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Research Article

Experimental Analysis of Hybrid Earth Air Tunnel Heat Exchanger in Series Connection Coupled with Water Cooled Heat Exchanger Installed at Bikaner

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Abstract

EATHE is a system which maintains surroundings temperature comfortable to human body and has no bad impact on environment of earth like other air-conditioning system i.e. works on VCRC which uses CFCs as refrigerant i.e. causes global warming and ozone layer depletion. In this research paper, Thermal Performance of Simple EATHE is developed by introducing new concept i.e. Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger in which outlet air temperature of Simple EATHE is further decreased by using wastage water of water cooler i.e. flowing inside the Water Cooled Heat Exchanger which is coupled at outlet of EATHE in Series Connection. The setup of system is installed at Mechanical Engineering Department Government Engineering College Bikaner. Experimental Analysis was carried out on the system in the month of September. The Minimum, Average & Maximum Air Temperature Difference was found as 11.7̊c, 16.27̊c & 23.7̊c respectively.

Keywords: *EATHE, Summer Cooling, Series Connection, Hybrid System, Heat Exchanger, Thermal Performance.*

1. Introduction

During the decades, the global energy consumption for winter heating and summer cooling of buildings has increased. So the energy saving is much important factor for the whole world. Costly and power consumable air-conditioning system are used for maintaining surrounding air temperature comfortable to human body which works on VCRC in which harmful CFCs are used as refrigerant. Since CFCs have bad impact on environment of earth i.e. causes global warming and ozone layer depletion. Therefore there are two important factor: power consumption & environment pollution. These two factors can be eliminated by using other passive techniques such as EATHE. Most of people feels comfort zone when the surroundings air temperature is kept in the range of 22̊c to 28̊c and the relative humidity of ambient air is kept in the range of 45 to 55%. The physics of EATHE is so simple: the earth ground temperature at a certain depth remains same and comfortable to human body throughout the year. So this uses as winter heating summer cooling purpose. This research paper is based upon experimental analysis of hybrid EATHE in series connection coupled with water cooled heat exchanger i.e. installed at mechanical engineering department government engineering college Bikaner. Bikaner city is situated in Rajasthan State, Country India. The climate of Bikaner city is dissert i.e. hot arid climate. Due to geographical condition of Bikaner the summer temperature of Bikaner is reached to extreme hot and winter temperature of Bikaner is reached to extreme cold. So the air-conditioning plays much important role in Bikaner to survive life here and this is also be achieved by using EATHE system. Therefore the installation of EATHE system was carried out in our college campus. We used wastage water of water cooler for further reducing air temperature which is coming from ground inside the buried pipes of EATHE in series connection.

So water cooled heat exchanger was connected at outlet of EATHE in series connection. EATHE in series connection occupies less space as compared to simple EATHE so space limitation problem was also analyzed. Several researches were carried out on the EATHE system that concludes that the thermal performance of EATHE is depended upon air inlet velocity, buried pipe geometry, pipe material, climate conditions and mostly on thermo-physical properties of soil. This research paper investigates the experimental analysis of Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger. Experiment were carried out in the month of September at Bikaner.

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2. Experimental Setup

2.1 Description of Experimental Setup

Experimental setup of system has been installed at mechanical engineering department government engineering college Bikaner (28.0229°N, 73.3119°E) Rajasthan India (334004). Since soil temperature remains constant through the year at a depth of 3 to 4 meters (Bharadwaj SS and Bansal NK, 1981). So our system was placed at a depth of 11ft. Mild steel pipes were used in the system due to lower cost, strength and durability. The total length of EATHE in Series Connection was taken as 53.67ft and the water cooled heat exchanger length was taken as 6ft. The inner diameter and thickness of EATHE in Series Connection was taken as 40mm and 3mm respectively. The inner diameter and thickness of water cooled heat exchanger was taken as 110mm and 2.5mm respectively. The experimental setup of Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger is shown in Fig. 5.

