International Journal of Engineering & Technology, 7 (4.39) (2018) 150-154

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Fabrication and Experimental Analysis of Geothermal Energy Resourses

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Abstract

This paper state that the practical approach of finding the utilization of geothermal energy resources we did fabrication and calculate all parameters. The objective is to design such a ventilation system in accordance with a geo thermal heat exchanger to cool or heat a room for human comfort with the lowest possible effect to the environment. This paper mainly have three stages first is to temperature measurement, second one is piping design and last one is fabrication.

Keywords:

1. Introduction

The utilization of geothermal energy is used by the U.S. firstly. The geothermal energy resources industry of U.S. produces more energy from geothermal plants in compare of others. Technology experts are expanding the definition of useable geothermal resources and are improving the economics of generation. Geothermal energy produced about 3% of renewable energy-based electricity consumption in the U.S and they are generally using to cool and heat by using geothermal energy [2].
In our experiment we use a long cemented pipe through which air is suck to circulate. As air travels through the pipe, it gives up or receives some of its heat to/from the surrounding soil and enters the room as conditioned air during the cooling and heating period. To extract energy from the underground we mostly use the air as carrier of heat. air is moving in tubes in sinusoidal form for extracting more heat of ground Geothermal resources, as opposed to hydrocarbon ones, are generally renewable since the circulation of heat and fluid is continuous. There is a constant terrestrial heat flow to the surface, then to the atmosphere from the immense heat stored within the Earth, and fluid enters the reservoir from the recharge zones or injected in the subsurface through injection wells (in industrial plants). Heat can be extracted at different rates. To guarantee a sustainable use of geothermal energy, the rate of consumption should not exceed the rate of generation, so that the heat removed from the resource is replaced on a similar time scale. Geothermal plants typically develop below a certain level of energy production [3]. Geothermal typically provides according the load and depends on weather and seasonal variation, therefore producing almost constantly and distinguishing it from several other renewable technologies that produce variable power or heat with time.

2. Methodology

Now present geothermal plant grows up to 6%to 10%.Many countries working in geothermal project because it is one of the best non-conventional energy resources ,it is economically friendly as we know that how the climate are changing then we can use source of geothermal to provide the comfort of human being, now there are some data of developed countries like china and USA, who are utilizing geothermal energy resources
Fig. 1 shows the growth of use of geothermal energy worldwide. Countries around the world also utilize geothermal direct use applications. Including GHPs, direct use capacity reached 51 GWt in 2010[3]..
Many countries in Central and South America as well as japan have developed a portion of their geothermal resources for electricity generation and cooling and heating room [4] . El Salvador and Costa Rica are seasoned users of geothermal energy. Chile, Argentina, Columbia, and Honduras have significant amounts of geothermal potential; however, these countries are still in the early stages of identifying and exploring their resources [3].
Now Indonesia is also a popular name of which is using geothermal energy resources. The existing buildings are one of the highest energy consumers in the Republic of Serbia. Almost 50% of the consumed energy in Serbia is consumed in buildings and heating 65% that is consumed for building heating. Since only one percent of residential buildings is built in Serbia a year, the existing residential buildings are the basic resource for any kind of energy efficiency measure application.[4]

3. Design Considerations

Design parameters that are well documented in this paper are:
Material of tube: This is basically for thermal point of view,. We use PVC or concrete have been used because of conductivity of soil surrounding the pipe. The material has to be strong enough to withstand crushing when the pipe is buried. Corrugation (as in corrugated PVC) gives a stronger structural strength but should be avoided as it traps water in the pipes.
Length criteria: Length can typically range from 10 to 100 m. Longer tubes correspond to more effective systems, but the required fan power and the cost also increase.
Diameter: Smaller diameters are preferred from a thermal point of view, but they also correspond (at equal flow rate) to higher

friction losses, so it becomes a balance between increasing heat transfer and lowering fan power. Typical diameters are 10 cm to 30 cm but can be as large as 1 m for commercial buildings.

4. Spacing: Spacing should be large enough that tubes are thermally independent, typically at least 1 m apart. Tubes can also be placed in a radial pattern. Pipes are inserted in a sinusoidal form

5. Number of tubes The number of tubes is dictated by air flow requirements, the length of the tubes and the required thermal performance. We use 15 tubes to circulate air .

6. Depth. Deeper are essential for good performance. It depend on place to place but Typical depths are 1.4 to 3.5m. The pipes can be positioned under the building or in the ground outside the building foundation.

