

Solar Refrigerator Using Peltier Effect

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Abstract - Our study on developing and refining a solar-powered refrigerator that makes use of the Peltier effect is described in this abstract. Homes and locations without easy access to energy can adopt such a system. One side of these modules gets cold and the other side gets hot as electricity passes through them. The purpose of this temperature differential is to produce a cooling effect. Our primary goal is to use solar energy as effectively as possible while achieving maximum cooling.

Fans and heat sinks are added to enhance cooling efficiency and remove heat more efficiently. To monitor and modify the system's operation for increased efficiency, a microcontroller-based control system is employed.

Key Words: Peltier module, battery, cooling fan, solar panel, and solar charge controller.

1. INTRODUCTION

In a period of growing energy needs, environmental concerns, and the urgent need for sustainable solutions, the hunt for innovative and environmentally friendly refrigeration systems has garnered a lot of attention. Among these, "Solar Refrigeration Using the Peltier System" has emerged as a viable and encouraging substitute effect." To address the pressing issues of sustainability and energy efficiency, the Peltier effect-powered solar refrigeration concept combines cutting-edge thermoelectric technology with renewable energy sources.

Conventional refrigeration systems, which typically

employ chemical refrigerants and mechanical compression, have long been the most widely used choice for cooling and preservation purposes. Environmental concerns have brought attention to the need to transition to sustainable and eco-friendly cooling methods.

2. WORKING PRINCIPLE

Thermoelectric cooling is based on the Peltier effect. Heat is absorbed at one junction and released at the other when a DC electric current passes between two different semiconductor materials (n-type and p-type). Heat-absorbing side gets cold, while the other side gets heated. Refrigeration makes use of this temperature differential.

Solar panels in the suggested setup use sunlight to create electrical energy. A solar charge controller controls the power output and charges a 12V battery. Peltier modules (TEC1-12706) receive current from the stored energy. The Peltier module's hot side dissipates heat via an aluminium heat sink and cooling fan, while its cold side cools the compartment.

When the solar panel transforms solar energy into DC power, the operation starts. A solar charge controller receives this energy and keeps the 12V, 7.5Ah battery's cycles of charging and discharging stable. The Peltier module subsequently receives the electrical energy that has been stored.

As the current flows through the Peltier module, heat is released into the environment through the heat sink on the hot side and absorbed by the cold side from the cooling chamber, lowering the module's temperature. Better heat conduction is ensured by applying thermal paste between the heat sink and module to increase performance.

Until the necessary temperature range (16°C–24°C) is reached, the system keeps running. The cooling chamber is continuously monitored by a digital temperature indicator, which makes sure the temperature stays within acceptable bounds.

Numerous investigations into thermoelectric refrigeration systems using renewable energy have been carried out. Using the Peltier effect, Gaurav Gupta et al. (2014) suggested a compressor-less air conditioning system that demonstrated significant energy savings over vapour compression techniques.

A solar-powered thermoelectric refrigerator was built by Ganesh Dhumal et al. (2015), who also established a mathematical model that precisely predicted system efficiency and temperature reduction. Using heat pipes and liquid-cooled heat sinks, K. K. Nandini and Muralidhara (2013) illustrated a Peltier-based cabinet cooling system that improved overall thermal performance. Using Peltier modules, Palash Nakhate et al. (2017) created an environmentally friendly refrigerator and emphasised its benefits over conventional refrigerants.

3. LITERATURE SURVEY

Thermoelectric refrigeration systems powered by renewable energy have been the subject of numerous investigations. Using the Peltier effect, Gaurav Gupta et al. (2014) created a compressor-less air conditioner that used a significant amount less energy. A solar-powered thermoelectric refrigerator with a precise efficiency model was developed by Ganesh Dhumal et al. (2015). Palash Nakhate et al. (2017) created an environmentally friendly Peltier refrigerator, while K. K. Nandini and Muralidhara (2013) enhanced cooling performance via heat pipes and liquid-cooled heat sinks.

These investigations demonstrate that thermoelectric devices are small, silent, and eco-friendly; nonetheless, heat dissipation and COP still require improvement. The present project's goal is to create an inexpensive, solar-powered Peltier cooling system for off-grid use based on this study.

4. MAIN COMPONENT

1. Solar panel



Fig 1. Solar Panel

Photovoltaic cells, which are found in solar panels, use sunlight to create electricity. The main source of power for the entire system is this electricity. Details: Justification: The 55W, 12V solar panel was chosen since it is compatible with the voltage needs of our system. It can effectively capture solar energy and is the right size for our first prototype.

