© 2016 IJSRSET | Volume 2 | Issue 6 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Experimental Analysis of Earth Air Heat Exchanger (EAHE) Systems in Different Laying Arrangements

Golu Dadhore, Asst. Professor. Priyank Dixit, Asst. Professor. O.P Shukla
Kailash Narayan Patidar College of Science & Technology, RGPV Bhopal, Madhya Pradesh, India

ABSTRACT

The present world energy scenario indicates that the conventional energy sources are depleting and per capita energy consumption is indication of living standard of a nation so, it becomes very important to find and explore nonconventional energy sources to meet the energy requirement of the society. The nonconventional energy sources are better option of clean and sustainable energy. This kind of energy is, at principle, inexhaustible and can be found and exploited equally well on the planet. The increased need for thermal comfort, the rising cost of energy consumption and environmental issues have made alternative and hybrid techniques and methods very attractive. Earth tubes, also called earth- air heat exchangers (EAHX) offer the possibility of reducing use of nonrenewable energy in ventilation and air conditioning systems and provide good indoor air quality for the conditioned environments. The following conclusion is made on the basis of experimental investigation done on Earth Air Heat Exchanger: The average Temperature rise from inlet to outlet is from 3 to 7°C in both series and parallel arrangements,Nusselt Number in parallel connection for different Reynolds Number is higher than the Nusselt number in series connection,Nusselt number in parallel connection varies from (19 to 24) and (18 to 22) in series connection, COP of the parallel connection is higher than the COP of series for the Reynolds number greater than 30000.

Keywords : Earth Air Heat Exchanger, COP, Nusselt Number, Reynolds Number, Thermal Comfort.

I. INTRODUCTION

Nowadays, there is a growing interest to the systems based on renewable energy sources due to rising cost of energy and environmental concerns. As one result of efforts of decreasing energy cost and importance of indoor air quality, it is seen that earth energy can be used easily as energy sources by using an earth-air heat exchangers (EAHX) in ventilation and air conditioning systems. EAHX, also called earth tubes, ground-coupled heat exchangers, earth channels, earth–air tunnel, or pipe system, are quite simple. EAHX systems consist of pipes in which air passes and a fan for air movement. It has long been known that the earth has a huge energy capacity. 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.

II. METHODS AND MATERIAL

EAHX systems can be used in a vast variety of buildings such as commercial buildings, offices, showrooms, and cinema halls. EAHX can be used in either open loop system (figure 1) or closed loop system (figure 2).

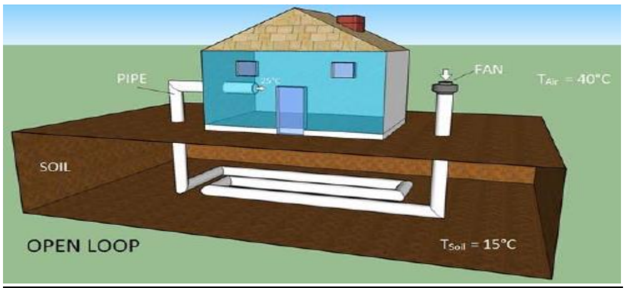

Figure 1. Open loop EAHE

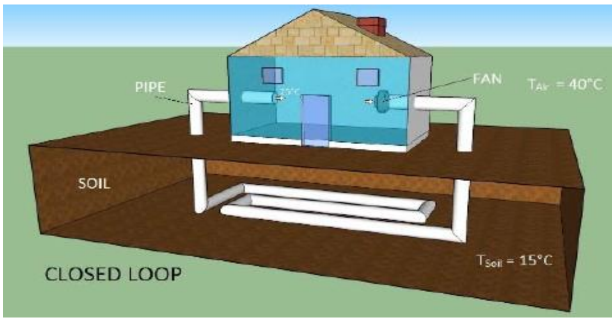

Figure 2. Closed loop EAHE

1. Background

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).

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.

