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DESIGN AND TESTING OF REFRIGERATION SYSTEM BY USING PELTIER PLATE

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Abstract: The application of Peltier effect is in thermoelectric refrigeration systems and for good refrigeration performance, there should be effective heat dissipation. The greenhouse gas effect is the most important problem of the Twenty-first century. To solve this problem, we have worked on the invention of different devices to lessen its impact. we design and fabricate the portable refrigerator powered by thermoelectric refrigeration system. The design of refrigeration is based on thermoelectric effect (Peltier effect) to create both the sides i.e. hot and cold. The objectives of this study are to develop a working thermoelectric refrigerator to cool a volume of 21 L that utilizes the Peltier effect to cool and maintain a selected temperature range of 16°C to 24°C. A domestic refrigerator is operated continuously to maintain food storage conditions. Because the continuous use of, it accounts more electrical consumption. A remarkable amount of waste heat is rejected in the refrigeration system by the condenser. In this, we use water flow from the tank to a water block and Peltier which will produce cool in the refrigeration system.
Key words: Thermoelectric refrigeration system, Peltier effect, Thermoelectric module, Portable refrigerator, Insulated cabin.

I. INTRODUCTION

The Peltier effect is used in thermoelectric refrigeration (TEC), which is the direct conversion of electrical energy into Cold and heat. Thermoelectric refrigerators havemany advantages over traditional refrigeration systems, which include compressors, condenser, evaporator which also include small size, long life, no noise, accurate temperature control, and most importantly, there is no need for refrigerant. Because of this it is use in refrigeration, electronic device cooling, medical device temperature control. Thermoelectric refrigerator works on the PELTIER effect that the Peltier - see back effect, or thermoelectric effect, is the direct conversion of electric voltage to thermal differentials 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.

However, its cooling capacity is less and Coefficient of performance (COP) is lower than the compressor. Operating Principles of Thermoelectric Material When a circuit of two dissimilar metals and two junctions is formed, a current will flow between the junction or the circuit. This miracle is known as the see back effect. Due to the increasing demand for refrigeration in various fields led to release of harmful gases like CO2 all over the world, which is a contributing factor to global warming on climate change. Thermoelectric refrigeration is a new alternative method. To create cold and hot surfaces thermally in parallel, the thermoelectric module is made up of semi-conductor material and they are electrically connected in series configuration. Although they are less efficient than the vapor compression system, they are very light, low in cost, silent in operation, and environmentally friendly. It does not need large and heavy piping and mechanical compressors, which are used in VC cooling system. It uses only fan in this project, no other moving parts are uses such as firmness approval thermoelectrically cooling over traditional refrigeration in some situations. The dense size and weight requirement as well as motility, in the design rule out the use of traditional refrigeration. While the Peltier effect was discovered by jean Charles athanase Peltier in 1834, thermoelectric devices have only been applied market oriented during the latest years. Thermocouples are used in thermoelectric modules which are formed by pairs of P-type and N-type semiconductor thermoelements. To create cold and hot surfaces thermally in parallel, the thermoelectric module is made up of semi-conductor material and they are electrically connected in series configuration.

II. EXPERIMENTAL SET UP

1.Working Principle

Our main power supply for this system is an AC 220 voltage. AC to DC is converted by SMPS that's the main function of SMPS. Since all our instruments in this project are DC, we need DC power. This SMPS will be supply fixed 12V DC, 30Amp system. Here we use Peltier, water block, temperature sensor, aluminum sheet etc. Firstly, we on the power button to on system. Then motor will be rotate the tank water. After that water goes in water block, then the water pass through the Peltier and system produces cool inside of this system. This is the main function of our system.

A Peltier plate, also known as a thermoelectric cooler, operates on the principle of the Peltier effect. When heat is absorbed at one junction and released at another junction, an electric current pass through two different conductors. In a refrigeration system with a water pump, the Peltier plate is sandwiched between the heat sink. The water pump circulates water through one of the heats sinks to absorb heat from the desired area. Meanwhile, the Peltier plate absorbs heat from the other side of the plate, transferring it to the second heat sink, where it is dissipated. This creates a cooling effect on one side of the plate and a heating effect on the other side. The direction of heat transfer can be reversed by changing the direction of the electric current flowing through the Peltier plate. Overall, the Peltier plate allows for precise and efficient temperature control in refrigeration systems, with the added benefit of being compact and having no moving parts.

