DEPARTMENT OF MECHANICAL ENGINEERING INDIAN INSTITUTE OF TECHNOLOGY ROPAR
RUPNAGAR-140001, INDIA

Development Engineering Project (CP-302)
END-SEM REPORT

For

Enhancing Efficiency and Cost-Effectiveness through Automatic Dosa Maker Implementation

Submitted by

Ayush Singh (2021MEB1275)

Dinesh Swami (2021MEB1282)

Pratima (2021MEB1308)

Yash Rai (2021MEB1338)

Supervised by

Dr. Prabir Sarkar

Second Semester AY 2023-2024

Acknowledgments

We extend our heartfelt gratitude to Professor Dr. Prabir Sarkar for his unwavering support and invaluable guidance throughout our project journey. His profound expertise and extensive experience have been instrumental in steering us through various approaches and methodologies to analyze the problem. Without his mentorship, our project wouldn't have reached its current successful stage, and we deeply value his sincere and profound guidance.

We also wish to convey our sincere appreciation to Mandeep Sir from the Design Studio of our institution, as well as the dedicated workshop staff, for their consistent support and assistance. Their wealth of knowledge, technical prowess, and guidance have been indispensable to us. Providing us with essential equipment, materials, and technical aid, they played a pivotal role in the execution of our project, aiding us in the design and assembly processes. Their welcoming demeanor fostered a conducive working environment, wherein we felt comfortable seeking assistance whenever required.

We express our heartfelt thanks to the esteemed Indian Institute of Technology, Ropar, for providing us with the platform to explore and expand our creative horizons. This opportunity enabled us to venture into the broader landscape, nurturing our innovative ideas to address critical existing issues.

Furthermore, we extend our gratitude to our friends, colleagues, and well-wishers for their unwavering support and assistance throughout our journey. We are also deeply appreciative of the constant encouragement and support extended by our families and friends, which served as a source of strength and motivation throughout our project endeavors.

TABLE OF CONTENTS

❖ Introduction:

Dosa, a dish, in South Indian homes, is a delightful rice pancake crafted from fermented batter. The batter combines rice and black gram, which are soaked and ground together with a sprinkle of salt for taste in a water ratio of 3;1 or 4;1. Achieving the desired texture involves mixing the fermented batter with water. This report delves into the cultural significance and nutritional merits of dosa, shedding light on its enduring appeal and timeless relevance in contemporary gastronomy.

Beyond its tantalizing taste, dosa boasts commendable nutritional credentials. The fermentation process not only lends it a delightful tanginess but also enhances its digestibility, making it a wholesome source of carbohydrates, proteins, vitamins, and minerals.

Dosa's culinary versatility shines through in its ability to harmonize with an array of accompaniments, ranging from the classic coconut chutney to the zesty tomato chutney, catering to a spectrum of palates and preferences.

A notable advantage of dosa lies in its convenience and extended shelf life. The feasibility of preparing dosa batter in advance and storing it for subsequent use underscores its practicality, offering a hassle-free solution for busy lifestyles without compromising on flavor or quality.

In this report, we'll delve into the potential benefits of implementing automatic dosa makers to streamline the dosa-making process. Automatic dosa makers have the promise of making dosa preparation simpler and more affordable. We'll examine how these machines operate, why they could be advantageous, and the obstacles they might encounter along the way. Join us as we explore the exciting possibilities that automatic dosa makers bring to the world of dosa-making.

❖ Objectives/ Aim:

➔ Engineer a precise batter dispensing mechanism that allows users to control dosa thickness, ensuring uniformity in dispensing and cooking.

➔ Design mechanical components with easy disassembly and reassembly features, facilitating maintenance tasks and reducing downtime for users.

This project aims to design and develop an economic and automatic dosa maker equipped with innovative features to enhance efficiency and user experience. The primary objectives include:

1. **Space Optimization**: Develop a dosa maker design that occupies minimal space while maximizing functionality, catering to both commercial and domestic settings with limited kitchen space.

2. **Automatic Batter Dispenser**: Implement an automated batter dispensing system to streamline the dosa-making process, ensuring consistent batter distribution and minimizing manual intervention.