7. Flow rate: Flow rate much more depend on fan power. As a compressor is used to circulate flow rate and flow rate also depends on pipe diameter and thermal conductivity.

8. Controls: Windows play a vital role to control the heating and cooling of the building.it should be properly insulated, when outside temp is above the 32^0c then inside temp is between 18^0 to 24^0c.

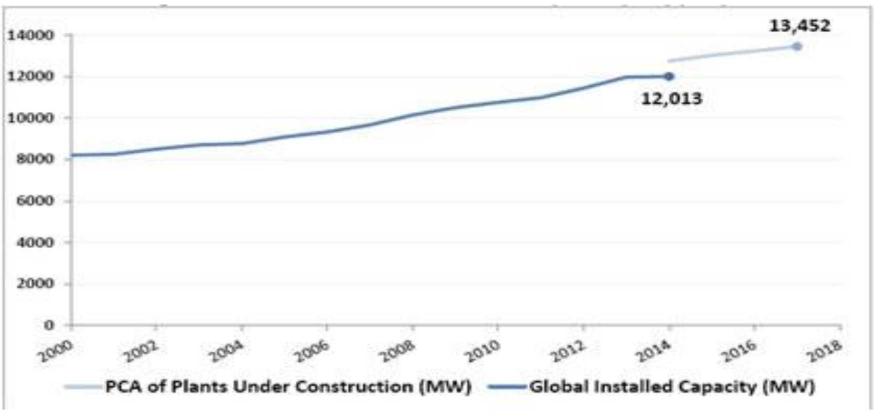

Fig. 1: Global Installed Capacity of Geo Plants [3]

4. Design and Calculation Work

4.1 Room Specification

Room is the fluid machinery lab chosen for case study purpose, as this was the only room, which was located near large vacant ground space. We created 3D model of the room for displaying the exact shape and size of the room.

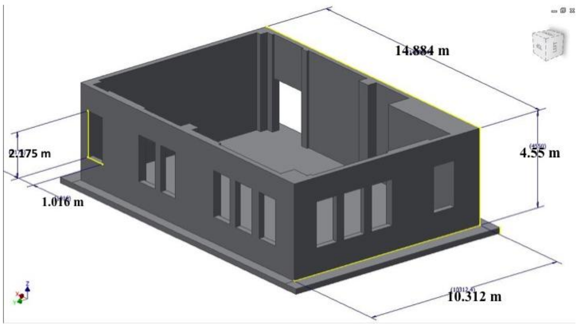

Fig 2: 3D Model of Room

1. Height of room = 4.55 m
2. Length of room = 14.884 m
3. Breadth of room = 10.312 m
4. Height of a window = 2.175 m
5. Width of a window = 1.016 m

4.2 Design Condition:

These conditions are given to identify rest of the physical parameters of moist air. Outdoor conditions are listed in table while the inside design conditions are decided by designer on the basis of human comfort level chart (given in ASHRAE handbook).

Outside design condition: 43.3^0C DBT Inside design condition 25.00C DBT

23.9^0C WBT 17.8^0C WBT

30% RH 50% RH

Suffix used i: Indoor condition o: Outer condition

4.3 Parameters Considered for Design:

The parameters are chosen on the basis of major factors, which constitute in the load on set up. They will help the designer to draft the problem's solution on the basis of what is given.

4.3.1 Room Load:

The total load is the sum of sensible and latent heat loads. This load is the start of calculation for analysis of different factors role in the load calculations.

4.3.2 Sensible Heat:

This load is due to the temperature difference between the system (cabin) and the surroundings. No role of humidity difference is considered so DBT is the only factor in consideration.

1. Solar heat and transmission gain through glass
2. Solar heat and transmission gain through roof, floor and walls
3. Infiltration
4. Heat gain through room appliances

4.3.3 Latent Heat:

The load is caused by the humidity differencebetween the system (cabin) and the surroundings. The moisture present in the air due to perspiration, leakage of air through vents/doors/windows, stack effect, density difference (in high storied buildings).

1. Internal heat gain from people
2. Infiltration

4.4 Assumptions

1. Thickness of the wall is constant, i.e.
2. No load due to piping tanks.
3. Evaporation of water from free surface and steam is negligible.

4.5Thermo Physical Quantities Used:

These are the properties, which are related to any material medium with their physical characteristics and their nature when subjected to under different thermal conditions.

4.5.1 Heat Transfer Coefficient (H):

It is the property of the fluid. It tells about at what rate heat flow from the convective surface will take place. It depends on the method of convection used ($H_{forced\ convection} > H_{natural\ convection}$).

