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Performance Evaluation of Thermoelectric Refrigerator Using Peltier Effect

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Abstract: ***The worldwide growth in call for refrigeration brought about the manufacturing of extra power and this, in turn, brought about extra use of CFCs. CFCs, in particular, are a notable factor in the ozone layer's depletion. TER (Thermoelectric Refrigerator) is a revolutionary option that eliminates the use of refrigerant. As a result, it is critical, especially in underdeveloped countries where extended life and inexpensive maintenance are required. The goal of this research is to design and build a functional TER that uses the Peltier effect to cool this volume to much lower temperature in under two hours and retain it for at least the next 1/2 hour. In this project, we created a TE system that works with both solar and electrical power. Food preservation, military or aerospace equipment, medicinal and pharmaceutical equipment are just some of the uses for the project.***

Keywords: Thermo-electric Refrigerator, CFCs, COP, Peltier Effect

I. INTRODUCTION

Refrigeration is a method of cooling a place, substance, or equipment by lowering and/or maintaining its temperature below that of the surrounding environment, i.e. refrigeration is a method of moving heat/warmth from one location to another. Because cold is the absence of heat, lowering a temperature requires "removing heat" rather than "adding cold."

According to the Second Law of Thermodynamics, some work must be done to accomplish this. This work/process is typically accomplished by mechanical means. However, this can also be accomplished via magnets, lasers, or other methods.

Refrigeration has had and continues to have a significant impact on the economy, culture, farming, and land tenure. The concept of preserving meals/food can be traced back to the ancient Roman and Chinese civilizations. However, the vapor compression refrigeration technology has advanced quickly during the last century, from ice harvesting to temperature-controlled rail cars.

Refrigeration's uses can now be found in domestic refrigerators, industrial refrigerators, cryonics, and air conditioning, among other places, as a result of studies and improvements in the field.

A growing surge withinside the call for refrigeration is visible and this has caused a boom with inside the intake of energy that's a contributing issue for worldwide warming and weather change. TE refrigeration is a useful opportunity as it is able to use waste energy for similarly cooling systems and therefore offers us the choice of being environment friendly.

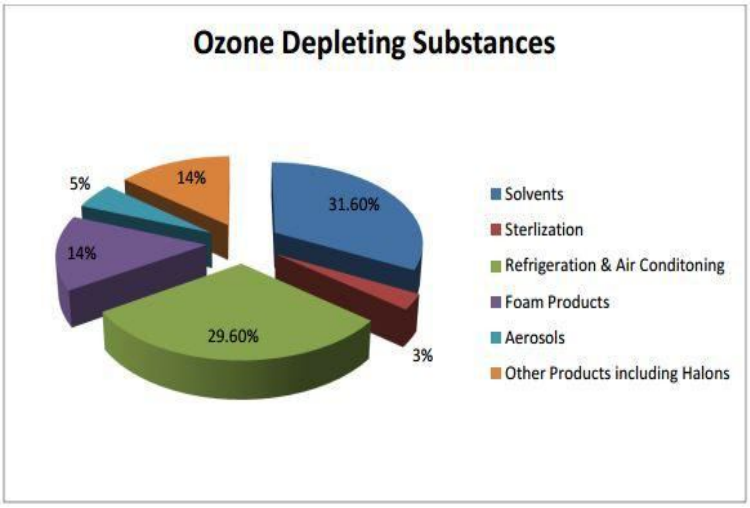

Fig -1: Sources that deplete the Ozone layer

II. LITERATURE SURVEY

"Performance Evaluation of a TER (Thermoelectric Refrigerator)", by Onoroh Francis, Chukuneke Jeremiah Lekwuwa, Itoje Harrison John[1]. From this research paper, we have studied mainly about Seebeck effect, thermoelectric and hybrid refrigerators and also about thermoelectric materials. Because of its benefits, thermoelectric cooling is one of the most promising alternative R&AC technologies. To improve the COP of the current cooling refrigerator/system, thermoelectric effect is applied.

Gao Min (2006) created a number of sample thermoelectric refrigerators using a variety of heat exchangers and evaluated their refrigeration rate in terms of COP, heat pumping capacity, cooling rate, and thermal stability. For a basic operation temperature of 50°C, the sample refrigerator's COP is estimated to be in the range of 0.3-0.5. The possibility for a TER's cooling performance to be improved is also explored, as the current thermoelectric modules are utilized in electronic cooling applications.

