Research Article *ISSN: 2319-507X*
Prashant Mohite, IJPRET, 2013; Volume 1(8): 60-65 *IJPRET*

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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EXPERIMENTAL STUDY OF HORIZONTAL LOOP PARALLEL FLOW GROUND HEAT EXCHANGER

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Accepted Date:

27/02/2013

Publish Date:

01/04/2013

Keywords

Ground heat exchanger, Horizontal loop, Parallel flow

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Abstract

A Ground Heat Exchanger (GHX) is a heat exchanger buried in soil which captures from and/or dissipates heat to the ground. It uses the Earth's near constant subterranean temperature to warm or cool air or other fluids. This paper reports the results of an experimental study of three types of ground heat exchanger loops buried in soil at a depth of 1.25 m using parallel flow configuration and in horizontal position. Three loops were fabricated viz. Bare Tube GHX, Finned Tube GHX and Wire & Tube GHX. Material used for ground heat exchanger loop was Mild Steel. Total length of piping of loop is 12.2 meter. Experiment was carried out on three loops with mass flow rate of 1.2 liters per min and 1.7 liters per min. Inlet and outlet water temperatures as well as ground temperatures were measured during testing. Experiments were carried in the month of March-April 2012 in Mumbai. Results shows heat transfer from Finned Tube GHX is 13% more than that from Bare Tube GHX and in case of Wire & Tube GHX, heat transfer is 5% more than that for Bare Tube GHX for a water flow of 1.2 liters per minute. For a flow rate of 1.7 liters per minute, the heat transfer from Finned Tube GHX is 18% more than Bare Tube GHX and in case of Wire & Tube GHX; heat transfer is 5% more than that for Bare Tube HX. Hence extended surface can be used in soil to enhance heat transfer.

INTRODUCTION

The Earth receives solar energy in the form of heat. The Earth stores heat in upper part of the crust. The stored solar energy is measured in the form of heat and the heat received from the sun varies according to latitude and season. So the Earth has a high heat storage capacity and low thermal conductivity. Due to low thermal conductivity, it transports heat slowly; its temperature changes slowly-on the order of months or even years, depending on the depth of the measurement. That's why the Earth is warmer than the ambient air in the winter and cooler than the ambient air in the summer. This constant temperature of the Earth provides a free renewable source of energy that can easily provide enough energy year-round to cool an average suburban residential home.

Using the Earth as a heat sink, a connection is made between the object (building/home/mall/hospital/etc.) which is to be cooled and the Earth. This Earth connection begins as piping starting from the object being cooled & ultimately returns as piping into the object being cooled. This Earth connection is called as "Ground Heat Exchanger (GHX)".

MATERIALS AND METHOD

Construction of loop -

Three ground heat exchanger (GHX) loops were fabricated in college and were tested for 1.2 liters per minute and 1.7 liters per minute.

Bare Tube GHX loop -

The dimensions of Bare Tube GHX loop was 8 feet long, 3 feet wide. Parallel flow arrangement was used as shown in photograph 1.

Photograph 1- Bare Tube GHX loop

The loop was buried at a depth of 1.25 m where temperature fluctuations are reduced. Mild Steel was used for loop to add strength. Branch pipes were permanently welded for Header pipes and joints were covered by M-seal, making it leak proof.

PVC pipes were connected at inlet and outlet. Plastic Elbow used for connection. 25 mm and 22 mm diameter pipes were used for header pipes and branch pipes, respectively. The distance between each pipe kept as 1 foot (30.5 cm) so heat rejected from pipes would not interact with other pipe.

Finned Tube GHX loop –

Finned tube was used as heat exchanger for enhancing heat transfer. Spirally wound crimped fins were used with spacing of 8 fins per inch. Base of fin is twisted by passing it through pair of spur gear and is mechanically bonded to hollow tube. The end of fin is brazed to pipe. Material used for fin and tube is mild steel. Thickness of fin was selected as 0.3 mm due to restriction by manufacturers.

