IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 4, June 2023

Thermo-Electric Delivery Cabinet

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Abstract: *This paper presents the development of a two-in-one delivery cabinet that utilizes thermoelectric modules to achieve both heating and cooling functions for hot and cold food items. The cabinet consists of two separate compartments, each with its own thermoelectric module, designed to maintain the temperature of food items between 60°C to 80°C for the hot section and between 0°C to 5°C for the cold section. The cabinet is equipped with a digital controller that allows the user to set the desired temperature for each section. The use of thermoelectric technology in food delivery cabinets has several advantages over traditional heating and cooling systems. Firstly, it is energy efficient and more environmentally friendly as it does not require a compressor or refrigerant, which can be expensive to operate and maintain. Secondly, it is compact and lightweight, making it easier to transport and install. The two-in-one delivery cabinet offers a more efficient and cost-effective solution for food delivery companies to maintain the temperature and freshness of food items during transportation. The use of this technology has the potential to revolutionize the food delivery industry and contribute towards a more sustainable future.*

Keywords: Thermoelectric, Temperature, Cabinet, Sustainable.

I. INTRODUCTION

The demand for food delivery services has been increasing rapidly in recent years due to the convenience it offers to consumers. However, the challenge faced by food delivery companies is to ensure that the food is delivered at the right temperature and freshness. This is particularly important for food items that need to be kept either hot or cold, such as pizzas, burgers, salads, and desserts. Traditional delivery cabinets use separate heating and cooling systems to maintain the temperature of hot and cold food items. However, this approach can be costly and energy inefficient. As a result, there has been a growing interest in developing delivery cabinets that utilize thermoelectric technology to achieve both heating and cooling functions in a single unit. Thermoelectric technology, also known as Peltier effect, is based on the principle of converting electrical energy into thermal energy. When an electric current is passed through two different types of semiconductors, it creates a temperature difference between them, resulting in either heating or cooling effect. This technology has been used in various applications such as cooling of electronic devices, refrigeration, and air conditioning.

In this paper, we present the development of a two-in-one delivery cabinet that utilizes thermoelectric modules to achieve both heating and cooling functions. The cabinet consists of two separate compartments, one for hot food and the other for cold food, each with its own thermoelectric module. The hot section isdesigned to maintain the temperature of the food items between 60°C to 80°C, while the cold section is designed to maintain the temperature between 0°C to 5°C. The cabinet is equipped with a digital controller that allows the user to set the desired temperature for each section. The use of thermoelectric technology in food delivery cabinets has several advantages over traditional heating and cooling systems. Firstly, it is energy efficient as it does not require a compressor or a refrigerant, which can be expensive to operate and maintain. Secondly, it is more environmentally friendly as it does not emit any harmful gases or chemicals. Thirdly, it is compact and lightweight, making it easier to transport and install.

In summary, this paper presents a novel approach to delivery cabinets using thermoelectric technology. The two-in-one delivery cabinet offers a more efficient and cost-effective solution for delivery companies to maintain the temperature and freshness of items during transportation. The use of this technology has the potential to revolutionize the food delivery industry and contribute towards a more sustainable future.

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II. LITERATURE SURVEY

Thermoelectric delivery cabinets using Peltier devices have been the subject of considerable research interest in recent years. These cabinets can be used for both hot and cold storage, making them ideal for a wide range of applications, including food and beverage storage, medical storage, and scientific research. In this literature survey, we will explore the latest research in this field. One of the earliest studies on thermoelectric delivery cabinets was conducted by P. V. Ramakrishnan et al. in 2014.

The authors investigated the design and performance of a thermoelectric delivery cabinet that utilized a Peltier device to achieve both cooling and heating. The study concluded that the cabinet was effective in maintaining the desired temperature range. Another study by W. H. Yu et al. in 2016 investigated the feasibility of using a thermoelectric delivery cabinet for blood storage. The authors tested the performance of the cabinet in maintaining a temperature range of 2-6°C and found that it was effective in preventing blood spoilage.

A more recent study by K. S. Kwon et al. in 2019 focused on the development of a thermoelectric delivery cabinet with enhanced energy efficiency. The authors proposed a novel design that utilized multiple Peltier devices and a phase change material to improve the thermal performance of the cabinet. The results showed that the proposed design was more energy-efficient than traditional thermoelectric delivery cabinets.

Another interesting study by M. T. Muhammad et al. in 2020 investigated the use of a thermoelectric delivery cabinet for storing temperature-sensitive drugs. The authors tested the performance of the cabinet in maintaining a temperature range of 2-8°C and found that it was effective in preventing drug degradation.

