



AN-NAJAH NATIONAL UNIVERSITY

FACULTY OF ENGINEERING  
AND INFORMATION TECHNOLOGY

COMPUTER ENGINEERING DEPARTMENT

**Hardware Graduation Project:  
Candle Craft Line**

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# Dedication

We extend our gratitude to our friends, family, and Those who have dedicated their lives to giving us all the necessary information and knowledge. Without your support, we could not have completed this work.

Special thanks to the dedicated engineer "Mr. Abdullah Hinnawi" who accompanied us for the duration of the project, and gave us all the necessary tips, information, and guidance.

Additionally, we would like to thank the carpenter "Mr. Alaa Zurba", and engineer "Mr. Abd Almoneim Masri" for their practical assistance.

# Acknowledgment

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To our supervisor, Dr. Raed Qadi, who was kind and inspiring, patient with us, and full of encouragement even when things didn't go according to plan. He was also very passionate when he inquired about our progress, giving us the impression that he was happier than us when we made progress.

We offer a heartfelt "Thank You" to everyone who helped us through good times and bad, and we are pleased to share this report and project with you.

## **DISCLAIMER**

This report was written by student(s) at the Computer Engineering Engineering Department, Faculty of Engineering, An-Najah National University. 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 the student(s). 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.

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# Abstract

We observe a growing trend in artisanal projects, particularly in candle making. Candles play a significant role in home decor, enhancing ambiance, and providing pleasant scents. Due to the increasing demand and presence of handmade candles on various occasions, manual production can become burdensome, especially for large orders. Our project aims to establish a production line for candles in transparent cups, tailored to user preferences. Users, as project owners, can specify the number of cups, colors, and scents desired.

The candle production process involves multiple stages, starting with wax mixture preparation based on the required cup quantity. The mixture is then melted, colored, scented, and thoroughly mixed to achieve a homogeneous blend. The cups undergo a simple heating process to facilitate the pouring without errors. Finally, the cooling stage is to dry the wax inside the cups.

Initially, we will develop a comprehensive project design and ensure a detailed plan is in place.

Then, the hardware component will be constructed, and the project will be implemented, integrating it with a mobile application for seamless communication between all components. This will be achieved through the creation of an "Automatic Wax Mixing and Pouring System in Cups" based on Arduino technology. The system utilizes Arduino programming to control and manage the entire process, integrating various components such as sensors, motors, relay switches, heaters, and other relevant elements.

This project aims to streamline candle production to meet large-scale demand while accommodating specific customer preferences, thereby addressing the growing market demand for these handmade artisanal products.

# 1. Introduction

## 1.1 Problem Statement

The “Candle Craft Line” project aims to address several challenges faced by different segments of society, including:

1. Manual candle production is hard work and time-consuming, making it unrealizable for large-scale orders.
2. There is an increasing demand for customized handmade candles custom-made for various events and celebrations.
3. The candle craft industry can cause many dangers to its makers is insecure.
4. High costs associated with hiring skilled artisans for candle making.
5. Limited availability of diverse candle designs and scents in the market.

## 1.2 Significance

This project attempts to establish an automated production line for candles in transparent cups, suited to individual preferences. It aims to:

- simplify candle production to meet growing market demands.
- Offers options such as customizing colors and perfumes for candles to meet customers’ diverse needs.

## 1.3 Objectives and Scope

The primary objectives of the project include:

1. Designing and implementing an automated system for wax mixing, coloring, and pouring into transparent cups and then cooling.
2. Including Arduino-based technology to control and manage the production process.
3. Developing a mobile application for smooth communication and customization of candle orders.

## 1.4 Report Organization

This report is structured as follows:

- **Second chapter:** - In this chapter, we covered the important subjects we learned previously, in addition to the external courses and the primary constraints and obstacles we encountered while working on the project.
- **Third chapter:** - The literature review chapter is a summary of previously published works that are similar to ours in concept.
- **Fourth chapter (Methodology):** - Details the technique taken in designing and implementing the automated “Candle Craft Line” machine System.

- **Fifth and final chapter:** - These two chapters present the outcomes of the project implementation, discuss outcomes related to initial objectives, provide a summary of the project, and mention some possible characteristics in the future.

## **2. Constraints and Earlier Coursework**

### **2.1 Constraints**

#### **2.1.1 Lack Of Mechanical knowledge**

Numerous mechanical components of the project were partially understood by us, but even with our extensive research, certain questions remained unanswered, and proper planning and execution still required the expertise of a mechanical engineer.

Some parts that are responsible for balance and weight distribution need an experienced mechanical engineer to fix them to be suitable for the motors that we use. So the ideas and the initial designs were presented to the engineer for supervision.

#### **2.1.2 Inexperience**

To make sure the idea we're aiming for is feasible, we've conducted lots of straightforward tests in various scenarios.

But all these tests took time that we could have invested in other things.

#### **2.1.3 Lack of funds**

Since some solutions required additional funding, the project would be too costly and unaffordable, particularly when done on a small scale.