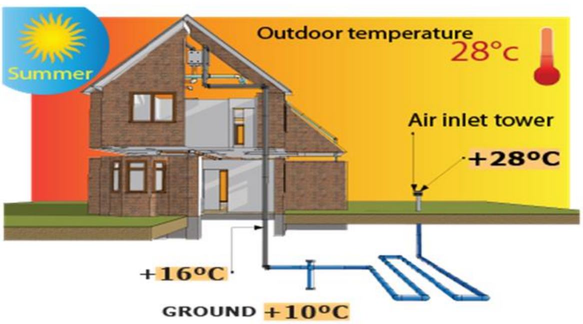

Figure 3. Working of EAHE in summer condition

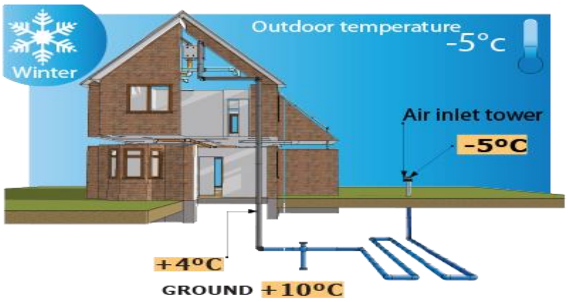

Figure 4. Working of EAHE in winter condition

3. Problem Formulation

The main objective of experimental work is to study the variation in heating effect caused by Earth Air Heat Exchanger in winter climate condition by using GI pipes of 2.5 inch diameter for parallel connection and also for series connection. In winter climate condition, ground temperature is higher than atmospheric temperature. Hence air flowing through the buried pipe exchange heat with underground earth surface in winter climate condition. In this experiment, blower sucks atmospheric air into the pipe and circulates through the buried pipe, due to which air gets heated. The heated air is circulated into the delivery pipe for heating in winter.

Following procedure is adopted:-

- Inlet and exit temperature is calculated at different mass flow rate
- Coefficient of performance is calculated at different mass flow rate
- Nusselt number is calculated at different mass flow rate
- Convective heat transfer coefficient is calculated at different mass flow rate
- To compare which arrangement is better for 2.5 inch diameter.

4. Experimental Investigation

The parameters like pipe material, length of pipe, diameter of pipe, spacing between pipes, number of pipes, soil type, depth of burial, and air flow rate are mainly considered for proper designing of effective EAHE system. The EAHE system if properly designed can be feasible and economical option to replace conventional air-conditioning systems as there is no need of compressors, burners, or chemicals and only blowers are required to move the air. The EAHE systems have many advantages over other passive heating/cooling techniques. The main advantages include minimized air pollution, higher COP, simpler design, low maintenance, and operational costs . In the last two decades, a lot of research has been done to develop analytical and numerical models for analysis of EAHE systems. The performance analysis of EAHE involved either the calculation of conductive heat transfer from the pipe to the ground mass or the calculation of convective heat transfer from the circulating air to the pipe and changes in the air temperature and humidity.

Experimental Setup

Figure 5. Experimental setup in series connection (2.5 inch diameter) without covered soil

5. Experimental Conditions

Table 1. Experimental Conditions

Parameters	VALUE
Depth	**1.5 m**
Reynolds no.	**15000-47000**
Diameter	**0.0635 m**
Length of Pipe	**19 m**
Material of pipe	**GI**
Blower capacity	**2 hp**

III. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Following results were obtained during the experiment

Table 2. Observation table for parallel Connection 2.5 inch GI pipe

S NO.	MANOMETRIC HEIGHT (in cm) H_{mano}	Inlet air temp. (Celsius)	Outlet air temp. (Celsius)	Pipe Temp. (Celsius)	Avg. air temp. (Celsius)	Temp. Difference e
1.	2	**19.84**	**20.89**	**20.36**	**20.36**	**1.05**
2.	4	**17.99**	**19.84**	**20.63**	**18.91**	**1.84**
3.	6	**14.83**	**17.46**	**20.10**	**16.14**	**2.63**
4.	8	**12.19**	**15.35**	**18.25**	**13.77**	**3.16**
5.	10	**10.08**	**13.51**	**16.67**	**11.79**	**3.42**

