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Underground Domestic Water-Tank Air Heat Exchanger

[1]swapnil Jain, Md. Irfan Ahmed[2]
[1]*Electrical Engineering Department, Career Point University, Kota*
[2]*Electrical Engineering Department, Career Point University, Kota Rajasthan*
Corresponding Author: Swapnil Jain, Md

ABSTRACT— The environmental temperature variations in certain states of India like Rajasthan, Madhya Pradesh are becoming extreme from comfort point of view. Temperature ranges from 5˚C in winter to 50˚C in summer, against 24˚C, which is standard comfort condition for human being. These extreme temperatures are increasing load on Heating Ventilating and Air-conditioning (HVAC) systems. These extreme conditions do not allow atmosphere to be kept in direct communication with indoor room conditions. This lack of ventilation has a hazardous effect on human health. Small underground water tanks of capacities ranging from 3000 liters to 5000 liters are readily available in urban areas of India due to different reasons. These water bodies can be used as heat source or sink during winter or summer respectively. Earth Air Heat exchanger (EAHE) system is the leading contemporary approach to reduce Air-Conditioning loads on the system. The characteristic of earth strata at a depth of 3-4 m where temperature remains constant between 25˚C to 28˚C throughout the year by Vikas Bansal et al. [1]. This layer of earth can be used as heat source in winter and heat sink in summer. Metal or plastic pipes are laid at a depth of 3-4 m and in required length to remove heat from air. This heat is further dissipated in earth mass surrounding the pipes.
KEYWORDS: *Underground Domestic Water Tank Air Heat Exchanger (UDWTAHE), Earth Air Heat Exchanger (EAHE), Cooling Capacity, Heating Ventilating and Air-conditioning (HVAC).*

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I. THE CONCEPT OF UDWTAHE

The environmental temperature variations in certain states of India like Rajasthan, Madhya Pradesh are becoming extreme from comfort point of view. Temperature ranges from 5˚C in winter to 50˚C in summer, against 24˚C, which is standard comfort condition for human being. These extreme temperatures are increasing load on Heating Ventilating and Air-conditioning (HVAC) systems. These extreme conditions do not allow atmosphere to be kept in direct communication with indoor room conditions. This lack of ventilation has a hazardous effect on human health. Small underground water tanks of capacities ranging from 3000 liters to 5000 liters are readily available in urban areas of India due to different reasons. These water bodies can be used as heat source or sink during winter or summer respectively.

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II. PHYSICAL ARRANGEMENT

Physical arrangement of proposed 'Underground Domestic Water-Tank Air Heat Exchanger'

Following assumptions for physical arrangement are made for the analysis purpose

1. A typical domestic room of dimension 3m x 3m x 3m is defined for testing 'Underground Domestic Water Tank Air Heat Exchanger' system performance, with wall and roof details as shown in figure- 4.1.
2. The reference house consists of 4-6 family members with four conditioned rooms.
3. For UDWTAHE system set-up, GI pipe coil of calculated length is submerged inside the domestic

underground water tank of size 1.22 m x 2.44 m x 1.22 m (4 ft. x 8 ft. x 4 ft.).

Pipe is fixed with the 'U' type steel clamps to the tank wall. Inlet end of UDWTAHE system, pipe is connected to a variable speed motorized blower. A small enclosed compartment is fabricated in which blower is installed to avoid direct sun light, rain, storm etc. Ambient air is forced through the submerged GI pipe in the water tank using blower. The cool air from the outlet of the UDWTAHE can be fed directly to the Test Room or to the suction of desert cooler.

The tank acts as a heat sink and absorbs the heat of the atmospheric air. After a period of time the temperature of the tank water rises and starts evaporating. Therefore, a vent pipe with a suitable ventilation fan is provided in the tank to exhaust the evaporated water outside of the tank.

