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This report is submitted in partial fulfillment of the requirements for the degree of Bachelor of Computer Engineering at An-Najah National University

Sep 11, 2025

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Acknowledgment

We would like to begin by expressing our deepest gratitude to our families for their unwavering support, encouragement, and love throughout the journey of this project. To our parents, whose sacrifices and guidance have shaped us into who we are today, we are forever grateful.

We also extend our heartfelt thanks to our professors and academic advisors who have accompanied us throughout this journey, helping bring this project to life. A special thanks goes to **Dr. Luai Malhis and Dr. Sufyan Samara** for their continuous guidance, patience, and valuable insights, which have been instrumental in the development and success of our project.

We cannot forget our friends, whose constant support and uplifting messages kept us going through the toughest days. Their encouragement and friendship have played a vital role in our motivation and perseverance.

Lastly, this work is dedicated to the resilient people of Gaza. We proudly pay tribute to the families enduring hardship and to the martyrs who gave their lives for a noble cause. The strength and willpower of the people of Gaza continue to inspire and motivate us every day.

Abstract

This project presents the design and installation of a semi-automatic production line for **Sesame Circle**, a traditional sesame biscuit. The system improves efficiency, hygiene, and consistency by automating key steps such as dough cutting, shaping, flavoring, baking, and packaging. The goal is to deliver a cost-effective and scalable solution for small bakeries while preserving the authentic taste and tradition of the product.

Introduction

Sesame Circle is a traditional sesame biscuit widely enjoyed in local communities. Its production is usually manual, which makes the process time-consuming, less hygienic, and inconsistent. With the growing demand for higher quality and faster production, small bakeries face challenges in maintaining efficiency while preserving authenticity.

To address this, the project introduces a semi-automatic production line that automates key stages such as dough cutting, shaping, baking, and packaging. This solution improves efficiency, hygiene, and consistency while remaining cost-effective and suitable for small-scale bakeries.

Background

Sesame Circle, a traditional sesame biscuit, has long been a staple in local bakeries and households. It holds cultural and economic significance, as it is not only a popular snack but also a symbol of culinary tradition passed down through generations. Traditionally, the production process has been carried out manually, relying heavily on labor for dough preparation, cutting, shaping, flavoring, and baking.

While manual production ensures authenticity, it presents several challenges in terms of efficiency, hygiene, and consistency. Small bakeries often struggle to meet increasing customer demand due to the time-consuming nature of the process, and variations in product quality may occur depending on the skills of workers. Additionally, hygiene standards can be difficult to maintain in manual settings, especially when production scales up.

These limitations highlight the need for a modernized solution that can support small bakeries in enhancing productivity without losing the traditional essence of Sesame Circle. By adopting a semi-automatic production line, bakeries can achieve higher efficiency, better quality control, and improved hygiene, while still preserving the authentic taste and cultural value of the product.

Constraints, Standards, and Earlier Coursework

Constraints

Dough Consistency

In the cutting stage, the dough texture caused problems; some types were too soft or too hard, making them unsuitable for the ring-shaped mold.

Solution: Several dough recipes were tested until the proper consistency was found, one that fits well into the shaping mold and maintains its structure.

Shaping Stage

When the dough entered the shaping mold, it sometimes stuck to the surface or failed to form a proper circular shape.

Solution: The mold material and surface finish were improved (e.g., smoother coating and slight modifications to mold dimensions) to reduce sticking and ensure a consistent circular form.

Baking Process

During baking, the dough was not fully cooked on the inside while the outside risked burning.

Solution: The oven's conveyor belt was adjusted by moving it forward and backward multiple times to ensure even heat distribution and full baking without burning the outer layer.

Sensor Positioning for Accurate Cutting

The initial sensor setup failed to detect the correct cutting point, resulting in inconsistent portion sizes. Since the labneh flow was not uniform, static positioning was not sufficient.

Solution: A hybrid approach was implemented, combining sensor data with timing synchronization of the piston movement. This improved cutting precision and ensured uniform portion sizes.

Electrical and Space Considerations

The system included several low-voltage components (relays, motors, sensors) that required precise wiring. Poor wiring management could cause false triggers or instability. Additionally, the mechanical layout—covering the piston, shaping mechanism, dual scoops, and packaging platform—had to be both compact and efficient.

Solution: Careful planning of the internal structure was carried out to prevent collisions, simplify maintenance, and ensure smooth, continuous flow throughout the production process.

Standards

Throughout the development of Sesame Circle, we adhered to essential electrical and mechanical standards to ensure the system's safety, durability, and ease of use. Given the presence of AC components, rotating parts, and delicate material handling, proper safety measures were prioritized at every stage of the design.

Electrical Standards and Safety Measures We Followed:

Wire Selection:

- 2.5mm² copper wires were used for motors and load-bearing components to ensure proper current flow and reduce the risk of overheating or voltage drop.

Relays:

- AC-powered components such as the **cutter motor**, **piston relay**, **forming stage, sesame decorating stage, and baking stage** were controlled by relays housed in protective boxes, providing electrical isolation and preventing accidental contact.

