**An-Najah National University**

Faculty of Engineering and Information Technology

Computer Engineering Department

# Pottery Cups Machine

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## ❖ Dedication

This work is dedicated to our families for keeping the flame of motivation to see our efforts through and allowing us to soar to such heights. It is also dedicated to all those who supported us, even with one word of encouragement. Last but not least, we dedicate this work to ourselves with our perseverance and dedication.

## ❖ Acknowledgment

In view of these months working on our project, we want to express our appreciation to Dr. Manar Qamhieh for her constant guidance and notes, which helped us to do this work in the best possible way. We also want to thank each other for having always been a reliable partner. And, finally, we are grateful for the endless support we have got from our families and friends.

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## ❖ Disclaimer

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# ❖ Abstract

The Pottery Cup production project aims at modernizing the traditional forms into an automated process of clay cup production whereby the result would greatly improve upon efficiency and consistency in the manufacture of pottery, with less reliance on skilled labor and a corresponding decreased rate of human errors. The project addresses the increasing demand for sustainable, handcrafted products and introduces a modern means of producing quality clay cups. Furthermore, automating production would promote faster production and reduced cost, thus bringing handmade pottery to a wider market.

The objectives of the project include designing an automated system for the production of pottery cups with consistency while minimizing production time and costs, and maintaining high quality that proves to be artisanal.

The project will achieve its goal by developing an "Arduino-based automated pottery cups production system." Key components include sensors, DC motors, stepper motors, couplers, drivers, and lead screws for precise motion control during clay cutting, molding, and shaping, also LCD and keypad for allowing users to input parameters. An Arduino Mega microcontroller will be the central control unit, with an ESP-32 module for wireless communication.

Our project is a first that is being worked upon in Palestine. While automation is well known in different manufacturing industries, there has not been an application where the automation of pottery cup production is studied in the region. This project provides an innovative solution especially suited to the requirements of local artisans and manufacturers, thereby providing a first-ever system that marries traditional craftsmanship with modern-day automated techniques.

The manufacture of clay cups is all done by fully automated systems with a fully automatic molding machine creating cup shapes just by inputting raw materials. The cutting station works electrically to cut the clay into more or less accurate measurements; this is followed by the molding and pressing of clay into the mold, whereupon a compressor mechanism goes down to apply pressure as soon as the clay enters the mold. This ensures the mass of clay gets evenly distributed and is shaped per the mold design. Thereafter, the movable mold base lifts, while the last step involves drawing simple designs or shapes on the surface of the cup, completing the automated process. This whole new process not only makes work easier, but lends accuracy, consistency, and creativity to one fluid operation.

# ❖ Chapter1: Introduction

## 1.1 General background

The increasing demand for sustainable and high-quality pottery products has thrown into stark relief the constraints of traditional pottery-making methods that are inefficient and labor-intensive. The project aims to mitigate these constraints with automation-an application of modern technology for the manufacture of clay cups. The proposed system incorporates innovation into the artistry of pottery with the intent of preserving the aesthetic appeal and cultural significance of traditional pottery while enhancing the production process.

This automation reduces reliance on skillful artisans, reduces errors, and ensures equal quality of pottery in every batch. The system ensures automated flow to achieve maximum efficiency and cost-saving with IMCs and a user-friendly interface. It leads the transition from manual pottery production to automated production systems, thus increasing efficiency, cost-saving, and time-saving benefits. Bridging traditional craftsmanship and state-of-the-art automation, this project provides an avenue for an efficient and economically viable solution to meet the rapidly increasing market demand for sustainable and artisanal pottery products.

## 1.2 Objectives of the work

Our project aims to create an automated pottery production system that reduces dependency on skilled labor while providing uniform quality and efficient production of clay cups. It caters to both small-scale artisans and large manufacturers and is designed to work mostly on its own with some human input.

The system automates essential steps within the pottery production process through the latest technology. The activities covered include cutting the right amount of clay, shaping it through press forming, carving designs, and conducting finish work with precision. The system also proposes operational flexibility with two modes: via keypad and LCD display for local control and through a mobile app connected by ESP for remote operation. The interface is designed to be user-friendly and accessible for easy manipulation of the process.

The project therefore seeks to change the face of pottery production by establishing a balance between traditional craftsmanship and modern automation, thus providing a system solution that is open for scaling to meet the demands of an ever-growing market where sustainable pottery of high quality is in demand.

## 1.3 Significance of the Work

As a novel concept in the market, our automated pottery production system combines traditional craftsmanship with modern technology to create high-quality clay cups. By automating key processes like clay cutting, press forming, and precision finishing, our system enhances production efficiency while maintaining the artisanal quality of pottery. The system's dual operation modes, including a mobile application and keypad with LCD, provide users with flexibility and control. It must also operate autonomously, which makes it appropriate for small artisans and large-scale manufacturers. By diminishing the need for skilled labor and minimizing human error, our project provides a cost-effective and scalable solution to meet the rising demand for sustainable pottery products.

## 1.4 Organization of the report

The main body of this report is made up of a number of chapters, each of which has its own specific purpose. The first chapter called the Introduction, covers aspects like the general background of the project, the aims of the work, the significance of the work, and the logical organization of the report. The second chapter," Theoretical Background and Previous Work," places the project in the context of whatever is already known. It looks back historically at the previous research and theories backing the work in view. The Methodology chapter then describes the hardware components, how the system works, and how any constraints encountered were dealt with. The findings would then be presented in the Results and Discussion chapter, which would also discuss the results. Finally, in the conclusions and recommendations chapter, the last chapter, the project is summarized, along with suggestions that would contribute to the improvement and refinement of the approach in any future endeavor.

# ❖ Chapter 2: Theoretical Background and Previous Work

## 2.1 Theoretical Background

Pottery has been a vital part of human civilization for centuries, serving both functional and artistic purposes. Traditionally, the pottery industry was labor-intensive, very inconsistent as it could easily succumb to variability, and highly dependent upon skilled artisans. This scenario is mitigated by the application of automation and technological advances that have touched off a groundswell of improvements in various fields of manufacturing, including ceramics, considering enhanced productivity, reduced costs, and high-end product yields.

Elettrondata's [1] study on Automation in Ceramics Manufacturing sheds light on the potential of various processes facilitated by automation such as storage, weighing, dosing, and clay transportation. In particular, automation in presses for the electric drive process has been shown to enhance efficiency and product consistency.

One of the most important applications in ceramics is press molding, which finds extensive use in shaping clay into specific forms. The use of presses applies uniform pressure, ensuring uniformity and eliminating defects in molded bodies. Work by Mascera-Tec talks about how the press molding process improves the mechanical properties, chemical stability, and wear resistance of ceramics by creating high-density, low-pores, low-defect molded bodies [2].

Currently, there is the application of advanced robotics in the sculpting sector, such as in the domain of ceramic manufacturing. For illustration purposes, a project by Automated Technology Group (ATG) in the UK has integrated ABB robots in the manufacturing of high-end ceramic vessels. Legislature contributes to the maintenance of traditional aesthetics while boosting efficiency, thereby proving the worth of robotics in the pottery-making industry [3].

Thermo-mechanical modeling has been employed to simulate the forming and sintering processes in ceramics. The aforementioned findings were recently reported in the arXiv, explaining the application of a micromechanical material model for the analysis of cold forming and sintering of ceramic powders to reduce instances of defects during the manufacturing process [4].

Despite all the achievements, the big focus has been on ceramics in the industrial sector Do-it-yourself pottery has been neglected by academic and industrial research in this regard. This project is envisioned to bridge the gap and hybridize modern automation with traditional craftsmanship. The system being proposed shall take over downstream processes like clay cutting, press forming, carving, and finishing. By draping the accuracy of automation over the art of handcrafted pottery, this project would give an expandable and manageable remedy for producing lovely terracotta cups at low expense.