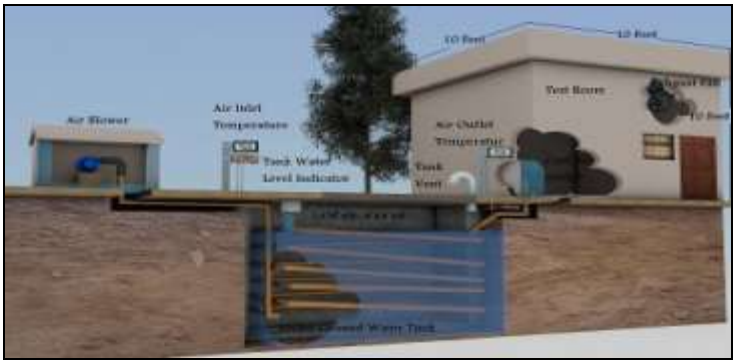


Figure-1.1 Schematic diagram of Underground Domestic Water-Tank Air Heat Exchanger System [2].

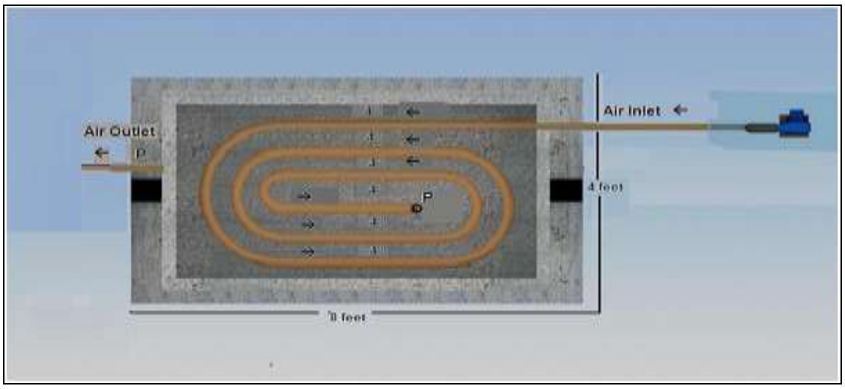


Figure-1.2 UDWTAHE system plan

III. RESULTS AND DISCUSSION

The results of the Underground domestic water tank heat exchanger analysis performed used the highest possible efficiency that the system could provide and the necessary effectiveness of ETHE (ε) was determined to achieve the optimum output temperature. Tables show the effect of air flow velocity on outlet air temperature of UDWTAHE system. It is seen in Elementary Heat Exchanger Analysis results that the outlet air temperature of system increases with increase in air flow velocity. This is because of the fact that as the air flow velocity is increased, the time to which air remains in contact with water is reduced.

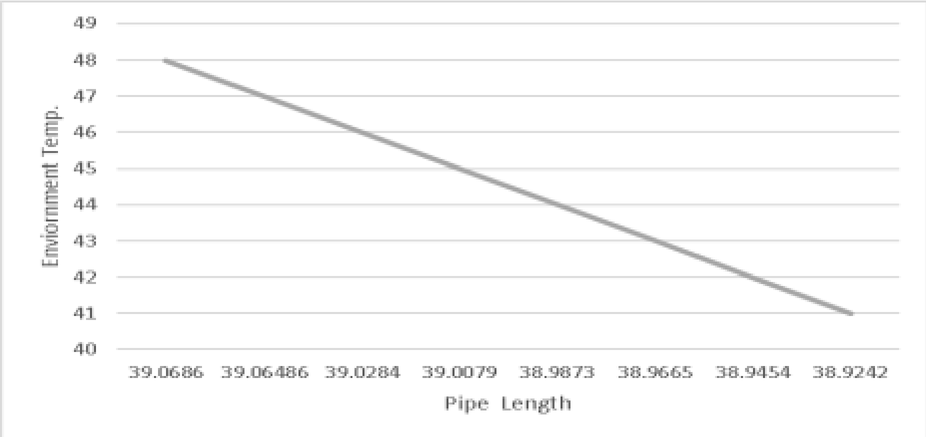
Formulae:
Volume Flow Rate V = velocity* area
Mass Flow Rate m= V* density
Heat Flow Rate Q= mCp(To-Tin) / t
Coefficient of performance COP = Q/Wnet in

