An-Najah National University

Faculty of Engineering & Information Technology

Department of Computer Engineering

Hardware Graduation Project

Taste Of Eid

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February 2, 2025

Acknowledgment

First, we thank God for helping us complete this project in the best way possible. Without His guidance and support, this achievement would not have been possible.

After God, we extend our gratitude to our family, who have been our main source of support. They believed in us from the beginning and provided everything we needed to complete this project.

A special thanks goes to our project supervisor, Dr. Emad Natsha, for his continuous guidance and support throughout this journey.

We also want to thank our friends who supported us during all stages of this project. Their encouragement and cooperation meant so much to us.

Finally, we express our gratitude to everyone who contributed to the success of this project, whether their contribution was big or small. Every effort made a difference.

Disclaimer

This report was written by Jana Sami Barakeh and Lemara Fuad Ali in fulfillment of the requirements for a Bachelor's degree in Computer Engineering. It has not been altered or corrected, other than editorial corrections, as a result of assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of us. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

Abstract

Maamoul is one of the cultures that comes with Eid traditions in our Arab countries. its integral part of our hospitality. there is a special ritual that the maamoul goes in to look in a delicious and interesting look. it talks a lot of work, effort and time to produce it in that precious quality.

Our project reflects a production line with cultural importance and social aspect. The importance of this production line is increasing the quality and the ability to meet the increasing demands on the maamoul in a good quality and a speed higher than the traditional way due to the automation and the organization of production stages.

The machine aims to simplify the entire production process starting from stuffing the dough with dates then passing it to the shaping stage and then sending it to the baking stage. We decided to design the machine using Arduino and connect it to a set of sensors that will manage the different operations of the machine to ensure consistency in shape and quality, including the complex filling method that includes air pistons that allow the dough and filling to be pressed and then cut to extract the appropriate shape for the dough piece to move on the belt that is helped by an electric motor.

To reach the stage of choosing the engraving shape, which includes molds of different shapes, where the piece will be sensed in the right place, then the mold will be lowered to the right level and pressed to take the shape of the mold, then the mold will be lifted. This stage will include dealing with several presses, motors and sensors.

Then control the stage and time of baking the maamoul, as a baking system will be created that uses horizontal movement for a specific period of time back and forth to ensure that the product is cooked. Motors and sensors will be included in this stage, and materials that comply with health standards will be used in all stages of production, such as using stainless steel in the dough storage stage, to ensure that the materials do not react with time and maintain the quality and safety of the product, we will also develop an easy-to-use user interface that allows the user to control the machin.

We looked into the local sweet shops available in Palestine, especially in the Nablus and Tulkarm areas, to see similar machines used in making maamoul and understand how they work. However, we found some stages lacking. For example, there were machines that only cut the dough, while the pressing process was done manually, and there was no automated roasting process.

Contents

List of Figures

Chapter 1

Introduction

1.1 Statement of the problem

The process of making Maamoul manually requires a lot of effort and time. It also requires many workers to complete it quickly, as well as significant effort in filling the dough, shaping it, cutting it, and then baking it. Given the high demand for Maamoul in the market, and to overcome the challenges of maintaining high quality and consistency in shape, we developed a cost-effective and easy-to-use Maamoul machine that meets these demands and reduces the effort required.

1.2 Objectives

The project aims to enable customers to make maamoul according to their preferences and requests. The machine will allow customers to choose the number of pieces required and then choose the appropriate shape and then bake it. Customers can do this through the keyboard or mobile application, and there is also an LCD screen to guide customers through the process, ensuring ease of use and keeping the user informed. Moreover, the machine will track dough levels and filling stock and when quantities are insufficient, the administrator will be notified.

1.3 Significance

The Maamoul machine offers an automated Maamoul production line, which is important for several reasons:

- Production efficiency is enhanced by automating the pressing of dough and filling processes to produce stuffed and ready-made Maamoul.
- Consistency in product quality is achieved by ensuring uniform size and evenly distributed filling.

- The customer experience is improved through a mobile application that allows users to place and customize their orders conveniently.
- This machine bridges the gap between manual labor and expensive machinery by offering a cost-effective and high-quality solution.

