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Comparative Study of Coefficient of Performance (COP) of Earth Tube Heat Exchanger-A Review

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ABSTRACT:

Application of ground coupled heat exchanger (GCHE) systems has been increasing worldwide. They are being utilized in various applications such as space conditioning, water heating, agricultural etc. These systems have the ability to reduce cooling load during the summer and heating load in the winter, providing energy savings and environmental benefits through reduced emissions. Additionally, GCHE systems have the potential to convert a primary energy, making them an attractive solution for sustainable heating and cooling. Experimental and modelling studies play a crucial role in understanding and optimizing the performance of ground coupled heat exchanger systems. These studies provide valuable insights into the performance, efficiency, and limitations of GCHE systems, helping researchers and engineers make informed decisions in system design and operation. Some of the studies reviewed focus on earth-air heat exchanger systems, which involve the exchange of heat between the air in contact with the ground and the surrounding environment. Other studies focus on ground source heat pump systems, where heat is extracted from or injected into the ground for heating and cooling purposes.

In this paper we review so many paper related to earth tube heat exchanger and we found earth tube heat exchanger is a good substitute of air conditioner. It is Eco-friendly and familiar to environments. material of earth tube heat exchanger are very important because of material of earth tube heat exchanger play very interesting role of heat transfer from soil to tube (ETHE) and tube (ETHE) to soil. Finally we conclude that on the basis of literature we proposed work on compression of coefficient of performance of different material design of earth tube heat exchanger and proposed to study effect of material of ETHE to coefficient of performance of system.

Key wards: ETHE,GI Pipe, Copper Pipe, Heating, Cooling

1.1 Background:

Energy systems based on renewable energy sources (RES) have recently undergone massive development due to the global focus on sustainability and green systems [1]. This has been accompanied by a significant reduction in the use of fossil fuels in order to reduce the impact of energy systems on the environment [2]. In this context, heat recovery and energy storage systems have shown great potential to save energy and reduce the negative effects of most renewable energies such as power fluctuations and interruptions. Another attractive approach is the increased use of geothermal energy (GE), as it is the most stable renewable energy source. It is also available in all seasons and can be used for various applications such as heating, cooling and power generation [3]. GE is mainly divided into two types: deep and shallow. The former is based on the extraction of hot geothermal fluid from deep underground layers, which is used for direct heating or electricity generation. Near-surface geothermal energy, on the other hand, is generally used for heating and cooling via a ground-coupled heat exchanger [4–6]. At a certain depth, the average ground temperature is higher than the ambient air in winter and lower in summer, making shallow GE a good source for heating and cooling [7]. This depth can vary depending on the region, soil properties and ambient air conditions.

Ground-to-air heat exchangers have been used in agricultural facilities (animal barns) and horticultural facilities (greenhouses) in the United States in recent decades and have been used in conjunction with solar chimneys in hot arid regions for thousands of years, probably since the Persian Empire. Since the mid-1990s, these systems have been widely used in Austria, Denmark, Germany and India and are slowly being introduced in North America. The fluctuations of the ground surface are reduced. Due to the time lag between the temperature fluctuations on the ground surface and below the ground, the temperature below the ground at a sufficient depth is always higher than the outside air temperature in winter and lower in summer. This temperature difference can be used for pre-heating in winter and pre-cooling in summer by installing a suitable GCHE system. The advantages of GCHE systems are high efficiency, stable capacity, good air quality, better thermal comfort, simple control, simple equipment, low maintenance costs, environmental friendliness, long-term cost efficiency, tax benefits and noiselessness as the system is installed underground. Disadvantages are the higher initial costs and the limited availability of trained technicians and contractors.

In many cases, solar energy is used directly or indirectly to provide heat or electrical energy. Solar gains within the building are avoided in order to reduce cooling requirements or the size of the air conditioning system. The use of the earth as part of the energy system can be achieved by three primary methods: direct, indirect and isolated. In a direct system, the building envelope is in contact with the earth, and heat conduction through the building elements (primarily walls and floors) regulates the indoor temperature. In an indirect system, the interior of the building is conditioned by air that is conducted through the ground, e.g. in ground-to-air heat exchangers [2]. The insulated system uses the earth temperatures to increase the efficiency of a system by lowering the temperatures at the compression coil.