3. **Dosa Thickness Control**: Integrate a dosa thickness control mechanism to allow users to customize dosa thickness according to their preferences, enhancing versatility and culinary satisfaction.

4. **Temperature Control**: Incorporate advanced temperature control technology to maintain optimal cooking conditions, ensuring uniform cooking and preventing over or undercooking of dosas.

5. **New Heating Element**: Develop and incorporate a novel heating element that enhances energy efficiency, reduces cooking time, and ensures even heat distribution for perfectly cooked dosas.

❖ Problem Description

Dosa, the beloved South Indian dish, is a favorite for many, but making it can be quite a hassle. The traditional way takes time and skill, making it tricky for businesses to keep up with demand, and for home cooks to enjoy it whenever they want. Automatic dosa makers promise to change that by doing the hard work for us. They're designed to make dosa-making quicker, easier, and more consistent, which sounds great, but there are some things to consider before jumping in:

1. **Cost**: These machines can be expensive upfront. While they'll save money in the long run by cutting down on labor costs and boosting productivity, not everyone can afford the initial investment, especially smaller businesses or home cooks.

2. **Ease of Use**: Automatic dosa makers are pretty high-tech. Making sure they're easy to use, maintain, and fix if something goes wrong is crucial for folks to actually use them.

3. **Quality**: We all want our dosas to taste just right. Ensuring that dosas made by these machines are as good as the ones made by hand is key. Things like getting the batter consistency right and making sure they cook just like they should are important for winning people over.

4. **Getting the Word Out**: Many people might not even know these machines exist or might be skeptical about their effectiveness. Educating folks about the benefits and debunking any myths about them will be important to get people on board.

5. **Following the Rules**: Food safety is a big deal. Making sure these machines meet all the regulations for hygiene and quality is essential for them to be trusted by both businesses and consumers.

❖ Concepts

Designing an economic automatic dosa maker involves integrating various elements to streamline the dosa-making process while keeping costs in check. We also try to make the dosa maker compatible with kitchens of all sizes, and thus we try to brainstorm different ideas and find out which design will suit the best to attain the objective of our project, which is to make an economical and automated dosa maker. Here are some conceptual ideas to consider

➔ **Table-Top:**
In this concept, a basic tabletop model is recreated where the base cooking plate revolves and the batter is introduced from a hooper mechanism to the table, which gets spread on the table with a flat plate and is further removed by the same flat plate.

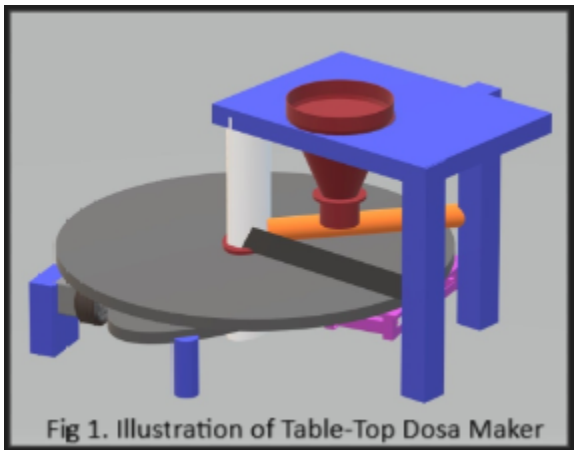


Fig 1. Illustration of Table-Top Dosa Maker

The limitations it provides are

- It does not provide a collection mechanism for the dosa that is cooked
- Oil and water dispensers could not be added
- Requires larger setup
- Achieving complete automation is very costly

➔ **Printer Mechanism:**
In this concept, we spread the dosa on the printer cylinder and let it cook for the required time on the cylinder, only after which a flat plate comes into contact to remove the dosa, which is then collected simply on a plate.

The advantages it gives us over other methods are:

- Collection mechanism is achieved
- Both oil and water dispensers are integrated
- Could be made approximately in the size of a desktop printer
- This completely automates the dosa-making process.


Fig 2. Illustration of Printer Mechanism

Reference Image:- https://evochef.in/

❖ Workflow

1. Identification of Problem with Automatic Dosa Maker

- Making dosas traditionally involves several steps, including preparing the batter, spreading it evenly on the pan, etc. An automatic dosa maker streamlines this process, saving significant time in the kitchen.