1.4 Organization of the report

This report is well structured to explain all the ideas of implementing the Maamoul machine easily to the reader. It starts with highlight the problem that cause us to design this machine, then give a general background of the work, and the objectives of it.

Following this, the methodology section explains in detail the hardware components and software implementation. Then explain the results of testing the work and followed it with a discussion that analyzes these results in relation to the objectives of the project.

Finally, the conclusion section recap the main ideas and suggestions to the future work.

Chapter 2

Constraints and Earlier Coursework

2.1 Constraints and limitations

2.1.1 Insufficient Mechanical Knowledge

The main challenge we faced was with the mechanical aspect of the project. After designing the system, we encountered several issues. The first was that the funnel's design was slightly oversized, which caused difficulties with the pistons' length in reaching the end of the funnel and applying the necessary speed and pressure to press the Maamoul. Additionally, we faced some challenges in setting up the electrical connections for certain parts, as the pistons required high voltage.

2.1.2 Lack Of Time

As we know, time management is key to the success of any project. However, it was challenging for us to search for the idea, identify the necessary parts, connect them, and complete the project. We faced several difficulties, and due to our lack of experience, the process took a long time as we had to research, inquire, and experiment with multiple solutions before arriving at the final one.

Additionally, we faced obstacles related to the roads and barriers leading to Nablus, as we work at the university there. Furthermore, the occupation army frequently raided our cities, preventing us from reaching the university and continuing work on the project

2.1.3 Cost

The addition of other features of the project required a high cost as the project is designed for a small system.

2.2 Standards and Codes

- Our code was developed using the Arduino IDE in C++, which supports various libraries and functions that simplify coding and allow seamless control of hardware components through the Arduino platform. The software system was designed and written to comply with standards and guidelines for hardware integration.

2.3 Earlier coursework

- Microcontroller Utilizing PIC Controllers: This course provided us with valuable knowledge on programming microcontrollers, controlling connected components, setting up serial communication, and using tools like I2C and PWM. These fundamental skills were essential in building our project.
- Circuits and Electronics: These courses gave us a solid understanding of basic circuits and electronic components, which was crucial during the development of our project.
- Critical Thinking and Research Skills: In this course, we learned how to write scientific research papers and prepare comprehensive reports. It enhanced our critical thinking skills and taught us how to source information from reliable research materials.
- Networks: This course helped us understand the basics of networks and communication, enabling us to build a network for users to control the system remotely via a mobile application.

Chapter 3

Literature Review

Ma'amoul is a traditional Middle Eastern shortbread cookie, cherished across various cultures, especially in Palestine. These cookies are typically made from semolina or farina and are filled with sweet fillings such as dates, walnuts, or pistachios. In Palestinian traditions, ma'amoul holds significant cultural and religious importance, being a staple during festive occasions like Eid and Easter.

The process of making ma'amoul is often a communal activity, bringing together family members and neighbors. Women gather to prepare the dough, infuse it with aromatic spices like mahlab and mastic, and meticulously shape and decorate each cookie using special tools. This ritual not only results in delicious treats but also reinforces community bonds and preserves cultural heritage.

The cookies themselves are a delightful blend of textures and flavors. The exterior is a buttery, slightly crumbly shell made primarily from semolina, offering a subtle nutty flavor. Inside, the fillings provide a sweet contrast: dates lend a rich, caramel-like sweetness; walnuts add a crunchy, earthy depth; and pistachios offer a unique, slightly sweet nuttiness. Each variation provides a different sensory experience, catering to diverse palates.

Beyond their delectable taste, ma'amoul cookies are steeped in symbolism. For Palestinian Christians, the round shape of the date-filled ka'ek is said to represent the crown of thorns placed on Jesus's head during the crucifixion, while the dome-shaped ma'amoul stuffed with nuts symbolizes the sponge offered to Jesus. For Muslims, these cookies are integral to Eid celebrations, marking the end of fasting periods with their sweet richness.

In essence, ma'amoul is more than just a cookie; it is a vessel of cultural expression, a testament to shared histories, and a symbol of unity and resilience. Whether enjoyed during religious

festivities or as a daily treat, ma'amoul continues to be a cherished delicacy, embodying the rich tapestry of Palestinian culinary traditions.