## 2.2 Earlier Work

The course on microcontrollers played a very important role in our understanding of the system of microcontrollers and its applicability in hardware control. In this course, we learned a lot about the principles and methods that are applicable to the effective use of microcontrollers.

The microprocessor module also helped us gain a lot of knowledge and skills in handling ICs and modules, especially regarding their behavior in terms of current and voltage. This module equipped us to handle complex electronic components and their functionalities.

Another instrumental course was the CPU lab, which added a lot to our practical skills in wiring, soldering, and debugging hardware parts. The hands-on experience that was gained in this lab was invaluable in honing our abilities to effectively troubleshoot and rectify hardware-related issues.

The critical thinking and scientific research component of our curriculum adequately developed our research skills in how to write a professional paper. This module indeed equipped us with the necessary tools and techniques required to conduct effective research and then present one's research results in an organized and professional manner. In addition, writing editors such as LaTeX assisted us in producing highly technical documents.

# ❖ Chapter 3:  Methodology

This chapter will contain a description of the hardware components used for building the system, the interconnections among them, and the design of the entire system. We shall also cover the workings of the system along with the mobile application and software.

## System Architecture:


*Figure 1 System Architecture*

The development of a machine designed to fabricate clay cups addresses problems associated with traditional pottery-making methods. This machine has three operational modes: cutting the clay to the required length, molding it by placing it in a compression cup styled as a cup, or lightly etching a sketch on the surface. This automation here increases productivity and quality while decreasing the need for handcrafting skills.

## Hardware Components Used:

- ### Microcontroller

Absolutely! The central unit of our hardware project is the Arduino Mega, which is a microcontroller equipped with 54 digital I/O pins, 16 analog inputs, and 256KB of memory. These pins work as the connectors of our Project components buttons, motors, and Sensors. Implementation through the Arduino Integrated Development Environment (IDE), we craft intricate code to make the accuracy and efficiency work at the highest level. The IDE also facilitates real-time Communication with the Arduino Mega, allowing us to upload and execute code seamlessly. This dynamic interaction between hardware and software forms the backbone of our project, where the Arduino Mega's adaptability and memory contribute to a responsive and intelligent experience, truly showcasing the fusion of technology.


*Figure 2 Arduino Mega*

- ### LED Stripe

Used to give light effects as a final feedback.

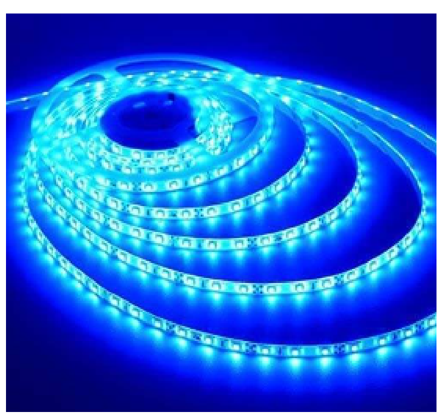


*Figure 3 LED Stripe*

- **ESP32 Development Board ESP-WROOM-32 30pin:**

  ESP32 is a highly integrated solution for Wi-Fi and Bluetooth IoT applications that utilizes around 20 external components. ESP32 integrates an adjustable antenna switch, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules. The whole solution for ESP32 requires a minimal Printed Circuit Board (PCB) area. ESP32 takes as its foundation CMOS technology for the industry-standard radio chip with integrated baseband into a single chip. Furthermore, it accommodates some advanced calibration circuitries that remove external circuit imperfections or adapt to changes in external conditions. Such properties help reduce mass production costs, considering that the ESP32 solutions are impervious to the need for sophisticated and costly external equipment for Wi-Fi testing.

  The ESP8266 is a popular and affordable Wi-Fi module that can function as a standalone microcontroller. It comes integrated with Wi-Fi.

  It has connectivity, GPIO pins for interfacing with other components, and is programmable in the Arduino environment.

  We used it for connecting to WIFI and receives commands from mobile application that will command the machine and send them to mega.

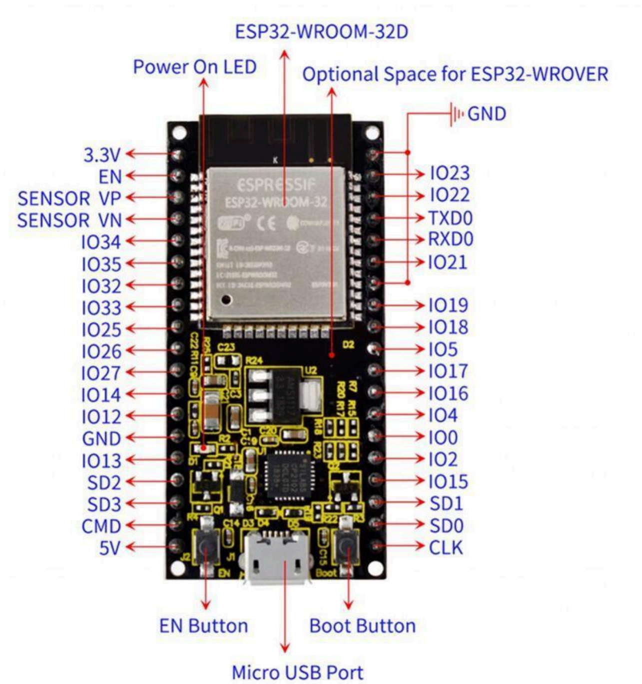



*Figure 4 ESP32*

- **Single Channel Relay Module:**

There are numerous cross-system applications of single-channel relays: most frequently modern broad home automation systems, industrial controlling systems, and even some automotive electronic devices. Usually, a single-channel relay consists of a coil, armature, and contacts. A single-channel relay can also remotely or automatically control electrical loads by enabling, disabling, or switching lights, motors, or heaters. Single-channel relays provide simplicity and versatility to the system besides fundamental reliability. A single-channel relay is mechanically operated, that requires one engineering input to each engineering output. A single-channel relay can be split into two sections: The Control Side, and The Output Side.

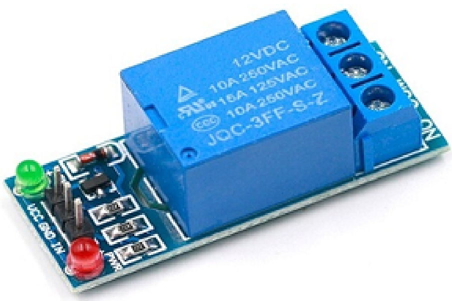



*Figure 5 Relay*

- **LCD Display:**

An LCD, or liquid crystal display, is a flat-panel display technology that utilizes the optical characteristics of liquid crystals to modulate light to form images and text. LCD displays are used in many electronic devices including televisions, computer monitors, smartphones, and digital clocks. They give a high-quality output with sharp images and vivid colors. A set of pixels are embedded in LCDs, which can be programmed to display a variety of shapes and colors. LCDs have low power consumption, are available in various sizes and resolutions, and can therefore be used in many applications including information displays, user interfaces, and visual output ports in electronic devices.

*Figure 6 LCD*

- **I2C module for LCD:**

The I2C module for LED displays helps users connect an LED display to a microcontroller for easy communication over I2C. It reduces wiring by using fewer pins and is commonly used in projects within the pin counts of many microcontrollers. This module makes LCD integration into IoT systems and robots much more efficient and practical.

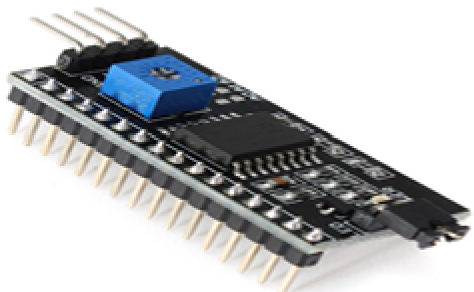


*Figure 7 I2C*

- **Keypad:**

A keypad, which may stand for the phrases “keypad entry system” or “keypad input device” is a user interface element that consists of buttons or keys arranged in a grid or array. Each single button usually signifies a character, digit, or function. Keypads are frequently used for entering numerical data, text ,or control commands into electronic devices and security systems and many more. You may find them in calculators, remote controls, security alarm panels, and ATMs. To the users, keypads are very easy to use since it is very simple to input information, and are even used with other advanced display devices like LCDs.

