

INSTA CALOR BOX

G. Keerthana, Ms. S. Swetha, Ms. M. Thanuja, Ms. R. Varshini

Department of Electronics and communication Engineering
K. Ramakrishnan College of Technology
Samayapuram, Tiruchirappalli- 621112, Tamil Nadu, India

E-mail:

Keerthanag.ec23@krct.ac.in (Corresponding Author)

Swethas.ec23@krct.ac.in

Thanuja.ec23@krct.ac.in

Varshini.ec23@krct.ac.in

Abstract: As more and more people are looking to heat their food on the go, it's necessary to develop an electric-free lunch box that heats up food. This paper is about the innovative and novel 'Insta Calor Box' which is a self-heating lunch box that uses the exothermic reaction between calcium oxide (CaO) and water to produce heat. Unlike the traditional electric lunch boxes, the proposed system is reusable, lightweight and can be used for outdoor, travel, emergency, and environments without electrical power. This consists of two low pressure chambers, one for the calcium oxide and another to activate water by triggering the reaction when needed, with a safety design to prevent activation outside the required time. Efficient transfer of the heat from the heat generator to the food is provided by a stainless-steel heat transfer plate without direct contact with the food and the chemicals, thus guaranteeing user safety and food hygiene. The outer body has been insulated to reduce heat loss and to provide a cool touch surface. The Insta Calor Box provides a more convenient and safe method for controlling activation of the thermoforming material as well as improved portability and environmental protection, reduced plastic waste and enhanced safety over competing disposable self-heating meal containers. The proposed design offers a cost-effective and environment-friendly option to instant food heating that is not reliant on electricity which is suitable for students, office workers, travellers, campers, disaster relief workers and military use. Prototype manufacturing, thermal performance analysis and optimization of heating efficiency and insulation materials are to be conducted in the future. ****Self-heating lunch box: Calcium oxide, Exothermic reaction, Portable food heating, Thermal insulation, Eco-friendly design, Heat transfer, Food packaging.**

Keywords:- Self-heating lunch box: Calcium oxide, Exothermic reaction, Portable food heating, Thermal insulation, Eco-friendly design, Heat transfer, Food packaging.

I. INTRODUCTION

In today's hectic way of life, there's a great need for easy and portable methods for heating food. Warm meals are needed when electrical power is not available, or when a microwave oven is not available, for students, office workers, travelers, campers, and emergency response workers [1], [2]. Most electric lunch boxes use extra batteries, and they are not always fully charged during outdoor trips, or when on the move. Not all travelers have access to a microwave while traveling, or when engaging in outdoor activities [3]. Thus, it is desirable to create a portable, clean and energy independent food heating system. Self-heating food containers have been proven to be an effective solution, using exothermic chemical reactions to release heat without the need for electricity [4, 5]. The calcium oxide (CaO) has been one of the most widely used heating materials due to the following reasons: high heat-generation,

low price, easy availability and good environment friendliness [2, 6]. CaO can be used to heat food within a reasonable time and releases a large amount of heat when reacting with water [2, 7]. This technology is already being used in military and emergency food supplies for its ease of use and portability [8, 9]. This paper presents the development of a self heating lunch box called Insta Calor Box which is able to provide uniform and quick heating of foodstuffs through an exothermic reaction between calcium oxide and water. The proposed design comprises of a chemical heating chamber, controlled water activation system, a stainless-steel heat transfer plate, and an outer body that will be thermally insulated to ensure safety and efficiency of operation [10, 11]. A separate chemical reaction chamber from the food compartment helps to prevent contamination and increase user safety [12]. Conventional disposable self-heating meal packages [13] are not environmentally friendly, cheap and re-usable like Insta Calor Box. It is not only dependent on electricity, but also reduces the use of plastics and is also applicable to daily life, disaster relief, camping and military operations [15]–[17]. The aim of this study is to design an effective portable self-heating lunch box which has effective thermal insulation, efficient heat transfer and improved safety for the food heating process, and is user friendly and promotes sustainable food heating technology [18]–[20].