Ground-to-air heat exchangers can be analyzed for performance using various software applications based on weather measurement data. These software applications include GAEA, AWADUKT Thermo, EnergyPlus, L-Autism, WKM and others. However, many ground-to-air heat exchanger systems have been improperly designed and constructed and have failed to meet design expectations. Ground-to-air heat exchangers appear to be best suited for air pretreatment rather than full heating or cooling. Pretreating the air for an air-source or ground-source heat pump often provides the best economic return, with the investment often paid back within a year of installation.

Most systems consist of smooth-walled pipes with a diameter of 100 to 600 mm (to prevent condensation and mold from forming so easily), rigid or semi-rigid plastic, plastic-coated metal pipes or plastic pipes coated with antimicrobial inner layers. They are installed at a depth of 1.5 to 3 meters (5 to 10 feet), where the ambient temperature in the temperate latitudes where most people live is 10 to 23 °C (50 to 73 °F) all year round. The ground temperature becomes more stable with increasing depth. Smaller diameter pipes require more energy to move the air and have less ground contact area. Larger pipes allow air to flow more slowly, which also results in more efficient energy transfer and allows much larger volumes to be transferred, so more air can be exchanged in less time if you want to rid the building of unpleasant odors or smoke, for example, but have poorer heat transfer from the pipe wall to the air due to the greater distances involved.

1.2 Ground Coupled Heat Exchanger:

GCHE systems have several main objectives. These are to achieve the best operating efficiency, the lowest possible operating costs and environmentally friendly operation, the lowest possible acquisition costs and surface area, to increase indoor comfort and the long-term durability of the system, to enable easy maintenance and servicing and to generate revenue from certified emission reduction (CER). The sequestration of one ton of carbon dioxide equivalent (CO2-e) is represented by one CER unit. A developing country such as India can generate additional CER revenues of 234,107 euros through the use of GCHE [6]. GCHE systems are preferred in locations where the temperature fluctuations at the earth's surface are high and where a reduction in CO2 emissions into the atmosphere is required. Depending on the connection and orientation, they can be classified as serial and parallel, horizontal and vertical. Depending on the flow rate, it can be classified as EAHE or underground air tunnel (UAT) and AKW system. The EAHE system concept is mainly used in colder countries for space cooling and heating in summer and winter respectively (see Fig. 1) [7]. EAHE systems contain underground pipes in various combinations, both in open and closed circuits. The air is blown through the buried pipes using an appropriately sized fan installed at the inlet or outlet [8]. EAHE systems are inexpensive and have a long service life, but they are susceptible to air pollution from bacterial growth, corrosion from humid air and chemical reactions in the tunnel, which can affect public acceptance in residential buildings and requires further investigation. The above disadvantages of using EAHE systems are overcome in AKW systems suitable for cooling/heating of residential and small commercial buildings.

