International Journal of Advance Research in Science and Engineering
Vol. No.4, Issue No. 12, December 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

MAINTAINING THE COMFORT TEMPERATURE OF SYSTEM BY USING EAHE

Snehil Tripathi[1], Ajay Kumar Tiwari[2], Ashutosh Kumar Singh[3]

[1, 2]Research Scholar, [3]Professor, Millennium Institute of Technology, RGPV Bhopal (India)

ABSTRACT

An earth-air heat exchanger (EAHE), also known as an earth tube heat exchanger or Canadian well, is a system for cooling and heating buildings using the ground as a heat sink/source. The earth–air heat exchanger (EAHE) is a promising technique which can effectively be used to reduce the heating/cooling load of a building by preheating the air in winter and vice versa in summer. In the last two decades, a lot of research has been done to develop analytical and numerical models for the analysis of EAHE systems. Many researchers have developed sophisticated equations and procedures but they cannot be easily recast into design equations and must be used by trial-and-error. The method to calculate the earth's undisturbed temperature (EUT) and more recently developed correlations for friction factor and Nusselt number are used to ensure higher accuracy in the calculation of heat transfer. The developed equations enable designers to calculate heat transfer, convective heat transfer coefficient, pressure drop, and length of pipe of the EAHE system. A longer pipe of smaller diameter buried at a greater depth and having lower air flow velocity results in increase in performance of the EAHE system.

Keywords: EAHE, Fins, Reynolds's No., EUT, Heat Transfer.

I.INTRODUCTION

An earth-to-air heat exchanger draws air through covered pipes. As temperature of the ground below 2.5 m to 4 m is practically constant, it considerably reduces ambient air temperature variation. It therefore provides space conditioning during the year, with the incoming air being heated in the winter and cooled in the summer by means of earth coupling.

Earth tubes are low technology, sustainable flaccid cooling-heating systems utilized mostly to preheat air intake. Due to ground properties the air temperature at the pipe outlet maintains moderate values all around the year. Temperature fluctuates with a time lags (from some days to a couple of months) mainly relative to the depth considered. Temperature remains in the comfort level range (15-27 c).

In recent years, ground heat source heat pump systems have become increasingly popular for use in residential and commercial buildings. These systems include several different variations, all of which reject heat and/or extract heat from ground:

(1) ground-coupled heat pump (GCHP) systems;

(2) Surface water heat pump (SWHP) systems;

(3) ground-water heat pump (GWHP) systems:

a. Standing column well (SCW) systems;

b. Open loop groundwater systems.

This technology is not recommended for cooling of humid climates due to moisture reaching dew pint and often remaining in the tubes. However, in southern European coastal regions as in Greece where the climate remains dry and hot. In such locations these systems could have exciting results.

The material of a pipe can be anything from plastic, metal or concrete. However concrete should be avoided in order not to be dependent on carbon filtration UV sterilization for the stuffy air coming out of concrete earth tubes.

1.2 Working Principle of Earth Air Heat Exchanger

Earth air heat exchanger exchanges heat between air and ground by the process of convection and by conduction it transfers heat to the tube wall.

1.2.1 Summer Conditions

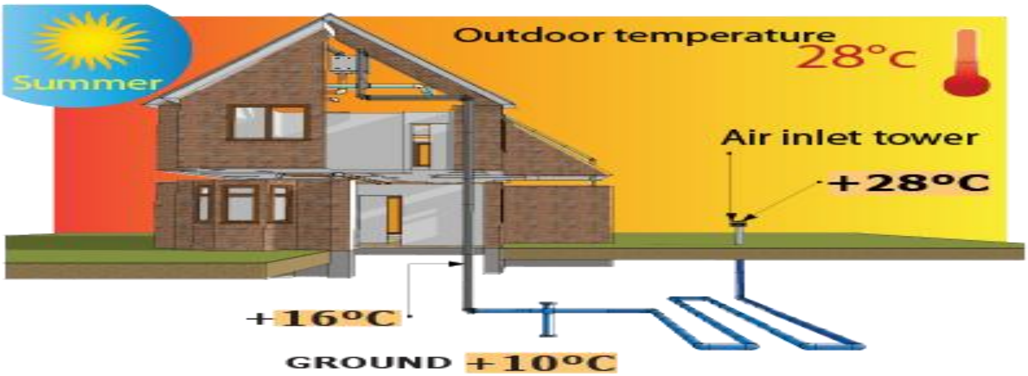

Fig 1 Working of EAHE in summer condition

i) Hot air enters into the tube ii) Air loses heat to the ground iii) Cool air enters into the house