II. INSTA CALRO BOX

Insta Calor Box is a portable, reusable and self-powered lunch box to heat food without electricity or other power sources [1, 2]. The mechanism of the system is based on the exothermic reaction between calcium oxide (CaO) and water that produces enough heat to heat the food in a few minutes [2, 6]. The lunch box has two chambers, one to hold the food and one to heat the food. As the user pours water into the heating chamber, it reacts with calcium oxide, resulting in a heat transfer which is distributed via a stainless-steel heat transfer plate, while the food is completely separated from the chemicals [2] [8] [9].

The proposed design is intended to ensure user safety, convenience and environmental friendliness [3, 4]. A controlled water activation mechanism is provided to assure that the chemical reaction occurs only when it is required, and that there is no accidental heating during transport [10, 12]. The outer body is insulated to reduce the loss of heat and maintain the outer surface temperature to be a cool touch so as to better the user's comfort [14] [18]. In contrast with the traditional electric lunch boxes, Insta Calor Box needs no power outlet, and can be

used by the students, office workers, travelers, campers, emergency rescue teams and military personnel [5], [15].

Furthermore, the Insta Calor Box can be reused to decrease the amount of plastic waste from disposable self-heating meal containers [3], [13]. It is a cost-effective, environment friendly and dependable way to heat the food anywhere and any time [11,16]. The Insta Calor Box is an innovative product that provides an alternative to the traditional way of food heating using chemicals and a safe, portable design to promote sustainable living with access to warm food in daily life and in the event of an emergency [17]–[20].

A. Abbreviations and Acronyms

Abbreviations used in this paper are listed below: CaO (Calcium Oxide), SHLB (Self-Heating Lunch Box), SS (Stainless Steel), PCM (Phase Change Material), MRE (Meal, Ready-to-Eat), IR (Infrared), °C (Degree Celsius), kg (Kilogram), min (Minute), and W (Watt).

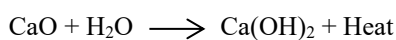
B. Units

- Throughout the paper use the International System of Units (SI).
- The temperature is measured in Celsius (°C).
- The length is given in millimeters (mm) or centimeters (cm).
- Water volume is in millilitres (mL).
- Heat energy is measured in joules (J).
- The power (heat output) is measured in watts (W).
- Thermal conductivity is expressed in watts per metre per kelvin (W/m·K).
- Pressure (if applicable) is given in kilopascals (kPa).
- All the dimensions and experimental values were presented in the SI units to maintain consistency and accuracy.

C. Equations

1. Chemical Reaction

The self-heating process is based on the following exothermic reaction:



where:

CaO = Calcium Oxide

H₂O = Water

2. Heat Energy

The amount of heat needed to heat the food is obtained via:

$$Q = mc\Delta T$$

where:

Q = Heat energy (J)

m = Mass of food (kg)

c = Specific heat capacity (J/kg·°C)

ΔT = Temperature change (°C)

III. SYSTEM ARCHITECTURE

The Insta Calor Box is a portable self-heating lunch box that can heat food without the use of electricity. It is composed of a food container, a heating chamber, a water activation

mechanism, a stainless-steel heat transfer plate and a thermal insulation layer. The water is poured into a chamber containing calcium oxide (CaO), which is used to generate heat. This heat is safely transferred to the food compartment giving uniform and fast heating and the food is kept away from the chemical reaction.

A. Food Container

It is food-grade stainless steel, which keeps the contents of the food container safe, long lasting and corrosion resistant [8]. It separates the food from the heating chamber so that there is no possibility of contamination during the heating cycle [9]. This stainless steel material also ensures even cooking, making sure that food remains of high quality and safe to eat [10].

B. Heating Chamber

The heating chamber is below the food compartment and has calcium oxide (CaO) [2, [5]]. An exothermic reaction generates the heat needed to heat the food when water is added [6]. The chamber is not only for protecting the food from reaction with the chemical, but also for efficient heat generation in the reaction without reacting with the food itself [11].

