Optimization of Air Conditioning and Emission Reduction by Geothermal Heat Exchanger

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Abstract— In the present scenario a very large portion of energy is used for the air conditioning of the buildings which is the wastage of energy as it is required for cooling in summer and for heating in winters. So it is desired that we must use the renewable sources of energy for this purpose and geothermal energy may be one of the suitable energy source. Geothermal (or Geo-exchange) is a type of HVAC System (Heating, Venting, and Air-conditioning).The earth absorbs almost 50% of all solar energy and remains a nearly constant temperature of 10°C (50°F) depending on geographic location. Working with an underground loop system, a geothermal unit utilizes this constant temperature to exchange energy between the building and the earth as needed for heating and cooling. Geothermal is the most efficient Air-conditioning system because the ground temperature stays stable and has no regard for the above ground ambient temperature. A geothermal heat exchanger simply takes advantage of this low temperature energy source and sends it up to a usable level to cool the building. Geothermal Heat Exchanger draws energy out of the ground which stays relatively constant year round. This is typically an arrangement of pipes with selected piping material and loop design, buried in the ground. Soil temperature at a certain depth, adequate piping material, configuration and performance of the installed system evaluated experimentally. The temperature gradient of 15ºC to 25ºC on average has been achieved from the developed working model.

Keywords: HVAC System, GCHE System, Mechanical Properties

I. Introduction

In today's world, the fears of diminution of fossil fuels and up raising cost of energy are very common. Hence, more sustainable and renewable energy sources are required to provide solutions to long-standing challenges of energy crises. A similar system has been designed to compensate the energy demand for commercial heating and cooling. It is disclosed that the temperature at the certain depth in the ground remains relatively constant all over the year. This can be an efficient source of space heating and cooling and mitigate the environmental problems through emission reduction. The ambient room temperature is higher and lower than the underground soil temperature during winter and summer season respectively. Consequently, there is an increase or decrease in the coefficient of performance, ventilation and air conditioning (HVAC) system. The concept of the ground-coupled heat exchanger (GCHE) is clear as shown in fig. The atmospheric air is drawn through the channel buried at a particular depth, gets cooled in summer and vice versa in winter. In this way reduction in the heating and cooling load of buildings can be achieved. Several calculation models had been developed for ground- In today's world, the fears of diminution of fossil fuels and up raising cost of energy are very common. Hence, more sustainable and renewable energy sources are required to provide solutions to long-standing challenges of energy crises. A similar system has been designed to compensate the energy demand for commercial heating and cooling. It is disclosed that the temperature at the certain depth in the ground remains relatively constant all over the year. This can be an efficient source of space heating and cooling and mitigate the environmental problems through emission reduction. The ambient room temperature is higher and lower than the underground soil temperature during winter and summer season respectively. Consequently, there is an increase or decrease in the coefficient of performance, ventilation and air conditioning (HVAC) system. The concept of the ground-coupled heat exchanger (GCHE) is clear as shown in fig. The atmospheric air is drawn through the channel buried at a particular depth, gets cooled in summer and vice versa in winter. In this way reduction in the heating and cooling load of buildings can be achieved. Several calculation models had been developed for ground- coupled heat exchangers. The important performance parameters that need to be considered during the investigation of this air conditioner include the change in the air temperature at inlet and outlet of the pipe, flow rate of the flowing fluid.

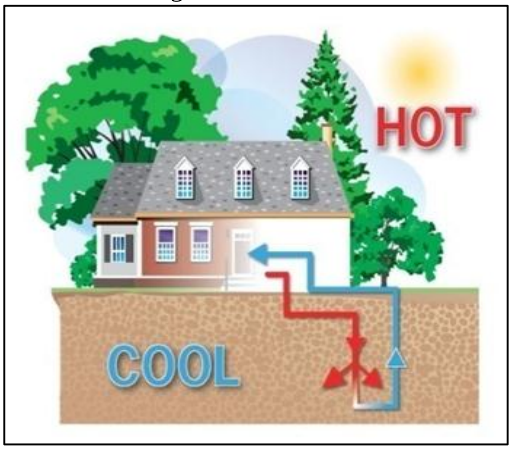


Fig. 1.1: geothermal cooling

II. Literature survey

The temperature of soil is constant at 2 to 3 m depth. At 2 to 3 m depth the temperature is usually approximately equal to the mean annual air temperature. This temperature is called earth's undisturbed temperature. This undisturbed temperature is lower than the atmospheric temperature in summer. In winter the undisturbed temperature is greater than atmospheric temperature.