Chapter 4

Methodology

The system structure, hardware components, the overall system design, and mobile app will show in detail in this chapter.

4.1 Choosing the idea

Initially, we started looking for problems in our environment and difficulties we face. Given our frequent association with maamoul, as we make it on any happy occasion to express joy, especially on holidays, as it is considered an essential thing, and given the time and effort we spend making it, we saw that making a maamoul machine that reduces the time and effort expended would be good. By choosing this idea, the project addresses a realistic problem while integrating engineering principles to develop a practical, innovative, and easy-to-use solution.

4.2 System Structure

The outer design of the project is shown in the figure 4.1.
It is constructed with three stages, we will discuss them separately in detail.

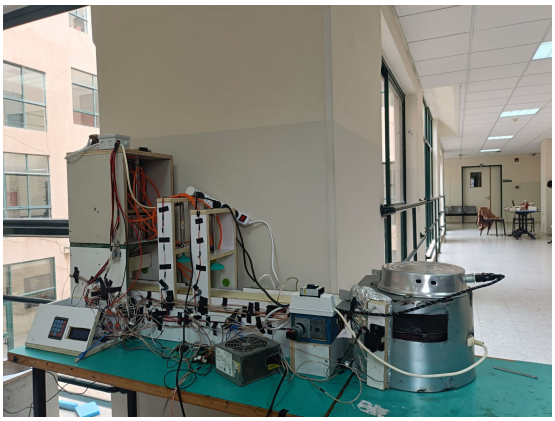

Figure 4.1: Outer design of the Maamoul Machine

4.2.1 Start preparing the Maamoul

This is the first stage where the user selects the number of pieces required. This stage includes:

4.2.1.1 Design of the Stainless Steel Funnel

We designed a stainless steel funnel to meet health standards for handling the dough and filling. The design consists of two nested funnels: the outer funnel for the dough and the inner funnel for the filling (see 4.2).

This funnel encloses the pistons responsible for pressing the dough and filling and releasing the prepared pieces. Initially, we created the design using 3D Max 4.3, where we could model and visualize the funnel's structure and functionality. To ensure its practicality, we also tested the design in real life using water and juice bottles, simulating the flow of dough and filling to verify the functionality of the funnel.

Figure 4.2: The design of the Stainless Steel Funnel

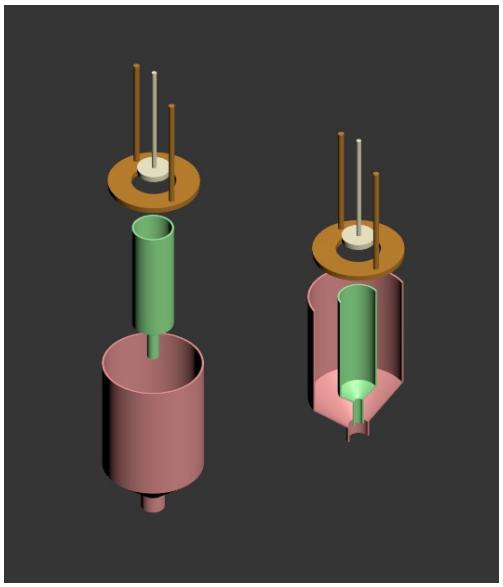

Figure 4.3: 3DMax Design

4.2.1.2 Piston pressing stage

When the number of pices is taken, the pistons begin their work, where the pistons responsible for pressing the dough are first pressed (2 piston). The dough is pressed for a certain period, then the three pistons are pressed for a certain period to put the filling in the middle of the pice (two for the dough and one for the filling). The last stage is to press again by the dough pistons. Upon completion of this stage, the pice is prepared and stuffed. Then we move to the other part of the first stage. 4.4.

Figure 4.4: Pistons

4.2.1.3 Dough cutting stage

This stage consists of a servo and a sharp blade for cutting. After the last press of the pistons is completed, the servo is turned on to cut the pice. 4.5.