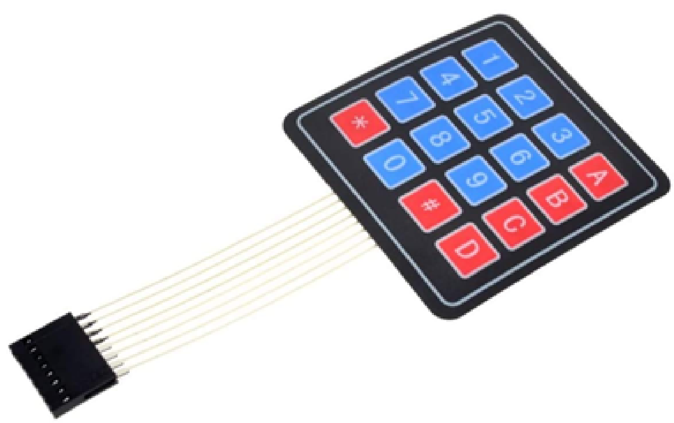


*Figure 8 Keypad*

- ## Power supply:

A power supply is an essential electronic component that converts input voltage from a source, such as a wall outlet or a battery, into the required output voltage and current needed to operate various electronic devices. Power supplies provide the necessary energy to run everything from small gadgets to complex systems. They come in various forms, including AC-DC adapters for household devices, DC-DC converters for voltage regulation, and power distribution units (PDUs) for data centers. Power supplies ensure the stable and reliable operation of electronics by delivering the appropriate and consistent electrical power for their functioning.

*Figure 9 Power supply*

- ## Motors:
  - **NEMA 23 Stepper Motor with 2.3 Nm Torque:**

A high-torque precision motor, the NEMA 23 stepper motor is a Commonly Used Motor in Industrial and automation applications. It has high accuracy with high load operations as it has a torque rating of 2.3 Nm (newton meter) enabling it to have 2.3 Nm of Torque. The motor operates with a 2-phase/4-phase configuration for smooth motion control.

*Figure 10 Stepper Motor 2.3*

- **NEMA 23 Stepper Motor with 1.3 Nm Torque:**

  NEMA 23 stepper motor rated 1.3 Nm is a good option for practical applications where moderate power consumption is balanced by the need for controlled motion. It is often used in devices such as 3D C printers.

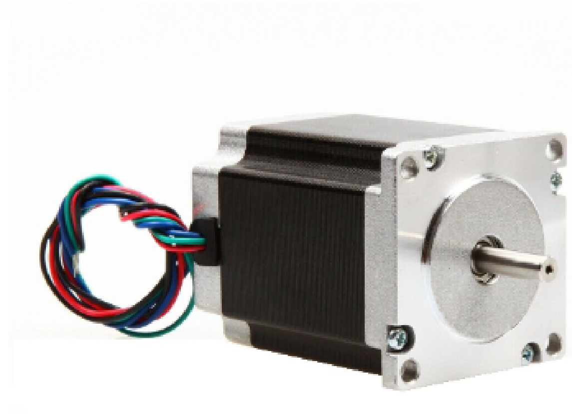


*Figure 11 Stepper Motor 1.3*

- **Servo MG995 Metal Gear High Torque Servo, Black - 180 Degree:**

  The MG995 Metal Gear High Torque Servo is a reliable and robust servo motor known for its durability and performance. It features all-metal gears for enhanced strength and longevity, making it suitable for applications requiring high torque and precision. With a 180-degree rotation capability, it is commonly used in robotics, RC vehicles, and automation projects. The black casing provides a sleek look while ensuring durability, and its ability to handle high loads makes it ideal for demanding tasks.


*Figure 12 Servo Motor*

- **DC Motor:**

    1- The Orange MG555 12V 100RPM Square Gearbox DC Motor qualifies as an adaptable, rugged little motor desirable for many DIY projects and robotic applications. The square gearbox built into it ensures smooth torque and therefore a constant speed which renders its operation effective for various mechanical systems. The motor itself can cater to an encoder for feedback on position and speed, which is a crucial requirement in precision automation projects. With a working voltage of 12 V and a rotational speed of 100 RPM, this product can be used for conveyor belts, robotic arms, and smaller automation setups.

*Figure 13 DC Motor*

    2- The motor and gearbox from the Ryobi ID-122 drill are a great choice for repurposing in projects due to their compact and efficient design. The motor operates on 230V with a power rating of 250W, capable of providing high-speed rotation up to 3300 RPM. This universal motor is lightweight and delivers consistent performance, making it suitable for various applications. The attached gearbox effectively converts the motor's high speed into usable torque, offering a good balance of speed and power.

*Figure 14 Drill motor*

- **Drivers:**

- **HY DIV268N Stepper Driver**

The HY-DIV268N is a commonly used stepper motor driver module. It is a bipolar stepper motor driver capable of driving stepper motors with a maximum current of up to 5A. The module supports various micro-stepping modes (full-step, half-step, etc.) and provides step and direction control inputs for motor control.
- We used it to drive stepper motors.


*Figure 15 Stepper Driver*

- **l298n Motor Driver**

The L298N motor driver module is a widely used dual H-bridge motor controller that enables the control of two DC motors or a single stepper motor. It is capable of driving motors with higher current and voltage requirements, making it suitable for various robotics and automation projects. The module offers both forward and reverse control for each motor and can handle peak currents, contributing to efficient motor operation. The L298N's compatibility with microcontrollers and ease of integration has made it a popular choice for driving motors in applications such as mobile robots, CNC machines, and remote-controlled vehicles.

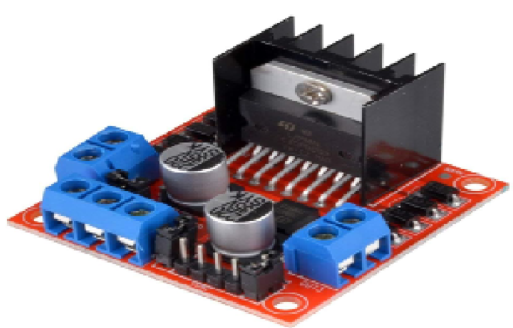


*Figure 16 H-bridge*

- **Feedbacks components:**

- **Limiting Switch**

Limit switches are essential components used in automation systems to detect the physical limits or positions of moving parts. They produce a signal when an object is either in a predetermined position or obstructing its motion. The limit switches may either be mechanical switches or proximity sensors; they have very important roles in the reliable and safe functioning of any machinery and robotics system. By detecting the limits of motion, such switches prevent overtravel, protect equipment, and offer positional feedback, thereby increasing the reliability and efficiency of the entire system.

*Figure 17 Limit switch*

- **Push Button**

A push button is a commonly used switch that completes an electrical circuit when pressed and opens it when released. It is often used for momentary operations and can be found in various electronic devices and systems for functions such as powering on/off or triggering actions.

*Figure 18 Push Button*

- **Ultrasonic Sensor**

An ultrasonic sensor is a handy device used to measure distances or detect objects by sending out high-frequency sound waves and listening for the echo that bounces back. Another method of operation is measuring how long it takes for sound to travel from the transmitter to the object and back, and from this time interval, calculating the distance based on the speed of sound. With a transmitter to send the sound waves and a receiver to catch the echo, they find common applications in robotics, obstacle detection, and level measurement. It has an extensive range and is very reliable and accurate, even in dimly lit or difficult surroundings.