- Constant monitoring and manual effort are needed for making dosa, which can be simply eliminated by just pouring the batter into the machine and letting it take care of the cooking process.

- Achieving consistent results with manual dosa-making can be challenging, especially for those who are not experienced. But a machine can surely offer uniform cooking, texture, and taste.

- Manual dosa preparation involves repetitive tasks, such as spreading the batter and flipping the dosa, which can be physically demanding. Automatic dosa makers eliminate or minimize these tasks, reducing the effort required.

2. Study of literature review on existing products

Existing dosa makers on the market offer a range of features to simplify the dosa-making process. Consumers can choose from various models based on their needs, preferences, and budget. There are many common features in them that collectively contribute to the efficiency, convenience, and user-friendly nature of dosa makers, making them popular kitchen appliances for those who enjoy preparing dosas at home.

- Non-stick coating on the cooking surface prevents dosa batter from sticking, making it easier to flip and remove dosas. Facilitates hassle-free cooking and cleaning and reduces the need for excessive oil or ghee.

- Adjustable temperature control allows users to customize cooking temperatures based on their preferences and the type of dosa they are preparing. Ensures versatility in dosa preparation, accommodating various thicknesses and textures.

- Indicator lights indicate when the dosa maker has reached the desired temperature or is ready for use. It helps users monitor and

control the cooking process, ensuring optimal conditions for dosa preparation.

- A Batter Spreader is included with some dosa makers to help spread the batter evenly across the cooking surface. Facilitates uniform dosa thickness, aiding users in achieving consistent and well-cooked dosas.

- Oil Collector Tray collects excess oil or ghee during the cooking process. Promotes healthier cooking by draining excess fat from the dosa and keeping the cooking surface clean.

- Powerful Heating Element generates heat for quick and efficient dosa preparation. Reduces cooking time, making the dosa maker more time-efficient.

- Ergonomic Controls are user-friendly buttons or dials for adjusting temperature and other settings. Enhances ease of use, especially for individuals who may need more cooking experience.

3. Identification of components required for proposed work

- Frame: Aluminum or stainless steel for durability and heat resistance.

- Cooking Surface: Non-stick (Teflon) coated aluminum

- Heating Element:

  - ☐ Thermostat-controlled heating element (made of nichrome wire).
  - ☐ Ceramic Band Heaters
  - ☐ Cartridge Heaters

