Design & Development of AC System by Using Thermo-electric Phenomenon

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Abstract— In this thesis, Air conditioning system is widely used in home, industry, hospitals and vehicles. Traditional AC system which use refrigerant like R-22 and the whole working procedure produces CFC, HCFC and HFC which are greenhouse gases. They have capacity to produce bad effects on environment. Use of such refrigerant and system for air conditioning has environmental, economic and health effect. Replacement of AC system can be done by using Thermo electric cooling (TEC) phenomena. This system can easily replace traditional system. This research covers the following aspects. It gives a picture of a conceptual design of an air conditioner using TEC modules to achieve desired amount of cooling. TEC module works on the peltier effect. The appearance of this thermoelectric type of air conditioner resembles a conventional window air conditioner. This brings the simplicity in construction. The air conditioner is intended to take up the cooling load in volume of space as in conventional automobiles such as car, home, office, industry. Software used is AUTO-CAD software.

Keywords: Thermo-electric cooling (TEC), Peltier effect, Greenhouse gases

I. INTRODUCTION

A. TEC module:

Thermoelectric cooling system is achieved when a direct current is passed through one or more pairs of n- and p-type of semiconductor materials. Figure 1 is a diagram of a single pair consisting of n- and p-type semiconductor materials. In the cooling mode, direct current is allowed to passes through n and p junction of a semiconductor material. The temperature, denoted as TC (Cold Temperature) of the interconnecting conductor is decreased while heat is absorbed from the environment. This heat absorption from the environment (cooling) occurs when electrons pass from a low energy level in the p-type material through the interconnecting conductor to a higher energy level in the n-type material. The absorbed heat is transferred through the semiconductor materials through electrons to the other end of the junction, denoted as TH (Hot Temperature) where the electron are liberated once it return to a lower energy level in the p-type material. This phenomenon is called the Peltier effect. A second phenomenon is also important in thermoelectric cooling system known as Seebeck Effect. When a temperature differential is established between the hot and cold ends of the semiconductor material, a voltage is generated.

The Peltier effect is controlled by the Peltier coefficient, defined as the product of Seebeck coefficient of the semiconductor material and the absolute temperature. The Peltier coefficient relates to a cooling effect as current passes through the semiconductor junction n to p, and a heating effect when current passes through p to n junction, as shown in Figure 1. Reversing the direction of the current reverses the temperature of the hot and cold ends

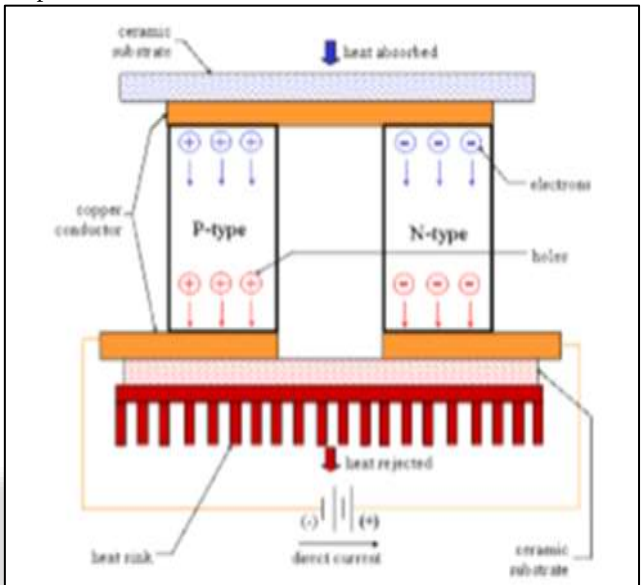

Figure 1: Schematic of thermoelectric module operation for cooling and heating

Fig. 1: TEC module

1) The Peltier Effect:

Thermoelectric coolers operate according to the Peltier effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. Heat is deposited at the other junction.

The main application of the Peltier effect is cooling. However the Peltier effect can also be used for heating or control of temperature. In every case, a DC voltage is required.