International Journal of Modern Trends in Engineering and Research (IJMTER) Volume 02, Issue 07, [July– 2019] ISSN:2349–9745; ISSN :2393-8161[2]. In this journal they have used Peltier module to make a refrigerator to reduce electricity consumption and also reduce space consumption compared to regular refrigerator which requires more space and electricity.

Mayank Awasthi's article "Design and Development of Thermoelectric Refrigerator"[3] appeared in the International Journal of Mechanical Engineering and Robotics. We mostly learned about heat sinks from this research report. The primary condition or requirement is to lower the temperature of the volume in a shorter amount of time while maintaining a retention time of at least 30 minutes.

Dr. Jitendra and Ajitkumar Nikam, Mechanical Engineering Department, Rajashri Shahu College of Engineering, Pune, have written a research paper titled "A Review on the Use of Peltier Effects."[4] The usage of Peltier plates in freezers is explored in this research article. COP is a function of the temperature difference between the source and the sink. As COP is used to determine a system's efficiency, temperature differences should be reduced to a minimum for optimum efficiency.

III.LITERATURE SUMMARY

Journal papers and generals researched here are connected for work in the field of design and improvement of a thermoelectric refrigerator. TEC is an alternative R&AC technology for its advantages. It will increase the COP of the present cooling system. The main purpose is to cool the given quantity to much lesser temperature within less duration and to offer retentivity for at least the next half an hour. The coefficient of performance (C.O.P) of refrigerators is the temperature difference between the source and sink. To obtain maximum efficiency the temperature difference should be minimal. The need of replacing the peak load demand for electricity for air conditioning application coupled with the desire of gas utilities to balance their heating loads with a summer alternative has led to the development of heat-powered refrigeration cycles. The result has been researched into improved desiccant material and cycles to enhance performance and decrease costs. Recent refrigerators use less energy as smaller and higher-efficiency motors and compressors, better insulation materials, larger coil surface areas are used.

IV.PELTIER EFFECT

Peltier effect states that "when an electric current flows across two dissimilar conductors, the junction of the conductors will either absorb or emit heat depending on the flow of the electric current". The heat absorbed or released at the junction is proportional to the input electric current. The constant of proportionality is called the Peltier coefficient.

Peltier effect is used for thermoelectric cooling is used to generate a heat flux between the junction of two unlike materials. Since heat flux is created, there is conversion of temperature difference to electric voltage. Application of Peltier effect can be seen in coolers that are used while traveling, for cooling electric components and compact instruments.

The two dissimilar conductors are doped in ceramic water and this ceramic component is Peltier device for which products the cooling effect which we use it as component for refrigeration.

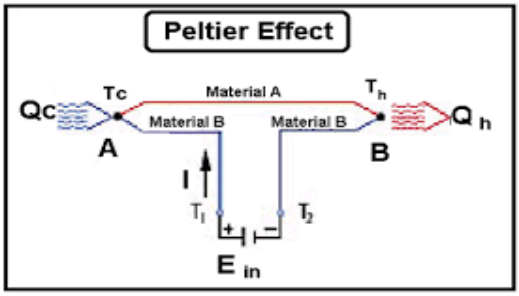

Fig -2: Peltier Effect

V. MATERIALS AND METHODS

The Essential Components of Thermoelectric Refrigerator are

A. Thermoelectric module
B. Heat sinks
C. Heat sink fan
D. Battery
E. Thermal casting
F. Temperature indicator
G. Solar panels
H. Required connection cables

1) A solar panel is used to convert solar energy into electricity. Electricity is used to charge battery (12V, 7Ah) connected after solar panel. Current flows into the battery conversion switch, then to Peltier module.
2) An alternate way to use current is from mains, but Peltier assembly (Peltier module, cooling fan) desires only 12V DC current. By utilizing step down transformer, the current is put down to 12V current. Once the conversion is done, current flows to battery conversion switch followed by Peltier assembly.
3) Refrigerator(box) inner dimension (35cm × 25cm × 29cm). It is made of wood of thickness 12mm. For insulation, 20mm thick polystyrene foam (thermocol sheet) attached to inner surface of wooden box in first experiment. Whereas in the 2nd experiment a GI sheet of 2mm is attached to 40mm thick polystyrene foam(themocol). For keeping the thermocol intact with the container, fevicol is used. The door is attached to the box using hinges.
4) The Peltier assembly includes a heat sink, cooling fan, and the backside of the refrigeration container using four screws. On the cooling side, the smaller sink is attached and on the hotter side, larger sink is attached. At last, a temperature indicator is installed where temperature difference between the box and atmosphere is observed.
5) Once assembling all components is done, power switch is put on, then according to Peltier effect, electric power generates a temperature difference between the two sides of the device. At the hotter side, heat is passed through the heat sink and is dissipated to the atmosphere similarly on colder side, air is dissipated through the heat sink and drops the temperature of the box. More the heat dissipated at the hot side more will be cooling at the colder side.