Table 3. Results obtained for parallel Connection 2.5 inch GI pipe

S.No	Manometric hight(in cm)	Reynolds no. (Re)	Velocity (m/s)	Mass flow rate Kg/s	Heat transfer Q in watt	Convective heat transfer coeff. H In WM^2/K	Nusselt no. (Nu)	COP
1.	2	19772.75	4.68	.01785	18.95	9.48	23.40	0.0127
2.	4	28134.63	6.61	.0253	47.02	7.23	17.94	0.031
3.	6	34865.86	8.06	.0311	82.65	5.51	13.77	0.0554
4.	8	40671.67	9.27	.0361	114.99	6.76	17.03	0.077
5.	10	45862.76	10.33	.040	139.74	7.55	19.13	0.094

Table 4. Observation table for series Connection 2.5 inch GI pipe

S NO.	MANOMETRIC HEIGHT (in cm) H_{mano}	Inlet air temp. (Celsius)	Outlet air temp. (Celsius)	Pipe Temp (Celsius)	Avg. air temp. (Celsius)	Temp. Difference
1.	2	15.62	22.74	23.79	19.18	7.12
2.	4	12.71	17.20	18.78	14.96	4.48
3.	6	11.13	13.24	14.83	12.19	2.11
4.	8	9.55	12.19	13.51	10.87	2.63
5.	10	7.97	9.55	10.87	8.76	1.58

Table 5. Results obtained for series Connection 2.5 inch GI pipe.

S NO.	MANO METRIC HEIGHT (in cm) H_{mano}	Reynolds No. (Re)	Velocity (m/s)	Mass flow rate Kg/s	Heat transfer Q in Watt	Convective heat transfer coeff. H Wm^2/k	Nusselt no. (Nu)	COP
1.	2	19872.01	4.68	.017	128.20	7.33	18.15	0.086
2.	4	28612.86	6.57	.025	114.96	7.93	19.89	0.077
3.	6	35464.28	8.00	.0313	66.56	6.66	16.84	0.044
4.	8	41185.74	9.22	.036	96.30	9.63	24.46	0.064
5.	10	46473.37	10.27	.040	64.83	8.10	20.72	0.043

3.2 Effects of Reynolds Number on Nusselt Number with Parallel Connection:

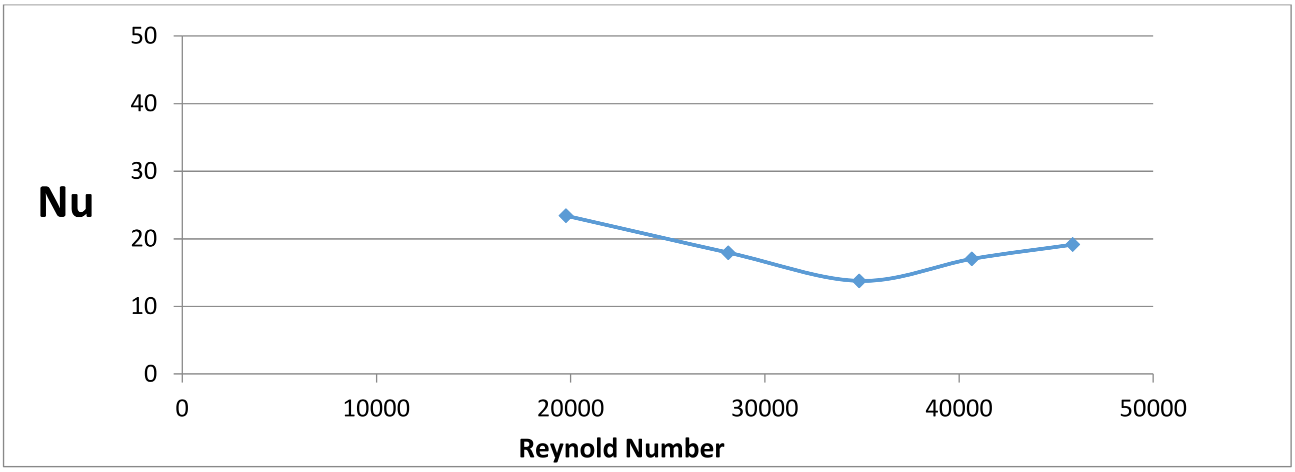

Figure 6. shows that the drop in Nusselt Number as we increase the Reynolds number.

