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GEOTHERMAL AIR CONDITIONING

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ABSTRACT

This paper discusses the use of geothermal energy in air-conditioning system. Geothermal energy is an interesting alternative concerning the production of energy for air conditioning of building (heating or cooling). The content of the paper includes a description of the Geothermal cooling system. In this paper includes the experimental analysis of the system and the heat transfer calculations. This paper will helpful for those who wish to understand about the basic working of geothermal cooling systems. The main purpose of the project is to promote the use of geothermal energy.

KEYWORDS: Geothermal Energy, Geothermal Air-condintioning System, Design of Geothermal cooling system.

INTRODUCTION

Geothermal is named comes from two Greek letter "Geo" have means 'earth' and "thermal" that means 'heat'. Renewable energies (sunlight, wind, tidal, wave, geothermal etc.) are utilize by engineering technologies and convert into more usable forms. Geothermal energy is extract from heat stored in the earth. This heat occurs from a combination of two sources: the original heat produced from the formation of the earth by gravitational collapse and the heat produced by radioactive decay of various isotopes. Because of thermal conductivity of rocks is so low, it taking many billions of years for the earth to cool.

Fundamentally, two types of geothermal systems can define: conductive and convective. In a conductive geothermal system temperature in the subsurface increase linearly with depth due to conductive heat flow vertically upward. In a convective geothermal system, temperature remains nearly constant with depth, signifying heat flow primarily by fluid convection.

The increasing energy demand the fact that fossil fuels are finite resources and the problem of pollutant emissions has allowed renewable energy sources to be considered and developed, including geothermal. There are many uses of geothermal energy: geothermal heat pump, space heating, greenhouse and covered ground heating, agricultural crop drying, industrial process heat, snow melting and space cooling, bathing and swimming.

There are two main utilization methods for geothermal energy:

1. Direct use: In direct use of geothermal energy means the thermal energy from underground is use directly as heat or cold. The significant advantage of geothermal energy is its independent of the time means available at any time and any climate conditions.

2. Power generation: Geothermal energy use in power generation means that geothermal energy is base load, suited to producing energy at constant level. Geothermal energy's potential is omnipresent, environmental friendly and only marginally developed. If a resource temperature is greater than about 90^0C, it can be utilize to generate electricity.

This paper deals with our appearance of using geothermal energy as a future alternative for conventional heating and cooling systems. Geothermal air conditioning system is considered as the most efficient air conditioning systems available till date on this planet. This works on the basic principle that "The temperature remains constant below the earth throughout the year irrespective of the temperature above the ground".

LITERATURE REVIEW

During the seasonal changes the temperature of air also changes and the variation is over a time period

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of day or gradually over the season. Due to variation in temperature of atmoshphere, there is change in running efficiency of all HVAC systems. On the other hand, geothermal exchange systems use as a constant thermal body in which the earth gives you higher energy efficiency level. Earth with its huge mass is a neutral source of thermal energy for cooling or heating purposes. During summers as the temperature of the earth is lower than the atmospheric temperature, while during winters the earth temperature is higher than the atmospheric temperature, so it can be used for cooling purposes and heating purposes respectively.

Approximately 5 to 8 feet below from the earth upper layer, its affected by the seasonal changes and the variations are from 3^0 C to 6^0 C, further below within the range of 8 to 20 feet this variation reduced and change from 2^0 C to 4^0 C. After this the temperature remains nearly stable with in a variation of 1^0 C as we progress in to the earth and nearly constant after a depth of around 30 feet. Thus in most parts of India requiring cooling the average temperature in earth below 8 feet depth is around 25^0C with respect to geographical conditions. For check the temperature of particular area measure the temperature of water coming out of the bore well at that area. The soil between 6 feet to 10 feet depth had stable temperature and suitable for installation of the Earth-Tube heat Exchanger. The point about temperatures below ground is that they are relatively stable or constant compared to the daily and seasonal variations of above ground temperatures because of the insulating effect of the ground itself. The deeper you go, the further from the surface, the more constant the temperature compared to the surface.