Circuit Design and Insulation:

- All wiring was neatly routed and separated from moving mechanical parts to prevent friction damage or accidental disconnection.
- Electrical joints and terminals were secured and insulated using heat-resistant tubing or cold silicone to enhance system reliability and safety.

Cutting Blade Safety:

- The cutting blade was securely mounted on a fixed holder with only the tip exposed for cutting functionality.
- It is surrounded by a protective structure on all sides, forming a partially enclosed area that allows safe operation while minimizing the risk of injury or contact.

Keypad and LCD Interface:

- The system is controlled via a 4x4 membrane keypad, allowing users to select the number of beads and start the operating cycle.
- Notes and operating status are clearly displayed on a 16x4 I2C LCD, providing real-time updates on the current process stage.
- The interface is designed to be simple and easy to use, allowing for seamless interaction without the need for technical expertise or prior training.

Earlier Coursework

During this project, we relied on several key courses that played a vital role in expanding our knowledge and ensuring the project's success:

- **Microcontrollers & Lab:**

This course was fundamental in understanding hardware implementation, serial communication, and programming Arduino to handle controller logic. It also provided practical experience with sensors and hardware components.

- **Electrical Circuits:**

It guided us in selecting the right resistors and sensors, ensuring proper integration of the hardware components.

- **Computer Networks:**

We gained insights into serial communication techniques, which were crucial for achieving system portability and improving efficiency.

- **Critical Thinking & Research:**

This course sharpened our ability to research effectively and document our work comprehensively.

- **Self-Learning:**

By exploring free online resources, we were able to overcome challenges and deepen our understanding of complex topics.

Literature Review

The food industry has witnessed significant advancements in automation to enhance productivity, hygiene, and product quality. Several studies highlight the benefits of integrating semi-automatic and automatic systems in bakery production lines, where consistency and efficiency are crucial. According to research on food automation technologies, mechanized cutting and shaping tools greatly reduce labor requirements and minimize human error, resulting in more uniform products.

In the bakery sector, semi-automatic systems have been widely adopted because they balance cost and efficiency. Fully automated lines, while highly productive, are often too expensive and complex for small and medium-sized enterprises. Studies emphasize that semi-automatic solutions allow small bakeries to modernize their operations without sacrificing affordability. These systems usually automate the most labor-intensive stages such as dough preparation, shaping, and packaging, while leaving room for manual adjustments to preserve authenticity.

Research also indicates that challenges such as dough consistency, accurate shaping, and uniform baking are common in bakery automation. Previous work suggests that improvements in sensor placement, conveyor belt synchronization, and mold design can significantly enhance process reliability. Furthermore, adopting compact layouts and efficient wiring management in multi-component systems improves safety, maintainability, and continuous flow within production lines.

Building on this body of work, the present project develops a semi-automatic production line for Sesame Circle biscuits. It draws from earlier research on bakery automation while focusing on cost-effectiveness, compact design, and cultural preservation. By addressing issues of dough handling, shaping precision, and baking uniformity, the project adapts automation principles to meet the specific needs of small local bakeries.

Methodology

Hardware parts

Microcontroller

- Arduino Mega 2560

Motors and Drivers

- DC Motors
- Stepper Motor Nema 23 + TB6600 Driver (5A)

Sensors

- Capacitive Proximity Sensor PNP
- Ultrasonic Sensor
- Laser Module and LDR Module
- Temperature sensor

Actuators

- Pneumatic Piston + Pneumatic Solenoid Valve 220V

Power Supplies and Switching

- Power Supply (Computer)
- Relay 2Channel
- Switching Power Supply

Input Devices

- 4*4 Keypad

Other Components

- Connecting Wires
- Resistors
- IBT_2 (H-bridge)
- LCD 16x4 (I2C)
- RFID Module
- Contactor

Description

In this section, we will discuss each component and explain how it is used in our machine

Arduino Mega 2560

Figure 1 Arduino Mega 2560

The Arduino Mega is the core of the **Sesame Circle** system, responsible for managing all interactions between the various subsystems. It controls the motors, handles inputs from the keyboard, and coordinates the entire process—from cake shaping to baking.

The Arduino Mega also collects data from sensors (such as proximity sensors for grain detection), ensuring real-time monitoring of system performance and health. It also provides precise timing control for components such as stepper motors and DC motors.

One of the most important features of the Arduino Mega is its large number of input/output ports, making it ideal for managing multiple devices simultaneously. It is also supported by the Arduino IDE, providing a user-friendly development environment suitable for both beginners and experienced developers. Thanks to its 256KB flash memory, it handles complex logic operations, task scheduling, and data processing without any performance issues. Overall, the Arduino Mega serves as the central controller for the **Sesame Circle** system, efficiently integrating all mechanical and electrical components into a synchronized and reliable automation workflow.

Power supply computer

Figure 2 Power Supply Computer

In our project, we used a computer power supply to give different parts and modules steady, dependable power. Its dependability and capacity to supply adequate power across several voltage rails are the reasons we used it.