Wire & Tube GHX loop -

Finned Tube GHX loop was more costly than Bare Tube GHX. Thus another configuration of fins was used having lower cost than Finned Tube GHX.

Bare Tube GHX was modified as Wire and Tube GHX. Mild Steel rod of 3 mm diameters were welded on the surface of tube along the length of header pipes. It acts as an extended surface as in case of condenser of refrigerator. The spacing between the two fins / rods was 3.5 cm.

Methodology –

The GHX loops were to be used for rejecting heat to ground of Air conditioner having capacity of 1.5 ton. The designed temperature for condenser was assumed to be 45^{o}C. So water from condenser was expected to be in the range of 40^{o}C-57^{o}C. To match the water temperature from condenser, 3 KW geyser was used.

The connections were made between the ground heat exchanger loop and geyser

with the help of PVC pipes. Water was supplied to the geyser from an overhead tank. Ball valve was provided at outlet of geyser to vary the flow rate to ground heat exchanger.

Photograph 2 - Experimental setup

Inlet water temperature and outlet water temperatures were measured with thermometers and thermocouples. Thermocouples were buried nearby the 1st branch pipe. Ground temperatures were measured during testing. Observations were taken at 15 minute interval of time.

RESULTS AND DISCUSSION –

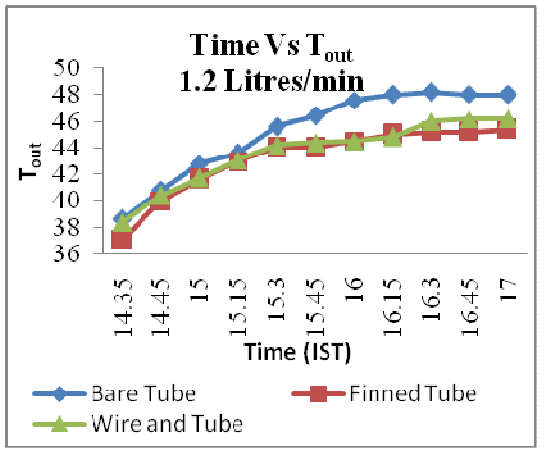

Fig 1 - Profile of Time Vs Outlet Temperature

Fig 1 shows variation of Outlet Temperature w.r.t. Time for 1.2 litres per min.

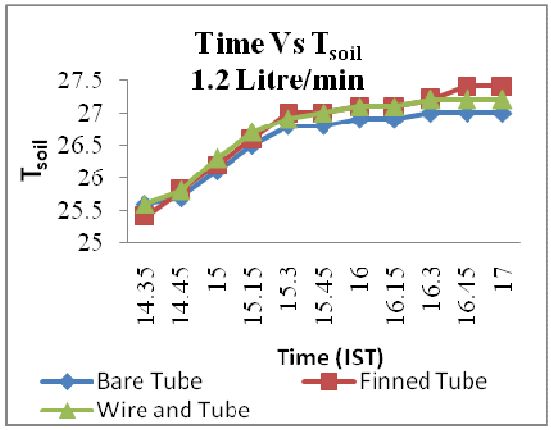

Fig 2 - Profile of Time Vs Temperature of soil

Fig 2 shows variation of Temperature of soil w.r.t Time for 1.2 litres per min.

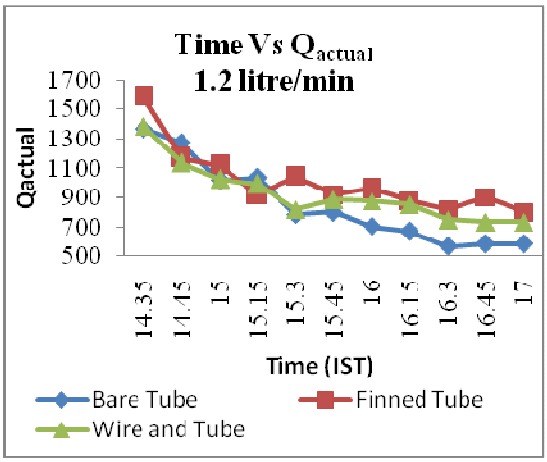

Fig 3 - Profile of Time Vs $Q_{actucal}$

Fig 3 shows Variation of Actual heat transfer by GHX w.r.t. time for 1.2 litres per min.