1. H_o = 23.3 W/m^2 K (Air Velocity=12.5 km/h)
2. H_i = 8.5 W/m^2 K (Still Air)

4.5.2. Thermal Conductivity (K)

It is the property of conducting medium (solid/stationary gas), which tells about the heat flow rapidity or slowness in a medium.Higher conductivity offers less temperature difference and lower conductivity offers more temperature difference like insulators.

Table 1: Thermal Conductivity Of Various Materials

S. No.		Thermal Conductivity (W/mK)
1.	Brick	1.04 W/m K
2.	Plaster	0.72 W/m K
3.	Glass	0.77 W/m K
4.	Concrete	1.37 W/m K
5.	RCC	0.9 W/m K

4.6. Formulae Used:

The following formulas are used for the calculation of cooling load-

4.6.1 Overall Heat Transfer Coefficient (U)

It is the coefficient, which takes into account the heat transfer due to conduction and convection.
Overall Heat Transfer Coefficient
$(1/U_0) = (1/H_i) + \sum (\Delta X_i/K_i) + (1/H_0)$
Where, i is for Brick, Plaster, Concrete, Wood etc.

4.6.2 Effective Temperature Difference

$\Delta \mathbf{T_e} = (T_{em} - T_i) + \lambda (T_e' - T_{em})$
Where λ is decrement factor (depends upon thickness of wall)
T_{em}= Mean solar air temperature,T_e' =Maximum solar air temperature

4.6.3 Heat Transfer Through Walls

The relation 4.1 gives the heat transfer through walls.

$$\mathbf{Q} = U*A*(\Delta Te + 9.55\ ^0C) \quad (4.1)$$

Where, correction for Equivalent temperature difference= 9.55 ^{0}C
Decrement factor takes into account the reduction of intensity of radiation whiletravelling along the thickness of wall. The above factor is considered on the basis of Schmidt unsteady heat transfer analysis.

4.7 Calculation of Overall Heat Transfer Coefficient

The overall heat transfer coefficient for different portions of room is given by the following expression:

Outside Wall(U) = (1/23.3) + (0.1/0.77) + (1/8.5) + (0.0125/8.65) = 3.426 W/m^2K
Roof(U) = 1/{(1/23.3) + (0.2/9) + (0.0125/8.65) + (1/8.5)} = 5.42 W/m^2K
Floor(U) = 1/{(1/23.3) + (0.2/9) + (0.0125/8.65) + (1/8.5)} = 5.42 W/m^2K

4.8 Design Calculations:

This calculation takes into account all the physical factors of cabin and their relation with thermo physical properties.

4.8.1 Area and Volume of Room

Area = 147.44 m^2
Volume=670.852 m^3or 23672.72 ft^3

4.8.2 Ventilation Rate for Room:

Assuming frequency of air change= 8 min.This value is chosen by considering the purpose for which this space is being used and the efficiency of the underground heat exchanger.

4.9 Load Calculations

It is calculations of all loads, which are responsible for room heating.

4.9.1 Internal Heat Gain

Load due to the inside present things

1. Occupancy Load
2. Lightning Load
3. Appliance Load

4.9.1.1 Occupancy Load

It takes into account the load of occupancy i.e.; human beings.
Design of setup by considering 50 people at a time
$Q_{(occupancy)}$ = (No. of people)*(Sensible + Latent) Heat = 50*(70+70) = 7000 W

4.9.1.2 Lightning Load

It is the load due to lighting arrangement of room like bulbs, CFL etc.
For Fluorescent
$Q_{(lightning)}$ = Total watt * 1.25 = 40*8*1.25 W= 400 W

4.9.1.3 Appliance& Motor Load

This load is due to the presence of appliances.
Sensible Heat- Motors are not present in our case
study hence no heat gain to the space
2.Latent Heat- Assuming the load due to moisture released by appliances is negligible.
12 Motors are present in our case study hence heat gain to the space.
Total heat gained due to motors = Q(motor) * factor of safetyQ (motor) = 23300*1.115=25980W

4.9.2 External Heat Gain

It is the heat gain from outside the room. E.g. heat gain due to sun light, hot air etc.