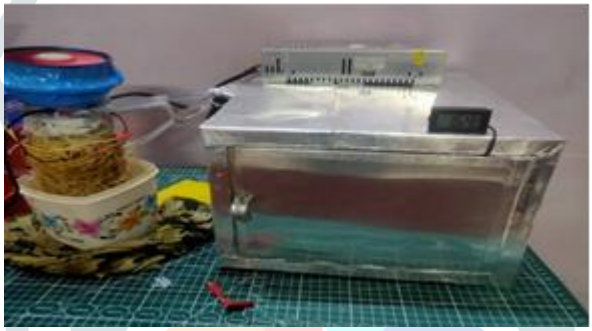


Figure1 - Setup Photo

2. Experimental Setup Development:

In this proposed work, the main aim is to develop a portable refrigeration system with a capacity of 21 liters. The system should be capable of maintaining the temperature of the cabinet between +10°C and +17 °C range for a long time. We can use this system in the areas heaving lack of power, alternating sources of energy like solar energy of battery to be incorporated in the design. It should be portable, compact as well as light weight. Moreover, the system is meant for outdoor use hence it should have better insulation and radiation control mandatory. For the worse condition, this system is design for maintaining a fixed room temperature throughout operational period, the design is in the way that it can acceptable for refrigerating the chamber from ambient temperature to the required temperature. So, we have used a water pump, a water block which absorbs the heat of the Peltier and cooled it.

Geometry of Model: With the constraints imposed by the objectives a double walled rectangular box with an insulation of inside and outside Aluminum sheet, polystyrene, foams between the walls as shown in figure1.

Geometry: It constitutes doubled walled cabin with insulation having the following dimensions

Top and bottom panel dimensions = 0.32 x 0.32m

Vertical side panel dimension = 0.22 x 0.22m

Front and back panel dimensions = 0.30 x 0.30 m

Materials: Aluminum sheets with thermal conductivity of 237W/mK were used Expanded polystyrene (EPS) slabs with 10 mm thickness having a density of 30kg/m3 and thermal conductivity of 0.33W/mk were used to give the required thermal insulation.

III. COMPONENTS

This system heat or cool the product using thermoelectric module the construction set up for this system require following part

1. Switch Mode Power Supply 2. Temperature Sensor 3. Cooling Fans 4. Aluminum Box 5. Heat Sink. 6. Peltier plate. 7. Water Pump.

1. Switch Mode Power Supply

A Switch mode power supply is also known as SMPS, which is an electronic power supply that merge a switching regulator for efficient electric power conversion. The SMPS we are using is of 30A. The Meanwell range of SMPS are design to convert AC to DC Supply. Their open case design permits them to be cooled either by fan forced air or by free air convection. All models come with short circuit, overload and over voltage protection, in order to guarantee performance.

2. Temperature sensor

The LCD Electronic Fish Tank Water Detector Thermometer can make sure you know exactly what the ambient temperature of your fish tank is. For Measuring temperature in Specific Places, it features a probe submerged into the fish tank to measure LED display HC and water temperature when the temperature exceeds 110^0C and it displays LC when the temperature is within -50^0C.

3. Cooling Fan

The rate of cooling is increased with the help of radiator cooling fan.3inch fan is operating at 12V with a dimension of 80x80x25mm with a speed of 2600 RPM.

4. Aluminum Box

Aluminum is a preferred material for these applications due to its excellent thermal conductivity and lightweight nature. It allows for efficient heat transfer and distribution within the box. The aluminum box has a thermal conductivity of 237 W/m^0 k. The principle of operation is relatively simple: when an electric current is passed through a Peltier plate, one side of the plate becomes cold, while the other side becomes hot.

5. Heat Sink

Heat sink is type of heat exchanger use to cool the system. Heat sink is having a thermal conductor which carries out heat from heat source in to fins/pins providing large surface area for heat to disappear throughout the rest of the computer. A heat sink is made up of aluminum or copper. In computers, heat sinks are used to cool CPUs, GPUs, and some chipsets and RAM modules.