Thermoelectric coolers offer a myriad of benefits when traditional cooling methods are unsuited. Additionally, thermoelectric coolers are environmentally safer than other cooling units in the market. Some benefits of using thermoelectric cooling in electronic devices include:

- No chlorofluorocarbons or refrigerant emissions
- Low maintenance
- Long lifetime
- Controllable
- Compatible with extreme environments or remote locations
- Capable of cooling far below ambient temperatures
- Performance independent of orientation

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II. LITERATURE REVIEW:

A. Development of Portable Air Conditioning System Using Peltier and Seebeck Effect by N. Shafiei, M. H. Harun, K. A. M. Annuar

The society bustle factor in this day and age, most people want to find equipment that is often used in everyday life in a small and light weight design. The purpose of this project is to develop portable air conditioning system without using any gas. The system used thermoelectric heat pump as main device for producing cool air known as Peltier Effect. The generating system theoretically can recycle the heat loss to produce additional electricity for other usage. The efficacy of this system tested using two types of experimental using Peltier and Seebeck Effect. Both experimental are conducted

This research is based on the application of conventional air-conditioning system that used coolant as a medium for cooling system. Hence, the initiative of this system is focused on replacing coolant with peltier module which able to generate hot and cold system in one device. This unique device is not using any gas that might harmful to the users.

B. Study and Fabrication of Thermoelectric Air Cooling and Heating System by Prof. N. B. Totala1, Prof. V. P. Desai

HVAC system (commonly used in the air conditioners) is very efficient and reliable but it has some demerits. It has been observed during the last two decades that the O3 layer is slowly destroyed because of the refrigerant (CFC and HFC) used for the refrigeration and air- conditioning purposes. The common refrigerant used is HFC's which are leaked and slowly ascend into the atmosphere. When they reach to O3 layer they act on O3 molecules and the layer of O3 is destroyed. A single molecule of HFC can destroy thousands of O3 molecules and that's why it has created a threat for the not only to maintain earth eco system stable but also to existence of earth.

C. Design and Fabrication of a Peltier Operated Portable Air Cooling System by Nilesh Varkute, Akshay Chalke

Air Conditioning is the science of controlling primarily three parameters of human comfort, temperature, relative humidity and air quality. Air conditioners, dehumidifiers and evaporative coolers serve the purpose however air conditioners are termed expensive and coolers prove ineffective in humid conditions. The study conducted in the work aims at developing a Peltier operated air cooler coupled with a dehumidifier to achieve dual objective of dehumidification and sensible cooling.

D. Air Conditioner using Peltier Module by Allwin Jose, Alan D'souza, Sarvesh Dandekar

Conceptual design and a different kind of construction of environment friendly, portable Peltier air conditioner are elaborated. An arrangement for fresh air entry could be made by providing another inlet communicating outside atmosphere to air duct with adjustable dampers to control required amount of fresh air. This whole unit with casing could be installed on a window with hot side facing outside of room for heat dissipation. This unit could be attached on a wall with some arrangement of heat dissipation to outside of room. This air conditioner could be coupled (provided the required electric power) with solar photoelectric panels, generating electricity from solar energy.

E. Electric vehicle battery thermal management system with thermoelectric cooling by Siddique, S.H. Majid, M. Biglarbegian, S.A. Gadsden, S. Mahmuda

The liquid coolant has indirect contact with the battery and acts as the medium to remove the heat generated from the battery during operation. Forced air assisted heat removal is performed from the condenser side of the thermoelectric liquid casing. Detailed experiments are carried out on a simulated electric vehicle battery system. Experimental results reveal a promising cooling effect with a reasonable amount of power dissipation. Moreover, the experimental test shows that the battery surface temperature drops around 43 oC (from 55 oC to 12 oC) using TEC-based water cooling system for a single cell with copper holder when 40 V is supplied to the heater and 12 V to the TEC module.