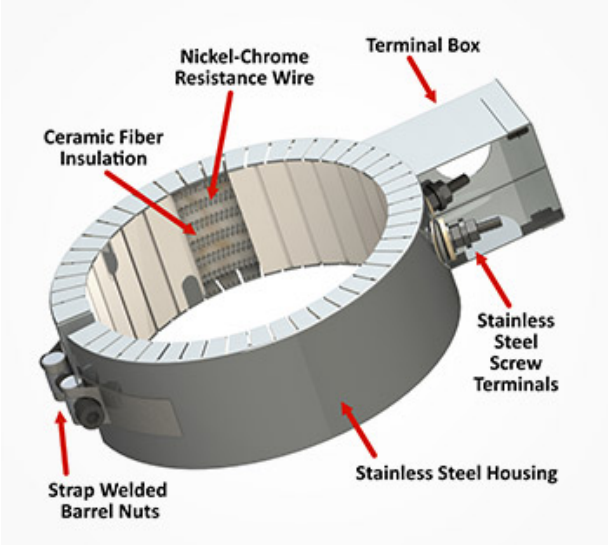


Fig 3. Ceramic Band Heater

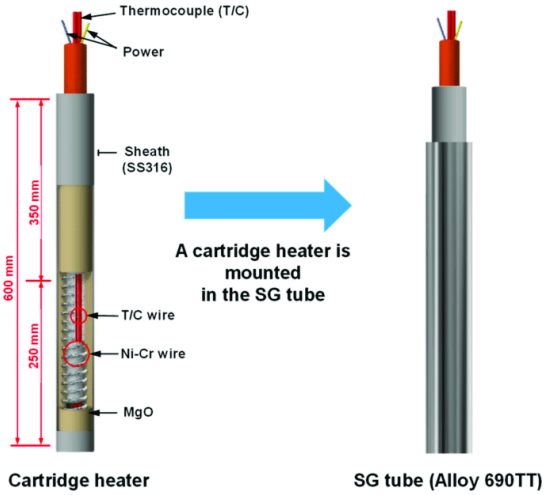


Fig 4. Cartridge Heater

Reference Image:- https://www.anupamheaters.com/ceramic-band-heaters.html

https://www.researchgate.net/figure/Design-of-cartridge-heater-and-heater-mounted-SG-tube_fig2_343792309

- Thermostat: Bi-metallic thermostat for temperature control.
- Temperature Control System: Adjustable thermostat control with a simple dial or digital interface.
- Insulation Material: Heat-resistant insulation material.
- Power Cord and Plug: High-quality power cord with a suitable plug.
- Indicator Lights: LED lights or indicator lamps.
- Batter spreader: Lightweight and durable plastic or metal.
- Oil Collector Tray: Removable and easy-to-clean tray.
- Base and Feet: Stable base with non-slip feet.

4. Designing of the model using CAD

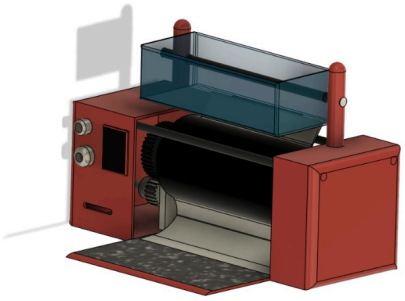


Fig 5. Isometric Cad View

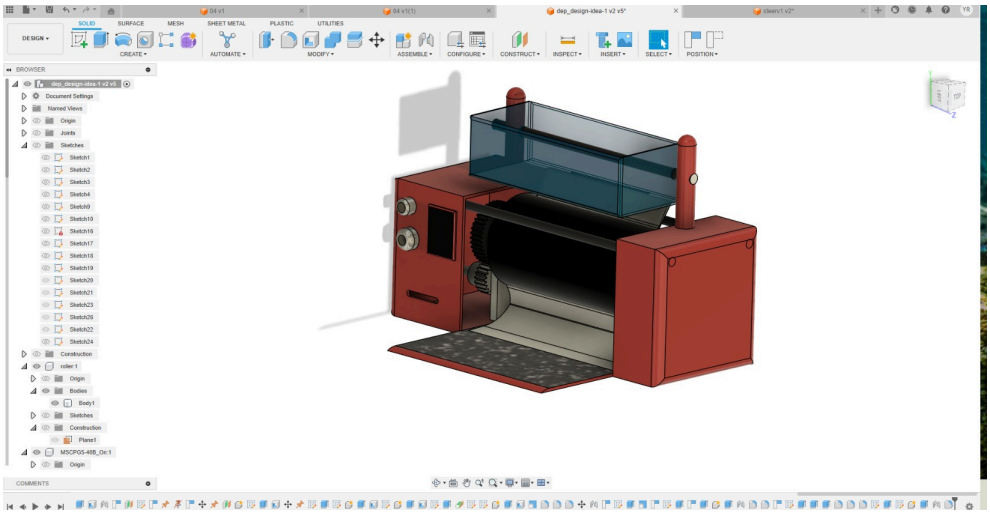


Fig 6. CAD View in Fusion UI

We made a CAD model for a dosa-making machine, focusing attention on the design and feel of the machine. The design we are pursuing stands out for its simple and user-friendly aspect, perfectly combining the modern look with an intuitive interface that allows you to set temperatures and thickness of dosa at ease. This CAD creation depicts the key features of an exceptionally user-friendly, visually appealing automated cooking system.

