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Experimental analysis of air Conditioner by Combination of Different Techniques

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ABSTRACT: In the world scenario the biggest problem is always attach with energy. We are facing a large scarcity of energy and for that it will always beneficial to minimize the energy consumption. So for that this paper contain an experimental method by which we can see how much energy we can save by applying three different energy source for establishing an air conditioning system. While in three energy source one is conventional energy source and another two is non conventional energy source. The conventional energy source is applied to simple vapor compression cycle and non conventional energy source is applied to extract energy from peltier effect and earth heat exchanger. This paper also contains a big role of heat pipe which is used to transport energy from on point to other. This project also contains the compression of energy consumption with three different conditions which are:

1. ***When only vapor compression cycle is used.***
2. ***When vapor compression cycle is used with earth heat exchanger.***
3. ***When vapor compression cycle is used with earth heat exchanger as well as peltier moduel.***

I. INTRODUCTION

The effect of air-conditioning demand makes the energy consumption has been increasing quickly. The investigation report shows that of the total energy consumption in buildings in Metro city, the energy amount used by air-conditioning system is 46.1% in restaurant building, 40.5% in commercial building, 49.7% in office building, and 30.3% in hospital building. 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. In order to reduce the energy consumption in air-conditioning building, apparatus dew-point air supply is usually used in air-Conditioning systems. But as the moist air leaving the cooling coil is usually too high in relative humidity (about 95% Rh) and too low in temperature to be used in occupied spaces directly, people usually feel uncomfortable. Besides, if the relative humidity in occupied spaces and low-velocity ducts and plenums exceeds 70%, fungal contamination such as mold, mildew, etc., can occur and threatens public health. Therefore, from the requirement of keeping good indoor thermal comfort and air quality, and of reducing the risk of catching disease, it is a strong recommendation to keep the supply air humidity below 70%. This means that relative humidity control in the air supply is important aspect. But if conventional cooling coils are used to improve the indoor thermal comfort and air quality, external energy will be used to reheat the air stream from the apparatus dew-point to the required air supply state. To solve this problem, a Peltier Module and Earth heat Exchanger air-handling coil can be employed [1].

II. Problem statement

In order to study the performance of combined air conditioning system and analysis of the variation of COP in different combination of vapor compression system, earth heat exchanger and Peltier Module, the experimental setup is being arranged and fabricated, along with vapor compression system. Testing and performance analysis of newly combined air conditioning system will be done at different experimental setup, and then affecting system parameters will be analyzed. Suitable manufacturing methods will be employed to fabricate the components and then assemble the test setup. The fabrication will be carried out as per layout shown below. Test & Trial on hybrid peltier air conditioner determine, temperature gradient, cooling ability (tonnage) and COP of system, under given conditions and derive performance characteristic.

III. Objective

The main objective of this investigation is to study the performance of the Hybrid Air Conditioning System. The proposed work includes the determination of heat load, to maintain 13 to 15ºC temperature in the cabinet of volume close to 5 liters.

1) Test &Trial on combined air conditioner determine temperature gradient, cooling ability (tonnage) and COP of system, under given conditions
- Vapor Compression Air Conditioning unit and derive performance characteristic
- Vapor Compression Air Conditioning unit with Earth heat exchanger unit and derive performance characteristic
- Vapor Compression Air Conditioning with Peltier module unit and derive performance characteristic.
- Vapor Compression Air Conditioning with Earth heat exchanger and Peltier module unit and derive performance characteristic.

2) Performance analysis of combined air conditioner with temperature under given conditions
- Vapor Compression Air Conditioning unit and derive performance characteristic
- Vapor Compression Air Conditioning unit with Earth heat exchanger unit and derive performance characteristic
- Vapor Compression Air Conditioning with Peltier module unit and derive performance characteristic.
- Vapor Compression Air Conditioning with Earth heat exchanger and Peltier module unit and derive performance characteristic.