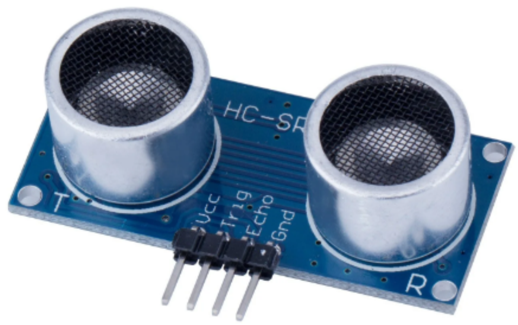



*Figure 19 Ultrasonic*

- **LDR Module**

The LDR module or Light Dependent Resistor module works as a light intensity sensor, which detects the intensity of light in its surroundings. When light falls on the sensor, the light-sensitive resistor's resistance decreases, indicating an increase in brightness. The LDR module can come with circuit schematics inside, which can output both digitally and in analog, thus proving itself as being versatile and convenient. It is used abundantly in applications such as automatic lights, alarms that operate with changes in light, and other energy-saving devices. This simple circuit is a favorite among hobbyists and engineers.

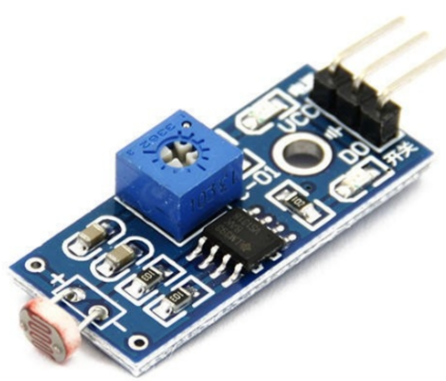



*Figure 20 LDR*

- **Laser Pointer Module**

  The Arduino Red Laser Pointer Module is a small and reliable device that emits a focused red laser beam, typically operating at a wavelength of 650 nm. It is easy to use with a 3.3V or 5V power supply, making it compatible with Arduino and other microcontroller projects. When paired with an **LDR module**, it can be used in projects like laser tripwires, object detection, or alignment systems. The laser beam triggers the LDR by interrupting or reflecting light, enabling innovative and interactive DIY applications. Its compact size and low power requirements make it a favorite for both beginners and experienced hobbyists.

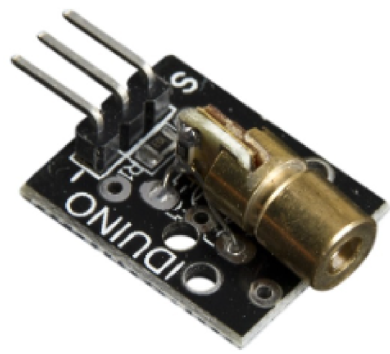


*Figure 21 Laser Diode*

# Mechanical Components:

- **Lead Screw with Brass Copper Nut (T8*2mm)**

  Precision-movement systems are often crafted with high durability and quality components. Indeed, "T8*2" means a diameter of 8mm and a pitch of 2mm providing for precision and accuracy in linear motion. When fitted with the brass copper nut, this configuration ensures great wear resistance, smooth operation, and long-term reliability. Lead screws are ideal for CNC machines, 3D printers, and automation projects. They give precise control to linear movements, making it compatible for many mechanical and automation applications.

*Figure 22 Lead Screw with Nut*

- **Stainless Steel Shaft Rods 50cm Length / 8mm Diameter**

  The use of 8mm stainless steel shaft rods in mechanical applications offers several advantages. Stainless steel is known for its excellent corrosion resistance, making it suitable for environments where exposure to moisture or chemicals is a concern. The 8mm diameter provides sufficient strength and stability for many applications while still being relatively lightweight. Stainless steel shaft rods are commonly used in various industries, including robotics, automation, manufacturing, and machinery. They are often employed as linear motion guides, axles, support shafts, or rotational components

*Figure 23 Rods*

- **Linear Ball Bearing Block 8mm**

A linear ball bearing block with an inner diameter of 8mm is one of the components in any linear motion system. The block housing contains a linear ball bearing, which provides smooth and accurate linear movement along a shaft or rail.

*Figure 24 Ball Bearing*

- **Bearing**

A bearing is a device used to support a rotating or moving element in machines and to provide assistance in reducing friction. Bearings are used quite extensively in applications across many types of rotating machinery including motors, wheels, and gears for smooth movement.


*Figure 25 Bearing*

# Process of Work

## ▯ ASM Design

In the beginning, we determined the desired specifications and the mechanism that the machine would have, and then we determined the behavior of this machine and how to interact with it, then we obtained the ASM then based on it we concluded the required controller component.

1- <u>Power On and Initial Setup:</u>

When the machine is powered on, the LCD screen lights up and displays a message saying "Starting system..." to let the user know that everything is being set up. Then, it asks the user to press any key to start the configuration process.

- User Action:
  The user is prompted to press a key to begin. This is where the journey begins.

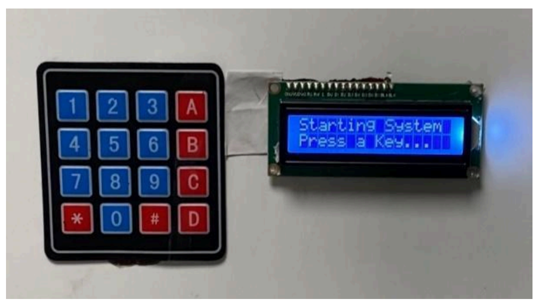
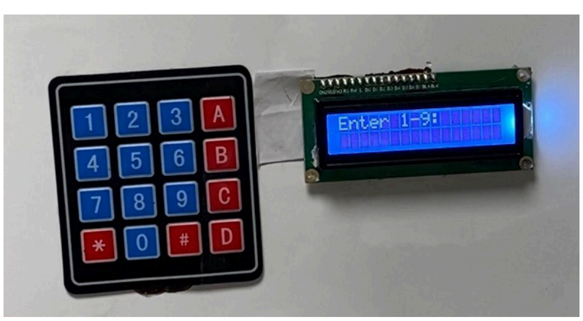



*Figure 26 Initial Setup*

2- <u>Set the Number of Cups to Make:</u>
Once the user presses a key to proceed, the screen asks: “Enter 1-9:” The user is then asked to input how many cups they want to create—anywhere from 1 to 9.

- User Action:
  The user enters a number, and the machine will show the number of cups to be made.



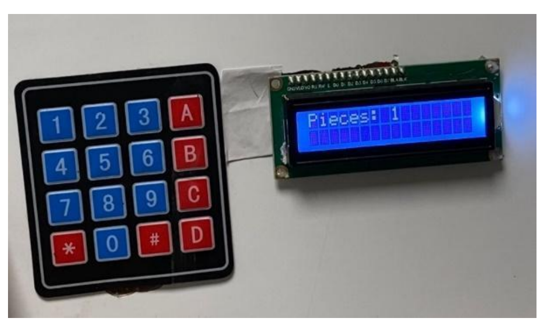



*Figure 27 Set Number of Cups*

3- Choose the Shape of the Pottery:

After the number of cups is set, the machine moves on to shape selection. The user is prompted to pick one of two shapes for the cups. They can choose **Shape 1** or **Shape 2**.

- User Action:
  The user presses '1' for Shape 1 or '2' for Shape 2. The machine confirms the selection with a message on the screen, and the servo motor adjusts to the chosen shape.
  If '1' is selected, the servo moves to 85°, setting the machine up for the first drawing tool. If '2' is selected, the servo moves to 160° for the second drawing tool.


*Figure 28 Set Shape*

4- The Process Begins: Clay Cutting
Once the shape is selected, the machine proceeds to prepare the correct amount of clay for each cup by cutting it precisely.

**Components Used:**

- Servo Motor: Acts as a holder at the bottom of the pipe to control the release of clay.
- DC Motor with Gearbox: Moves the cutting blade.
- Blade: Cuts the clay to the required size.
- Limit Switch: Detects when the blade reaches the correct depth (used to toggle DC's direction).

