International Journal on Future Revolution in Computer Science & Communication Engineering
Volume: 4 Issue: 1

ISSN: 2454-4248
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A Review Paper on Geo-Thermal Heat Exchanger

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***Abstract*—**Since conventional air-conditioner causes ozone layer depletion and global warming, also consumes large amount of energy or power for the purpose of summer cooling and winter heating. Therefore the energy conservation is important objective for the entire world, also environment pollution is much important factor for the whole world. These two factors can be eliminated by using other passive techniques such as ground heat exchanger. Ground heat exchanger consumes less power/energy as compare to conventional air-conditioner also have no bad impact on environment. The soil temperature at certain depth about 10 ft is kept constant throughout the year so this uses as heat sink or heat source in summer session or winter session respectively. The ground heat exchanger is generally known as earth air tunnel heat exchanger. A setup of earth air tunnel heat exchanger was installed at our college campus to investigate the thermal performance of this in summer session and winter session. Earth air tunnel heat exchanger is made of mild steel pipe having length of 45.67 ft, 40 mm inside diameter and 3 mm thickness, placed at a depth of 11 ft. The geometry of earth air tunnel heat exchanger is zigzag type. Variable speed type cheston air blower of 5.5 kwatt was used to supply air at different velocities. K-type thermocouples were used to measure inlet and outlet air temperature. Digital vane type anemometer was used to measure the air velocity. A water cooled heat exchanger was used to develop the performance of the earth air tunnel heat exchanger.

Keywords*-Ground Heat Exchanger, Summer Cooling, Winter Heating, Water Cooled Heat Exchanger, Thermal Performence.*

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I. INTRODUCTION

During the decades, the global energy consumption for winter heating and summer cooling of the buildings has significantly increased. So the energy saving is much important factor for the entire world. Costly and power consumable air-conditioning systems are used for maintaining surrounding air temperature comfortable to human body which works on VCRC in which harmful CFCs are used as refrigerant. Since CFCs have bad impact on environment of earth i.e. causes global warming and ozone layer depletion. Therefore there are two important factor: power consumption and environment pollution. These two factors can be eliminated by using other passive techniques such as EATHE. Most of peoples feel comfort zone when the surroundings air temperature is kept in the range of 22℃ to 28℃ and the relative humidity of ambient air is kept in the range of 40 to 60%. The physics of EATHE is so simple: the earth ground temperature at a certain depth remains constant and comfortable to human body throughout the year. So this uses as winter heating and summer cooling purpose. EATHE is a system in which buried tubes are placed in the ground at a certain depth, through which air is drawn from the surrounding by the external source like air blower. Due to high thermal inertia of the soil, the ground temperature remains lower than outside air temperature in summer and remains higher than outside air temperature in winter. This ground temperature is known as undisturbed temperature which remains same throughout the year. Thus Earth uses as a heat source or a heat sink. Earth uses as a heat source in the winter session and earth uses as a heat sink in the summer session.

II. WORKING PRINCIPLE OF EATHE

EATHE is a arrangement of metallic, plastic and concrete pipes which are connected in different arrangements and placed underground at a certain depth. Through the buried pipes fresh atmospheric air is transferred by the air blower. Due to temperature difference between the earth soil and the atmospheric air, heat transfer will take place between the soil and the air that gives better cooling and heating effect in the summer session and winter session respectively. EATHE uses fresh atmospheric air as refrigerant in order to minimize environment pollution and also uses green or clean energy to minimize the conventional energy consumption. The schematic diagram of working of EATHE is shown in Fig 1.