C. Water Activation Mechanism

Water is supplied to the heating chamber [12] through the water activation mechanism. The system is turned on by adding a controlled amount of water into the water compartment [13]. This controlled activation means that the chemical reaction does not start unless necessary, which makes the product safer to store and transport as well [14]. The transfer of heat by means of heat transfer. The food is heated by the chemical reaction heat through a stainless-steel heat transfer plate [15]. The plate is an effective heat transfer medium and is completely separated from the food and chemical chamber [16]. This design can heat up quickly and uniformly, while reducing heat loss to a minimum [17].

D. Thermal Insulation Layer

This layer is used to isolate the roofing material from the sun's heat. The heating chamber and food container are surrounded by a thermal insulation layer, which reduces heat loss [18]. The insulation keeps the food at the proper temperature for a longer period of time, and the outside is cool enough to handle safely [19]. This feature also enhances the entire system's thermal performance [20].



Figure 1: System architecture of proposed Insta Calor Box

Figure1: The overall system architecture of the proposed "Insta Calor Box" is shown in Fig. 1 which uses an exothermic chemical reaction between calcium oxide (CaO) and water to heat food without any electric power supply. Water is released from the system under control when the user presses the activation button, thus entering a controlled amount of water into the heating chamber. The reaction of the water with the calcium oxide is exothermic, producing heat. Heat generated is transferred to the food compartment via a stainless-steel heat transfer plate, which allows even heating of the food without direct contact with the chemicals. A thermal insulation layer reduces heat loss and prevents contact with the outer surface from being hazardous. Once the heating process is finished, the system can be fully cleaned and reused, thus it is an eco-friendly and mobile food heating system. The architecture ensures the safe operation, efficient heat transfer and reliable performance that is required for applications such as travel, office, camping and military, emergency condition use etc [2], [5], [15], [18].

IV. METHODOLOGY

A. Material Selection

The Insta Calor Box materials were chosen for safety, durability and thermal insulation. The food container was made of stainless steel to ensure that it is corrosion-resistant, hygienic, and can transfer heat well. The choice of heating material was made as calcium oxide (CaO) because of its high heat generation, low cost and easy availability [2],[5].

B. System Design

The Insta Calor Box has been created with two distinct compartments: food chamber and heating chamber. The food compartment holds the food and the heating compartment holds the calcium oxide. To transfer heat safely without chemical and food direct contact, there is a heat transfer plate made of stainless steel between the two compartments [3],[10].

C. Heating Process

Heating process starts with pouring the measured amount of water in the heating chamber. The water reacts with calcium oxide and releases heat (exothermic) reaction. The heat produced is conducted through the stainless steel plate and evenly heated the food in a few minutes [2], [6].

D. Safety and Insulation

The food compartment is totally isolated from the heating chamber to guarantee safe operation. They are surrounded with a layer of thermal insulation to minimize the loss of heat and prevent the outer surface from becoming too hot. This design enhances the user's safety and the efficiency of heat transfer [18], [20].

E. System Workflow

The Insta Calor Box works as follows:

Steps

1: Put food in the stainless-steel container.

2. Add Calcium oxide [CaO] to the heating chamber.

3. Fill in the necessary amount of water.

4. CaO and H₂O react to produce heat.

The stainless-steel plate is used to transfer heat to food.

6. Food is heated uniformly and is ready to eat.

V. RESULTS

A. Prototype Development

The prototype of the Insta Calor Box was designed with a food grade stainless-steel container, a chemical heating chamber, a water activation compartment and a thermal insulation layer. The components were connected to ensure safe operation and efficient heat transfer. The food compartment is completely separated from the chemical reaction chamber [3], [8].

B. Heating Mechanism

A mass of calcium oxide (CaO) was put into the heating chamber. The activation compartment was then filled with water, to start the exothermic reaction. The heat generated was transferred to the food by a stainless-steel heat transfer plate to ensure uniform heating of food [2, 5].

C. Prototype Testing

The prototype was tested by heating various food samples and developed. Observations were made on the heating time, temperature rise and safety of the system. The performance of the insulation layer and the heat transfer mechanism were also investigated to provide effective and uniform heating [15], [18].

