# FABRICATION OF THERMOELECTRIC COOLING SYSTEM USING PELTIER EFFECT

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**Abstract** - The ongoing development in science and technology has created a variety of system that can be used in producing refrigeration effect. Present conventional refrigerators use Ammonia, and R12 as refrigerant which are harmful to environment. The proposed project aims to develop small units of cooling appliances to be used for storage of medicine in medical shops, hospitals etc., to maintain food items for the patients in the hospitals and for uses in small pan-shops for cold storage. Even in guest houses and hotel rooms, these small units are required. A cooling effect using a thermoelectric module and Peltier-effect will eliminate the use of harmful refrigerants and also the moving parts like compressor, evaporator etc. are being eliminated by using this method. Using this environmental friendly method of refrigeration, it reduces the cost of refrigerator and helps to protect Ozone layer. By eliminating the refrigerants, effective cooling of 48 litres in volume can be achieved.

**Keywords:** Portable , Eco Friendly

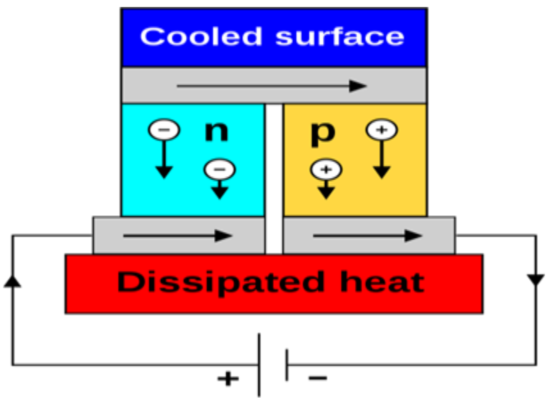
## 1.INTRODUCTION

The fundamental application of a refrigerator , to keep food cold and fresh for longer time is due to reduced spoilage of food by the slowed down activity of bacteria at the cooler temperatures . Cold temperatures help food stay fresh longer. There are several types of Refrigeration systems that are designed to produce cooling. Thermoelectric cooling is based upon "The Peltier Effect". The main objective of our project is to produce the cooling effect by using the "Peltier Module". By using this type of Refrigeration system, we are avoiding the conventional mechanical devices, usage of harmful refrigerants and usage of green-house gases thereby protecting our environment. Using the Thermoelectric materials, we can convert electrical energy into thermal energy and vice versa

**Principle of Peltier Effect**

One of the connections created by the two dissimilar materials may heat up while the other cools down when an electric current passes between them. This is referred to as the Peltier effect, which is the Seebeck effect in reverse. The Peltier coefficients and the current passing through the materials determine how much heat is produced or absorbed. Thus, the Peltier effect can be employed as a silent refrigerator without any moving fluid and to pump heat from one place to another. Thermoelectric refrigerators are small, green, and safe because they don't use dangerous refrigerants. Applications for satellites, spacecraft, dehumidifiers, and fiber optics can all benefit from the Peltier effect's cooling properties.

A longer lifespan and less maintenance are provided by the absence of mechanical wear and moving parts. Since no refrigerants are utilized, there is no issue with leaks. The size and shape of the thermoelectric coolers will be flexible. By regulating current, the TEC coolers offer precise control over heat produced or dissipated. Its poor coefficient of performance and expensive cost for a given cooling capacity are its key drawbacks.




1.1 Peltier Effect

## 2 . Literature Survey

Tarun Prasad Sonwani, et.al May 2020 [5], In this scenario this refrigeration system is useful in journey period, carrying medicines and making the temp of the food stuff stable at what they were kept.

Muhammad Fairuz Remeli, et.al ICMER 2019 [6], the validated theoretical analysis could be used to predict the suitable parameter such as the suitable heat sinks to be used, the size of the cooler, the cooling temperature and the performance of the cooler including the coefficient of performance (COP).

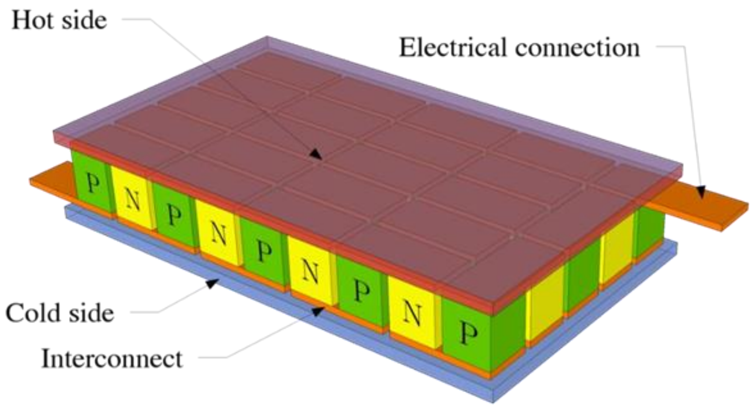
Manish Nair and Brajesh Tripati, April 2019 [7], In this Conference paper work showcases the performance parameters of thermoelectric refrigerators in two different cases. As a result there will be less power consumption and totally eco-friendly refrigeration compared to conventional refrigeration with the same refrigerating effect.