3.3. Effect of Reynolds Number on Heat Transfer Coefficient

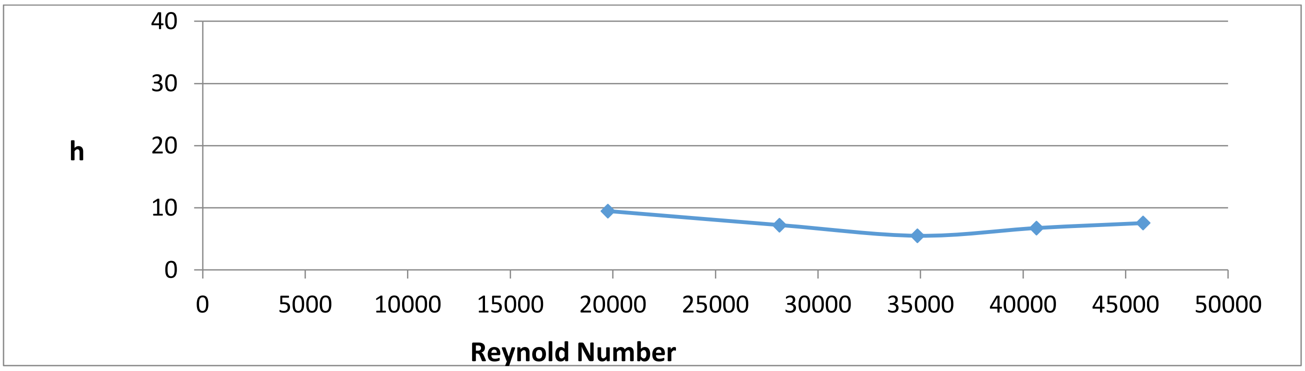

Figure 7. Effect of Reynolds number on Heat transfer Coefficient

3.4 Effect of Reynolds Number on Temperature Difference

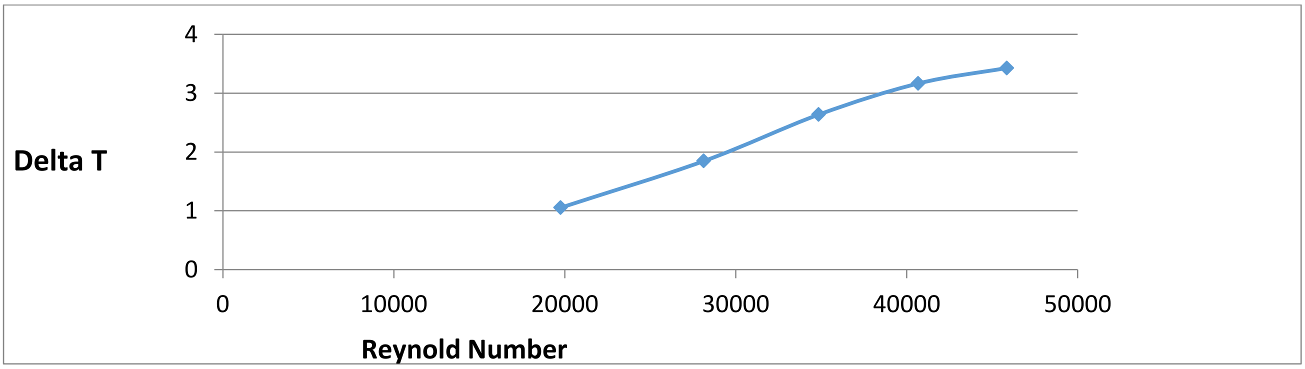

Figure 8. Effect of Reynolds Number on Temperature Difference

3.5 Effects of Reynolds Number on Nusselt Number with Series Connection