3) Performance analysis of combined air conditioner with load under given conditions
- Vapor Compression Air Conditioning unit and derive performance characteristic
- Vapor Compression Air Conditioning unit with Earth heat exchanger unit and derive performance characteristic.
- Vapor Compression Air Conditioning with Peltier module unit and derive performance characteristic.
- Vapor Compression Air Conditioning with Earth heat exchanger and Peltier module unit and derive performance characteristic.

IV. LITERATURE REVIEW

In view of proposed dissertation work concerned, following few of the researchers have done their experimental study and investigated results which have been review as follows

Ankit kumar & Rajneesh Kumar Gedam [1] The demand of air –conditioning system makes the consumption of energy very largely. According to world energy report it shows that from the total available energy the total energy consumption in different buildings in metro city only by air-conditioning system is around 46.1% while by restaurant it is found to be 40.5%. Other than this commercial building and hospital building used 49.7% and 30.3% respectively of their useful energy on air conditioning system. So in this project the main concept is to investigate the performance of hybrid air conditioning system.Also to determine the heat load to maintain 22 to 25^0C temperature in the closed volume. Another point is comparison between different available system and also the performance and testing of different system with different combination.

Kumar Rawat et al [2] 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 (Q_{max}=19W) and a heat sink fan assembly (R_{th}=0.50 ºC/W) for each thermoelectric module used to increase heat dissipation rate. A temperature reduction of 11º C without any heat load and 9º C with 100 ml of water in refrigeration space with respect to 23º C ambient temperature has been experimentally found in first 30 minutes at optimized operating conditions. The calculated COP of thermoelectric refrigeration cabinet was 0.1. Also compatibility of thermoelectric cooling systems with solar energy made them more useful and appropriate for environment protection.

M.J. Goldsworthy [3] Residential buildings should be places in which their occupants feel comfortable and content. In an energy conscious world the challenge of offering improved indoor comfort is contrast with the desire to minimize grid energy consumption (both from an efficient distribution perspective and to minimize fossil fuel consumption) as well as the associated cost. Selecting the most cost effective building designs or modifications that met these dual goals regardless of occupant behavior is a non-trivial task. One way of approaching this problem that guarantees no grid connected energy usage is to use an off-grid PV battery driven air-conditioner. Here we use a detailed simulation model to investigate the suitability of a small off-grid PV-battery system to power an air-conditioner to provide occupant comfort for a range of different building thermal designs across Australian climates. Results show that even in tropical climates, there are certain building thermal designs that lead to indoor temperatures <25°C at all times with a modest size PV-battery system.

Christine Junior et al [4] Thermoelectric technology allows for the direct conversion of a temperature difference into an electric potential and vice versa. Thermoelectric devices can act as coolers, heaters, or power generators and applications of small capacity thermoelectric modules are widespread. Applications of large capacity thermoelectric devices have been limited for decades by their low efficiency. New environmental regulations regarding the manufacture and release of CFCs have revived the interest in this area. Recent investigations on thermoelectric materials promise that their thermoelectric efficiency can be improved dramatically. This would mean a breakthrough for new fields of applications for thermoelectric modules. A new Modelica model of a Peltier water-water heat exchanger was developed for transient simulations. The new model uses component models from the objectoriented Modelica library TIL. The new model was used to simulate the transient behavior of a Peltier heat exchanger during a sudden reversion of the applied voltage. The numerical results were compared to measurement results from a prototype.

Lisa Mucke et al [5] In conventional air-conditioning systems with vapour compression cycles the dehumidification is realized by cooling the air below the dew point of the supply air. One possibility to avoid cooling the air below the dew point and thus to reduce the electric energy demand of air-conditioning systems are hybrid liquid desiccant air-conditioning systems (HLDACS) which use an open absorption cycle for dehumidification of the air. This conceptual study examines four different HLDACS with respect to their electric energy demand and shows energy saving potentials compared to a conventional air-conditioning system for three different climatic design conditions. All considered systems consist of an open absorption system in combination with either a vapour compression system (VCS) or an indirect evaporative cooling system. The results show that electric energy savings of 30 to 60 % depending on the HLDACS and climates are possible.

