Experimental Investigation of Geo-thermal Green Air-Conditioning System

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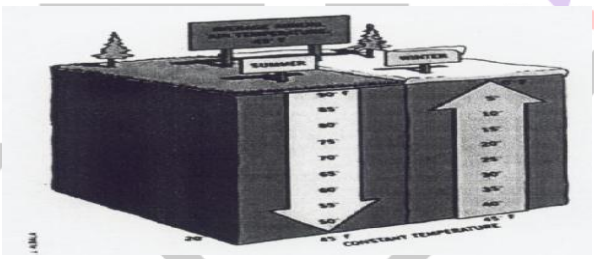
Abstract:-**This project work describes in detail, the Geothermal Green Air Conditioning. The contents of the paper includes a brief description of the Geothermal cooling system by a good number of necessary and descriptive drawings which makes this paper very easy to understand. Also an additional system of evaporative cooling coils has been incorporated and readings have 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. A photovoltaic (PV) module which is a packaged connects assembly of typically 8×10 solar cells. Solar Photovoltaic panels constitute the solar array of a photovoltaic system that generates and supplies solar electricity to the system. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 365 watts.**

Keywords: **- Geothermal Green Air Conditioning system, Geothermal cooling and Evaporative cooling, R134a refrigerant based Geothermal heat exchangers, Integration of R134a refrigerant based Geothermal Heat Exchangers with HVAC systems, 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 Green 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 temperature



[Fig.1 Principle of working]

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 suitable 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: - 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][5].

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].

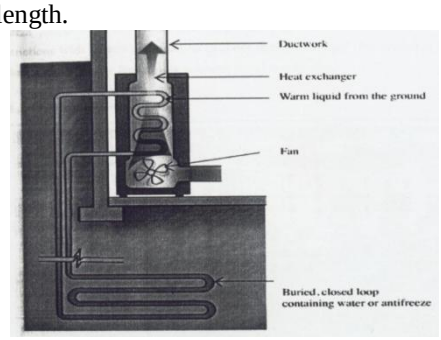
It has also been studied that the geothermal space temperature controlling system has been successfully tested in controlling the green house area of growing crops. The experiments have successfully proved that the geothermal conditioning helps in saving 10% to 40% of costs incurred in conventional system.[4][6]

The earliest proposal for comfort cooling in the U.S. using ice was possibly that of George Knight of Cincinnati who, in 1864, proposed a hospital cooling system in Scientific American. It featured a ventilating system with an air washer to clean and cool the air. The water for the air washer was run through a cooling coil immersed in melting ice. Outside air was forced by a fan through the cold water spray to be distributed overhead through perforated outlets. After 1870, refrigeration and large building heating and ventilating systems began to be commercialized.[7]

By photoelectric effect in semiconductors, we can transform the solar energy in solar cells to power energy. Transformation of solar energy to power energy has wide utilization. Disadvantage of solar energy generation is its dependence on daylight, season and cloudiness in the area. Even though, it is a potential energy, which should not be ignored. Photovoltaic effect which permits to construct photovoltaic (PV) cell, was discovered by A. Becquerel in 1839 (2, 4). Subsistence of the PV transformation from solar radiation to power energy is so-called inert photovoltaic effect. If solar radiation falls on the semiconductor material, the concentration of a charge carrier will rise when compared to the condition without luminance. Incident photons transfer their energy making electrons and holes excite, what can be used for current conduction. It is necessary that the electric field is made in semiconductor, which will isolate electrons and holes from each other. This kind of field is acquired by PN junction (5). Equipment that can use this effect is called a photovoltaic (solar) cell. This equipment directly changes solar radiation to direct current (DC) (3, 4, 5). The solar photovoltaic cell is a semiconductor diode. PN junction is formed in the thin slices of silicon in a small depth below the surface whith metal contacts both sides. When solar radiation falls on the cell, electrons and free holes are generated. Electric field of PN junction separates them, and sends them to opposite sides; electrons to the N layer, which becomes a negative pole of the photovoltaic cell and holes to P layer, which becomes a positive pole.[8]

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 refrigerant to/from the ground to the conditioned space. Fig 3 shows actual

layout of Geothermal Green 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.



