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Eco-Friendly Thermoelectric Mini Fridge with Temperature Control

Ramkrishna Bharsakade[1], Mangesh Dhanmane[2], Varun Dharwar[3], Aryan Dharmadhikari[4], Oamkar Dhanwate[5], Om Dhanawat[6] and Neel Dharia[7]
[1-7]Vishwakarma Institute of Technology Pune India
Email: { ramkrishna.bharsakade varun.dharwar23 mangesh.dhanmane23 om.dhanawat23 oamkar.dhanwate23 aryan.dharmadhikari23 neel.dharia23}@vit.edu

***Abstract*— The thermoelectric refrigerator utilizes thermoelectric modules (Peltier modules) to generate a temperature gradient between the external environment and the refrigerator interior by applying a potential difference. This design contrasts with conventional refrigerators, which rely on compressors and greenhouse gases for temperature regulation. The system includes an Arduino Uno-based control mechanism to maintain a user-defined temperature, utilizing a thermistor and relay for precise control. The temperature is displayed on a 7-segment LCD. This refrigerator offers an environmentally friendly, user-friendly solution for cooling.**

***Keywords* — Arduino Uno, Thermistor, Thermoelectric/Peltier module, Relay, LCD display.**

I. INTRODUCTION

Amidst growing concerns about pollution and greenhouse gases, the thermoelectric refrigerator presents an economical and eco-friendly cooling solution. Utilizing thermoelectric modules (Peltier modules) based on semiconductor technology, the refrigerator creates a temperature differential by supplying a potential difference across the modules, with one side becoming cooler and the other hotter. These modules consist of N and P-type semiconductors connected in series via metal connectors.
Various models incorporate radiators and alternative cooling methods, with some utilizing solar energy. Temperature control in our thermoelectric refrigerator is managed by an Arduino Uno, which regulates the power supply to maintain the desired temperature. A relay switches the power to the refrigerator on and off based on temperature readings from a thermistor.

II. RELATED WORKS

Significant research on thermoelectric refrigerators includes Maneewan et al. [1], who investigated small thermoelectric cooling systems and found that the TEC1-12708 Peltier module is effective for portable cooling systems.
Mehta and Yadav [2] explored the theoretical aspects of electrical power supplies, providing a foundation for innovative electric cooler designs using N and P-channel semiconductors.
Nandhini K.K. and Muralidhara [3] developed a Peltier-based cooling system with a heat pipe and liquid-based heat sink.

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Palash Nakhate and Niraj Pawaskar created an eco-friendly refrigerator with a Peltier module, a heat sink, and a fan module, powered by a 12V supply via SMPS, allowing precise temperature control. Arjun Kumar GB [4] designed a solar-powered thermoelectric refrigeration system.
M. Tayde [5] emphasized the importance of regulating temperature to address heat loss in evaporators, condensers, and compressors, highlighting the need for maintenance. Prof. Kalimuthu.M [6] designed a portable mini cooler for medications, using simple components like Peltier modules, aluminum blocks, and plexiglass boxes, with temperature control supported by an SMPS.
Maamar Quali [7] underscored the importance of temperature control in modern refrigerators, noting the impact of frequent door openings and thermostat regulation on energy consumption, with solar energy powering the system. Prof. Assen Zalatrov [8] developed a small, solar-powered refrigerator for vaccine transport, featuring temperature sensors, exhaust fans, and a Peltier module between heat sinks.

III. METHODOLOGY

The prototype development comprised four main steps: component selection, circuit setup, water cooling for the Peltier module, and construction of the refrigerator chamber.

A. Component Selection

Five TEIC 12703 Peltier modules (3A, 30x30mm)
Aluminum water-cooling block (40x160mm)
Small water pump
Arduino Uno, DC to DC converter, relay, Arduino cable, SMPS, thermistor, LCD display
1-liter water tank, 11x6 inch copper sheet, Sunboard sheet

B. Complete Circuit Setup

Connect Peltier modules in parallel to increase cooling capacity.
Use wires and connectors to link Peltier modules, water pump, DC to DC converter, and power supply.
Connect the temperature sensor to the Arduino Uno and relay, and the relay to the Peltier modules.
The sensor monitors the refrigerator temperature, displayed on the LCD, and the relay controls the Peltier modules based on the set temperature.

Figure 1. Circuit view

C. Water Cooling Setup:

Apply thermal paste to the hot side of the Peltier modules and attach them to the aluminum water-cooling block.
Attach a copper plate to the cold side of the modules for better cooling distribution.
Connect the water pump to the water tank and water-cooling block to circulate water, cooling the hot side of the Peltier modules. A radiator is recommended to manage water temperature over time.

D. *Construction of Chamber:*

Build a rectangular chamber using wooden sheets.
Attach Sunboard sheets inside for insulation.

IV. Result

A. Temperature Vs Time Graph

The temperature vs. time graph shows a gradual decrease in temperature within the refrigeration unit. The cooling rate slows over time, indicating the diminishing temperature reduction as intervals increase.

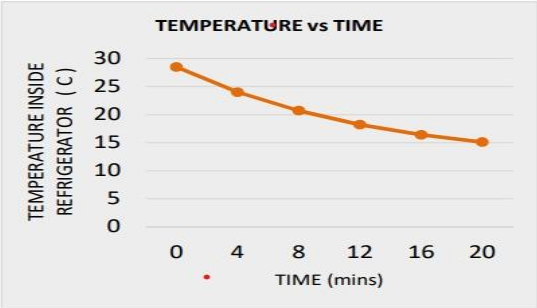

Figure 2. The temperature vs. time graph

B. Reading of Temperature on LCD Display

This portable refrigerator efficiently transports food and medications while maintaining a specified temperature, offering better efficiency than traditional refrigerators.

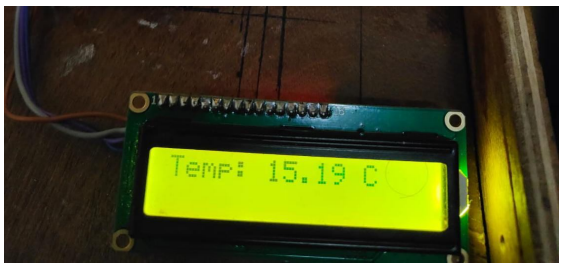

Figure 3 Reading of Temperature on LCD Display

V. Conclusion

The compact, Peltier module-based refrigerator prototype effectively demonstrates the application and innovation of Peltier technology. This environmentally friendly solution avoids the use of harmful chemicals like CFCs, making it suitable for current and future generations.

Future Scope

The prototype has potential for commercial and travel applications. Future research aims to minimize CFC emissions and explore renewable energy sources, such as solar panels, to power the Peltier modules, reducing dependence on external power sources.

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