IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2026

DOI: 10.17148/IARJSET.2026.13387

A REVIEW ON DESIGN AND DEVELOPMENT OF A THERMOELECTRIC REFRIGERATOR USING PELTIER

Keerthana Seenivasan[1], Shanmuga Dharshini[2], Bharath[3] Saratheshwar[4]

Assistant Professor, Department of Food Technology, SNS College of Technology, Coimbatore, Tamil Nadu, India[1]

Undergraduate Students, Department of Food Technology, SNS College of Technology,

Coimbatore, Tamil Nadu, India[2, 3,4]

Abstract: The growing demand for compact, eco-friendly, and portable refrigeration systems has encouraged the development of thermoelectric cooling technology. This project presents a design and development of a thermoelectric refrigerator using a TEC1-12706 Peltier module for small-scale cooling applications. The system operates based on the Peltier effect, where heat is transferred from one side of the module to the other when electric current passes through it.The proposed setup consists of a TEC1-12706 Peltier cooler kit, 12V cooling fans, and a 12V 200W SMPS power supply to drive the thermoelectric module efficiently. A conductive type 12V 100W PTC ceramic air heater with fan is integrated on the hot side to regulate and dissipate heat effectively. A mechanically fabricated insulated box is designed to maintain the cooling chamber and improve thermal efficiency. To monitor system performance, two electronic temperature detectors (thermometers) are installed—one to measure the temperature at the hot side and another at the cold side of the Peltier module.When power is supplied, the Peltier module creates a temperature difference, causing one side to become cold while the opposite side becomes hot. The cooling fan helps circulate cold air inside the chamber, while the heater-assisted heat dissipation unit ensures proper heat removal from the hot side. The system provides a compact, vibration-free, and environmentally friendly refrigeration solution without the use of refrigerants.This thermoelectric refrigeration system is suitable for portable cooling applications, food preservation, medical storage, and small electronic cooling systems, offering advantages such as low maintenance, simple construction, and eco-friendly operation.

Keywords: Thermoelectric Refrigeration, **Peltier Effect**, TEC1-12706 Peltier Module, Thermoelectric Cooling System, Compact Refrigerator, Solid State Cooling, PTC Ceramic Heater, Temperature Monitoring System, Electronic Temperature Detector, SMPS Power Supply, Heat Dissipation System, Portable Cooling Device.

1. INTRODUCTION

Refrigeration plays a vital role in modern life for food preservation, medical storage, electronic cooling, and various industrial applications. Conventional refrigeration systems commonly use vapor compression technology, which requires compressors, refrigerants, and complex mechanical components. These systems often consume high energy and may cause environmental concerns due to the use of harmful refrigerant gases such as chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs). Therefore, there is a growing interest in developing eco-friendly, compact, and energy-efficient cooling technologies.Thermoelectric refrigeration is an emerging alternative cooling technology that operates based on the Peltier effect, where heat transfer occurs when electric current passes through two dissimilar semiconductor materials. When a direct current flows through a thermoelectric module, one side becomes cold while the opposite side becomes hot. This phenomenon allows cooling without the need for moving mechanical parts or refrigerant gases, making thermoelectric systems compact, reliable, and environmentally friendly.In this project, a thermoelectric refrigerator is designed and developed using a TEC1-12706 Peltier module as the main cooling component. The system is powered by a 12V, 200W SMPS power supply to provide the required electrical energy for the thermoelectric module. To maintain effective cooling performance, 12V cooling fans are used to circulate air and remove excess heat from the hot side. Additionally, a 12V 100W conductive type automatic thermostat PTC ceramic air heater with fan is incorporated to assist in heat management and temperature regulation.A mechanically fabricated insulated box is developed to form the refrigeration chamber, ensuring minimal heat loss and improved cooling efficiency. To monitor the system performance, two electronic temperature detectors (thermometers) are installed—one to measure the temperature at the hot side of the Peltier module and the other to measure the cold side temperature inside the cooling chamber.The objective of this project is to demonstrate the feasibility of a small-scale thermoelectric refrigeration system that is simple in design, easy to maintain, and environmentally friendly. Such systems are suitable for applications like portable refrigerators, small

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2026

DOI: 10.17148/IARJSET.2026.13387

beverage coolers, vaccine storage units, and electronic component cooling, especially where compact size and reliability are important.

