHEs at different atmospheric conditions observed that in cooling style the inlet temperature of the air drops with rise in the tube length. The temperature reduction for the length of 1.2m differs from 1-3 C° at velocity 6.5m/sec. 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While [76] showed experiment was through winter season for the influence of diverse inside flow velocities, concluded that the best growth in EAHE exit temperature at the velocity 5m/s than to velocity at 2.5m/s and 3.5m/s. Badgaiyan P et al. [35] estimated the performance of EAHE with several working parameters was studied. They proved that thermal performance enhanced with increasing the length of pipe, wherever the outlet temperature reduced. Additionally, they concluded that for three velocity of air flow (4, 5, and 6 m/s). the less outlet temperature found with 4 m/s air velocity.. Mushtaq I. Hasan and Sajajd W. Noori .[61] study a numerically the general performance of the EAHE by five forms of the earth air heat exchanger channel. 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Noori [46] studied numerically the effect of the parameters (inside condition, pipe diameter, pipe length, and exit condition) on the general performance of the EAHEs .They pretend results presented that the EAHE systems with pipe radius (6 in) has the best values of general performance. Then, the diameter of pipe more suitable is 2 in from the thermal of performance point of overview.

3.3. Effect of diameter of pipe:

Mihalakakou et al. (1995) [62] discuss the parametrical typical in which changing parameters were pipe radius ,pipe length, speed of the air inlet the cylinder and the buried of depth pipe under the ground superficies. conclude with increase the velocity the temperature is enhance.. Maerefat and Haghighi [63], Pohstiri et al. [65] have advanced the mathematical typical based on energy conservation equations and resolved by iterative way to find out the ability of the solar chimney and EAHE system. pipe lengths of EAHE must be used to afford a best thermal security condition less than 35m .They results showed of the influence of EAHE system tube radius on the system of performance exposes that the rise of the EAHEs diameter above to 0.5m does not rise the area air temperature .academics [66,67] have discovered that the system provide best the thermal of performance by rising the tube length burying, the tube at the depth up to 3 m, expanding the superficies of the pipe, decreasing the tube diameter and the air flow rates inlet the pipe. G.N. Tiwari et al. [69] experimentally estimate thermal conductivity of the soil, earth - to air heat exchanger system has been planned ,measurement of room with improved values of radius of pipe, length of pipe, number of air variations, and depth at which(HE). They observed that the exit air temperature a reduction of 5 – 6 C° in summer for the number of 5 air variants with 0.10 m and 21 m enhanced diameter and length of pipe correspondingly. Salman H et al. [39] studied to investigate the impact of the pipe of length, air velocity , and pipe diameter on performance of the air thermal HE system in Basrah . The result have presented that the potential of Earth Tube is providing lesser outside temperature of air inside to the area. They discover that the temperature at outlet from the buried pipe declines with rising the length of pipe , declining pipe radius, declining mass flow rates of the flowing air in the tube and rising depths above to 4m. Numerical study by Benhammou et al. [31] to estimate the thermal of performance of earth air HE system a passing one dimensional season below the climate conditions of Algerian Sahara. through summer . They noted from the results that the air temperature in outlet from the system with pipe length of 30 m is less by 2 ˚C compared with 10 m pipe length. Also, they observed that the air temperature in outlet decrease by 1.8 and 1.2 with using 10 cm pipe diameter 30 cm and 1 m/s the air of velocity in place of 3 m/s. Similarly with the found of [49]. Ahmed et al . [59] discussed numerical and experimentally investigation about the thermal performance of the EAHE system with diverse parameters (pipe length , pipe space ,pipe diameter and pipe material) in Egyptian weather conditions. The results showed by using computational fluid dynamic saw that the air temperature at outlet increases with reduced radius, increasing tube length and decreasing the flow rate. Jahkar et al. [68] studied the parametric were done to analyses the influence of mass flow rate, diameter of buried tube , pipe length and tube of material on the performance enquiry of the EWHE system . They obtained that with an rise in mass flow rates, the temperature in the outlet of EHWE rises . While [76] showed experiment was through winter season for the influence of diverse inlet flow velocity, concluded that the batter growth in EAHE exit temperature at the velocity 5m/s than to the speed at 2.5m/s and 3.5m/s. Mushtaq I. Hasan and Sajad W. Noori [48] studied numerically the influence of the parameters (inside condition, pipe diameter, pipe length, and exit condition) on the general performance of the earth air heat exchanger(EAHE) system .They simulated result presented that the EAHE systems by pipe diameter (6 in) has the better values of general performance. Then, the diameter of tube more suitable is 2 in from the thermal performance point of overview.

