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Mechanical Engineering

Elixir Mech. Engg. 83 (2015) 33294-33297

ISSN: 2229-712X

# Performance Investigation of Hybrid Air Conditioning System with and without combined Earth Heat Exchanger and Peltier Module

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**ARTICLE INFO**

**Article history:**
Received: 16 April 2015;
Received in revised form:
20 June 2015;
Accepted: 25 June 2015;

**Keywords**
Air conditioning,
Peltier effect,
Earth heat exchanger,
Ground source, Energy saving.

**ABSTRACT**

Air conditioning system is highly required device for getting comfort to human being also in industry application. But this device is hungry of lager amount of electricity. The ever increasing energy requirement puts a great burden on the further economical development as India is poor in energy resources. How to reduce the energy consumption by using new energy saving technologies and equipment is an important task now days. A study was carried out to investigate the effect of Earth Heat Exchanger ( Heat Pipe) , Peltier Module with and without combination with vapour compression air conditioning system with return air. The results show that the coefficient of performance of the system can be improved and the energy required by the compressor can be reduced when Peltier Module and Earth Heat Exchanger is used before cooling coil and provide supplementary cooling air to evaporator coil. On the basis of this study, it is recommended that HVAC systems should be installed with Earth (heat pipe) heat exchangers and peltier module for dehumidification enhancement.



## Introduction

In the present age with depleting sources of energy, there is always a target to get the best energy ratios so that there will be minimum electric power consumption in operation of the air conditioning units. Manoj Kumar Rawat et al [6] studied experimentally that, Thermoelectric Refrigeration system and they have been designed and developed an experimental thermoelectric refrigeration system having a refrigeration space of 1 liter is cooling by four numbers of thermoelectric cooling module. C. K. Loh, Danie [9] studied experimentally, thermoelectric devices (TED) are also being used as the heat source in heat sink laboratory experiments. The primary benefit of using a TED as a heat source in laboratory testing is that the TED is a unidirectional heat pump. Lakhi Nandlal Goenka [11] studied experimentally that, the HVAC system including at least one thermoelectric device for providing supplement heating and cooling for air supplied to compartment. The first circuit can configure to remove the heat from an electric side of a hybrid vehicle. The second circuit can configure to remove heat from a fuel-fed of a hybrid side. Uğur Kemiklioğlu, Selim Solmaz [13] described a novel air conditioning system based on thermo-electric cooling or the Peltier effect materials that is designed specifically for automotive vehicles. The design is motivated by the fact that Peltier elements can provide hot and cold flow on demand and they do not necessarily require moving parts. Prof. N. B. Totala, Prof. V. P. Desai, Rahul K. N. Singh [14] Thermoelectric devices (thermoelectric modules) can convert electrical energy into a temperature gradient. The application of this cooling or heating effect remained minimal until the development of semiconductor materials. Judith Koetzsch & Mark Madden[6] discussed how thermoelectric coolers work, improvements that have been made in their efficiency and the advantages of thermoelectric cooling for industrial enclosures.

A.M. Alklaibi [4] evaluated; a loop heat pipe integrated the possible configurations of incorporating to the air-conditioning system to perform the reheat process for the purpose of reducing the energy consumption, evaluated and compared them to the conventional way of performing the reheat process. J.W. Wan et al [3] investigated the effect of heat-pipe air-handling coil on energy consumption in a central air-conditioning system with return air. By taking an office building as an example, the study shows that compared with conventional central air-conditioning system with return air, the heat-pipe air-conditioning system can save cooling and reheating energy. Yat H. Yau [5] experimentally investigated that, tropical HVAC systems installed with heat pipe heat exchangers for dehumidification enhancement and saving the energy. Dr.Obaid T.Fadhil Dr.Ahmed A.M.Saleh[12] study carried to compare the thermal performance of a sintered powder metal wick heat pipe. Pure water and absolute ethanol are used as two different working fluids.