#### **2.1.4 Lack Of Time**

The most important factor in any project is time. The time required for these activities—research, communication, testing, development, comprehension of requirements, planning, and lost time from inexperience—adds up quickly.

#### **2.1.5 Lack Of Tooling**

Some special tools were needed to cut, prepare, and assemble all the parts that were not available or too expensive for home use, so a specialist was required to help with it.

Most parts require a shearing machine, carpenter, or metal agent.

#### **2.1.6 Lack Of Market Knowledge**

Further planning and research were required to obtain the correct specifications in order to place an accurate order, as some parts are not simply store-bought but rather are custom-built to a specified specification.

## **2.2 Earlier coursework**

### **2.2.1 Microcontrollers and PIC**

These courses covered every aspect of the Arduino, including basic serial communication. These fundamental abilities enabled us to set up and test basic functionalities early in the project, which was very important. More practice and education were needed, though, for more complex Arduino applications.

### **2.2.2 Network and wireless communication**

These courses included all the basics of using and connecting the ESP, including setting up the development environment, configuring Wi-Fi connectivity, and implementing basic communication protocols.

### **2.2.3 Circuit and Electronics**

These courses included basic electronic components and circuit design. We learned about resistance, condensate, diodes, transistors, integrated circuits, and other electronics, paving the way for us to learn about the construction of our project "Candle Craft Line".

### **2.2.4 Critical Thinking and Research Skills**

The research and the writing of this report were all taught in this course, and it's one of the few non-technical courses which also is life long.

## 3. Literature Review

Craftsmen have been making candles for centuries, progressing from simple designs with wax and wick to intricate, personalized items that improve atmosphere and interior design. This review of the literature looks at recent advancements and research in the areas of automation, artisanal craft technology integration, and candle production.

### 3.1 History of a Candle

The history of the wax industry is too old to be determined, but it began with people using it as lighting and later developed decorative applications to give homes unique scents and colors.

Michael Faraday, a renowned British scientist, wrote "The Chemical History of a Candle" in 1861. This highlights that the wax industry predates this book by a significant margin.[Faraday, 1861]

### 3.2 Traditional Candle Industry

The process of manufacturing candles involves several well-defined steps to ensure quality and consistency. First, we select and prepare the wax, the primary material. The wax is melted under human inspection until it is fully dissolved.

The heat is then extinguished, and we wait for the wax to reach the required temperature. The fragrance and desired color are added once the wax has cooled to the correct temperature. It is then manually stirred and poured into glasses or molds with a wax wick.

### 3.3 Candle Industry in Factories

In large factories, almost all manufacturing is done manually. Employees add wax and then dissolve under the control of smart devices.

The workers then add the fragrance and color required and the mixing is done by a custom mixer then the casting process begins where the workers add the wax wick of the cup or mold and place it to be cast on it by the device.

The process is not completely automated, but it is slightly automated.

### 3.4 Similar Projects

Although numerous production lines have been used in the past, our machine is distinct in terms of the product it produces (wax), how it is used, and how many processes are carried out on it.

## 4. Methodology

The methods and techniques we used to design the production line are described in detail in this section. From the design of the moving circuit and its components to the stations that the cups should pass through to the production lines and the cups storage line, we connect the parts to create the finished product.

### 4.1 Choosing the idea

Selecting a project idea is crucial, if not the most crucial, aspect of any project. While looking for a project to work on, we came across many ideas, some of which were unsuitable for a graduation project and others that we just couldn't get into because there wasn't a "Click" for them.

Then one day I came upon an advertisement for the global wax market, which stated that the current phase of wax expansion is a very profitable project. This piqued my interest, so I started researching wax and how to make it. I discovered that his industry was fraught with challenges, and I also realized how high the risks were.

And that's when it happened—it was our "Eureka" moment—because one of us is really talented in the arts and crafts, and the other finds them fascinating.

Therefore, we set out to create a machine that would facilitate the process of making wax, minimize waste, save time and effort, lower risk, and offer security and safety to wax makers.

### 4.2 Mechanical Part

The project can be broken up into the following several linked sections to help with understanding the mechanical parts:

#### 4.2.1 Circular Movement for Material Drop

##### 4.2.1.1 Movement

These receptacles are all arranged on a wooden circle. It rotates before coming to a stop above the heating bowl. Adjustment and control of the wooden circle positioning are done by the IR sensor.

When the process begins, the circle is stopped at a point called the starting point and then the circle begins to move, and it stops when the wax bowl arrives over the heater exactly.

Wait until the heating process ends and the temperature falls until it reaches below 65 degrees, then the circle begins to move then stop for colors and fragrances, and then the circle moves in the opposite direction to return to the starting point in preparation for re-work when required.



