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Influence of parameters on performance of earth air heat exchanger in arid and hot climate

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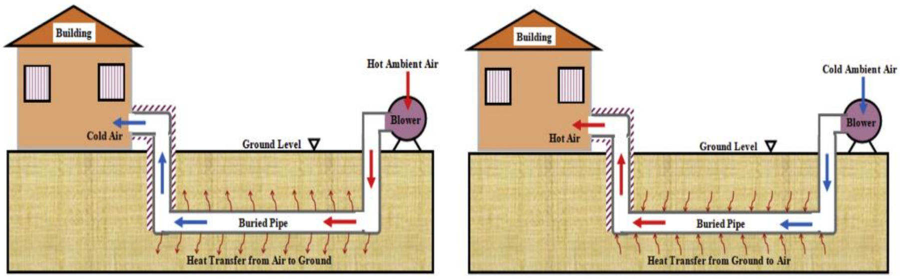
Abstract

This paper presents a study influence parameter on the performance of an earth air heat exchanger (EAHE) in arid and hot climate. The effect of velocity, length and drop in temperature of the air is studied at the inlet and outlet of the pipe. The results show that maximum temperature drop available at low velocities because air gets larger time to get heat transfer in the underground pipe in soil and also the greater length of the pipe of earth air heat exchanger has more effect on performance of earth air heat exchanger. The temperature drops of air increases with decrease in air velocity, as in this study the temperature drop is 7.9 °C corresponding to 10 m/s velocities and 4.9 °C corresponding to 20 m/s velocities.

Keywords: earth air heat exchanger, arid and hot climate, performance of earth air heat exchanger, geothermal energy

1. Introduction

In the present, less use of high-grade energy for cooling or heating requires more focus. An enormous amount of high-grade energy is consumed for the same the buildings/houses. It is not good at all to meet the demand of huge high-grade energy consumption in the building, industrial and other sectors. Therefore, alternative technology based on sources of renewable and sustainable energy should be developed and used. Geothermal energy is one of the renewable energy sources that are utilized to process and supply air at low expense of energy and with a low impact on the environment. The ground-air heat exchanger is one a passive technology using geothermal energy [1]. The results of the study concluded that the technology of different temperatures with soil temperature found many benefits, such as saving energy and preserving the environment. These benefits may help us a lot in the future in the area of renewable energy resources which is the peak of society's demand. Energy loss can be reduced with the help of this type of system. In this research paper, the Earth air heat exchanger (EAHE) is studied for the hot-dry climate [2,3]. Air-conditioning systems consume huge high-grade energy and reduction of the same is a big challenge is in the present scenario. The challenge can be overcome by the use of ground-coupled heat exchanger in the air conditioning system. In ground-air heat exchanger (GAHE) system, ambient air is made to flow through buried pipes employing a blower. During its course of flow through these pipes, air exchanges heat with the surrounding soil and get heated up or cooled down depending on ambient conditions [4,5]. The conditioned air, so obtained from GAHE system can further be used for cooling/heating in summer/ winter season, respectively, as shown in Fig. 1.Several researches in prior studies developed numerical models to optimize the performance of a ground heat exchanger as a function of several parameters mainly tube length, ground temperature and inlet water temperature. compared different systems and applications of ground heat exchangers. Furthermore, they evaluated the reliability of various one, two- and three-dimensional models developed to aid in studying the performance of ground heat exchangers. Based on their study. With regard to the cooling of hot and dry air, the objectives of this study are to study the variation in inlet and outlet temperatures from morning to evening, to investigate experimentally the effect of speed and length on the outlet temperature of the earth-air heat exchanger in hot and dry climates, to compare the experimental results obtained in this study with those of previous studies.