Many methods and ideas like evaporative cooling, thermoelectric cooling etc. have been tried to keep the electricity consumption to a minimum in air conditioning applications. Individually these ideas do not stand good but by combination of two or more concepts in a collaborative manner stands a possibility to develop an energy efficient method of air conditioning. Thus there is a proposal to use the conventional vapour compression cycle in conjunction to thermoelectric cooling (Peltier Module) and earth heat exchanger technique to reduce the power consumption of the air conditioner and thereby increase in COP of system.

This combined effect technique can be applied to low cost domestic cooling, commercial and industrial installations. Hence there is scope to investigate the performance of Hybrid Air Conditioning system with and without combined Earth heat exchanger and Peltier module.

## Experimental Setup

Performance tested with and without combined Earth Heat Exchanger and Peltier Module. The schematic view of experimental setup to study the performance of Hybrid Air Conditioning System is as shown in fig.1. Experimental setup

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consists of with and without combination of Earth heat exchanger, Peltier module with conventional vapour compression system, which is placed before and parallel to evaporator to provide supplemental cooling air to conditioned space.

Peltier module consists of two bonded semiconductors, and power provides to module by AC or DC 12 volt. Peltier cooling causes heat to be absorbed from the vicinity of the cooling plate and to move to the heat sink. The heat is carried through the cooler by electron transport and released on the hot side as the electrons move from a high to low energy state. Current passing across the junction results in either a forward or reverse bias, resulting in a temperature gradient. If the temperature of the heat sink is kept low by removing the generated heat, the temperature of the cold plate can be cooled by tens of degrees.

Earth heat exchanger is an underground heat exchanger that can capture heat from ambient air and dissipate heat to the ground. The fan then blows across this cooled surface and circulates cooled air throughout the enclosure as shown in fig 1. When the cooling air flows across the Earth heat exchanger, Peltier module and the precooled air passes through the cooling coil, they reduces the temperature of air and also load on the cooling coil.

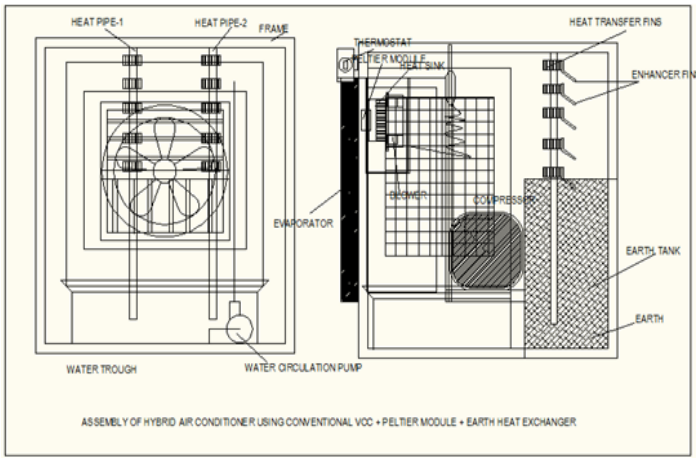
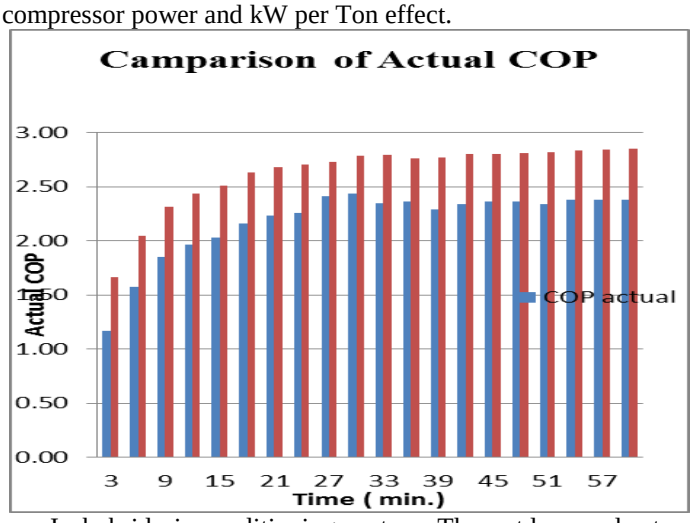