Figure 4.1: Wooden Circle

#### 4.2.1.1.1 Circle Movement Components

Electrical and Mechanical Components of This Parts:



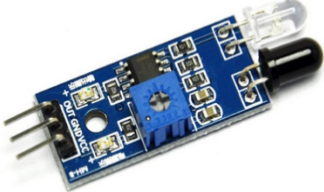
Item Name	Item Image	Quantity
Stepper Motor (nema 23)		1
Driver YS-DIV268N-5A		1
IR Sensor Reference for the circle		1

Table 4.1: Circle Movement Components

#### 4.2.1.2 Wax Storage

We brought a "Cereal Dispenser" container, which dropped the cereal by turning a knob or lever, to serve as a pure wax store. Next, we set up the motor to be in charge of dropping the wax in the first place.

Additionally, we added an ultrasonic sensor to the top of the container cover to determine whether it is full or empty.



Figure 4.2: Wax Storage

#### 4.2.1.2.1 Wax Storage Components

Electrical and Mechanical Components of This Parts:

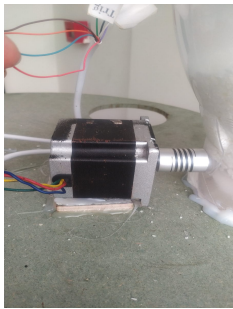
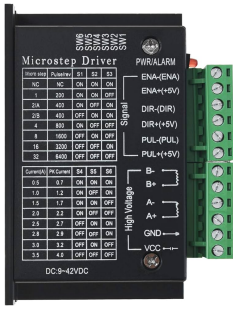

Item Name	Item Image	Quantity
Stepper Motor		1
Driver Microstep Driver		1
Ultrasonic		1

Table 4.2: Wax Storage Components

### 4.2.1.3 Heating The wax

After the pure wax falls into the heating bowl the heating process begins, each cup of wax (68 gm) needs approximately 7.5 minutes to dissolve completely with the continuous stirring of the mixer inside the bowl.

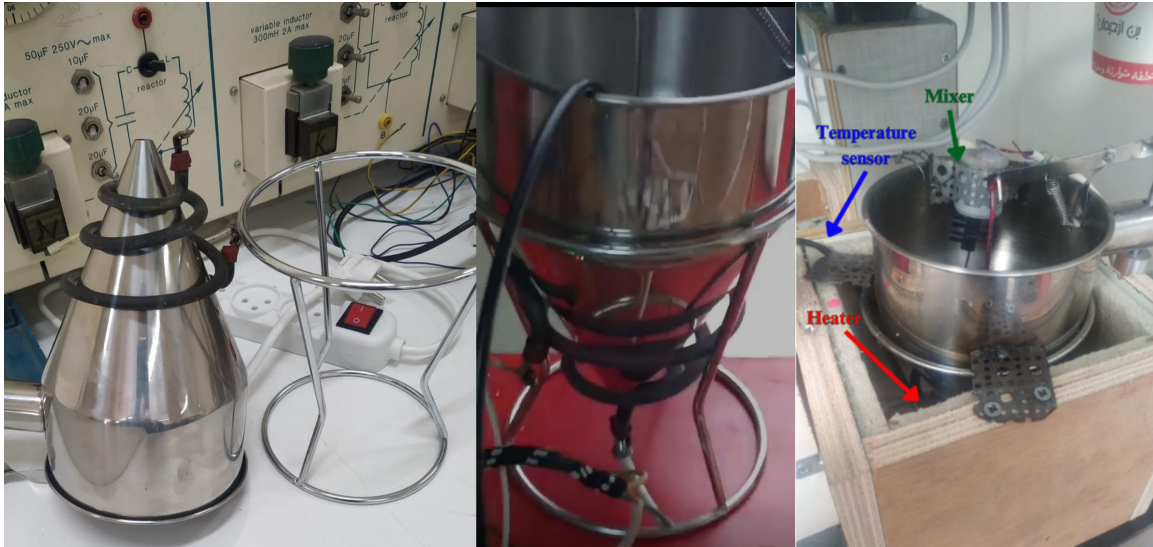

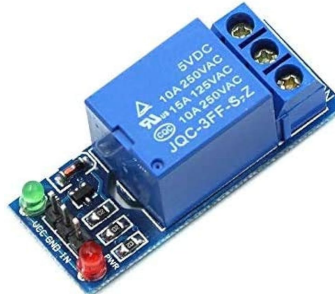


Figure 4.3: Heating Bowl

#### 4.2.1.3.1 Heating the Wax Components

Electrical and Mechanical Components of This Parts:

Item Name	Item Image	Quantity
Mixer		1
Relay mixer control		1



Item Name	Item Image	Quantity
Waterproof Temperature Sensor		1
4kOhm Resistor		1

Table 4.3: Heating the Wax Components

#### 4.2.1.4 Colors and Perfumes Storage

We considered a number of mechanical suggestions for this part but ultimately opted for the most cost effective and professional solution. Where we made payment to bring the syringe and establish a connection between the Linear Actuator, the principle of their work:

The syringe automatically fills and seals when the Linear Actuator moves in the opposite direction from the clock. When it moves in the opposite direction, the nut rises and the syringe rises with it.

The push button is placed at the bottom of the syringe, where when the whole syringe is discharged the syringe presses the push button, indicating that it is empty.