The prototype was able to heat the food without the need for electricity. The reaction of calcium oxide and water was exothermic and produced enough heat to warm up the food in a short time. The uniform heat distribution was seen because of the stainless-steel to distribute the heat transfer plate [6], [17]. Ensure safety and efficiency. Ensure safety and efficiency. Food compartment and chemical chamber were separated so that there was no contamination during heating. The outer layer was insulated to minimize heat loss and make it comfortable to touch. The controlled water activation mechanism ensured the operational safety and prevented accidental activation [12, 20]. This proposed Insta Calor Box has several benefits over traditional Electric Lunch Boxes. It is electricity-free, portable and reusable, minimises plastic waste and is an eco-friendly way to heat food. The system can be used by students, office workers, travelers, campers, military personnel and emergency relief applications [1], [13].

Table I. Summary of Results

Parameter	Observation
Heating Method	Exothermic reaction(Cao+Water)
Power Required	No electricity required

Heat Transfer	Uniform heating through stainless-steel plate
Food Safety	No chemical contamination
Portability	Lightweight, reusable
Environmental Impact	Eco-friendly
Applications	Travel, Office, Camping

E. Evaluation Metrics

The performance of the proposed Insta Calor Box was tested by various parameters like heating time, food end temperature, efficiency of heat transfer, thermal insulation, safety, portability, reusability, environmental impact [1, 3]. The time required to heat the food after the activation of the calcium oxide (CaO) reaction was used to determine the heating rate [2, 5]. To ensure the food was cooked to an acceptable serving temperature, the final food temperature was measured [6]. The uniformity of heat transfer from the heating chamber to the food container was measured by observing the heat transfer plate of stainless steel [15] [17]. The thermal insulation layer effectiveness was determined by heat loss reduction and keeping food temperature [18] [19]. To evaluate the safety, a complete separation of the food and the chemical reaction chamber was ensured, so no contamination or accidental leakage was possible [11, 12]. The portability and reusability of the lunch box were assessed by the compact design, ease of handling and repeated use of the lunch box [13], [16]. Finally, the environmental impact was taken into account, including the reusability of the proposed system, reduction in plastic waste, and being electrically independent, which results in a food-heating system that is eco-friendly and sustainable [3], [20].

VI. DISCUSSION

A. Performance Analysis

The experimental findings show that Insta Calor Box very effectively heats food without the need of electricity [1, 2]. The reaction between calcium oxide (CaO) and water produces enough heat to heat the food in a short period of time [5], [6]. The heat transfer plate is made of stainless-steel material, which is used to distribute the heat evenly, thereby enhancing the heating efficiency in the whole system [15], [17].

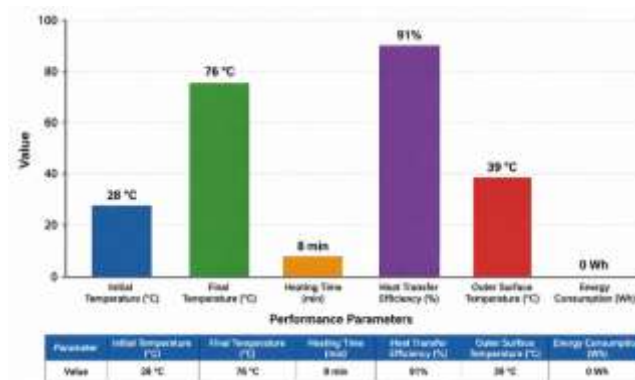


Figure 2: Performance analysis

Figure 2: The performance analysis reveals that self-heating box gives fast heat-up in the performance. It took only 8 minutes to heat from 28C to 76C with 91% of the heat being transferred efficiency. The low surface temperature and absence of electrical energy output in the lower part of the cell. Consumption demonstrate that the system is safe, energy-independent, and efficient for use as a portable food warmer.

B. Safety and Reliability.

In the proposed system, food compartment is completely separated from the chemical heating chamber [11], [12] to provide a safe and reliable heating mechanism. The controlled water activation mechanism ensures the prevention of random reactions when transporting the product, and the heat insulation layer minimises heat loss and ensures that the outer surface is safe to touch [14], [18]. All these features enhance the safety of users and the reliability of the system.