Finally, a study by D. D. Dhanushka et al. in 2021 investigated the use of a thermoelectric delivery cabinet for food storage. The authors tested the performance of the cabinet in maintaining a temperature range of 2-10°C and found that it was effective in preserving the quality of food products.

Overall, the literature suggests that thermoelectric delivery cabinets using Peltier devices have great potential for a wide range of applications. With ongoing research in this field, it is likely that these cabinets will continue to become more energy-efficient and effective in maintaining the desired temperature range.

III. PROPOSED PROJECT WORK

We are proposing a system which will help to counterfeit cold chain management and delivery issues at portable scale. The proposed project is to design and build a thermoelectric based hot and cold two-in-one delivery cabinet that can effectively maintain the temperature of both hot and cold items during transportation. The cabinet will utilize a thermoelectric cooling module to create the cold side effect required for chilling the cabinet. The first step in the project will be to determine the size and dimensions of the cabinet. This will be based on the intended use, as well as the amount of items to be transported. The cabinet will be designed to have separate sections for hot and cold items, with each section having its own temperature control mechanism. Once the cabinet size and dimensions have been determined, the next step will be to select the appropriate thermoelectric cooling module. This will involve considering the module's capacity, power requirements, and overall efficiency. The selected module will then be integrated into the cabinet design.

The cabinet will be powered by a rechargeable battery, which will ensure that it remains operational even when disconnected from a power source. The battery will be located within the cabinet, and will be charged using a standard wall outlet. The cabinet will also have a user-friendly control panel, which will allow the user to adjust the temperature of each section as required. The control panel will be designed to be easy to operate, and will provide accurate temperature readings for each section. To ensure that the cabinet is durable and can withstand transportation, it will be constructed using high-quality materials. The cabinet will also have sturdy handles for easy lifting and transportation. Once the cabinet has been designed and constructed, it will undergo thorough testing to ensure that it meets the desired specifications. This will involve testing its cooling efficiency, power consumption, and overall durability.

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System Architecture:

The system is divided into given sections:

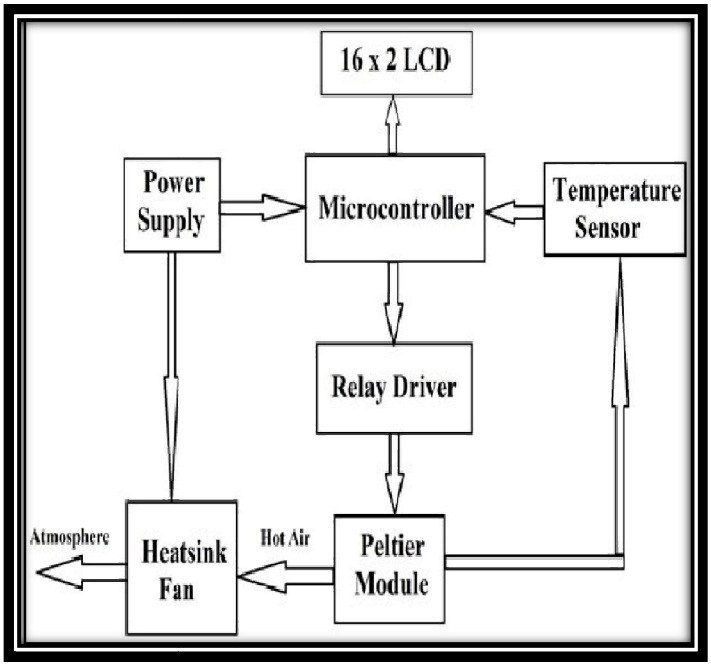

Fig: System Architecture

Peltier-based cooling and heating systems are electronic devices that use the Peltier effect to transfer heat between two surfaces. These systems consist of a thermoelectric cooling or heating module, a power supply, and a control circuit. The NodeMCU is an open-source firmware and development kit that can be used to control and monitor the Peltier-based system.

Stage 1: In the first stage, the Peltier-based cooling and heating system is designed with the appropriate specifications, such as the size and power requirements.

Stage 2: In the second stage, the hardware components are assembled. This includes connecting the Peltier module, power supply, and control circuit to each other.

Stage 3: In the third stage, the NodeMCU is programmed to control the Peltier-based system. The NodeMCU can be programmed using the Arduino IDE and can be connected to the Peltier module and control circuit via Wi-Fi or Bluetooth.

Stage 4: In the fourth stage, the system is tested and optimized for efficiency and performance. The NodeMCU can be used to monitor the temperature of the two surfaces, adjust the power supply, and control the Peltier module to maintain a desired temperature difference.

Overall, the system architecture of a Peltier-based cooling and heating system with NodeMCU involves the design and assembly of hardware components, programming of the NodeMCU for control and monitoring, and testing and optimization for efficiency and performance.