2. Solar charge controller



Fig 2. Solar Charge Controller

An essential middleman in a solar power system is a solar charge controller. It maximises system efficiency and battery longevity by ensuring that the energy produced by solar panels is effectively and securely stored in the battery or energy storage system. Details: Reason: A 12V solar charge controller is essential for controlling the battery charging process, avoiding overcharging, and prolonging the battery's life, all of which contribute to the system's dependable performance.

3. Battery



Fig 3. Battery

The battery serves as a reservoir for energy storage, enabling the system to function at night or on overcast days. It ensures unbroken cooling by offering a constant power source.

Details: 12V voltage rating; 7.5AH (Ampere-Hours) capacity Justification: When there is little or no sunshine, the 12V, 7.5AH battery acts as a backup power source. When solar energy is insufficient, its capacity allows for prolonged operation, guaranteeing continual cooling.

4. Peltier Module

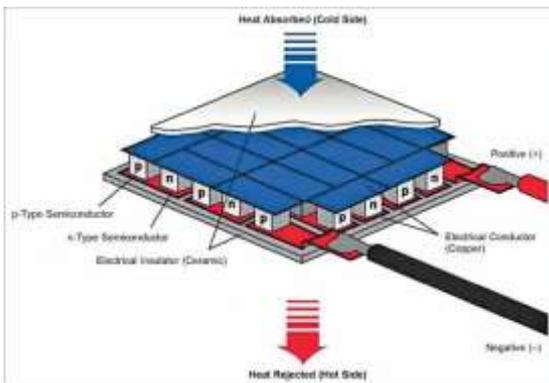


Fig 4. Peltier Module

The system's central component are Peltier modules, which use the Peltier effect to produce a cooling effect by running an electrical current through them. Refrigeration is made possible by this temperature disparity.

Details: Model: TEC1-12706

Rating for Voltage: 12V

Present Rating: 6A

Maximum Cooling Capacity: about 50–57 watts

Justification: The TEC1-12706 Peltier modules are perfect for our solar-powered system because they can be powered by a 12V source. Their large cooling capacity is essential to our prototype's efficient refrigeration.

5. Heat sink



Fig 5. Heat Sink

In order to ensure effective heat transport, heat sinks are essential. They aid in keeping the cooling compartments at the proper temperature by dispersing heat produced by the Peltier modules.

Details:

High heat conductivity material (such as aluminium)

Rationale: In order to effectively dissipate heat from the Peltier modules' hot side, avoid overheating, and guarantee reliable cooling performance, heat sinks are crucial.

6. Cooling compartment



Fig 6. Cooling Compartment

Temperature regulation is particularly important in cooling compartments. The system's job is to keep these

compartments at the proper low temperature while storing goods that need to be refrigerated.

Details:

Composition: Wood

Measurements: Height x Width x Depth = 35 cm x 25 cm x 25 cm

Justification: The Peltier modules, heat sinks, and cooling chamber can all be housed in the wooden cooling container's designated dimensions. Its insulating qualities support effective cooling with foil paper or polystyrene (Thermocol) and assist maintain the optimum interior temperature.

7. Temperature indicator



Fig 7. Temperature Indicator

The temperature indicator provides precise and current information about the environmental conditions within the refrigeration system by continuously monitoring the temperature inside the cooling chamber.

Features: An appropriate range digital temperature indicator. Justification: To make sure the system runs within the intended cooling range, a temperature indicator with a display is a crucial instrument for tracking and managing the cooling chamber's internal temperature.

