Parametric Analysis of Earth Air Tube Heat Exchanger having soil with Different Moisture Content

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Abstract

Extraction of energy from the earth also called as geothermal energy is a source of renewable energy which provides low grade thermal energy with a very low impact on the environment. The techniques available for utilizing geothermal energy includes ground source heat pumps and earth to air tube heat exchangers. EATHE is an underground heat exchanger that works through burying pipes in the ground, which can cool or warm air by dissipating heat to or capturing heat from the ground. In the system cold or hot air as per the environmental conditions pass through the tubes buried underneath the ground, heat transfer takes place. As a result, temperature of air at the outlet of EATHE remains constant throughout the year. The effectiveness and performance of EATHE also depends on the moisture content of soil, making wet configuration of system.

In this study, commercial CFD software ANSYS FLUENT is used to simulate the EATHE system to compare and validate the previously done experimental analysis. The geometrical model has been created for simple (dry) tunnel. One end of the pipe is the inlet of air while the other end of the pipe is the outlet

This study consists of development of three different models of EATHE system i.e. dry soil system, soil with 5% moisture content, soil with 10% moisture content. We simulated the model for three different time intervals i.e. 1 hour, 6 hours and 12 hours operation for each case and compare the results withthe experimental study. The velocity of incoming air is kept constant at 5m/s.

Key words: *Earth Air Tube Heat Exchanger, Parametric Analysis, Earth's Undisturbed Temperature*

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1. INTRODUCTION

Conservation of energy is one of the most significant global challenges in now a day. The energy crisis of the mid 1970s dealt a harsh blow to developing countries including India. The most energy beneficial outcomes of crisis are that it stimulated interested in the diversification of energy sources and renewable energy. Meanwhile, environmental concerns push this trend much further. Earth as a heat supply and warmth sink may be a well-studied topic. Victimization the world as an element of the energy system or earth tempering will be accomplished through 3 primary methods: direct, indirect and isolated. This paper is targeted on indirect system. This system i.e Earth Air Tube Heat Exchanger System, sometimes called earth tubes, or ground coupled air heat exchanger are an interesting and promising technology. Tubes are positioned in the ground, through which air is passes because of the high thermal inertia of the exterior climate are damped deeper in the ground. Further a delay arises between the temperature fluctuations within the ground and at the surface. Thus at a sufficient depth the soil temperature is lower than the outside air temperature in summer and higher in winter. When the fresh air is drawn through the earth tube heat exchanger the air is thus cooled in summer and heated in winter. In combination with other passive system and good thermal design of the building, the earth air heat exchanger can be used to preheat air in winter and avoid air conditioning units in building in summer, which result in a major reduction in electricity consumption of a building.

II. LITERATURE REVIEW

In recent years, there is a global consensus for exploration and utilization of different renewable energy sources to meet the energy demand [1] of a rapidly growing world population and limited energy resources of conventional or fossil fuels. The new options should be eco friendly as well as abundant in nature. The various options may be nuclear, wind, bio mass, solar etc. Solar energy is a renewable, eco friendly and freely available energy resource on earth.

Kumar et al [3]presented a numerical model to predict energy conservation potential of earth air heat exchanger (EAT) system. This model improves upon previous studies by incorporating effects of ground temperature gradient, surface conditions, moisture content and various design aspects of EAT. The model is found to be more accurate in predicting tube extracted temperature variations along the length (error range ±1:6%).Puri [2] evaluated the single pipe carrying hot fluid buried in the ground of medium wet sand by Parametric study for system variables pipe diameter, initial soil moisture concentration and temperature, and fluid-tube interface temperature using finite element model. It was found that temperature profiles developed faster in higher moisture soil than lower moisture soil. It was also pointed out that smaller diameter pipes are superior for enhancing the rate of heat transfer, though, the pressure drop was also higher in small diameter pipes. Kumar et al. [5] presented a numerical model to predict energy conservation potential of earth air heat exchanger (EAT) system. This model improves upon previous studies by incorporating effects of ground temperature gradient, surface conditions, moisture content and various design aspects of EAT. The model is based on simultaneously coupled heat and mass transfer in the EAT and is developed within the scope of numerical techniques of Finite Difference and FFT (Matlab). The model was validated against experimental data of a similar tunnel in Mathura (India), and was then used to predict the tube-extracted temperature for various parameters such as humidity variations of circulating air, air flow rate and ambient air temperature. The model is found to be more accurate in predicting tube extracted temperature variations along the length (error range ±1:6%). They developed the, mathematical model as a transient axi-symmetric system.

