American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-12, pp-157-170
www.ajer.org

Research Paper Open Access

"Experimental Investigation Of Geothermal Air Conditioning"

Gaffar G.Momin
(M.E Mech,.Heat Power) Assistant Professor in Mechanical Engineering,PCCOE,Nigdi,Pune,INDIA-411044

***Abtract:* -** This project work describes in detail, the geothermal Air Conditioning. The contents of the paper includes a brief description of the Geothermal cooling system by a good number of necessary and descriptive drawings which makes this paper very easy to understand. Also an additional system of evaporative cooling coils has been incorporated and readings has been observed and comparison between the readings shall be made. In addition to these ,the paper also contains the details regarding the different type of other ground source cooling systems which are used these days. Above all , This paper gives a detailed description of closed looped Geothermal cooling system. This description is empowered with the experimental analysis of the system and the heat transfer calculations. This paper will help for those who wish to understand about the basic working of different Geothermal cooling systems especially those who wish to study close loop Geothermal cooling system

***Keywords:* -** *Principle of working of Geothermal Air Conditioning system ; comparison of Geothermal cooling and Evaporative cooling ; water based Geothermal heat exchangers ;integration of water based Geothermal Heat Exchangers with HVAC systems ; Air based Geothermal Heat Exchangers; COP Comparison of Geothermal cooling and Evaporative cooling.*

I. INTRODUCTION

This paper deals in depth with our demonstration of using geothermal energy as a future alternative to traditional heating and air conditioning systems. Geothermal energy is the energy which is harnessed from the mother earth. Geothermal air conditioning system is considered to be the most efficient air conditioning systems available till date on this planet. This works on the basic principle (Fig.1) that the

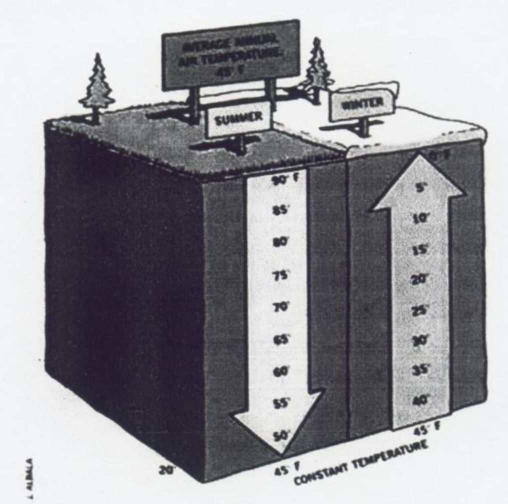

Fig 1. Principle Of Working

temperature remains constant below earth throughout the year irrespective of the temperature above the ground. During the seasonal changes the temperature of air changes from one extremity to the other and the variation is over a time period of day or gradually over the season. Due to variation in temperature there is increase or decrease in running efficiency of all HVAC systems, be it the ones dependent on air cooled condensers water cooled systems with cooling towers. Geothermal exchange systems on the other hand use a constant thermal body earth to give 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 earth is lower than the atmospheric temperature see it can be used for cooling purposes where as during winters the earth temperature is higher than the atmospheric temperature, it can be used for heating purposes. The temperature within earth is negligibly affected by variation in atmospheric temperatures. While going down into earth the upper 5 to 8 feet is affected by the seasonal changes with a time lag of a few days to months the variations are from 3 to 6^0 C, but as we progress down with in the range of 8 to 20 feet. This variation reduces down to a change of 2 to 4^0 C over a time period of a few months based on lag in transfer of thermal gradient through earth. After this the temperature remains nearly stable with in a variation of 1 degree 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 a variation of around two degrees either way with respect to geographical conditions. For checking the temperature of Earth the simplest procedure is to check the temperature of water coming out of the bore well in your local area.

After many experiments and measurements it was noted that the soil strata between 2 m to 3 m depth had stable temperature regime sutable for installation of the Earth-Tube heat Exchanger (ETHE).Temperature in this stratum displays no diurnal fluctuation. 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 (very slow to warm up and very slow to cool down). The deeper you go, the further from the surface, the more constant the temperature compared to the surface air variation .e.g. animals in both hot and cold climates often burrow to reach the stable cooler or warmer areas respectively, compared to above ground air temperatures. It is better, to live at a constant temperature below ground in a desert than to live exposed on the surface and suffer temperatures than may vary from below 0 to over 120^0F in the course of every 24 hours.

Air heats up and cools down quickly compared to bodies of water and soil and rock heats and cools slowest of the three. At greater depths however temperature gradually increase and some of our deep mines and drill holes are reaching the temperatures considerably above 50^0C- 55^0C as we get closer to the molten inner core of the planet. But the average temperature in the region below 2-8 m remains constant to 28^0C.As a second step one single pass Earth-Tube heat Exchanger (ETHE) was built to investigate the actual cooling and heating performance. This ETHE is made of 15 m long copper pipe of 12.5 cm nominal diameter. It is buried 3m deep below surface.

Fig 2. Earth Sheltering

II. LITERATURE REVIEW

Besides food, clothing and shelter human started to reach for comfort. In ancient days also, at the time of beginning of the civilization humans used to live in the caves or hilly seasons, the reason behind this was that the temperature in these regions almost remains constants irrespective of the climate change. Hence comfort human condition was achieved without much effort. But with the advancement and growth of civilization humans moved to the plain and plateau regions for the establishment of society. And as the technology advanced their came the different air conditioning systems for human comfort, along with the threat to global warming, because of the increased used of refrigerants and fossile fuels to generate electricity to run this system. but because very of increasing global warming everyone’s attention is turning to more conventional methods, the fig.2 shows the view of Turf houses in Keldur, Iceland.

