DESIGN AND FABRICATION OF AN EFFICIENT COLD CONTAINER FOR MEDICINE WHICH CAN BE DELIVERED ON MOTORCYCLE

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Abstract - *The efficient transport of temperature-sensitive medicines is crucial in healthcare logistics, especially when delivering them on a motorcycle. This paper proposes an alternative solution to address this challenge by utilizing a Peltier module in the design of an efficient container. The objective of this work is to determine the appropriate size and capacity of the container based on the volume of medicine and the required duration for maintaining cold temperatures. Additionally, the use of computational fluid dynamics (CFD) software is explored to enhance the quality of medicine delivered to customers. The proposed design incorporates a refrigeration system installed on the motorcycle, which can be charged by an electric vehicle or an external power source. The paper discusses the design of the prototype, outlines the electronic components required, and explains the functionality of the prototype.*

Key Words: Cold container, Peltier module, heat sink, cooler fan, Digital thermometer, medicine storage, Thermocol, Solid edge.

1.INTRODUCTION

In recent years, the field of healthcare logistics has witnessed significant advancements to overcome the challenges of delivering temperature-sensitive medicines to remote areas or during emergencies. Ensuring the integrity and safety of these medicines is crucial to provide quality healthcare services. This research article presents the design and fabrication of an innovative solution—an efficient container specifically designed for medicine delivery on a motorcycle.

The use of motorcycles for medicine delivery has gained traction due to their maneuverability, cost-effectiveness, and ability to navigate through congested urban areas. However, the lack of proper temperature control during transportation has been a major concern, potentially compromising the efficacy of the medications. The development of an efficient container that can be integrated into a motorcycle addresses this critical issue and opens new possibilities for effective and timely medicine delivery.

The primary objective of this study was to design and fabricate a container that maintains a stable and controlled temperature throughout the delivery process. By employing state-of-the-art insulation materials, advanced cooling systems, and intelligent monitoring mechanisms, the container ensures that the medicines remain within the required temperature range, safeguarding their efficacy and potency.

The integration of a container onto a motorcycle offers several advantages. Firstly, it enables the delivery of temperature-sensitive medicines to remote areas, where access to healthcare facilities may be limited. This technology bridges the gap between healthcare providers and patients, ensuring that life-saving medications reach those in need promptly. Additionally, the container can facilitate last-mile delivery, overcoming the challenges associated with congested traffic and difficult terrains, making it especially valuable in densely populated or geographically diverse regions.

Furthermore, the integration of this technology with telemedicine platforms can enhance the overall healthcare ecosystem. Doctors can remotely prescribe medicines, leveraging teleconsultations, and have them delivered quickly and safely to patients' doorsteps, thereby reducing the burden on traditional brick-and-mortar pharmacies.

The future scope of this research is promising. It encompasses areas such as healthcare logistics, telemedicine integration, technology advancements, sustainability, and regulatory considerations. Continued innovation, collaboration between researchers, manufacturers, and healthcare providers, and alignment with emerging trends will contribute to the growth and implementation of this novel solution.

2. ADVANTAGES OF PELTIER MODULE

Compact and Lightweight: Peltier cooling systems are compact and lightweight compared to Thermocol boxes. They are highly portable and easy to transport, making them suitable for various applications where space is limited or mobility is required.

No External Power Source: Peltier cooling systems can be powered by a direct current (DC) power source, including batteries or solar panels. This makes them suitable for remote locations or areas with unreliable electricity supply, where traditional cooling methods may not be feasible.

Less Noise and Vibration: Peltier cooling systems operate silently and have minimal vibration, making them suitable for environments where noise or vibration may be a concern,

such as laboratories, medical facilities, or residential settings.
Environmentally Friendly: Peltier cooling systems do not use harmful refrigerants, such as chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs). This makes them more environmentally friendly and reduces the risk of ozone depletion and global warming potential.

Better Energy Efficiency: Peltier cooling systems are more energy-efficient compared to traditional compressor-based cooling systems. They do not require refrigerants or complex mechanical components, resulting in lower energy consumption and reduced operating costs over time.