1.2.2 Winter Conditions

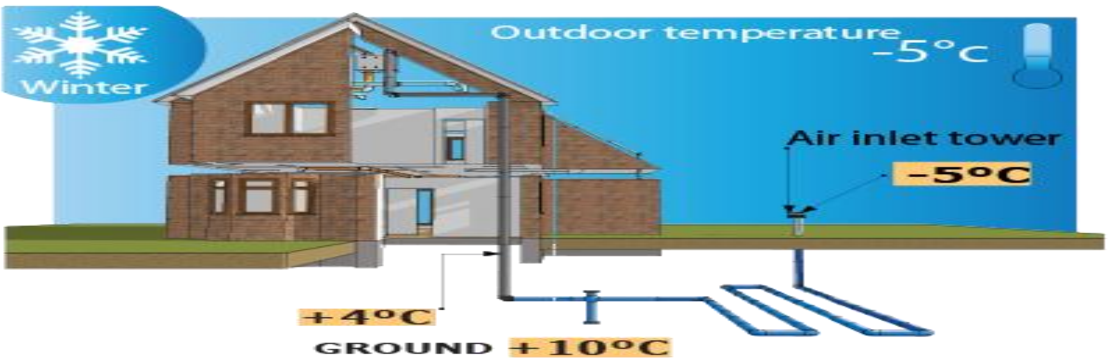

Fig 2 Working of EAHE in winter condition

i) Cool air enters into the tube ii) Air gains heat from the ground iii) Hot air enters into the house

1.3 DESIGN PARAMETERS OF EARTH AIR HEAT EXCHANGER

1.3.1 Location

If the purpose of the system is to heat, then it must be located in the sunny area. If the purpose of the system is to cool, then it should be located near shaded area of a lake or river.

1.3.2 Depth of Pipe

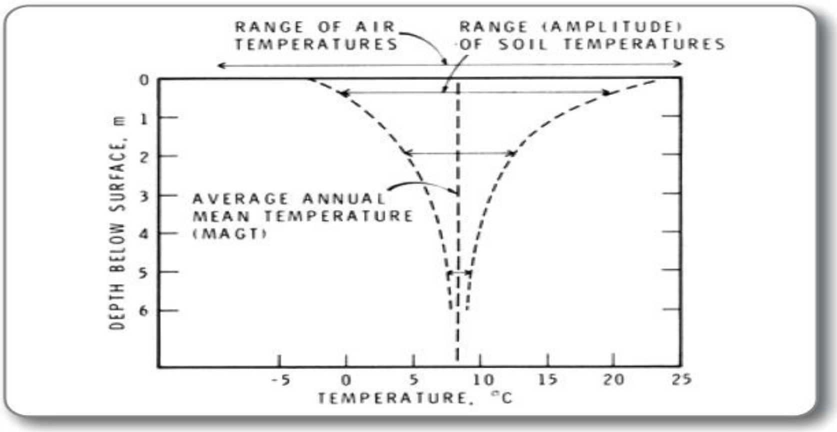

Fig 4 Temperature v/s Depth

Pipe should be buried as deep as possible but favorable depth can vary from 1.5 m to 3 m. A system designed for cooling requires more depth of pipe than a system designed for heating in same location.

II. PROBLEM FORMULATION

The main objective of my experimental work is to study the variation in cooling effects caused by Earth Air Exchanger in summer climate condition by using fins and without fins in series connection. In summer climate conditions, ground temperature is lower than atmospheric temperature. Hence air flowing through the buried pipe exchange heat with underground earth surface in summer climate condition. In this experiment, blower sucks atmospheric air into the pipe and circulates through the buried pipe, due to which air gets cooled. The cooled air is circulated into the delivery pipe for cooling in summer. We compare whether fins arrangement is better or without fins for horizontal series arrangement.

III. EXPERIMENTAL SETUP

The setup consists of without fins and fins arrangement of pipe along with inlet and outlet section, control valve, blower and various devices of measurement of pressure and temperature drop.

