REFRIGERATION USING PELTIER EFFECT

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Abstract- Refrigerators are being used nowadays, There are various types of refrigeration systems available in the market, each with advantages and disadvantages of its own. Using a thermoelectric cooling system will maintain a consistent temperature throughout and be lightweight, portable, and simple to use. This makes it perfect for the transportation and storage of live human organs as well as medications, immunizations, and blood banks. The gadget can be utilized in cars as long as the vehicle has a 12V DC source. The thermoelectric cooler is a new technique that has many advantages. At its prototype size, this portable mini refrigerator can chill many 200-ml bottles or a soft drink canister. Based on the outcome, a more refined model can be built. When mass-produced, our attempt to create an environmentally friendly refrigerator without the risk of handling a hazardous refrigerant is fairly inexpensive, and it can be installed in a car's glove compartment or have its refrigeration compartment. The main motto of this project is to design a prototype of a thermoelectric Refrigerator using the Peltier effect

Key Words: Refrigeration, Thermo-electric Cooler Module, Peltier Device, etc

1. INTRODUCTION

The fundamental segment of this framework is the "Thermoelectric Cooler Module". The module operates by the Peltier Effect". The device has two sides, hot and cold and when a D.C. electric current flows through that module, it brings heat from one side to the other, so one side gets cooler and the other side gets hotter. The hot side is attached to a heat sink so that it remains at ambient temperature whileone goes below room temperature. Thermoelectric cooler modules consist of an array of p-type and n-type semiconductor elements that are heavily doped with electrical carriers. The elements are arranged into array that is electrically connected in (parallel) series and thermally connected in parallel. This array is then affixed to two ceramic substrates, one on each side of the elements.

P and N semiconductor cube pairs are arranged and linked in an array so that the pairs have a thermal parallel connection but an electrical series connection. The Peltier element's heat-sink side heats up, and its cold side cools (or cools anything in thermal contact with that side) when a current is given to this system (the TEC) due to the way the current passes through the semiconductors. intended to provide retention for the minimum of the following half hour after cooling this volume
to temperature within six hours.

2. LITERATURE REVIEW

Dr S. Sreenath Reddy* et. al [April 2019]- Researchers conducted an experimental study comparing green refrigeration and air-conditioning technology, finding thermoelectric cooling as a promising option with an efficiency 5–15% higher than conventional compressor cooling. [1] Vivek Vaidya* et al. [2017]- Researchers developed a portable cooler and heater using solar energy and thermoelectric and photovoltaic modules. They found that misuse can heat the CPU, requiring a high heat capacity. [2] G. Lavanya* et al. [2016]- Researchers developed refrigerator jackets using the Peltier effect, achieving an 18 oC cooling air temperature in 20 minutes in static conditions. [3] Meghali Gaikwad* et al. [Mar-2016]- Researchers developed a thermoelectric R&AC system, comparing vapour compression and absorption refrigerators' costs and efficiency. They found the vapour compression system the most energy-efficient and had the lowest operating and purchasing costs. [4] Kirti Singh* et al. [April 2015]- Researchers tested thermoelectric refrigerators using solar energy for cold storage, finding they can only lower temperatures for light loads and cannot handle load fluctuations.
[5] Manoj Kumar Rawat*et al. [Feb- 2013]- Researchers designed and fabricated a thermoelectric refrigerator using germanium and alloys, achieving an interior cooling volume of 0.0258 m3, significantly better than conventional refrigerators [6]

3. Advantages of Thermoelectric Refrigerators

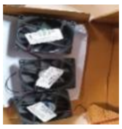
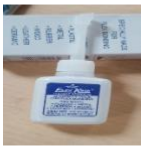
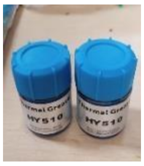
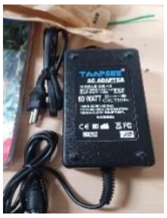
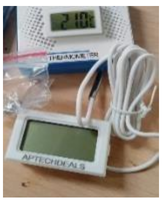
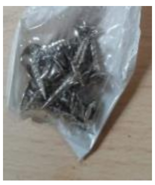
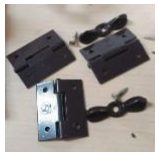
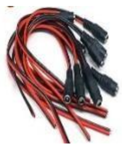
- **No Moving Components**: Because TE modules are electrically operated and have no moving components, they require very little maintenance.
- **Capacity to Heat and Cool Using the Same Module:** Depending on the applied DC power's polarity, thermoelectric coolers can heat or cool. This feature enables a system to operate without separate heating and cooling components.
- **Electrically "Quiet" Operation**: TE modules can be utilized with sensitive electronic sensors and produce almost no electrical noise, in contrast to mechanical refrigeration systems. They also don't produce any noise.