6. Peltier Plate

Peltier modules containing two external ceramic plates which are separated by semiconductor pellets. When a current is pass through a semi-conductor pellet one of the plates absorbs heat and another plate removes heat. Peltier plates are made up of P-Type and N-Type of Semiconductor. Temperature differential is created by thermoelectric coolers (TEC or Peltier) on each side. They are widely used in industrial areas, for example, computer CPU, CCDs, portable refrigerators, medical instruments, and so on.

7. Water Pump

Water pump is a dc electric water pump motor that powered by a 12V direct current power supply Centrifugal force is generated by a high speed rotated impeller to booster, lift and to transfer liquid such as water, coolant for sprayers, cars, shower, garden etc.

IV. DEVELOPMENT OF ANALYTICAL DESIGN

1. Fabrication of the Cabin:

Cabin Walls*:* The rectangular double walled cabin is made using aluminum sheets of 4mm thickness. The Designed dimension (300mm x 300mm x 300mm), of the cabin is obtained by performing suitable bending operations on the sheet.

Insulation*:* Expanded polystyrene foams are made by mixing the polystyrene with a solvent, adding a gas under pressure and finally the mixture is extruded to produce the required thickness. The thermal conductivity of slab is 0.33 W/mk.

2. Assembling Module of Cabin:

When the TE module is mounted, then we can install it on the insulated double walled cabin. Once the TE module assembly is incorporated into the cold plate of (Aluminum) should be concurrent with the inner wall and the fins are unprotected too outside. The power input socket and the control panel are covered by a shield.

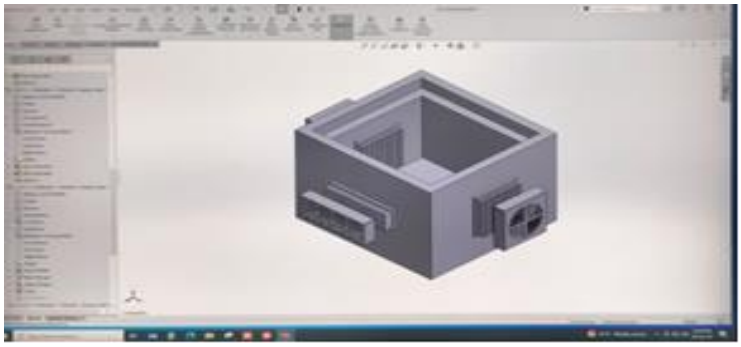


Figure 2 – Solid works model of cabin.

Table 1 – Table of parameters

1. Specification of Cabinet		
Parameters		**Value**
Outside Dimension (mm)	Width (w)	300

S.r No.	Parameters	Values
1.	Outside Temperature (Do) (°C)	34.2
2.	Inside Temperature (Di) (°C)	16.8
3.	Internal Fan Motor	1
4.	Outside Material Thickness (mm)	6
5.	Inside Material Thickness (mm)	5
6.	M/C Area Top Temperature (°C)	48.4

3. Choosing the Peltier module

Among three TEC One of the TEC-12706 module is efficient of producing 250 W of cooling, but in order for one module to produce 250 W of cooling, which needs a direct current power supply rated at 30 amps and 18 V. So, by using three modules, power supply which is available at the lab can be used to supply each module rated at 12 V.
Using three Peltier TEC1-12706 modules:

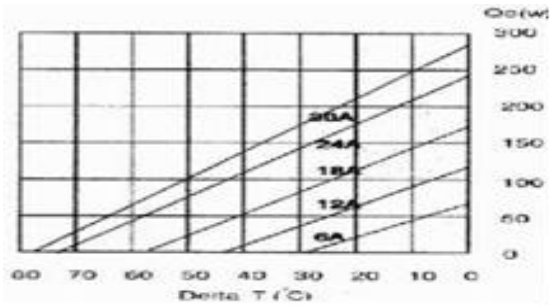
Cooling capacity required for each module = 330\3

