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Design Advance Utility Box Using Peltier Plates

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Abstract: *Increase in use of appliances like refrigerator which consists of halocarbons and chlorofluorocarbons, they produces many harmful gas such as Freon which causes green house effect and damage the ozone layer of the earth. Also the energy consumption is an another concern in today's world. the conventional refrigerator consume large amount of power ranging from 300 watt to 1500 watt. In this paper advance utility box is used to tackle the above problems. To reduce the emission of harmful gases and global warming, thermoelectric model (TEM) is used. TEM is used for heating and cooling of the system. In TEM, Peltier plates are the main component for heating and cooling purpose. The proposed model is compact in size, lower in cost, and eco-friendly. It is having potential application of storage of food, beverages, medicine at lower temperature and cooling of various electronic devices. This paper will give brief idea about how TEM actually works and it's several advantages and with the use of this how any model can be developed to the best level of it.*

I. Introduction

With the global warming, the release of chloro flouro carbon (CFCs) in the atmosphere has raised alarm in the nearby days. The major contributors are cooling devices like refrigerator, ACs, etc. At the same time the large use of non- renewable energy sources has diverted the world towards the use of renewable energy, due to the rate of consumption of energy is greater than the rate of generation. This will lead to fatal energy crisis in futureand its traces can be seen now also. That's why energy crisis has been labelled as world-wide problem which needs immediate and efficient solutions. To tackle the energy crisis the use of renewable energy sources is increasing day by day. In this paper, solar panel is used to supply power to an utility box which consists of heating and cooling chambers.

As energy demand is increasing day by day, much stress is put on developing appliances that use less amount of energy because conventional appliances i.e. refrigerators and heaters consume large amount of power. In addition to this, one of the main disadvantage of the conventional refrigerator is that they are not eco-friendly. It contains refrigerant that can be damaging to the environment because of the CFC content which cause depletion of the earth's ozone layer. The full name for CFCs is chloroflourocarbons, which means that the synthetic compounds include chlorine (chloro), flourine (flouro) and carbon.CFCs are used to produce cold air in refrigerators and air conditioners.

The problem is that when CFCs are released into the air they can get to the stratosphere (one of the layers of atmosphere around the earth) and destroy ozone gas. This may lead to the creation of "hole" in the ozone layer around the earth and allow in more ultraviolet radiation from the sun.

Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons destroy the earth's protective ozone layer, which shields the earth from harmful ultraviolet (UV-B) rays generated from the sun. CFCs and HCFCs also warm the lower atmosphere of the earth, changing global climate. Hydrofluorocarbons (HFCs) also act to warm the planet

The thermoelectric (TE) cooler provides an alternative solution to the above mentioned problems due to its various advantages.

Thermoelectric (TE) cooler

- do not use ozone depletion such as coolant so it is environment-friendly
- There are no moving part
- compact in size
- noise free
- maintenance free

Along with several advantages it has some limitations like low rating. So the TEM using Peltier plates is generally used in applications where small size is needed and cooling demand are not too great. The Thermoelectric cooler is used for cooling of electronic devices, storage of medicines, foods and beverages.

A. *Thermoelectric module*

A thermoelectric module is a semiconductor based electronic component that function as a small pump moving heat from one side of the device to the other [1].

Fig.1 Thermoelectric module

A basic thermoelectric module consists of semiconductor elements (p-type & n-type) that work as two dissimilar conductors arranged in specific order. The layer of elements is soldered between two ceramics plates, placed electrically in series structure and thermally in parallel structure. The heat is carried out through the transportation of electron and it will move from high state to low state. The pumping capacity is directly proportional to the number of pairs of 'n' and 'p' type (couples). The semiconductor device used in the system is the Peltier plate, which works on Peltier effect. The 'n' and 'p' type semiconductor, usually Bismuth Telluride, is the most used material to achieve the Peltier effect because they are used for carrying out the heat. They also control the charge carrier type in the system.

There are various types of Peltier plates available in the market according to the rating. The Peltier Plates used here TEC12706. Where,

TE - Thermoelectric as it works on thermal and electrical energy.

C - standard size (40x40mm).

In place of C, S can also be seen which stands for small size (30x30mm)

127 - no. of p-n couples.

06 - The maximum current, which is in amperes. But the major disadvantage of TEM is the low efficiency. So the TEM using Peltier plates is generally used in applications where small size is needed and cooling demand are not too great.