The community here use to build houses covered from earth from three sides till roof ,having windows and door on the same side ,this helps in maintaining the temperature inside the house closed top the ground

temperature. but with the growing population and modernization more compact and sophisticated solutions have being formed ,like using ground or lake water for the purpose or laying a network of pipes below ground surface at a specific depth and circulating water or refrigerant.this are also called as ground loops.
It has been also observed that temperature of a soil below certain depth always remains constant by the work carried by L.A Ramdas at.al, agricultural metrologist in pune. this ensures proper cooling of refrigerant passing through the earth[3].
The earth heat exchanger are advantageous features to reduce energy consumptions in residential buildings. In winter they pre-heat ventilation air with minimal operation costs-necessary for low energy architecture, in summer they help to prevent passive houses with relevant solar gains from overheating by pre-cooling ventilation air[1].

Earth-Tube Heat Exchanger(ETHE) is a device that enables transfer of heat from ambient air to deeper layers of soil and vice versa. since the early exploration of its use in cooling commercial livestock buildings(Scott et al 1965)there has been considerable increase in its application. ETHE is used to condition the air in livestock buildings(Spengler and Stombaugh 1983). It is used in North America and Europe to cool and heat green houses(Sant Mouris et al 1995). There have also been works aiming at gaining better understanding of its working in cooling and heating mode(Baxter 1992,1994). Mathematical models of ETHE have also been developed(Puri 1985;Goswami and Dhaliwal 1985). There has also been some work in India. Sawhney et al(1998) installed an ETHE based system to cool part of a guesthouse. Sharan et al(2001) installed an ETHE based cooling system for tiger dwelling at Ahmedabad Zoological Garden. Authors have visited Tata Energy Research Institute,where a system is installed to cool rooms in its training center near Delhi.[2]

It has also been studied that the geothermal space temperature controlling system has been successfully tested in controlling the green house area of growing crops. The experiments have successfully proved that the geothermal conditioning helps in saving 10% to 40% of costs incurred in conventional system.[4]

III. WORKING

The ground loops is a heat exchanger that is similar to a cooling coil or an evaporator in a chiller. The goal is to transfer heat energy from the heat exchanger loop fluid to/from the ground to the conditioned space. Fig 3 shows actual layout of Geothermal Air Conditioner.

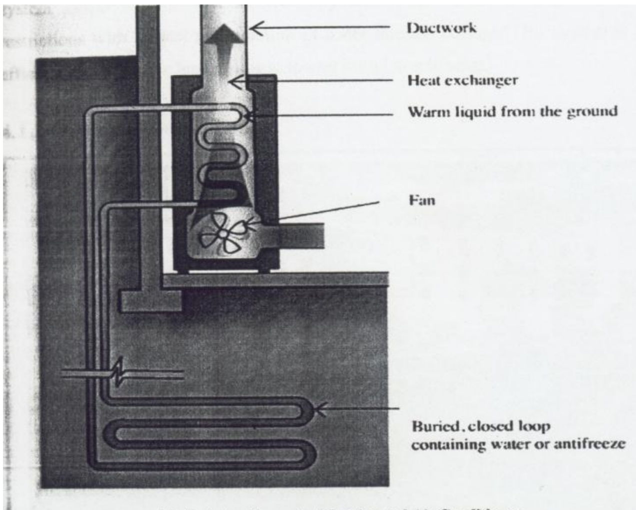

Fig 3. Actual Layout of Geothermal Air Conditioner

Hence depending upon space availability ,surface condition and ground temperature different loop design have been formed, each having its own strengths and weakness ,this are discussed below. The purpose of loop design is to estimate the required loop length.

4.1 WATER BASED GEO-THERMAL HEAT EXCHANGERS

4.1.1 Ground Water:

The simplest method is making a bore up to deep water table source and extracting water which is at the temperature of earth and then passing it through a heat exchanger for removing heat from a refrigerant,water or air as may be the case. Generally depending on the efficiency of the heat exchanger the temperature of refrigerant,water or air can be brought down with in a variation of 2 to 3^{o}C of the ground water temperature. This option involves extraction of water,circulation through a heat exchanger and re-injecting it back through an injection well. This system could require governmental approvals since in some places there are restrictions with respect to extraction of water through borings. This system is most efficient and gives the best results at lowest initial investments.

Open loop systems draw ground water directly into the building and heat/cool the confined space with it. The system requires sufficient ground water to meet the needs of the building. Ground water often has minerals and others contaminants in it that detrimentally affect the equipment. Open loop systems that use lake water are also available ,but should use filtration equipment or secondary heat exchangers to deal with contaminates. Lake water used in an open loop applications ,should be used in climates where the entering water temperature is above 40^{o}F. The ground ,must have the capacity to take open loop system discharge. These cannot be used below 40^{o}F without the risk of freezing. In addition open loop systems must allow for increased pump head from the lake/ground water level to the heat exchanger. Open loop systems cannot common on commercial and institutional applications.Fig.4 shows open loop system

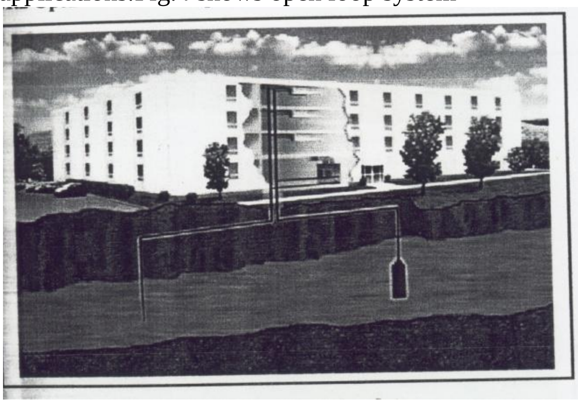

Fig.4.Representation of Open Loop System

Closed loop systems have a dedicated fluid loop that is circulated through the ground or pond in order to exchange energy. Gthe ground/pond water and loop water do not mixed. Closed loop systems are further broken down into different loop types,

4.1.2 Horizontal Loop

Fig.5 shows representation of horizontal closed loop system. A horizontal closed loop fluild is composed of pipes that run horizontally in the ground.