Jacovides et al. (1996) investigate the several characteristics of soil temperature in Athens are determine by the furrier analysis of 74 year recode (1917- 1990) of the soil temperature and at the various depth. The soil temperature presented along with Fourier amplitudes and phases of most harmonic.

Deglin et al. (1999) investigate the subsoil heat exchanger for air conditioning of livestock building. In this paper the model was investigate for cooling purpose. The three dimensional transient heat flow model was develop for simulating the heat flow from subsoil to air. The heat is transfer due to the temperature different between the sub soil and air.

Kabashnikov et al. (2002) investigate the analytic and numerical model for investigation of soil to air heat exchanger. The model is based on representation of temperature in the form of Fortier integral. The mathematical model which is use analysis gives the result on the basis of number of tube which is valid for 2 m depth.

Jens pfafferott (2003) Evaluation of earth-to-air heat exchangers with a standardized method to calculate efficiency of energy. The performance of three earth air tunnel heat exchanger for mid European office buildings in service, the aim is to finding their efficiency. A general method was used for compare the earth air tunnel heat exchanger operation is introduced. First of all the temperature behavior is described by plots over the time and characteristic lines and compared by the standardized duration curves. Second energy gain is illustrated on standardized graphs. Third the parametric model is used to provide general efficiency criteria. Thermal efficiency should be defined by both the dynamic temperature behavior and energy performance.

Bansal et al. (2012) investigate the Performance analysis of integrated earth–air-tunnel-evaporative cooling system in hot and dry climate. Performance analysis of the integrated EATHE evaporative cooling system over the complete year shows that while the ambient air itself is comfortable for the 25.6% of the hours, the use of integrated EATHE evaporative cooling system provides the comfortable air for 34.16% hours in one year, whereas the simple EATHE system is able to provide the comfortable air for only 23.33% additional hours.

III. WORKING OF GEOTHERMAL AIR CONDITIONER

As in summer the temperature increases to 45ºC to 48ºC so temperature of top layer of crust is increased equally so this arrangement will work as air conditioner during summer time the hot air is taken in Copper pipe and through copper pipe it is taken to ground and ground temperature is about 10ºC to 16ºC. As we know heat moves from high temperature to low same as water flows from place where water level is high to low so when this air is pushed back to room by opening of small radius copper pipe, it feels cool and same time the air which is hot is absorbed by the copper pipes and the hot air exchange through the fins and again it flows in to the room. The blower works with the help of solar panel, blower works automatically when the sensor senses the temperature. A geothermal heat exchanger or ground source heat exchanger (GSHE) is a central heating and/or cooling system that transfers heat to or from the ground.