(a) (b)

Many of the researchers have varied the parameters like diameter, length, depth and velocity for calculating the performance of EAHE's [1, 7, 8, 9]. After reviewing the literature, the velocity of air is taken in the range of 2.5 m/s to 4.8 m/s in the current study to observe the change in outlet parameters. The length of EAHE is taken as 10 m, 20 m and 30 and output parameters need to be studied with respect to time during the day and night for throughout the year so that its applicability and effectiveness could be carried out in all respects. The most of the researchers [10]. Various researchers have been working for the modeling and simulation of EAHE. The simplest models are used for simulation and to predict the performance of the system [14, 24-28]. This paper makes a first attempt to evaluate the thermal performance of earth to air heat exchanger for cooling purposes in an arid and hot climate. this study consists, of exchanger in 3 meter of depth. The results obtained studied prove that the EAHE system is a promising solution to reduce the energy consumption in greenhouses cooling.

2. Methodology :

When the EAHE system is kept in operation, the air flow caused from the outside to the inside by the blower. The outside air is cooled by the transformation of heat to the ground. In the present work, the warm and dry outside air has been treated in the EAHE system. The system operates from 10:00 am to 18:00 pm. The dry bulb temperature and the soil temperature are measured at regular intervals of reduced time during the operation. The air velocity is taken as 10 m/s, 15 m/s and 20 m/s of the system. the length is 10 m, 20 m and 30 m, and the depth is 3m. The results obtained from the study are then helpful for the study of EAHE for different parameters in hot-dry climate. At last the comparison of results is made with different research papers for validation. The results of the study are then useful for the study of EAHE for different parameters in hot and dry climates. Finally, the results are compared with different research documents for validation.

The EAHE is studied to determine the effect of varying velocity of the air and varying length of it for result in temperature drop of the air across it. To study the effect of velocity, the system is operated at velocities 20 m/s, 15 m/s and 10 m/s on 07-09May 2017, for the EAHE length of 10 m and buried at a depth of 3 m. Similarly, to study the effect of length, the EAHE is kept for lengths 10 m and 30 m.

3. Results and discussion:

Day based measurements of the temperatures for the EAHE are shown from morning 10 am to 6 pm on 07/05/2017, 08/05/2017, 093/05/2017, as shown in Figs. 2-6. It has been found that initially at the beginning of the day, the temperature drop of the air is small i.e. Approximately 3 °C at 10 am on 07/05/2017 corresponding to velocity 20 m/s, length 10 m and depth 3 m with the air inlet temperature 34.2 °C. But as soon as the outlet air temperature increases, the temperature difference between air and the underground soil is also increasing, which gives rise to heat transfer rate result in the temperature drop/ cooling of the air also increase. On the same day, 07/05/2017, the maximum temperature drops of 5.2 °C has been noted with the air inlet temperature 40.4 °C at 2 pm. The maximum temperature drop of the air is obtained, when the outlet temperature reaches to the maximum. Thereafter the temperature drop of the air in EAHE starts decreasing due to fall in the outdoor temperature.

3.1 *Effect of velocity*

The measurements are done on a daily basis for EAHE corresponding to its length 15 m and depth 1.5 m. The temperature drop of the air in the EAHE increases when the velocity of air decreases, the value of heat transfer coefficient decreases, but the retention time of heat transfer increases, So the second factor dominates over first one. Therefore, a decrease in velocity outlet temperature of the air decreases as shown in Figs. 2.The maximum temperature drop at velocities 20 m/s, 15 m/s and 10 m/s are found 4.9 °C (Tin = 40.5 °C), 5.8 °C (Tin = 40.9 °C) and 7.9 °C (Tin = 41.1 °C), respectively.

As velocity of the air decreases, then the present time on the air in the EAHE i.e. Duration of heat transfers from air to ground/soil increases. Perhaps the heat transfer from air to soil is multiple of heat transfer rate and duration heat transfer, therefore temperature drop of the air in EAHE is found higher at lower velocities. It seems that increase heat transfer rate due to increase in heat transfer coefficient at higher velocities is not much to counter the air presence time in the EAHE. The trends of variation of the temperature drop for day wise run of the EAHE at different velocities are found same

