

Review on Mini Refrigerator Using Peltier Module

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ABSTRACT

This project presents the design and development of a mini refrigerator using a Peltier module, based on the thermoelectric cooling principle. The Peltier module operates on the Peltier effect, where a temperature difference is created when direct current flows through the junction of two dissimilar semiconductor materials. When powered, one side of the module absorbs heat and becomes cold, while the opposite side releases heat and becomes hot, enabling effective cooling without the use of conventional refrigerants or compressors. The proposed mini refrigerator consists of a Peltier module, heat sink, cooling fan, insulated cooling chamber, power supply, and temperature control circuitry. The cold side of the Peltier module is attached to an aluminum plate inside the insulated chamber to absorb heat from the stored items, while the hot side is connected to a heat sink and fan to dissipate heat to the surroundings. Proper thermal insulation improves cooling efficiency and reduces power consumption. This system is compact, lightweight, noiseless, and environmentally friendly, as it does not use harmful gases such as CFCs or HCFCs. It is suitable for applications such as portable cooling, medicine storage, beverage cooling, and electronic component cooling. Although the cooling capacity is lower compared to conventional refrigeration systems, the mini refrigerator demonstrates an efficient and economical solution for low-capacity and portable cooling needs. The project highlights the feasibility of thermoelectric refrigeration for small-scale applications and promotes the use of green and sustainable cooling technologies.[1]

Keywords : - Peltier Module, Thermoelectric Cooling, Mini Refrigerator, Peltier Effect, Heat Sink and Fan

1. INTRODUCTION

Refrigeration plays a vital role in modern daily life, with applications ranging from food preservation and beverage cooling to medical and industrial storage. Conventional refrigeration systems generally rely on vapor compression technology, which uses compressors and chemical refrigerants. Although effective, these systems are bulky, noisy, require regular maintenance, and often use refrigerants that are harmful to the environment. These limitations have created a demand for compact, eco-friendly, and portable cooling solutions for small-scale applications. A mini refrigerator using a Peltier module is based on thermoelectric cooling technology, which operates on the Peltier effect. When a direct current is passed through a thermoelectric module made of two dissimilar semiconductor materials, heat is absorbed on one side of the module and released on the opposite side. This creates a temperature difference that can be utilized for cooling or heating, depending on the direction of current flow. Unlike conventional refrigeration systems, thermoelectric cooling does not require compressors, moving mechanical parts, or refrigerant gases. The proposed project focuses on the design and fabrication of a compact mini refrigerator using a Peltier module.

The cold side of the module is used to cool an insulated chamber, while the hot side is attached to a heat sink and cooling fan to effectively dissipate heat to the surrounding environment. Proper thermal management and insulation are essential to enhance cooling performance and system efficiency. The system operates on a low DC power supply, making it suitable for portable and battery-operated applications. This mini refrigerator offers several advantages such as silent operation, compact size, lightweight construction, low maintenance, and environmental friendliness. It is particularly useful in applications such as storing medicines, vaccines, beverages, cosmetics, and electronic components where small cooling capacity is sufficient. Although thermoelectric refrigerators have lower efficiency compared to traditional refrigeration systems, their simplicity, reliability, and eco-friendly nature make them ideal for small-scale and portable cooling solutions. The project demonstrates the practical implementation of thermoelectric cooling technology and highlights its potential as a sustainable alternative for low-capacity refrigeration needs in domestic, medical, and automotive applications.[3]

1.1 OBJECTIVE

- To design a refrigerator will be portable.
- To construct a 10 L refrigerator from which minimum 15°C temperature will be obtained.
- To construct a scale down prototype.
- To construct a refrigerator where air will be used as refrigerant.
- To construct a refrigerator where the heat will be obtained by using Peltier effect..

2. LITERATURE SURVEY

Okorie, G. A., Faci, N. D. & Okorie, P. U. (2024) Designed and fabricated a mini thermoelectric refrigerator using a Peltier module, focusing on portability, size, and cost effectiveness. The study highlights using heat sinks and fans to remove heat from the refrigerated chamber and demonstrates the cooling capability of a solid-state thermoelectric system. [1]

Ghazali, N. Z., Mohd Shah, N. S., Kuamthab, N. E. & Mohamad, M. (2021) Developed a thermoelectric mini portable fridge with wireless temperature monitoring, integrating sensors and control to maintain internal temperatures. The research demonstrates the application of Peltier cooling coupled with embedded electronics for better usability. [2]

Nagesh Kudva, Veeresha R. K. & Muralidhara (2020) Reviewed advances in thermoelectric (Peltier) modules and their applications in cooling, highlighting thermoelectric refrigeration's eco-friendly nature and compact design advantages over conventional systems. [3]

Mutyala, R., Yashwanth, N., Jayaprakash, B., Verma (2023) Investigated a solar-powered Peltier mini refrigerator, demonstrating that Peltier modules can be integrated with renewable energy sources for compressor-less cooling systems. [4]