Muhammad Tauseef [6] Thermal performance of several combinations of working fluids in the Organic Rankine Cycle (ORC) powered Vapor Compression Cycle (VCC), for the domestic air conditioning. Seven working fluids, R245fa, R123, R134a, R1234yf, R1234ze (E), Butane and Isobutane were considered and a total of forty nine candidates were analyzed. The objective was defined to provide air at 15 °C to a space whose temperature was desired to be at 24 °C, as the outdoor temperature varies from 30 °C – 40 °C. The hot water at 100 °C and 1.5 atm was considered as the heat source. With pressure ratios, COP, mass flow rates and the ratio of COP to pressure ratio as the performance indicators, Isobutane gave the best performance in the standalone VCC. For the ORC as the prime mover for the VCC, by considering the system thermal efficiency, cycle pressure ratios, mass flow rates and expander outlet volumetric flow rates as the criteria, R134a was found to be the best candidate. Henceforth R134a ORC-Isobutane VCC was the best combination. and by optimizing the system parameters of the VCC condenser sub cooling, its condenser temperature and the ORC condenser pressure, this combination gave a COP of 0.219, with dry air at the VCC evaporator inlet and 0.281, with 50% relative humidity air at the VCC evaporator inlet.

Jean Peltier [7] Thermoelectric are based on the Peltier Effect, The Peltier Effect is one of the three thermoelectric effects; the other two are known as the Seebeck Effect and Thomson Effect. Whereas the last two effects act on a single conductor, the Peltier Effect is a typical junction phenomenon. Thermoelectric coolers are solid state heat pumps used in applications where temperature stabilization, temperature cycling, or cooling below ambient are required. There are many products using thermoelectric coolers, including CCD cameras (charge coupled device), laser diodes, microprocessors, blood analyzers and portable picnic coolers. This article discusses the theory behind the thermoelectric cooler, along with the thermal and electrical parameters involved.

Xin Zheng at el [8] A multiple energy source air-conditioning system was developed for large office buildings in Beijing, China to reduce the energy consumption and improve the energy utilization in public buildings. Three systems are compared with an air source heat pump system, a ground source heat pump coupled with an air source heat pump system and a solar assisted ground source heat pump coupled with an air source heat pump system. Cost-benefit analyses are given for each type of air conditioning system. The building load was computed using the DeST simulation software. Economic indicators are used to evaluate the systems economics in terms of the initial investment, life cycle cost (LCC), operating cost, payback period, energy conservation rate and cooling and heating cost in hourly moments. The results indicate that the multiple energy sources system has better energy conservation and economics. For a solar heating fraction of 40% to building loads, the required solar heat collector area is 135m2, the energy conservation rate is 43.18% and the payback period is 2.76 years. Although the initial investment is greater than for the other systems, the operating costs are lower at 65932 CNY/year and LCC is lowest at 863300 CNY. The lowest heating costs among the three systems are at 760 CNY/kJ.

Haitao Wang et al [9] A heat pipe air conditioning (AC) system which used heat pipe heat exchanger (HPHE) to realize secondary heat recovery was proposed. With the meteorological parameter of Hefei city (31◦53_N and 117◦15_E) asthe reference, we analyzed the consuming energy between secondary heat recovery HPHE AC system and the common heat recovery HPHE AC system theoretically. The analysis of experimental data revealed thatthe average heat recovery efficiency of the HPHE AC system in winter is 21.08%, while 39.2% in summer.The results show that the secondary heat recovery HPHE AC system has a certain energy-saving advantage.

Chetan Jangonda et al [10] In recent years, with the increase awareness towards environmental degradation due to the production,use and discharge of ChloroFluoro Carbons (CFCs) and Hydro Chlorofluorocarbons (HCFCs) as heat carrier fluids in conventional refrigeration systems has become a subject of great concern and resulted in extensive research into development of refrigeration technologies. Thermoelectric operated cooler provides a best alternative in refrigeration technology due to their distinct advantages. While using thermoelectric effect in system the COP of the system also increases. A brief introduction of thermoelectricity, principal of thermoelectric cooling and thermoelectric materials has been presented in this paper. The literature review of some research paper has been seen in this paper. The purpose of this paper to review on various application of thermoelectric phenomenon by using thermoelectric module technology.