- **Tiny Size and Light Weight**: The overall thermoelectric cooling system is significantly lighter and smaller than a comparable mechanical system. Moreover, a variety of conventional and distinctive sizes and configurations are provided to meet the demanding application requirements

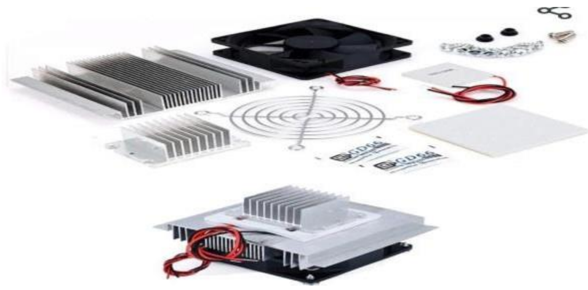
4. SET-UP DESCRIPTION

Thermoelectric refrigerators are built using different components, which are as follows:

Table 1: LIST OF COMPONENTS

S. No	Component Name	Component
1.	CPU FANS	
2.	HOT GLUE	
3.	THERMAL PASTE	
4.	ADAPTER(12 volts 5 amperes)	
5.	DIGITAL THERMOMETER	
6.	SCREWS	
7.	HANDLE	
8.	HINGES AND STOPPERS	
9.	PVC SHEETS	
10.	DC CONVERTER (FEMALE JACK)	

THERMOELECTRIC PELTIER REFRIGERATION COOLING KIT



4.1 Peltier Module

When using thermoelectric cooling, the Peltier effect is a convenient way to cool an object without the need for intricate equipment or moving parts to keep the cooler isolated from its surroundings.

that prevents the cooler from interacting with its surroundings. Devices called Peltier elements, or thermoelectric coolers, are made to make use of this phenomenon.

The most common application of Bismuth and Telluride semiconductors together is in thermocouples of Peltier elements (TECs). Below are the elemental descriptions of all the semiconductor cubes with extra free electrons listed above.

4.2 Heat Sink:-

A thermoelectric cooler is a heat pump that transfers heat from one place to another as opposed to a heat absorber that absorbs heat magically. A TE module experiences heat on one face and cold on the other when electricity is applied. The heat from the (warmer) area being cooled will move from the cold face to the hot face by the rules of thermodynamics.

4.3 DC Power Supply:-

Because the Peltier Module needs a DC power source to function, a power driver is employed to supply the cooler with a steady current at 12 V and 10 Amp**.**

4.4 Insulated Case:-

When applied, a material or mixture of materials known as thermal insulation slows the transfer of heat and can be tailored to fit any size, shape, or surface. Thus, insulation is the result of thermally isolating the system and significantly lowering the rate of heat transmission between the system and the body or surrounding environment using insulating materials. We are aware that thermocouples are utilized by ice vendors due to their low cost and effective insulating qualities, which prevent the chilling medium's internal temperature from dropping.

5. BASIC CONCEPTS

Several theories and principles underpin how a thermoelectric refrigerator operates. These ideas mostly deal with refrigeration and heat transmission. The research includes a sizable portion of electrical ideas like semiconductors and their doping. The hypotheses that went into the building are listed below

1. The Theory of Peltier.

2. conducting semiconductors that are doped.

3. Heat sink transmission of heat

. 4. convection that is forced.

Below is a quick explanation of each of the aforementioned elements.

5.1 Peltier Theory: -

The Peltier effect governs the operation of thermoelectric coolers. The effect transfers heat between two electrical junctions, resulting in a temperature differential. A current is produced by applying a voltage across connected conductors. Cooling happens at one junction, where heat is eliminated as current passes through the joints of the two conductors. At the opposite intersection, heat is deposited. The Peltier effect is mostly used in cooling processes. On the other hand, temperature control or heating can also benefit from the Peltier effect. A DC voltage is required at all times.

Thermoelectric coolers are the models used to create solid-state heat pumps. Each has a variety of alternating n- and p-type semiconductors. Various semiconductors kinds have Peltier coefficients with complimentary values. Between two ceramic plates, the array of components is soldered electrically in series and thermally in parallel. Solid solutions of bismuth telluride, antimony telluride, and bismuth selenide are the best materials for Peltier effect devices because they can be manufactured in both n-type and p-type, and they function best at temperatures between 180 and 400 K.

The heat from the surroundings is absorbed when a current flows across one or more pairs of n-to-p-type elements, causing the junction's ("cold side") temperature to drop. Using electron transport, heat is transferred between the elements and dissipated when the electrons transition from a high- to a low-energy state on the opposing ("hot") side.

5.2 Semiconductors with Doping**:**

Doping is the process of adding dopants, or impurity atoms, to semiconductor materials during the manufacturing process. Dopants change a semiconductor material's electrical characteristics by increasing the number of accessible charge carriers in the material. Semiconductors that have foreign atoms or impurities integrated into their crystal structure are known as doped semiconductors. These impurities may be purposefully supplied to the semiconductor to give free carriers, or they may occur accidentally as a result of a lack of control during the semiconductor's growth. The dopants that are added to the semiconductor material determine which of the two doping processes—n-doping and p-doping—take place.