Manikandan S., Arunkumar R., Bharani K. & Meganathan M. (2019) Reported on the design of a mini cooler using Peltier modules, focusing on component arrangement (Peltier, heat sink, fan, insulation) to maximize cooling effect in a compact setup. [5]

Devakte, S. R. & Patil, J. A. (2025) Proposed a thermoelectric cooling system based on the Peltier effect for portable refrigeration, emphasizing eco-friendly operation and elimination of harmful refrigerants in small cooling units. [6]

3. WORKING & IMPLEMENTATION

Methods/Design Strategy:

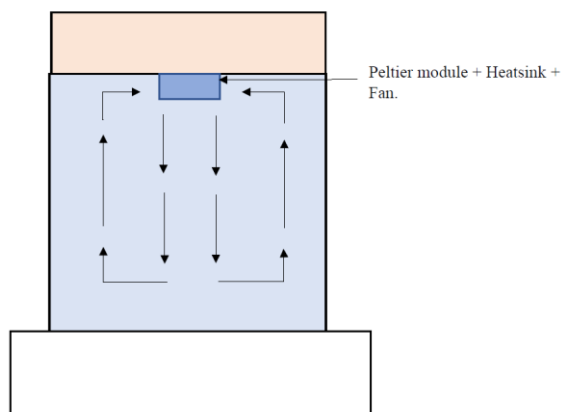
At first, we built a 3D-solidworks model of specified dimensions of the refrigerator unit. The volume of the inner compartment was 10400 cc. The dimensions were chosen minimally as to create enough cooling effect with a single Peltier module and to facilitate ease in placement.

One of the main objectives of our project was to make the project lightweight and also cost-efficient. To satisfy this interest, we used cork sheet to build the main frame of the refrigerator.

Cork sheets have air gaps within them. Thus, it also performs good as a heat insulator.

The Peltier module was attached with two heatsinks on both of its surfaces. Two cooling fans were also attached along with the fans. As the heated surface was reducing the temperature of the cold surface, a large sized heatsink and a fan with higher rpm was used on the heated surface.

The Peltier module along with heatsink and fans were installed on the top surface of the refrigeration unit. Thus, a mixed convection effect was created inside the refrigeration chamber. A schematic diagram of the whole cooler module is given below. [5]



Schematic Diagram of cooler module.

4.2 Working of system

The working principle of the mini refrigerator is based on the Peltier effect, a thermoelectric phenomenon in which heat is absorbed at one junction and released at another when direct current (DC) flows through a Peltier module. This enables cooling without the use of compressors or refrigerants. When a regulated DC power supply is applied to the Peltier module, one side of the module becomes cold (cold side) while the opposite side becomes hot (hot side). The cold side of the Peltier module is fixed to an aluminum plate placed inside the insulated refrigerator chamber. This plate absorbs heat from the air and objects inside the chamber, thereby reducing the internal temperature. Simultaneously, the hot side of the Peltier module is attached to a heat sink along with a cooling fan. The heat sink increases the surface area for heat dissipation, while the fan helps remove the accumulated heat to the surrounding atmosphere. Efficient heat removal from the hot side is essential to maintain a sufficient temperature difference across the Peltier module and to enhance cooling performance. As heat is continuously absorbed from the refrigerator chamber and expelled to the environment, the internal temperature gradually decreases. Thermal insulation around the chamber minimizes heat gain from the surroundings, improving cooling efficiency. In some designs, a temperature sensor and controller may be used to monitor and regulate the internal temperature by switching the power supply to the Peltier module ON or OFF. Thus, the mini refrigerator operates as a compact, noiseless, and eco-friendly cooling system suitable for small-scale applications such as beverage cooling, medicine storage, and portable refrigeration.[4]

5. CONCLUSIONS

The mini refrigerator using a Peltier module successfully demonstrates the application of thermoelectric cooling for small-scale and portable refrigeration. By utilizing the Peltier effect, the system provides cooling without the use of compressors, moving mechanical parts, or harmful refrigerants, making it eco-friendly, noiseless, and low in maintenance. The experimental results show that effective temperature reduction can be achieved through proper heat dissipation on the hot side and adequate thermal insulation of the cooling chamber. The project highlights the importance of efficient thermal management using heat sinks and cooling fans to improve the overall performance of the Peltier module. Although the cooling capacity and energy efficiency are lower compared to conventional vapor-compression refrigerators, the compact size, simplicity of design, and portability make this system suitable for applications such as medicine storage, beverage cooling, and electronic component cooling. Overall, this project proves that thermoelectric refrigeration is a viable alternative for low-capacity cooling requirements. With advancements in Peltier materials, power optimization, and insulation techniques, the performance of such systems can be further enhanced, contributing to sustainable and green cooling solutions for future applications.[3]

6. REFERENCES

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