5. Study and calculations of Heating element

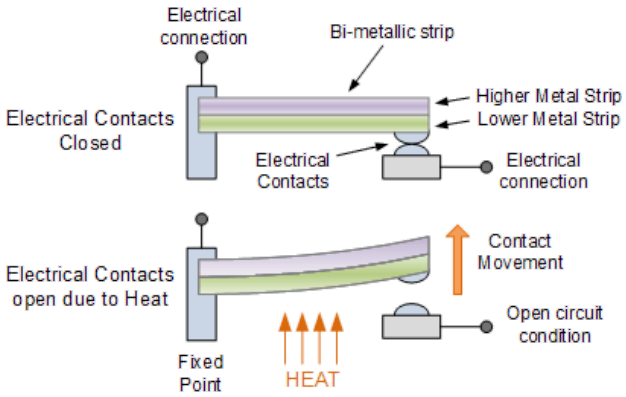


Fig 7. The thermostat working

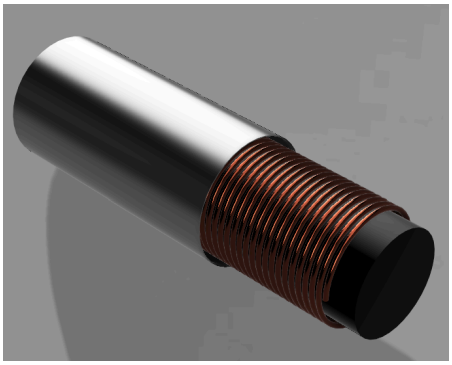


Fig 8. Concept design of coil

❖ Initial Design

In our endeavor to enhance the efficiency of our roller's heating system, we had engineered a heating core featuring a ceramic core intricately coiled with Nichrome A wire. This design ensures uniform heat distribution, utilizing an estimated 25-30 rounds of nichrome wire, equivalent to approximately 6-10 meters in length. To sustain uniform heating and provide electric insulation, we have incorporated mica or magnesium oxide powder. These insulating materials not only enhance heat dissipation but also contribute to the overall safety and reliability of our system. Temperature regulation is achieved through an energy thermostat knob, affording precise control over operating temperatures.

- This design posed several challenges and problems (discussed below this section), we had to come up with an alternative heating as well as insulating mechanism.

1. Wire diameter (d): 0.8 mm or 0.0008 m (21SWG)

2. Cross-sectional area (A): $A = \frac{\pi * 0.0008^2}{4}$ ~ 5.027 × 10-7 m^2

3. Core diameter (D_{core}): 100 mm or 0.1 m

4. Perimeter of the core (P_{core}): P_{core} = PI * D_{core} ~ 0.314 m

5. Total length of wire (L_{total}): For 30 rounds, $L_{total} = P_{core} \times 30$ ~ 9.42 m

6. Resistance (R): Resistivity of Nichrome A wire = 110 * 10^{-6} Ω.m

$$R = \frac{110 * 10^{-6} \Omega.m * 9.42\ m}{5.027 * 10^{-7}\ m^2} \sim 20.670\ \Omega$$

7. For metals, the resistance typically increases with temperature, and their temperature coefficient is positive. The relationship is often described by the formula:

$$R_t = Ro * (1 + \alpha * (T - To))$$
$$\alpha_{NIchrome} = 0.00017\ °C^{-1}$$

approximating the average temperature as 250 °C

$$R_{250} = 20.67 * (1 + 0.00017 * (250 - 20))$$

$R_{250} \sim 22.73\ \Omega$

8. Power (P): $P = I^2 * R$

Assuming a current (I) of 5A as in household switches,

$P = (5\ A)^2 * 22.7352\ \Omega \sim 568.25\ W$

➢ Problems with this heating element and design:

- The power generated within the nichrome wire is diminished due to its reduced thickness and fewer number of turns. Consequently, the heat transferred to the outer cylinder, serving as the cooking surface, may not be adequate to raise its temperature to the required level.
- Heaters, boilers, and heating elements designed for industrial use typically exceed a power rating of 1000W. In our case, the power output is approximately only 500w.
- Securing and guaranteeing the safe attachment of the nichrome wire coiled over the mica sheet, which is affixed to the metal cylinder, poses significant challenges and difficulties. Any malfunction or accidental slipping of wire over the mica sheet could lead to a short circuit and electrical current issues.
- Mica sheets available in the market have little to no flexibility, deliberate and forced attempts to round the mica sheet cause cracks, rendering the design prone to current leaks and improper internal thermal insulation.
- Mica sheets are also thermal insulators, hence transferring heat to the outer cooking surface will be inefficient and ineffective.