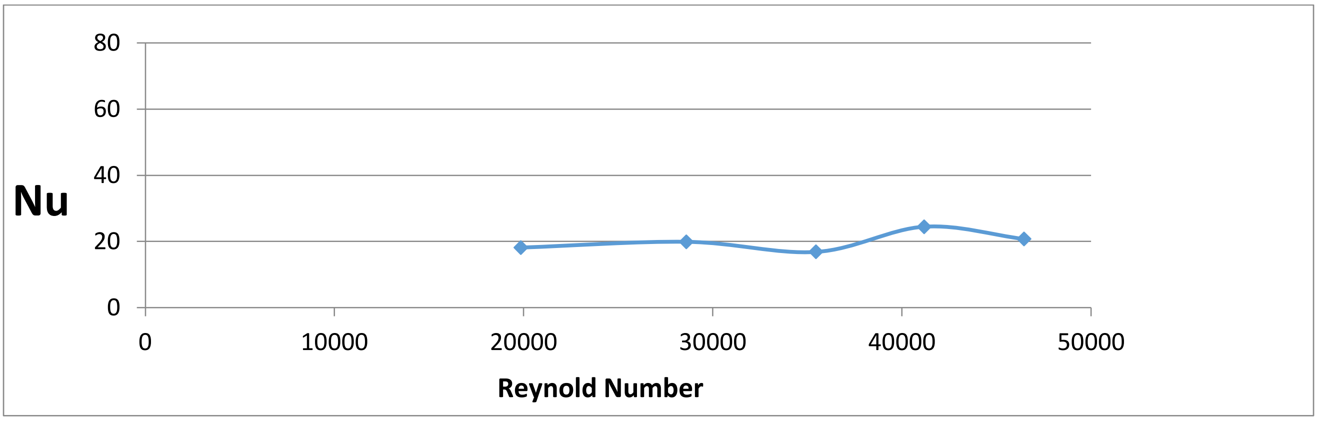

Figure 9. Effects of Reynolds Number on Nusselt Number with Series Connection

3.6 Effects of Reynolds number on Heat transfer Coefficient with series connection

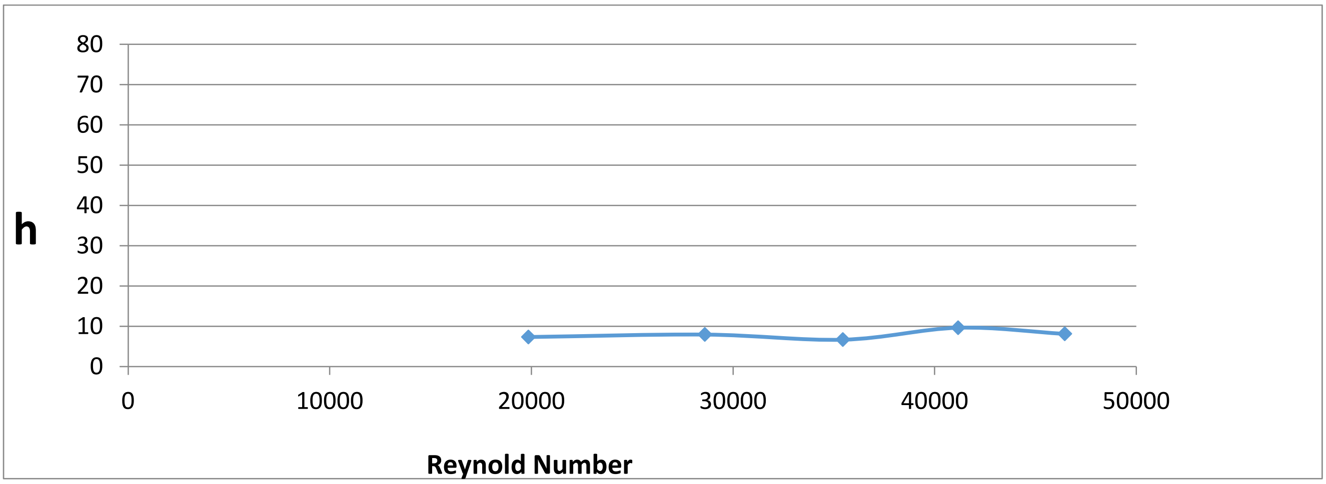

Figure 10. Effects of Reynolds number on Heat transfer Coefficient with series connection