**Process:**

Clay in Pipe: The clay is inside a vertical pipe, held in place at the bottom by the servo motor.
Blade Movement: A DC motor with a gearbox is positioned slightly higher up the pipe. Attached to the motor is a sharp blade, which is responsible for cutting the clay to the correct size for one cup.
Limit Switch Activation: When the blade reaches the correct position, it presses a limit switch. This signals the system to reverse the DC motor, moving the blade back up to close off the pipe.
Releasing the Clay: Once the blade has moved, the servo motor at the bottom opens, allowing the cut piece of clay to drop onto the molding area.

Resetting: The servo closes again, and the DC opens up to let the clay go down, the system is ready for the next cut, but this occurs at the last of the whole process.

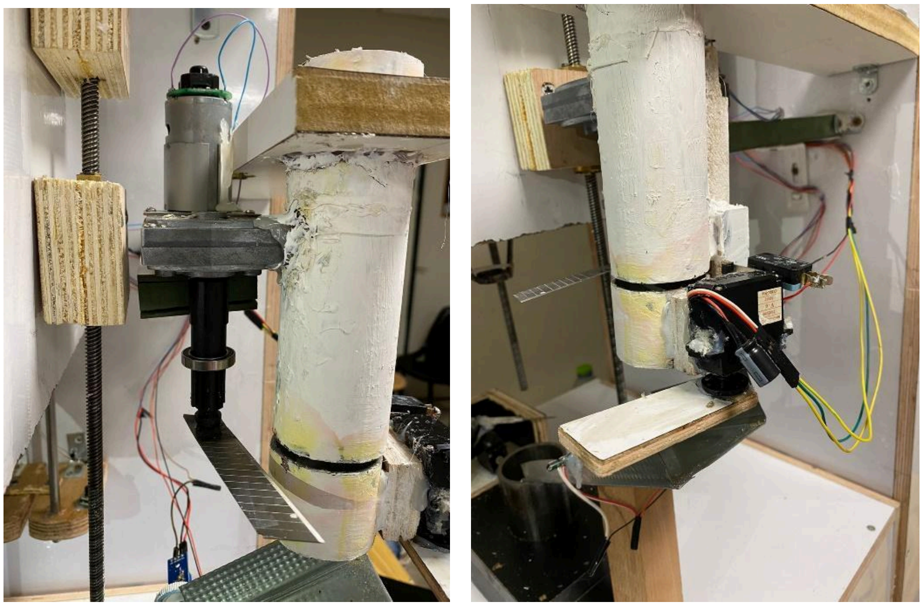


*Figure 29 Clay Cutting*

5- Clay Molding: How the Cup Takes Shape

After the clay has been cut and released, the machine moves on to shape it into a cup using a compression mechanism.

**Components Used:**

- LDR & Laser Module: Detects when the clay passes through the sensor and it's in mold.
- Lead Screws (T8*2mm) & Stepper Motors (NEMA 23, 2.3 Nm): Control the movement of the pressing box.
- Guide Rods: Ensure stability and smooth vertical movement of the mold press.
- Push Buttons (Upper & Lower Limits): Define the range of movement for the pressing box.
- Ultrasonic Sensor: Measures the distance to determine the status of the pressing motor.
- Relay & Pressing Motor: Turns on when the press is in position, applying force to shape the clay.

**Process:**

<u>Clay Detection:</u> As the clay drops into position, it passes through an LDR and laser sensor. This signals the machine to begin the molding process.

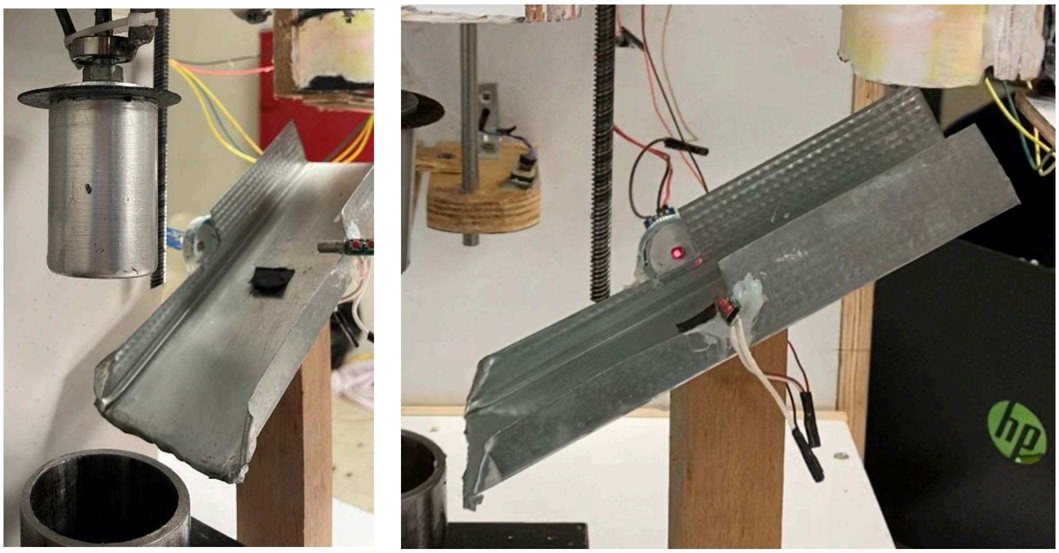


*Figure 30 Clay Detection*

<u>Lowering the Pressing Box:</u> Two NEMA 23 stepper motors drive lead screws, smoothly lowering the pressing box towards the clay.

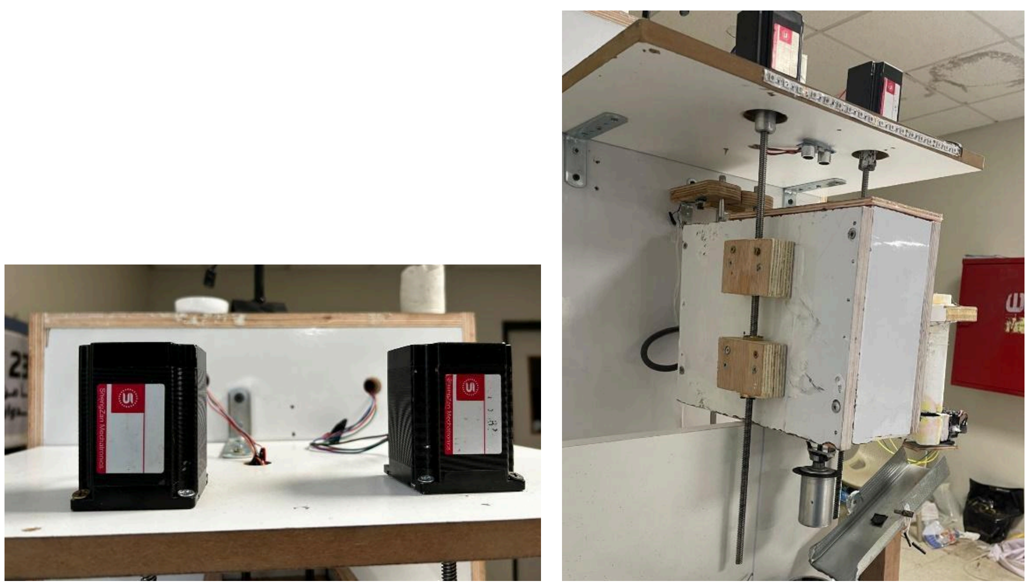


*Figure 31 Pressing Box*

Safety Control with Push Buttons: To prevent over-travel of the box, two push buttons act as limit switches at the top and bottom edges, ensuring precise movement, and also getting feedback when the process is done to go next.