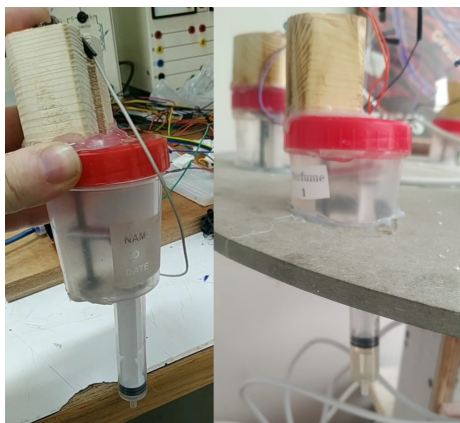


Figure 4.4: Colors and Perfumes Storage

I have two options for perfume and two options for colors because I have four (4) "syringes" containers.

#### 4.2.1.4.1 Colors and Perfumes Storage Components

Electrical and Mechanical Components of This Parts:

Item Name	Item Image	Quantity
6V Linear Actuator		4
H-Bridge Driver for Linear Actuator		2
Syringe		4
Ball Bearing		4

Table 4.4: Colors and Perfumes Storage Components

## 4.2.2 Movement of the Cup Storage System

### 4.2.2.1 Movement

With a slight tilt, we created a basic moving line that functions as a cup warehouse, allowing the cups to fall precisely and easily onto the subsequent production line.

Additionally, a laser and LDR have been installed to verify the presence of cups.



Figure 4.5: Cup Storage System

#### 4.2.2.1.1 Cup Storage Components

Electrical and Mechanical Components of This Parts:

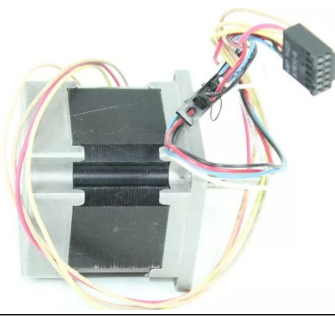
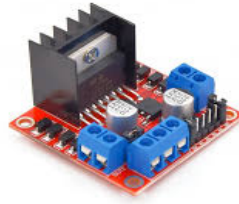
Item Name	Item Image	Quantity
Stepper Motor		1
H-Bridge		1

Table 4.5: Cup Storage Components

## 4.2.3 Production Line Operations

### 4.2.3.1 Movement

We invested in a high-quality product line that functions precisely and flawlessly. It moves to stand at the first station when the cup falls on it, back to move to stop at the other station if it's finished, and so on.

In addition, a laser and LDR have been installed to verify the existence of a cup at the required station and so we have 3 lasers and 3 LDRs because we have three stations:

- Heating The Cup.
- Pour The Wax into The Cup.
- Cooling The Wax Cup.

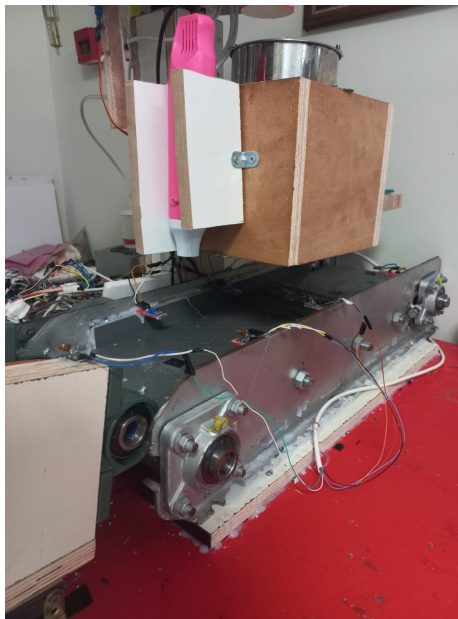



Figure 4.6: Production Line

#### 4.2.3.1.1 Production Line Components

Electrical and Mechanical Components of This Parts:

Item Name	Item Image	Quantity
Stepper Motor (nema 23)		1


Item Name	Item Image	Quantity
Driver YS-DIV268N-5A		1

Table 4.6: Production Line Components

## 4.2.4 The Operations on The Cups

When the cup drops on the production line, the cup has to go through three stages:

### 4.2.4.1 Heating The Cup

When the cup arrives at the first stop the cup stands directly under the air heater where the cup is heated and is empty.