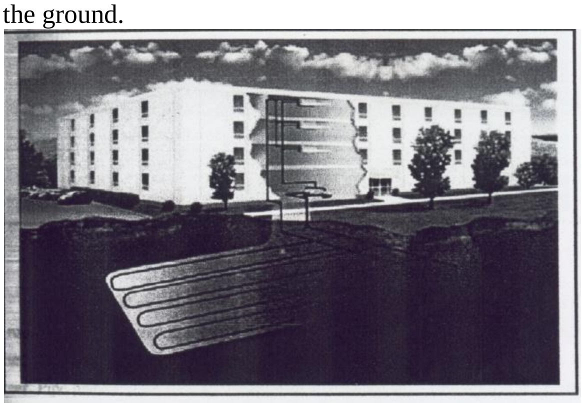

Fig 5. Representation of Horizontal Closed Loop System

A long horizontal trench ,dipper than frost lines, is dug and U shaped or slinky coils or placed horizontally inside the same trench. Excavation for horizontal loop fields is about half the cost of vertical drilling, so this is the most common layout used wherever there is adequate land available. A horizontal loop runs piping parallel and closed to the surface. The undisturbed ground temperature often changes seasonally depending upon where the loops are installed. Horizontal loops are easier to installed but require significantly more area(approximately 2500 ft^{2}/ton) than other loop types.

4.1.3 Vertical Loop

Fig.6 shows representation of vertical closed loop system. A vertical closed loop field is composed of pipes that run vertically in the ground. A hole is bored in the ground, typically 75 to 500 feet(23-150 meter)deep. At this depths, the undisturbed ground temperature does not change throughout the year. Pipe pairs in the hole are joined with a U shaped cross connector at the bottom of the hole. The borehole is commonly field with a bentonite grout surrounding the pipe to provide a thermal connection to the surrounding soil ort rock to improve the heat transfer. Thermally enhanced grouts are available to improve this heat transfer. Grout also protects the ground water from contamination and prevents artesian wells from flooding the property. Vertical loop fields are typically used when there is a limited area of a land available. Boreholes are spaced atleast 5-6 meter apart and the depth depends on the ground and buildings characteristics. Vertical loops are only require approximately 250-300 ft^2/ton.

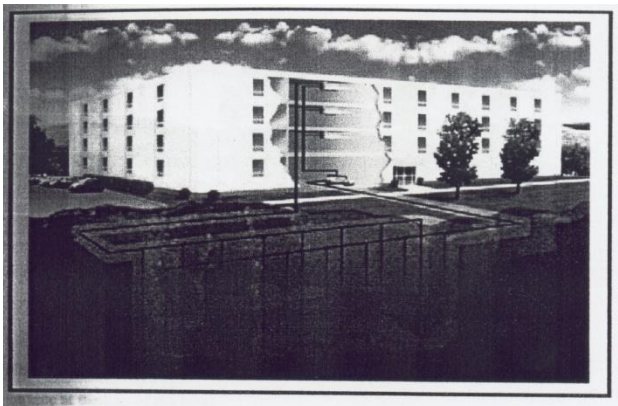

Fig 6. Representation of Vertical Closed Loop System

4.1.4 Surface Water Loop

Fig.7 shows representation of surface water closed loop system. Surface water or pond loops use a body of water as the heat sink. Heat escapes the water through surface evaporation, so the process is closely connected to pond temperature and ambient wet bulb. In winter, when the pond could be frozen, heat transfer is dominated by contact between the loops ,the bottom water and the soil surface at the bottom of the pond.

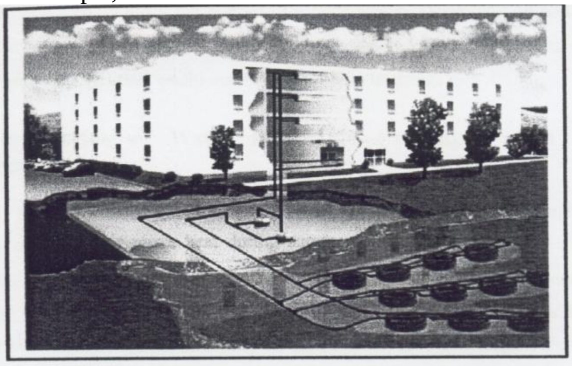

Fig 7. Representation of Surface Water Closed Loop System

4.1.4 Slinky Coil Geothermal Ground Loops

Fig.8 shows representation of Slinky Coil Geothermal Ground Loop. Slinky coil geothermal ground loops are gaining popularity, particularly in residential geothermal system installations.

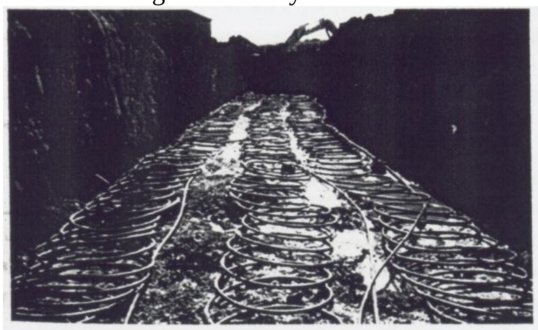

Fig 8. Representation of Slinky Closed Loop System

Slinky coil ground loops are essentially a more economic and space efficient version of a horizontal ground loop. Rather than using straight pipe, slinky coils, as you might expect, use overlapped of piping laid out horizontally along the bottom of a wide trench. Depending on soil, climate and your heat pumps run fraction, slinky coil trenches can be anywhere from one third to two thirds shorter than traditional horizontal loop trenches.

4.2 INTEGRATION OF WATERBASED GEO- HEAT EXCHANGERS WITH HVAC SYTEMS

The water coming out of a geo-exchange system is circulated through a water cooled condenser to remove heat during summers since the water is at a constant temperature of earth which is generally lesser than the atmospheric temperature and the wet bulb temperature during the day. The efficiency of the condenser is improves the efficiency of the complete HVAC system. This results in more BTU's of thermal cooling delivered for the energy consumed. This additional amount of BTU's delivered can be termed as the cooling provided by the Earth.