Thermoelectric module with Peltier plates has been previously used to develop other prototype model [2], [3].

The objective of the paper is to present a model which can help to full fill the basic need of cooling and heating at a smaller level and to open a new door for various research work and modification which can increase the efficiency .

II. Theory

Thermoelectric Module works on thermoelectric effect. The thermoelectric effect is the transformation of temperature difference to electric voltage and electric voltage to temperature difference i.e. vice versa. A thermoelectric appliance creates voltages when there is different temperature on each side. On the contrary, when a voltage is applied to the device, it creates a temperature difference. Thus, an applied temperature gradient causes the charge carrier in the material to diffuse from the hot side to the cold side [4].

The word "thermo electric effect comprises three separately identified effects: -

1) Seebeck Effect
2) Peltier Effect
3) Thomson Effect

These effects are explained below:

1. The Seebeck Effect

Thomas seebeck discovered in 1821 when we make a circuit with junction of two dissimilar metal wire and create a temperature difference at both junction then an electromotive force or potential difference can be achieved that was named as seebeck effect[

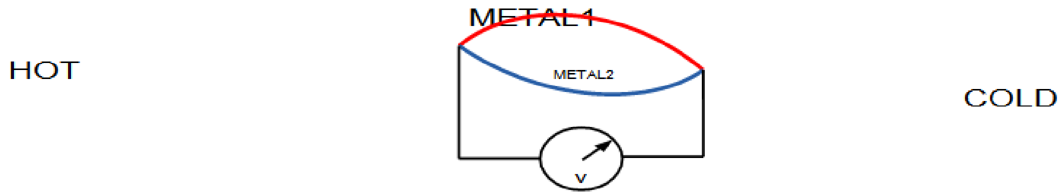


Fig.2 Seebeck effect

When there is a temperature difference in a thermoelectric material, an electric Current is induced due to movement of holes and electrons in the semiconductor materials. The effect that causes this phenomenon is called the Seebeck effect [5]

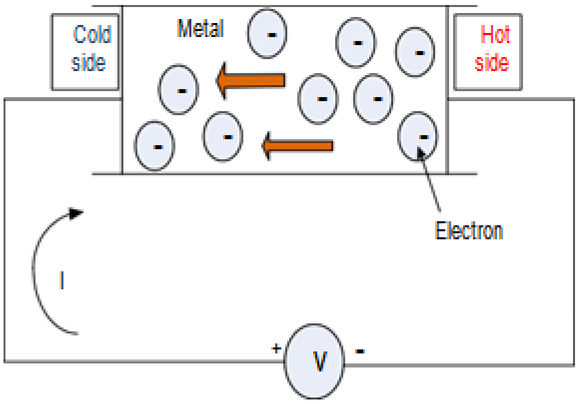


Fig.3 Movement of electron in thermoelectric material

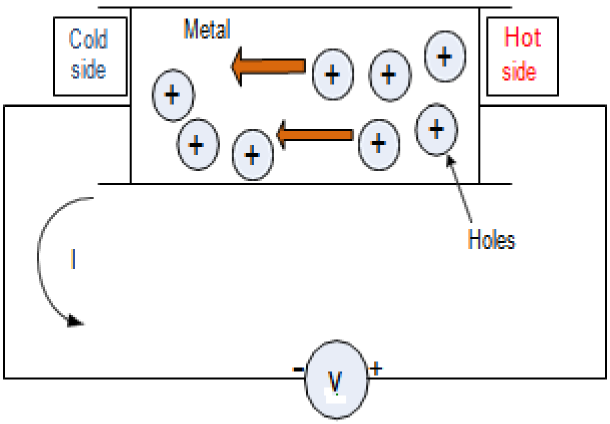


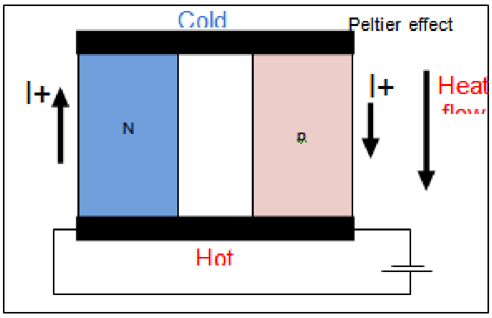
Fig.4 Movement of holes in thermoelectric material

2. Peltier effect

After Thirteen years of Seebeck's discovery, French physicist Jean Peltier found out that the Seebeck effect is a reversible process or we can say that when we give current through the circuit one junction will be hot and another will be cool

When we connect a number of dissimilar wire thermally in parallel and electrically in series we call it thermoelectric module.