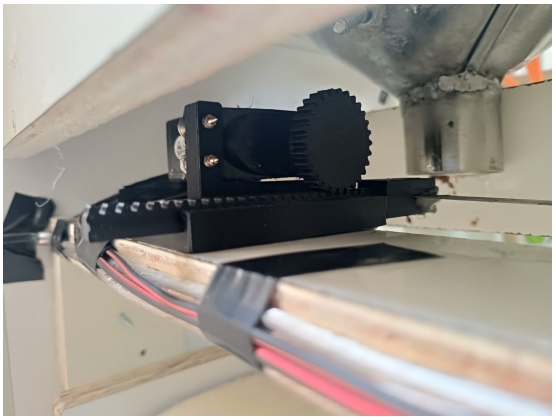

Figure 4.5: Cutting stage

4.2.1.4 Checking the Maamoul

A laser and ldr was placed to check the readiness of the Maamoul and start the second stage. If the Maamoul does not come out, we know that there is no dough or filling and that the ingredients have become empty.

4.2.2 Forming the Maamoul

This is the second stage, which also consists of pistons, each one of them is designated for a specific shape, as we have two shapes. The number for each shape is determined by the user and to ensure that it reaches the required shape, a laser and ldr was placed to know that the

Maamoul has arrived. When its presence is confirmed, it is pressed by the piston on the shape mold and then shaped and moved to the final stage. 4.6.

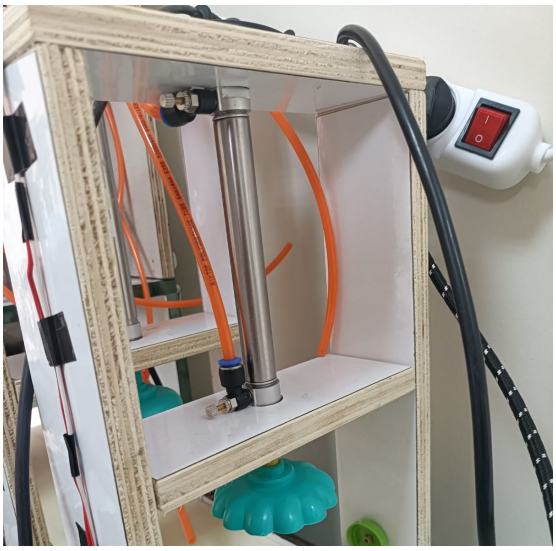

Figure 4.6: Forming the Maamoul

4.2.3 Baking the maamoul

After finishing the work to form, the baking stage begins, and this is the final stage.

4.2.3.1 Design The Oven

We designed the oven to perfectly match our concept. It rotates to collect the Maamoul pieces as needed and continuously turns inside the oven to ensure even heat distribution.

Figure 4.7: Oven

4.2.3.2 Putting the maamoul in the oven

We placed a laser and ldr to ensure that the maamoul has been formed, and when it reaches the laser, the motor responsible for moving the plate is turned on, and when the plate is moved, the piece of iron is hit with a limit switch to ensure that we have reached the place where the maamoul will be pushed to, and when confirmed, the servo is turned on and a piece of iron is placed on it to push the maamoul into the oven. 4.8.

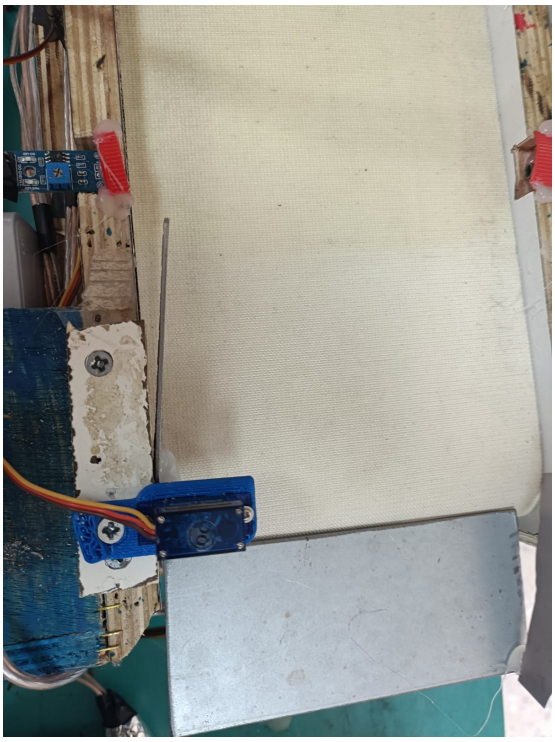

Figure 4.8: Putting the maamoul in the oven

4.2.3.3 Taking the maamoul out of the oven

the oven door was opened and a servo was placed with a piece of iron on it, and it is turned on after a certain period that was measured to start taking the maamoul out of the oven.