During winters this water is at a higher temperature it provides heat thus when circulated through the heat exchanger it now adds heat energy to it. Generally it is seen that the efficiency of the HVAC system coupled to a geo-exchange heat exchanger improves from 10 to 20 % over a time period of one season depending on manner in which it is used. Locations where Cooling Tower is more beneficial during certain time periods of the day i.e. evening and night time the geo-exchange system can be used in series or parallel with a cooling tower to take advantage of both the systems to get maximum efficiency levels.

These underground heat exchangers are best suited to be used with Ground-Source Heat Pumps since they are designed to provide cooling during summers and work in reverse during winters thus taking the maximum benefits of the earth's thermal properties. Heat pumps when coupled with geo-exchange systems are very energy efficient with Energy Efficiency Ratio (EER) of 13 to 22. Climate Master one of the major manufacturers of heat pumps in the world has come out with water-source heat pumps giving EER of up to 27 at part load when coupled with geo-exchange systems.

4.3 AIR BASED GEO-THERMAL HEAT EXCHANGERS

We shall now examine the use of geo-exchange systems with the option of just running air through the earth in larger diameter tubes. The process involves laying pipes varying in diameters from a few inches to a feet or more and then circulating air through it this air when it comes in contact with the internal surface of the pipes attains a temperature within the range of 2 to 3^0C of the earth temperature. The pipes layout and length is again designed after calculating the full day load the properties of the material used in pipes and the nature of the surrounding soil. These pipes are placed at an depth of 10 to 20 feet below ground in trenches or open excavations which are then filled back, here the provision is made for cleaning these pipes and manholes are provided accordingly. Provision is also made for removal of any water accumulation caused due to humidity in the air.

4.4 GEO-EXCHANGE SPACE COOLING/HEATING

The system is used for direct conditioning the internal temperature of the building space. In this the pipes are laid in a closed loop with a circulating fan placed with in the loop, the internal air is re-circulated the ground loop and the temperature slowly reduced over a number of circulations. Again the principle is same for temperature variation of 3^0C from the earth temperature is achievable with in the closed environments. This is very useful in areas where the ground temperature is low and can thus provide HVAC solutions at a very low running cost. Generally people make the mistake of not designing the system or the air circulation system properly or use it in locations where the earth temperatures are high and then are not satisfied. Thus these systems should be properly designed for the best results. Hilly regions circulation of air through earth tubes provides heating and is very effective.

4.5 FRESH AIR PRE-COOLING

The second use of this system is for pre-cooling of fresh air which is a major energy consumer in commercial and office buildings. In this case instead of a closed loop system fresh air is forced in at one end and then circulated through the earth pipes and allowed to mix with internal air at a mixing point on the other end of the earth tube. Again in this case the length and diameter of earth tube should be based on material of pipe and soil conditions and should be properly calculated for the total load over the time period of the day. Provisions for the moistening the soil around the pipes should be made for in dry soils to expedite the heat exchange. This process can again reduce fresh air temperatures within 3 to 5^0C of the earth temperature and thus give substantial energy savings.

IV. EXPERIMENTAL SET UP

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

5.1.Geothermal Pit

Fig.9 shows Geothermal Loop & Pit. Pit is the area where the network of pipes carrying refrigerant is installed. As per the geographical location the depth of pit varies.

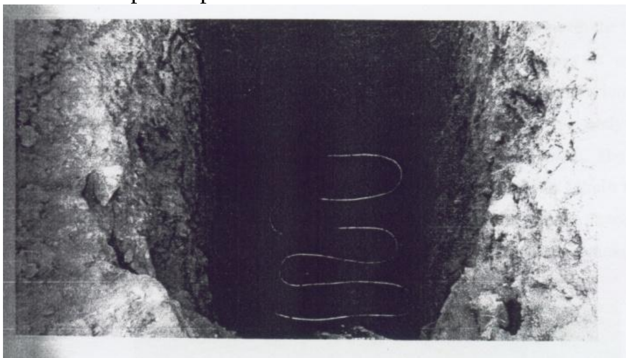

Fig 9. Geothermal Loop and Pit

The pit is usually dug till we get the moist soil. As per the design of copper pipe network the length and breadth of the pit decided. For pit of dimensions 2m X 1.5m and depth of 3m is dug. At the depth of 2.5m the excavated soil was moist which shows the presence of moisture in the Earth. Due to presence of moisture the heat transfer between refrigerant and earth will be more effective. Also presence of moistures ensures sufficiently low temperature below the Earth.

5.2 Loop of Copper Pipes

A closed loop system, the most common, circulates the fluid through the loop field's copper pipes. Copper was selected for the purpose of looping because it has very high thermal conductivity of 380 W/Mk and self life of up to 20 to 25 years. In a closed loop system there is no direct interaction between the fluid and the Earth; only heat transfer across the copper pipe. The amount of vertical or horizontal loop required is a function of the ground formation thermal conductivity, deep earth temperature and heating and cooling power needed and also depends on the balance between the amount of heat rejected to and absorbed from the ground during the course of the year. A rough approximation of the soil temperature is the average daily temperature for the region.

The total length of pipes installed was 15 meters and diameter of half inch (12.5 mm). Out of the total length 8 meters were used for creating the required network for actual heat transfer and 7 meters was used for making connections for inlet and outlet of the loop. The connecting length helps us to connect other component to the loop. Loops were made with the help of bender used to blend copper pipes.

5.3 Mono-block Pump

It helps to force the refrigerant from reservoir to the loop. The pump used is of standard type available in the market (Kirloskar Make) often called as "Tulu Pump" the smallest size which is domestic pump available in the market.