3.4. Effect of pipe of thickness:

Mushtaq I. Hasan and Sajad W. Noori (2018)[70] explained an numerical the influence of specific design and environmental factors (pipe material and thickness of tube wall, moist content of soil,) on the overall performance of the earth to air heat exchangers. they showed that the saturated soil displays the greatest general performance of EAHEs than by other soils, also the wall thickness and pipe material no significant influence on the overall performance.

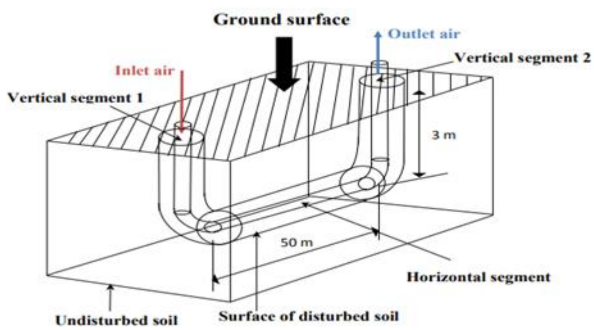

Figure 5: Schematic of EAHE system

Mushtaq I. Hasan and Sajad W. Noori..[71] studied numerically the effect of wall thickness and tube material on the overall performance of EAHEs . Their results noted the more suitable to use is PVC pipe because it is non-corrosive and less cost compared with steel pipe. The influence of wall thickness on the overall performance is less and can be neglected.

3.5. Effect of pipe material:

Vikas Bansal. et al. [72] discuss experimentally the influence of the operative parameters (the air velocity, the tube material) on the thermal performance of EPAHE systems to decrease the cooling capacity of the buildings in summer. they found the air temperature reduce with rise the speed, and the COP of the system differs from 1.9 to 2.9 for rise in the velocity of 2.0 to 5.0 m/s. In addition the maximum rises in temperature for steel and PVC pipes are 10.3 and 12.7 8C correspondingly. V. Bansal et al. [52-56] performed the numerical simulation of cooling capacity and thermal performance of EAHEs in the warm and dry conditions. They have observed that the performance of the EAHEs is not significantly influenced by the material of a pipe buried, while the velocity of air during a pipe buried has been noted significantly influenced the performance of the EAHEs . Mohammad Hossein et al. [55] Carried experimentally treatments the influence of important parameters, counting pipe material and burial pipe (pipe length, depth, air velocity) and on the performance of the EAHE system. They discovered that 5.5 of COP of the system to cooling mode was greater than 3.5 for heating COP of material which is higher for steel than PVC. Also, the differential temperatures were 14.4◦C and 9.4◦C for cooling and heating types . Hatraf et al. [73] have studied the parameters effectiveness the performance of EAHE during experimentation and modeling. They have done design using the simple typical varied some and the supply of the air temperature. they found was that the pipe of material has no influence on a performance of the HE, which is arrangement by the found of Bansal et. al [52]. Serageldin et al., [75] calculated the thermal of performance of the EAHEs used to cooling and heating in the Egyptian climate conditions. They have advanced the mathematical typical founded on unsteady, one dimensional, quasi to state for energy conservation equation Three diverse kinds of pipe material were used , specifically steel , PVC and the copper. The exit air of temperature was 19.7 °C in PVC tube, and 19.8 °C for together copper and steel correspondingly. So, it is established that the difference in the exit air temperature for many pipe material is also lesser and later it is negligible. Mushtaq I. Hasan and Sajad W. Noori [70] , Mohd, Noor A et al. [74] explained a numerical the influence of certain design and environmental factors (tube material and thickness of pipe wall, moist content of soil,) on the overall performance of the earth to air heat exchangers systems in Nasiriyah town in southern of Iraq. they showed that the saturated soil displays the greatest general performance of EAHEs than with further soils , also the wall thickness and pipe material no significant influence on the overall performance. Mushtaq I. Hasan and Sajad W. Noori.[71] studied numerically the influence of wall thickness and tube material on the general performance of EAHE. The results showed the more suitable to use is PVC pipe because it is non-corrosive and less cost compared with steel pipe. The influence of wall thickness on the overall performance is less and can be neglected, The pressure drop and the exit air temperature for the two materials improved with rising the velocity of air.