Switching Power Supply

Figure 3 Switching Power Supply

A 12V DC power supply (Mean Well NES-350-12, 350W) was used to provide dedicated power for the oven's DC motor, which requires high current to operate reliably. This power supply converts the AC mains input into a stable 12V DC output, ensuring sufficient and consistent energy delivery. Using a separate power supply for the motor improved system stability, reduced electrical interference, and guaranteed the motor's performance during the baking stage.

The Laser Module and LDR

Figure 5 Laser

Figure 4 LDR

We used a **laser and an LDR (Light Dependent Resistor)** to detect the biscuit after the cutting and shaping stages. This setup ensured that each piece successfully passed through the shaping process and allowed us to identify any potential issues before entering the baking stage.

2-Channel Relays

Figure 6 2-Channel Relays

The Sesame Circle production system utilized multiple 2-channel relay modules to control the main motorized components throughout the production line. Relays allowed low-voltage signals from the microcontroller to safely operate higher-current devices, ensuring reliable and precise automation. In the cutting stage, one relay module controlled the screw conveyor and the cutter to move and cut the dough accurately. In the shaping stage, another relay module drove the shaping belt, guiding each piece through the mold. During the decorating stage, a relay module operated the motor responsible for adding toppings, and in the baking stage, a relay module controlled the oven to maintain proper heat and conveyor movement. Using dedicated relay channels for each stage enabled synchronized operation, improved safety, and consistent production quality across the entire process.

4*4 **Keypad**

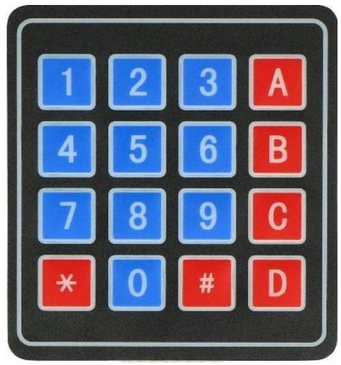


*Figure 7 (4*4) Keypad*

The Sesame Circle system uses a 4D keyboard as the primary input method for user interaction. This keyboard allows the user to select the number of cookies desired. The keyboard provides a simple, economical, and reliable user interface. Its compact design and intuitive display make it ideal for efficiently controlling food automation processes without the need for a complex user interface.

LCD Display:

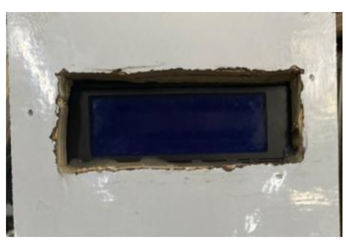


Figure 8 LCD Display

The Sesame Circle system features a 16x4 LCD screen that serves as a user interface to guide and inform the operator throughout the process. Upon startup, the screen displays a welcome message, providing an interactive and friendly experience. When the user interacts with the 4x4 keypad—entering the number of cookies—the required information is immediately displayed on the screen, ensuring clear communication and ease of use. Additionally, the system integrates an RFID module for user authentication. This feature allows users to scan their RFID card to confirm or process an order, providing a seamless and modern way to manage transactions securely and efficiently within an automated workflow.

First-stage

Mixing and Cutting Machine

Figure 9 Mixing Machine

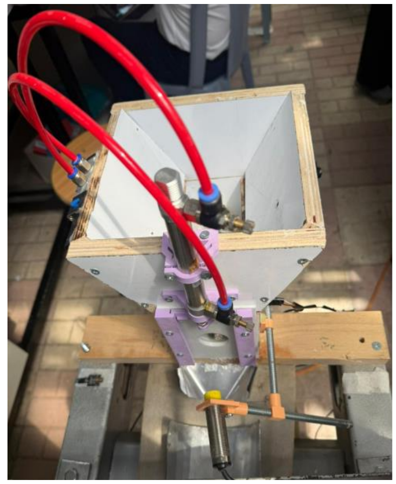


Figure 10 Cutting Machine

Component:

DC Motor:

Figure 11 DC Motor

We use a DC motor, specifically a windshield wiper motor, in the first-stage dough cutting system. The motor is connected to a screw mechanism that propels the dough forward to prepare it for cutting. We chose the windshield wiper motor because it provides strong torque, which is necessary to apply sufficient force to handle the dough texture.

Second-Stage:

Pneumatic Piston + Pneumatic Solenoid Valve 220V

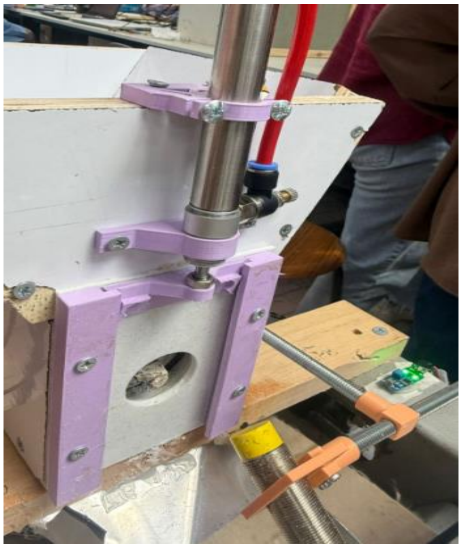


Figure 12 Pneumatic Piston

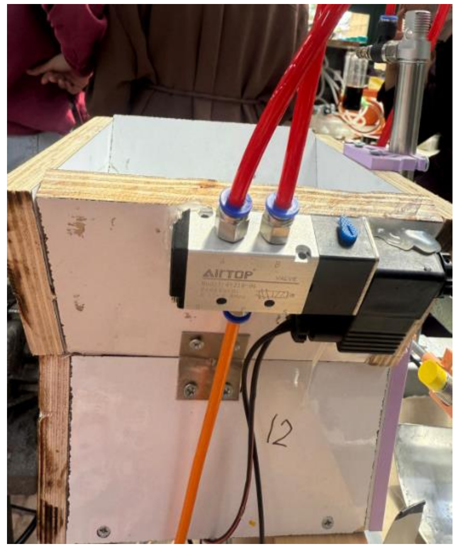


Figure 13 Pneumatic Solenoid Valve 220V

We use larger diameter pneumatic presses to provide sufficient surface area to generate the force needed to handle the dough pieces. Each press is controlled by a 220-volt pneumatic solenoid valve, which regulates the flow of compressed air and ensures precise timing and responsiveness during the cutting process.

Capacitive Proximity Sensor (NPN)

Figure 14 Capacitive Proximity Sensor (NPN)

The capacitive proximity sensor (NPN) is a specialized industrial sensor capable of detecting the presence of specific materials based on their dielectric properties. In our project, this sensor is used to detect the dough as it exits the machine nozzle during cutting or forming.

This sensor was chosen for its **high accuracy and reliability** in detecting **soft, non-reflective materials,** which are often difficult to detect using conventional infrared or ultrasonic sensors.

How it Works:

The sensor works by detecting changes in capacitance. When the dough enters its electric field, it creates a disturbance, increasing the capacitance. The sensor detects this change and sends a signal to the system to move to the next stage, such as forming or cutting.

Third-Stage:

Circular cake forming machine

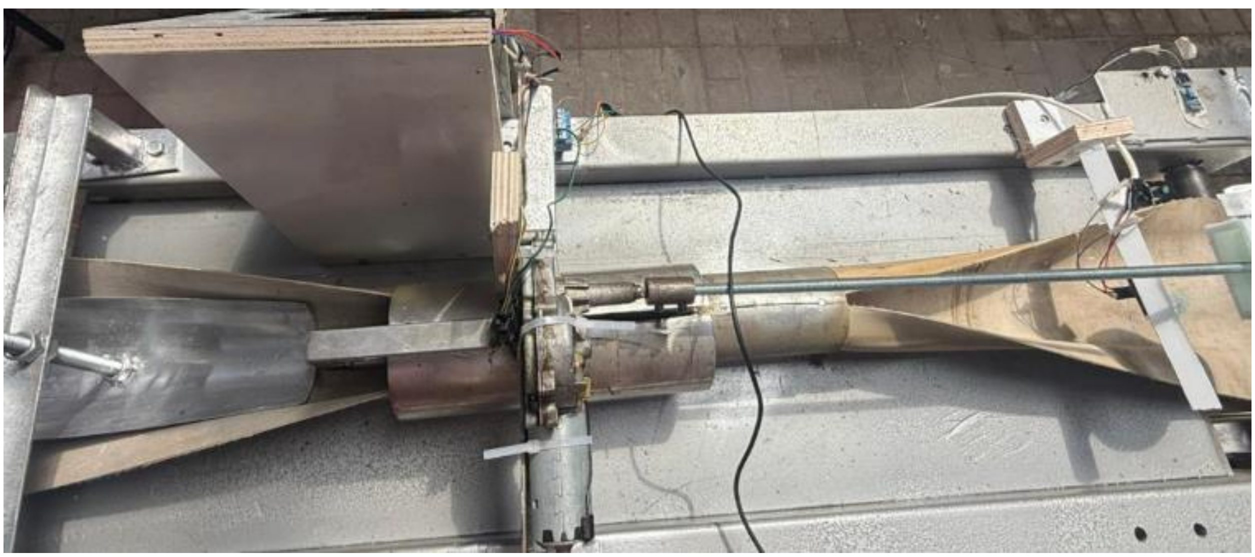


Figure 15 Circular cake forming machine

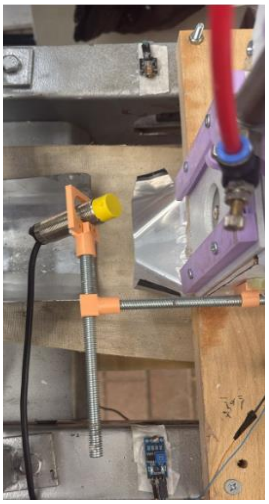
Components

Chinese water pump motor

Figure 16 Chinese water pump motor

In the shaping stage, a Chinese water pump motor was used as the driving force to push the dough through the mold and form it into a circular shape. This motor played a crucial role in ensuring a continuous and consistent dough flow, which is essential for maintaining the accuracy and uniformity of each biscuit. By providing stable pressure and movement, the motor allowed the dough to take the desired ring shape without interruptions, making it a key component in the success of the shaping process.