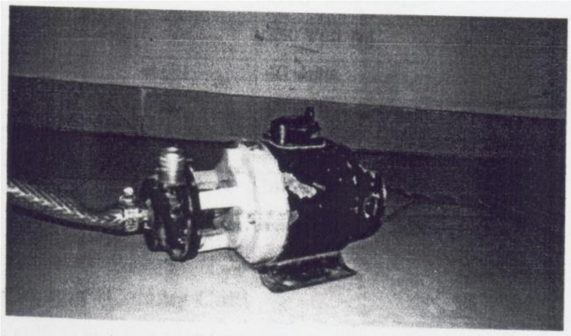

Fig 10. Monoblock Pump

It pressurizes the water with the help of rotating impeller thereby providing it hydraulic energy. The pump sucks in the water from reservoir and the outlet is connected to the inlet of geothermal loop.Fig.10 shows the Mono-block Pump.

Table.1 Specifications of Mono-Block Pump

Make	Kirloskar-50 mono-block pump
Type	Electric
Phase	Single phase, 50 Hz.
Voltage	230 V
Power	0.5 KW
Head	15 m
Discharge	500 Litres/Hr.

5.4 Fan

An electric fan is used to blow the air at the cooling coil. This fan is installed on the rear of cooling coil thereby creating a forced draught to the system. The fan used for this experiment was a standard 12 inch exhaust fan. The blades are made up of mild steel plate and coated with paint to avoid rusting. The fan blades and the motor are enclosed in a frame for mounting purpose.

Table.2. Specifications of fan

Make	Brighty fans
Type	Electric
Phase	Single phase, 50 Hz
Voltage	230 V, A.C.
Power	40 watts
Dia.	12 inches (blade diameter)
RPM	1400 rpm
Sweep	300 mm

5.5 Heat Exchanger (Cooling Coil)

Cooling coils are made up from copper material & are installed for heat transfer between cool water and the air. The heat exchanger used for this purpose is of standard radiator of diesel engine available in the market. The body is totally made up of copper for instantaneous heat transfer. The heat exchanger consists of two tanks viz. upper and lower. These tanks are separated by arrays of number of elliptical tubes very small cross section. The cooled refrigerant enters the lower tank and floods the heat exchanger up to the upper tank. Large no. of thin fins connects the small pipes together to increase the surface area and ultimately increasing the heat transfer rate. Hot air is blown on this heat exchanger which passes over its surface and heat transfer takes place between air to the water. The hot water is collected from the upper tank of the heat exchanger.Fig.11 shows the cooling coil of the radiator.

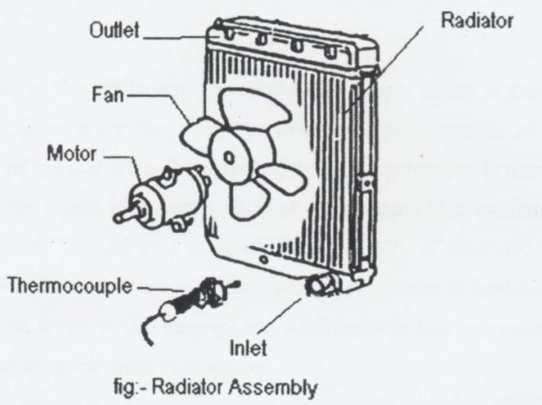

Fig 11. Cooling Coil

5.6 Refrigerant

The most common refrigerant used for geothermal air conditioner is water. Its high heat capacity and low cost makes it a suitable heat transfer medium. Various additives like (ethylene glycol or propylene glycol). Since water is freely available and does not cause any harm if leaked and its boiling and freezing point makes it the best suitable refrigerant that could be used for the system.
Some thermal properties of water are tabulated in table 3.

Table 3.Thermal properties of water .

Maximum density at 4^0C	1000 Kg/m^3
Freezing temperature	0^0C
Boiling temperature	100^0C
Latent heat of melting	334 KJ/Kg
Latent heat of evaporation	2270 KJ/Kg
Critical temperature	380-386 ^{0}C
Critical pressure	221.2bar(22.1 MPa)
Specific heat capacity of water	4.187 KJ/KgK
Specific heat capacity of Ice	2.108 KJ/KgK
Specific heat capacity of water vapour	2.108 KJ/KgK
Thermal expansion from 4^0C to 100^0C	4.2 X 10^{-2}
Bulk modulus of elasticity	2.15 X 10^9 Pa

5.7 Reservoir

Reservoir stores the refrigerant for continuous supply to the water pump so that no any air bubbles enter the pump to avoid the phenomenon of aeration. Reservoir gets the refrigerant from the outlet of the heat exchanger. It than supplies the refrigerant to the mono-block pump. Bucket of standard size available in the market which is made up from plastic material is used as a reservoir. The capacity of reservoir used is 20 litres. Plastic reservoir is used because plastic is a bad conductor of heat and reduces the flow of heat from water to the atmosphere. Additional insulation was applied for piping provided from reservoir to pump to avoid heat losses.Fig.12 shows reservoir.

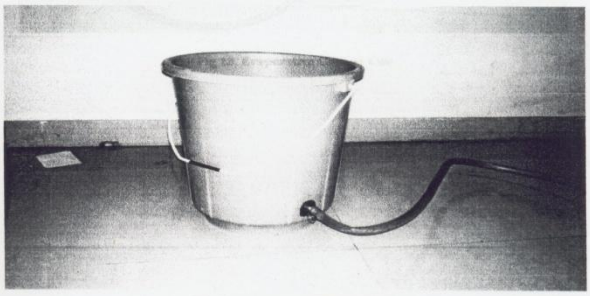

Fig 12. Reservoir to Collect Water

5.8 Evaporative Cooling Coil

This coil is using the same copper tube fabrication of loop of geothermal heat exchanger. The tube was formed in the shape of helix and they are covered by gunny bags or grass pads. Gunny bags or grass pads helps to retain the moisture and thereby accelerating the evaporative cooling process. Two such cooling coils of 2m length ,each is used for evaporative cooling. These coils were then mounted on the system. An additional fan blowing air on this coil may help to increase the rate of evaporative cooling.