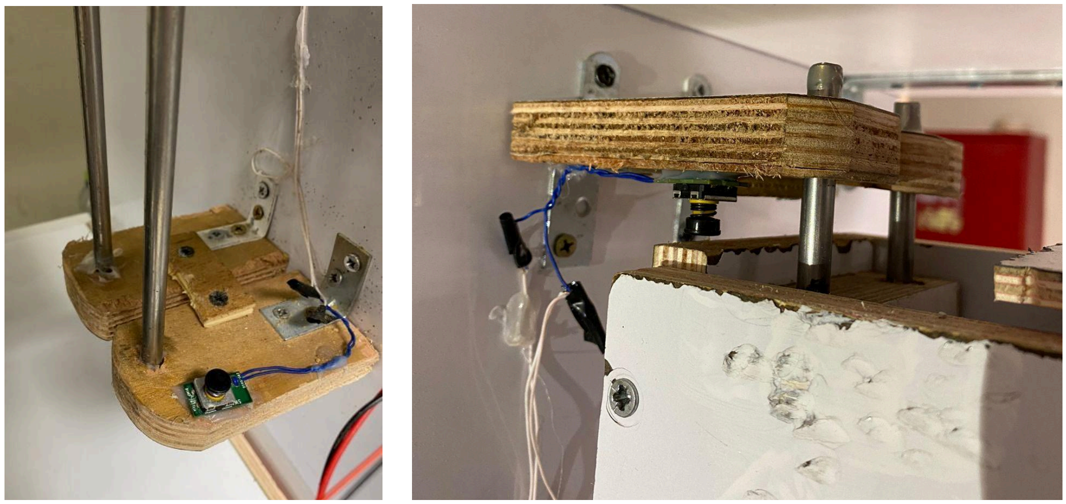
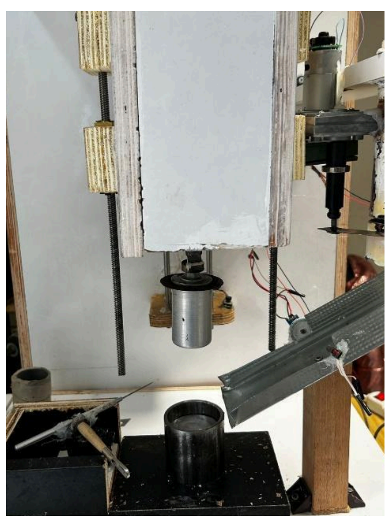


*Figure 32 Control with Push Buttons*

Ultrasonic Sensor Check: As the press is close to the mold, an ultrasonic sensor detects the distance and activates a relay, which turns on the pressing motor
Molding the Cup: The pressing motor goes in, applying controlled force to shape the clay into a cup. The pressing box continues to move downward until it reaches the lower push button, signaling the relay to deactivate and turning the motor off.
Once the molding is complete, the box reverses upward until it presses the upper push button. At this point, the system toggles direction for one second, and then the stepper motors turn off, marking the completion of this phase and moving to the next step in the process.



6- Design the Cup:

Once the cup has been molded, it's time to give it a simple shape. This step involves moving the mold base and using a special tool to engrave the pattern onto the cup.

**Components Used:**

- Lead Screw Stepper Motor (NEMA 23, 1.3 Nm): This motor lifts the mold base up slowly, preparing it for the design process.
- Rotational Stepper Motor (NEMA 23, 1.3 Nm): This one rotates the mold base, helping the engraving tool move around the cup in a smooth circle.
- Servo Motor: The servo moves the selected engraving tool (there are two shapes) into position and controls how the design is carved onto the cup.

**Process:**

Getting Ready for the Design: After the molding is done, the machine knows it's time to start the engraving and The engraving tool (servo) gets into position, ready to start carving.

Lifting and Rotating the Mold Base: The first stepper motor lifts the mold base so the cup is in the right spot for engraving. The second motor starts in parallel rotating the base, which ensures the tool moves around the cup to create the design.

Engraving the Design: Depending on the shape the user chose (Shape 1 or Shape 2), the servo controls how the engraving tool moves to carve the design. As the base rotates, the engraving tool follows the pattern to design the cup.

Controlled Movement: The motors work for a set amount of time to make sure the design is perfectly applied. Once the engraving is done, the cup is ready and must be taken manually.

Ready for the Next Cup: The mold base lowers back into its starting position and stops, and the engraving tool resets. The machine is now ready for the next cup in the production process.

*Figure 34 Cup Designing*

# ASM Design Cont.

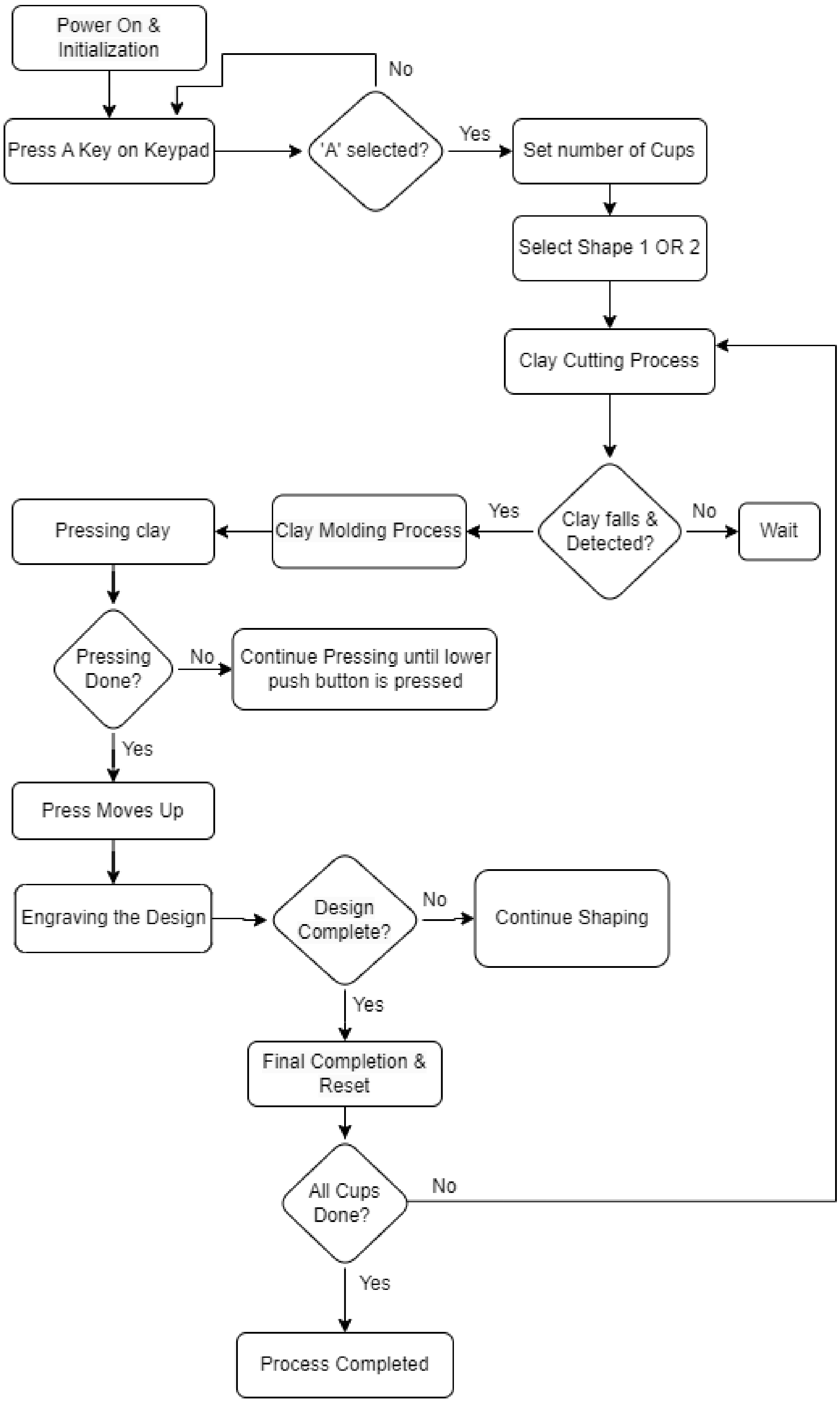



*Figure 35 ASM*

## Controlling the Pottery Cups Machine via ESP32

The essential component in our Automated Pottery Cups Machine is an ESP32 microcontroller that enables wireless control through a mobile application. This feature eliminates manual operation, thus enabling user interaction with the machine for easy use on their smartphones.