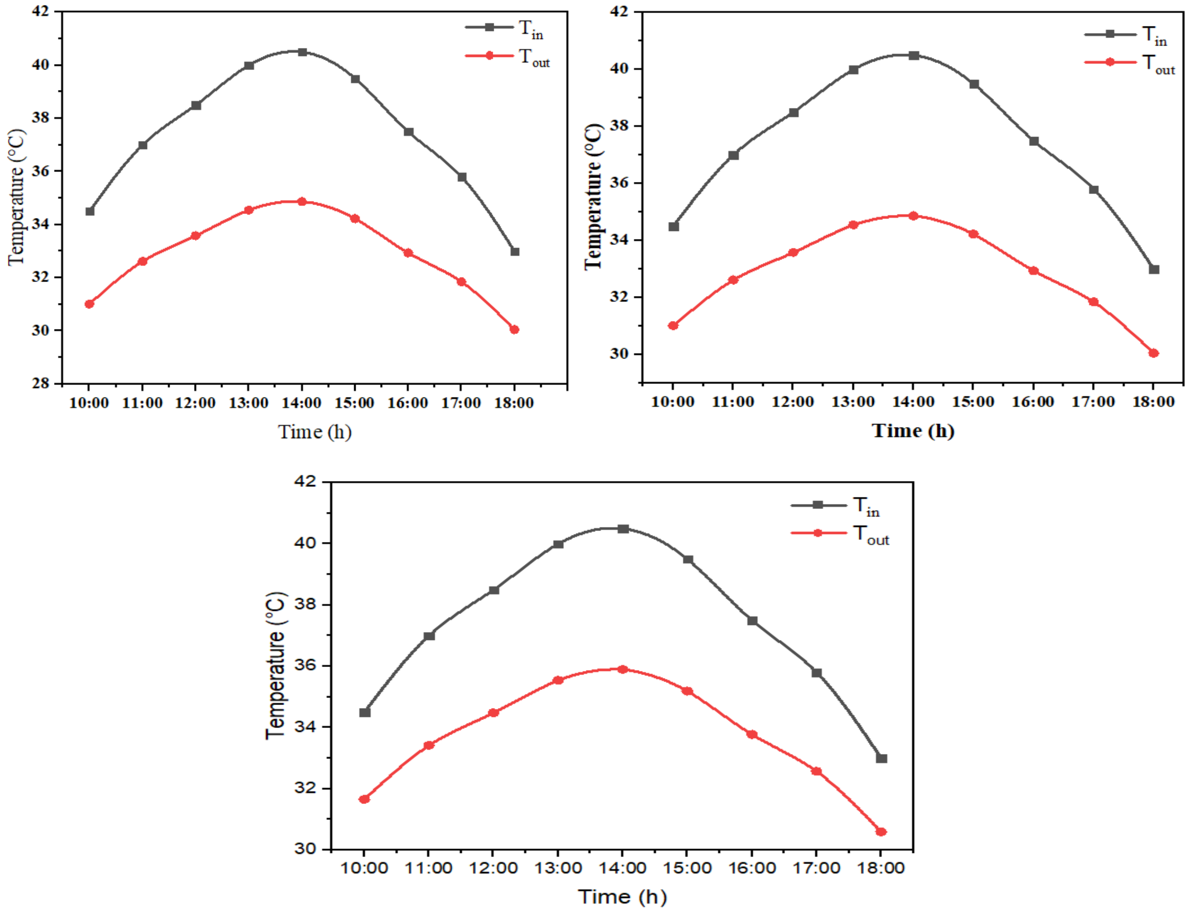


Fig.2. Variation of the air temperature velocity the exchanger versus the time

3.2 Effect length

The measurements are done on a daily basis for EAHE corresponding to its depth 3 m and velocity of the air 10 m/s. The temperature drop across the EAHE is shown in Figs.3. The maximum temperature drop found at length 10 m, 20 m and 30 m, are 10.2 °C (Tin = 40.5 °C), 13.2 °C (Tin = 40.9 °C) and 14.1 °C (Tin = 41.1 °C), respectively .It has been observed that the available surface area for heat transfer of the system is an essential factor in the study of EAHE. The large length increases the surface area for heat transfer, but the pressure drop through the pipe, increases the power consumption as well as less heat transfer in the later part of the pipe. Length should be selected that it can balance the thermal and economic factors for the best performance at the lowest cost. The optimum value of the pipe length is determined by the actual cost of the pipe, the excavation cost and operating cost corresponding to the cooling amount. Excavation costs vary greatly from location to location and one soil type to another. The trend of variation of the temperature drop for day wise run of the EAHE at different lengths is found equal.