Prof. Rajendra. P. Patil, et.al May 2017 [4], this paper reviews the developments in TER system over the years. This study on the thermoelectric refrigeration emphasize that the TER system is a novel refrigeration system which will be a better alternative for conventional refrigeration system.

Rakesh. B. K., et.al May 2016 [3], used a Peltier Module (TEC1-12706) sandwiched between the two CPU heat sinks creating a temperature of 298 K and 283 K Which produced a cooling effect of 12 W..

## 3.Selection of TEC Module

It is necessary to compute the cooling load Qc. The product of the water's mass flow rate, specific heat, and temperature differential yields the cooling load, or Qc. The heat sink, which is at room temperature, is connected to the hot side of a TEC Module for refrigeration applications. Heat moves from one end to the other when a DC current is supplied. The temperature on the cold side falls below the surrounding air temperature. Multiple coolers can be staged or cascaded together for lower temperatures in certain applications, however this results in a significant decrease in overall efficiency (COP). The difference between the desired (cold side) and ambient (hot side) temperature (the heat source's temperature) ultimately determines the maximum coefficient of performance (COP) of any refrigeration cycle.The higher the temperature difference (delta), the lower the maximum theoretical COP.




## 4. COMPONENT REQUIREMENTS

1 Thermoelectric Module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The Peltier module is manufactured by using Bismuth telluride material and it has a specification i.e., TEC1-12706 and its properties are 127 P and N-type semiconductor couples.

2. Heat Sink with Fan


Heatsink size = 85.4 × 68.3 × 41.5 mm
Fan size = 70 × 70 × 25 mm
Fan speed = 3300 ± 10% RPM
Bearing type = Porous bearing
Rated voltage = 12V DC
Noise = 19dBA (min)

3. Insulating Materials

Cut quality, more affordable materials were used in our project in order to cut the final product's cost. These three materials are Polystyrene, Mild Steel Sheet, and Glass Fiber; table 5.2 lists their respective qualities. To reach 20C in the refrigerator, use a fan-equipped heat sink and a Peltier module.

4. Thermal Paste (Thermal Grease)

| | | |
|---|---|---|
| Viscosity | = | 250 Ns/m2 |
| Specific gravity | = | 2.77 (at 250C) |
| Thermal Conductivity | = | 2.9 W/m K |
| Thermal Resistance | = | 17 mm2 K/W |
| Operating Temperature | = | -50 to +120 0C |

4. **DIMENSIONS:** A three wall rectangular box having the following dimensions is selected

Panel dimensions,

| | | |
|---|---|---|
| Vertical, front and back | = | 0.44 x 0.47 m. |
| Top and bottom | = | 0.44 x0.44 m |
| Area of the System | = | 0.132 $m^2$ |
| Volume of the inside chamber | = | 48 litres |

**Parts of the system:**

1. Plastic Fibre Insulation
2. MS Sheet Insulation
3. Polyurethane Insulation
4. Heatsink and TEC Assembly
5. Cooling Chamber

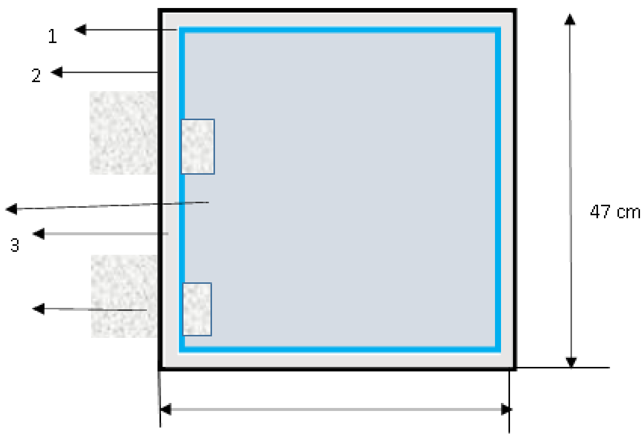
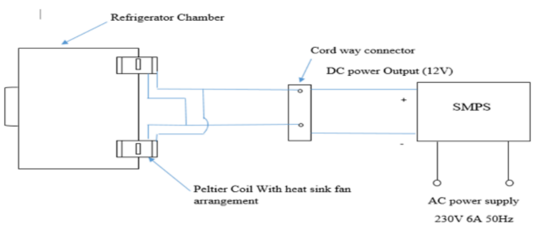