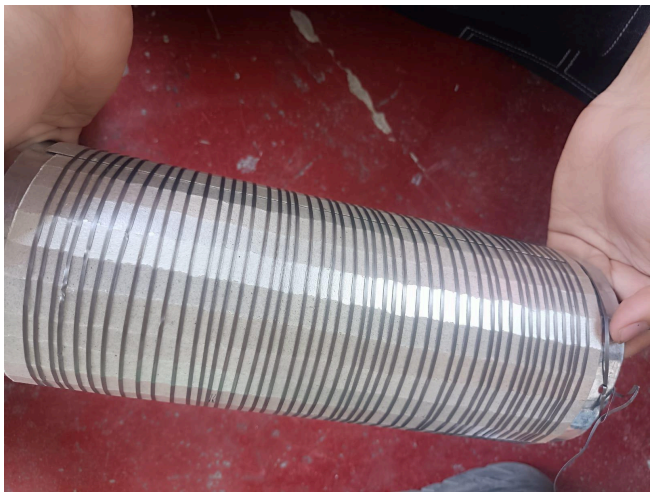


Fig 9. First approach for heating coil

➢ **Changes required:**

a. Better approach for Heating Element
b. To achieve the required wattage from heating element
c. Design that ensures user safety
d. An alternative approach for insulation
e. Need of insulation that does not hinder heat transfer

❖ Final Design

In the final design of our automatic dosa maker, we have integrated a ceramic band heater to ensure optimal cooking performance and energy efficiency. The ceramic band heater is a key component of the dosa maker, responsible for providing uniform and consistent heat distribution across the cooking surface. These heaters are crafted using high-quality ceramic materials, which are known for their excellent thermal conductivity and durability. The making of ceramic band heaters involves precision engineering and craftsmanship. First, ceramic materials are carefully selected for their thermal properties and resistance to high temperatures. Then, the ceramic band is meticulously wound with nichrome wire, which serves as the heating element. The band is then encased in a protective sheath, usually made of stainless steel, to ensure durability and safety. The result is a robust and reliable heating element that delivers precise temperature control and efficient heat transfer, ensuring that every dosa cooked in our automatic dosa maker is perfectly cooked to perfection.

Fig 10. Final model of our automatic dosa maker

❖ Components used

- **Heating Element:** The heating element is responsible for heating the cooking surface to the desired temperature for dosa cooking. In our model, we use a Ceramic band heater on the inside of the cooking surface. Generally, ceramic band heaters are used to heat the inside of the cylinder, so we re-engineer it to heat the outer surface instead of the inner.

Fig 10. Ceramic Band Heater

Fig 11. Beads used in ceramic band heater

Reference image:-
https://www.tempco.com/Products/Electric-Heaters-and-Elements/Band-Heaters/Ceramic-Band-Heaters.htm
https://du-co.com/ceramic-products/standard-products/standard-band-heater-tooling/

- **Batter Dispenser:** For the batter dispenser, we use a static sheet metal structure, which stays at a fixed distance from the heating surface. The batter is filled in a container kept above the structure from which the batter is dispensed in the structure.

- **Cooking Surface:** The cooking surface is where the dosa batter is spread and cooked. We use a mild steel heating surface, which is easily available, and we fit the ceramic band heater inside it.

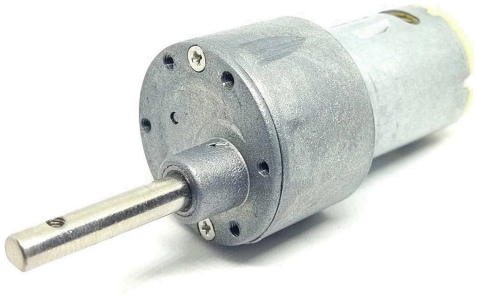
- **Gears:** We are using 2 gear set for the rolling mechanism of cooking surface. The gears are in the ratio of 1:8 that is for one rotation of heating surface, the motor will turn 8 times.