Against this background, present research work includes the preparation of EATHE model in solid works and parametric analysis of different types of moisture conditionsof system in ANSYS Fluent to obtain the temperature difference in inlet and outlet air for different moisture content of the soil. Validationofresultsobtainedfromnumericalsimulationwith the previously reported experimentalinvestigations.

III. GATHEModelling

The experimental model of GATHE is made in solid worksasmentionedearlier.Thedifferentdimensions of EAHE is mentionedbelow:

1. Length= 30m
2. Diameter=0.1016m
3. Inlet Air Velocity= 5m/s
4. Inlet Air Temperature = 307.8 K
5. Burial depth = 3.7 m
6. Element type is Hexahedron.
7. The method of meshing used is Sweep.

At Inlet of GATHE the subsonic flow regime with medium turbulence is taken. The values of velocity of air flow is 5m/s is taken with the static inlet temperature of the air as 307.8 K respectively is defined at inlet. The density, specific heat capacity, dynamic viscosity and thermal conductivity of air is defined at static temperature at the inlet. At outlet the relative pressure of GATHE pipe was taken as zero atm in subsonic flow regime.

IV. Results and Discussion

In this section comparison of dry soil 5% wet soil and 10 % wet soil systems were compared and it was observed that maximum temperature drop was obtained for the 10% wet soil design of EATHE system.

