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A COMPREHENSIVE REVIEW ON HORIZONTAL EARTH AIR HEAT EXCHANGER

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ABSTRACT

Earth air tunnel heat exchanger, it is known that the thermal performance of earth air tunnel heat exchanger system is dependent upon several parameters like inlet air velocity, tube length, tube inner diameter, tube thickness, tube material, climate conditions and highly dependent upon thermo-physical properties of ground soil. Since the thermal performance of earth air tunnel heat exchanger is highly dependent upon thermo- physical properties of ground soil, so the ground soil having lower thermal conductivity requires much longer tubes for the desirable heat transfer in between the air and earth soil. Thus for installing the earth air tunnel heat exchanger, space limitation is the major problem for obtaining the desirable results. In highly populated country like India earth air tunnel heat exchanger is no more used for air-conditioning purpose due to space limitation problem and it is also giving limited cooling effect depending upon climate conditions. Therefore in this Dissertation Work, above two major problems were analyzed carefully. Thermal performance of EATHE is more effective for summer season as compare to winter season.

1. INTRODUCTION

The energy consumption in commercial places like Hospitals, Industries etc. for Winter Heating and Summer Cooling has been increased during the decades. Energy saving is much important point everywhere, particularly in desert climate. The desert climate can be defined as hot & arid and such type of climate exists in a number of areas throughout the world. In India, climate of west Rajasthan is dessert. In general peoples feel comfort zone when the surroundings air temperature is kept between 20℃ to 26℃ and relative humidity or moisture content in the surroundings air is kept between 40% to 60%. Now a days, this is achieved by using Air-Conditioning mostly in the commercial places. Air conditioning system is mostly used for the comfortable summer cooling and winter heating as well as the industrial productions. Modern Air-Conditioning System works on Vapour Compression Refrigeration Cycle in which various refrigerants are used that defects the environment and ozone layer of earth. Due to the Ozone Layer Depletion & Global Warming by using Chlorofluorocarbons (CFCs) and the need to minimize high grade energy consumption various passive techniques are used now a day's introducing new method i.e. Earth Air Tunnel Heat Exchanger. An Earth Air Tunnel Heat Exchanger has one or more buried pipes which are placed under the ground in order to produce cooling effect in summer as well as heating effect in winter comfortable to human body with respect to climate conditions. The physics of Earth Air Tunnel Heat Exchanger is very simple: beyond a certain depth of earth, the temperature of ground remains comfortable to human body with respect to environment conditions which is kept constant throughout the year. This ground temperature in known as undisturbed temperature and remains hotter as compare to ambient air temperature in winter session and remains cold as compare to ambient air temperature in summer session. Therefore this is treated as cold or hot sink in summer or winter session respectively. Thus the Earth Air Tunnel Heat Exchanger becomes effective and economical for winter heating and summer cooling to reduction in energy consumption. There is no Global Warming & Ozone Layer Depilation in case of Earth Air Tunnel Heat Exchanger, since it uses fresh air as refrigerant and no Chlorofluorocarbons (CFCs) used in this as refrigerant. Several Researchers have described that the Earth Air Tunnel Heat Exchanger installed in a building is an effective and economical passive energy system for summer cooling and winter heating. The Thermal Performance of Earth Air Tunnel Heat Exchanger is dependent upon inlet air velocity, geometry of buried pipe, pipe material, climate conditions and mostly on soil thermo-physical properties.

2. LITERATURE REVIEW

Mathur et al. (2017) compared straight and spiral earth air tunnel heat exchangers in cooling and heating modes at MNIT Jaipur, as one example of the many experimental and