Above literature review reveals that.

1) Most of the research work has been carried on hybrid air conditioning with conventional VCC and thermoelectric cooling (Peltier Module) provide supplemental heating and cooling for air supplied to conditioned space. And enhance COP of the system.
2) Some of the research has been carried on conventional VCC and Earth heat exchanger indicates that air-conditioning system can significantly reduce its energy consumption and improve both the indoor thermal comfort and air quality when a heat-pipe air-handling coil is employed in the air-conditioning process, enhancement the dehumidification of the system

V. PROPOSED EXPERIMENTAL SET-UP

5.1 Heat pipes

Heat pipes are two-phase heat transfer devices with high effective thermal conductivity. Due to the high heat transport capacity, heat exchanger with heat pipes has become much smaller than traditional heat exchangers in handling high heat fluxes. With the working fluid in a heat pipe, heat can be absorbed on the evaporator region and transported to the condenser region where the vapor condenses releasing the heat to the cooling media

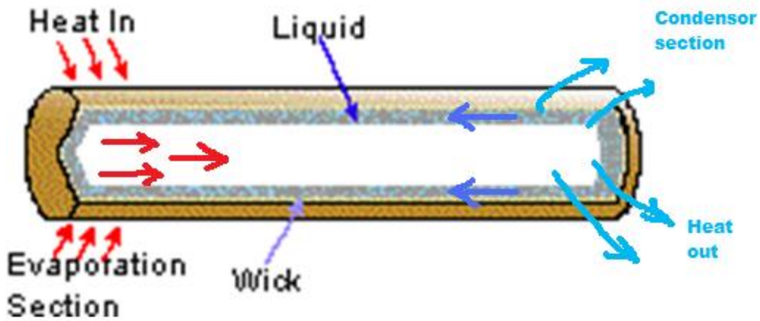

Fig No.1. Heat pipe.

When heat is added to the evaporator section, the working fluid boils and converts into vapour absorbing latent heat. After reaching the condenser section, due to partial pressure build up, the vapour transforms back into liquid thus releasing latent heat. From the condenser section, heat is taken away by means of water cooling / air cooling with fins etc. The liquid condensate returns to the original position through the capillary return mechanism, completing the cycle. Due to very high latent heat of vaporization a large quantity of heat can be transferred.

A heat pipe is a simple device that can transfer heat from one point to another without having to use an external power supply. It is a sealed tube that has been partially filled with a working fluid. In HVAC applications, this fluid is refrigerant. The sealed refrigerant - which will boil under low-grade heat - absorbs heat from the warm return air such as in an air-conditioning system and vaporizes inside the tube. The vapor then travels to the other end of the heat pipe (the high end), which is placed in the stream of cold air that is produced by the air conditioner. The heat that was absorbed from the warm air at the low end is now transferred from the refrigerant's vapor through the pipe's wall into the cool supply air. This loss of heat causes the vapor inside the tube to condense back into a fluid. The condensed refrigerant the travels by gravity to the low end of the heat pipe where it begins the cycle all over again.

5.2 Air conditioner

An air conditioner (often referred to as AC) is a home appliance, system, or mechanism designed to dehumidify and extract heat from an area. The cooling is done using a simple refrigeration cycle. In construction, a complete system of heating, ventilation, and air conditioning is referred to as "HVAC". Its purpose, in a building or an automobile, is to provide comfort during either hot or cold weather.

An air conditioning unit:

1. The coils and pipes in an air conditioning unit contain refrigerant gas. The refrigerant gas enters the compressor as warm, low-pressure gas and leaves it as hot, high-pressure gas.
2. In the condenser coils, hot, compressed refrigerant gas loses heat to the outdoor air and becomes liquid while it is still warm.
3. The warm, liquid refrigerant passes through the tiny opening of the expansion valve, expands, and partly turns to gas at a low temperature.
4. In the cooling coils, the refrigerant takes up heat from the indoor air and leaves the coils as warm, low-pressure gas.
5. The indoor air gives up heat to the refrigerant in the cooling coils and also loses moisture as it is chilled. The moisture condenses on the coils and trickles down to outside drain holes. Cooled air is blown back into the room.