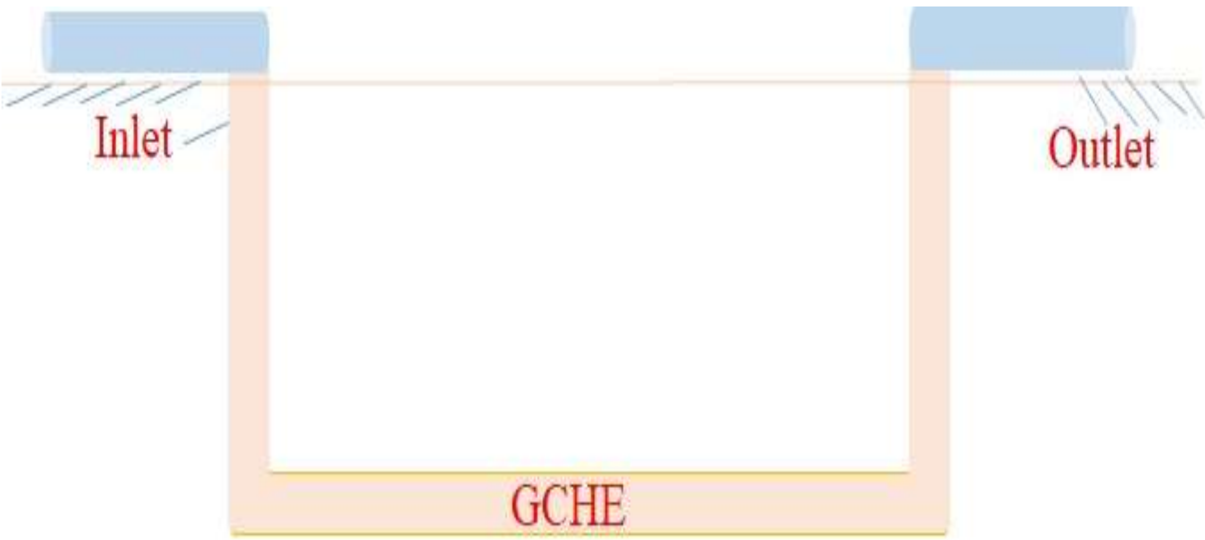

Fig.1. Schematic Image of Ground Coupled Heat Exchanger (GCHE)

1.2.1 Types of Eart Tube Heat Exchanger:

There are three types

1.Open loop system

2.Closed loop system

1.2.1.1 Open loop system

In open systems, the ambient air is passed through pipes buried in the ground to preheat or pre-cool it, and fresh fluid is circulated through the ground heat exchanger. This system provides ventilation and hopefully cools or heats the inside of the building.

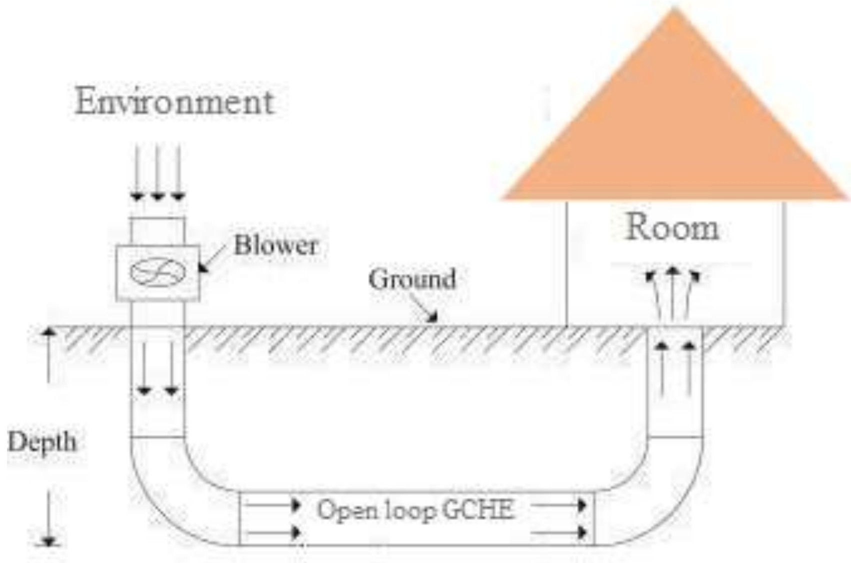

Fig.1.2. Open loop GCHE

1.2.1.2 Closed loop system:

In closed systems, both pipe ends are located within the control environment, which can be a room in the case of air and a tank in the case of water. The system is called a closed circuit because the same fluid is always passed through the circuit. Closed loop geothermal heat exchangers can be parallel, straight or tilted and a heat transfer medium circulates within the heat exchanger.