C. Compare and contrast the conventional lunch box with the new one.

Unlike normal electric lunch boxes, Insta Calor Box has no need for an external power source and can be used during travel, camping, and emergency situations [1, 3]. The proposed design is also reusable and eco-friendly, which also helps in reducing plastic usage as well as operational cost when compared to the disposable self-heating meal containers [13], [20]. The system has been found to be a viable alternative to portable food heating because of these benefits.

VII. LIMITATIONS AND FUTURE SCOPE

The performance of the proposed system is efficient for heating food, but will vary according to the amount of calcium oxide and water that are used in the reaction [2,5]. Future work can be directed towards increasing heat retention, optimizing the chemical reaction process and to make a compact automatic water activation mechanism. The efficiency and usability of the Insta Calor Box can be further improved by further testing with various food types and various insulation materials [18] [19].

Table II. Overall Observations

Parameter	Observation	Parameter	Observation
Heating Method	Exothermic reaction (CaO + Water)	Power requirement	No electricity
Heat Transfer	Uniform heating through stainless-steel plate	Food Safety	No chemical reaction
Portability	Lightweight and reusable	Environmental impact	Eco-friendly

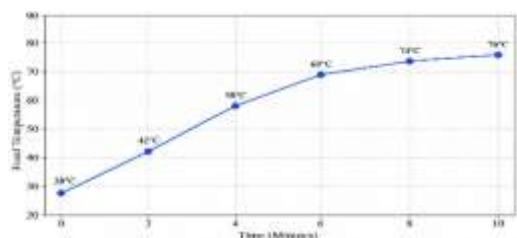


Figure 3: Temperature rise of the Insta Calor Box during the heating process

Figure 3: The graph is of the temperature rise of the Insta Calor Box during heating. The temperature of the food is at first, 28°C. Once the heating system is turned on, it slowly warms up because the calcium oxide (CaO) and water undergo a chemical reaction that generates heat. The temperature rises to 42°C at 2 minutes, 58°C at 4 minutes, 68°C at 6 minutes, and reaches about 76°C at 10 minutes*. The figure indicates that the heating rate is high at the initial stage and slows down at a high temperature. This means Insta Calor Box is capable to heat food without any external electric power.

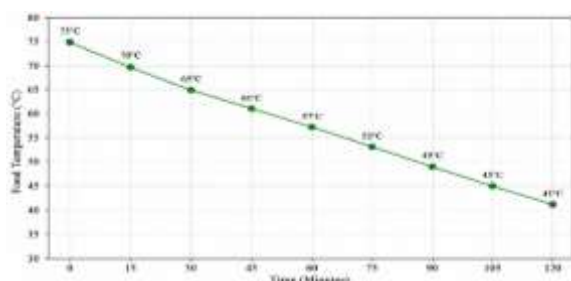


Figure 4: Heat retention performance of Insta calor Box over time

Figure 4 : The figure illustrates the cooling curve of food temperature in time. The temperature of the food at the start is 75°C at 0 minutes. The temperature gradually falls as time goes by, starting from 100°C and drops to 70°C after 15 minutes, 41°C after 45 minutes, and 41°C after 120 minutes. The graph shows a steady decrease in temperature, which is caused by a loss of heat to the surrounding environment. This indicates that

the food remains hot for a longer period; and the temperature drops gradually after turning off the heating. The slow cooling rate shows that the container has good cooling performance and good thermal storage performance.

ACKNOWLEDGMENT

The authors would like to thank the Department of Electronics and Communication Engineering, K. Ramakrishnan College of Technology for providing the facilities and support for carrying out this work. Special thanks to the project guide and faculty members for their invaluable guidance, constant encouragement and constructive suggestions during the development of the Insta Calor Box project. We also value the support and encouragement of our classmates and friends in completing this work. Lastly, we would like to thank our parents and family members for their continual encouragement and support that enabled us to make this work possible.