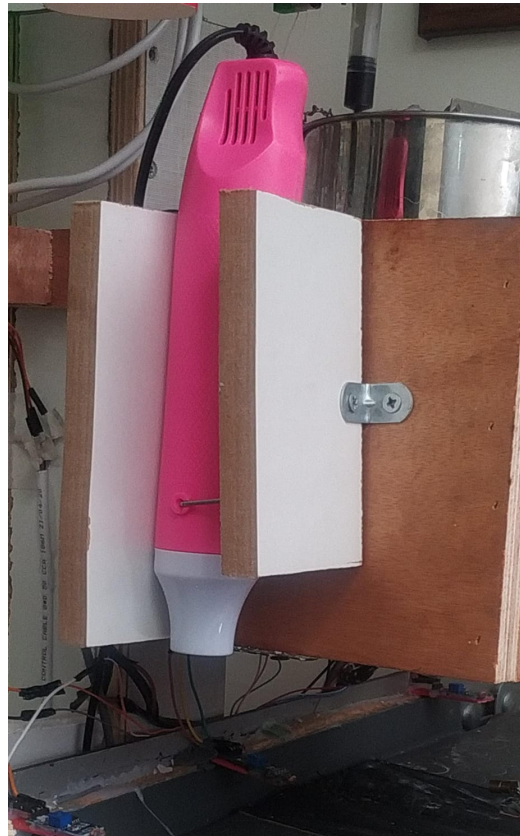


Figure 4.7: Heating Cup

#### 4.2.4.1.1 Heating Cup Components

Electrical and Mechanical Components of This Parts:


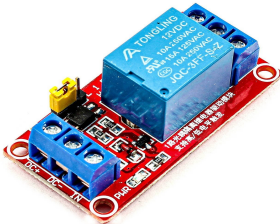
Item Name	Item Image	Quantity
Heat Gun		1
Relay 12V Heat Gun control		1

Table 4.7: Heating Cup Components

#### 4.2.4.2 Pour The Wax into The Cup

Then The production line moves with the cup to stop under the wax heater exactly.

The motor connected with a screw rotates with the clock, the nut mounted with the hand of the heating bowl moves down the screw and the heater hand is raised and the wax flows for a certain time (the amount of filling a cup or half cup as requested by the user), and then the motor moves in the opposite direction for the heating bowl to be closed.

What we did - the engine connected to a screw with a nut on it - is the same business principle Linear Actuator but if we wanted to buy it from the stores we wouldn't find it available that big and it would be costly.

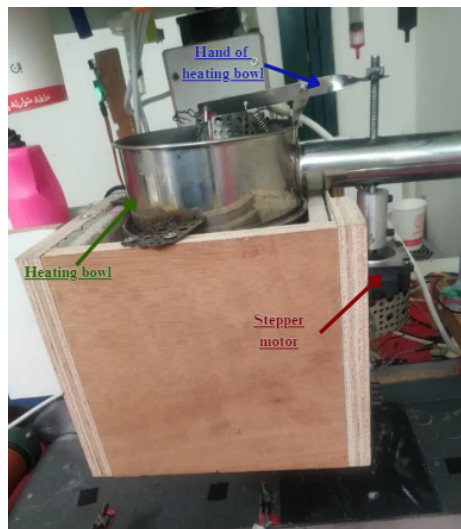


Figure 4.8: Pour The Wax into The Cup

#### 4.2.4.2.1 Pouring Wax Components

Electrical and Mechanical Components of This Parts:


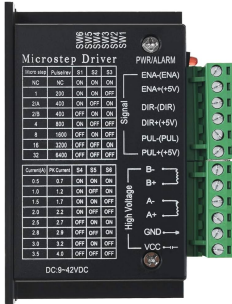
Item Name	Item Image	Quantity
Stepper Motor (nema 23)		1
Driver Microstep Driver		1

Table 4.8: Pouring Wax Components

#### 4.2.4.3 Cooling The Wax Cup

Then The production line moves with the cup to stop under the cooling system exactly.

The cooling system is a fan above which the Thermoelectric-Peltier and the heat sink which is connected between them by thermal paste.

The cooling system starts working before the cup reaches underneath, starting with the cup descending to the production line to provide a cooler temperature when the cup arrives.

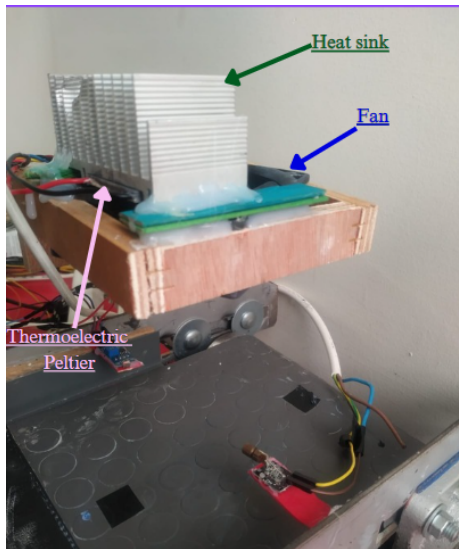

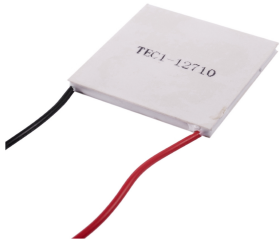


Figure 4.9: Cooling System

#### 4.2.4.3.1 Cooling System Components

Electrical and Mechanical Components of This Parts:

Item Name	Item Image	Quantity
Fan		1
Peltier		1


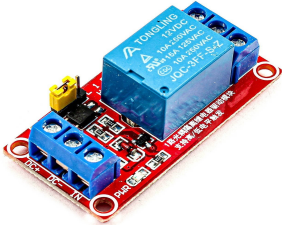
Item Name	Item Image	Quantity
Thermal Paste		1
Relay 12V		1

Table 4.9: Cooling System Components

### 4.3 Controller Part

The controller component, which consists of the following parts, is in charge of controlling and powering the mechanical component:

#### 4.3.1 Arduino

Arduino is the main controller of the machine, which is also a link between the upcoming user orders via the keypad or the mobile application and the Candle Craft Line machine.