F. Thermoelectric cooling technology applied in the field of electronic devices: Yu Wangd, Di Liudand Fu-Yun Zhaoa

Effects of cooling load, air temperature and all thermal conductances in heating side on the cooling performance have been attempted, regarding surface temperature of electronic devices and COP as evaluation indexes. Our analysis reveals that thermal control for electronics of high heat flux could be achieved by enhancing heat transfer in the hot side of thermoelectric system and increasing the numbers of thermoelectric coolers. Overall, governing parameters and modeling for practical applications have been presented, and the cooling potential of thermoelectric technology for electronic devices could be enhanced further.

III. PROBLEM STATEMENT:

Design, develop and fabricate a Model to which reduce consumption of electricity, lesser working cost and environmental.

Now a day's air conditioning is used for the purpose of heating and cooling the system. But it has some disadvantage of unexpected changes in humidity and temperature change individual respiratory system. It also leads to ambient noise which causes noise pollution, dry skin problem occurs due to AC.

IV. BASIC DESIGN CALCULATIONS

1) Temperature of the water pouring into the tank=26 C=T1
2) Temperature of the water moving out of the tank due to Peltier effect=22 C=T2
3) Temperature of the water flowing through copper pipe and coming in contact with the room where refrigeration is required=22 C=T3
4) Temperature of the water again collected in the bottom tank=26 C=T4
5) Volume of the working fluid=30 Ltrs.
6) Dimensions of single peltier module=(20*20*2)mm3

When we supply the electric current to the Peltier plates one of their sides give us reduction in temperature and one of its other side give us increase in temperature. We have to harness this cooling effect to cool the small-scale fruit

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storage tank, and the heat released at the other side is again used to increase the temperature of water.

In the first case when water is in contact with the peltier module conduction occurs,so accordingly the calculations were done.

A. Heat transfer due to conduction,

$$Q_c=KA(dt/dx)$$
$$=K*A*(T1-T2)/L$$

Where,
K=Thermal conductivity of peltier module=0.303 W/mK.
A=Surface area of the peltier module=(0.304*0.304)=0.0924 m2
T1=26 and T2=22
L=Thickness of peltier module=0.002m
Hence,

$$Q_c=K*A*(T2-T1)/L$$
$$= (0.303) *(0.0924) *(22-26)/0.002$$
$$Q_c=-55.99 \text{ Watts.}$$

As, we are using two peltier modules,
Qc= -111.98 Watts

Now in the second case the temperature of the water moving out of the tank=22 C due to peltier effect. This temperature water is moving around the box through the coil.

$$T3=T2=22 \text{ C}$$

As this water is going to reduce the temperature of the box, so its temperature will be increased and temperature of the box reduced. This moving water is again collected in the tank its temperature is given as,

$$T4=26 \text{ C}$$

Now,

$$Q=mC_p(T3-T4)$$

m=Mass flow rate of fluid.
C_p=Specific heat capacity of working fluid (Water)=4182 J/KgC
Now we are using a copper pipe with diameter D=20mm=0.02m
Area of the pipe= (3.14/4)*(D)2

$$A=3.141*10^{-4} \text{ m2}$$

As the water is moving under gravitational head and the angle at which copper pipe is inclined to the box is very low, so that maximum heat transfer can be found out. Velocity of the moving water,

$$V=0.025 \text{ m/s}$$

Hence the discharge

$$Q_d=A*V$$
$$=(3.141*10^{-4})*(0.025)$$
$$Q_d=7.85*10^{-6} \text{ m3/s}$$

Now we know that mass flow rate of fluid (m)=Density of fluid*Discharge

$$m=997*7.85*10^{-6}$$
$$m=7.82*10^3 \text{ kg/sec.}$$

Now the amount of heat transfer is calculated as,

$$Q=mC_p(T3-T4)$$
$$=(7.82*10^3)*(4182)*(22-26)$$
$$Q_2=-130.92 \text{ Watts}$$

Now the net Q is given as,

$$Q=Q_c+Q_2=(-111.98)+(-130.92)$$

=-242.9 Watts.