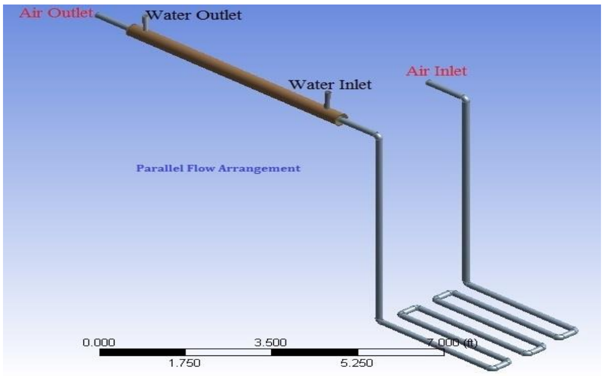

Fig. 1 ANSYS Geometry of System

Fig. 2 Pipe in Series Connection

Fig. 3 Water Cooled Heat Exchanger

Fig. 4 Installation of Setup Using JCB Machine

Fig. 5 Experimental Setup of Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger

2.2 Instruments Used

Cheston Air Blower of 5.5 kwatt having variable speed regulator was used to force surroundings air into the buried pipes of the system. Digital Vane Probe Type Anemometer was used to compute air velocity. Digital Thermometer +2-k-Type Thermocouples were used to compute air temperature.

2.3 Experimental Methodology

The experimental results were taken on the system in the month of September over 8 working days at constant inlet air velocity of 10m/s. Readings of air temperature were recorded in the month of September from 9A.M. to 1P.M. i.e. I-Session and from 3P.M. to 6P.M. i.e. II-Session. Readings were taken every after one hour interval of time. Thus the readings were recorded at 9A.M., 10A.M., 11A.M., 12P.M., 13P.M. & 15P.M., 16P.M., 17P.M. & 18P.M. The system was kept shutdown from 6P.M. to 9A.M. (15 Hours) for soil regeneration. The ambient air was forced to the buried pipe of the system with the help of Cheston air Blower of 5.5 kWatt having variable speed regulator at a constant air velocity of 10m/s. The air velocity was measured by using Digital Vane Probe Type Anemometer. Digital Thermometer + 2-k-Type Thermocouples were used to record air temperature of Ambient, Inlet & Outlet.

2.4 Calculation of Experimental Results

Using experimental results, air temperature difference (ΔT) was computed. Also average air temperature difference was to be calculated.
Air Temperature Difference (ΔT) is given by following equation:

$$\Delta T = T_1 - T_2 (1)$$

Average Air Temperature Difference ($\Delta T_{avg.}$) is calculated by using following equation:

$$\Delta T = \frac{\sum_1^{72} \Delta T}{72} \quad (2)$$

Where T_1 & T_2 are inlet & outlet air temperature respectively.

3. Result & Discussions

Table 1 Experimental Results

Air Temperature (c)	Minimum	Average	Maximum
Ambient Air Temperature (T_a)	37.5	42.53	49.2
Inlet Air Temperature (T_1)	38.2	43.36	49.9
Outlet Air Temperature (T_2)	25.5	27.09	28.8
Air Temperature Difference (ΔT)	11.7	16.27	23.7