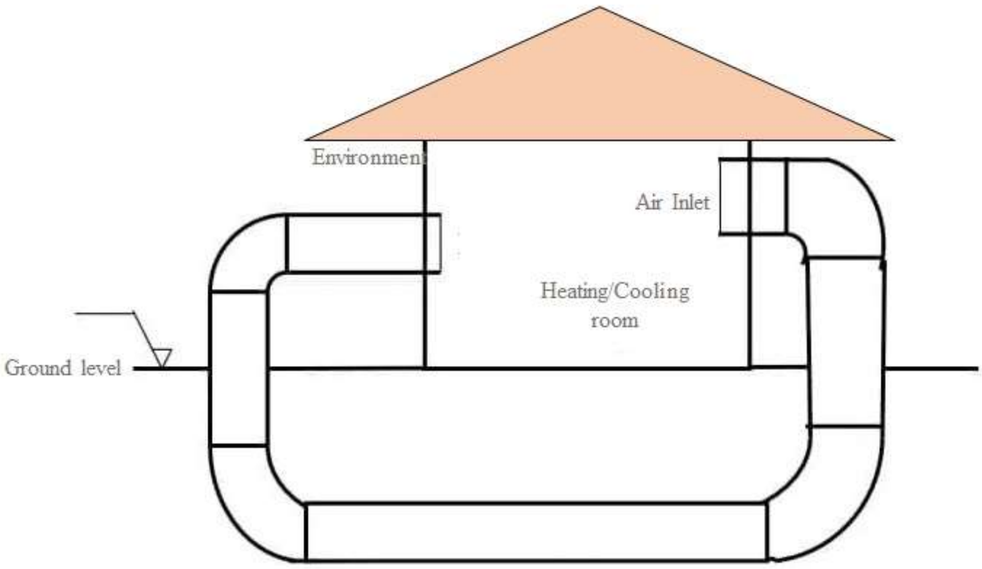

Fig.1.3. Closed loop GCHE

1.3 Thermal Labyrinths of Earth Tube Heat Exchanger:

A thermal labyrinth performs the same function as a soil pipe, but they usually consist of a rectilinear space with a larger volume, sometimes built into building basements or under first floors, which in turn is subdivided by numerous internal walls to form a labyrinthine air path. Maximising the length of the air path provides a better heat transfer effect. The construction of the labyrinth walls, floors and partitions is usually made of cast concrete and high thermal mass concrete blocks, with the outer walls and floors in direct contact with the surrounding soil.

1.4 Safety of Earth Tube Heat Exchanger:

If humidity and the associated mold growth are not taken into account when planning the system, occupants may be exposed to health risks. In some locations, moisture in the soil tubes can be easily controlled by passive drainage if the water table is sufficiently deep and the soil has a relatively high permeability. In situations where passive drainage is not feasible or needs to be supplemented to further reduce moisture, active (dehumidifiers) or passive (desiccants) systems can treat the airflow.

Formal research indicates that ground-to-air heat exchangers reduce air pollution from building ventilation. Rabindra (2004) states, "It has been shown that the tunnel [earth-to-air heat exchanger] does not favour the growth of bacteria and fungi, but rather reduces the amount of bacteria and fungi, making the air safer for humans to breathe. It is therefore clear that the use of EAT [Earth Air Tunnel] not only helps save energy but also reduces air pollution by reducing bacteria and fungi."[2] Similarly, in a study of twelve earth-to-air heat exchangers that varied in construction, tube material, size, and age, Flueckiger (1999) stated, "This study was conducted due to concerns about possible microbial growth in the buried tubes of earth-coupled air systems. However, the results show that no harmful growth occurs and that, with few exceptions, concentrations of viable spores and bacteria in the air actually decrease after passage through the pipe system"," and further, "Based on this research, the operation of ground-coupled air-to-ground heat exchangers is acceptable as long as regular checks are carried out and appropriate cleaning facilities are available"." [3]