Figure 4.10: Arduino Mega

### 4.3.2 Keypad with LCD

The keyboard is used to control the machine and its system by the user, and it shows on the screen a number of requirements that the user must enter as follows:

- Press (\*) if you need to start the system.
- Press (3) if you need to empty the first syringe of perfume.
- Press (6) if you need to empty the second syringe of perfume.
- Press (9) if you need to empty the first syringe of color.
- Press (#) if you need to empty the second syringe of color.
- Press (A) if you need to fill the first syringe of perfume.
- Press (B) if you need to fill the second syringe of perfume.
- Press (C) if you need to fill the first syringe of color.
- Press (D) if you need to fill the second syringe of color.
- Press (7) if you need cleaning mode.

If you choose option (\*), you will be asked a number of questions that appear on the LCD and you will have to answer them by pressing on the keypad the following:

- Enter the number of cups (choose 1 or 2).
  - 1 for one cup
  - 2 for two cup
- Enter the number for the perfume:
  - 1 for the first perfume
  - 2 for the second perfume
  - 0 for no perfume
- Enter the number for the color:
  - 1 for the first color
  - 2 for the second color
  - 0 for no color
- Enter the amount for the cup:
  - 5 for a half cup
  - 8 for a full cup

When pressing 3, 6, 9, or # mode, make the colors and perfumes syringe empty.

When pressing A, B, C, or D modes, make the colors and perfumes syringe fill.

When pressing 7, Is Cleaning Mode, this model is based on the principle of heating the wax in the heating bowl for a period of time, then the heating bowl is opened to pour the wax into the bowl that the user wants without the need for any other part of the project.

This is suitable when there is wax left for some reason in the heating bowl, and then it freezes inside, making it difficult to remove the wax from the heating bowl.

Also, you can see the state of the machine on the screen.

We have referred above to some of the unknown terms intended such as:

- Cleaning Mode: mode to clean the heating bowl by heating it for a specific time, then open the bowl hand to pour all the wax into the bowl without using any other parts of the machine.
- Fill the syringe : This mode is used to fill the syringe with color or perfume.

- Empty the syringe : This mode is used to empty the syringe with color or perfume.



Figure 4.11: Keypad With LCD

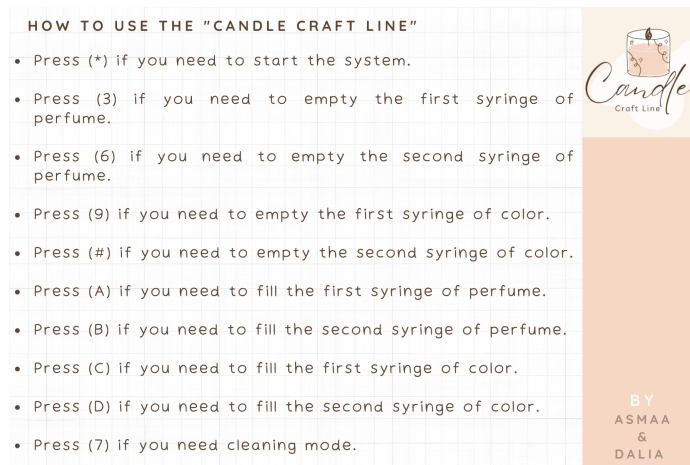


Figure 4.12: First page of manual

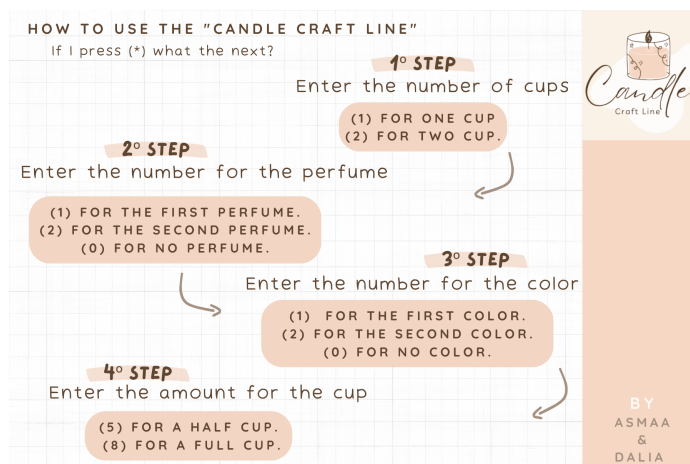


Figure 4.13: Second page of manual

#### 4.3.2.0.1 User Input

Electrical and Mechanical Components of This Parts:

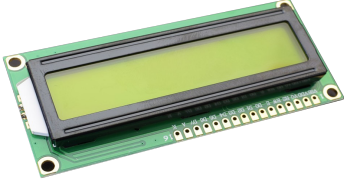

Item Name	Item Image	Quantity
LCD For Display		1
Keypad		1

Table 4.10: User Input

### 4.3.3 ESP 32 Controller

We have used the ESP 32 controller as a link between the app from which the user gives commands and the Arduino Mega which controls the Candle Craft Line machine.