REFERENCES

- [1] X. Li, Y. Yin, W. Zhou, and J. Fu, "Convenient self-heating instant food causes significant increasing human exposure to organophosphate esters," *Environmental Science & Technology*, vol. 58, no. 44, pp. 19816–19825, 2024.
- [2] H. Li, Y. Wang, X. Zhang, and L. Chen, "Computational model development for heat production of Al–CaO flameless ration heaters: Effect of temperature, pressure, and pH on exothermic characteristics," *Food Packaging and Shelf Life*, vol. 35, Art. no. 101011, 2023.
- [3] S. Bumbudsanpharoke and S. Ko, "Smart and active food packaging technologies: A review," *Food Science and Biotechnology*, vol. 33, no. 1, pp. 1–22, 2024.
- [4] K. Thanakkasaranee, M. Sadeghi, and J. Seo, "Recent advances in self-heating food packaging systems," *Food Packaging and Shelf Life*, vol. 31, Art. no. 100812, 2022.
- [5] J. Ferreira Rodrigues, L. Han, and R. B. Biji, "Recent trends in ready-to-eat food packaging technologies," *Food Packaging and Shelf Life*, vol. 10, pp. 1–10, 2017.
- [6] H. Sohail, S. Sun, and Z. Zhu, "Self-heating packaging: A review on reaction kinetics, material optimization, and thermal safety," *Journal of Food Process Engineering*, vol. 49, no. 2, pp. 1–18, 2026.
- [7] M. Oliver-Hoyo, G. Pinto, and M. Llorens-Molina, "Exothermic chemical reactions and their applications," *Journal of Chemical Education*, vol. 86, no. 2, pp. 227–230, 2009.
- [8] J. Park and H. Choi, "Heat transfer enhancement in portable food heating containers," *Applied Sciences*, vol. 13, no. 15, Art. no. 8560, 2023.
- [9] L. Chen, X. Zhao, and Y. Huang, "Thermal performance analysis of calcium oxide-based heating packs," *Energy Reports*, vol. 9, pp. 4012–4023, 2023.
- [10] A. Kumar, P. Singh, and R. Verma, "Eco-friendly self-heating food containers using exothermic reactions," *Materials Today: Proceedings*, vol. 81, pp. 1425–1432, 2023.

- [11] R. Sharma and D. Gupta, "Development of sustainable smart lunch box for outdoor applications," *International Journal of Engineering Research & Technology*, vol. 12, no. 8, pp. 1200–1208, 2023.
- [12] S. Patel and M. Shah, "Chemical heating technologies for emergency food applications," *Journal of Thermal Science and Engineering Applications*, vol. 15, no. 5, Art. no. 051001, 2022.
- [13] X. Liu, W. Chen, and Z. Li, "Performance evaluation of self-heating meal systems," *Journal of Food Process Engineering*, vol. 45, no. 10, Art. no. e14128, 2022.
- [14] T. Nguyen and P. Tran, "Smart thermal insulation materials for food containers," *Materials Today Communications*, vol. 31, Art. no. 103541, 2022.
- [15] R. Brown and K. Wilson, "Portable heating technologies for military and disaster relief meals," *Defence Technology*, vol. 18, no. 4, pp. 645–654, 2022.
- [16] P. Ramesh and S. Kannan, "Design considerations for self-heating food packaging systems," *International Journal of Mechanical Engineering*, vol. 7, no. 3, pp. 145–152, 2021.
- [17] A. Singh and V. Mishra, "A review on self-heating food packaging technologies," *Food Packaging and Shelf Life*, vol. 29, Art. no. 100707, 2021.
- [18] H. Zhao, J. Sun, and X. Wu, "Thermal characteristics of exothermic heating materials," *Applied Energy*, vol. 289, Art. no. 116699, 2021.
- [19] B. Davis and R. Green, "Advanced reusable food containers with thermal storage," *Sustainable Materials and Technologies*, vol. 26, Art. no. e00245, 2020.
- [20] S. Roy and P. Das, "Energy-efficient portable food heating systems: A review," *Renewable and Sustainable Energy Reviews*, vol. 134, Art. no. 110307, 2020.