EXPERIMENTAL SET UP

Experimental set up consists of the following major components which are listed below:

Geothermal Pit

In geothermal pit, installed copper tube loop which carrying refrigerant. A depth of pit is varies according to geographical location. As per the design of copper pipes network we decided pit dimensions which are 6.5 feet x 4 feet and depth of 8 feet. The pit is usually dug till we get the moist soil. At the depth of 8 feet we got moist soil, which shows us the presence of moisture in the Earth. Due to presence of moisture the heat transfer between refrigerant and earth will be more effective and presence of moisture ensures sufficiently low temperature below the Earth.

Earth-Tube Heat Exchanger

The copper loop buried in the ground and it is working like a heat exchanger same as cooling coil and evaporative coil working in chiller. The purpose is to transfer heat energy from the heat exchanger loop fluid to/from the ground and from/to the conditioned space. With help of loop design we find required loop length. Here we used closed loop heat exchanger system so there is no direct interaction between the fluid and the Earth. Copper selected as a material for the looping because it has a very high thermal conductivity of 380 W/Mk and life up to 25 years. The total length of pipes installed was 16 meters and diameter of 12 mm.

Evaporative Cooling Coil

This coil is using the same copper tube fabrication of loop of geothermal heat exchanger. The tube was formed in the helix shape and covered by gunny bags or grass pads. Gunny bags or grass pads helps to retain the moisture and thereby improve the evaporative cooling process. With help of additional fan we able to improve the rate of evaporative cooling.

Cooling Coil Heat Exchanger

Cooling coils made up from copper material and installed for heat transfer between cool water and the air. For this purpose, we used standard radiator available in market. Hot air is blown on this heat exchanger, which passes over its surface and heat transfer takes place between air to water.

Reservoir

Reservoir stores the refrigerant for continuous supply to the water pump. Plastic bucket used as a reservoir. Plastic is a bad conductor of heat and reduces the flow of heat from water to the atmosphere. Additional insulation also applied for piping to avoid heat losses.

Refrigerant

The most common refrigerant used for geothermal air conditioner is water. Since price of water is almost negligible and does not cause any harm if leaked. Its high heat capacity and low cost makes it a suitable heat transfer medium.

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Table 1. Thermal Property of Water

Maximum density at 4^0C	1000 Kg/m^3
Freezing temperature	0^0C
Boiling temperature	100^0C
Latent heat for boiling	334 KJ/Kg
Latent heat of evaporation	2270 KJ/Kg
Critical temperature	380-386 ^{0}C
Critical pressure	221.2bar
Specific heat capacity of water	4.187 KJ/Kg.K
Thermal expansion from 4^0C to 100^0C	4.2 X 10^{-2}
Bulk modulus of elasticity	2.15 X 10^9 Pa

Pump

Pump use for force the refrigerant from reservoir to the loop. The pump used is standard type available in the market. It pressurizes the water and circulate throughout the circuit. The pump sucks in the water from reservoir and the outlet connected to the inlet of geothermal loop.

Table 2. Specification of Pump

Type	Electric
Phase	Single phase
Voltage	180 - 240 V
Power	0.5 HP
Head	6 to 28 m

Fan

An electric fan used to blow the air at the cooling coil. The fan used for this experiment was a standard exhaust fan.

Table 3. Specification of Fan

Type	Electric
Phase	Single phase
Voltage	230 V, A.C.
Dia.	12 inches (blade diameter)
RPM	1400 rpm

Installation of Thermocouple

Thermocouples installed at proper intervals where we want to measure temperature. Here we installed at the inlet of heat exchanger buried in the ground, while the second installed at the outlet of it or inlet of evaporative coil. The third installed at the outlet of the evaporative coil. Ambient air and reservoir temperature measured with the help of another thermocouple.