IJARSE
ISSN 2319 - 8354

Fig. 5 Experimental setup of series connection (2.5 m) without covered soil

The Earth Air Heat Exchanger in series conncetion as shown in fig. consists of horizontal pipe of inner diameter of 64 mm with total length of 19 m. Three pipes made up of GI of length 3 m each are connected in series and buried at a depth of 2.5 m in ground with dry soil. The series arrangement of GI pipe is connected to a common intake and outlet maniforld for air passage. Atmospheric air was sucked during the pipe by means of centrifugal blower by a 3 phase, 2 hp, 230 V and 2800 rpm motor. The blower is used to suck the hot ambient air through the pipelines and delivered the cold air for required place. The mass flow rate of air was measured by orifice meter.

Fig 6 Experimental setup of series connection (2.5 m) without covered soil with fins

IV. METHODOLOGY

As we have discussed the data is collected experimentally by using different components. The flow of air changes by using control value. The data obtained through experiment has been used to determine the Nusselt number. Heat transfer coefficient and coefficient of performance.

4.1 Experimental Conditions

Parameters	Value
Depth	2.5 m
Reynolds number	50000-150000
Diameter	2.5 inch
Length of Pipe	19 m
Material of Pipe	GI
Connection	Fins and Without Fins arrangement
Capacity of blower	2 hp

Table 1 : Experimental Parameter Range

4.1 Data Reductions

Mean bulk air temperature (T_{fav})

Simple arithmetic mean of measured inlet and exit temperatures of air under testing

$T_{fav} = (T_i + T_o)/2$ Where, Ti = Inlet temperature of air in Celsius

Te = Outlet temperature of air in Celsius

Mean Pipe air temperature (T_{pav})

Thermocouple wires are arranged at equal distance on pipe. Hence average reading of all points are

$T_{pav} = (T_1 + T_2 + T_3 + T_4 + T_5 + T_6)/6$

Where,

T_{pav} = temperature of pipe at different locations of pipe

Pressure drop across the orifice plate (ΔP_o)

$$\Delta P = \Delta h \times 9.81 \times \rho_m \times 1/5$$

Where,

Δh = difference of mercury level in U tube manometer

ρ_m = density of mercury 13600 kg/m^3

Mass flow rate measurement (m in kg/s)

$$m = C_d \times A \times [2p(\Delta p)/(1-\beta)^4]^{0.5}$$

Where, $\beta = d_2/d_1$

C_d = coefficient of discharge of orifice meter i.e. 0.62

A= Area of orifice plate, m^2

p= density of air in kg/m^3

Velocity of air (V)

$V = m/(\rho A)$

Where,

A = area of pipe in m^2

Reynolds number (Re)

$Re = V D_h/$ □

Where,

□= kinematic viscosity of air at t in m^2/s

Heat transfer rate (Q)

$Q_a = m \times C_p \times (T_o - T_i)$

Where,

m = mass flow rate

C_p = heat capacity

T_i = initial temperature

T_o = final temperature

Heat transfer coefficient (h)

$h = Q_z / Ap (t_{pav} - t_{fav})$

Where,

A_p is the heat transfer area assumed to be the corresponding pipe area

Nusselt Number (Nu)

$$Nu = h\, D_h / k$$

Where,

k = thermal conductivity

D_h = hydraulic diameter

Coefficient of Performance

$$Cop = Q_a / W$$

Where,

Q_a = Heat Transfer Rate

W = Work done by Blower

VI. RESULTS

6.1 Obsevation Tables

Serial No.	Mercury deflection (cm)	Inlet air temp. (Celsius)	Outlet air temp. (Celsius)	Pipe Temp. (Celsius)	Avg. air temp. (Celsius)	Temp. Difference
1	1	42.51	37.32	35.11	39.91	5.19
2	2	39.22	35.09	34.13	37.15	4.13
3	3	36.76	33.50	32.03	35.13	3.26
4	4	34.12	30.85	29.71	32.52	3.38
5	5	32.43	30.13	27.53	31.28	2.31

Table 2 Observation table for series combination 2.5 inch GI pipe without fins

Serial No.	Mercury deflection (cm)	Inlet air temp. (Celsius)	Outlet air temp. (Celsius)	Pipe Temp. (Celsius)	Avg. air temp. (Celsius)	Temp. Difference
1	1	43.12	35.89	34.88	39.50	7.23
2	2	39.86	34.32	33.12	37.09	5.54
3	3	37.84	34.23	32.65	35.95	3.45
4	4	35.36	32.21	31.32	33.78	3.15
5	5	31.69	28.82	27.69	30.25	2.87