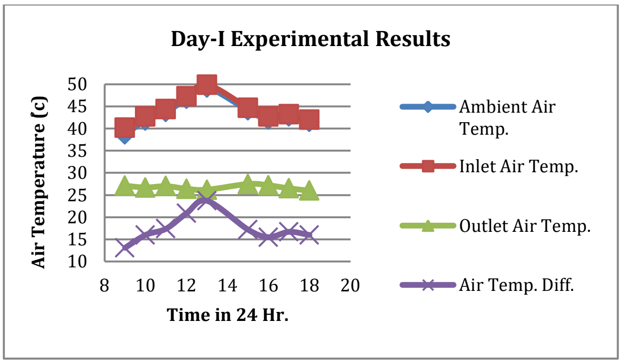

Fig. 6 Day-I Experimental Results

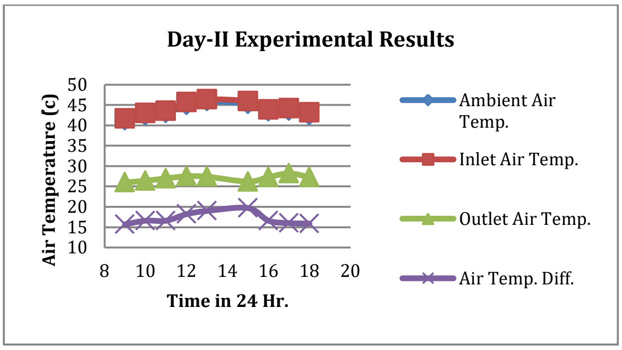

Fig.7 Day-II Experimental Results

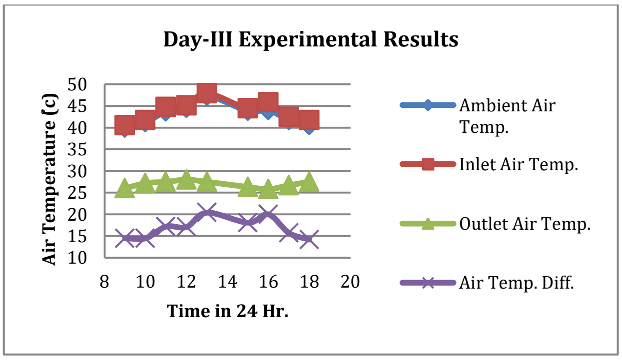

Fig. 8 Day-III Experimental Results

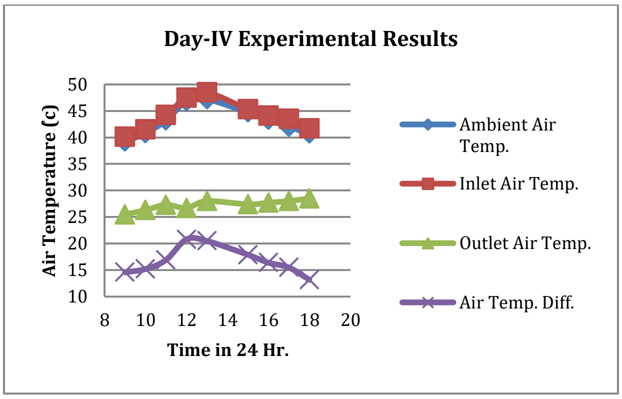

Fig. 9 Day-IV Experimental Results

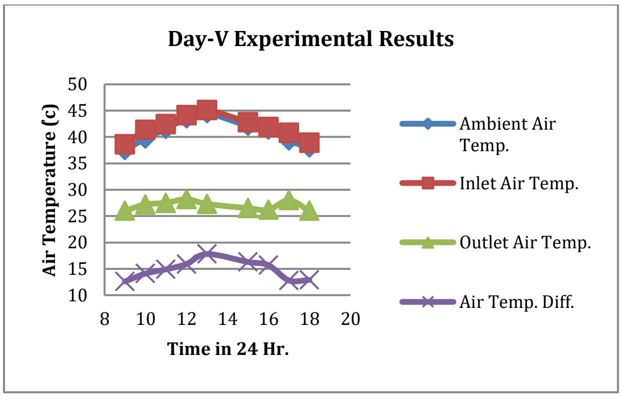

Fig. 10 Day-V Experimental Results

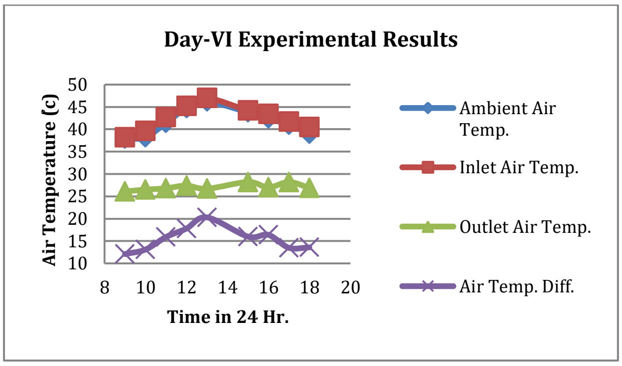

Fig. 11 Day-VI Experimental Results

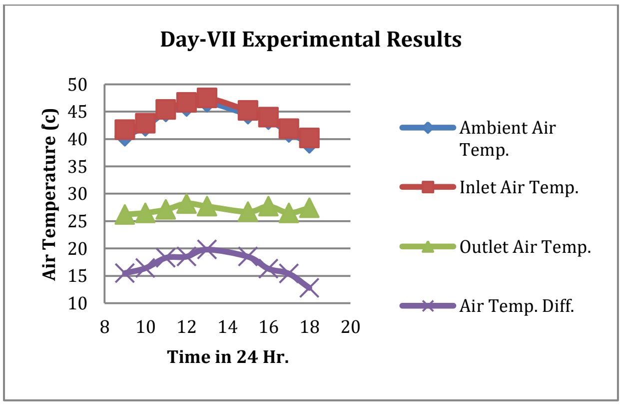

Fig. 12 Day-VII Experimental Results

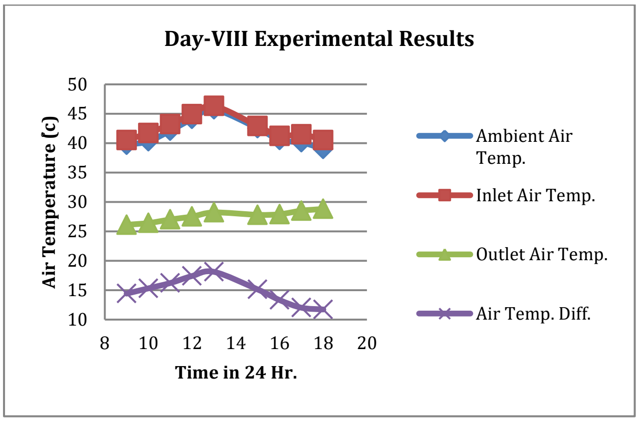

Fig. 13 Day-VIII Experimental Results

The Maximum, Minimum & Average Ambient Air Temperature were recorded as 49.2˚c, 37.5˚c & 42.53˚c respectively.
The Maximum, Minimum & Average Inlet Air Temperature were recorded as 49.9˚c, 38.2˚c & 43.36˚c respectively.
When ambient air is forced through the buried pipes of the system with the help of blower then the inlet air temperature increases due to blower running at very high speed & frictional effects also the blower rise the pressure of ambient air so corresponding temperature of air rises.
The Maximum, Minimum & Average Outlet Air Temperature were recorded as 28.8˚c, 27.09 & 25.5˚c respectively.
The Maximum, Minimum & Average Air Temperature Difference were found as 23.7c, 11.7c & 16.27c respectively.
Thus the Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger provides comfort cooling by utilization of wastage water of water cooler.

Conclusions

The thermal performance of the Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger was analyzed experimentally which concludes following points:

1) Space limitation problem was analyzed by replacing Simple EATHE with EATHE in Series Connection. EATHE in Series Connection occupies less space as compare to Simple EATHE.
2) Utilization of wastage water of water cooler was carried out for comfort cooling i.e. give effective results (Cooling) as compare to Simple EATHE.
3) Maximum, Minimum & Average Air Temperature Difference was observed as 23.7˚c, 11.7˚c & 16.27˚c respectively.

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