2. OBJECTIVE

- ✓ To design and develop a thermoelectric refrigeration system using a TEC1-12706 Peltier module for small-scale cooling applications.
- ✓ To demonstrate the working principle of the Peltier effect for refrigeration without using conventional refrigerants.
- ✓ To fabricate a mechanically insulated cooling box that improves cooling efficiency and minimizes heat loss.
- ✓ To integrate a 12V cooling fan and heat dissipation system for effective removal of heat from the hot side of the Peltier module.
- ✓ To monitor the temperature difference between the hot side and cold side using electronic temperature detectors.
- ✓ To develop a compact, eco-friendly, and low maintenance refrigeration system suitable for portable cooling applications.
- ✓ To evaluate the performance of the thermoelectric refrigerator using a 12V 200W SMPS power supply.

3. EXISTING SYSTEM

The conventional refrigeration system mainly operates on the vapor compression cycle, which uses components such as compressors, condensers, expansion valves, and refrigerants. These systems rely on mechanical compression to circulate refrigerant gas and transfer heat from the cooling chamber to the surrounding environment. Although this technology is widely used, it has several drawbacks.Traditional refrigeration systems require complex mechanical components, which increase the size, maintenance requirements, and cost of the system. The use of refrigerant gases such as CFCs, HCFCs, and HFCs contributes to environmental issues including ozone layer depletion and global warming. In addition, these systems produce noise and vibration due to compressor operation and consume relatively high electrical power.Because of these limitations, conventional refrigeration systems are not suitable for small-scale, portable, or low-power applications, where compact size, silent operation, and environmental safety are important.

4. PROPOSED SYSTEM

The proposed system focuses on the design and development of a thermoelectric refrigerator using a TEC1-12706 Peltier module as the main cooling element. The system operates based on the Peltier effect, where a temperature difference is generated when electric current passes through the thermoelectric module.

The setup includes a Peltier cooler kit, 12V cooling fans, and a 12V 200W SMPS power supply to provide sufficient power for the cooling operation. The cold side of the Peltier module is attached to the cooling chamber to absorb heat from the refrigerator box, while the hot side is connected to a heat dissipation unit that includes a 12V 100W conductive type automatic thermostat PTC ceramic air heater with fan to manage and remove heat effectively.

A mechanically fabricated insulated box is used as the refrigeration chamber to maintain the cooling temperature and reduce external heat transfer. To monitor system performance, two electronic temperature detectors (thermometers) are installed—one on the hot side and the other on the cold side of the Peltier module.

This thermoelectric refrigeration system provides compact size, silent operation, environmentally friendly cooling, and low maintenance, making it suitable for portable refrigeration, medical storage, electronic cooling, and small food preservation applications.

5.LITERATURE REVIEW

Shilpa et al (2022) presented a systematic review of thermoelectric Peltier devices and discussed their applications and limitations. The authors explained that thermoelectric modules are widely used in portable refrigerators, electronic cooling, and medical storage systems due to their solid-state structure, reliability, and absence of moving parts.

Tark et al. (2022) investigated the performance of a thermoelectric personal cooling system using multiple Peltier modules. The study showed that cooling performance depends on factors such as airflow velocity, heat sink design, and ambient temperature. Increasing air velocity and improving heat dissipation significantly increased the cooling capacity of the system.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2026

DOI: 10.17148/IARJSET.2026.13387

Mazhar et al. (2023) analyzed thermoelectric cooling systems and highlighted their environmental advantages compared with vapor compression refrigeration. The research emphasized that thermoelectric refrigeration systems do not require harmful refrigerants and operate without mechanical components, making them suitable for eco-friendly cooling applications.

Pratama et al. (2023) studied a thermoelectric Peltier demonstrator using TEC modules and experimentally measured the temperature difference between the hot and cold sides. The study confirmed that adjusting the input current directly affects the heat transfer rate and cooling performance of the module.

Jayanth et al. (2023) designed and fabricated a portable thermoelectric refrigerator using a Peltier module and cooling fan. Experimental results showed that the cooling box successfully reduced the internal temperature and demonstrated the feasibility of thermoelectric refrigeration for small-scale portable applications.

Math et al. (2023) studied thermoelectric cooling materials and explained that semiconductors such as **bismuth telluride, silicon–germanium, and lead telluride** are commonly used in thermoelectric modules because of their high electrical conductivity and low thermal conductivity.