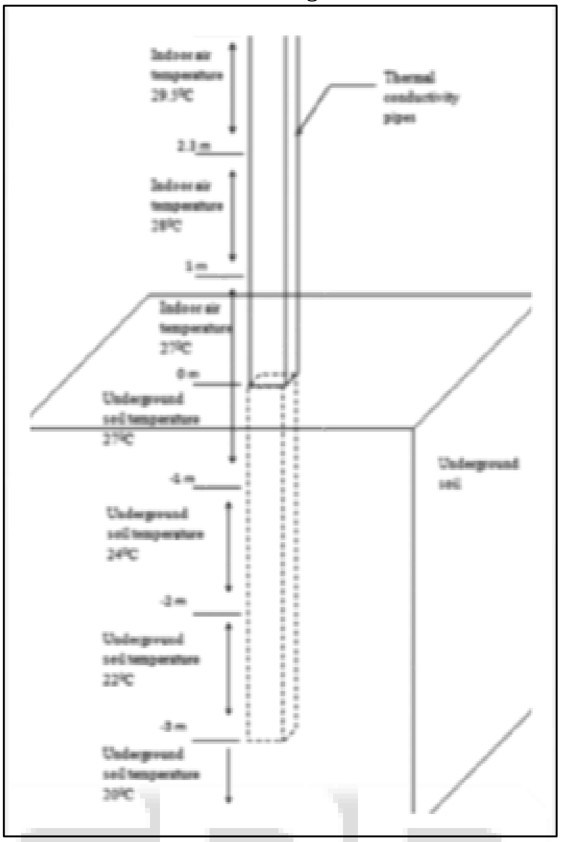
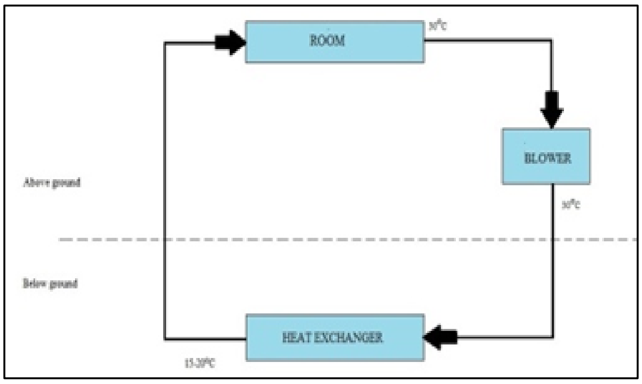


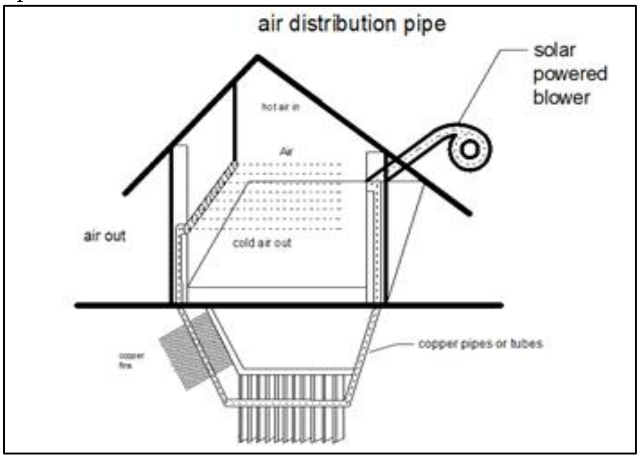
Fig. 4.1: Temperature survey

It uses the earth all the time, without any intermittency, as a heat source (in the winter) or a heat sink (in the summer).

Heating exchanger consists of number of rectangular hollow fins which helps in cooling the worm air of the room. The warm air from the room is driven by blower and reaches to the heat exchanger where air gets cool. As the fins are hollow some of the air is trapped in the fins and the trapped air stays in it for quite a second. We all know that temperature flows from higher degree to lower degree. Here air has high temperature and ground earth has Lower temperature. Now Transfer of heat between warm air of room and natural temperature of earth takes place. For example, if the room air is 26°c and ground temperature is 10°c the temperature of air can be reduced up to 5 to 10°c now the cool air enters the room.



Initially the room temperature is 30ºC; the hot air in the room rises up. The blower absorbs the inside temperature of the room which is at 30°C. It then passes to the ground through the pipes and reaches the heat exchanger. The soil temperature below the ground is at 10-15°C. Finally it passes inside the room at temperature of 15-20°C. Again when the air gets heated inside the room, it rises up and the cycle is repeated.