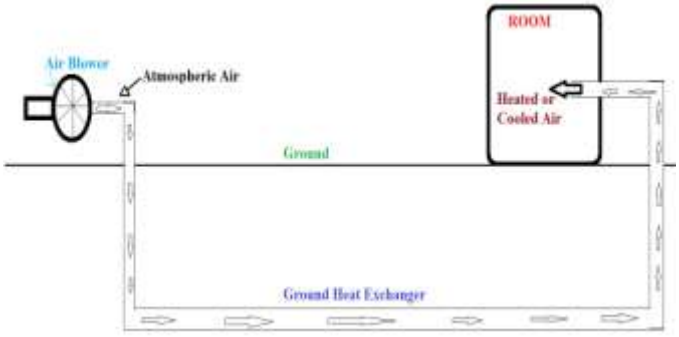

Fig 1. Working of EATHE

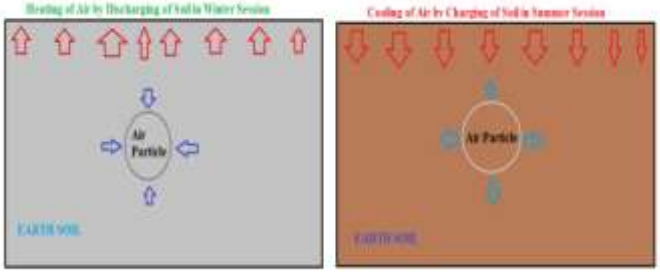

Fig 2. Principle of EATHE

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III. TYPES OF EATHE

A. *Open Earth Air Tunnel Heat Exchanger*

In this type of earth air tunnel heat exchanger, fresh air directly from atmosphere is forced through the buried tubes for heating and cooling purpose. Air is not recirculated through the buried pipes in open system. The schematic of open earth air tunnel heat exchanger is shown in Fig. 3.

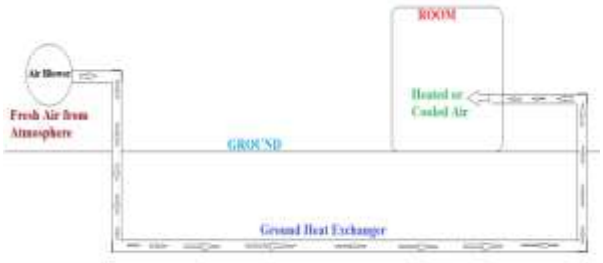

Fig 3. Open EATHE

B. *Closed Earth Air Tunnel Heat Exchanger*

In this type of earth air tunnel heat exchanger, the inlet and outlet ends of the heat exchanger pipe are kept inside the control room as shown in Fig. 4. The room air is recirculated through the closed loop with the help of air blower for heating and cooling purpose. Thus the system is to be called closed loop system since the same fluid is circulated throughout the circuit. The schematic of closed earth air tunnel heat exchanger is shown in Fig 4.

Fig 4. Closed EATHE

IV. DIFFERENT ARRANGEMENTS OF EATHE

A. *Earth Air Tunnel Heat Exchanger in Series Connection*

In this arrangement, the no. of rows of pipes are connected to each other in series connection of pipes as shown in Fig. 5.

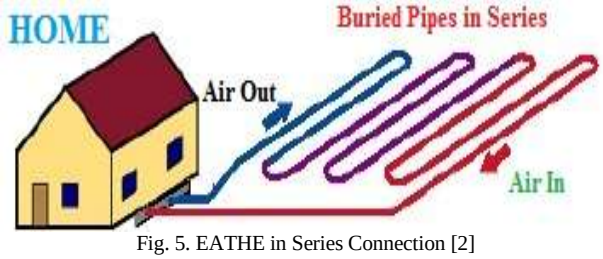

Fig. 5. EATHE in Series Connection [2]

B. *Earth Air Tunnel Heat Exchanger in Parallel Connection*

In this arrangement, the no. of rows of pipes are connected to each other in parallel connection of pipes as shown in Fig. 6.

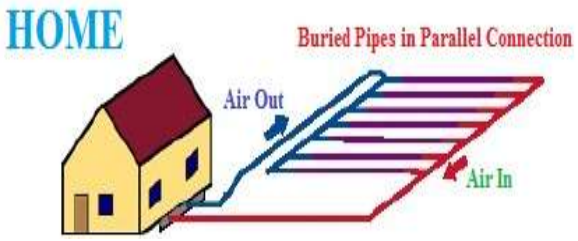

Fig. 6. EATHE in Parallel Connection [2]

V. EARTH GROUND TEMPERATURE

The earth ground temperature distribution is divided into three zones: Surface Zone, Shallow Zone and Deeper Zone [2]. The surface zone is up to about 1m depth. The Shallow Zone is up to maximum depth of about 20m. And the remaining is Deeper Zone, where the ground temperature remains constant throughout the year [2]. Fig. 7 shows the earth ground temperature variation with respect to day of the year for the depth of 2ft, 5ft, 12ft and Ground Surface [6].