= 110 W

Temperature difference, $\Delta T = T(h) - T(c)$

$= 50 ° C - 18 ° C$

$\Delta T = 32 ° C$



	Length (L)	320
	Height (h)	220
Inside Dimension (mm)	Width (w)	260
	Length (L)	270
	Height (h)	180
Door Dimension (mm)	Width (w)	275
	Depth (d)	275
	Height (h)	275
Usable Volume = 21.13 Lit		

Figure 3 Voltage Graph For TEC-12706 Module

Table 2 – Table of Specification of Cabinet

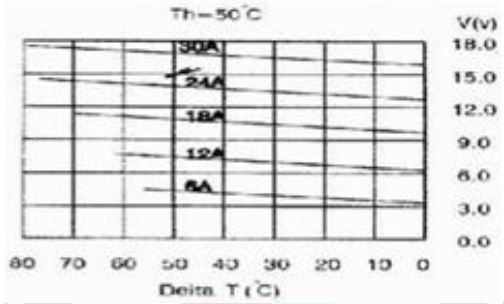


Figure 4 - Current For TEC-12706 Module

V. RESULT AND DISCUSSION

Table 3 - Table of Data Collection

Sr. No	Time (Min.)	T_h (Hot side temperature), °C	T_C (Cold side temperature), °C
1	01(Min)	34.2°C	34.2°C
2	04(Min)	64.5°C	28.6°C
3	06(Min)	78.4°C	26°C
4	09(Min)	90.3°C	23.6°C
5	12(Min)	91.1°C	21.8°C
6	16(Min)	92.2°C	20.6°C
7	20(Min)	92.6°C	19.3°C
8	24(Min)	93.8°C	19.5°C
9	28(Min)	97.9°C	18.1°C
10	34(Min)	100°C	16.4°C

$$\mathrm{COP} = \frac{\mathrm{T1}}{\mathrm{T2} - \mathrm{T1}} = \frac{16.4}{34.2 - 16.4} = 0.921$$

Table4 - Table of Temperature difference vs. voltage

Sr No	V (Output voltage), V	ΔT (Temperature difference)
1	0.30	20.0
2	0.60	52.0
3	0.86	77.3
4	1.02	80.8
5	1.40	83.1
6	1.90	86.4
7	2.10	89.4
8	2.56	90.2
9	2.86	93.0
10	3.18	94.0