IV. Components

– Heat Exchanger
– Blower
– Solar Panel
– Thermocouple and Digital Temperature Indicator
– Copper Tubing

A. *Heat Exchanger*

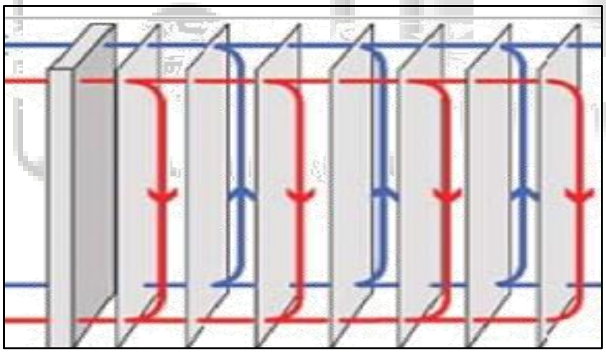


Fig. 4.1: Geothermal Heat Exchanger

Heat exchanger diagram is shown in the figure below. It has a hollow type of copper fins and it sits under the ground level about 20 meters below. Copper heat exchanger has numerous advantages.

It uses the earth all the time, without any intermittency, as a heat source (in the winter) or a heat sink (in the summer). This design takes advantage of the moderate temperatures in the ground to boost efficiency and reduce the operational costs of heating and cooling systems. Depending on latitude, the temperature beneath the upper 6 meters (20 ft) of Earth's surface maintains a nearly constant temperature between 10 and 16 °C (50 and 60 °F), if the temperature is undisturbed by the presence of a heat pump. Like a refrigerator or air conditioner, these systems use a heat pump to force the transfer of heat from the ground.

Like a refrigerator or air conditioner, these systems use a heat pump to force the transfer of heat from the ground. Heat pumps can transfer heat from a cool space to a warm space, against the natural direction of flow, or they can enhance the natural flow of heat from a warm area to a cool one.

Copper fins heat exchanger is used in our project which has number of hollow fins hollow fins. The warm air from the room is driven by blower and reaches to the heat exchanger where air gets cool. As the fins are hollow some of the air is trapped in the fins and the trapped air stays in it for quite a second. We all know that temperature flows from higher degree to lower degree. Here air has high temperature and ground earth has Lower temperature. Now Transfer of heat between warm air of room and natural temperature of earth takes place. For example, if the room air is 26°c and ground temperature is 10°c the temperature of air can be reduced up to 5 to 10°c now the cool air enters the room.

Other all the components are regular usable components.

V. Experimentation

After a comprehensive research and review of the literature of existing geothermal space conditioning systems, copper pipe was found suitable material to be used for the geothermal piping system for either cooling or heating because of its excellent heat transfer properties, chemical inertness, cost-effectiveness, long lifetime and various other physical properties. The schematic arrangement of the experimental system is shown in Fig. The system consists mainly of two units: the condenser, and the air circulating device.

The, copper pipe with an internal and external diameter were 12mm and 13mm respectively, buried under the earth soil. Open looping design was selected to minimize the frictional and pressure losses. A blower and an axial fan were used as an air circulating device to circulate the air through the pipe. The characteristics and specifications of the components used in the experimental system are given in cost analysis table.

Horizontal closed loop system is found most efficient and economically viable to be used for cooling of buildings. The axial fan is installed as a mean of the suction device at the outlet that sucks the air coming from the buried pipe and through it in the test model box 60cm × 45cm × 40cm. Air was circulated continuously to achieve a reduction in temperature in the Demonstration box. The experimental approach uses the constant temperature of subsurface of earth and mass flow rate of the circulating air at the outlet of the heat exchanger, stabilized (steady-state), outlet temperature achieved and noted which is used in the experimental analysis. To check the performance of our geothermal system at the maximum temperature during the summer season the inlet of the pipe is attached with a blower to take the atmospheric air of the hot day of May. The system cooled down the inlet air temperature of 32°C to 24°C. In this experiment, the temperature of inlet and outlet is measured by using thermocouples.