Fig -3: Experimental Setup where only polystyrene foam sheet is used inside the wooden box.

Fig -4: Top View of the Experimental Setup where GI sheet is attached with the polystyrene foam sheet.

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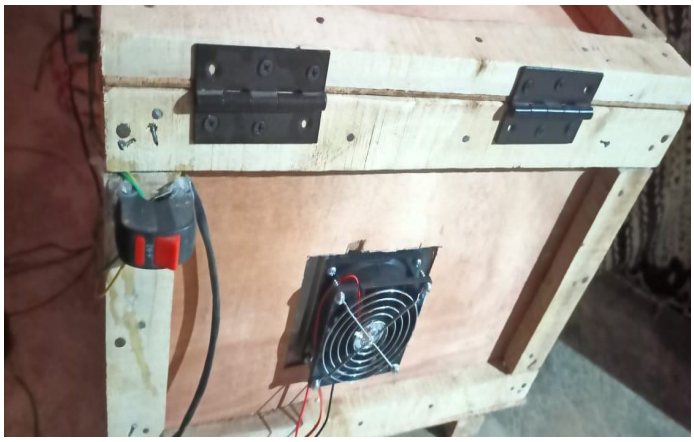

Fig -5: Side View of the Experimental Setup where GI sheet is attached with the polystyrene foam sheet.

VI. RESULT & DISCUSSION

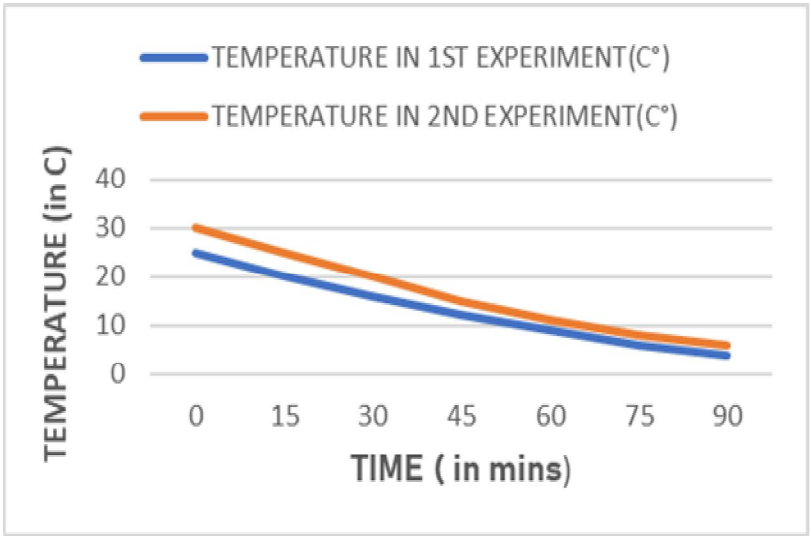

Fig -6: Temperature vs Time

TABLE I
Temperature recordings of 1st and 2ndexperiment

TIME (MINS)	TEMPERATURE IN 1ST EXPERIMENT(C°)	TEMPERATURE IN 2ND EXPERIMENT(C°)
0	25	30
15	20	25
30	16	20
45	12	15
60	9	11
75	6	8
90	4	6

VII. CONCLUSION & FUTURE SCOPE

After studying about the Thermoelectric refrigeration system, we could conclude that Thermoelectric cooling is one of the best alternatives to the current refrigeration system used. With its usage of Peltier effect, there is total elimination of refrigerants and reducing the impact of the refrigerants on the environment.

From our project, we observed that attaching a metal sheet inside the wooden box has higher duration of retentivity compared to when only polystyrene foam sheets was used. Also, advancements in materials technology could lead to more drastic rise in the cooling performance.

The Future work to be carried out is with the significance of thermoelectric coolers is notable in the present time when the world is facing the challenge to provide such devices while recognizing ecological compatibility and the cost of the device. Thus, it is important to research and study on TEs devices to deliver their maximum performance within technological limitations of manufacturing.

