DESIGN AND FABRICATION OF PELTIER EFFECT REFRIGERATOR

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ABSTRACT:

Refrigeration is the process of heat removal from space in order to bring it to a lower temperature than the surrounding temperature. The Peltier refrigeration system, also known as the thermoelectric cooling system, is a solid-state cooling technology that operates based on the Peltier effect. Unlike traditional refrigeration systems that use compressors, condensers, and refrigerants, Peltier systems utilize a unique phenomenon involving the transfer of heat when an electric current passes through two dissimilar conductors.

The main objective of our project is to build a refrigerator which is compact, movable and which does not cause any harm to the environment. The most important utilization of this portable cooler will be for the preservation of medicines in extreme conditions. A Thermoelectric module (TEM) is used instead of compressor so that it becomes portable and light weight, and it works on the principles of Peltier effect. The use of Peltier effect is to create a heating side and a cooling side and also to maintain effectiveness. The total arrangement will be studied, fabricated & analyzed.

Keywords : Thermoelectric module, semiconductor, Peltier, refrigeration,

INTRODUCTION

when a circuit of two dissimilar metal and two junction is formed a current will flow between the junction or the circuit. This phenomenon is known as the see back effect. C. peltier , a French watchmaker and an amateur scientist discovered a reverse effect of the See back. He discovered that using joined dissimilar metals heat pump can be made Due to the increasing demand for refrigeration in various fields led to production of more electricity and consequently more release of harmful gas like CO2 all over the world which is a contributing factor of global warming on climate change.

Thermoelectric refrigeration is a new alternative method. The thermoelectric modules are made of semiconductor materials electrically connected in series configuration and thermally in parallel to create cold and hot surfaces. Although they are less efficient than the vapour compression system, they are

very light, low in cost, silent in operation, and are environmentally friendly. A thermoelectric

module thus uses a pair of fixed junctions into which electrical energy is applied causing one junction to become cold while the other becomes hot. Because thermoelectric cooling is a form of solid-state refrigeration, it has the advantage of being compact and long lasting. It uses no moving parts except for some fans,
employs no fluids, and do not require bulky piping and mechanical compressors used in vapour-cycle cooling systems. Such sturdiness favour thermoelectric cooling over conventional refrigeration in certain situations. The compact size and weight requirements, as well as portability in the design, rule out the use of conventional refrigeration

2. THERMOELECTRIC COOLING MODULES

Although Peltier effect was discovered more than 150 years ago, thermoelectric devices have only been applied commercially during recent decades. Lately, a dramatic increase in the application of TE solutions in optoelectronic devices has been observed, such as diode lasers, photo detectors, solid- state pumped
lasers, charge-coupled devices (CCDs) and others. The thermoelectric module consists of thermocouple formed by pairs of P-type and Ntype semi-conductor thermo element which are electrically connected in series configuration and thermally connected in parallel configuration. Due to their solid state construction the modules are considered to be highly reliable. For most application they will provide long, trouble free service. For cooling application, an electrical current supply is given to the module, heat is transferred from one side to the other, and the result is that the module will become cooler at one side and hotter at the other side. Thermoelectric refrigerator works on the PELTIER effect that The peltier - see back effect, or thermoelectric effect , is the direct conversion of thermal differentials to
electric voltage and vice versa. The Peltier-see back effect and Thomson effect are reversal of one another ,joule heating cannot be reversible under the laws of thermodynamics.

3. DESIGN OF THERMO ELECTRIC REFRIGERATOR

This study involved a theoretical modelling, constructing and testing of a Peltier thermoelectric cooler. Figure 4 shows a schematic diagram of the stipulated cooler. A mini thermoelectric cooler body was constructed with a foam box. The Peltier thermoelectric module consisted of an internal heat sink, a
Peltier thermoelectric cell (TEC) and the external heat sink was located at the centre of the upper side of the cooler box. The installation started with the thermoelectric module sandwiched

between two heat sinks and followed with the installation of two cooling fans on the heat sinks body. One of the heat sinks was installed to enhance the cooling of the box and the other one to give a greater effect of heat

rejection. The module was prepared so that the internal heat sink was in the cooler box, the TEC was in the middle and parallel to the wall and the external heat sink was exposed to the surroundings