Table 3 Observation table for series connection 2.5 inch GI pipe with fins

Serial No.	Reynolds No. Re	Velocity	Mass flow rate Kg/s	Heat transfer Q in watt	Convective heat transfer coeff. h In W m^2/k	Nusselt number No.	Cop
1	55268.30	12.91	0.0507	265.44	14.59	26.49	0.1779
2	79026.28	18.91	0.0718	298.73	26.11	65.27	0.200
3	96791.97	22.40	0.0879	285.55	24.57	61.42	0.1933
4	112490.60	25.86	0.101	343.76	32.29	82.02	0.230
5	125765.39	28.91	0.113	263.25	18.50	46.25	0.1768

International Journal of Advance Research in Science and Engineering
Vol. No.4, Issue No. 12, December 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Table 4 Results of different parameters of 2.5 inch series connection without fins

Serial No.	Reynolds No. Re	Velocity	Mass flow rate Kg/s	Heat transfer Q in watt	Convective heat transfer coeff. h In W m^2/k	Nusselt number No.	Cop
1	55265.30	12.90	0.0506	368.39	21.02	52.56	0.2469
2	79026.11	18.93	0.0718	400.50	31.125	77.81	0.2684
3	96759.23	22.44	0.088	305.72	24.454	61.13	0.2049
4	112492.60	25.85	0.102	323.54	34.71	86.79	0.2168
5	125775.40	28.90	0.110	317.90	32.779	81.94	0.2130