**Figure 1.0 Experimental setup**

In conventional air condition system ,the outdoor and return air is mixed before evaporator. The cooled supply air leaving the coil is further delivered to the room which get the latent and sensible loads in the room. Table 1 shows the result of conventional air condition system which includes actual COP, compressor power and kW per Ton effect.



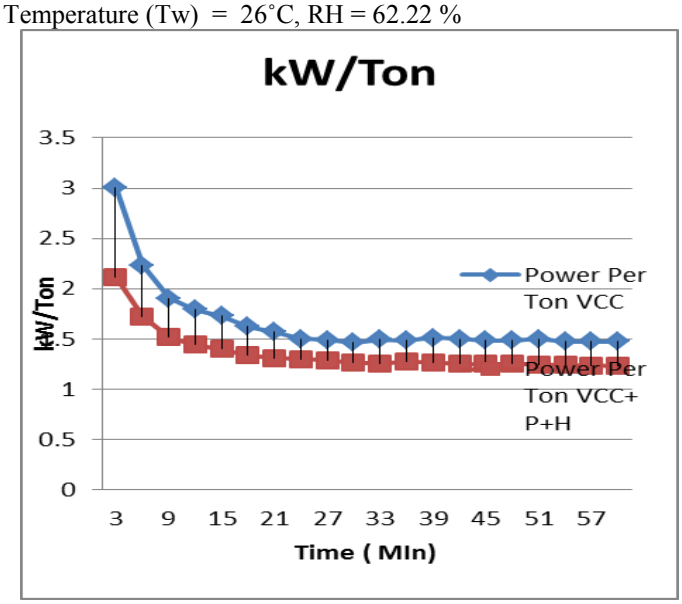

In hybrid air conditioning system, The outdoor and return air is passed e through the Earth heat exchanger, Peltier Module and cooling coil. Table 2 shows the details.

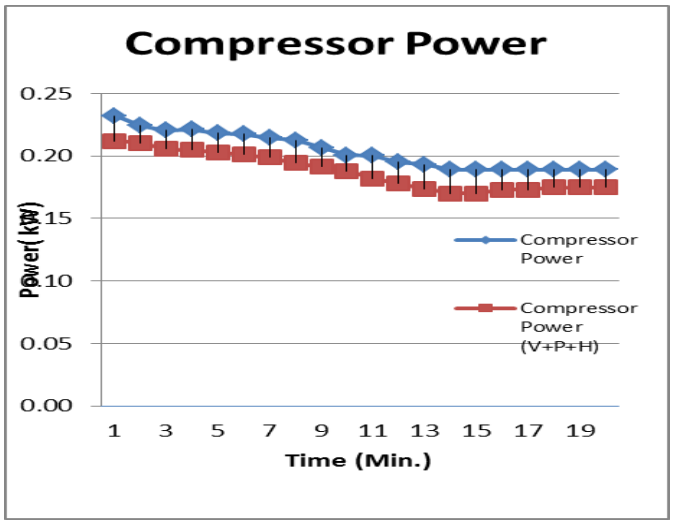
The effectiveness of Earth heat exchanger is of actual heat transfer to maximum possible heat transfer.