The Laser Module and LDR



Product formation after formation

Figure 17 Product formation after formation

Fourth-stage

Flavor Dispensing Mechanism

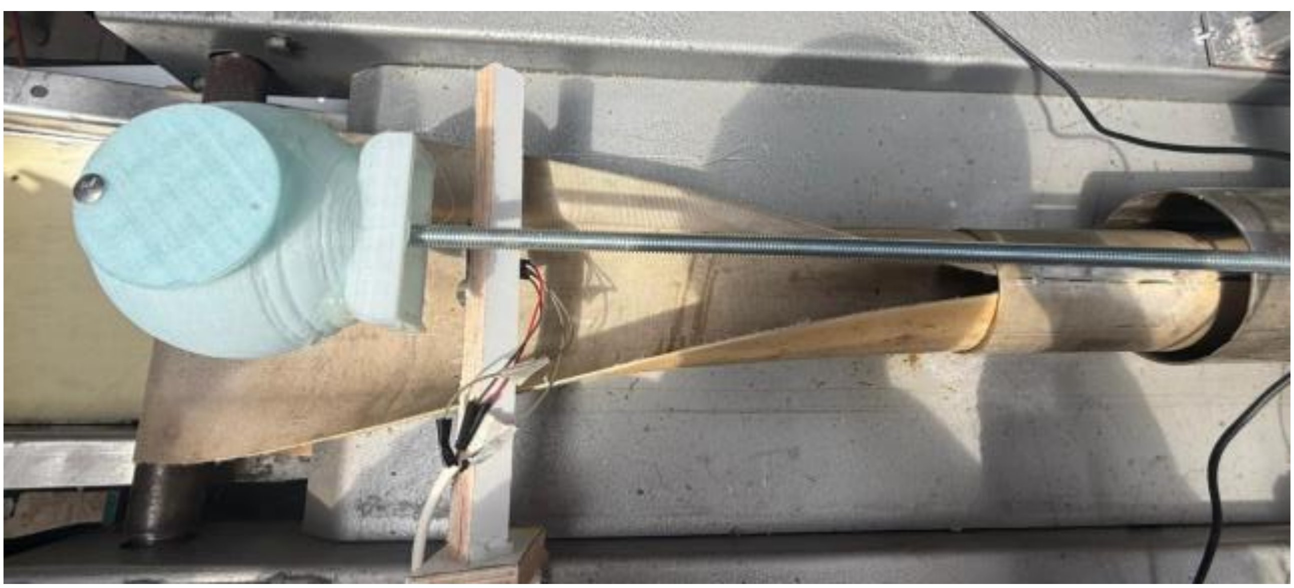


Figure 18 Flavor Dispensing Mechanism

Components

Rear wiper motor

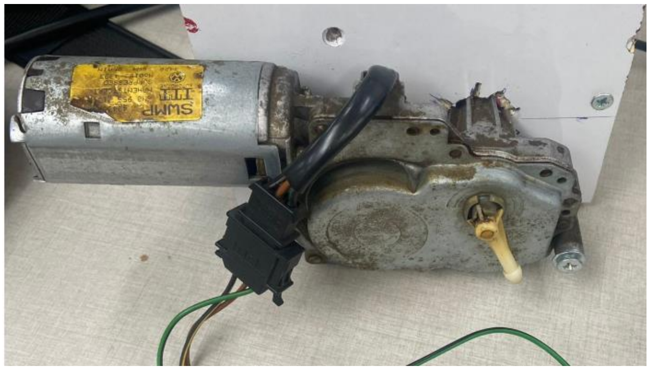


Figure 19 Rear wiper motor

In the decorating stage, a rear wiper motor was used to automate the sesame sprinkling process. This motor was selected because it does not perform a continuous full rotation, but instead provides a controlled half-rotational motion in both directions. Such movement was essential for evenly sprinkling sesame seeds onto the dough pieces, as it ensured a precise back-and-forth operation instead of uncontrolled spinning. By using this motor, the system achieved accurate and reliable sesame decoration, improving both consistency and efficiency in the production process.

Ultrasonic Sensor

Figure 20 Ultrasonic Sensor

To detect the presence of the cake before dispensing the flavor, we've incorporated an ultrasonic sensor. The sensor verifies that the cake is properly positioned beneath the dispenser. Upon confirmation, the flavor is released, helping prevent waste and ensure accuracy during the seasoning phase.