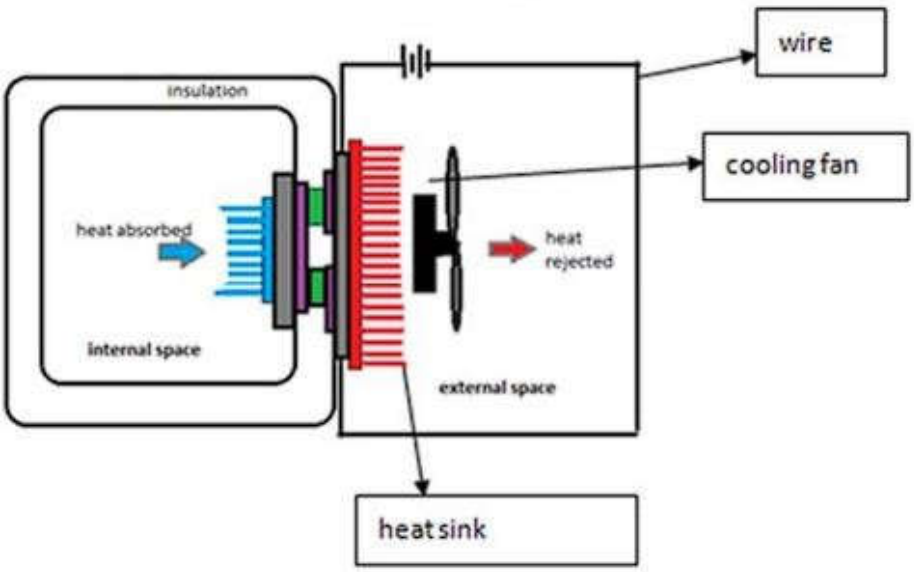

Figure 1: Schematic diagram

Peltier working principle

The Peltier module operates based on the principle of the Peltier effect, which is a thermoelectric phenomenon discovered by French physicist Jean Charles Athanase Peltier in 1834. The Peltier module consists of two different types of semiconductor materials (typically bismuth telluride) connected in series and sandwiched between two ceramic plates. When an electric current passes through the module, it causes a temperature difference to develop between the two junctions of the semiconductor materials.

Here's how the Peltier module works:

Heat Absorption and Heat Release:

- When a direct current (DC) passes through the Peltier module, it creates an electrical potential difference across the junctions of the semiconductor materials.

- At one junction (the cold side), electrons absorb heat energy from the surrounding environment, causing the temperature to decrease.
- Simultaneously, at the other junction (the hot side), electrons release heat energy into the surrounding environment, causing the temperature to increase

2. **Thermal Conduction:**

- The absorbed heat energy is carried by electrons as they move through the semiconductor material from the cold side to the hot side.
- This process of thermal conduction results in the transfer of heat from the cold side to the hot side of the Peltier module

3. **Temperature Gradient:**

As a result of the Peltier effect, a temperature gradient is established across the Peltier module, with one side becoming colder and the other side becoming hotter.

Direction of Heat Transfer:

- The direction of heat transfer through the Peltier module depends on the direction of the electric current. Reversing the polarity of the current will

reverse the direction of heat transfer, causing the cold and hot sides to switch roles.

Cooling and Heating Applications:

- By controlling the direction and magnitude of the electric current passing through the Peltier module, it can be used for both cooling and heating applications.
- In cooling applications, the cold side of the Peltier module is utilized to absorb heat from the environment, while the hot side releases heat.
- In heating applications, the polarity of the current is reversed, causing the hot side to absorb heat and the cold side to release heat.