VI. Geothermal vs conventional air conditioner

Comparisons between Geothermal and conventional air source units are convoluted because of the sharp decrease in efficiency of air source equipment as a function of outside air temperature (Table 5.1). Manufacturers of air source equipment are quick to post impressive energy efficiency ratio (EER) and Seasonal Energy Efficiency Ratios (SEER) numbers on their "high efficiency" models, but a closer examination of the actual performance data shows that these lofty numbers do not correlate well under realistic installed conditions (figure 5.1). A typical example of a 3ton air source unit shows manufacturer's EER as 12.0. However, a closer look at performance values yields a calculated EER value of 10.5, at rated conditions. This would represent a daytime temperature of about 32.2° C. When the outside temperature rises to 37.7°C, the air source EER drops to 9.2, which represents a reduction in efficiency of 12%. If outside temperature rises to 43.3° C, the air source EER drops even further to 7.7, which represents a reduction in efficiency of 27%. This means that the unit is requiring 27% more electricity to yield the same cooling. As indicated in the table 1, geothermal systems for air conditioning are considerably more efficient than the conventional air source units. Simple calculations show that energy costs for a Geothermal are nominally 40% less than air source; 50% less than air source at 100 degrees; and can be as much as 55% less than air source as temperatures rise further.

	Trial 1	Trial 2	Trial 3
Outside temperature	32.2	37.7	43.3
Geothermal	17	17	17
Air source	10.5	9	8

Table 6.1 EER Comparison Geothermal vs. Air Source Cooling

Using geothermal air conditioning system we can save lot of energy bills. Also it is long lasting system compared to conventional air conditioning system. Geothermal is clean, sustainable and renewable source of energy.

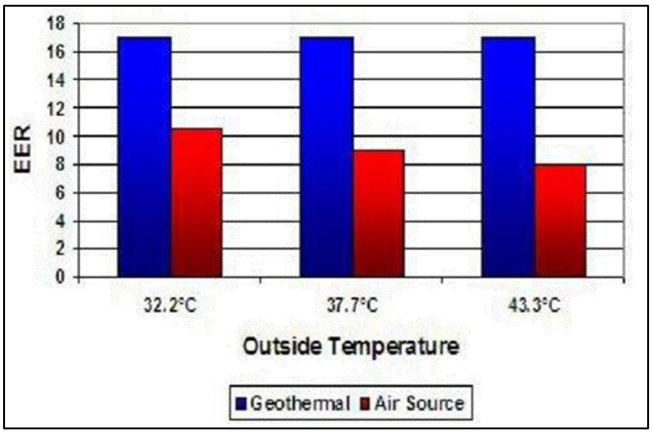


Fig. 6.1: Comparison Geothermal vs. Air Source Cooling.

VII. OBSERVATIONS AND RESULTS

The energy performance and the temperature variation of discussed cooling systems is analyzed for 6 days for the duration of 60min at three specific time of day such as 8 AM to 9AM, 12 PM to 1 PM and 4 PM to 5 PM according to the direction of sun.

Fig. 7.1: Cooling house using geothermal heat exchanger

Day	Time	Duration	Atmospheric Temperature	Initial Temperature	Final Temperature
Day 1	8 AM to 9 AM	60 min	26ºC	21ºC	20ºC
	12 PM to 1 PM	60 min	36ºC	29ºC	25ºC
	4 PM to 5 PM	60 min	32ºC	28ºC	24ºC
Day 2	8 AM to 9 AM	60 min	27ºC	20ºC	20ºC
	12 PM to 1 PM	60 min	35ºC	28ºC	25ºC
	4 PM to 5 PM	60 min	33ºC	27ºC	24ºC
Day 3	8 AM to 9 AM	60 min	26ºC	20ºC	19ºC
	12 PM to 1 PM	60 min	36ºC	30ºC	27ºC
	4 PM to 5 PM	60 min	34ºC	29ºC	25ºC
Day 4	8 AM to 9 AM	60 min	24ºC	19ºC	18ºC
	12 PM to 1 PM	60 min	35ºC	28ºC	25ºC
	4 PM to 5 PM	60 min	33ºC	28ºC	25ºC
Day 5	8 AM to 9 AM	60 min	26ºC	20ºC	20ºC
	12 PM to 1 PM	60 min	37ºC	29ºC	28ºC
	4 PM to 5 PM	60 min	34ºC	28ºC	25ºC
Day 6	8 AM to 9 AM	60 min	22ºC	18ºC	18ºC
	12 PM to 1 PM	60 min	34ºC	27ºC	25ºC
	4 PM to 5 PM	60 min	32ºC	26ºC	25ºC

VIII. Advantaged, Disadvantages and Applications

A. Advantages

- They are extremely efficient.
- They are significantly less noisy than regular unit.
- They require little maintenance usually periodic checks and cleanings are enough.
- They can be effectively used for commercial air conditioning.
- Pollution free.
- Uses solar power.

