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Development of Mini Refrigerator Using Peltier Module

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ABSTRACT

The foundation of refrigeration technology has long been compressor-based cooling systems, but these systems are usually big, costly, and inappropriate for smaller-scale cooling applications. To solve this problem, in order to create compact, energy-efficient refrigerators, our research investigates the application of thermoelectric cooler (Peltier) technology. This study's main objective is to investigate whether thermoelectric cooling can effectively cool cans and small food items while reducing system size and energy consumption. We propose developing a small refrigerator can cooler based on the well-established knowledge of the Peltier effect, which allows temperature variations to be generated through heat transfer between electrical junctions. Our framework consists of two Peltier modules, electronics, and a thermal insulating frame to optimize the effectiveness of cooling.
Key Words: Thermoelectric cooler, Peltier effect, Energy Efficient, Compact.

1. INTRODUCTION

It is necessary to preserve food and beverages, but traditional compressor-based cooling systems often consume heavy, expensive and significant energy. To resolve these challenges, thermoelectric cooling using a peltier module has emerged as a promising alternative to small scale refrigeration applications. The peltier module operates on the thermoelectric effect, where an electric current creates a temperature difference between the two surfaces, allowing heat transfer and cooling. This technique enables the design of the suitable compact, light and energy-efficient refrigerator to cool small foods, beverages and medical supply. The study focuses on developing a mini refrigerator using a Peltier module to evaluate
its cooling efficiency, power consumption and practical purposes. By integrating thermoelectric cooling with Proper insulation and electronic control system, the purpose of the project is to create an effective, portable refrigeration solution. To cross these boundaries, thermoelectric cooling using a peltier module provides a promising option. Peltier effect allows heat transfer between two surfaces when an electric current is applied, leading to a temperature difference. This technique eliminates the requirement of refrigerant and moving mechanical parts, making it an environmentally friendly, compact and energy-skilled cooling solution. The purpose this study is to design and develop a mini refrigerator using the Peltier module, which focuses on cooling efficiency, power consumption and overall viability for small scale applications. The system will include Peltier modules, heat sinks, insulation and electronic control circuits to increase its performance.

2. MATERIALS

Material selected for the construction of one Mini refrigerator using Peltier modules are Important to ensure efficiency, thermal performance, And overall durability. The main components include High quality peltier modules. These are modules Gathered at heat sink made of material With high thermal conductivity, such as copper. Heat Sink Assembly also involves the use of thermal Ensuring interface material, effective heat transfer. Summer sink has active cooling facility Inclusion of fans. Are sealed and gaskets To prevent heat leakage, maintain The integrity of the refrigerated environment. Additionally, transparent or opaque materials, such as Comes as temporary glass or plastic, can be used for seeing or accessing the contents of the chamber.
Power supply covers a source or adapter providing voltage and current required for Peltier module. Power management component, like voltage regulators have been included Ensure stable operations. Energy efficient Components are chosen to minimize Consumption, especially during standby Periods. Safe component, while handles, hinges and adjustable legs contribute to purposeful and stability. Use of environmentally friendly refrigerant And recycled materials align with ecosystem Thermal -like ideas, and security facilities Fuses and grounding components are integrated Ensure safe operation. Calibration equipment and testing Equipment with

temperature measurements Device and power meters are employed to verify Assess accuracy and energy consumption. Selection and integration of these materials collectively contribute to successful design and Construction of a mini refrigerator using Peltier addressing

3. METHODOLOGY

The Peltier module-based mini refrigerator's design methodology takes a methodical approach to guarantee peak performance and energy efficiency, effectiveness. The main factors and processes involved in the design process are delineated in the following comprehensive steps:

3.1. Peltier Module Selection: Begin by determining the required cooling capacity based on the intended use of the mini refrigerator. Select Peltier modules with specifications aligned with the cooling requirements, taking into account factors such as voltage, current, and thermal characteristics. Considerations should also include the electrical insulation of the modules to prevent short circuits during operation.

3.2. Heat Sink Design: Design the heat sinks to efficiently dissipate the heat generated by the Peltier modules. Consider the material, shape, and size of the heat sinks to maximize surface area and enhance thermal performance. Include fans for active cooling, if needed.

3.3. Refrigeration Chamber: Select insulating materials with low thermal conductivity to minimize heat transfer. Optimize the configuration of the chamber for uniform cooling, considering factors such as airflow and placement of Peltier modules. Integrate seals and gaskets to maintain airtight conditions and prevent heat leakage.

3.4. Power Supply and Energy Efficiency: Design the power supply system to meet the voltage and current requirements of the Peltier modules. Include power management components, such as voltage regulators, to ensure stable operation. Implement energy-efficient components and consider low-power modes for standby periods to minimize overall power consumption.

4. ASSEMBLY PROCESS

The Assembly process involves transforming the design concepts into a functional prototype. The following detailed steps provide guidance for constructing the mini refrigerator:

4.1. Peltier Module Assembly:
Assemble the selected Peltier modules onto the designed heat sinks. Ensure proper electrical connections and use thermal interface materials to optimize the thermal coupling between the modules and heat sinks. Secure the assembly to prevent movement during operation.