V. FABRICATION

6.1 Fabrication of Evaporative coil

Evaporative coil is made also made of copper in spiral form. The advantage of spiral form is that more surface can be covered in less area. This coil is then covered with gunny bags on which a continuous drop by drop supply of water is provided. This set up was placed in direct sun light for effective results.

The outlet of Geo-Thermal Exchanger is directly connected to the Evaporative coil with flexible pipe. Sufficient insulation is provided on the pipes connecting different components of the system.

6.2 Cooling Coil

A simple radiator with an exhaust was used as a cooling coil. The radiator was fixed on the window followed by the fan. Outlet of evaporative coil is connected to the bottom of the cooling coil and its outlet is again connected to the reservoir.

6.3 Installation of Thermocouple

Three thermocouples were installed at proper intervals. The first was installed at the Geothermal inlet, while the second was installed at the outlet of it which is also the inlet of Evaporative coil. The third was installed at the outlet of the evaporative coil. Ambient air and reservoir temperature is measured with the help of another thermocouple. Fig.13 shows the typical diagram of Geothermal Air Conditioning.

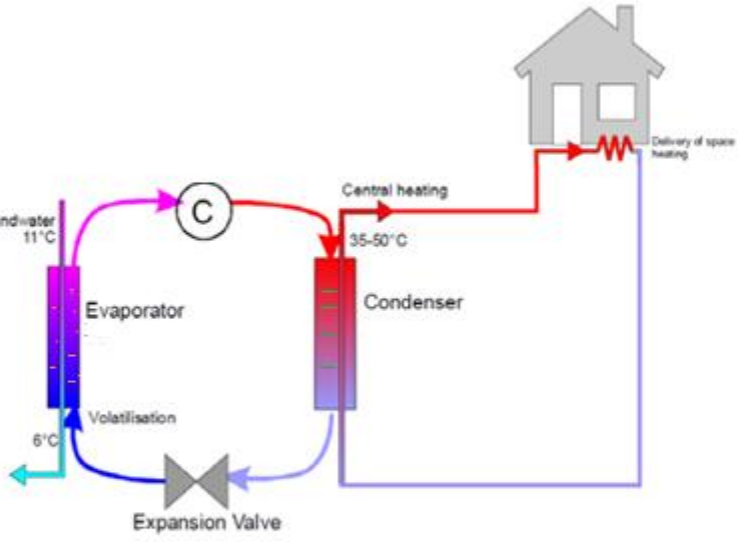

Fig.13. A Typical Diagram Of Geothermal Air Conditioning

VI. EXPERIMENTAL PROCEDURE

In the experimental set up we used a closed loop system. There should be continuous supply of refrigerant (water). For this purpose a reservoir was used, in one demonstration we used a bucket with a outlet connection at the bottom. This outlet was connected to a mono-block pump. Pump circulates the water in the Geothermal coil, where the heat transfer between the water and the earth takes place. The outlet of the Geothermal coil is connected to the Evaporative coil. This refrigerated water from the Geothermal coil is pushed through the evaporative coil, where its temperature is further reduced. The Evaporative coil is covered with gunny bags or grass pads, which are continuously kept wet. A fan or blower is attached on the Evaporative coil for effective evaporation. The outlet of the Evaporative coil is connected to a flow control valve, which is connected to the cooling coil. The flow of water is controlled for complete heat transfer between the Geothermal coil and the earth, cooling coil and ambient air. The cooling coil is attached on the window with a fan. The velocity of air flowing over the cooling coil is controlled by selecting proper speed of the fan. The outlet of cooling coil is again returned to the reservoir which is again pumped in to the Geothermal coil and hence, the cycle continued. Fig.14 shows block diagram of Geothermal cooling and evaporative cooler.

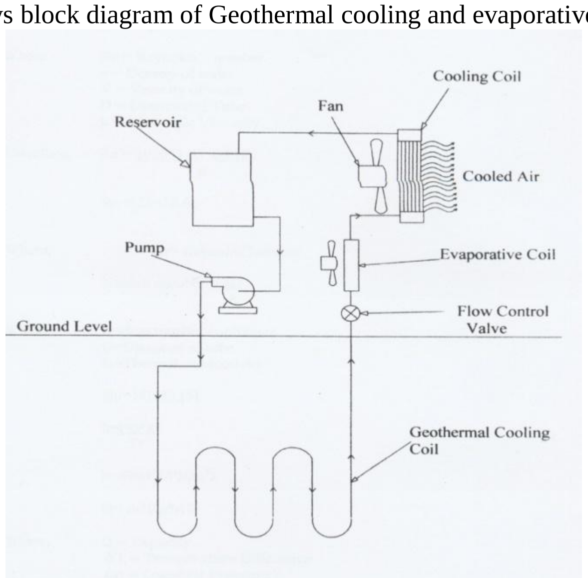

Fig.14.Block Diagram of Geothermal Cooling With Evaporative Cooler.

VII. CALCULATIONS

8.1 Calculation for Length of Geothermal Loop

$$Re = \rho VD/\mu$$

$Re = 1000 * 1.65 * 0.0125/\mu$
Hence Re = 28428.66
Mass flow rate = m=1000*1.227*10^{-4}*1.65
m=0.25kg/s
therefore, Q =0.25*4.187*6
Q = 5.87 KW
Q = U_0*A*ΔT
5.087*1000= 1842.084*A*6
Therefore A= 0.46025 m^2
A= πDL
0.46025=3.14*0.0125*L
Hence L=11.2m

8.2 Calculation for COP of system

8.2.1 Without evaporative cooling

COP=$Q_{out/}W_{in}$
COP=0.2025*4.187*(33.8– 27.6) * 100/230
COP=2.2855

COP of system without evaporative cooling is 2.2855.