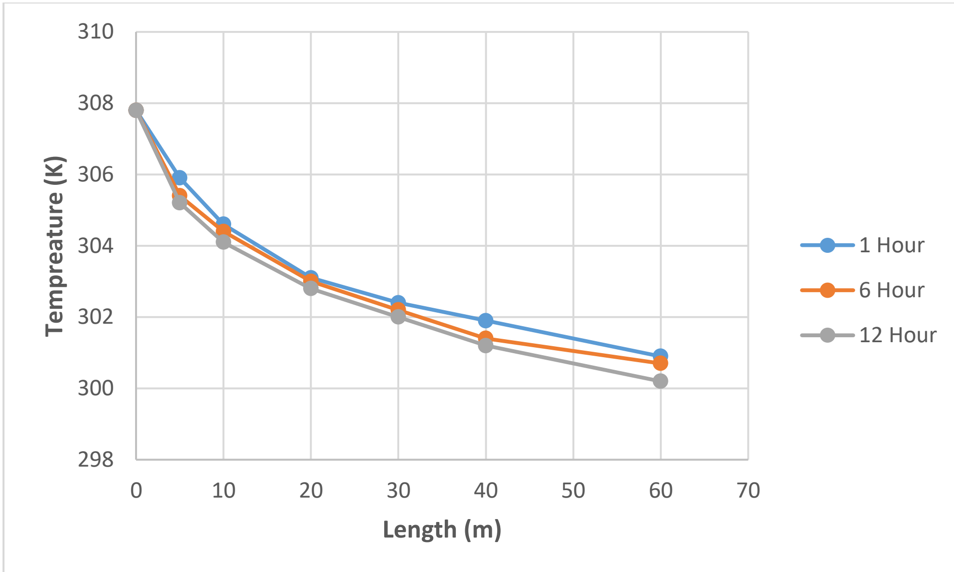

Fig.1 Comparison of EATHE system at for dry soil

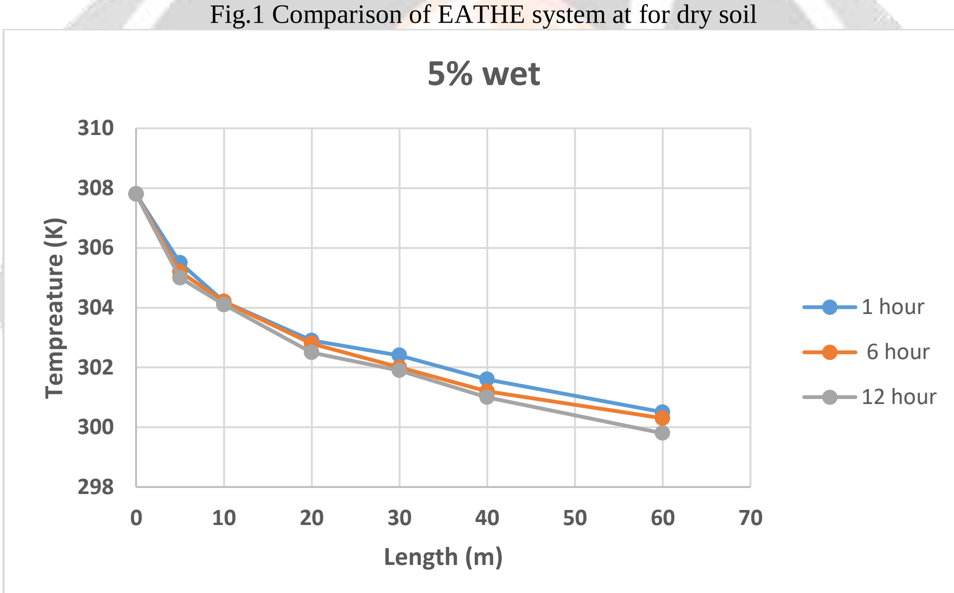

Fig 2. Comparison of EATHE system for 5% wet system

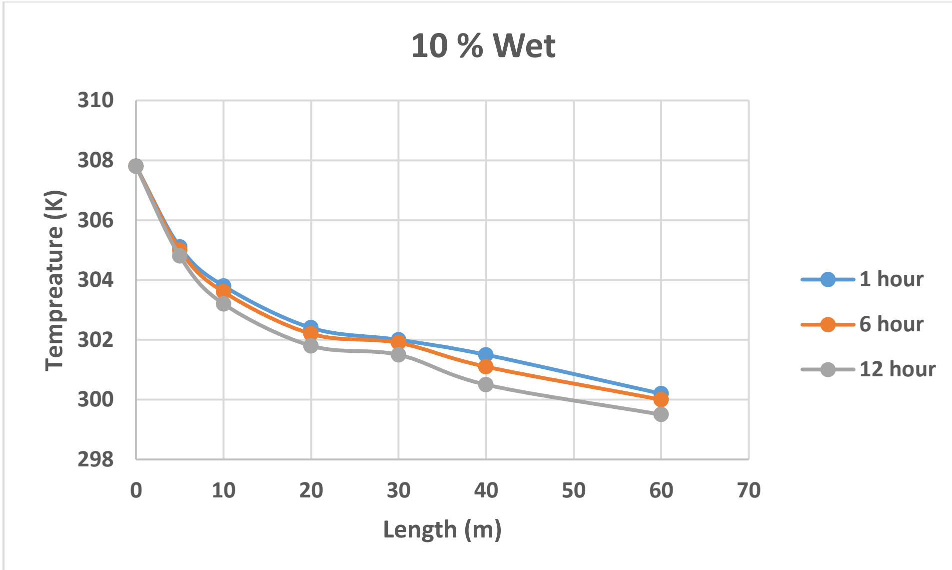

Fig 3. Comparison of EATHE system for 10% wet system

5. Conclusion

This present investigation on Earth Air Tube Heat Exchanger has led to the following conclusions.

- In the first mode of operation, dry soil with soil thermal conductivity 0.52 W/m-K is simulated for three different time interval i.e 1 hour, 6 hours and 12 hours. Simulated results for each time interval is compared and validate with experimental results for 6 hours.

- In the second mode of operation, wet soil of 5% moisture content having soil thermal conductivity 0.74 W/m-K is simulated for three different time intervals i.e. 1 hour, 6 hours and 12 hours. Simulated results for each time interval is compared and analysed.

- In the third mode of operation, wet soil of 10% moisture content having soil thermal conductivity 0.917 W/m-K is simulated for three different time intervals i.e. 1 hour, 6 hours and 12 hours. Simulated results for each time interval are analysed and compared.

Decrement in temperature was observed as the moisture content of the system increases. Moisture content beyond 10 % water is not analysed as it may make the outlet air humid which is not good for human ergonomics.

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