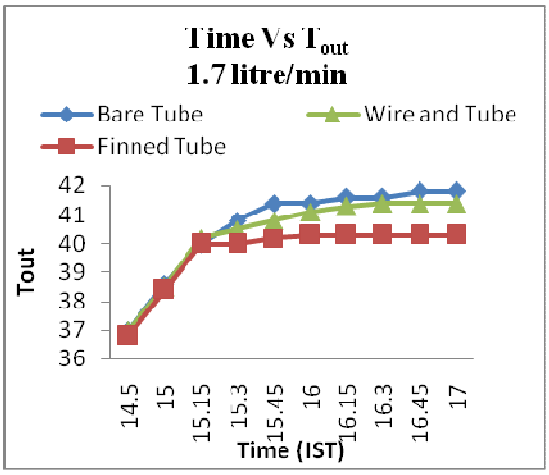

Fig 4 – Profile of Time Vs outlet Temperature

Fig 4 shows variation of Outlet Temperature w.r.t. Time for 1.7 litres per min.

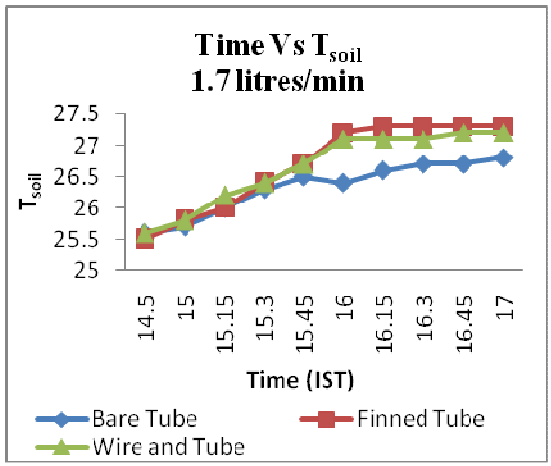

Fig 5 - Profile of Time Vs Temperature of soil

Fig 5 shows variation of Temperature of soil w.r.t. Time for 1.7 litres per min.

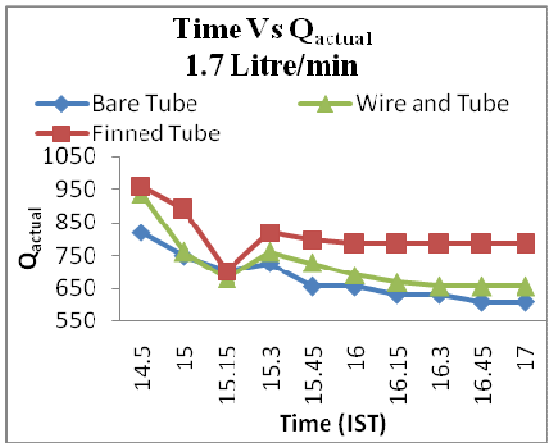

Fig 6 - Profile of Time Vs Q_{actual}

Fig 6 shows variation of Actual heat transfer by GHX w.r.t. Time for 1.7 litres per min.

CONCLUSION: -

Table 1: Comparison of Actual Heat Transfer of GHX's for different flow rate -

For water flow rate of 1.2 litres per minute.	**Bare Tube**	**934 W**
	Finned Tube	1055 W
	Wire & Tube	980 W
For water flow rate of 1.7 litres per minute.	**Bare Tube**	**685 W**
	Finned Tube	810 W
	Wire & Tube	721 W

- Heat transfer from the Finned Tube GHX and Wire & Tube GHX is more than Bare Tube GHX for 1.2 litres per minute and 1.7 litres per minute. Hence extended surface can be used in soil.

- Though Heat transfer from finned tube GHX loop is more than other two; it is not affordable because of more cost of fabrication.

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