N-Type :

N-doped semiconductors are rich in additional electrons that can be used as charge carriers. A group IV substance (such as Si) typically forms bonds with four additional Si through four covalent bonds or four valence electrons. A Group V metal (P or As) with five valence electrons is doped into Si material to create an N-type semiconductor. This allows the extra electrons in the Group V metal to roam freely and serve as charge carriers.

P-Type :

Group III (In, B) dopants, which contain three valence electrons, are used in P-type semiconductors. These materials require an additional electron for bonding, which results in "holes." Positive-charge carriers are semiconductors doped with phosphorus. When a current is applied, it appears as though a hole is moving because an electron moves to fill a hole, forming a new hole where the electron was previously. Electrons and holes go in opposing directions.

5.3 Heat Transfer Through Heat Sink:-

An electrical device used to disperse unwanted heat is called a heat sink. It is typically attached to an electronic device and is constructed of a high-quality thermal conducting substance. By dispersing excess heat, it cools the circuit components, preventing overheating and early failure while enhancing component performance and dependability. When two items with different temperatures come into contact, thermal conduction happens. In this, the slow-moving molecules of the colder object collide with the fast-moving molecules of the hotter substance. As a result, energy is transferred from the heated object to the cooled object. Therefore, heat is transferred by a heat sink from a high-temperature component, like a transistor, to a low-temperature medium, like air, or any other

5.3 Forced Convection:-

Forced convection is a unique kind of heat transfer where fluids are pushed to circulate to maximize heat transmission. This kind of compulsion can be applied with . a fan, a pump, a suction attachment, or an extra gadget. Hotter materials will naturally float to the top of colder ones due to this density difference. The entire heat sink maintains a more comfortable temperature by employing forced convection. This process is commonly used in cooling systems for electronics and in HVAC systems to regulate indoor temperatures. By increasing the rate of heat transfer, forced convection helps to dissipate heat and maintain optimal operating conditions efficiently.

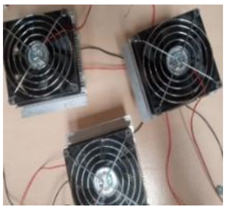
6. Specifications of Refrigerator

6.1 For the Peltier module –

Voltage: 12V; maximum voltage (V): TEC1-12706 is the model number. 15.4 Q, V Wmax = 92 W, Amax = 6 A Internal resistance: 1.98 ohm +/- 10%HS Code: 854150; 150mm Power Cord Among them are cooling cells. Utilise: Cold room and stove,The measurements are 40 x 40 x 3.9 mm. a 12-volt DC power unit as the power source The temperature indicator is 12 volts, the fans are 7 amps, and the module is 12 volts. 6 amps of power and a minimum of 12 volts are required. electrical requirements 12 volt DC power unit is the power source; the rated supply is 12 volts and 10 amps. Unit and cooling fan speed: 1000 RPM at low, 1500 RPM at medium, and 1900 RPM at high. The dimensions are 116*80.6*122.5 mm.The following are the refrigerator's measurements: 55 cm in height, 24 cm in breadth

7. ASSEMBLY OF REFRIGERATOR

7.1 Assembly for Heat Sink and Fan



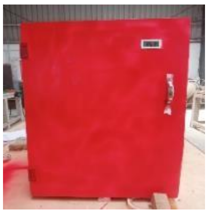
Several screws hold the fan in place on the heat sink. To optimize heat transfer from the sink to the air, a series of copper pipes are also installed through the heat sink.

7.2 Peltier Module Assembly

Peltier Module Assembly The Peltier module is connected to the heat sink and fan using a thermal paste that allows heat to pass from the module to the heat source without creating any resistance.

7.3 Final Refrigerator Assembly

To ensure that the cold air from the Peltier module is dispersed uniformly throughout the refrigerator, it is fastened to the top of the Frame, or the main body of the space occupied by the refrigerator. 10 mm plywood is used to construct the frame. Positioned on the upper part of the frame is the Peltier module, which contains the heat sink. Inside the refrigerator's temperature is displayed by a digital thermometer fastened to the top of the frame.



7.4 Inside of the Refrigerator

To improve insulation, the refrigerator's inside is composed of thermocol wrapped in aluminium foil. Additionally, it contributes to enhancing the cooling impact within the section.

Table -2: EXPERIMENTAL TABULAR FORMAT

S. No	Time	Water		Air	
		Before	After	Before	After
1	5 hour	32	25	24	22.8
2	3 hour	25.9	18	27	23.3
3	1 hour	25	18	31	22.3

8. CONCLUSIONS

Based on the research conducted by all thermoelectric refrigeration researchers, it has been determined that this technology has a great deal of potential in the future. It has several benefits, like being quiet, small in size, and able to maintain a high temperature while using less power. Since thermoelectric refrigerators have been widely used in all major application areas—except manufacturing and creation. Thus, it can be said that the creative idea of using this device to cool the coolant in place of a traditional coolant cooler will aid in decreasing tool wear and enhancing surface polish and tool life

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