4.3 Hardware components

4.3.1 Microcontrollers

Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 [1]. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

Primary processor of Arduino Mega 2560 board is ATmega2560 chip which operates at a frequency of 16 MHz. It accommodates a large number of input and output lines which gives the provision of interfacing many external devices such as motors, sensors, drivers and relays, and all hardware components that are needed to accomplish our project. The board also features a USB serial processor ATmega16U2 which acts an interface between the USB input signals and the main processor. 4.9

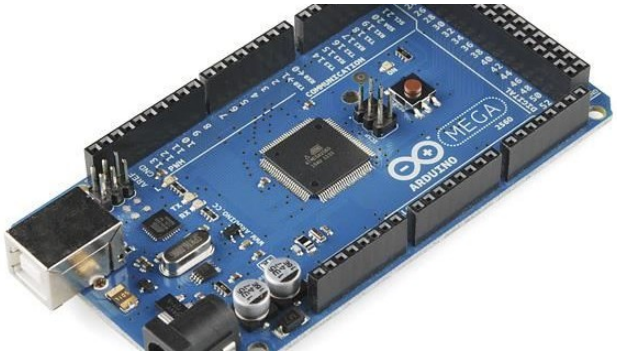

Figure 4.9: Arduino Mega2560

Esp32-WROOM-32

Based on the ESP8266 Wi-Fi transceiver module and the CH340 USB converter chip, this compact (Open Source) development and prototyping board is ideal for IoT applications.
The Wi-Fi module is compatible with the 802.11 b/g/n standard at 2.4 GHz, has an integrated TCP/IP stack, 19.5 dBm output power, data interface (UART / HSPI / I2C / I2S / PWM) and PCB antenna.
It also has a micro USB connector and reset button. Programmable with Arduino IDE, it includes interpreters for processing commands for languages such as LUA [2]. We used it in our project to connect it with the mobile application that we have created. 4.10

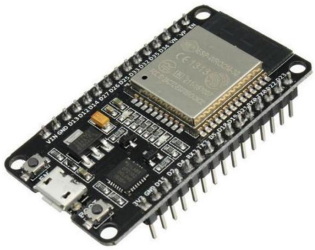

Figure 4.10: Esp32-WROOM-32

4.3.2 Input/Output Devices

Pistons and Selectors

Pistons are mechanical components commonly used in machines to transfer force and motion. In the context of the Maamoul machine, pistons play a crucial role in automating the processes of dough pressing, filling insertion, and shaping.

A piston consists of a cylindrical component that moves back and forth (reciprocates) within a cylinder. This motion is driven by a fluid or air pressure in pneumatic systems, or by hydraulic pressure in hydraulic systems. In the Maamoul machine, pneumatic pistons are typically used due to their efficiency, precision, and ease of control. 4.11

The pistons are powered by compressed air, and their motion is regulated using selector valves in conjunction with a control system.

Selector valves, also known as directional control valves, are responsible for directing the flow of compressed air to the appropriate chambers of the pistons, allowing for precise forward and backward motion. This ensures the synchronization needed for the machine's operations, such as pressing the dough, inserting the filling, and shaping the Maamoul. 4.12

The combination of pistons and selector valves guarantees reliable, repeatable performance, making them integral components of the Maamoul machine.

Figure 4.11: Air Piston

Figure 4.12: Selectors Valve

LCD and I2C

This LCD screen 4.13 is a 16x2 character LCD display with an I2C interface 4.14. It has two rows for text display, with each row able to show up to 16 characters. The white characters will be displayed on a blue background, providing a clear and visually appealing display.

In our project, there are many components are connected to Arduino pins, therefore, we were careful to use fewer pins for each component so that we wouldn't have to use another Arduino. Additionally, wiring and connections can become quite complex. To address these issues, we introduce this I2C 16x2 Arduino LCD display, which utilizes the I2C communication interface. This means that it only requires 4 pins to connect the LCD display, including VCC, GND, SDA, and SCL instead of using a minimum 6-pins. Using the I2C interface allows us to save at least 4 digital/analog pins on the Arduino, this makes the project's connections easier and more convenient.[3].