8.2.2 With evaporative cooling

COP=$Q_{out/}W_{in}$
COP=0.2025*4.187*(34.0– 21.3) * 100/260
COP=4.1415

COP of system without evaporative cooling is 4.1415.

Table 4 Result of Geothermal Cooling

Time hr.	$T_{amb.}$ ^0C	$T_{gin.}$ ^0C	$T_{gout.}$ ^0C	$T_{air.}$ ^0C	COP
10.00	32.2	31.9	26.7	27.2	1.9169
11.00	35.6	32.2	26.9	27.8	1.9537
12.00	38.9	33.1	27.4	28.2	2.1012
13.00	40.3	33.8	27.6	28.8	2.2855
14.00	39.3	33.6	27.3	28.5	2.3224
15.00	38.2	33.1	26.9	28.1	2.2855
16.00	36.8	32.7	26.8	27.6	2.1749
17.00	33.9	31.8	26.7	27.8	1.8800

Table 5 Result of Geothermal Cooling

Time hr.	$T_{amb.}$ ^0C	$T_{gin.}$ ^0C	$T_{gout.}$ ^0C	$T_{gout.}$ ^0C	$T_{air.}$ ^0C	COP
10.00	33.1	32.2	26.8	22.9	24.6	3.4283
11.00	35.8	33.2	27.1	22.8	24.2	3.8338
12.00	38.4	33.5	27.2	21.5	23.2	4.4236
13.00	40.5	34.0	27.7	21.3	23.0	4.6817
14.00	39.2	33.6	27.3	21.4	23.3	4.4973
15.00	38.5	33.1	27.1	21.6	23.6	4.2393
16.00	37.1	32.6	26.5	22.1	23.1	3.8706
17.00	35.4	32.1	26.8	22.3	24.3	3.6126

VIII. CONCLUSION

From the above results it can be concluded that the Geothermal conditioner gives fairly constant temperature output irrespective of the ambient temperature. The output temperature is near to 25^{0}C which is comfort temperature of human body. With adding the evaporative cooling to the ground cooled water, the COP of the system almost doubles which make the system more effective.

Fig.15,16,17,18,19,20 shows the Experimental Results.

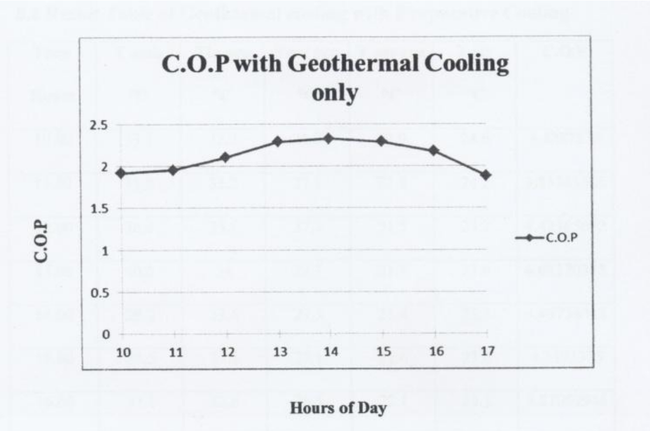

Fig 15. Graph of C.O.P Characterstics on Time Line

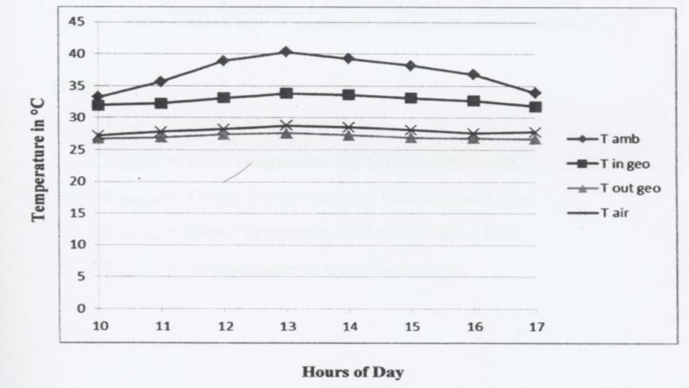

Fig 16. Graph of Different Temperature characterstics on Temp V/s Hours

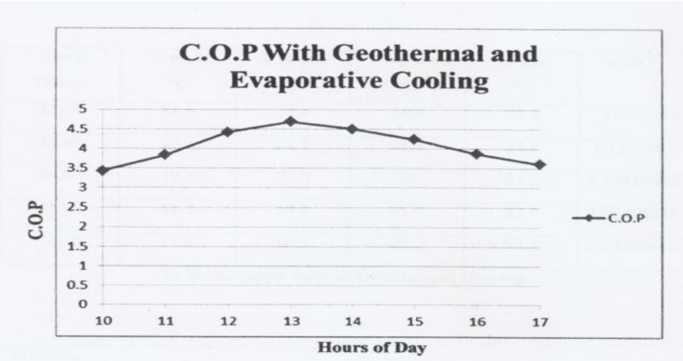

Fig 17. Graph of C.O.P of system with evaporative cooling.

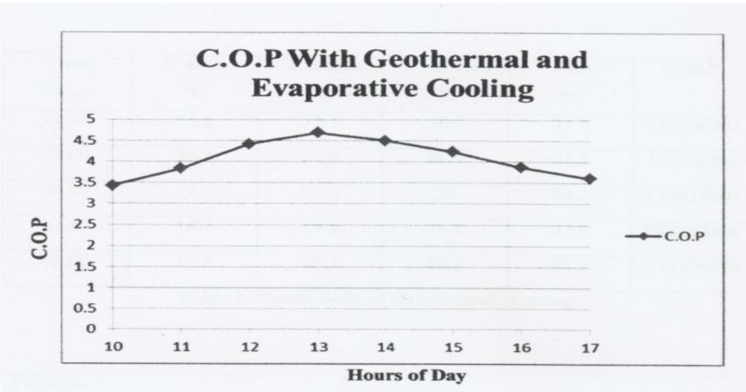

Fig 17. Graph of C.O.P of system with evaporative cooling.