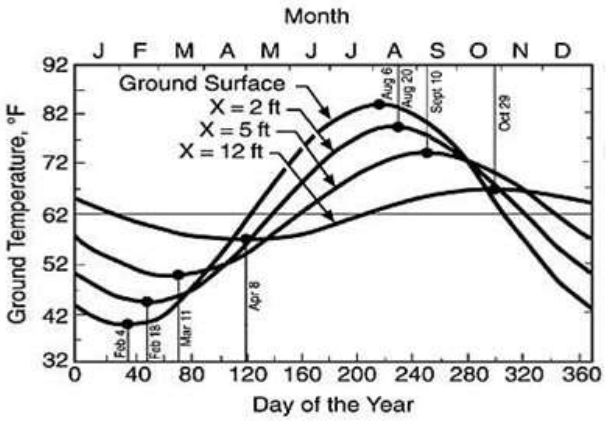

Fig. 7. Earth Ground Temperature Vs Day of the Year [6]

VI. DEVELOPMENT OF THERMAL PERFORMENCE OF EATHE

Since the earth air tunnel heat exchanger gives limited cooling or heating effect as compare to conventional air-conditioner. Therefore, it is necessary to develop the thermal performance of the earth air tunnel heat exchanger by using integrated or hybrid or coupled system. Thermal performance of earth air tunnel heat exchanger for winter heating purpose is maximized by using the solar air heating duct at the outlet of earth air tunnel heat exchanger. This concept was done by the Sanjeev Jakhar, Rohit Mishra, M.S. Soni and Nikhil Gakkhar [3].

Fig. 8. Experimental Setup of EATHE Coupled with Solar Air Heating Duct [3]

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Fig. 8. shows the experimental setup of EATHE coupled with solar air heating duct. Thermal performance of earth air tunnel heat exchanger for summer cooling purpose is maximized by using the water cooled heat exchanger at outlet of earth air tunnel heat exchanger. This concept was done in our college campus. We used the waste water of water cooler in the water cooled heat exchanger to develop the cooling performance of the earth air tunnel heat exchanger. Fig. 9 and 10 represent the counter and parallel flow arrangements of the EATHE coupled with water cooled heat exchanger respectively. In the counter flow arrangement both the fluid air and water flow in the different direction. In the parallel flow arrangement both the fluid air and water flow in the same direction.

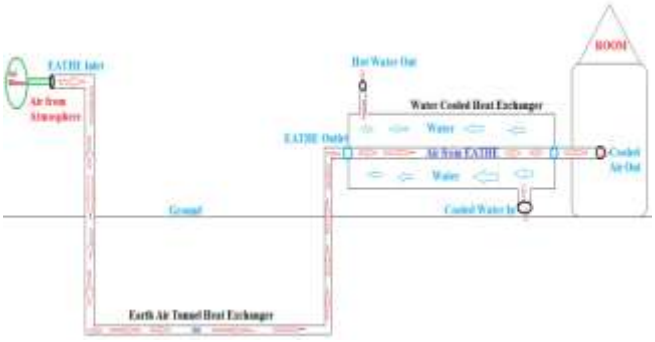

Fig. 9. Layout of EATHE Coupled with Water Cooled Heat Exchanger (Counter Flow Arrangement)

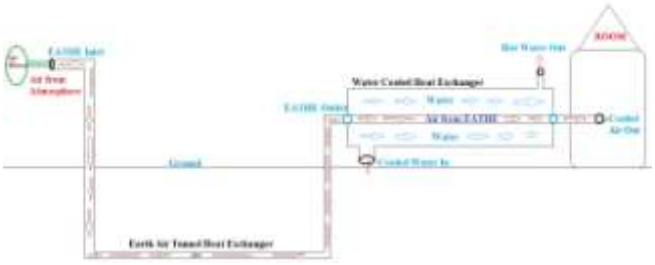

Fig. 10. Layout of EATHE Coupled with Water Cooled Heat Exchanger (Parallel Flow Arrangement)

VII. EXPERIMENTAL SETUP & METHODOLOGY

A. *Description of Experimental Setup*

Experimental setup of both systems has been installed at Mechanical Engineering Department Government Engineering College Bikaner (28.0229° N, 73.3119° E) Rajasthan India (334004). Since soil temperature remains constant throughout the year at a depth of 3 to 4 m [1]. So our system was placed at a depth of 3.3528 m. Mild steel pipes were used in the system due to lower cost, strength and durability. The total length of Simple and Hybrid EATHE in Series Connection System was taken as 13.92 m and 16.36 m respectively. And the length of Water Cooled Heat Exchanger was taken as 1.83 m. The inner diameter and thickness of the buried pipes for the EATHE in Series Connection was taken as 0.04 m and 0.003 m respectively. The inner diameter and thickness of the buried pipe for the Water Cooled Heat Exchanger was taken as 0.11 m and 0.0025 m respectively. The experimental setup of both systems is shown in Fig. 16.