When there is a current passing through conductor heat must be continuously added to or rejected from the conductor in order to keep the junction temperatures constant.
The total amount of heat added or rejected is proportional to the amount of current supplied. This phenomenon is called the Peltier effect and can be defined using the following equation alkaline solution are exposed in an uneven way to solar radiation [8]



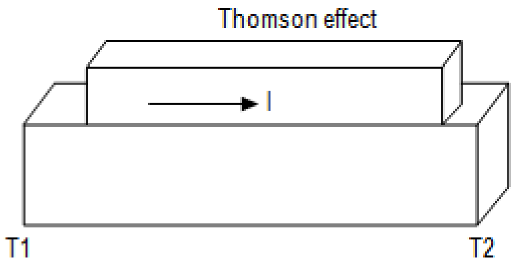


Fig.6 Thomson effect Where τ is the Thomson coefficient [7].

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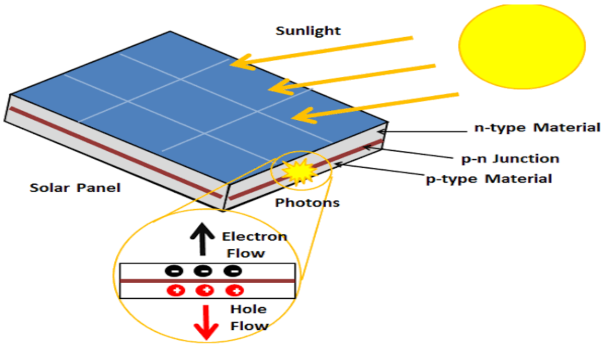

Fig.7 Photovoltaic effect

III. Experimental Setup

a. *Block diagram*

πAB = Peltier Coefficient

Qpeltier = Amount of heat added or rejected from the system I = Current passing through the thermoelectric material [6].

3. *Thomson Effect*

The Thomson effect is similar to the Peltier effect in many ways, but the main difference is that Thomson effect needs a temperature difference and a flowing current. When the current flows through a wire with a temperature gradient, heat will be absorbed or liberated across the wire depending on the material and current direction. Heat absorption or liberation is proportional to the current and the temperature gradient. The Thomson heat transfer rate is defined by the equation

QThomson= I

4. Photovoltaic Effect

The solar panel is used to convert solar energy into electrical energy by means of photovoltaic effect Photovoltaic effect means the conversion of light or radiation into electricity. The photovoltaic effect was first discovered by French physicist A.E. Bequerel in 1839. He explained his discovery as 'the production of an electric current when two plates of platinum or gold immersed in an acid, neutral

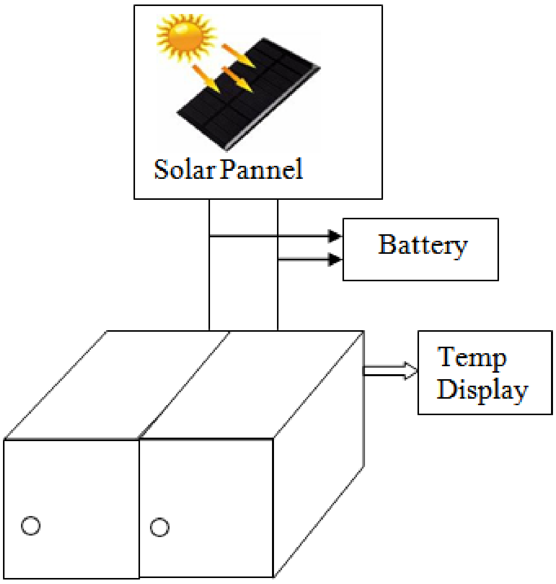

Fig.8 Block Daigram

As already discussed TEM is a semiconductor electronic component that functions as a small pump moving heat from one side of the device to another. A practical TEM generally consists of two or more elements of N-type or P-type doped semiconductor material that are electrically connected in series and thermally in parallel. Here the semiconductor device is the Peltier Plate and there are six such plates. The TEM divides the box into two sections or compartments- one for cooling and other for heating purpose. So to be able to provide the temperature over the whole compartment and to facilitate improved results, a heat exchanger is required. Heat sink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a medium (air, fluid) where it is dissipated away from the device, thereby allowing regulation of device's temperature at optimal levels. Heat sink is designed to maximize its surface area in contact with the cooling medium surrounding it such as air. If there is no air flow around the heat sink, energy cannot be transferred. So along with heat sink, for cooling, convection and transfer of heat, fans are also used. In this model, Axial flow fan are used because of high velocity flow. These fans causes air to flow through it in axial direction, parallel to shaft.