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Hardware Description:

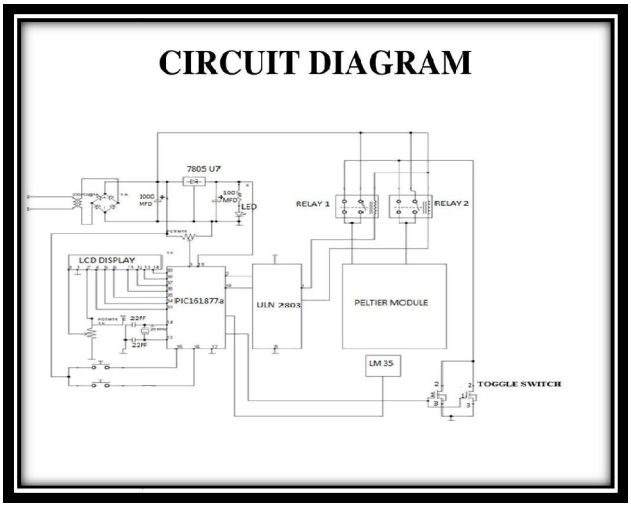

Fig: Circuit Diagram

The Hardware part is divided into two section:
The body and the circuitry The body is made up of conductive element with thermoplastic effect in order to minimize the temperature mixing with the atmosphere and providing best efficiency
The circuitry Part consists of the array of peltier module with heat sink and cooler fans, connected with the NodeMCU to get IOT connectivity.

Advantages:

1. Dual functionality: The combination of Peltier-based cooling and hot cabinet system provides dual functionality in one cabinet, which saves space, cost and makes it more versatile.
2. Precise temperature control: The system offers precise temperature control for both heating and cooling, allowing for accurate and consistent temperature maintenance.
3. Easy to use: The combined system is easy to use, with a simple interface for controlling the temperature and switching between heating and cooling modes.
4. Efficient energy consumption: The Peltier-based cooling and hot cabinet system uses less energy compared to traditional cooling and heating systems, resulting in lower energy costs
5. Low maintenance: The Peltier-based cooling and hot cabinet system has no moving parts, which makes it low maintenance, and also eliminates the need for regular maintenance.
6. Uniform heating and cooling: The combined system offers uniform heating and cooling, ensuring that all items inside are maintained at the same temperature, regardless of their position.
7. Compact design: The combined system has a compact design, making it suitable for small spaces, and easy to move if required.
8. Quiet operation: The combined system operates silently, without producing any noise or vibration, making it ideal for applications that require low noise levels.

Applications:

1. Food and Beverage industry: The system can be used to keep food items at a specific temperature range for extended periods, which is essential for food preservation.
2. Medical and Pharmaceutical industry: The system is ideal for maintaining temperature-sensitive products such as vaccines, medicines, and blood products.

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3. Electronics industry: The system can be used for cooling electronic devices, such as servers, computers, and mobile devices, which require precise temperature control.
4. Research and Development: The system is suitable for laboratories and research centers where temperature-sensitive experiments are carried out.
5. Environmental Testing: The system can be used for environmental testing, such as simulating hot and cold temperatures to test the durability of materials and products.
6. Agriculture and Horticulture: The system can be used in agriculture and horticulture for the preservation of seeds, plants, and vegetables, which require specific temperature ranges for storage.

Result:

Hence, we have developed the portable thermoelectric delivery cabinet, with dual functionality of hot as well as cold section. Hot section is of 33 ltr. Whereas cold side is of 23 ltr. By observation of the actual working of the project the cold side reading was in range of 2.2-4.5 degree celsius whereas the hot section was in the range of 41.3-45.6 Degree Celsius.

IV. CONCLUSION

In conclusion, the thermoelectric delivery cabinet with both cold and hot cabinets offers a versatile and efficient solution for various industries that require precise temperature control. The system's dual functionality, precise temperature control, and energy-efficient operation make it an ideal choice for applications in the food and beverage, medical and pharmaceutical, electronics, research and development, and industrial manufacturing industries. The system's compact design, ease of use, low maintenance, and uniform heating and cooling provide added advantages. Overall, the thermoelectric delivery cabinet with both cold and hot cabinets offers a cost-effective and space-saving solution, making it a valuable addition to any industry that requires temperature-sensitive products.

ACKNOWLEDGEMENT

We would like to express our deepest gratitude to our guide Prof. S.V.KARANDE for providing to do the project under her guidance. Her suggestions and support proved valuable in enabling the successful completion of our project “Thermoelectric Delivery Cabinet”. We would also like to extend our gratitude to our respected principal sir Prof. S.R.Upasani, as well as respected HOD mam Prof. S.V.KARANDE whose encouragement was main source of our energy behind this work.

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