5. BLOCK DIAGRAM

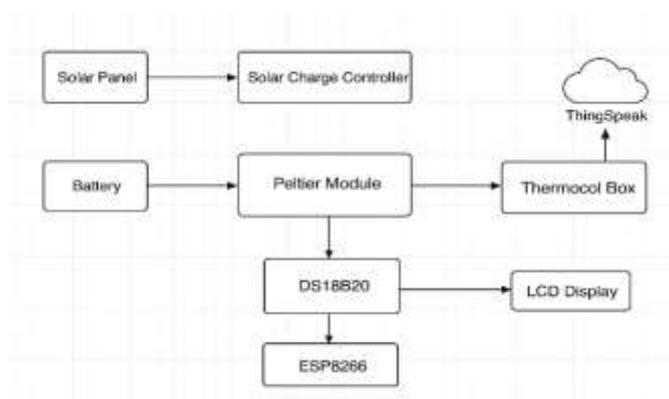


Fig 8: Block Diagram

This system is a solar-powered Peltier cooling system with IoT temperature monitoring. The solar panel generates electrical energy. The solar charge controller regulates and charges the battery safely. The battery supplies power to the Peltier module, which produces cooling. The cooling effect is applied to the thermocol box to maintain low temperature. The DS18B20 temperature sensor measures the box temperature. The ESP8266 reads temperature data and sends it to the ThingSpeak cloud through Wi-Fi. The LCD display shows the temperature locally.

6. READING TABLE

Sr No.	Time (min)	Cold Temperature (°C)
1	0	36
2	1	25
3	1.5	21
4	2	18
5	2.5	17
6	3	15
7	4	14
8	5	13
9	6	11.5
10	7	10

Graph

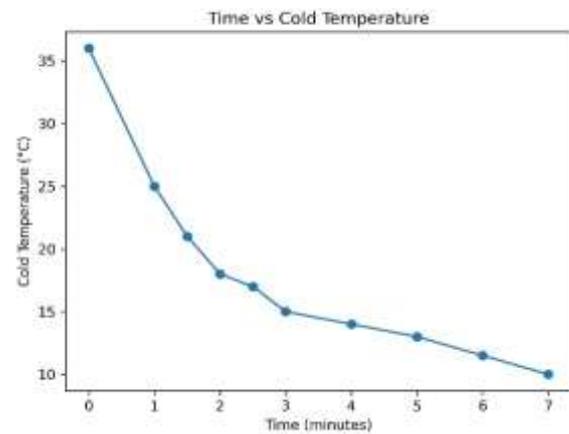


Fig 9: Actual Setup

7. CONCLUSIONS

The feasibility of integrating thermoelectric technology with renewable solar electricity for sustainable cooling is demonstrated by the project "Solar Refrigeration Using Peltier Effect." The prototype eliminated the need for chemical refrigerants and produced consistent cooling performance compressors. It is appropriate for off-grid settings and rural applications due to its quiet, portable, and environmentally friendly functioning. In order to address global energy and environmental concerns, this project also demonstrates the application of electrical and renewable energy engineering principles. This system can be expanded to meet greater refrigeration needs with further power management and heat dissipation optimisation. All things considered, it is a positive step toward sustainable and clean cooling systems.

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REFERENCES

- [1]. Gaurav Gupta, Ashok Kumar Yadav, and Shatrughan Singh (2014) - "Solar Air-Conditioning: Design for a Compressor-Less System using Peltier Effect", Vol 2 , Issue 2 , April - June 2014 | Pages: 213-218.
- [2]. Chintan, D. Patel, Prashant Sharma, and Amitesh Paul, (2014). "Parameter optimization of shell and tube type heat exchanger for improve its efficiency."- International Journal of Engineering Research and Science & Technology, 3(1), 11-18.
- [3]. Ganesh S. Dhumal, P.A. Deshmukh, M. L. Kulkarni, "Experimental Investigation Of Thermoelectric Refrigeration System Running On Solar Energy And Development Of Mathematical Model", International Engineering Research Journal (IERJ) Volume 1 Issue 5 Page 232-238, 2015, ISSN 2395-1621.
- [4]. K. K. Nandini and Muralidhara, "Peltier based cabinet cooling system using heat pipe and liquid based heat sink," National Conference on Challenges in Research & Technology in the Coming Decades (CRT 2013), Ujire, 2013, pp. 1-5, doi: 10.1049/cp.2013.2536.
- [5]. Palash Nakhate , Niraj Pawaskar , Purva Vatamwar , Saurabh Kalambe, "Ecofriendly Refrigerator Using Peltier Device", International Journal of Research In Science & Engineering e-ISSN: 2394-8299 Special Issue 7-ICEMTE March 2017 p-ISSN: 2394-8280.
- [6]. Prof. Pushkarny B.H. , Divyesh Patel, Akshay Parulkar, Hitesh Rai, Nadeem Khan, "Solar Refrigeration Using Peltier Effect", International Journal Of Research In Aeronautical And Mechanical Engineering, Issn (Online): 2321 3051, Vol.4 Issue 2, February 2016, Pgs: 67-74.