**Process:**

Wireless Communication- When establishing a connection to the mobile app, the ESP32 receives commands for **starting** and **stopping** the process, selecting cup **shapes**, and specifying the production **quantity**.

Command Execution- The ESP32 interprets the commands received and sends them to the Arduino via serial communication (UART).

Arduino Control- The Arduino, upon confirmation of the command, executes it to control the hardware components.

Feedback & Monitoring- The Arduino sends the process's status back to the ESP32, including signals such as completion or errors, which can be relayed to the mobile application for real-time monitoring.

**ESP received commands:**

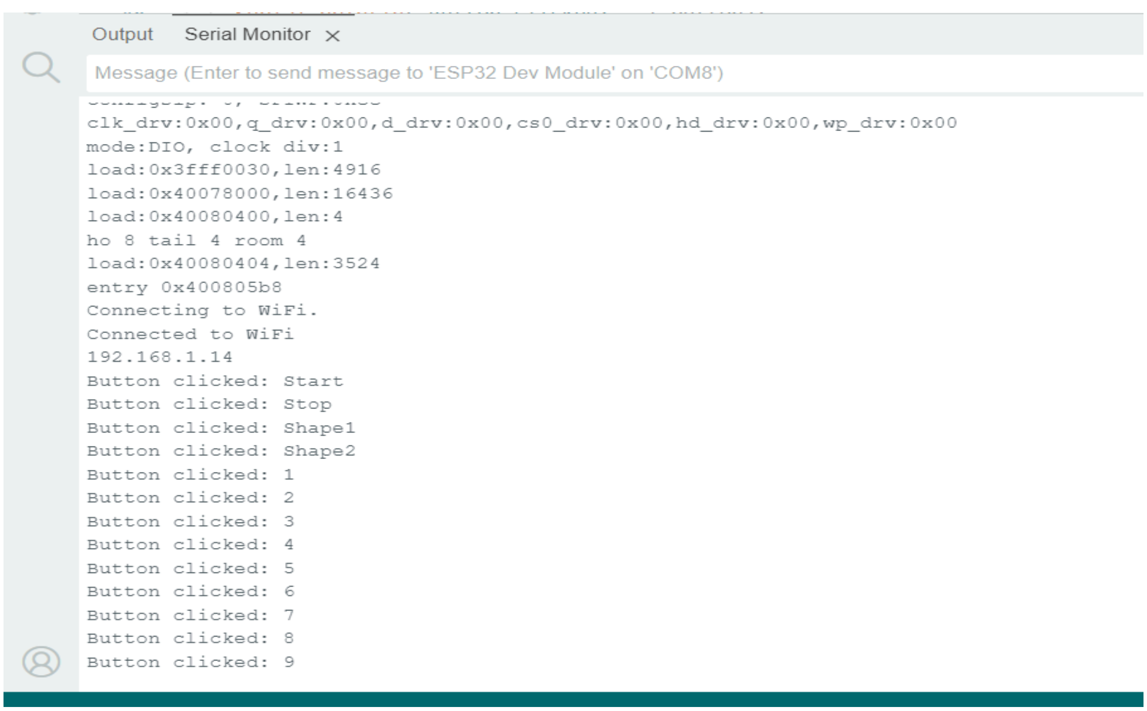



*Figure 36 ESP commands*

**Commands sent to Arduino:**

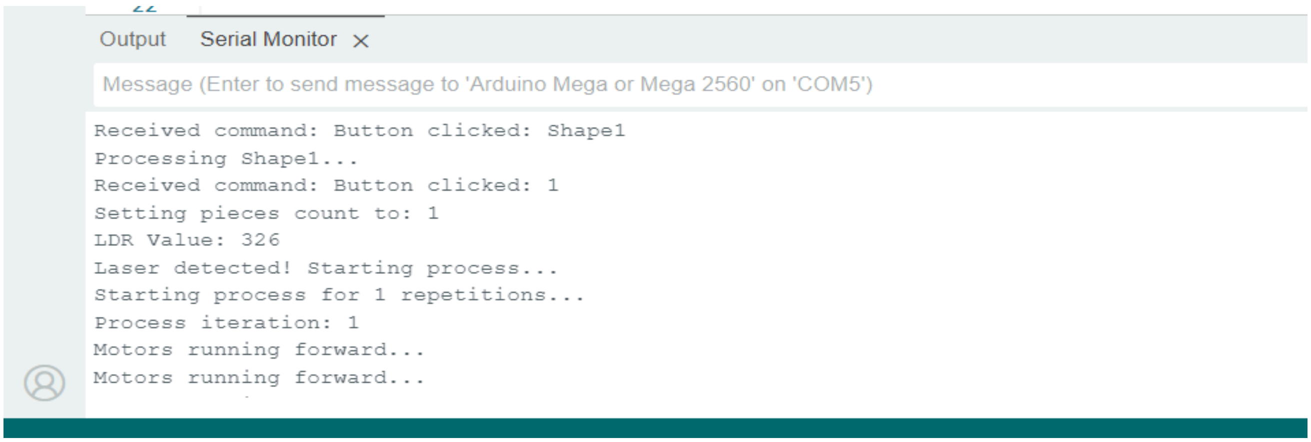



*Figure 37 Arduino commands*

**Mobile App Screenshots:**


*Figure 38 Mobile application*

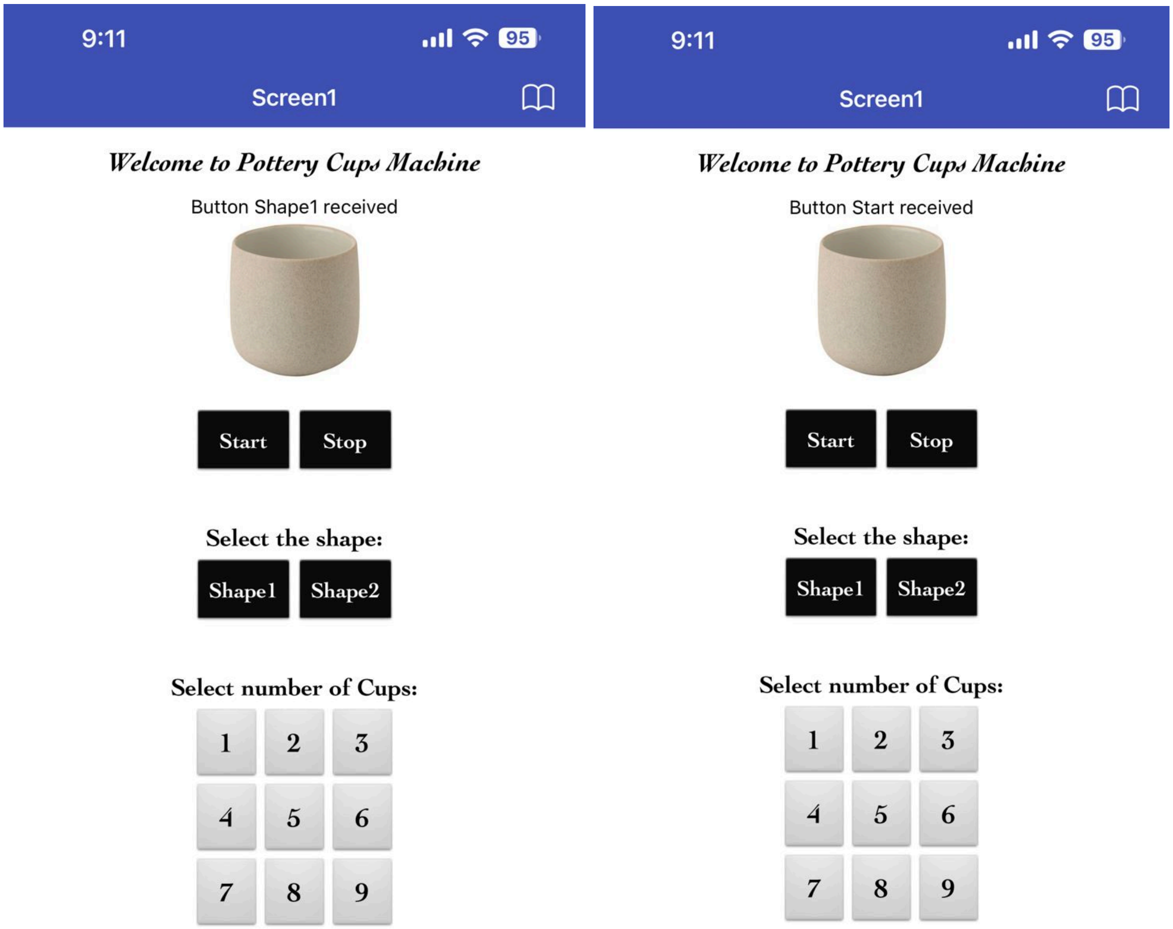



*Figure 39 Mobile application Cont.*

## Controller Design

Based on the previous steps these are our microcontroller connections:

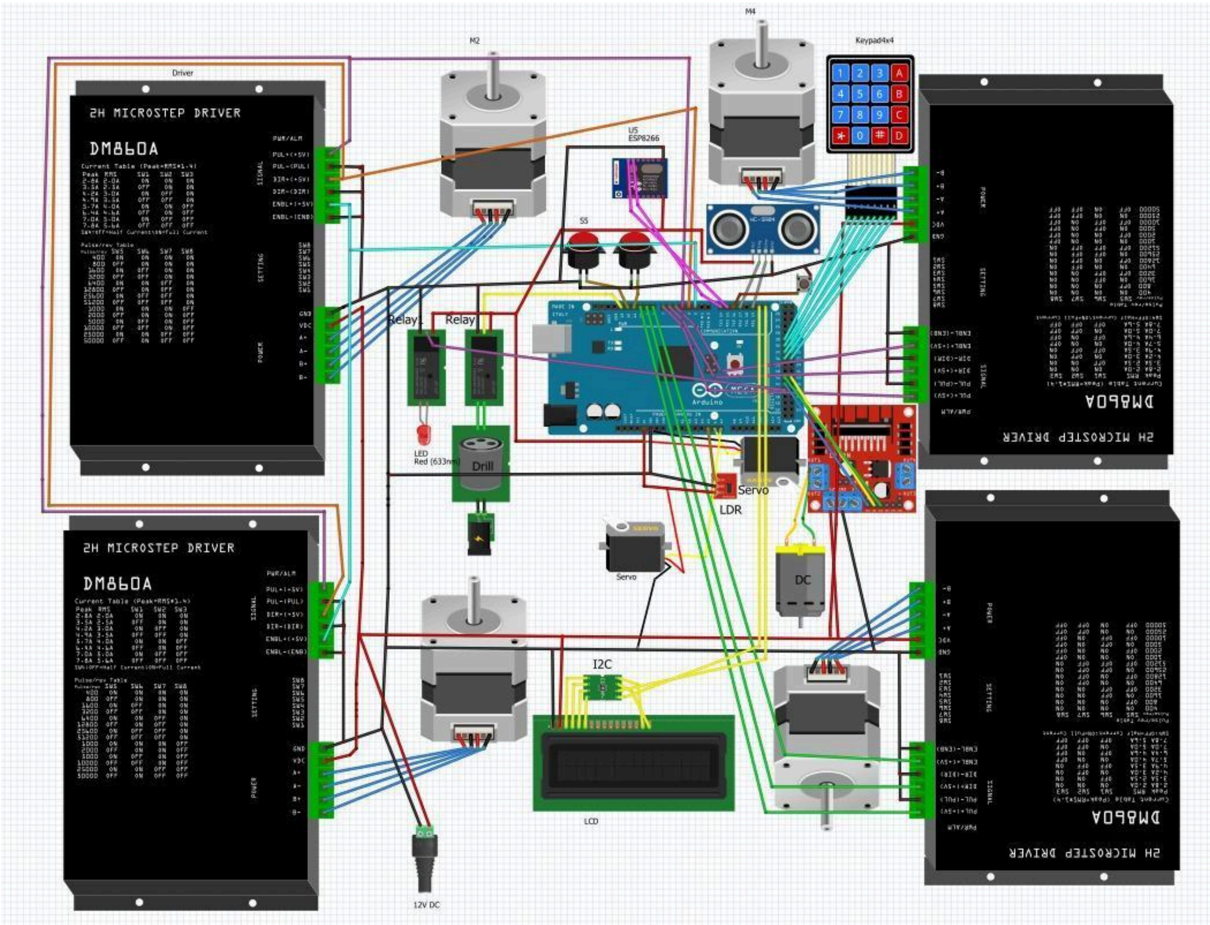



*Figure 40 Controller Design*

# Constraints

The development of the Automated Pottery Cups Machine bore several challenges, which affected our design and implementation. These constraints were:

**Motor Selection and Force Calculation**
A major challenge for us was choosing the right motor for press forming. It was mandatory to do a compressive strength test to calculate force so that adequate clay shaping might take place. After working through a few motor types, we found the drill motor to be most appropriate due to its ability to deliver enough pressing force.

**Components Very Highly Priced**
One challenge we encountered was the high cost of certain critical components, especially the pressing tool and clay mold. These had to be made strong and tough to endure many cycles of use, and hence, they were expensive. The costs of high-torque motors and precision sensors further strained our budget and limited our experimentation with alternative designs.

**Material and Component Availability**
Finding suppliers of electronic and mechanical components was compromised with limited local availability. Some of the key elements like high-torque motors and precision sensors were either difficult to find or overpriced, causing delays in testing and assembly.