5.3. Vapor-compression cycle

The vapor-compression cycle is used in most household refrigerators as well as in many large commercial and industrial refrigeration systems. Figure 5 provides a schematic diagram of the components of a typical vapor-compression refrigeration system.

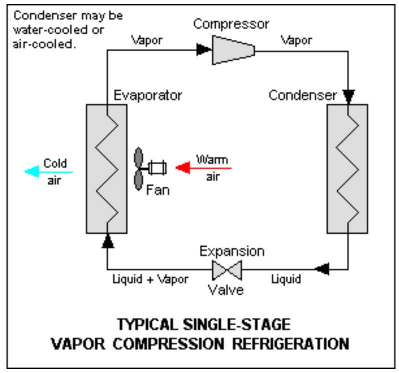

Fig No.2. Vapor-compression refrigeration

That results in a mixture of liquid and vapor at a lower temperature and pressure. The cold liquid-vapor mixture then travels through the evaporator coil or tubes and is completely vaporized by cooling the warm air (from the space being refrigerated) being blown by a fan across the evaporator coil or tubes. The resulting refrigerant vapor returns to the compressor inlet to complete the thermodynamic cycle.

The above discussion is based on the ideal vapor-compression refrigeration cycle, and does not take into account real-world effects like frictional pressure drop in the system, slight thermodynamic irreversibility during the compression of the refrigerant vapor, or non-ideal gas behavior (if any).

5.4 Peltier module

The Peltier effect was discovered in 1834 by a French watchmaker and part time physicist Jean Charles Athanase Peltier.

Peltier found thatthe use of a current at an interface between two dissimilar materials results in the absorption of heat and release of heat at the subatomic level, this is a result of the different energy levels of materials, particularly n and p type materials. As electrons move from p type material to n type material, electrons jump to a higher energy state absorbing energy, in this case heat, from the surrounding area. The reverse is also true. As electrons move from n type material to p type material, electrons fall to a lower energy state releasing energy to the surrounding area [18].

5.4.1 Features of peltier module-

1. Peltier module can convert thermal energy into electricity, or when electricity is provided to the peltier module then absorption of heat(cool side) on one side and rejection of heat(hot side) on other side.
2. Conventional systems can use or generate harmful gasses like ChloroFluoro Carbons (CFCs) and Hydro Chlorofluorocarbons (HCFCs).The peltier module can’t use or generate these harmful gasses.
3. The conventional refrigeration system can generate some noise during operation. The peltier module can’t generate any noise during operation. It is quite in operation.
4. Peltier module can operate on DC power source.
5. By using proper closed loop circuit, the peltier module can control precise temperature.
6. Long life, with mean time between failures (MTBF) exceeding 100,000 hours.
7. Controllable via changing the input voltage/current [18].

5.4.2 Peltier construction

Two unique semiconductors, one n-type and one p-type, are used because they need to have different electron densities. The semiconductors are placed thermally in parallel to each other and electrically in series and then joined with a thermally conducting plate on each side. When a voltage is applied to the free ends of the two semiconductors there is a flow of DC current across the junction of the semiconductors causing a temperature difference. The side with the cooling plate absorbs heat which is then moved to the other side of the device where the heat sink is. TECs (Thermoelectric cooler) are typically connected side by side and sandwiched between two ceramic plates. The cooling ability of the total unit is then proportional to the number of Thermoelectric cooler in it. When two conductors are placed in electric contact, electrons flow out of the one in which the electrons are less bound, into the one where the electrons are more bound. The reason for this is a difference in the so-called Fermi level. Between the two conductors Fermi level represents the demarcation in energy within the conduction band of a metal, between the energy levels occupied by electrons and those that are unoccupied.