3.6. Effect of pipe depth buried underground:

Pfafferot.[75] and Pfafferot et al. [76] studied the average of yearly temperature profile at depths of 1 m, 2 m, 4 m and 8 m. They results presented that the temperature at depths of 4 and 8 m was stable during the time in the range of 9 to 13°C. Cucumo et al. [77] explained the effect of the burial pipe depth on the performance of earth to air heat exchanger systems. The model allowable also to calculate the temperature of air inlet the tube and of soil nearby the buried pipe, taking into description the thermal perturbation of greater free superficies and the possible phase change (concentration) in the buried pipes. A like model was advanced by Su et al. [78] for discuss the thermal performance of EAHEs used for the building energy saving. Mohammad Hossein et al. [55] Carried experimentally treatments the influence of important parameters, counting pipe material and burial pipe (pipe length, depth, air speed) and on the performance of an EAHE. They discovered that 5.5 of COP of the system for the cooling style was greater than 3.5 for heating COP of material which is higher for steel than PVC. Also, the differential temperatures were 14.4◦C and 9.4◦C for cooling and heating modes. Academics [66,67] have discovered that a system provides best the thermal of performance by rising the pipe length burying, the pipe at a depth up to 3 m, expanding the superficies of the pipe, decreasing the pipe diameter and the air flow rates inlet the pipe. Mushtaq I. Hasan and Sajad W. Noori.[79] thesis discussed a numerical study about the potential decrease in the request of energy and the overall performance of (EAHE) systems for heating and cooling of the house buildings by EAHE system of southern of Iraq in Nasiriyah city. they showed that more appropriate to use is the EAHE system of case 2 compared with case 1 and case 3 II (consist of one layer buried with 3 m depth of EAHE system and the EHAE of this case3 II buried with depth of 4 m) with saving in energy 17.84% of winter at January months and 9.33 % of summer months at August month.

4.The disadvantages. of this application:

1. Possibility of Depletion of Geothermal Sources.
2. High Investment Costs for Geothermal System.
3. Land Requirements for Geothermal System to Be Installed.
4. environmental Concerns about Greenhouse Emissions.

5. Conclusions:

The EAHE is one of the systems that can be used for decreasing energy consumed in buildings ,thermal performance of the EAHE depends on several chief influences such as under earth temperature difference, plan and specification of the EAHE pipe, the following conclusions can be decided:

1.Thermal performance improved with using finned pipe wherever the air temperature was recorded drop about 20.5 ˚C compared with 17.7 C° when the pipe is finless

2. The wall thickness and pipe material no significant influence on the overall performance

3. The effect of EAHE system tube diameter on the system of performance exposes that the rise of the EAHEs diameter

lead to increase in area of pipe that it cause increase in temperature outside of pipe and it cause decrease in pressure drop.

4. The EAHEs had the ability to decrease home cooling energy request through the summer season by 30%.

5. The increase in length of pipe of EAHE lead to decline in the temperature interning to the poultry houses, then it increased with increasing the velocity of air and pipe cross section.

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