[Fig.3 Actual layout of the Geo-thermal Air-conditioner]

IV. REFRIGERANT BASED GEO-THERMAL HEAT EXCHANGERS:-

R134a :-

R134a is also known as tetrafluoroethane(CF_3CH_2F) from the family of HFC refrigerant .with the discovery of the damaging effect of CFCs and HCFCs refrigerants to the ozone layer , the HFC family of refrigerant has been widely used as their replacement .

It is now being used as a replacement for R-12 CFC refrigerant in the area of centrifugal ,rotary screw ,scroll and reciprocating compressors . it is safe for normal handling as it is non – toxic , non-flammable and non-corrosive .

Currently it is also being widey used in air conditioning system in newer automativevehicle .

It exists in gas form when exposed to environment as the boiling temperature is -14.9ºF or -26.1ºC.

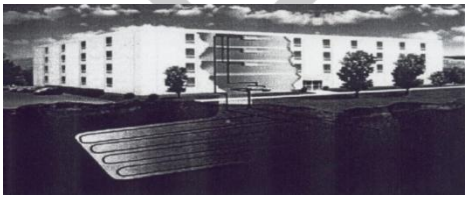
This refrigerant is not 100% compatible with the lubricants and minerals-based refrigerants currently used in R-12.design changes to the condenser and evaporators need to be done to use this refrigerant the use of smaller hoses and 30% increase in control pressure regulation also have to be done to the system .

CHARACTERISTIC OF R134a REFRIGERANT

S.No	Properties	R-134a
1.	Boiling point	-14.9ºF or -26.1ºC
2.	Auto-ignition Temperature	1418 ºF or 770 ºC
3.	Ozone depletion level	0
4.	Solubility in water	0.11% by weight at 77 ºF or 25 ºC
5.	Critical Temperature	252 ºF or 122 ºC
6.	Cylinder colour code	Light Blue
7.	Global Warming potential	1200

CLOSED LOOP:-Closed loop system have a dedicated fluid loop that is circulated within the system (Evaporator, compressor, condenser, expander). Closed loop systems are further broken down into different loop types,

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.

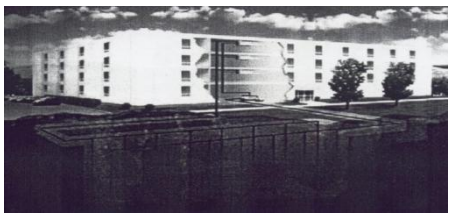


[Fig.5 Representation of the horizontal closed loop system]

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 ft2/ton) than other loop types.

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 ft2/ton.



[Fig.6 Representtion of the Vertical closed loop system]

SLINKY COIL GEOTHERMAL GROUND LOOPS:-Fig.7 shows representation of Slinky Coil Geothermal Ground Loop. Slinky coil geothermal ground loops are gaining popularity, particularly in residential geothermal system installations.

[Fig.7 Slinky coil Geo-thermal ground loop]

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.

V. INTEGRATION OF R134a REFRIGERANT BASED GEO- HEAT EXCHANGERS WITH HVAC SYTEMS:-The Refrigerant R134a coming out of a geo-exchange system is circulated through a cooled condenser to remove heat during summers since the Refrigerant 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 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 Refrigerant R134a 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.

VI. 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.

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 50C of the earth temperature and thus give substantial energy savings.

VII. EXPERIMENTAL SET UP:- Experimental set up consists of following major components which are listed below.

[Fig.8 Experimental setup]

GEOTHERMAL PIT:-Fig.9 shows the Geo-thermal Pit.Pit is the area where the network of pipes carrying refrigerant is installed. As per the geographical location the depth of pit varies. 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.

[Fig.9 Geo-thermal pit]

LOOP OF COPPER PIPES (CONDENSER):- 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.