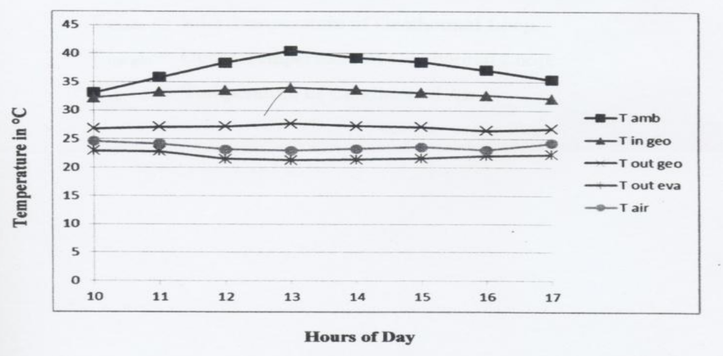

Fig 18. Graph of Different Temperature characterstics with evaporative cooling on Temp V/s

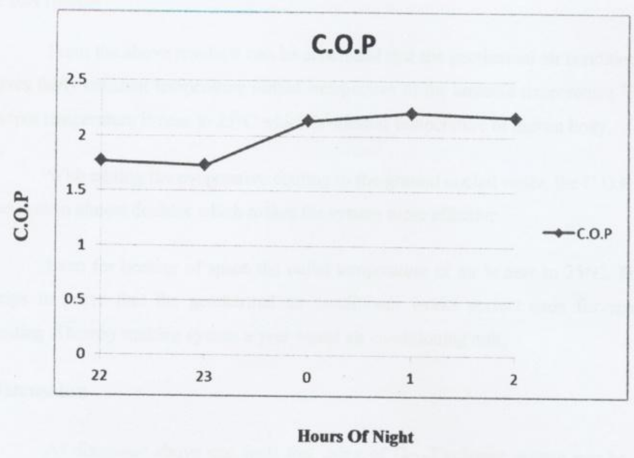

Fig 19. Graph of C.O.P of system for Geothermal Heating

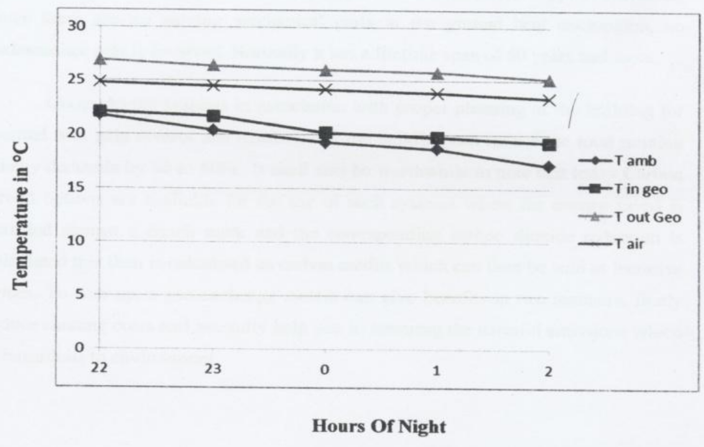

Fig 20. Graph of Different Temperature characterstics of Geothermal heating on Temp V/s Hours

Even for heating of space the outlet temperature of air is near to 25^0C. This helps to prove that the Geothermal air conditioner works perfect even for space heating. Thereby making system a year-round air conditioning unit.

IX. DISCUSSION

As discussed above on feels that using of Geo-Exchange system can be of immense benefit in reducing the running energy loads in HVAC systems. This reduction in going to increase over the years as the cost of power supplied increases. Since there are no moving mechanical parts in the ground heat exchangers, no maintenance cost is involved. Normally it has a life time span of 50 years and more.

Geo-exchange systems in association with proper planning of the building for thermal heat gain control and insulation of the building can reduce the total running energy demands by 40 to 60 %. It shall also be worthwhile to note that today Carbon credit options are available for the use of such systems where the energy saved is certified against a bench mark and the corresponding carbon dioxide reduction is calculated this then is calculated as carbon credits which can then be sold at lucrative prices. To sum up, a Geo-Exchange system can give benefits in two manners, firstly reduce running costs and secondly help you in lowering the harmful emissions which is hazardous to environment.

11. FUTURE SCOPE

The system can use electricity produced from renewable sources, like solar and wind power, to heat and cool down spaces much more efficiently thana conventional air conditioner. This makes the system complete green i.it will not use any energy generated by conventional sources. Even using of modified heat exchangers and lowering the heat losses further improvement in the COP of the system can be achieved.

REFERENCES

[1] St.Benkert, F.D.Heidt, D. Scholar Department of physics, University of Siegen D-57068 Siegen, Germany, " CALCULATION TOOL FOR EARTH HEAT EXCHANGERS GAEA"

[2] Girja Sharan at.al, Professor Coordinator Cummins- IIMA Lab Centre for Mgt in Agriculture Indian Institute of Management, Ahmedabad " Performance of Single Pass earth-Tube Heat Exchanger ; An Experimental Study".

[3] L.A. Ramdas at.al.,agricultural meteorologist,"Soil Temperature In Relation To other Factors Controlling The Disposal Of Solar Radiation At the Earth's Surface"'1936.

[4] Girja Sharan , D A Institute of Information and Communication Technology, Gandhinagar " Environmental Control in Greenhouse and Animal Houses with Earth- Tube-Heat-Exchangers in Hot Semi-arid North-West India" 2009.

[5] Fundamentals of Heat Exchanger, By Ramesh K.Shah and Dusan P.Sekulic.

[6] Handbook of Air-Conditioning and Refrigeration, Second EDITION, McGraw Hill-By Shan K.wang.