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Experimental prediction of total thermal resistance of a closed loop EAHE for greenhouse cooling system☆

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ABSTRACT

The design of an earth to air heat exchanger (EAHE) requires knowledge of its total thermal resistance (R_{Tot}) for heating and cooling applications. In this research, a 47 m long horizontal, 56 cm nominal diameter U-bend buried galvanized was studied experimental EAHE used for the determination and evaluation of thermal properties of heat exchanger. This system was designed and installed in the Solar Energy Institute, Ege University, Izmir, Turkey. Based on the experimental results, generalized relationships were developed for predicting of thermal resistance of the heat exchanger. Average total heat exchanger thermal resistance was estimated to be 0.021 K-m/W as a constant value under steady state condition.

1. Introduction

Various design tools have been developed for the determination and evaluation of thermal properties of borehole heat exchangers by many researchers. Kavanaugh [1] proposed an equation for calculating the required total borehole length by including various terms in the steady state heat transfer equation to account for load cycle effect, and thermal interference from adjacent boreholes and other tubes inside the borehole. Mogensen [2] presented thermal response test (TRT), which has been used as a very effective method to determinate the ground thermal conductivity. Rottmayer et al. [3] studied the performance of a single borehole by applying finite difference method to discrete both the interior of a single borehole and the surrounding ground using cylindrical coordinate system and neglecting heat conduction in vertical direction. Lee and Lam [4] improved a computer simulation of borehole ground heat exchangers for geothermal heat pump systems. Yu et al. [5] enhanced a simplified model for measuring thermal properties of deep ground soil. Lee and Lam [4], Yu et al. [5], Bose [6], Zeng et al. [7], D.Y. Goswami and S. Ileslamlou [8], Goswami and Dhaliwal [9] etc. described borehole heat resistance (R_0) models in their studies.

The purpose of this survey is about to define total heat resistance of an earth to air heat exchanger, which was installed by Ozgener et al. [10] at the Solar Energy Institute of Ege University (latitude 38.24 N, longitude 27.50 E), Bornova, Izmir, Turkey. There are no studies undertaken so far related to the estimation of thermal resistance of an earth to air heat exchanger.

2. Experimental set up

2.1. Test facility

A schematic diagram of the constructed experimental system is illustrated in Fig. 1. This system mainly consists of two separate circuits: (i) the fan (blower) circuit for greenhouse cooling, and (ii) the ground heat exchanger (GHE) (underground air tunnel). The main characteristics of the elements of the system are given in Table 1. The underground air tunnel system studied was installed at the Solar Energy Institute of Ege University (latitude 38° 24′ N, longitude 27° 50′ E), Izmir, Turkey. Solar greenhouse was positioned towards the south along south–north axis. The greenhouse will be conditioned during the summer and winter seasons according to the needs of the agricultural products to be grown in it. Fig. 1 shows a schematic of the system which utilizes an underground galvanized pipe in combination with a blower to keep the greenhouse temperature at the set condition. A positive displacement type of air (twin lobe compressor) blower of 736 W capacity and volumetric flow rate of 5300 m^3/h was fitted with the suction head positioned in the southwest corner of the greenhouse [11].

As the warm ambient air passes through the underground air pipe it cools down, while the soil around the pipe gets heated, thereby reducing the heat transfer rate. This also causes some moisture from the soil to move away from the pipe, which decreases the thermal

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