We used them in our project to display the instructions that help the user use our machine such as choosing the type of coffee and amount of coffee, and display their choices from the keypad.

Figure 4.13: 16x2 LCD Screen

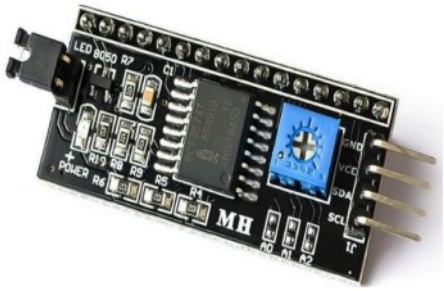

Figure 4.14: I2C LCD Driver

Keypad

A matrix keypad consists of switches arranged in a row-column matrix configuration. When a button is pressed, it connects a specific row to a column, allowing us to scan the array and identify the pressed button. The pinout for an Arduino 4×4 keypad typically consists of 8 pins, 4 for the rows and 4 for the columns. These pins can go to any digital Arduino pin. 4.15

We used it in our project to help the user choose the options to make the order he wants , by pressing the specified button.

After the LCD screen displays the message "Order Made", it displays these messages:

- Enter the number of pieces:
  - If pressing # will move to the second message.
  - If pressing * will delete the entered number for modification and enter a new number.
- Quantity of shape 1:
  -If pressing # will move to the third message.
  -If pressing * will delete the entered number for modification and enter a new number.
- All the data that were entered will be displayed

Figure 4.15: 4x4 Keypad

-Note: The number of pieces of shape 2 is calculated by the program automatically by this process.

Servo

The servo motor is a rotary or linear actuator designed for precise control of angular or linear position, velocity, and acceleration. It consists of a motor, a position sensor (usually a potentiometer), and a control circuit. Servo motors are widely used in robotics, automation, and CNC machinery due to their high efficiency and accuracy.

We used the servo motor for the cutting process and for inserting the Maamoul into the oven. 4.16

Figure 4.16: Servo

Contactor

A contactor is an electrically controlled switch used for switching an electrical power circuit. It

is widely used in automation and control systems to control high-power devices, such as motors, heaters, and lights, by using low-power control signals.
In the context of the Maamoul machine, we use contactor to control the oven.4.17

Figure 4.17: Contactor

4.3.3 Power Devices

Power Supply

ISO-450 ATX Computer Power Supply 350W, 5V 32A, 12V 16A, we used it to supply some of our components that needed a voltage, it provided us with 12v, 5v, 3.3v, and Ground, we used 12v for motors and 3.3v,5v for lasers.

4.3.4 Sensors

LDR Sensor and Laser

It is a type of resistor that operates based on the principle of photoconductivity, meaning its resistance varies with light intensity. Specifically, its resistance decreases as the light intensity increases.

We directed the laser light onto the LDR sensor, so its state was HIGH, means there is no object detected, but when an object is detected, it means that this object blocked the laser light from the LDR sensor, so its state changed to LOW.

We used 2 LDRs and a laser for each one, the first LDR was to detect if the moving coffee box

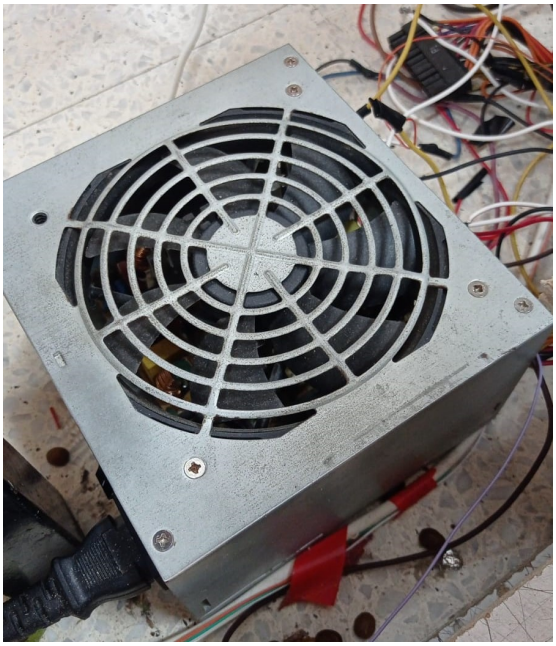

Figure 4.18: Power Supply

on the product line reaches exact position where the grinding mill is dropped the coffee, the second LDR was to detect if the moving box reaches the position where the wood will pressed the lid on box to close it.