Durability and Permanency: Peltier cooling systems have a longer lifespan compared to Thermocol boxes. They are built with solid-state components and have no moving parts, reducing the risk of mechanical failures and increasing their overall durability.

Customizability: Peltier cooling systems can be customized to suit specific requirements. They can be integrated into different sizes and configurations, allowing for the design of cold storage solutions tailored to specific applications and space limitations.

3. COMPONENTS

For the construction of the Thermoelectric Refrigerator four main components are used, which are as follows –

3.1 Peltier module

A Peltier module, is a type of electronic device that utilizes the Peltier effect to create a temperature difference between its two surfaces when an electric current is applied. It is commonly used in applications requiring precise temperature control or heat transfer.

Here's a description of the Peltier module and its functioning: A Peltier module consists of a series of thermoelectric junctions made from semiconductor materials, typically bismuth telluride. The module is constructed with alternating P-type and N-type semiconductor elements, forming a pattern of junctions between them. When an electric current is passed through the Peltier module, it causes electrons to move from one side (P-type) to the other (N-type) due to the properties of the semiconductor materials. This electron flow results in the absorption of heat on one side of the module and the release of heat on the other side.

The Peltier effect is based on the fact that when an electric current flows through a junction of two dissimilar conductors, heat is either absorbed or released depending on the direction of the current. In the Peltier module, multiple junctions are arranged in series, amplifying the overall temperature difference generated.

Peltier modules are widely used in applications such as refrigeration, temperature control in electronic enclosures, laser diode cooling, and thermal cycling in scientific and industrial settings. They offer advantages such as compact size, quick response time, and precise temperature control. It's important to note that Peltier modules require careful consideration of factors such as heat sinking, electrical power requirements, and thermal management to ensure their efficient and reliable operation.

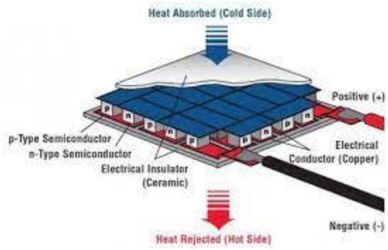

FIG -1: Peltier Module

3.2 Peltier 12706

The Peltier module 12706, specifically, refers to a specific model of Peltier module with characteristics defined by its dimensions and performance specifications. These specifications may include the maximum current and voltage ratings, the temperature difference it can achieve, and the heat pumping capacity.

FIG -2: Peltier 12706

3.3 Heat sink

40*40mm heat sink is used, A heat sink is a passive cooling device used to dissipate heat from electronic components, such as CPUs or GPUs, in order to prevent overheating. It consists of a metal component, usually made of aluminium or copper, that attaches to the heat-generating device. The primary function of a heat sink is to increase the surface area available for heat transfer. This is accomplished through the use of fins, ridges, or other structures that protrude from the base of the heat sink. These structures provide additional contact points for heat exchange with the surrounding air. When the electronic component generates heat, it is conducted through the base of the heat sink and then transferred to the fins. The increased surface area of the fins allows for more efficient heat dissipation. As a result, the heat is gradually transferred to the surrounding air, reducing the temperature of the electronic component.

FIG -3: Heat sink 40*40mm

3.4 Heat Sink with Cooler Fan

The container prototype incorporates two key components: a heat sink and a cooling fan, which work together to facilitate efficient heat transfer and temperature control. The materials used in the construction are aluminum 6061 for the heat sink and appropriate materials for the cooling fan.

The heat sink, typically composed of aluminum or copper, is designed to dissipate heat generated by a heat source such as a computer's CPU. In this case, the heat sink made of aluminum 6061 is utilized. The heat sink is constructed with fins or ridges that increase its surface area. This larger surface area allows for enhanced heat dissipation, promoting effective heat transfer from the heat-generating device to the surrounding environment.