Regardless of whether you use underground pipes with or without antimicrobial material, it is extremely important that the underground cooling pipes have excellent condensation drainage and are installed with a slope of 2-3 degrees so that the condensation can be constantly drained from the pipes. When implemented in a house without a basement on a flat plot, an external condensation tower can be installed at a depth lower than the point where the pipes enter the house, near the wall entrance. The installation of the condensation tower requires the additional use of a condensate pump to remove the water from the tower. When installing in houses with basements, the pipes are laid so that the condensate drain is at the lowest point in the house. In both installations, the pipe must have a continuous slope either to the condensation tower or to the condensate drain. The inner surface of the pipe, including all joints, must be smooth to facilitate the flow and drainage of condensate. Corrugated or ribbed pipes and rough internal joints must not be used. The joints between the pipes must be tight enough to prevent the ingress of water or gas. In certain geographical areas, it is important that the joints prevent the ingress of radon gas. Porous materials such as uncoated concrete pipes cannot be used. Ideally, underground pipes with antimicrobial inner layers should be used to inhibit the possible growth of mold and bacteria in the pipes.

1.5 Effectiveness of Earth Tube Heat Exchanger:

The use of ground-to-air heat exchangers for partial or complete cooling and/or heating of the ventilation air in buildings has not been very successful to date. Unfortunately, there are too many generalizations in the literature about the applicability of these systems – both pro and con. An important aspect of ground-to-air heat exchangers is the passive nature of the operation and the consideration of the large variability of conditions in natural systems.

Ground-to-air heat exchangers can be very cost-effective, both in terms of initial costs and long-term operating and maintenance costs. However, this is highly dependent on latitude, altitude, ambient temperature on the ground, climatic temperature and relative humidity extremes, solar radiation, water table, soil type (thermal conductivity), moisture content of the soil and the efficiency of the building envelope or insulation. In general, drysoils with low density and little or no ground shade are the least beneficial, while dense, moist soils with plenty of shade should do well. A slow drip irrigation system can improve thermal performance. Moist soil in contact with the cooling pipe conducts heat more efficiently than dry soil.

Earth cooling tubes are far less effective in hot, humid climates (like Florida) where the earth's ambient temperature approaches human comfort temperature. The higher the earth's ambient temperature, the less effective it is for cooling and dehumidification. However, earth can be used to partially cool and dehumidify the fresh air supply in passive-solar thermal buffer zones [4] such as the laundry room or a solarium/greenhouse, especially in areas with a hot tub, swim spa or indoor pool where warm, humid air is exhausted in the summer and a supply of cooler, drier replacement air is desired.

Not all regions and locations are suitable for ground-to-air heat exchangers. Conditions that may hinder or preclude proper implementation include shallow subsoil, a high water table and insufficient space. In some areas, geothermal heat exchangers can only be used for cooling or heating. In these areas, special consideration must be given to the thermal charge of the ground. In systems with a dual function (heating and cooling), the warm season ensures thermal enrichment of the ground in the cold season and the cold season ensures thermal enrichment of the ground in the warm season, but even in systems with a dual function, overloading of the heat storage tank must be taken into account.

1.6 Environmental Impact of ETHE:

With dwindling fossil fuel reserves, rising electricity costs, air pollution and global warming, properly designed geothermal cooling tubes offer a sustainable alternative to reduce or eliminate the need for conventional compressor-based air conditioning in non-tropical climates. They also offer the added benefit of a controlled, filtered, temperature-controlled fresh air supply, which is particularly valuable in tight, well-sealed, efficient building envelopes.

2. Objectives of Thesis:

1. Investigate the coefficient of performance (COP) of Ground coupled heat exchanger summer as well as winter session.

2. Compression of design material of Earth tube heat exchanger gives better coefficient of performance.

3. Finding which time system work more efficiently summer as well as winter session.

3. Methods/Material

We proposed two different types of earth tube heat exchange one of GI based earth tube heat exchanger and another is copper based earth tube heat exchanger.

Calculation of coefficient of performance of both system and compare all parameter like depth of tube, length of tube, diameter of tube and thickness of tube etc. and identify best of one in both systems.

4. Conclusion:

In last we proposed to conclude that which parameter increased or decreased to system give more accurate results.

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