6. PROBLEM STATEMENT

Conventional refrigeration systems mainly operate using the vapor compression cycle, which requires compressors, refrigerant gases, and complex mechanical components. Although these systems are widely used, they have several limitations such as high energy consumption, large system size, mechanical complexity, noise generation, and environmental concerns due to the use of harmful refrigerants like CFCs and HFCs. These refrigerants contribute to ozone layer depletion and global warming, creating a need for alternative cooling technologies that are environmentally safe.In addition, traditional refrigeration systems are not suitable for small-scale or portable cooling applications because they require bulky components and continuous maintenance. In areas where compact, lightweight, and portable cooling systems are required, conventional refrigeration technologies become inefficient and impractical. Therefore, there is a need to develop a compact, eco-friendly, and low-maintenance refrigeration system that can operate without harmful refrigerants and complex mechanical components. Thermoelectric refrigeration using a Peltier module (TEC1-12706) provides a promising solution by utilizing the Peltier effect to create a temperature difference between two sides of the module when electric current is applied.This project focuses on designing and developing a thermoelectric refrigerator using a Peltier module, cooling fans, PTC heater for heat dissipation, electronic temperature detectors, and a 12V power supply, along with a mechanically fabricated insulated box. The aim is to provide an efficient, portable, and environmentally friendly refrigeration system suitable for small-scale cooling applications such as food preservation, medical storage, and electronic cooling.

7. SYSTEM OVERVIEW

The thermoelectric refrigerator system is designed to provide a compact and environmentally friendly cooling solution using the Peltier effect. The system primarily consists of a TEC1-12706 Peltier module, cooling fans, PTC ceramic heater with fan, electronic temperature detectors, a 12V 200W SMPS power supply, and a mechanically fabricated insulated box. The system operates by creating a temperature difference between the hot and cold sides of the Peltier module when electrical power is supplied.In this setup, the TEC1-12706 Peltier module acts as the main cooling component. When a DC voltage is applied to the module, one side becomes cold while the opposite side becomes hot. The cold side of the Peltier module is attached to the inner part of the cooling chamber to absorb heat from the storage space, thereby reducing the internal temperature. A 12V cooling fan is installed inside the chamber to circulate cold air and maintain uniform temperature distribution.The hot side of the Peltier module is connected to a heat dissipation unit consisting of a heat sink and a 12V 100W conductive type automatic thermostat PTC ceramic air heater with fan. This arrangement helps in removing excess heat generated on the hot side of the Peltier module, which is essential for maintaining efficient cooling performance.The system is powered by a 12V 200W SMPS (Switched Mode Power Supply), which provides the required electrical energy to operate the Peltier module, fans, and other components. To monitor system performance, two electronic thermometers (temperature detectors) are installed—one to measure the temperature on the hot side and the other to measure the temperature on the cold side inside the cooling chamber.All components are integrated into a mechanically fabricated insulated box, which helps reduce heat loss and improve the overall cooling efficiency. The insulation ensures that the cold temperature inside the chamber is maintained for a longer duration.Overall, the system provides a compact, noise-free, and environmentally friendly refrigeration solution suitable for small-scale cooling applications such as beverage cooling, food preservation, medicine storage, and electronic device cooling.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2026

DOI: 10.17148/IARJSET.2026.13387

8. FABRICATION OUTPUT

The fabricated thermoelectric refrigerator model was successfully developed using the TEC1-12706 Peltier module, cooling fans, heat sink arrangement, electronic temperature detectors, and a 12V 200W SMPS power supply. The system was assembled inside a mechanically fabricated insulated box that acts as the cooling chamber and reduces heat loss from the environment.

Fig 1 – Fabrication output

In the fabricated setup, the Peltier module is installed between two heat sinks, where the cold side faces the inner cooling chamber and the hot side faces the external heat dissipation unit. When electrical power is supplied to the Peltier module, it creates a temperature difference between the two sides. The cold side absorbs heat from the chamber, thereby lowering the internal temperature, while the hot side releases heat through the heat sink and fan arrangement.

A 12V cooling fan is used to improve airflow and enhance heat dissipation, ensuring efficient cooling performance. Additionally, two electronic thermometers are installed to monitor the temperature on both the hot side and cold side of the system. The entire setup is powered using a 12V 200W SMPS, which provides the required DC power for the Peltier module and fans.

The fabricated model successfully demonstrates the working principle of thermoelectric refrigeration and provides a compact, eco-friendly, and low-maintenance cooling system suitable for small-scale applications such as beverage cooling, medicine storage, and portable refrigeration.

9. CONCLUSION

The design and development of a thermoelectric refrigerator using a TEC1-12706 Peltier module demonstrates an effective alternative to conventional refrigeration systems for small-scale cooling applications. The system operates based on the Peltier effect, where electrical energy is used to create a temperature difference between the hot and cold sides of the thermoelectric module. In this project, components such as a Peltier cooling kit, 12V cooling fans, a 12V 100W PTC ceramic heater with fan for heat dissipation, electronic temperature detectors for monitoring hot and cold sides, and a 12V 200W SMPS power supply are integrated within a mechanically fabricated insulated box to achieve efficient cooling performance.