Positioned near the heat sink is the cooling fan. The cooling fan consists of rotating blades that actively move air. It draws cooler air from the surroundings and directs it over the heat sink. As the air passes through the fins or ridges of the heat sink, it facilitates heat exchange and carries away the excess heat. This continuous airflow created by the cooling fan aids in maintaining a lower temperature within the container.

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FIG -4: Heat sink with cooler fan

3.5 Digital temperature sensor

A digital temperature sensor is an electronic device that measures and provides temperature readings in a digital format. It is commonly used in various applications, including environmental monitoring, industrial control systems, and consumer electronics.

FIG -5: Digital temperature sensor

3.6 Adapter (12Volts 5Amps): If you are referring to an adapter that provides a 12V output with a maximum current of 5 amps, it means that the adapter can supply up to 5 amps of current at a constant voltage of 12 volts. This type of adapter is commonly used to power electronic devices that require a 12V DC power source and have a maximum current draw of 5 amps or lower. The voltage output of 12V remains consistent, while the device connected to the adapter will draw the current it needs, up to a maximum of 5 amps.

FIG -6: Adapter 12v 5amps

3.7 SPECIFICATIONS OF PROTOTYPE

For Peltier module –

Model number: TEC1-12706, Voltage: 12V, U max (V): 15.4V, Imax (A): 6A, Q Max (W): 92W, Internal resistance: 1.98 Ohm +/- 10%, Power Cord: 150mm, HS Code: 854150, Type: Cooling Cells, Usage: Refrigerator/Warmer, Dimensions: 40*40*3.9mm.

For power –

Source: 12 volts DC power unit, Module: 12 volts, Fans: 5 amps, Temperature indicator: 12 volts, Minimum power required is 12 volts at 5 amp.

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Electrical data –

Power source: 12volts DC power unit, Rated supply: 12volts 5 amps.

Cooling fan and unit –

Minimum speed: 1000RPM, Moderate speed: 1500RPM, Maximum speed: 1900RPM, Dimensions: 122.5*116*80.6mm.

Material used-

Mild Steel of 4mm thickness for making the container.
Thermocol is used for making the inside of container.
Aluminium foil is used to sandwiched with thermocol.

4.CALCULATIONS

4.1 POWER LOAD CALCULATION:

Power supply from adapter = (12volts*5Amps) = 60 Watts
Peltier wattage = 60

Watts Estimated usage = 10

Hours per day Total energy = (60*10) = 600 Wh = 0.6 KWh
When the system is operated for 24 hours Total energy consumed = (60*24) = 1440 Wh = 1.44KWh

4.2 DESIGN CALCULATIONS

Container without insulation

Outer Diameter = 215mm
Inner Diameter = 207mm
Height = 182mm
Thickness = 4mm
Volume (π*r*r*h) = π*103.5*103.5*182
Volume = 6.12 litre

Container with insulation

Thickness of thermocol = 23 mm
Inner Diameter = 161 mm
Height = 151 mm
Volume (π*r*r*h) = π*80.5*80.5*151
Volume = 3.074 litre

5. DRAWING AND THERAML ANALYSIS

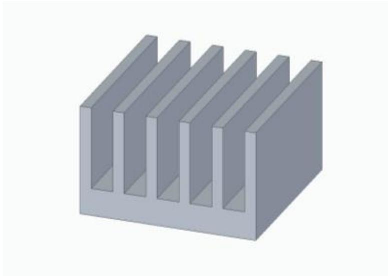

FIG -7: Heat Sink drawing

Table -1: Property of Aluminium 6061(HEAT SINK)

Property	Value
Density	2712.000 kg/m^3
Coef. of Thermal Exp.	0.0000 /C
Thermal Conductivity	0.221 kW/m-C
Specific Heat	920.000 J/kg-C
Modulus of Elasticity	68947.570MegaPa
Poisson's Ratio	0.330
Yield Stress	27.579MegaPa
Ultimate Stress	68.948MegaPa