**Table No 1 And 2:**

Initial condition:

Ambient Temperature (To) = 32˚C DBT , Wet Bulb Temperature (Tw) = 26˚C, RH = 62.22 %




**Results and Discussion:**

The Lower DBT 19.5°C show it is very beneficial in reduce the temperature of air entering in cooling coil via earth heat exchanger and peltier module. This results shows the reduce the consumption of compressor power as well as cooling coil capacity. It had been shown from testing results that the Thermoelectric cooling system is capable of cooling & heating the air when re circulating the air with the help of Peltier module.Peltier module cooling designed was able to cool an ambient air temperature from 32°C to 26°C. Cooling stabilizes within ten minutes once the blower is turned ON. The system can attain a temperature difference of set target which was 5-6°C. Result indicates worse efficiency compared to a typical AC system based on a cooling cycle. Performance of earth heat exchanger reduces after saturation of working fluid.

**Conclusion:**

Hybrid Air condition system beneficial for reduce the energy consumption and kW power per ton of cooling coil. Outdoor and return air dry bulb temperature, effectiveness of earth heat exchanger and cooling ability of Peltier module are the governing parameters that affect the overall saving in cooling coil capacity and compressor power.

**Table 1. Test on Vapour compression system**

| Sr.No. | Time | Mixed Air (Outlet)˚c | (Inlet)˚c | | RH | Compressor Power | Refrigerant Effect | COP actual | Power / Ton VCC |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Tr | Dry | Wet | % | KW | KW | | kW/Ton |
| 1 | 3 | 31.5 | 28.5 | 23 | 61 | 0.23 | 0.272 | 1.17 | 3.01 |
| 2 | 6 | 30.4 | 26.5 | 21.1 | 60 | 0.22 | 0.353 | 1.58 | 2.23 |
| 3 | 9 | 30.2 | 25.7 | 20.4 | 60 | 0.22 | 0.407 | 1.85 | 1.90 |
| 4 | 12 | 29.6 | 24.8 | 19.5 | 59 | 0.22 | 0.434 | 1.96 | 1.79 |
| 5 | 15 | 29.5 | 24.6 | 19.2 | 57 | 0.22 | 0.444 | 2.03 | 1.73 |
| 6 | 18 | 29.4 | 24.2 | 18.8 | 58 | 0.22 | 0.471 | 2.16 | 1.63 |
| 7 | 21 | 29.3 | 24 | 18.7 | 58 | 0.21 | 0.480 | 2.24 | 1.57 |
| 8 | 24 | 28.5 | 23.2 | 17.7 | 57 | 0.21 | 0.480 | 2.25 | 1.56 |
| 9 | 27 | 28.7 | 23.2 | 17.6 | 57 | 0.21 | 0.498 | 2.41 | 1.46 |
| 10 | 30 | 28.5 | 23.1 | 17.5 | 56 | 0.20 | 0.489 | 2.44 | 1.44 |
| 11 | 33 | 28 | 22.8 | 17.2 | 55 | 0.20 | 0.471 | 2.35 | 1.50 |
| 12 | 36 | 27.5 | 22.4 | 17 | 56 | 0.20 | 0.462 | 2.37 | 1.49 |
| 13 | 39 | 27.5 | 22 | 16.5 | 55 | 0.19 | 0.443 | 2.29 | 1.54 |
| 14 | 42 | 27.5 | 22 | 16.4 | 54 | 0.19 | 0.443 | 2.34 | 1.50 |
| 15 | 45 | 27.3 | 21.7 | 16..2 | 54 | 0.19 | 0.447 | 2.36 | 1.49 |
| 16 | 48 | 27.3 | 21.7 | 16.1 | 54 | 0.19 | 0.447 | 2.36 | 1.49 |
| 17 | 51 | 27 | 21.5 | 15.9 | 53 | 0.19 | 0.443 | 2.34 | 1.50 |
| 18 | 54 | 27 | 21.4 | 15.8 | 53 | 0.19 | 0.451 | 2.38 | 1.48 |
| 19 | 57 | 27 | 21.4 | 15.7 | 53 | 0.19 | 0.451 | 2.38 | 1.48 |
| 20 | 60 | 27 | 21.4 | 15.6 | 52 | 0.19 | 0.451 | 2.38 | 1.48 |