3.7 Effects of Reynolds number on temperature distribution with series connection

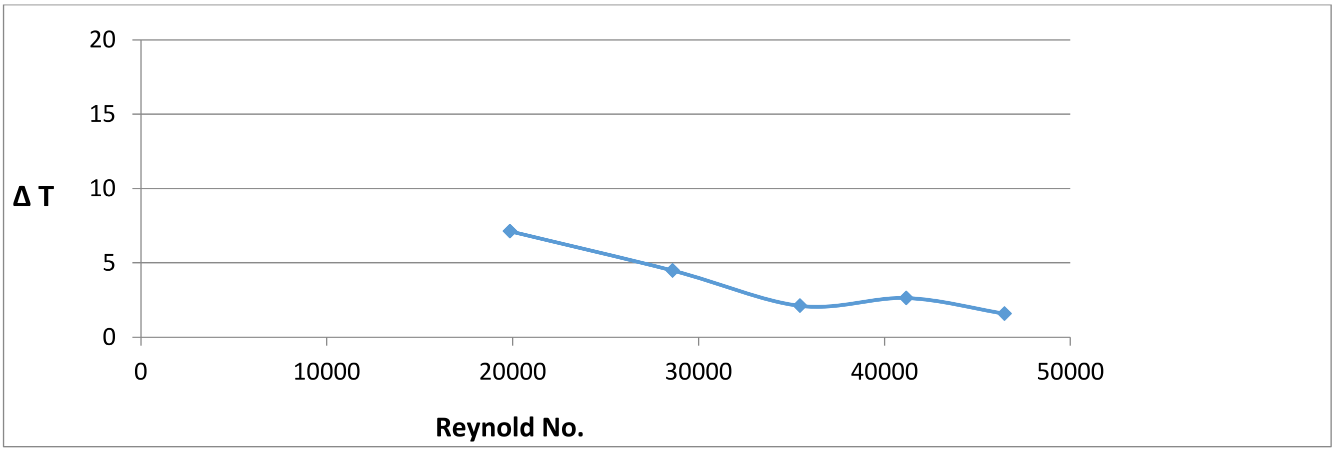

Figure 11. Effects of Reynolds number on temperature distribution with series connection