Fifth-stage

Transfer the cake to the oven

Figure 21 Transfer the cake to the oven

Component

NEMA 23 stepper motor paired with a 5A driver (YS-DIV268N-5A)

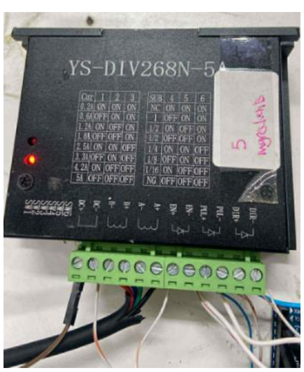


Figure 22 5A driver (YS-DIV268N-5A)

Figure 23 NEMA 23 stepper motor

was used to operate the conveyor belt responsible for moving the Cake into the oven. The stepper motor was chosen for its precision and ability to provide controlled incremental movements, which ensured smooth and accurate transfer of each piece without misalignment. The 5A driver supplied the required current to the motor, guaranteeing stable performance under load. Together, the motor and driver enabled reliable, consistent, and well-synchronized operation of the conveyor system, which was critical for achieving uniform baking results.

Sixth-stage

baking

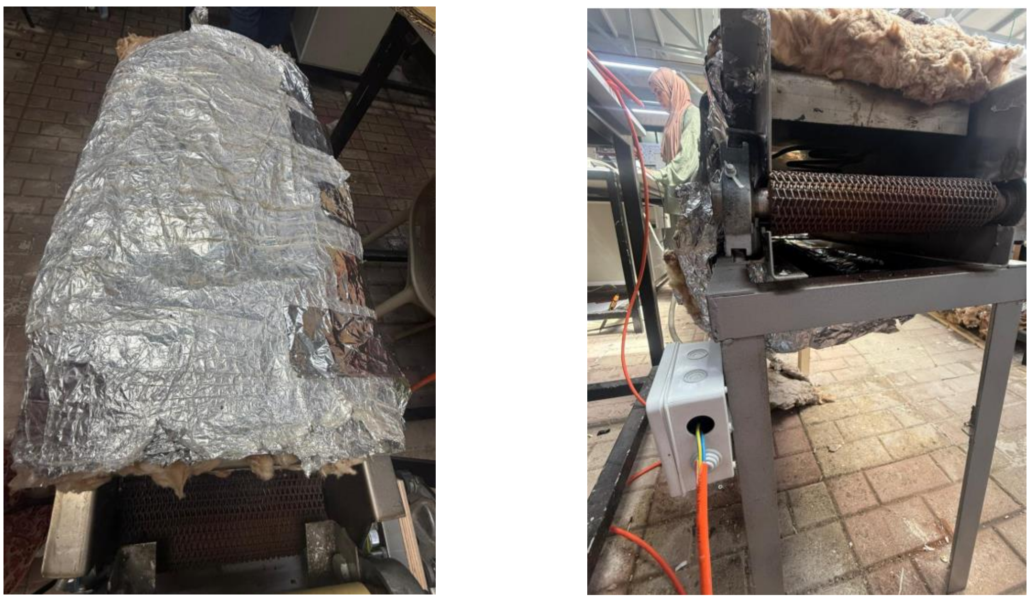


Figure 24 baking

Component

IBT_2 & DC Motor

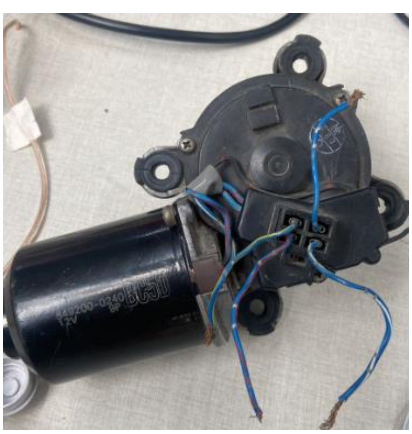


Figure 25 DC Motor

Figure 26 IBT_2

In the baking stage, an IBT-2 H-bridge module was used in combination with a DC motor to control the movement of the oven conveyor belt. The H-bridge allowed us to drive the motor in both forward and reverse directions, enabling the conveyor to move back and forth as needed during baking. Additionally, it provided control over the motor speed, which was important for adjusting the baking time and ensuring that the dough was cooked evenly from the inside without burning the outside. This setup offered flexibility, precision, and stability, making it an essential part of the oven control system.

Contactor

Figure 27 Contactor

A contactor is an electrically operated switch designed to control high-current devices such as ovens, motors, or heating elements. Unlike a relay, it is built to handle larger loads safely and reliably. In our project, the contactor was used in the baking stage to control the oven's electrical connection. It allowed the oven to be switched on and off using a low-voltage signal from the microcontroller, ensuring safe isolation between the control system and the high-power circuit while improving reliability and safety.

Temperature sensor

Figure 28 Temperature sensor

A temperature sensor was used to measure and monitor the oven's internal temperature during the baking stage. It provided real-time feedback to ensure the dough was baked evenly without burning. By sending continuous readings to the microcontroller, the sensor helped maintain consistent heat levels, improving both product quality and process reliability.