[Fig.10 Loop of copper pipes]

RECIPROCATING COMPRESSOR:-A reciprocating compressor or piston compressor is a positive-displacement compressor that uses pistons driven by a crankshaft to deliver gases at high pressure. The intake gas enters the suction manifold, then flows into the compression cylinder where it gets compressed by a piston driven in a reciprocating motion via a crankshaft, and is then discharged. Applications include oil refineries, gas pipelines, chemical plants, natural gas processing plants and refrigeration plants. One specialty application is the blowing of plastic bottles made of polyethylene terephthalate (PET). In the ionic liquid piston compressor many seals and bearings were removed in the design as the ionic liquid does not mix with the gas. Service life is about 10 times longer than a regular diaphragm compressor with reduced maintenance during use, energy costs are reduced by as much as 20%. The heat exchangers that are used in a normal piston compressor are removed as the heat is removed in the cylinder itself where it is generated. Almost 100% of the energy going into the process is being used with little energy wasted as reject heat.

[Fig.11 Reciprocating compressor]

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 3×3 inch exhaust fan. The blades are made up of plastic fibre to avoid rusting. The fan blades and the motor are enclosed in a frame for mounting purpose.

[Fig.12 Cooling Fan]

SPECIFICATION OF THE COOLING FAN:-

Amplitude: 1.5mm

Frequency: 10-55 HZ

Acceleration:981m/s^2

Application time : 6ms

Locked rotor protection : The motor is protected from burnout in the locked rotor condition at the rated voltage.

Polarity protection: The fan are reversed polarity protected at the rated voltage.

Insulation class: E class

BATTERY:-The battery used is the INTEX sealed rechargeable battery for the purpose of running the compressor and the fan which is recharged by the solar powered panel system.

Battery capacity = Power requirement (in watts) * Back up hours (in hrs) / Battery Voltage (in volts)

Table 1: Battery Specification

Power Requirement (in watt)	Voltage (in volt)	Running time (in hr)	Capacity(in hr)
20	12	8	14

SOLAR PANEL:-Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating. A photovoltaic (PV) module is a packaged connect assembly of typically 8×10 solar cells. Solar Photovoltaic panels constitute the solar array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions, and typically ranges from 100 to 365 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module.

An avg. Indian summer days will give 8hr of sunshine. So 10W panel will provide 80W worth of energy back into battery (8*10W= 80W)

Table 2: Specifications of Solar panel

SOLAR PANEL WATT	AMP	LENGTH (IN INCH)	WIDTH (IN INCH)	HEIGHT (IN INCH)	WEIGHT (IN POUND)
20	0.57	17.5	7.5	1	4.83

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.13 shows the cooling coil

[Fig.13 Cooling coil]

REFRIGERANT:-The most common refrigerant used for geothermal air conditioner is R134a. Its high heat capacity and low cost makes it a suitable heat transfer medium. Various additives like (ethylene glycol or propylene glycol). Since R134a 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.Fig.14 shows the Refrigerant R134a .

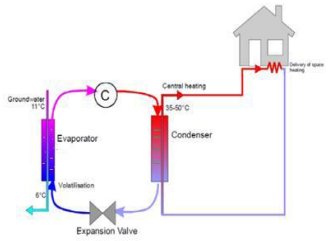
EVAPORATIVE COOLING COIL:-This coil is using the same copper tube fabrication of loop of geothermal heat exchanger. The tube was formed in the shape of helix . Two such cooling coils of 2m length ,each is used for evaporative cooling. These coils were then mounted on the system. An additional fan blowing air on this coil may help to increase the rate of evaporative cooling.Fig.15 shows evaporative cooling coil.

[Fig.14 Evaporative cooling coil]

FABRICATION

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 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.

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.16 shows the typical diagram of Geothermal Air Conditioning.