3.8 Comparison of Reynolds number vs. Nusselt Number for both connections

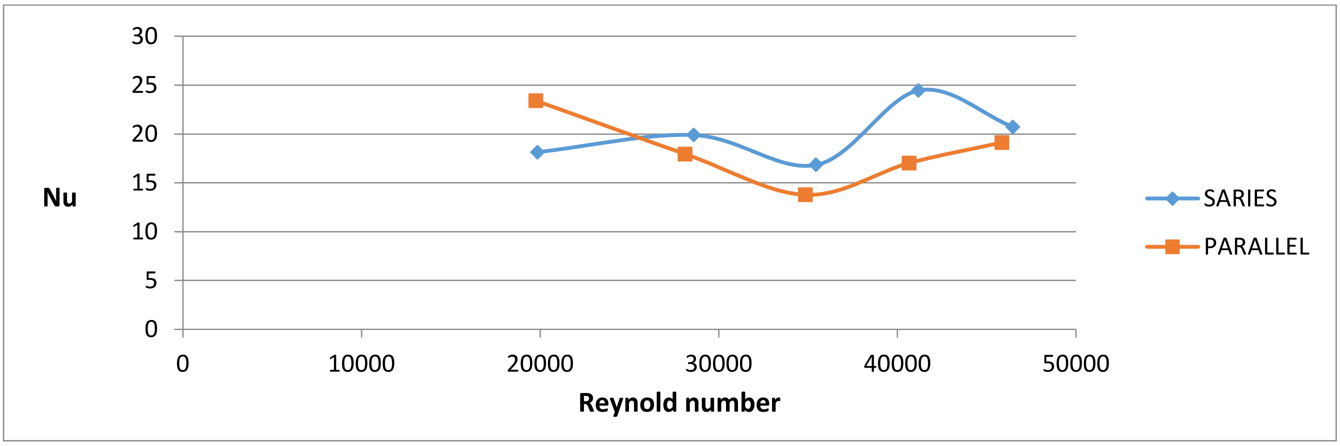

Figure 12. Comparison of Reynolds number vs. Nusselt Number for both connections

3.9 Comparison of heat transfer coefficient vs. Reynolds number for both connection

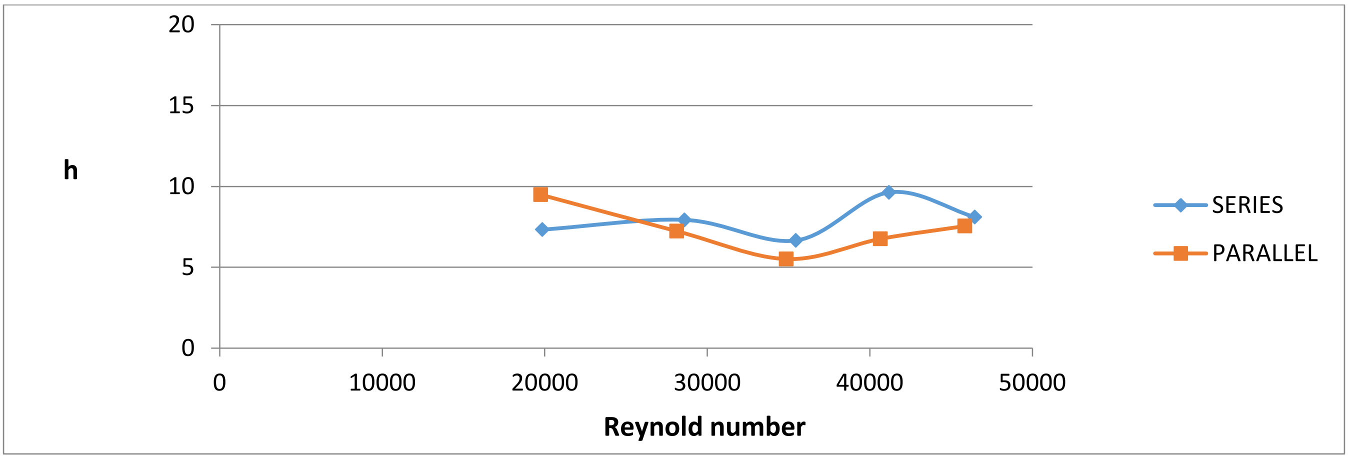

Figure 13. Comparison of heat transfer coefficient vs. Reynolds number for both connection