This work done here is to find out the optimum design and operating conditions to improve the refrigeration rate and COP at minimum cost of operation. This work can be extended to find out ideal number of stages in a multi-stage TE cooler to get the best results. The power supply to a thermoelectric cooler can be obtained from a thermoelectric generator or solar energy.

Further study can be done to couple a thermoelectric generator with a thermoelectric cooler and utilize waste energy from any application so that an independent source of power is not required. Presently, the thermoelectric materials give low coefficient of performance therefore they can be used in such application where other properties are more important than coefficient of performance for example weight of the cooling system or space availability. There is a lot of hope in this field to improve these systems for future applications. It has also been observed that rate of refrigeration and coefficients of performance do not go hand in hand in thermoelectric coolers.

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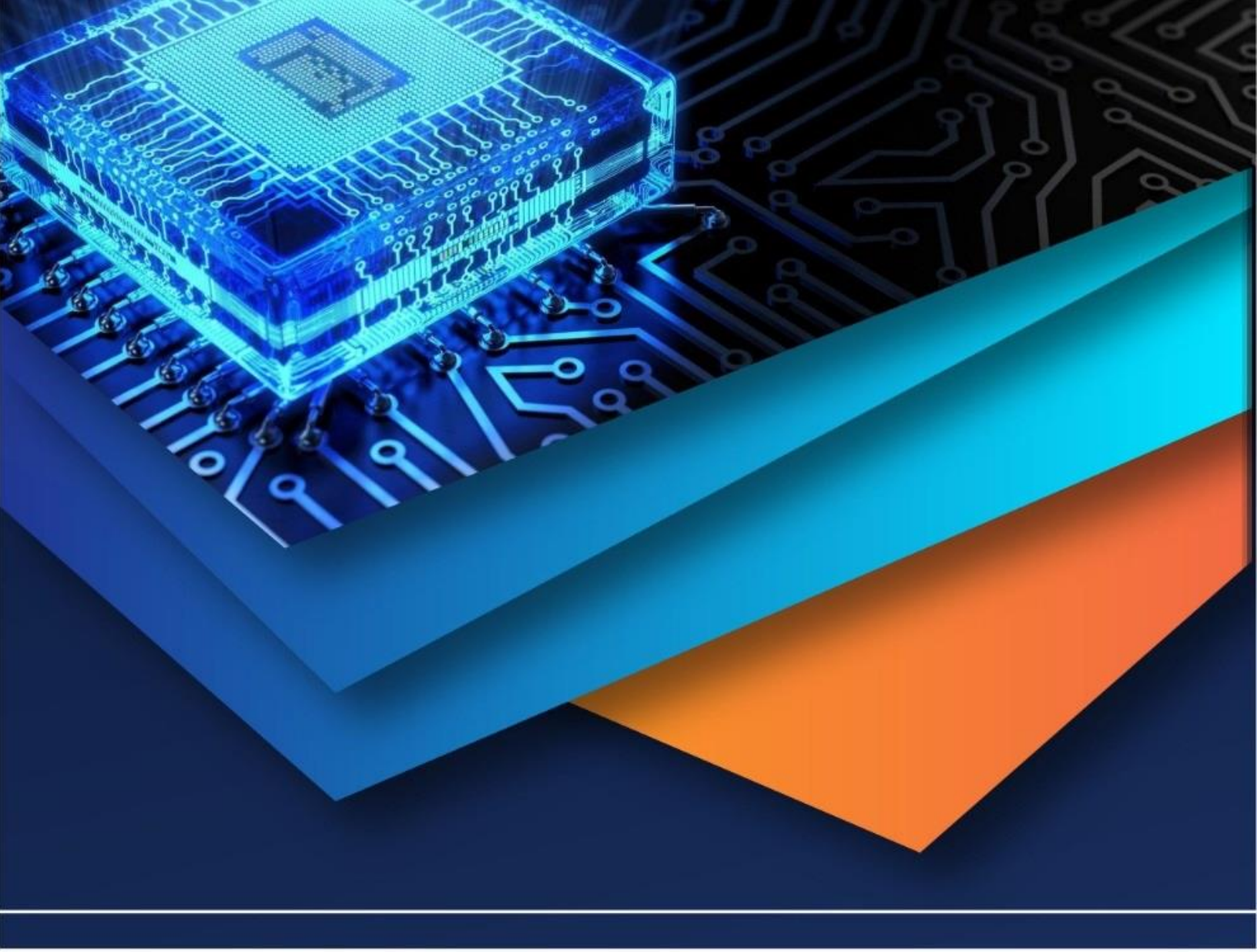

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