[Fig.15 Typical diagram of Geo-thermal Air-conditioning]

VIII. EXPERIMENTAL PROCEDURE:-In the experimental set up we used a closed loop system. There should be continuous supply of refrigerant (R134a).Vapour compression Refrigeration system is an improved type of air refrigeration system. The ability of certain liquids to absorb enormous quantities of heat as they vaporize is the basis of this system. Compared to melting solids (say ice) to obtain refrigeration effect, vaporizing liquid refrigerant has more advantages. To mention a few, the refrigerating effect can be started or stopped at will, the rate of cooling can be predetermined, the vaporizing temperatures can be governed by controlling the pressure at which the liquid vaporizes. Moreover, the vapor can be readily collected and condensed back into liquid state so that same liquid can be re-circulated over and over again to obtain refrigeration effect. Thus the vapor compression system employs a liquid refrigerant which evaporates and condenses readily. The System is a closed one since the refrigerant never leaves the system. The Air Conditioning System here undergoes the following four process:-

1. Compression
2. Condensation
3. Expansion
4. Evaporation

Compression :- Low temperature low pressure liquid refrigerant is compressed to high pressure high temperature vapour refrigerant.

Condensation:- High temperature high pressure vapour refrigerant is condensed to liquid refrigerant maintaining constant temperature and pressure .

Expansion – High temperature high pressure liquid refrigerant is converted to low temperature low pressure liquid refrigerant.

Evaporation – low temperature low pressure liquid refrigerant is converted to low temperatur low pressure vapour refrigerant.

As per the Experimental setup, the solar energy is converted into electrical energy with the help of solar panel setup and is stored in the battery .

Now the compressor is run by the power stored in the battery .once the compressor starts the air conditioning cycle starts.

The temperature inside the room is lowered as the heat inside the room is extracted by the evaporator which then rejected to the geo thermal pit by the help of condenser placed inside the ground.

IX. CALCULATION:-

FORMULA USED

$$\textbf{(COP)CARNOT}=\frac{T1}{T2-T1}$$

$$\textbf{(COP)THEORITICAL } =\frac{h1-h4}{h2-h1}$$

$$\textbf{(COP)ACTUAL } =\frac{mcpdT}{x\times 3600}\times t\times \textbf{EMC}$$

Where,
T1 = compressor inlet temperature.
T2 = compressor outlet temperature.
h1 = enthalpy at inlet to the compressor.
h2 = enthalpy at inlet to the condenser.
h4 = enthalpy at inlet to the evaporator.
m = mass flow rate of the refrigerant.
Cp= specific heat capacity of the air .
dT =change in temperature.

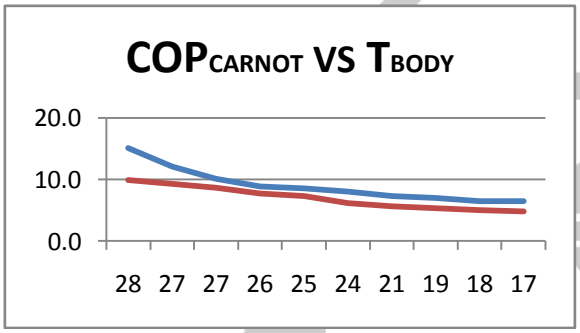
x =5 rev in 44sec of energy meter..
t = time(5min) .
EMC = energy meter constant (1200rev/kwh).
Conventional air conditioning system data.
T1 = 30°c,T2 = 50°c,TBody= 28°c
P1=1.03bar (pressure at inlet the compressor).
p2=8.27bar(pressure at inlet to the condenser).
p3= 8.27bar(pressure at inlet to the expander).
p4=1.03bar(pressure at inlet to the evaporator).