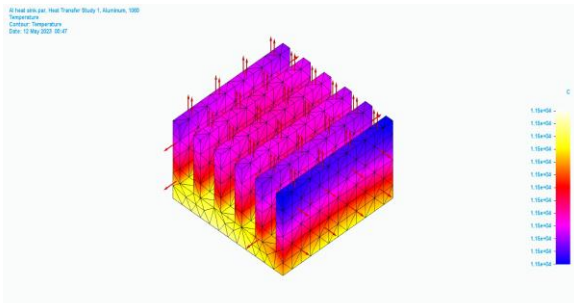

FIG -8: Heat Sink Thermal Analysis

From (fig 6) the Boundary Conditions given with load 60 W with Ambient Temperature of 28˚C which results minimum value 1.15e+04 C value.

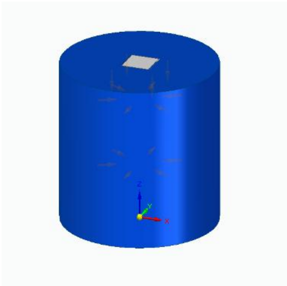

FIG -9: Container Drawing

Table -2: Property OF Thermocol (CONTAINER)

Property	Value
Density	886.000 kg/m^3
Coef. of Thermal Exp.	0.0002 /C
Thermal Conductivity	0.004 kW/m-C
Specific Heat	2219.000 J/kg-C
Modulus of Elasticity	144.790MegaPa
Poisson's Ratio	0.350
Yield Stress	9.653MegaPa
Ultimate Stress	35.356MegaPa

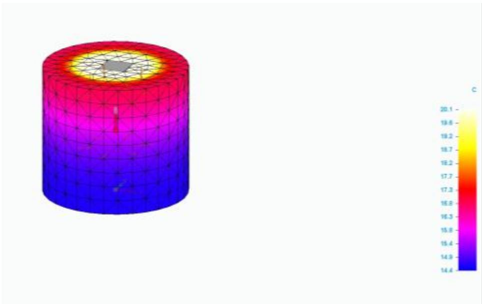

FIG -10: Container Thermal Analysis

From (fig 5.4) the Boundary Condition with load type of radiation to space with ambient temperature 0˚C and with convection of Ambient Temperature 28˚C which result minimum temperature 14˚C and maximum temperature20˚C.

6 ASSEMBLY OF CONTAINER

6.1 Assembly for Heat Sink and Fan

The heat sink is securely attached to the fan using multiple screws, ensuring a stable and reliable connection between the two components. The fan, designed to facilitate airflow and enhance cooling efficiency, is powered by a 12V 5Amp adapter.

The screws provide a firm and secure fastening mechanism, holding the heat sink and fan assembly together. This connection ensures that the fan operates in close proximity to the heat sink, allowing for efficient heat dissipation. By maintaining a consistent airflow over the heat sink, the fan aids in preventing heat buildup and maintaining the desired temperature inside the container.

6.2 Peltier Module Assembly

The Peltier module is connected to the heat sink and fan assembly using a thermal paste that ensures efficient heat transfer without creating resistance to the heat flow. This thermal paste acts as a medium between the Peltier module and the heat sink, facilitating the transfer of heat from the module to the heat sink unit. The use of a thermal paste helps to optimize the thermal conductivity and ensures effective cooling performance, allowing for the efficient operation of the Container system.

6.3 Final Container Assembly

The Peltier module, along with the heat sink, is securely attached on top of the frame or main body of the container. This arrangement ensures that the cold air generated by the module is evenly distributed in all directions inside the refrigerator compartment. The frame, constructed using 4mm mild steel, provides the necessary structural support and stability for the container.

The Peltier module, responsible for the cooling effect, is positioned on the upper portion of the frame. It is connected to the heat sink, which aids in heat dissipation and maintaining optimal temperature levels. The combination of the Peltier module and heat sink contributes to the effective cooling performance of the container.

To monitor and display the temperature inside the container, a digital thermometer is attached to the upper portion of the frame. This thermometer provides real-time temperature readings, allowing for easy monitoring and ensuring that the desired temperature range is maintained throughout the transportation of the medicines.