3.10 Comparison of temperature difference vs Reynolds number for both connection

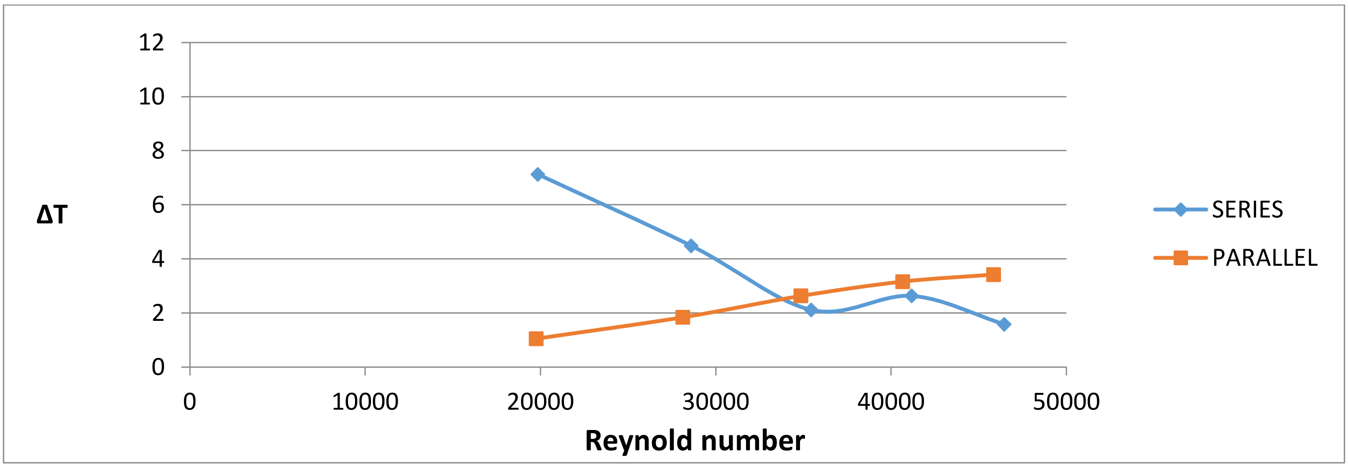

Figure 14. Comparison of temperature difference vs. Reynolds number for both connection

3.11 Comparison of COP vs. Reynolds number for both connections

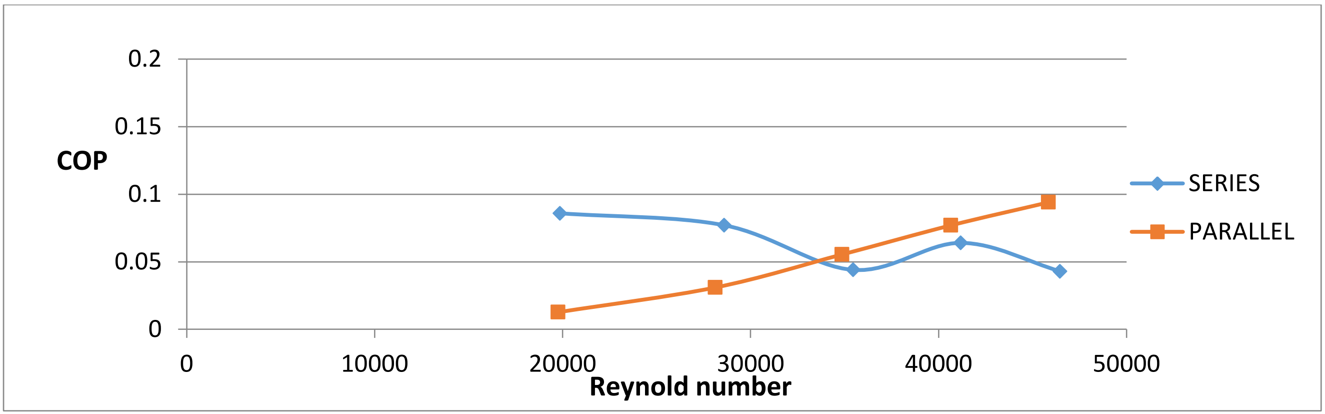

Figure 15. Comparison of COP vs. Reynolds number for both connections

IV. CONCLUSION

1. The average Temperature rise from inlet to outlet is from 3 to 7°C in both series and parallel arrangements.
2. Nusselt Number in parallel connection for different Reynolds Number is higher than the Nusselt number in series connection.
3. Nusselt number in parallel connection varies from (19 to 24) and (18 to 22) in series connection.
4. COP of the parallel connection is higher than the cop of series for the Reynolds number greater than 30000.

V. SUGGESTINS FOR FUTUREWORK

The technology of air conditioner with ground coupled condenser reduces energy consumption, fuel cost and global warming and air conditioner .The modified air conditioner seems to be interesting system for rainy climate and awaits further investigation. The Temperature of soil at different depth can also be obtained during the ground cooling as condenser. The experiment on different types of soil in the pit and compared with this results obtained and which soil give better results.

VI. REFERENCES

[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.