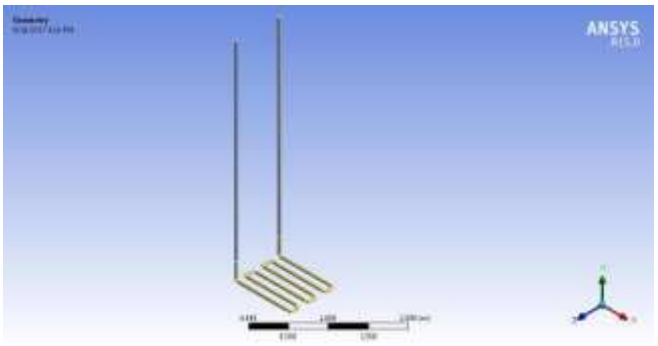

Fig. 11. Geometry of EATHE in Series Connection

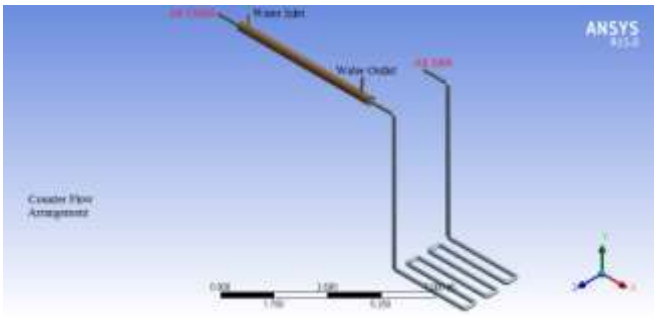

Fig. 12. Geometry of Hybrid EATHE (Counter Flow Arrangement)

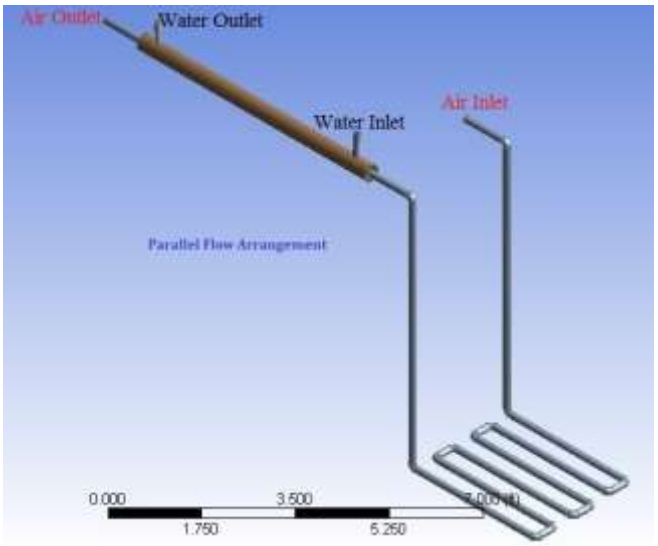

Fig. 13. Geometry of Hybrid EATHE (Parallel Flow Arrangement)

Fig. 14. Installation of Setup Using JCB Machine

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Fig. 15. Connection of Mild Steel Pipes in Series at Mechanical Workshop

Fig. 16. Water Cooled Heat Exchanger

Fig. 17. Experimental Setup of Hybrid EATHE

B. Instruments Used

K-Type Thermocouples are used to meseaure the air temperature. Digital Vane type Anemometer is used to meseaure the air velocity. Cheston Air blower of 5.5 kWatt is used to forced the air through the buried pipes.

Fig. 18. Instruments Used

VIII. CONCLUSION

In this paper the different techniques to develop the thermal performance of earth air tunnel heat exchanger in summer and winter session was reviewed. Earth Air tunnel heat exchanger is a passive technique to maintaining the room temperature in the developing country like India. It gives the better performance when the thermal conductivity of ground soil is more and length of buried pipes is large.

In this Review Paper concept of hybrid earth air tunnel heat exchanger was carefully done. As the earth air tunnel heat exchanger gives limited cooling effect depending upon climate conditions or geographical conditions, so we use the waste water of water cooler for further reducing the air temperature coming from earth air tunnel heat exchanger.

During observation it is found that the air temperature drop using waste water is up to 5-6℃.

In this review paper various types and arrangements of ground heat exchanger are also described.

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