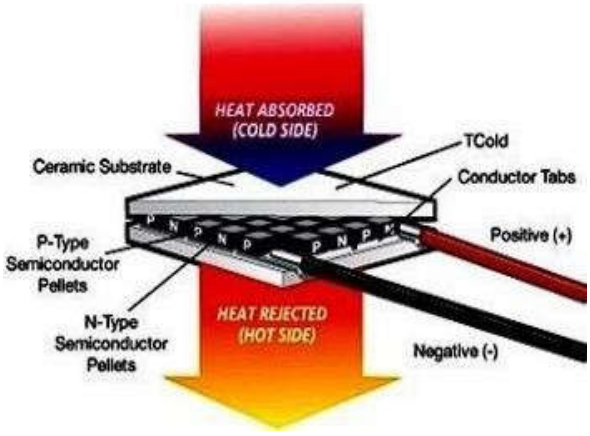

Figure 2: Peltier module

COMPONENTS

PELTIER MODULE: - The method of thermoelectric cooling (using the Peltier effect) is useful because it can cool an object without any moving pieces or other complex machinery that isolates the cooler from its ambient surroundings. The devices that are constructed to take advantage of this phenomenon are known as Peltier elements, or thermoelectric coolers (TECs). The most common combination of materials in the thermocouples of Peltier elements (TECs) are the two semiconductors Bismuth and Telluride. The semiconductor cubes with extra free electrons (and thus carry mainly negative charge) are known as N-type semiconductors, while those with few free electrons (and carry mainly positive charge) are P-type semiconductors. The pairs of P and N semiconductor cubes are set up and connected in an array so that the pairs have an electrical series connection, but a thermal parallel connection. When a current is applied to this system (the TEC), the way the current flows through the semiconductors induces a temperature difference, and causes the heat-sink side of the Peltier element to heat up, and the cold side to cool (or cooling whatever is in thermal contact with that side).

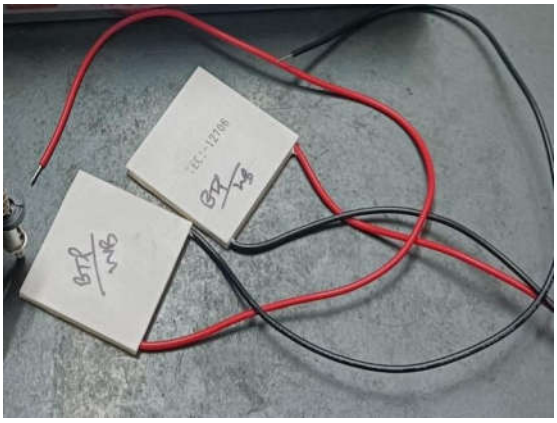

Figure 3: Electrical Connections

- HEAT SINK :- Rather than being a heat absorber that consumes heat by magic, a thermoelectric cooler is a heat pump which moves heat fromone location to another. When electric power is applied to a TE module, one face becomes cold while the other is heated. In accordance with the laws of thermodynamics, heat from the (warmer) area being cooled will pass from the cold face to the hot face
- DC POWER SUPPLY :- The Peltier Module requires DC power supply for its working, hence a power driver is used to deliver constant current to the cooler at 12V, 20Amp

- HEAT SINK FAN :- Sometimes the heat sink itself becomes during the heat transfer. To overcome this problem a device called heat sink fan is used for the removal of induced heat in the fins of the heat sink. So these fans are attached over the fins of the heat sink and it cools down the heat produced in the heat sink. In summary, a heat sink fan is a vital component in cooling systems, including mini refrigerators, as it enhances heat dissipation and contributes to temperature regulation and system reliability. By working in conjunction with heat sinks, heat sink fans help maintain optimal operating temperatures and ensure efficient performance of critical components.

Figure 4: Heat Sink Fan

- PVC SHEET(5mm) AND THERMACOLE(20mm) :- Used for making structure and for better insulation .To increase cooling performance and retain it for longer time of period.

SPECIFICATIONS OF REFRIGERATOR

For Peltier module -

Model number: TEC1-12706, Voltage: 12V, U max (V) : 15.4V, Imax (A) : 6A,Q Max (W) : 92W, Internal resistance: 1.98 Ohm +/- 10%.

Cooling fan and unit –

Minimum speed: 1000RPM, Moderate speed: 1900RPM, Maximum speed: 2600RPM, Dimensions: 90*90*45mm.