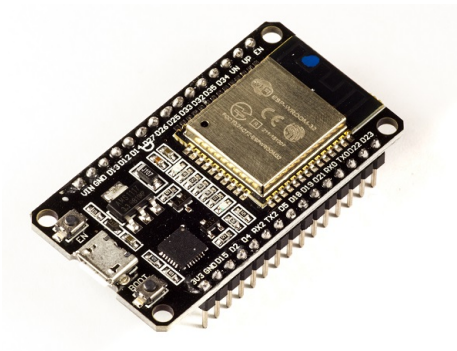


Figure 4.14: ESP 32 Controller

#### 4.3.3.1 Mobile Application

Below we see some photos of the mobile app, where the user can give it the same orders as previously in the keypad plus you can track the machine's condition such as: how much remains for the heating and other things.



Figure 4.15: Mobile Application 1

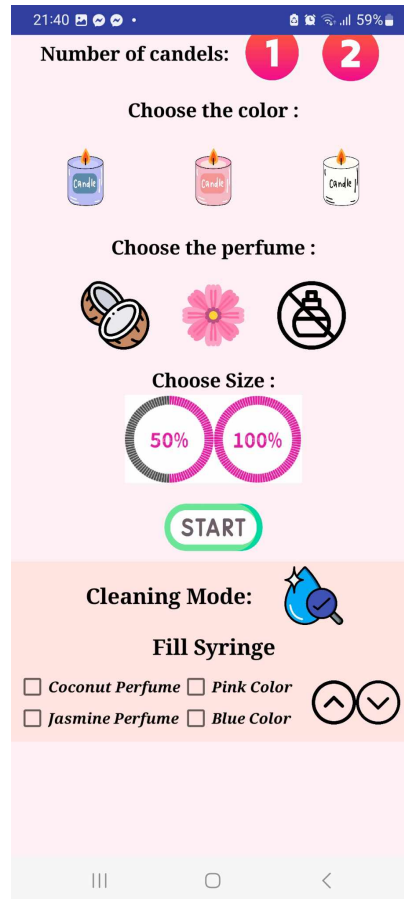


Figure 4.16: Mobile Application 2

In the first part of the page, the user shows the status of the machine or system, so that the user can track the working mechanism.

After that, the user selects the number of cups, color, and fragrance as preferred, as well as if he wants to fill half the cup or the full cup, then press to start to make a cup of candles.

To clean the heating bowl, press the cleaning mode.

To pack the syringes, you must choose which syringe you want to pack, and choose the arrow that points up, to unload the syringes, you must choose which syringe you want to empty, and choose the arrow that points down.

## 4.4 Flow Chart

Our flowchart provides you with the fundamental steps in the basic operation of the "Candle Craft Line" machine.