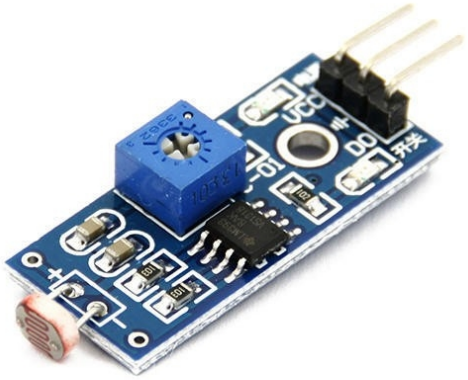

Figure 4.19: LDR Sensor

Figure 4.20: Laser

4.3.5 Motors and Drivers

4.3.5.1 DC Motors

SG37BL-A DC Brushless Gear Motor

In our project, I used the DC motor to rotate the metal sheet where the Maamoul is baked. The motor ensures the sheet rotates evenly, allowing heat to distribute uniformly across its surface. This process ensures that all Maamoul pieces are baked evenly. I used a relay to control the motor's operation, allowing it to be turned on and off as needed.

Figure 4.21: DC Motor

Other type of DC Motor

We used an existing motor from the car's wipers that operates as a DC motor. Look at the figure 4.22. We used it for the production line to make it rotate continuously. To control its operation, we connected it to an H-bridge circuit, which allowed us to manage its rotation direction and operation effectively. This motor was chosen because of its strength, which is essential for carrying and lifting the mill.

Figure 4.22: Wipers Motor

4.3.6 Other Components

4.3.6.1 Relays

A relay is an electronic switch that can be used to control high voltage and current loads using a low voltage and current signal. It is used to activate and deactivate the operation of other appliances within the same or different electrical network.

In our project, we used 2 relays. The first one was a Eight-channel relay it used to control the pistons, managing their operation for opening and closing during the shaping process and the pressing process for the dough and filling. The second relay was a two-channel relay, which was used to control the operation of the oven, including turning on the heat and operating the motor that rotates the metal sheet.
Its operation is simple and easy to program, as it involves turning the relays on or off for specific durations as needed.

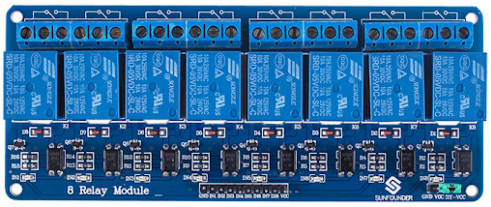

Figure 4.23: Relay eight channel

Figure 4.24: Relay two channel

4.3.6.2 Wires

Electrical Wire

We used them for wiring and connecting different components. We used power cables because we used a 220V voltage to supply power to the pistons and selectors.

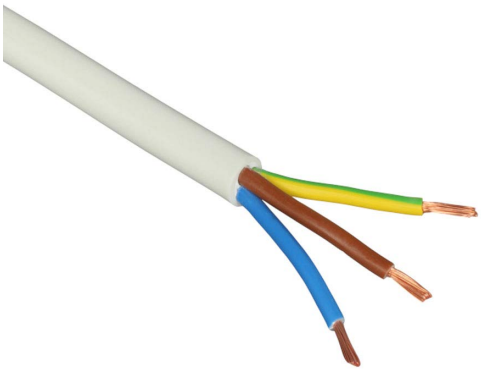

Figure 4.25: Electrical Wire

Intercom Wire

We used them for wiring and connecting different components. We benefited from its length.