computational studies conducted on the subject of earth air tunnel heat exchangers. We assumed a total of 60m for the buried tubes. The pipe's thickness was determined to be 0.003 m and its inner diameter to be 0.10m. Pipe material was selected as High Density Poly Ethylene, or HDPE. Based on their calculations, they determined that the EATHE spiral system takes up less room than the straight system. Additionally, compared to the straight EATHE technique, the spiral EATHE system is more effective [2]. Using thermal imaging, Sanjeev Jakhar et al. (2014) studied experimental results of a solar air heating duct connected to an earth air tunnel heat exchanger for the dry environment of Ajmer city were recorded. They found that using EATHE in conjunction with a solar air heating duct was much more successful than using EATHE alone. The polyvinyl chloride (PVC) material was used for the pipes. The specified length of the tubes is 60 meters.The earth tube's inner diameter was determined to be 0.010 m, while its thickness was 0.003 m, according to reference [3]. The
size of the pipe, the radius of the pipe, the air velocity inside the tube, and the depth to which the pipe was buried were the variables in the parametric model that Mihalakakou et al. (1995) created [4]. The effectiveness of both single and multiple parallel earth-to-air heat exchanger systems was studied by Santamouris et al. (1997) in relation to various ground surface boundary conditions [5]. An earth-air-pipe system linked with a building without air conditioning was assessed by Kumar et al. (2003) for its potential conservation [6]. The thermal performance of EATHE linked to a room with 100% fresh air and covered in PVC for winter heating was quantitatively evaluated by Bansal et al. (2009). According to their findings, the material of the pipe does not significantly affect the air temperature at the exit [7]. A parametric research testing the novel notion of a "derating factor" for the thermal performance of an earth air tunnel heat exchanger was conducted by Rohit Misra et al. (2012) using computational fluid dynamics (CFD) [8]. The power output of gas turbines was improved by S. Barkat et al. (2016) at Esypt by use of an earth-air tunnel heat exchanger cooling system [9]. The influence of soil thermal conductivity and operating time on the efficiency of an earth air tunnel heat exchanger was investigated by Bansal et al. (2012) at Govt. Engineering College Ajmer [10]. Using several locations for air conditioning in a room coupled with an earth air tunnel heat exchanger, Rahul Khatr et al. (2016) created a computational fluid dynamics (CFD) model to identify the best temperature distribution [11].

In 2014, O.P. Jakhar and Rajendra Kukana used a computational fluid dynamics (CFD) method to conduct a transient thermal study on an earth air tunnel heat exchanger throughout the summer. According to their findings, sandy soil has a greater cooling impact than sandy loamy soil [12]. In this study, a water-cooled heat exchanger is connected to a single unit of an earth air tunnel heat exchanger at the system's output end in order to increase the system's cooling capacity when used independently. Inside the water-cooled heat
exchanger, the waste water from the water cooler was used for cooling purposes. Three distinct input air velocities (10, 12, and 14 m/s) were tested experimentally. Under the hot and dry summer weather of Chittorgarh city, operations were carried out for nine hours every day.

3. EXPERIMENTAL METHODOLOGY

3.1. Description of Experimental Setup

Single earth air tunnel heat exchanger systems have been installed at the Chittorgarh .Therefore the experimental setup of earth air tunnel heat exchanger was installed at a depth of 3 m. The total length of earth air tunnel heat exchanger was taken as 13.92 m whereas the length of water cooled heat exchanger was taken as1.83 m. The inner diameter and thickness of earth air tunnel heat exchanger were taken as 0.04 m and 0.003 m respectively. The inner diameter and thickness of water cooled heat exchanger were taken as 0.108 m and 0.0025 m respectively. Pipe material for the both heat exchanger was taken as MS i.e. Mild Steel due to lower cost and good strength

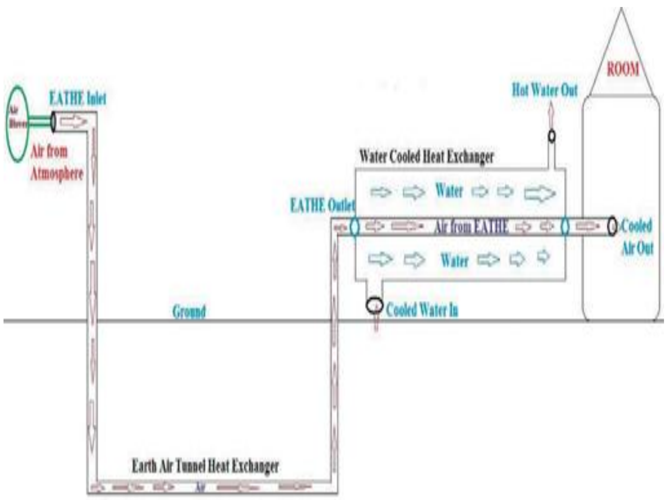

Figure 1. Block Diagram of Integrated EATHE

Table 1. Summary Of Experimental Setup

Parameters	Length (L)	Inner Diameter (D_i)	Outer Diameter (D_o)	Thickness (t)	Material
EATHE	45.67 ft	40 mm	46 mm	3 mm	Mild Steel
Water Cooled Heat Exchanger	6 ft	108 mm	113 mm	2.5 mm	Mild Steel

3.2. Experimental Methodology

For Cooling Potential Evaluation, Experimental Analysis was carried in the month of may and june from 9 A.M. to 1 P.M. i.e. I-Session and from 3 P.M. to 6 P.M. i.e. IIS ession. Readings were taken every after one hour interval of time. Thus the readings were taken at time 9 A.M., 10 A.M., 11 A.M., 12 P.M. & 1 P.M. and 3 P.M., 4 P.M., 5 P.M. & 6 P.M. The system was kept shutdown from 6 P.M. to 9 A.M. (15Hours) for soil regeneration.. The ambient air was forced through the buried pipe of the system with the help of Cheston Air Blower of 5.5 kW having variable speed regulator at a constant air velocity of 10m/s. The air velocity was measured by using Digital Vane Probe Type Anemometer. Digital Thermometer + 2-k-Type Thermocouples were used to record air temperature of Ambient, Inlet & Outlet.