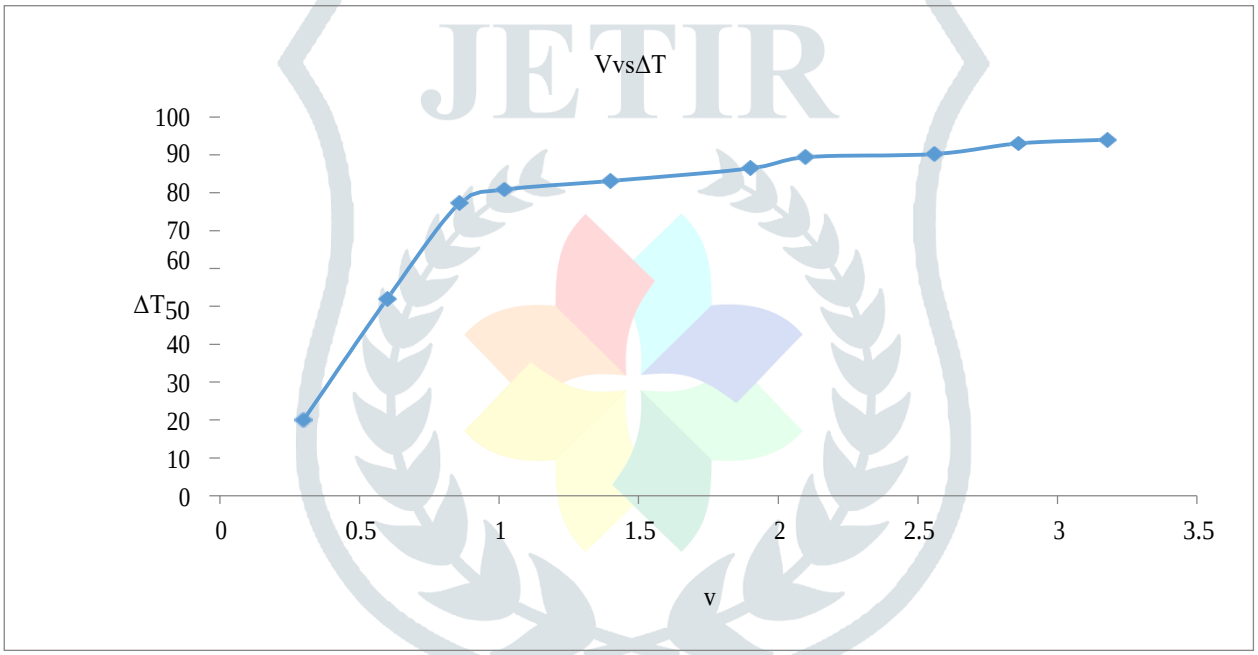


Figure 5 -Temperature difference vs. voltage graph

Table 5 - Table of Voltage vs. current

Sr no	V (Output Voltage), V	I(Current), A
1	0.30	0.11
2	0.60	0.18
3	0.86	0.25
4	1.02	0.29
5	1.40	0.30
6	1.90	0.35
7	2.10	0.40
8	2.56	0.45
9	2.86	0.50
10	3.18	0.65

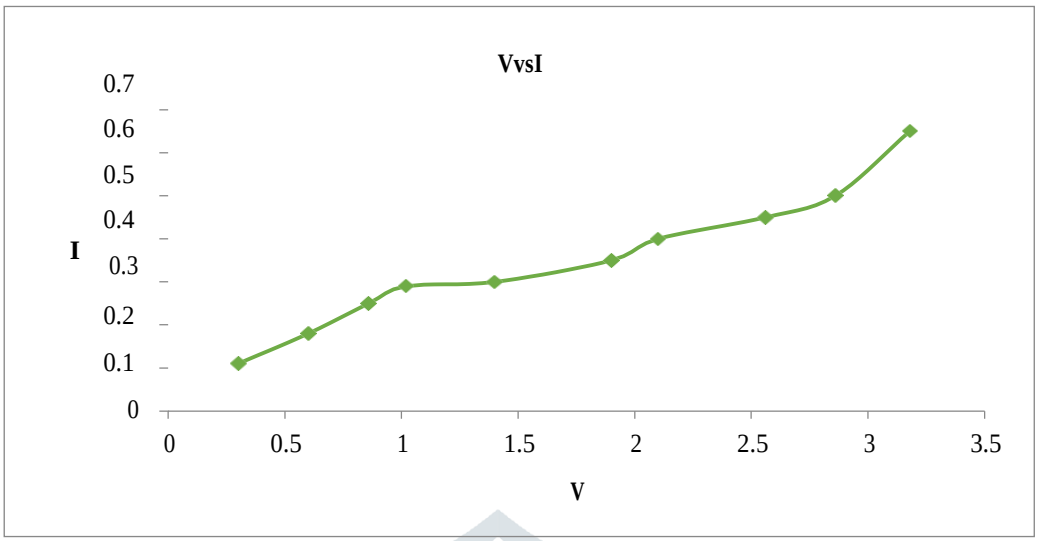


Figure 6 - Voltage vs. current graph

VI. CONCLUSION

1. The main objective of this project was to develop a refrigeration cycle system based on Environment, Energy efficiency. From table 5.1 of data collection, in that maximum and minimum temperature for the system is 34.2 and 16.9 from that we got COP of 0.97.
2. From table 5.2 Temperature difference vs. voltage, as we reach to the voltage of 0.30 V, the obtain temperature difference was 20^0C, as well as we reach the maximum voltage of 3.18V the temperature difference was at 94^0C, the temperature is directly proportional to the voltage.
3. From table 5.3 Voltage vs. current, as we reach to the voltage of 0.30V the obtain current was 0.11 A, as well as we reach maximum voltage of 3.18V the obtain current was 0.65 A, voltage is directly proportional to current.

VII. FUTURE SCOPE

The future scope for this system is as follows:

1. In future, Sensors, microcontrollers etc. can use in the system to obtain more desirable outcomes.
2. We can Also make this on IOT based in Future, adding other features such as Automatic heat sensor, deep fridge system.

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