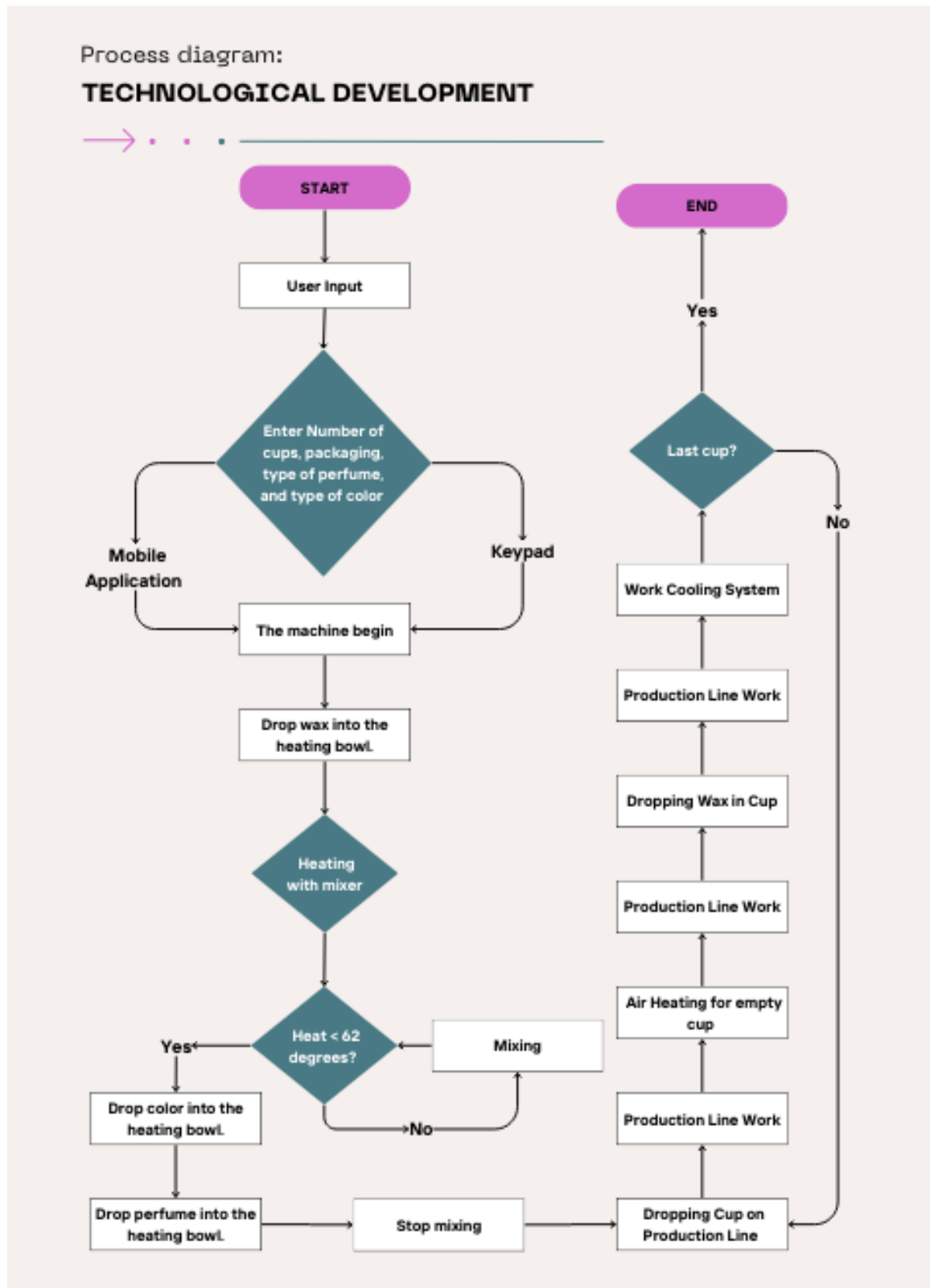


Figure 4.17: Flow Chart

## **5. Results And Discussions**

### **5.1 Automation**

Our original objective was to leave the user with the impression that the wax industry is over 95% automated, which we expertly accomplished. We also wanted the user to experience an unmatched sense of beauty when the cup packing process concludes correctly.

### **5.2 Movement**

For us, this is one of the trickiest steps. Moving circularly to get the material down in the heating bowl, moving the course of the cup store, and moving to the base production line were our three main movements.

To complete everything with such precision and effectiveness, we need a great deal of mechanical experience and time.

### **5.3 Heating Bowl**

It was difficult for us to find a suitable bowl for heating and at the same time easy to open and close to pour wax into cups without using a special valve as the valve is expensive and not the best performance especially since the nature of wax freezes after time due to the temperature descent.

However, we overcame this by bringing a piece of shop modifying their structure, and designing what is similar to the work of a Linear Actuator to open and close automated, but with better effectiveness than the Linear Actuator in the markets, thus solving all the problems and at the lowest possible cost.

### **5.4 Final Results**

The end product is an excellent project that satisfies all of our objectives and functions flawlessly in the majority of the scenarios we tested.

## **6. Conclusion**

### **6.1 Summary**

We created a clever automated spatial production line that gave the old method of manufacturing wax a high level of safety while also adding a nice touch and reducing quality for wax makers.

The project might require some adjustments that we were unable to make because of time constraints, lack of expertise, or other factors, but the most crucial thing is that we finished a business project that has a lot of room for improvement and is, hopefully, a step in the right direction. We would love it if someone completed the project and added a small amount of it as a future computer engineering project. Our long-term vision for this project is that it is the first project for a series of projects that add and improve it.

### **6.2 Improvements**

Some design improvements are needed to make it smaller and cover some parts that are not necessary for the user to see, also we need to adjust the quantity of the wax as it is not 100% accurate all the times

### **6.3 Future Work**

#### **6.3.1 More choices of colors and perfumes**

Make the system accommodate more than two colors and more than two perfumes.

#### **6.3.2 More Choices of mold**

Make the system not only accommodate glass cups but also molds and larger sizes of cups and molds.

#### **6.3.3 Make it faster**

Make the system faster by making a number of cups go on the production line at the same time, for example, when the first cup arrives at the step of casting wax, the second cup is in the heating process, and so on.

To do this we must bring a larger production line and make the distances equal between each step and the other.

### **6.4 Outcome**

We have developed a clever automated production system that functions flawlessly, gives wax makers time and ease, and modifies material quantities without wasting or losing any. All the while, the system increases safety for the makers.

## Bibliography

Faraday, M. (1861). *The chemical history of a candle* [Originally given as a lecture at the Royal Institution]. Griffin, Bohn; Company.