B. Disadvantages

- High installation costs and its positioning.
- Installation can be quite tricky so it's needed to hire a certified installer.

C. Applications

- Used for the cooling the room.
- It can use in the storage areas.
- Small residential homes, cabins, and multi-family structures.
- Schools & Institutional buildings.
- Office buildings.
- Shopping malls and stores.

IX. Environmental Impacts

The impact geothermal energy has on the environment is even recognized by the U.S. Environmental Protection Agency (EPA). In fact, they've called a geothermal air conditioner the most energy-efficient, environmentally clean, and cost-effective space conditioning systems available. Geothermal heat exchanger offer significantly lower emissions because they move the earth's thermal energy from one place to another via the circulation of a refrigerant fluid all done without burning a single fossil fuel.

Geothermal systems are almost electric which means that they emit no carbon monoxide, carbon dioxide or other greenhouse gases that can be harmful to your family and the environment. In fact, greenhouse gas emissions associated with the use of a geothermal heat exchanger are 55 to 60 percent lower than those from a standard air-source heat pump.

Geothermal air conditioner is the most energy-efficient, environmentally clean and cost-effective space conditioning systems available. It offers significant emission reductions potential, particularly where they are used for both heating and cooling of the space. Ground-source heat exchanger has unsurpassed thermal efficiencies and produces zero emissions locally

X. Conclusion

The biggest benefit of geothermal air conditioner is that they use solar energy that means it uses less electricity than conventional heating or cooling systems. According to the Environmental Protection Agency, geothermal heat pumps can reduce energy consumption and corresponding emissions up to 44% compared to air source heat pumps and up to 72% compared to electric resistance heating with standard air-conditioning equipment. Geothermal air conditioner also improves humidity control by maintaining about 50% relative indoor humidity, making geothermal air conditioner very effective in humid areas. Geothermal heat pump systems allow for design flexibility and can be installed in both new and retrofit situations. Because the hardware requires less space than that needed by conventional HVAC systems, the equipment rooms can be greatly scaled down in size, freeing space for productive use. This system also provide excellent "zone" space conditioning, allowing different parts of your home to be heated or cooled to different temperatures. Because this system has relatively few moving parts, and because those parts are sheltered inside a building, they are durable and highly reliable. The underground piping often carries warranties of 25–50 years, and the heat exchanger often last 20 years or more.

XI. Future Scope

The growth of this technology is slower than the other air conditioning technologies due to high cost of installation and limited knowledge of geothermal technology. The system can use electricity produced from renewable sources, like solar and wind power, to heat and cool down spaces much more efficiently than a conventional air conditioner. This makes the system complete green that means it will not use any energy generated by conventional sources. Even using of modified heat exchangers and lowering the heat losses further improvement in the performance of the system can be achieved. Equipment needed to provide heating/cooling and/or electricity from geothermal energy is already available on the market. However, the efficiency of the different system components can still be improved, and it is even more important to develop conversion systems that more efficiently utilize energy in the produced geothermal cooling at competitive costs. It is basically inevitable that more efficient plants (and components) will have higher investment costs, but the objective would be to ensure that the increased performance justifies these costs. Combined heat and power or cogeneration applications provide a means for significantly improving utilization efficiency and economics of geothermal projects, but one of the largest technical barriers is the inability in some cases to fully utilize the thermal energy produced. New and cost-effective materials for pipes, casing liners, pumps, heat exchangers and other components for geothermal plants is considered a prerequisite for reaching higher efficiencies.

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