**Table 2. Hybrid Air Conditioning System**

| Sr. No. | Time | Return Air | Heat Pipe leaving Temp. | Peltier Module leaving Temp. | (Inlet)˚c | | RH | Compressor Power (V+P+H) | Refrigeranting Effect | VCC+H+P (COP actual) | Power Per Ton VCC+ P+H |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | ˚c | ˚c | ˚c | Dry | Wet | % | kW | KW | | kW/ Ton |
| 1 | 3 | 30.8 | 29.3 | 28.3 | 26.9 | 21.5 | 60 | 0.21 | 0.352 | 1.66 | 2.117 |
| 2 | 6 | 29.9 | 28.4 | 27.4 | 25.2 | 19.8 | 59 | 0.21 | 0.430 | 2.04 | 1.721 |
| 3 | 9 | 29.8 | 28.3 | 27.4 | 24.5 | 19.2 | 59 | 0.21 | 0.476 | 2.32 | 1.518 |
| 4 | 12 | 29.5 | 28.1 | 27.0 | 24.0 | 18.6 | 58 | 0.20 | 0.499 | 2.44 | 1.444 |
| 5 | 15 | 29.0 | 27.4 | 26.5 | 23.4 | 18.2 | 59 | 0.20 | 0.508 | 2.51 | 1.403 |
| 6 | 18 | 28.7 | 27.6 | 26.5 | 22.9 | 17.6 | 57 | 0.20 | 0.529 | 2.63 | 1.335 |
| 7 | 21 | 28.5 | 27.4 | 26.4 | 22.6 | 17.4 | 57 | 0.20 | 0.532 | 2.68 | 1.312 |
| 8 | 24 | 28.4 | 26.8 | 25.9 | 22.6 | 17.3 | 57 | 0.19 | 0.525 | 2.70 | 1.301 |
| 9 | 27 | 28.0 | 26.4 | 25.5 | 22.2 | 16.8 | 56 | 0.19 | 0.523 | 2.73 | 1.287 |
| 10 | 30 | 27.8 | 26.2 | 25.3 | 22.0 | 16.6 | 56 | 0.19 | 0.523 | 2.78 | 1.264 |
| 11 | 33 | 26.9 | 25.2 | 24.2 | 21.3 | 15.9 | 55 | 0.18 | 0.508 | 2.79 | 1.259 |
| 12 | 36 | 26.5 | 25.1 | 24.1 | 21.1 | 15.8 | 55 | 0.18 | 0.491 | 2.76 | 1.273 |
| 13 | 39 | 26.3 | 24.0 | 23.8 | 21.0 | 15.6 | 54 | 0.17 | 0.482 | 2.77 | 1.268 |
| 14 | 42 | 26.2 | 24.7 | 23.8 | 21.0 | 15.5 | 54 | 0.17 | 0.476 | 2.80 | 1.255 |
| 15 | 45 | 26.0 | 24.5 | 23.6 | 20.8 | 15.3 | 53 | 0.17 | 0.477 | 2.80 | 1.255 |
| 16 | 48 | 25.8 | 24.5 | 23.5 | 20.4 | 14.8 | 52 | 0.17 | 0.486 | 2.81 | 1.250 |
| 17 | 51 | 25.7 | 24.3 | 23.5 | 20.3 | 14.5 | 50 | 0.17 | 0.488 | 2.82 | 1.246 |
| 18 | 54 | 25.4 | 24.2 | 23.5 | 19.9 | 14.2 | 51 | 0.17 | 0.495 | 2.83 | 1.242 |
| 19 | 57 | 25.3 | 24.1 | 23.4 | 19.8 | 14 | 50 | 0.17 | 0.497 | 2.84 | 1.237 |
| 20 | 60 | 25.0 | 24.1 | 23.4 | 19.5 | 13.8 | 50 | 0.17 | 0.499 | 2.85 | 1.233 |

Additionally earth heat exchanger used for dehumidification enhancement, does not require any external power also do not have any moving part.

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