External design

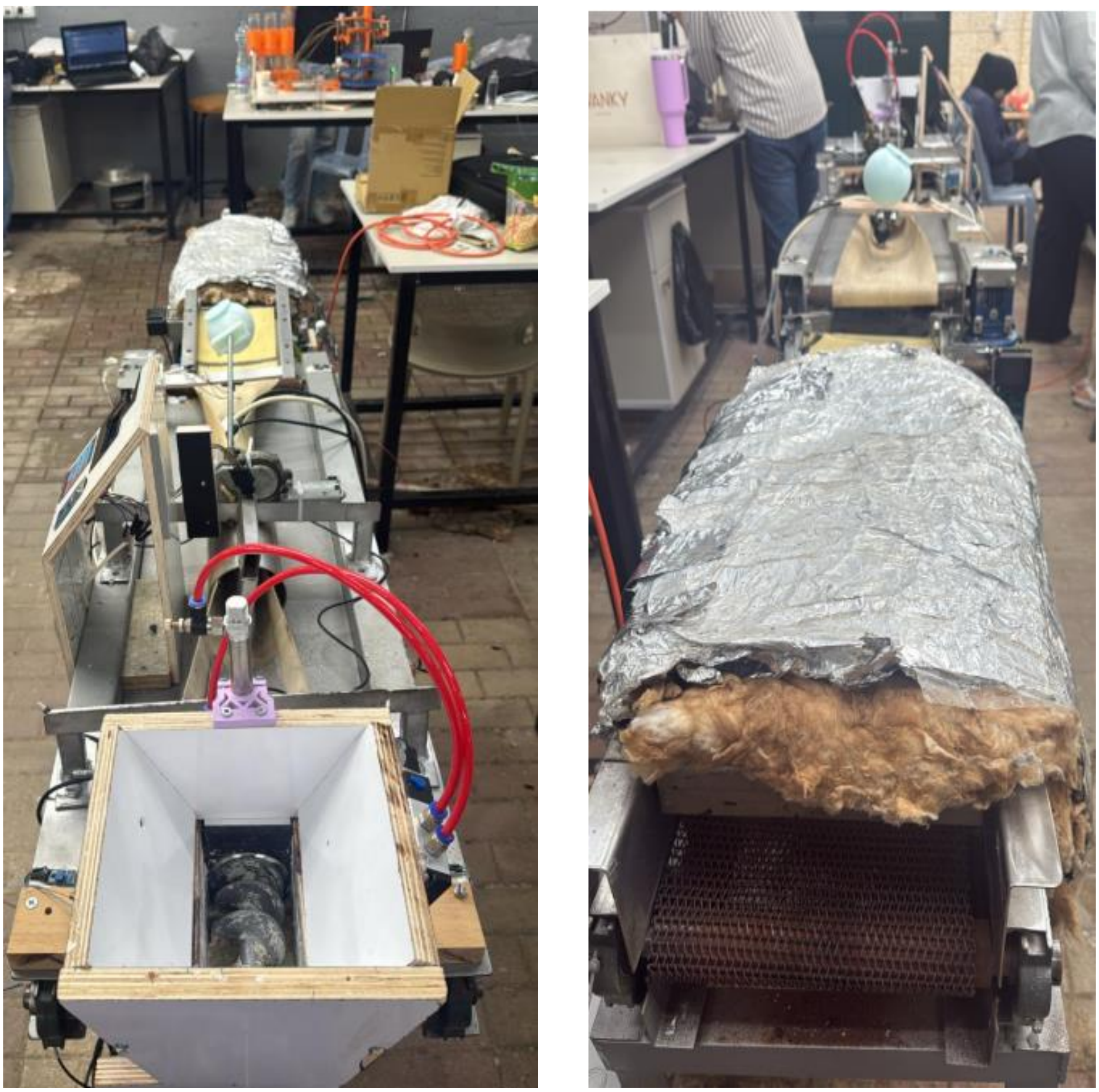
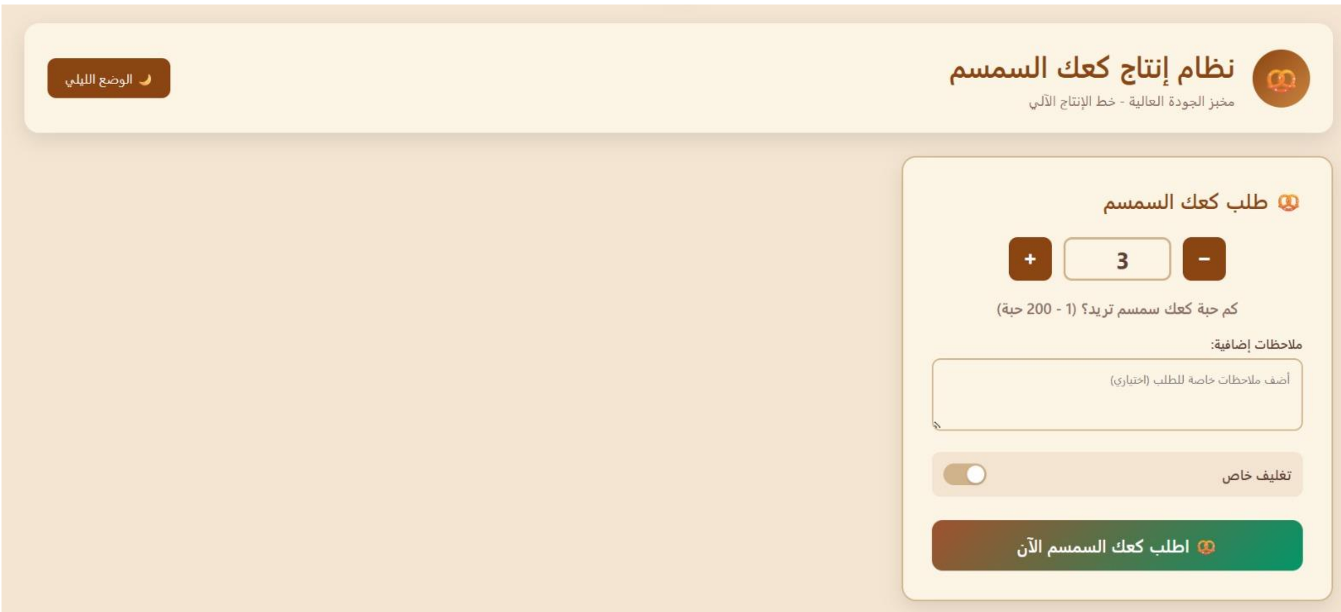