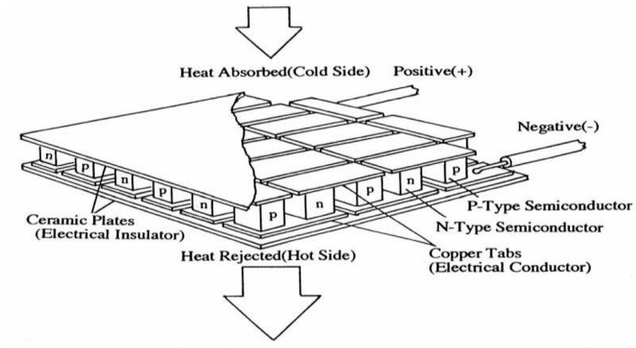

Fig No.3. Working principle of thermoelectric module.

When two conductors with different Fermi levels make contact, electrons flow from the conductor with the higher level, until the change in electrostatic potential brings the two Fermi levels to the same value. (This electrostatic potential is called the contact potential.). Current passing across the junction results in either a forward or reverse bias, resulting in a temperature gradient. If the temperature of the hotter junction (heat sink) is kept low by removing the generated heat, the temperature of the cold plate can be cooled by tens of degrees[18].

5.5 Proposed Experimental Set-up -

Suitable manufacturing methods will be employed to fabricate the components and then assemble the test set –up. The fabrication will be carried out as per layout shown below

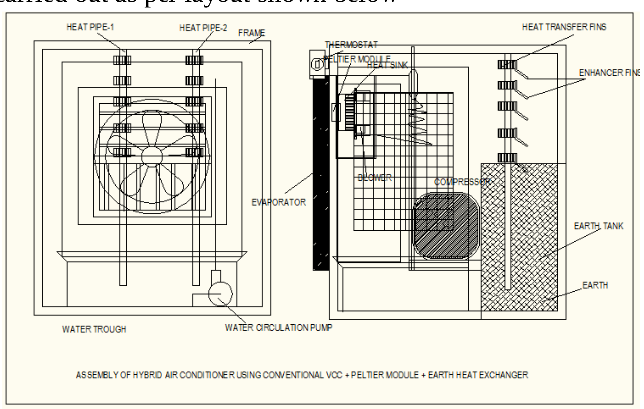

Fig No.4. Experimental proposed setup.

Experimental setup consists of conventional vapor compression system, Peltier module, Earth heat exchanger. Peltier module and Earth heat exchanger located parallel to evaporator which is minimize the incoming temperature of air and pass to space where area to be conditioned through evaporator. And check the validity of experimental results with theoretical calculations. Carry out comparative study of experimental and experimental analysis results to decide the optimization of number of peltier units and heat-exchanger units to achieve a desired temperature gradient. The fabrication will be carried out as per layout shown below. Test & Trial on hybrid peltier air conditioner determine, temperature gradient, cooling ability (tonnage) and COP of system, under given conditions and derive performance characteristic.

5.6 Expected outcome

The proposed study includes design of hybrid air conditioning system, from this proposed study; it is expected to decide feasibility hybrid air conditioning system. The outcomes of this dissertation work will helps to design modification and manufacture a kit based on hybrid air conditioning system for improvement of performance, dehumidification enhancement, lower cost of refrigeration as the heat load is reduced by non-conventional earth heat exchanger cooler I can find applications in post-harvest handling of horticulture and floriculture produce. It can be applied to low cost domestic cooling, commercial installations, and industrial installations.

5.7 Theoretical calculations

1. Compressor work (W) = V*I
2. Refrigerating capacity(Q) = m*Cp*ΔT
Where
m = mass flow rate of air. It is measured by specified fan.
3. Actual COP-
COP = (Q/W)
II] By Theoretical calculation-
1. By p-h chart considering dry saturated condition ,
$W=h_2-h_1$
$Q=h_1-h_4$
2. Theoretical COP = (Q/W)
III] Relative COP-
Relative COP=(Actual COP / Theoretical COP)
IV] Carnot COP-
Carnot COP = [TC / (T_h -T_c)]
Where
T_h=Temperature after compression.
T_c = Temperature inlet to the evaporator.

Above mention formulas are the basic formula of refrigeration and air conditioning system so that with the help of above mentioned formula and advanced formula we will study the different parameter whose details will be presented in final stage of the projects.

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