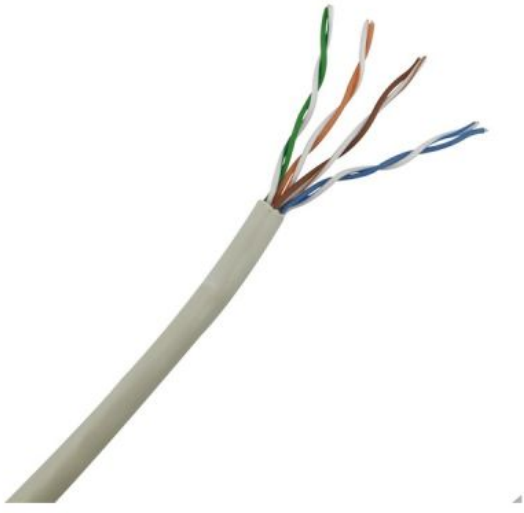

Figure 4.26: Intercom Wire

Arduino Wires

We used them to connect the components to the Arduino.

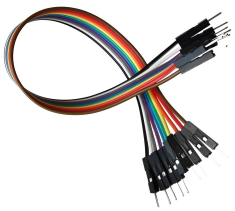

Figure 4.27: Male to Male

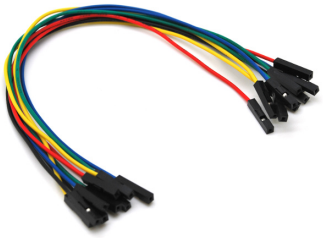

Figure 4.28: Female to Female

Figure 4.29: Male to Female

Chapter 5

Results and Discussion

After much effort and challenges, we were able to build an integrated and complete project, where we developed a production line for making and baking maamoul, which is characterized by many features and advantages, the most important of which are the basic features that any production line depends on.

Our project is characterized by focusing on choosing the appropriate number of pieces and the shape to be applied, then baking them and automating the entire process.

We supported the project by creating an easy-to-use mobile application that allows users to send their requests remotely without having to stand next to the machine and enter their requests via the keyboard.

The final product of the maamoul making machine is shown in Figure 5.1 5.1

Figure 5.1: Final Product

5.1 Challenges We Encountered and Their Solutions:

We deal with electronic components and mechanical assemblies, which requires prior knowledge and mechanical experience that we did not have, so we taught ourselves, when a component stops working we look for the reason and solution ourselves, so we gained great experience in this field.

5.1.1 Challenges with Pistons Design

We faced a problem in the initial design of the project, as we had very difficult restrictions in filling the funnel and in removing the dough and filling from it, due to the length of the pistons, which completely blocked the nozzle of the funnel, so we were forced to remove the entire piston model and reinstall it every time we wanted to fill the funnel.

5.1.2 Determine the quantity to be downloaded

We faced the problem of not having a suitable place to install the weight sensor to check the quantity of dough that was downloaded to ensure that the size of all picecs was equal. The solution was to adjust the number of pressures for both the filling and the dough. For example, we pressed the dough five times first, then one pressure for the filling, then five final pressures for the dough, and so on. However, we faced the problem of the accuracy of the quantity.

5.1.3 Printing the shape

We were limited by the type of dough used, as we used flour instead of semolina because semolina is very soft and when pressed, the dough breaks on its own. Because the dough is made of flour, it was difficult to put the shape on it, as it prints a shape but it is not very clear. Also, to prevent the dough from sticking to the mold, we used a piece of nylon and placed it on the mold so that the dough would not stick to it

Chapter 6

Conclusion and Future work

6.1 Conclusion

The automated maamoul making machine has become a reality, as we have successfully designed and built a production line capable of automating the maamoul making process. The machine simplifies the traditional manual process by automating critical steps such as pressing the dough, inserting the filling, forming, and cutting. Users can, as mentioned earlier, control the number of pieces and the shape to be printed, ensuring flexibility and satisfaction. In addition, the machine ensures consistent quality, efficient operation, and tracks inventory levels to alert the operator when replenishment is needed.

Building this project was not without its challenges. We faced several mechanical difficulties related to the design and synchronization of the presses and cutting mechanism, as well as technical challenges in identifying and integrating the necessary components. However, through perseverance and problem solving, we were able to overcome these obstacles and develop a functional and efficient system.

6.2 Future work

Certainly, there are some matters related to the project that we are looking to develop, including:

- Adding other types of fillings.
- Decorating Maamoul with Powdered Sugar.
- packaging the Maamoul .

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