Table 5 Results of different parameters of 2.5 inch series connection with fins

6.2 Comparison of Cop of The Set Up With or Without Fin

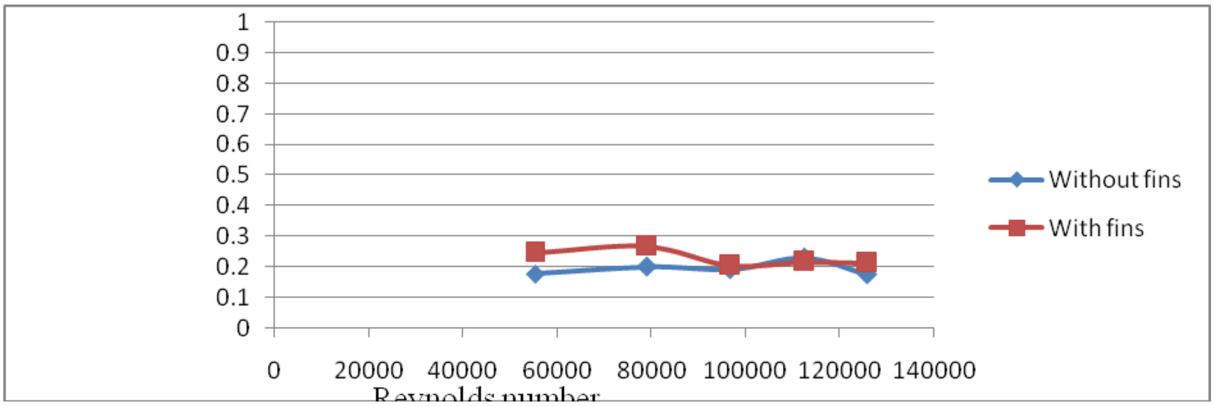

Fig.7 Comparing COP and Reynolds number for with and without fins arrangement

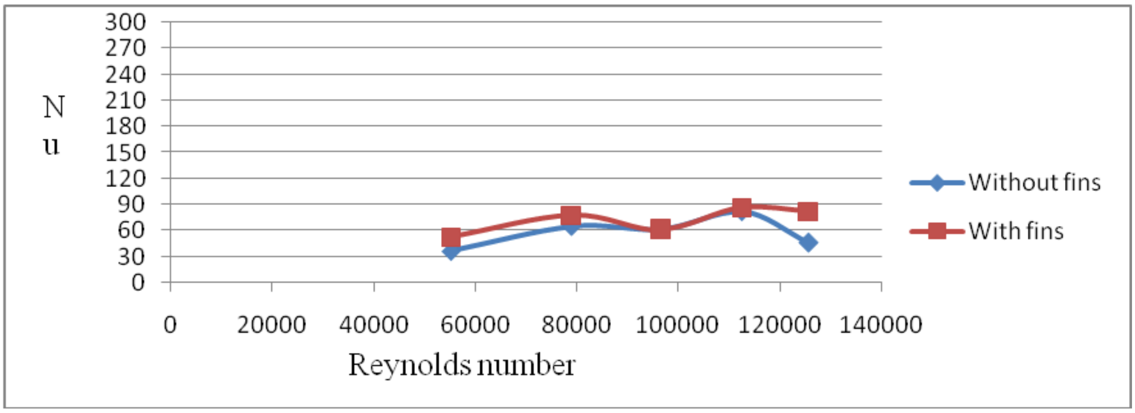

Fig.8 Comparing Nusselt number and Reynolds number for with and without combination

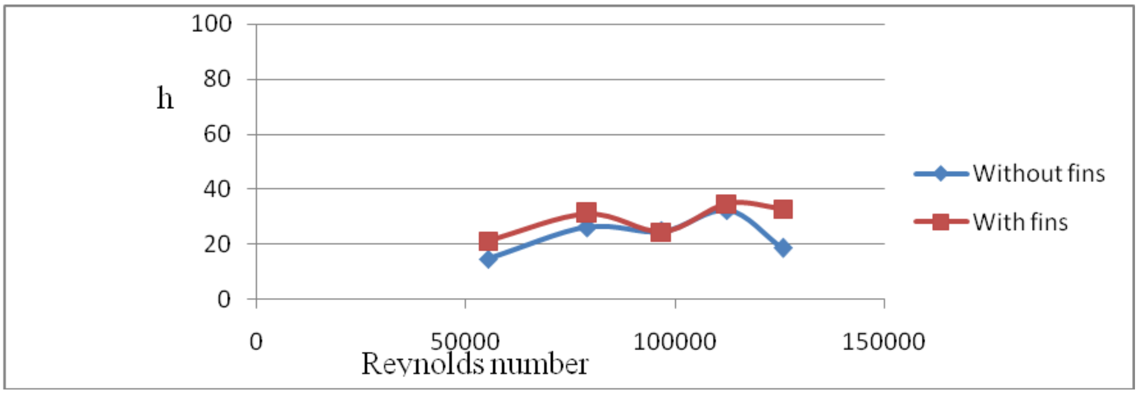

Fig 9 Comparing Convective heat transfer and Reynolds number for with and without fins

REFERENCE

[1]. Bansal Vikas, Misra Rohitm, Agrawal Ghanshyam Das, Mathur Jyotirmay. Performance analysis of earth-pipe air heat exchanger for winter heating. Enegry and Building 2009; 41:1151-4.

[2]. Bansal Vikas, Misra Rohitm, Agrawal Ghanshyam Das, Mathur Jyotirmay. Performance analysis of earth-pipe air heat exchanger for summer cooling. Enegry and Building 2010; 42:645-8.

[3]. Bansal NK, Sodha MS. Bhardwaj SS. Performance of earth-air tunnel system. Energy Research 1983; 7(4):333-41.

[4]. Manoj kumar Dubey, Dr. J.L.Bhagoria, Dr. Atul lanjewar , Earth Air Heat Exchanger in Parallel Connection

[5]. M. Santamouris, A. Argiriou, M. Vallindras, Design and operation of a low energy consumption passive solar agriculture greenhouse, Solar Energy 52 (1994) 371-378.

[6]. A. Tombazis, A Argirion, M. Santamouris, Performance evaluation of passive and hybrid cooling components for a hotel complex, International Journal of Solar Energy 9 (9) (1990) 1-12.

[7]. A.K. Khatry, M.S. Sodha, M.A.S. Malik, Periodic variation of ground temperature with depth and time, Solar Energy 20 (1978) 425-427.

[8]. Goswami DY, Ileslamlou S. Performance analysis of a closed loop climate control system using undergorund air tunnel. Journal of Sloar Energy Engineering 1990; 112:76-81.

[9]. Ozgener L, Ozgner O. Energetic performance test of an undergound air tunnel system for greenhouse heating. Energy 2010;35(10):4079-85.

[10]. Ozgener L, Ozgner O. Exergoconomic analysis of an underground air tunnel system for greenhouse cooling system. International Journal of Refrigeration 2010;33(5):995-1005.