4.2. Heat Sink Construction:
Fabricate the heat sinks according to the design specifications. Utilize materials with high thermal conductivity, such as aluminum or copper. Apply surface treatments or coatings to enhance heat dissipation. Incorporate fans into the heat sink assembly for active cooling.

4.3. Refrigeration chamber Construction
Construct the refrigeration chamber using insulating materials, considering both structural integrity and thermal efficiency. Install Peltier modules and heat sinks within the chamber, ensuring a proper fit. Integrate the electronic control system, including wiring and connectors. Use seals and gaskets to maintain an airtight environment.

4.4. Control System Integration:
Integrate the electronic control system components into the refrigeration chamber. Connect temperature sensors to the microcontroller, and program the control algorithms for responsive temperature regulation. Ensure proper wiring and insulation to prevent electrical issues.

4.5. Final Assembly and Testing:
Assemble all components into the final prototype. Conduct rigorous testing to evaluate functionality, temperature control accuracy, and energy efficiency. Use testing equipment, including temperature measurement devices and power meters, to validate the performance of the mini refrigerator.

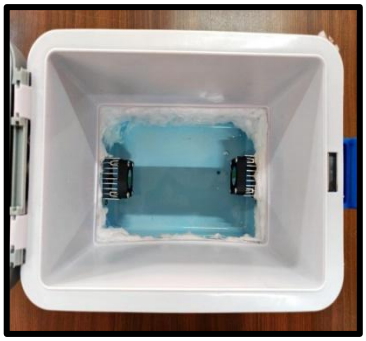

Fig.1: Actual image of mini refrigerator.

Fig.2: Actual image of mini refrigerator.

5. PERFORMANCE SPECIFICATIONS

- Initial Cabinet Temperature = 32.3°C.
- Outside Fin Temperature = 35 °C.
- Inside Fin Temperature = 18.7°C.
- Final Cabinet Temperature after 22 minutes = 19.3°C.
- Consumption of Two peltier = 116W (12V) DC.
- Cabinet Capacity = 6 litres.

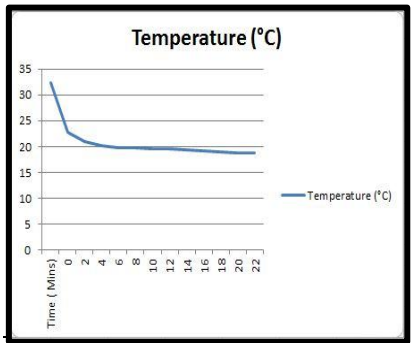

Fig.3 :Temperature drop and Time Graph

6. RESULTS AND DISCUSSION

The results collectively emphasize the viability of the mini refrigerator using Peltier modules as an efficient and compact cooling solution. The cooling efficiency and uniformity, coupled with favourable energy consumption metrics, position the system as a promising candidate for applications where portability and sustainable refrigeration are paramount. The precision of temperature control highlights the robustness of the electronic control system, emphasizing its ability to adapt to varying demands. Moreover, the comparative analysis underscores the advantages of the Peltier-based approach, particularly in scenarios where traditional refrigeration methods may be less practical or environmentally friendly.

Continuing from the initial discussion, this section provides further insights into specific aspects of the mini refrigerator's performance, addressing additional parameters and their implications.

6.1. Environmental Impact

An assessment of the environmental impact considers factors such as the choice of refrigerants and the overall ecological footprint of the Peltier based system. By adopting environmentally friendly refrigerants and recyclable materials, the mini refrigerator aligns with sustainable practices, contributing positively to its overall appeal.

6.2. Long-Term Stability

The stability and durability of the Peltier-based refrigeration system were examined over an extended period. Continuous operation tests and durability assessments revealed the robustness of the design, with the system maintaining consistent performance without notable degradation.

6.3. Noise Levels

An evaluation of noise levels during operation provides insights into the acoustic characteristics of the mini refrigerator. The Peltier-based system, known for its quiet operation compared to traditional compressors, ensures a low-noise cooling solution, enhancing its suitability for various environments, including residential and office settings.

6.4. User Interface Experience

Assessing the user interface and overall user experience is vital for practical applications. The ease of temperature adjustment, accessibility of controls, and any additional features for user convenience contribute to the overall usability and desirability of the mini refrigerator.

7. CONCLUSION

- The mini refrigerator that uses Peltier modules turns out to be a flexible and effective cooling solution.
- Its long-term stability, low noise levels, user interface, and environmental considerations all contribute to its allure for a variety of uses.
- Ongoing research and development initiatives can concentrate on continuous advancements and innovations in these particular fields while acknowledging these strengths.

Future Aspects:

- Future research avenues might examine improved Peltier module materials, cutting-edge control algorithms for better temperature regulation, and additional energy efficiency improvements.
- The next generation of mini refrigerators may also be made possible by research into the integration of smart technologies for remote monitoring and control.

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