4.9.2.1 Correction for Equivalent Temperature Differential

For daily range temperature = (34 to 43.3)^o C

= 9.3°C (range for outside)< 11.1
$T_o - T_i$ = 43.3°C (DBT) – 25°C (DBT
= 18.3°C > 8.3
Δ $T_{e(equivalent)}$= (18.3 – 8.3) + (9.3 -11.1) *0.2 = **9.55°C**
Table 4.2 shows that as the sun moves from one side of meridian to another side the temperature on earth due to its movement changes. So load varies hence at all possible timings calculation of heat transfer is done and the peak load is identified. Here in the table it is at 6:00pm the reason of happening this is due to the time lag (rise of temperature of buildings not in peak noon time but at somewhat later).

Table 2: Calculation of Heat Transfer through Roof

Time	**ΔT_e**	**$\Delta T_{e(corrected)}$ {ΔT_e + 9.55}**	**Heat Transfer (Q)**
9:00 am	1.8	11.35	61.517
11:00 am	5.0	14.55	78.861
1:00 pm	8.2	17.75	96.205
3:00 pm	9.4	18.95	102.709
4:00 pm	8.5	18.05	100.27
5:00 pm	7.8	17.35	94.037

Table 2 shows the same that has been done for the other wall to check the peak load.

Table 3: Heat transfer through Outside Wall (North)

Time (in PM)	**ΔT_e**	**$\Delta T_{e(corrected)}$ {ΔT_e + 9.55}**	**Heat Transfer (Q)**
9:00 am	2.3	11.85	40.6
11:00 am	6.5	16.05	55
1:00 pm	8.5	18.05	61.84
3:00 pm	9.4	18.95	65
4:00 pm	9	18.55	63.55
5:00 pm	8.3	17.85	61.1541

Table 4: Heat transfer through Outside Wall (East)

ΔT_e	**$\Delta T_{e(corrected)}$ {ΔT_e + 9.55}**	**Heat Transfer (Q)**
5.3	14.85	50.876
20.2	29.75	101.9235
20	29.55	101.2383
18.3	27.85	95.4141
15	24.55	84.1083
13.6	23.15	79.3119

Table 5: Load Calculation (Sensible)

Item	Area or Quantity (in m^2)	Temp. Difference	Factor	Q (Watts)
North Wall	46.9196	16.8833	-	792.16
East Wall	67.7222	24.95	2.5	4224.1722
Roof	153.4838	17.925	1.13	3108.852
Transmission Gain (Door)	5.06	18.3	0.63	58.336

Table 3 shows that the load calculation parameters. The heat transfer load due to temperature difference is considered. With every term factor is multiplied so that the actual conditions can be safely achieved with some allowances.

Table 6: Internal Heat Gain

Item	Quantity	Factor	Q(in Watts)
People	50	75	7000
Lights	8	1.25	400
Motors	15	1.115	25980

Safety factor is considered for the factors which could not be considered in earlier steps of calculations.
Safety factor= 5% of Sensible Heat Gain
Total Sensible Heat Gain = 0.05 * 41563.52 + 41563.52= 43641.7 Watts or 43.641 KW

4.9.3 Latent Heat Gain

Table 4 shows that here calculations are done on the basis of humidity gain by room along with that safety factor of 5%of latent heat load is considered.

Item	Area or Quantity	Sun Gain or Temperature Difference	Factor	Q (in Watts)
People	50	-	55	2750

Safety Factor= 5% of Latent Heat
Total Latent Heat Gain = 0.05*2750 + 2750= 2887.5 Watts

Final Load Calculation or Total Load

In this section; latent and sensible loads of the entire setup is added so that grand load is obtained.
Calculation of Net Load = Total Sensible Heat Gain + Total Latent Heat Gain = 43641.7 + 2887.5 = 46529.2 Watt Or 46.5292 KW
1 Ton of Refrigeration = 210 KJ/min or 3.5 KW
Therefore, Grand Total Cooling Load in TR= 46.5292/3. = 13.3 TR
5.2 Work done on site

Fig 3: Piping Installation

Fig 4: Piping Installation

Fig 5.1 & 5.2 shows the real piping done in the project, As we can see it is the horizontal looping system to make the length swept by air more than the actual length of the pit.

5. Conclusions

1. The parameters such as length, diameter, spacing, depth etc. have been studied.
2. The Geothermal ventilation system is implemented. By having open areas around building we can easily implement ventilation system. For implementation, we can use the regular labours. Special skills are not required.
3. After implementation of geothermal ventilation sys- tem in residential building, the energy use for cooling is reduced.
4. After implementation of geothermal ventilation system in residential building, the temperature inside the building is reduced.
5. Reduction in temperature has increased the thermal comfort of the occupants with less use of electrical energy.
6. Geothermal ventilation system is good option for conventional ventilation systems with one time in- vestment and less maintenance cost.

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