Fig.9 Experimental setup for proposed work

The TEM starts working as soon as power supply is ON and the Peltier receives 12v dc power. So for power supply, solar panel is used to make the model eco-friendly with renewable source of energy for reduced electricity consumption. But if solar fails or any other problem occur, normal ac power supply from the board can be used. For this, the ac supply is to be converted into 12V dc using complementary source for the Peltier to work.

Temperature sensors with LCD display is used in both the chambers to know the exact temperature. The system needs to be perfectly isolated to get better results. As there are no vibrations, thermal casing is enough to provide insulation and duct tape is used to completely seal this.

The six Peltier plates are connected in parallel and the fans are also connected in parallel. The wire terminals of the Peltier plates and fans are connected to the batteries which are charged through either solar panel or the ac using complimentary source. When the first battery is ON, due to the Peltier effect one side of the Peltier is cooled and other is heated. As far as cooling is concerned, when the battery is switched on the whole cooling chamber will observe a significant decrease in the temperature which can be seen clearly from the temperature display. Now to maintain constant temperature difference between the junctions, the other side of the Peltier starts heating. The fans and the heat sink reject this heat so the cooling side's temperature again decreases. The fans are also used to circulate this heat in the heating chamber and an increase in temperature is observed.

For the efficient working of thermoelectric module and to achieve better cooling capacity and coefficient of performance number of investigations have been performed [9], [10], [11], [12].

TEM system's performance depends on:

1. Temperature of the cold and hot sides.
2. Thermal and electrical conductivities of the material.
3. Contact resistance between TE device and heat sink.
4. Thermal resistance of the heat sink.

OBSERVATION TABLE ANDGRAPH

Sr no	Time sec	Room Temp(T1)	Box Temp(T2)	Peltier temp
1	60	26.1	21.6	11.3
2	120	26.6	19.3	8.6
3	180	27.1	19.1	6.5
4	240	28.3	17.4	3.3
5	300	26.5	16.8	3.1
6	360	26.3	16.4	2.9
7	420	26.3	16.1	1.6

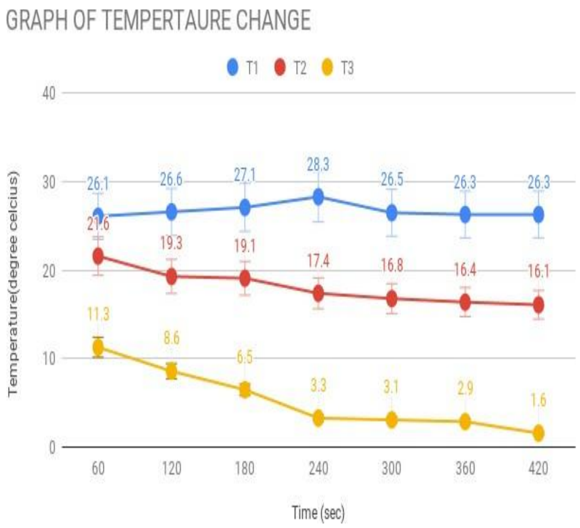

Fig.10 Graph plot between time and temperature change

IV. Conclusion

A thermoelectric Air cooling & heating system was designed and built which can be used for personal cooling & heating. Six TEMs were used for achieving the cooling with a DC power supply through external power supply. It had been shown from testing results that the system is capable of cooling & heating through re-circulating air with the help of blower fans. It was able to cool an ambient air temperature from 26.8°C to 15° C on the cooling side. The temperature stabilizes within thirty minutes once the blower is turned ON. Accomplishing the set target establish the success of theproject. All the components in the project had been tested individually and the results were found to be positive. The results may vary with different places and by using better quality Peltier plate.

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