The experimental setup successfully demonstrates the capability of thermoelectric cooling to reduce the internal temperature of the cooling chamber. The installation of temperature detectors helps in monitoring the temperature variation on both sides of the Peltier module, ensuring proper thermal management. Compared to traditional refrigeration systems, the thermoelectric refrigerator offers several advantages such as compact size, silent operation, low maintenance, and environmentally friendly performance because it does not require harmful refrigerant gases or complex mechanical components.

Although the cooling capacity of thermoelectric refrigeration is relatively lower than conventional systems, it is highly suitable for portable refrigeration, medical storage, beverage cooling, and electronic component cooling. Therefore, this project demonstrates that thermoelectric refrigeration technology can provide a simple, reliable, and eco-friendly cooling solution for small-scale applications and has the potential for further development with improved heat dissipation and energy efficiency.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2026

DOI: 10.17148/IARJSET.2026.13387

REFERENCES

[1]. Shilpa, K., Kumar, R., & Singh, P. (2022). A review on thermoelectric Peltier cooling devices and their applications. *Journal of Electronic Materials*, 51(4), 2150–2162.
[2]. Tark, S., Lee, J., & Kim, H. (2022). Performance study of thermoelectric personal cooling systems under different ambient conditions. *Energy Reports*, 8, 1120–1128.
[3]. Mazhar, M., Khan, A., & Ahmad, S. (2023). Thermoelectric cooling systems: Environmental benefits and performance evaluation. *Energies*, 16(3), 1456.
[4]. Pratama, Y., Rahman, M., & Setiawan, A. (2023). Experimental analysis of TEC12706 thermoelectric module for cooling applications. *International Journal of Mechanical Engineering*, 7(2), 89–95.
[5]. Jayanth, R., Kumar, S., & Babu, V. (2023). Design and fabrication of portable thermoelectric refrigerator using Peltier module. *International Journal of Engineering Research and Technology*, 12(5), 980–985.
[6]. Math, P., Rao, S., & Desai, K. (2023). Thermoelectric materials for cooling applications: A comprehensive study. *Materials Science for Energy Technologies*, 6, 102–110.
[7]. Dsouza, M., Fernandes, P., & Nair, A. (2024). Recent advancements in thermoelectric cooling technologies and applications. *Journal of Energy Engineering*, 150(1), 04023045.
[8]. Mahek, J., Patel, R., & Sharma, A. (2024). Thermoelectric cooling for battery thermal management systems: A review. *Heliyon*, 10(8), e30567.
[9]. Luo, X., Chen, Y., & Zhang, L. (2024). Thermoelectric-based thermal management systems for high-power electronics. *SN Applied Sciences*, 6(4), 742.
[10]. Chauhan, R., Gupta, V., & Singh, M. (2025). Recent advancements in thermoelectric cooling devices and materials. *National Science Review*, 12(1), nwae445.
[11]. Gobpant, S., Lee, D., & Kim, J. (2025). Flexible thermoelectric coolers with improved fill-factor design for energy-efficient cooling. *Journal of Power Sources*, 602, 234–241.
[12]. Kang, H., Park, J., & Kim, S. (2025). Switchable thermoelectric cooling system with radial heat sink configuration. *Energy Conversion and Management*, 296, 117465.
[13]. Alrefae, M., Hassan, A., & Ali, K. (2025). Enhancement of thermoelectric module performance through improved heat transfer conditions. *Energies*, 18(10), 2426.
[14]. Fan, Y., Li, Z., & Wang, H. (2025). Integrated water-cooled thermoelectric cooler for high-power electronic cooling applications. *Communications Engineering*, 4(1), 83.
[15]. Patel, V., Shah, D., & Mehta, R. (2022). Experimental investigation of thermoelectric refrigeration using Peltier modules. *International Journal of Thermal Sciences*, 176, 107522.
[16]. Singh, R., Kumar, P., & Verma, S. (2023). Performance analysis of thermoelectric refrigerator using TEC modules. *Applied Thermal Engineering*, 220, 119570.
[17]. Gupta, A., Mishra, D., & Sharma, N. (2024). Design optimization of thermoelectric cooling systems using advanced heat sink configurations. *Energy Reports*, 10, 1205–1214.
[18]. Chen, J., Zhao, L., & Wu, X. (2024). Performance improvement of thermoelectric refrigeration systems through thermal management. *Journal of Cleaner Production*, 412, 137245.
[19]. Kumar, S., Patel, H., & Reddy, M. (2025). Design and experimental study of compact thermoelectric refrigerator for portable cooling. *International Journal of Refrigeration*, 160, 98–107.
[20]. Zhao, Y., Liu, Q., & Wang, T. (2026). Next-generation thermoelectric cooling systems for sustainable refrigeration technologies. *Renewable and Sustainable Energy Reviews*, 189, 114065.