Fig 2. Geometry of System

## 5.System Connection




### 5.1 Specification of TEC

| | | |
|---|---|---|
| PRODUCT | = | TEC-12706 |
| OPERATIONAL VOLTAGE | = | 12V DC |
| CURRENT MAX | = | 6 Amp |
| VOLTAGE MAX | = | 15.4 V |
| POWER MAX | = | 92.4 |
| POWER NOMINAL | = | 60 |
| COUPLES | = | 127 |

### 5.2 Coefficient of Performance

`Peltier Dimensions = 40 * 40 *4 mm

Density = 7.642g/$cm^3$

Current = 6 A

Current Density = 625 A/$m^2$

Voltage = 12 V

Resistance = 12

| | | |
|---|---|---|
| Product | = | TEC-12706 |
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| Power max | = | 92.4 |
| Power nominal | = | 60 |
| Couples | = | 127 |
| Peltier module dimensions | = | 40× 40 ×3.5 mm |

Temperature of Hot Side = 50°C

Temperature of Cool Side = 25°C

Ambient Temperature = 32°C

Convective heat transfer coefficient = 10W/$M^2$

Specific Heat Capacity of Air = 1.1J/g°C

Cooling Power is:

$Q1 = (\alpha 2 - \alpha 1)\ T1I - U\ (T1 - T2) - ½\ I2\ R$

$Q1 = (5x10\text{-}4 + 7.2x10\text{-}5)\ 323x6 - 0.06\ (50\text{-}25) - ½x62x12$

= 216.39

Power Consumption:

$W = (\alpha 2 - \alpha 1)\ (T1 - T2)\ I + I2\ R$

= (5x 10-4 + 7.2 x10-5) (50-25) (6) + 62x12

= 432.085 W

COP of the TEC module is

COP = Cooling Power/ Power Consumed COP = Q1 / W

= 216.39/432.085

= 0.5 × 3 = 1.5

COP = 1.5

**Heat load calculation**

we can use this equation:

$$Q = \frac{\Delta T\ A}{\frac{1}{h} + \frac{L}{k}}$$

$$Q = \frac{\Delta T . A}{2 \times \frac{1}{(Hair)} + \frac{l1}{kpf} + \frac{l2}{kms} + \frac{l3}{kfib}}$$

$$Q = \frac{0.1225 \times 22}{2 \times \frac{1}{10} + \frac{0.001}{52} + \frac{0.001}{0.05} + \frac{0.032}{0.026}} = 1.625\ W$$

Passive load through the walls,

Qp = (Q1+ Q2 + Q3) x 2 = (1.625 + 1.625 + 1.625) x 2 = 9.75 W ≈ 10 W

Hear load due to Infiltrating air, QC ≈ 10W QTP = QP + QC = 10 + 10 = 20 W For safety,

QTP ≈ 25 W

| | TEC System | Conventional System |
|---|---|---|
| Usage (in hours) | 12 | 12 |
| Power used per hour (W) | 238 | 350 |
| Price per unit of power (Rs) | 3.5 | 3.5 |
| Cost per hour (Rs) | 0.83 | 1.22 |
| Cost per month (Rs) | 304 | 447 |

**Power Consumption**

Power Consumption increase with heat load , TEC are 10% – 15% efficient i.e. 10 joules of energy remove 1 joule of heat. Calculation of total power consumption of the refrigerator is,

Peltier Module:

Voltage = 12 V Current = 6 A Power = V×I

= 12×6

72 W

Having used 3 TEC module in this project, total power consumed for TEC is,

= 72 ×3 = 216 W

Fan:

Voltage = 12 V Current = 0.3 A Power = V×I

= 12×0.3

3.6 W

We are using 6 fans in our project, therefore total power consumed for fan is,

= 3.6×6 = 21.6 ≈ 22 W

Total Power consumption is, P = 216 + 22

= 238 W

## 6.RESULTS

An analysis of the constructed thermoelectric refrigerator's performance and an experiment were carried out. The refrigerator cabin was cooled by the thermoelectric module's cold end, and the temperature was monitored using a digital thermometer. For heat rejection, the hot end is fastened to a heat sink. A system cool-down experiment was carried out to verify the system's functionality.

## 7. CONCLUSION

The refrigerator cabin has been cooled using a thermoelectric refrigerator that uses three TEC modules, each of which consumes 72 W of power. Thermoelectric refrigerators are proven to be cost-effective when they operate within the temperature limitations of 25°C and 500°C, although they are only capable of handling light, steady loads. The scope of operation of a cascaded module design can be increased. The results of the cool-down experiment show a C.O.P. of 1.5, which can be raised with better field-work fabrication and insulating materials. When combined with renewable energy sources, the thermoelectric refrigerator's portability allows it to be utilized in remote locations and is an ideal tool for chilling electronic components.

## 8. REFERENCE

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