EXPERIMENTAL PROCEDURE

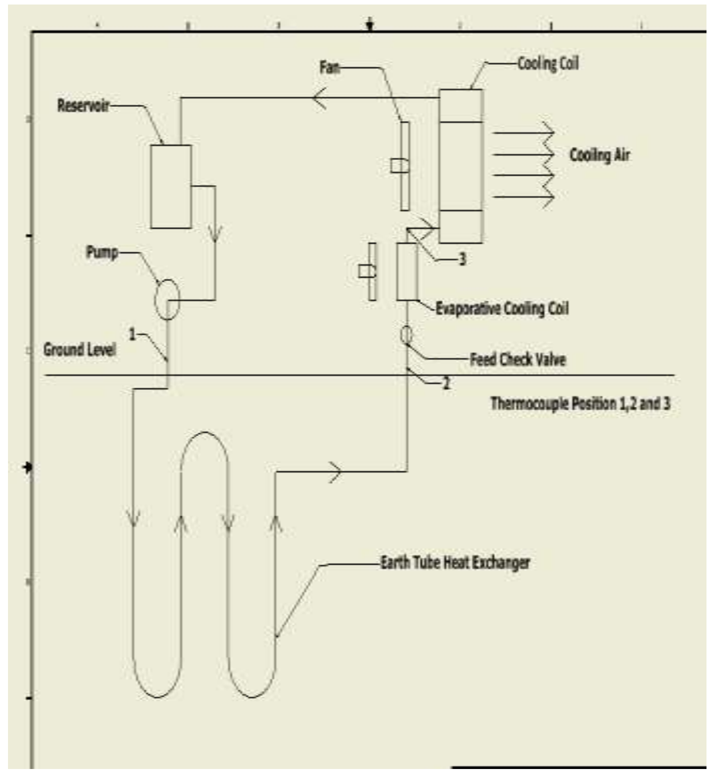

Figure 1: Actual Cycle of Geothermal Cooling with evaporative cooling coil

The arrangements of all the components are same as shown in above fig. The refrigerant (Here we used water) which stored in reservoir (Plastic bucket). Pump sucked water from reservoir and transfer to geothermal cooling coil where interaction of heat between water and earth. Outlet of the coil is directly connected with inlet of evaporative coil which covered with the gunny bags and a fan provided for the improve heat interaction rate. One feed check valve also provided for control rate of flow of water. Outlet of evaporative coil connected with inlet of cooling coil and one fan provided for control cooling rate in particular space. The outlet of cooling coil released water in reservoir and this same process continuous.

CALCULATION

We used below formula which related to simple heat transfer. From these equations, we found Co-efficient of performance (COP). Here we make two calculations for COP. First we operate cycle without an Evaporative cooling coil and find COP, after we connected the Evaporative cooling coil before the cooling coil and find the COP. The results are shows below in tabular form.

$\mathrm{Re} = \frac{\rho VD}{\mu}$, $Q = U_0 AT$, $A = \pi DL$, $COP = \frac{Q_{out}}{W_{in}}$

Table 4. Results without evaporative cooling

Time hr.	T_{amb} C^0	T_{gin} C^0	T_{gout} C^0	T_{air} C^0	COP
10.00	34.1	31.4	27.2	28.3	1.5482
11.00	37.3	32.1	27.6	28.5	1.6587
12.00	37.7	32.9	28.1	29.1	1.7692
13.00	38.0	33.2	28.2	29.4	1.8430
14.00	38.1	33.6	28.5	29.5	1.8798
15.00	40.5	33.8	28.6	29.7	1.9167
16.00	39.6	33.6	28.5	29.4	1.8798
17.00	38.2	33.1	28.1	28.7	1.8430
18.00	34.3	31.6	27.4	28.2	1.5481

Table 5. Results with evaporative cooling

Time	T_{amb} C^0	T_{gin} C^0	T_{gout} C^0	Tgout. C^0	T_{air} C^0	COP
10.00	32.5	31.4	27.3	23.2	26.0	2.6740
11.00	33.1	31.7	27.5	23.1	25.6	2.8044
12.00	36.4	32.1	28.0	22.8	25.3	3.0327
13.00	37.1	32.3	28.1	22.5	25.1	3.1957
14.00	37.9	32.6	28.3	22.7	25.2	3.2283
15.00	38.2	33.2	28.5	22.8	24.9	3.3914
16.00	38.1	33.1	28.2	22.6	25.0	3.4240
17.00	37.6	32.5	27.9	23.0	25.1	3.0979
18.00	34.3	32.1	27.7	23.1	25.6	2.9349

CONCLUSION

From the above results it can be concluded that the Geothermal conditioner gives fairly constant temperature output without affect of the surrounding temperature. When we used cycle with evaporative cooling coil the output temperature is near to 25^0C, which is comfort temperature of human body. Without evaporative cooling coil we found average COP = 1.7651 and with adding the evaporative cooling coil we found average COP = 3.087. From the above two results we said that when added evaporative cooling coil in the system we achieved almost double COP. This helps us to prove that the Geothermal air conditioner works better as space cooling.

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