Power supply –

AC input: 100-240v, 50/60hz, 1.11A, DC output: 12 - 20A, Output Power: 240W

Refrigerator dimensions –

Length: 25cm, Breadth: 21cm,

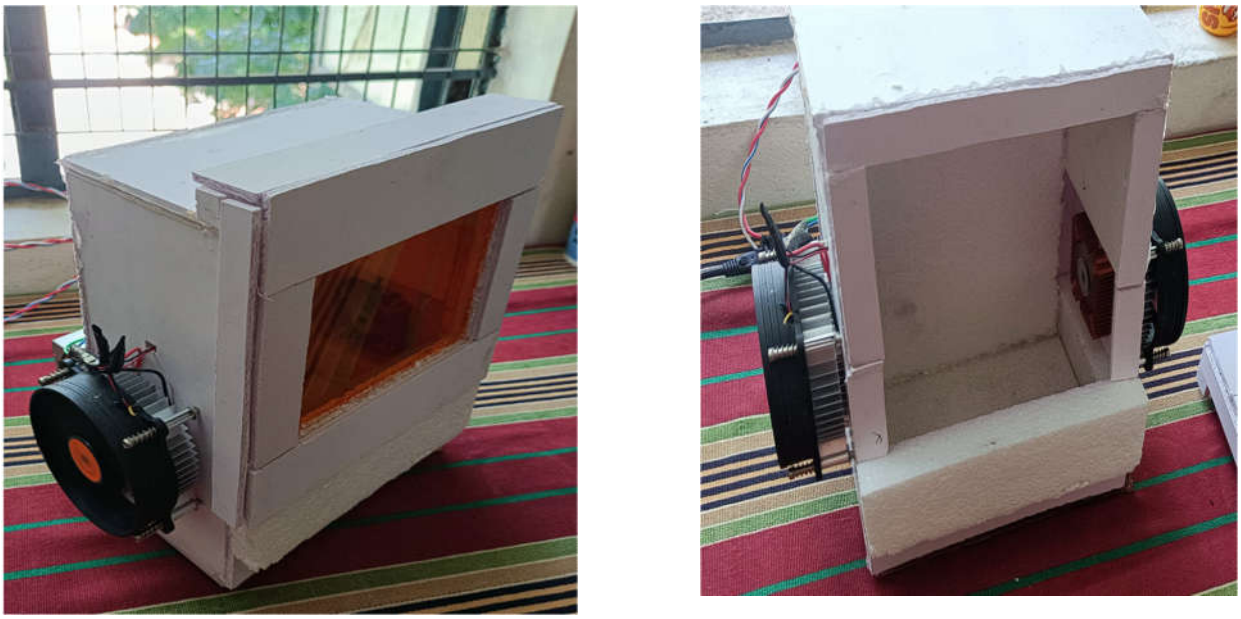

Figure 5: Fabricated model

RESULTS

The experiment for test sample of water (45ml) of water at 50°C and conducted the experiment for 3 trails at interval of 15 min. The temperature of water after conducting the experiment was found to be 25,27,24°C respectively. Average after three trails will be 25.3°C.

CONCLUSION

During construction of the device several minor changes were made to the design. Each of these changes we feel was justified as they made for easier construction while maintaining the performance of the device with respect to the project goals. The device was discovered to have ample precision and total heat transfer capabilities while meeting its accuracy requirement. It can be used for cooling small beverages, drinking water, medicines etc.

REFERENCES

1. Christian J L and Jadar R Barbosa Jr (2011), “Thermodynamic Comparison of Peltier, Stirling, and Vapor Compression Portable Coolers”, Applied Energy, Vol.

2. Optimization of operational conditions for a thermoelectric refrigerator and its performance analysis at optimum conditionsOptimisation des conditions de fonctionnement d'un réfrigérateur thermoélectrique et analyse de ses performances dans des conditions optimales

3. Manuraj Sahu, Gulab Chand Sahu, Manoj Sao, Abhishek Kumar Jain “Analysis of Heat Transfer from Fins Using Finite Difference Method” published in International Journal of Advance Research, Ideas and Innovations in Technology KITE/NCISRDC/IJARIIT/2018/Mech/105, IJARIIT (ISSN: 2454-132X), pp 261-269

4. Mr. Swapnil B. Patond,“ Experimental Analysis of Solar Operated Thermo-Electric Heating and Cooling System”, International Journal of Engineering Trends and Technology (IJETT) – Volume 20 Number 3 – Feb 2015 , ISSN: 2231-5381.

5. Dai YJ, Wang RZ, Ni L;. Experimental investigation and analysis on a thermoelectric refrigerator driven by solar cells. Sol Energy Mater Sol Cells 2003

6. Manoj S. Raut, Dr.P. V. Walke, “Thermoelectric Air Cooling For Cars”, International Journal of Engineering Science and Technology (IJEST), Vol. 4 No.05 May 2012 ,ISSN : 0975-5462.