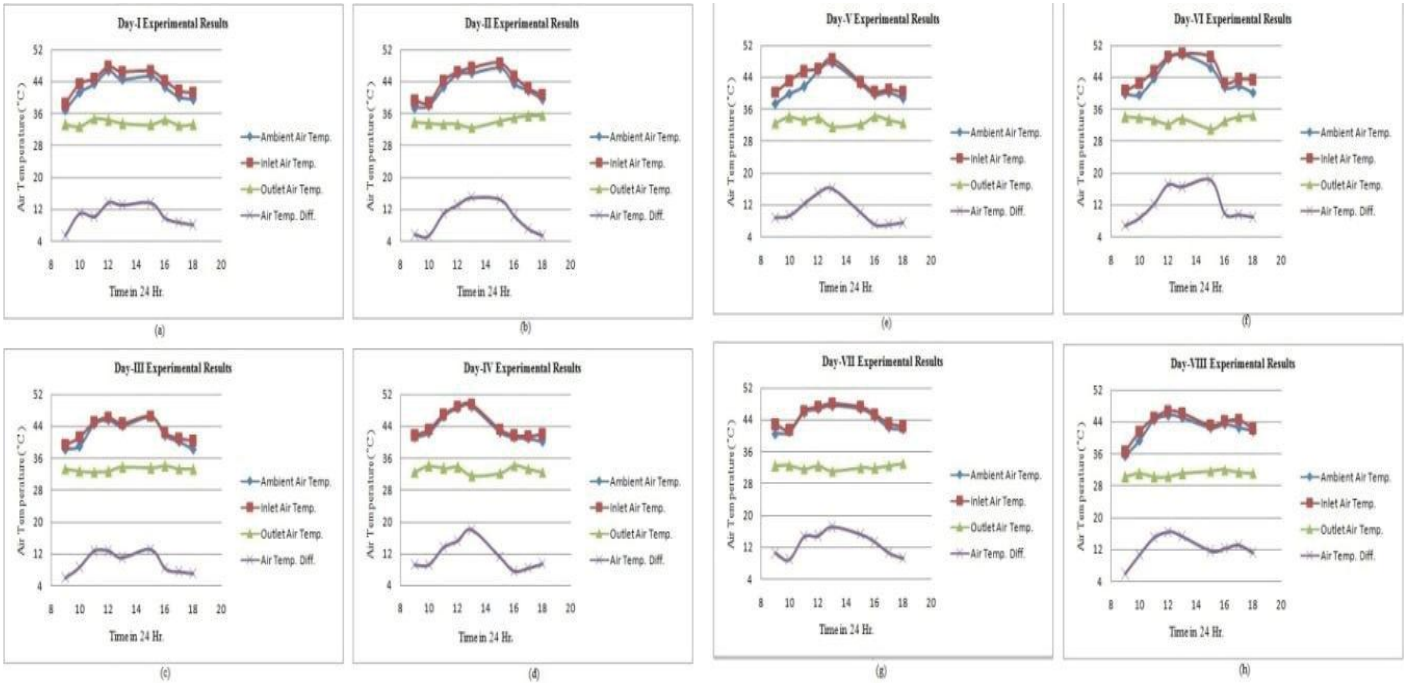

Figure 2. Simple System Experimental Results

4. CONCLUSION

The comparatively study of Simple and Hybrid Earth Air Tunnel Heat Exchanger in Series Connection concludes several points. Space limitation problem was analyzed by introducing Series Connection of Earth Air Tunnel Heat Exchanger System. Utilization of waste water of water cooler was carried out using Hybrid System. Experimental results shows that the Hybrid Earth Air Tunnel Heat Exchanger in Series Connection Coupled with Water Cooled Heat Exchanger is more effective and efficient as compare to Simple Earth Air Tunnel Heat Exchanger in Series Connection. The better cooling effect is provided by using waste water of water cooler in the Hybrid System as compare to Simple Earth Air Tunnel Heat Exchanger in Series Connection System. Higher Air Temperature Difference is found for Hybrid System as compare to Simple System during the working days.

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