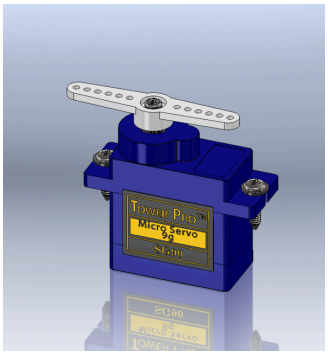
- **Motor:** We are using RS37-555 High Torque DC Motor which operates on 12 V and give maximum output of 66 RPM. This motor is driving the heating surface.

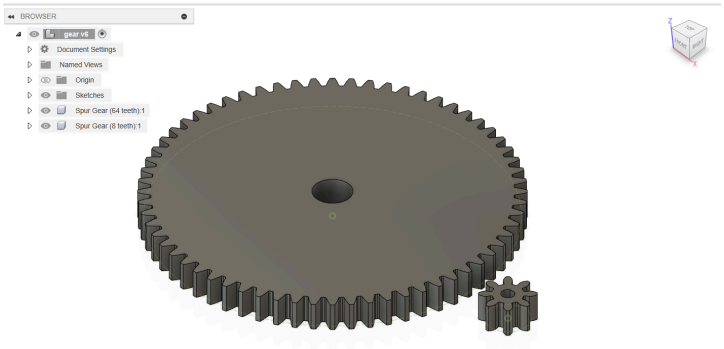
Fig 12. Energy Regulator

- **Servo Motor:** We are using an MG90 servo for rotating the batter container.
- **Frame:** We are using wooden blocks and sheet metal structures to provide strength and stability to the Dosa Maker.
- **Energy Regulator:** To control the temperature of the heating surface, we are using an energy regulator for controlling and maintaining uniform temperature.
- **Insulation Material:** To prevent any electric shocks, we are using mica pieces between the ceramic band heater and the cooking surface.
- **Power Cord and Plug**: The power cord supplies electricity to the dosa printer, while the plug allows it to be connected to a power source. High-quality power cords and plugs ensure safe and reliable operation.
- **Indicator Lights:** To know when the heating takes place and when the input is cutoff by the energy regulator.
- **Ball Bearings:** Ball bearings are used to ensure smooth rotation of the heating surface

Fig 13. Mica Piece







➢ Final Design CAD Model:

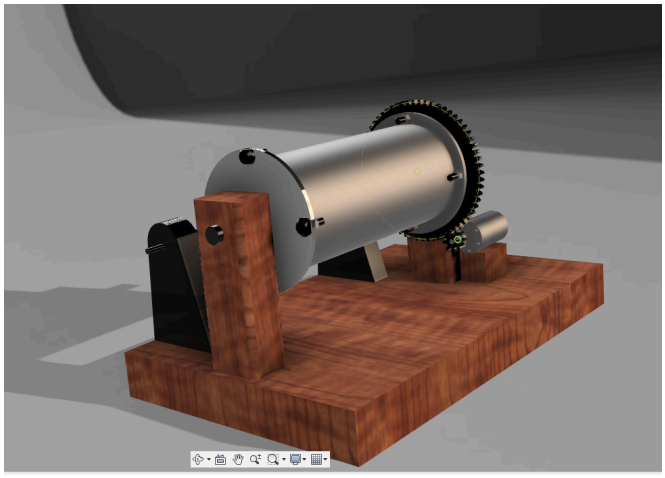


Fig 14. Isometric CAD view

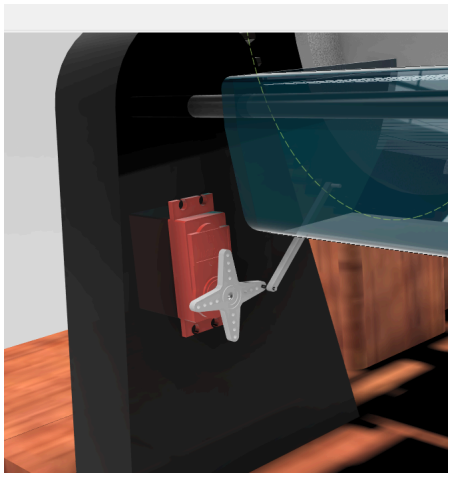


Fig 15. Servo for batter dispenser control

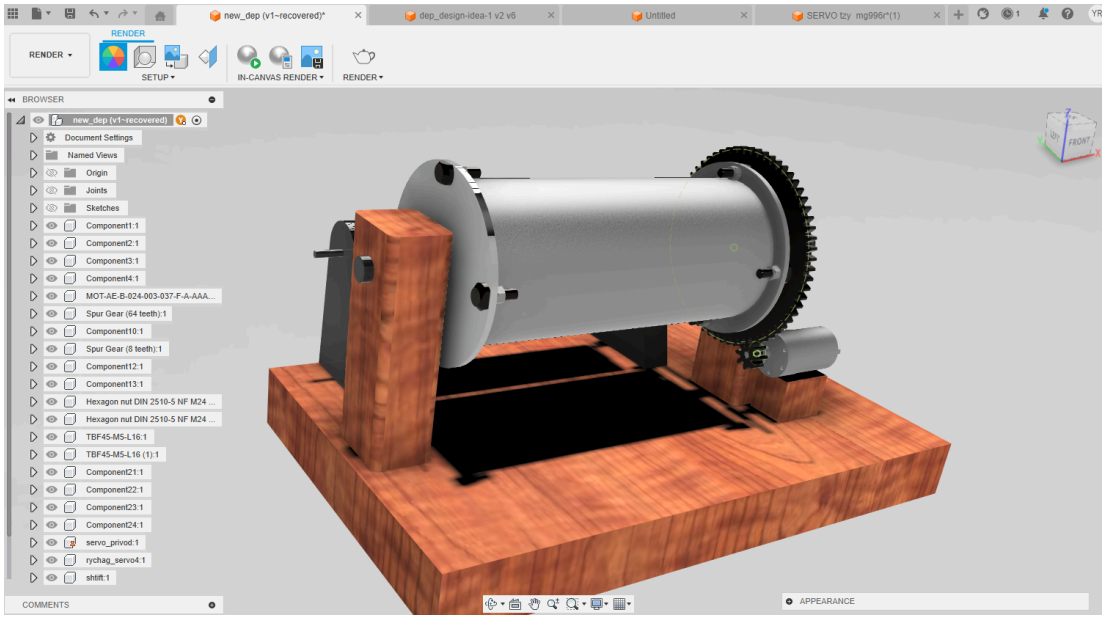


Fig 16. Isometric CAD view in Fusion 360 UI

❖ Dosa Maker in Action

The dosa maker has surpassed all expectations, proving to be an exceptional addition to any kitchen. It consistently delivers dosas of remarkable quality—nearly flawless in their execution, boasting a perfect blend of crispiness and flavor. Each dosa emerges from the machine with an inviting golden-brown hue, evoking anticipation with its tantalizing aroma and taste. The dosa maker owes its success to a combination of innovative design features and advanced temperature control mechanisms, ensuring that every dosa is cooked to perfection. With this remarkable appliance, enjoying the authentic taste of dosas has never been easier or more gratifying.

Fig 17 and 18. First dosa from our dosa maker machine

❖ Conclusion

- ➢ Automatic dosa makers show promise in transforming dosa preparation, offering benefits in efficiency, consistency, and cost-effectiveness.
- ➢ Features like space optimization, automatic batter dispensing, dosa thickness control, temperature regulation, and new heating elements enhance functionality.
- ➢ Successful integration of ceramic band heaters and static sheet metal structures demonstrates adaptability and innovation in dosa maker designs.
- ➢ Achieving near-perfect dosa quality validates the effectiveness of these advancements in delivering authentic culinary experiences.
- ➢ Challenges including cost considerations, technological complexity, market awareness, and regulatory compliance need addressing for widespread adoption.
- ➢ Overall, automatic dosa makers represent a significant advancement in making dosa more accessible and enjoyable while preserving its cultural heritage.

❖ References:

a. https://evochef.in/
b. https://ijream.org/papers/IJREAMV06I0262071.pdf
c. http://hbrppublication.com/OJS/index.php/JRAEE/article/view/300
d. https://www.theguardian.com/food/2020/sep/23/how-to-cook-the-perfect-dosa-recipe-felicity-cloake