By integrating the Peltier module, heat sink, frame, and digital thermometer, the container achieves efficient cooling and temperature control. The sturdy frame provides durability, while the combination of the Peltier module and heat sink ensures effective heat transfer and cooling performance. The digital thermometer enhances the monitoring capabilities, allowing for precise temperature control and ensuring the integrity of the medicines being transported.

6.4 Inside of the Container

To enhance the insulation and improve the cooling effect inside the refrigerator compartment, the interior of the container is constructed using thermocol sandwiched with aluminium foil. Thermocol, also known as expanded polystyrene foam, is a lightweight material with excellent insulating properties. By utilizing thermocol as the core material, the container can effectively minimize heat transfer from the external environment to the inside of the compartment.

The aluminium foil serves as a protective layer on both sides of the thermocol. Its reflective surface helps to reduce heat absorption and radiation, further enhancing the insulation capabilities of the container. The aluminium foil acts as a barrier, preventing external heat from entering the compartment and impeding the escape of cool air generated by the Peltier module. This insulation system ensures that the interior of the container maintains a stable and low temperature, providing optimal conditions for storing and transporting temperature-sensitive medicines.

The combination of thermocol and aluminium foil in the construction of the container interior effectively minimizes heat transfer, creating a thermally insulated environment. This insulation plays a crucial role in maintaining the desired temperature range and ensuring the integrity and efficacy of the medicines during transportation on a motorcycle.

6.5 Working of Prototype

FIG -11: Developed prototype so far

FIG -12: Developed prototype so far

7. RESULT

The experimental setup aimed to achieve a temperature reduction from 28°C to 17.3°C within a one-hour timeframe using the designed container. The experimental results confirm that the container effectively achieved the desired temperature reduction and maintained a controlled and stable temperature within the specified timeframe. This successful outcome highlights the potential of the container for efficient medicine delivery, ensuring that temperature-sensitive medications can be transported safely and effectively on a motorcycle.

8. CONCLUSION

In this paper, the developed prototype of the efficient cold container for medicine delivery on a motorcycle, utilizing a thermoelectric cooling system, has shown promising results. The incorporation of multiple Peltier modules and cooler fans improved the cooling rate, leading to enhanced efficiency and accessibility. The use of Mild Steel as the primary material facilitated the construction process while maintaining the structural integrity of the container. Further research and development are recommended to refine the design and optimize the performance of the cold container for wider implementation in healthcare logistics.

REFERENCES

[1] NiteshGohil, AkshatShukla, DeepDoshi, VinayVerma," Simultaneous Heating and Cooling functionality for a Lunch Box" IRJET Volume: 09 Issue: 09, Sep 2022, Page 965

[2] Tarun Prasad Sonwani, Ashish Kumar, Gulab Chand Sahu, Kundan Lal Sahu, "Thermoelectric Refrigerator Using Peltier Module" IRJET Volume: 07 Issue: 05 | May 2020 Page 7873

[3] M. Mirmanto, S. Syahrul, Yusi Wirdan "Experimental performances of a thermoelectric cooler box with thermoelectric position variations" Engineering Science and Technology, an International Journal 22 (2019) 177–184

[4] Saiganesh Gawde, Vaibhav Chorghe, Karan Pagare, Jay Gaokar Guided by -Prof Girish Lonare, Review on Solar Powered Thermoelectric Cooler" IRJET Volume: 09 Issue: 04 | Apr 2022, Page 1223

[5] Ajendra Kumar Singh, Solar Refrigerator", IJERT, Vol. 8 Issue 05, May-2019, IJERTV8IS050523

[6] Olarewaju Mubashiru Lawal, Zhibing Chang," Development of an effective TE cooler box for food storage" 2214-157X/© 2021 The Authors. Published by Elsevier Ltd.

[7] S. Sasikala, R. Arun Bharathi, S. Naveen Sundar, P. Srivarshan, K. Sathish Pandiyan," Portable solar cooler and heater" IRJET, Volume: 07 Issue: 09 | Sep 2020, Page 812