V. COMPONENTS

A. TEC Module

A standard module consists of any number of thermocouples connected in series and sandwiched between two ceramic plates. By applying a current to the module one ceramic plate is heated while the other is cooled. The direction of the current determines which plate is cooled. The number and size of the thermocouples as well as the materials used in the manufacturing determine the cooling capacity. Cooling capacity varies from fractions of Watts up to many hundreds. Different types of TEC modules are single stage, two stage, three stage, four stage, center hole modules etc.

B. Submesible Pump

It is a device which has hermetical sealed type motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between pump and the fluid surface. Submersible pumps push fluid to the surface as opposed to jet pumps which create a vacuum & rely upon atmospheric pressure. Submersibles are more efficient than jet pumps.

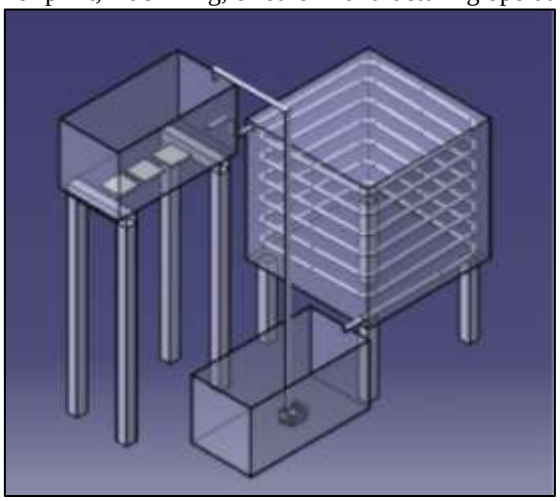
C. Copper Pipe

It is most often used for the supply of hot and cold tap water, and as a refrigerant line in HVAC systems. There are two basic types of copper tubing, soft copper and rigid copper. Copper tubing is joined using flare connection, compression connection, or solder. Copper offers a high level of corrosion resistance but is becoming very costly.

D. Design

1) CAD

It is the use of computer system to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.



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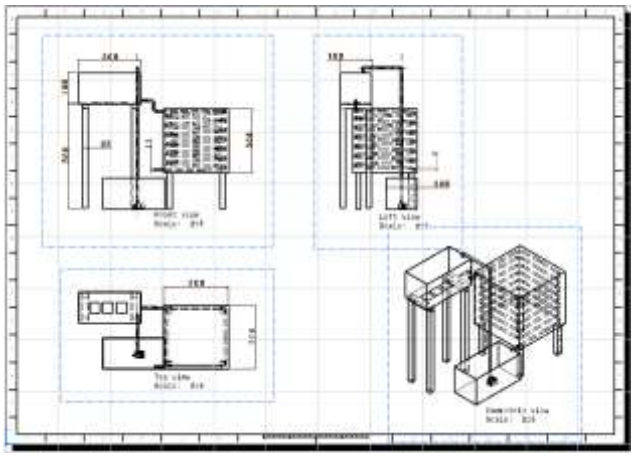
E. Drafting of Model



VI. FUTURE SCOPE

As we see world is facing horrible environmental crisis. Humans misused science in a affective way. Increase in global warming, temperature change are the biggest threat to the environment. Economic as well as health problems tends to create new innovations in traditional AC system.

TEC system has so much scope due to its characteristics like It doesn't tends to create hazardous gases like CFC, less consumption of electricity, water can be easily reused, very good as concern as health problems compare to traditional system, working cost is low.

In ambulance this system can be used efficiently.

In home appliances it can easily replaceable with traditional system in terms of costing, health, and environment

In office chamber it is way more superior than traditional one as concern as electricity and employees health.

Habitual aspect is also the main point, person using traditional system in day routine will feel uncomfortable in normal atmosphere. This system will keep you more natural than traditional.

World is restricting the excessive gases in environment by different ways. Use of this system is a step towards changing world

VII. CONCLUSION

Hence we can replace traditional air conditioning with the system includes thermo-electric cooling phenomena.

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