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Journal of Applied Mechanical Engineering

Research Article

Experimental Evaluation of Ground Heat Exchanger for Space Conditioning

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ABSTRACT

In this era, Pakistan facing energy problems, there is a need to use renewable energy resources. Geothermal space conditioning system is a newly technology just entering in Pakistan like some other under developing countries. Geothermal Heating and Cooling Systems provide space conditioning, heating, cooling, and humidity control. During the winter, geothermal system absorbs extra heat from the earth and transfers it into a space/house. During the summer, the system takes heat from indoors and moves it back underground.

Keywords: Heat exchange; Cooling systems; Geothermal system

INTRODUCTION

Ground Source Heat Pump (GSHP) is most energy efficient and friendliness to environment. It can achieve greater energy efficiency than typical AC systems. Its Initial cost directly depended on number of underground heat exchangers. Bore Hole Heat Exchangers (BHEs) with higher diameters have better thermal efficiency, economically enlarging the borehole diameters is not profitable [1].

E-QUEST energy simulation software package is used to examine energy performance simulations and analyses of life-cycle costs of the buildings containing the actual GSHP system and two alternative HVAC systems, with hot water heating and air-source heat pump. GSHP can save 16.5% power annually and this saving would reduce the emission of 69.3 metric tons of carbon dioxide and 2.7% of energy bills, annually. Initial cost of installation would be recovered by life-cycle cost saving [2].

USA residential buildings consume 22% of primary energy, to reduce this consumption of energy and greenhouse effect Geothermal Heat Pump (GHP) system has significant importance presently with its high efficient property. But only less than 0.5% of US homes could exploit GHP system. This system can save 66% of energy every year and can also stop emission of 76 million ton of CO_2 [3].

Use of geothermal energy in heating and cooling of agricultural structure a system must have three sub model, Soil temperature model, Earth To Air Heat Exchanger (ETAHE) model and Greenhouse model.

Result define that pipe length should be greater than 30 m and do not exceed 90 m to 150 m in designing an ETAHE model [4].

Ground Source Heat Pump (GSHP) are more efficient in minimizing the energy consumption for heating and cooling a building, but to size a GSHP over a year maximum of systems exceeds over sizing of system to fulfill the demand of heating load of building which is unsuitable for payback period. This paper illustrates the design moderation for GSHP called a 'smart manifold', which can make an oversized system to dynamically suitable resized and for most efficient operating conditions [5].

A heat pump and a ground heat exchanger (closed or open loop) form a system of Geothermal Heat Pumps or Ground Coupled Heat Pumps (GCHP). System use the earth as heat source and heat sink in heating and cooling mode respectively through a medium (water or mixture of water with antifreeze) by transferring heat from soil to heat pump [6].

GSHP system (installed in a 65 m^2 room in the Solar Energy Institute, EGE University, Izmir, Turkey) which is 50 m vertical 1.25-inch nominal diameter U-bend ground heat exchanger results that for 3000 m^2 area with 3.2 kW and 4.8 kW heating and cooling load respectively the heat extraction rate was 11 W/m and required bore hole length was 14.7 m/kW. The result shows that the performance of this system was very low which can be enhanced by reconsidering the design of ground heat exchanger, spacing between pipes, size of GSHP and Heat pump capacity [7].

Transient heat conduction around spiral pipes uses Green's function theory and image mechanism to describe the analytical solution for temperature result through a transient ring-coil heat source model. There are some effects of location and pitch of coils. Result shows that spiral coil model is best to experience the

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Received: February 02, 2021; **Accepted:** February 16, 2021; **Published:** February 23, 2021

Citation: Shairwani HN (2021) Experimental Evaluation of Ground Heat Exchanger for Space Conditioning. J Appl Mech Eng. 10:347. .

heat transfer process for pile geothermal heat exchangers. From simulation it can be concluded that the infinite ring-coil model is the best for engineering applications, for short time period but heat conduction must be considered through the two ends of the pile with smaller depth-to-diameter ratio for long period [8].

Calculation of heat transfer and coefficient of performance of a geothermal cooling system is done by simple heat transfer formulas. Cop (coefficient of performance) is measured, firstly by using evaporating cooling coil resulted as cop=3.087 and secondly by using without evaporating cooling coil resulted as cop=1.7651, which shows that system is more suitable and give double cop (coefficient of performance) by using evaporating cooling coil [9].

In an underground duct (which uses geothermal heat energy as heat source and heat sink) heat transfer occur according to first law of thermodynamics with lowest pressure loss resulting in very small power consumption and concluded that this is a best system for domestic use. There are smaller effects of temperature difference on different materials for duct like aluminum, copper and cast iron but poly butyl has 5% less affected as compared to the other. Pipe thickness has negligible effect on heat transfer rate [10].

EXPERIMENTAL SETUP

Description of system

Geothermal Heating and Cooling System has three major subsystems or parts: geothermal heat pump or a radiator to move heat between the fluid and the building or space, Buried copper coil (an earth connection for transferring heat between its fluid and the earth) and a centrifugal water pump to circulate the fluid in pipes (Figures 1 and 2). Schematic diagram shows the complete configuration of system (front view and side view). CAD model of the geothermal space heating and cooling system describe the complete process.

Figure 1: A radiator.).

Figure 2: Buried copper coil at 14 ft. depth.

Mechanism

Firstly, to burry copper coil (the ground heat exchanger) a geothermal pit was dug by the Hydraulic excavator. The coil was buried carefully in the pit. Copper coil was joined with two PVc pipes from both ends. One PVC pipe (inlet) joined with water pump and pump is attached with the water storage, while other pipe (outlet) joined to the radiator. Valves are fixed at both inlet and outlet points. A dial thermometer is also attached at the end of outlet pipe.

Measurement procedure

The Experiment was carried out at Tehsil Shujabad District Multan southern Punjab, Pakistan which is mostly very hot in summer season and cold in winter season but winter season is for short duration. Different readings are taken in different times of day at mass flow rate of 0.345 liter/sec.

During digging earth soil temperature was taken at different depths, with a K-Type Thermocouple.

Inlet temperature is noted by K-type thermocouple with a digital panel meter.

Water is circulated through a centrifugal pump into pipe and underground copper coil and return to the radiator (heat exchanger). Just before radiator a dial thermometer is attached by with outlet water temperature is measured.

Pre-cooling and pre-heating is done for a normal and average atmosphere temperature.

Soil and climate data

Main heat transfer process is occurring in between soil and underground heat exchanger (copper coil) through convection from water to pipe material and through conduction from pipe material to soil. So it is necessary to study the thermal properties of soil and water.

RESULTS AND DISCUSSIONS

Soil properties: Different soil types have their own thermal properties here we study the data of soil selected for our project experiment.

Thermal properties of water: The most common refrigerant used for geothermal air conditioner is water. Its high heat capacity and low cost makes it a suitable heat transfer medium. As convection is occurring in between pipe and water so thermal properties of water has been studied.

Weather data: As for accomplishing this project, Shujabad nearest city to Multan has been selected which has very hot climate. We start from the climate data that is available for Multan. Mean daily temperature here is 25.22°C and average high temperature is 32.59°C.

CONCLUSION

Temparature *vs* time and Qe *vs* DTLM and Q *vs* DTLM are evaluated accordingly.

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