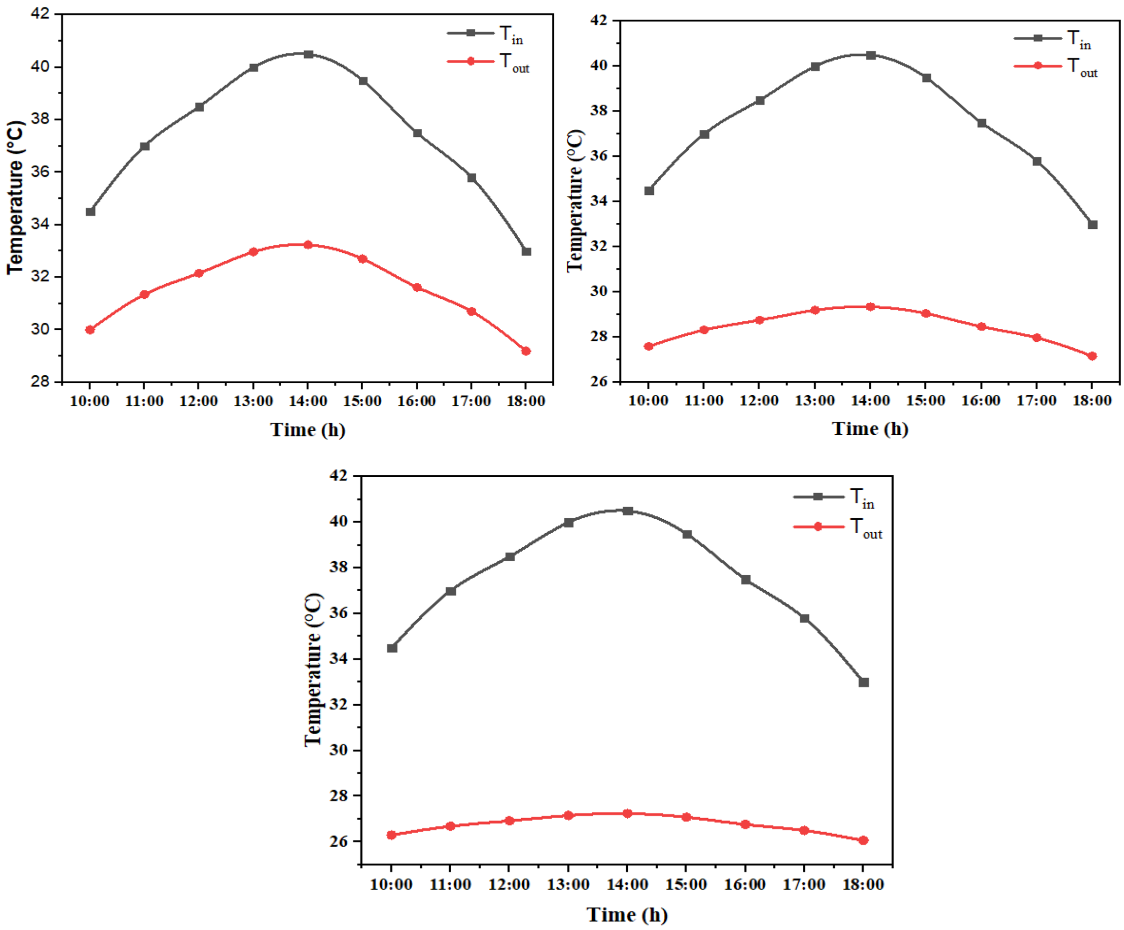


Fig.3. Variation of the air temperature along the exchanger versus the time

4. Average day wise temperature drop variation

Fig. 4 shows the average temperature drop of the air versus its velocity in the EAHE, at the depth of 3 m and for the length 10 m. As per the day wise observations with respect to the velocity 10 m/s (Tin average = 40.5 °C), 15 m/s (Tin average = 40,9 °C) and 20 m/s (Tin average = 41.1 °C), the average temperature drop have been found of 7.3 °C, 5.8°C and 4.8 °C, respectively. It is obvious that the effect of the velocity for the given EAHE is quite significant. Fig. 5 shows the average temperature drop of the air versus length of the EAHE, keeping the depth 3 m and the air velocity 10 m/s. As per the day wise observations for the length 10 m, 20 m and 30 m on day 07/05/2017. The average temperature drop has been calculated from the temperature drop observed across the EAHE for the entire run during a day, which were found 7.1 °C (Tin average = 40.5 °C), 11.2 °C (Tin average = 40.9 °C) and 14.1°C (Tin average = 41.1 °C) for the length 10 m, 20 m and 30 m, respectively. It is understandable that the major part of the average temperature

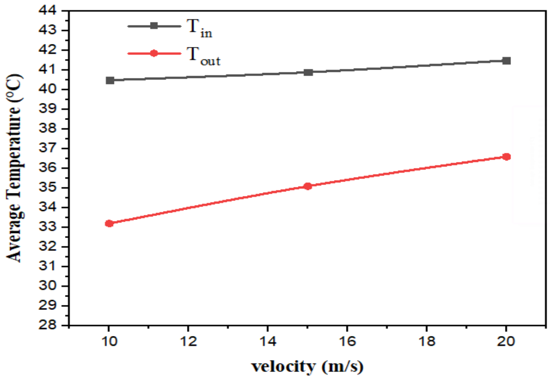


Fig. 4 Average temperature versus velocity

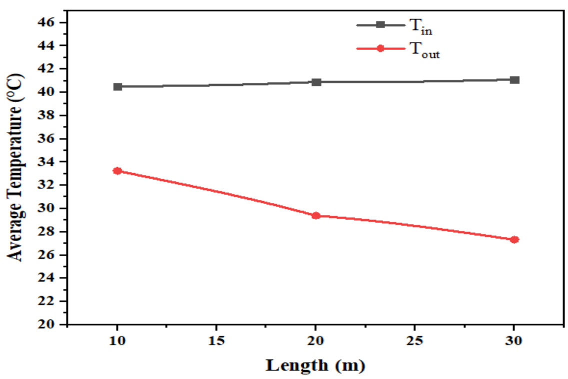


Fig.5 Average temperature versus velocity

5. Conclusion

The prime focus of the present research work has been about this study of earth air heat exchanger using PVC pipes, which are buried inside the earth to get heat transfer due to the thermal inertia of the underground soil. Hot-dry weather conditions selected for the study of the EAHE. The velocity of air and the length of pipes burying pipes have been selected as independent parameters for the study. Each of the above-mentioned independent parameters is varied, keeping all other parameters constant. The velocity of the air is varied from 10 m/s to 20 m/s, the length and depth of the EAHE pipes were varied from 10 m to 30 m respectively. The main conclusions emerging from the present work are the followings:

- The temperature drops of air increases with decrease in air velocity, as in this study the temperature drop is 7.9 °C corresponding to 10 m/s velocities and 4.9 °C corresponding to 20 m/s velocities
- The increased length of the pipe of earth air heat exchanger has more effect on performance of earth air heat exchanger.
- The temperature decrease corresponding to a length of 10 m is 7.26 °C, to a length of 20m is 11.45 °C and for a length of 30 m, it is 13.77 ºC. It is noted that for every 15 m increase in length there is an increase in 3 °C of the temperature drop. This results It is a feature that motivated our work on EAHE development.

6.References

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