1. Reference Parameters
Tube Diameter = 3”
Air Velocity = 7.79 m/sec
Tank Water =25^{0}C
Mass flow rate = 0.0368 kg/sec

Table 1.1: Atmospheric Temperature Vs Pipe lenth 3”

Environment temp Ta(oC)	RAV O/P temp. To(^{o}C)	Pipe Length L(ft.)	Heat Dissipated Q(kJ/sec)
48	30	39.0686	661.133
47	30	39.06486	624.4036
46	30	39.0284	587.674
45	30	39.0079	550.9444

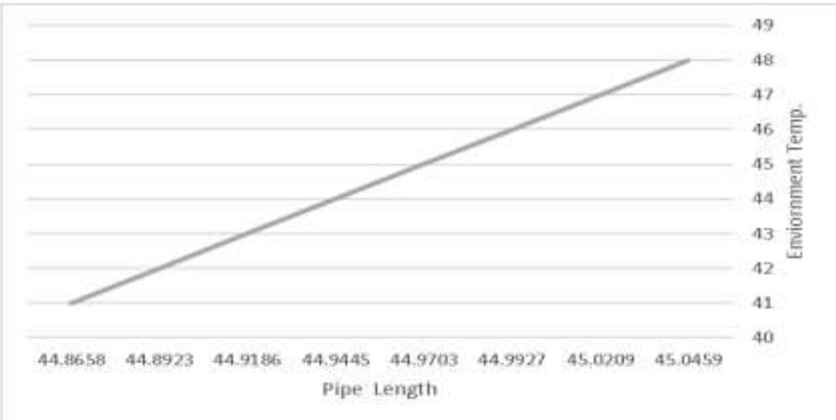
44	30	38.9873	514.2148
43	30	38.9665	477.4851
42	30	38.9454	440.7555
41	30	38.9242	404.0259



2. Reference Parameters
Tube Diameter = 4"
Air Velocity = 3.82 m/sec
Tank Water =25^{0}C
Mass flow rate = 0.0368 kg/sec

Table 1.2: Atmospheric Temperature Vs Pipe lenth 4"

Environment temp Ta(oC)	RAV O/P temp. To(°C)	Pipe Length L(ft.)	Heat Dissipated Q(kJ/sec)
48	30	45.0459	661.133
47	30	45.0209	624.4036
46	30	44.9927	587.674
45	30	44.9703	550.9444
44	30	44.9445	514.2148
43	30	44.9186	477.4851
42	30	44.8923	440.7555
41	30	44.8658	404.0259



The experimental results have been obtained for different inlet temperatures at different velocities. All the data are plotted on the same graph. The graphs show the difference between the inlet and outlet temperatures. The graphs corresponding to the various inlet air temperatures as shown above:

IV. CONCLUSION

Explanation of the results: we can see that the results are quite encouraging. The results are summarized under the following points:

- For the pipe of 4 m length and 0.5 m diameter, temperature drop of 8^0C-15^0C has been observed for the outlet flow velocity ranging from 5 m/s to13 m/s.

- At lower speed of 5 m/s, greater temperature difference is obtained but in terms of cooling obtained, it is optimal to use at 7 m/s.
- The COP of the system varies from 2.2 – 5.5 for increase in outlet velocity from 5 m/s to 13 m/s.
- At higher temperatures, maximum temperature difference is obtained so the system is most efficient to be used.

This work can be used as a design tool for the design of such systems depending upon the requirements and environmental variables. The work can aid in designing of such systems with flexibility to choose different types of pipes, different dimensions of pipes, different materials and for different ambient conditions. So this provides option of analyzing wide range of combinations before finally deciding upon the best alternative in terms of the dimension of the pipe, material of the pipe, type of fluid to be used. The effect of operating parameters on the performance of UDWTAHE system as discussed above shown almost similar results and trends as shown in other studies.

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