Figure 29 External design

The system can be controlled in two ways:

- App



- **RFID Access Control System with LCD Display and Keypad**

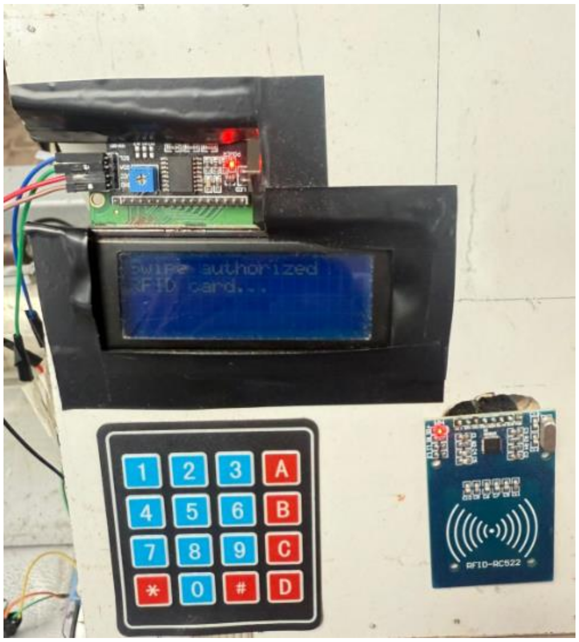


Figure 30 Request RFID

Figure 31 Menu

Figure 32 Temperature display

Figure 33 Order request

Figure 34 The order is in progress

Using the Keypad, the user can:

- **Display the oven temperature.**
- **Control the number of cake.**

Results and Discussion

The semi-automated production line for the "Sesame Circle" cake demonstrated its ability to automate key stages of the process, including cutting, shaping, decorating, and baking. The system produced biscuits that were uniform in size and shape, while maintaining the product's traditional taste and texture. The use of dedicated relays, sensors, and actuators ensured that each stage operated consistently and reliably.

Compared to manual production, the system significantly reduced labor requirements and minimized human error. The shaping mechanism, coupled with a controlled baking process, improved hygiene and provided more consistent results. The decorating stage, using a back-scan motor, allowed for even distribution of sesame seeds, enhancing overall product quality.

During testing, several challenges were identified. Problems with batter consistency and adhesion in the forming mold initially caused irregular shapes, but these were resolved through adjustments to the batter consistency and mold design. Similarly, the baking stage required fine-tuning the conveyor speed and direction to ensure the biscuits were fully cooked throughout without over-burning. These adjustments highlighted the importance of synchronization between mechanical components and control elements.

Overall, the system has proven to be a cost-effective and scalable solution for small bakeries. It has enhanced efficiency, improved product consistency, and preserved cultural authenticity, making it a viable alternative to entirely manual production, while remaining less expensive and complex than fully automated industrial systems.

Conclusion and Recommendations

In conclusion, the semi-automated sesame cake production line successfully achieves its goal of simplifying and automating the traditional cake preparation process, while preserving the authentic taste, texture, and quality of the final product. The system significantly reduces the manual effort required for dough cutting, shaping, sesame decoration, and baking, which is particularly helpful for small bakeries and local producers who often struggle with the repetitive and time-consuming nature of these tasks. Results demonstrate that the system delivers consistent, hygienic, and reliable production with minimal human intervention. By transforming traditional bakery practices into a semi-industrial process, the project achieves a balanced integration of cultural heritage and modern technological advancements.

Future Work

- Integrating advanced sensors and feedback mechanisms to improve control of dough texture, forming accuracy, and baking conditions.

- Developing a programmable user interface to adjust parameters such as dough thickness, portion size, and baking time.

- Scaling the system to accommodate larger industrial production while maintaining its compact design and ease of operation.

- Expanding the seasoning stage to add multiple flavors (such as anise or other traditional additives) to diversify the production line.

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