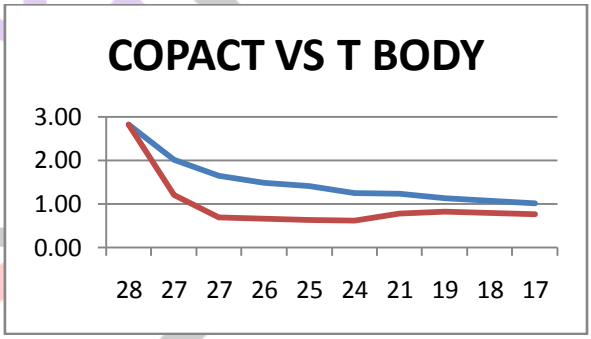
Therefore, $(COP)_{CARNOT}$ **=15.2**
$(COP)_{THEORITICAL}$ **=3.66**
$(COP)_{ACTUAL}$ **=2.81**

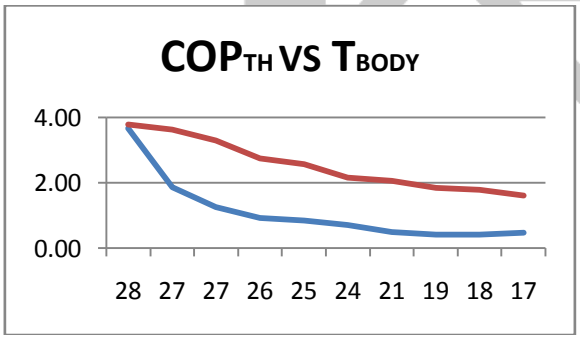
Geo-Thermal Air-conditioning system data
T1 = 25°c,T2 = 55°c,TBody= 28°c
P1=2.06bar (pressure at inlet the compressor).
p2=13.78bar(pressure at inlet to the condensor).
p3= 13.78bar(pressure at inlet to the expander).
p4=2.06bar(pressure at inlet to the evaporator).

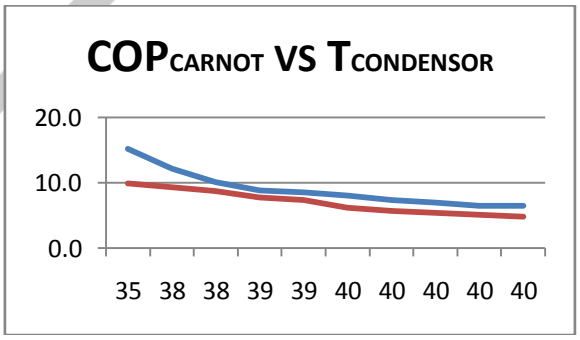
Therefore, $(COP)_{CARNOT}$ **=9.93**
$(COP)_{THEORITICAL}$ **=3.78**
$(COP)_{ACTUAL}$ **=2.81**

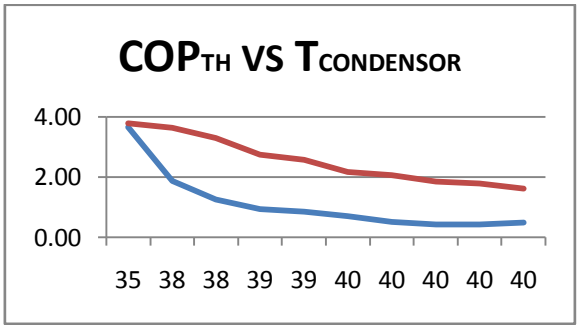
X. RESULTS:-

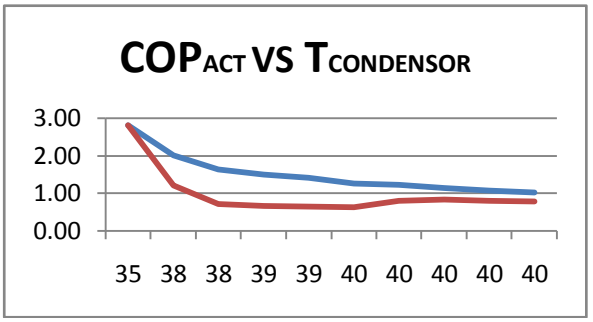












In the above Graph ,

REDColoured Curve represents Geo-Thermal Air Conditioning System.

BLUECloured Curve represents Conventional Air conditioning system.

XI. 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 28ºC 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.
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.
The system can use electricity produced from renewable sources, like solar and wind power, to heat and cool down spaces much more efficiently than a conventional air conditioner. This makes the system complete green, 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.

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