**Clay Consistency and Preparation**
The operational capabilities of this machine were largely dependent on the quality and consistency of the clay. Changes in moisture content and composition affected the molding process and sometimes resulted in major defects in the final product. Problems arose in trying to maintain a single uniform texture of clay in the absence of an integrated kneading system.

**Automation Complexity**
Automation of all processes together, synchronizing the various operations of clay cutting, press forming, carving, and precision finishing, required careful coordination. Meeting the needs of each stage to run flawlessly and error-free involved extensive testing and readjustments.

**Structural Durability and Mechanical Stability**
Repeated application of force during press forming stressed-out mechanical parts. Reinforcement and careful selection of materials were key to ensuring press durability and aligning it to the mold.
Despite the above constraints, a functional Automated Pottery Cups Machine was designed and built, thus establishing that automation can indeed be accommodated into traditional pottery making. The solutions devised to surmount the challenges have been enlightening and will serve as a firm foundation for future improvements.

## ❖ Chapter 4: Results and Analysis

This chapter explains a causal analysis of the many results of the Pottery Cups Machine- Of the importance and relevance of the work before us.

**Hardware Components**:
The essential hardware elements for the Pottery Cups Machine, working toward an automatic facility for pottery manufacturing, are the stepper motors that move exactly; the press forming mechanism and the carving tool; remote control via an ESP32 module. Each of these elements was tested extensively for functionality under various operation conditions, despite its prior durability and reliability checks.
The range of experiences with a number of motors that could be applied to the press forming process quickly brought us to brainstorm before exploring avenues for further simplification and enhancement for the ease of the user. **Compression strength testing** enabled us to verify the exact force requirements in creating the shape of the clay. From this analysis, we could make a justified selection of the appropriate motor specification. We finally settled upon the **drill** motor since, as we saw, it provided the needed force for pressing and hence appeared to be the best-suited motor for the job among the several kinds we had applied for testing.

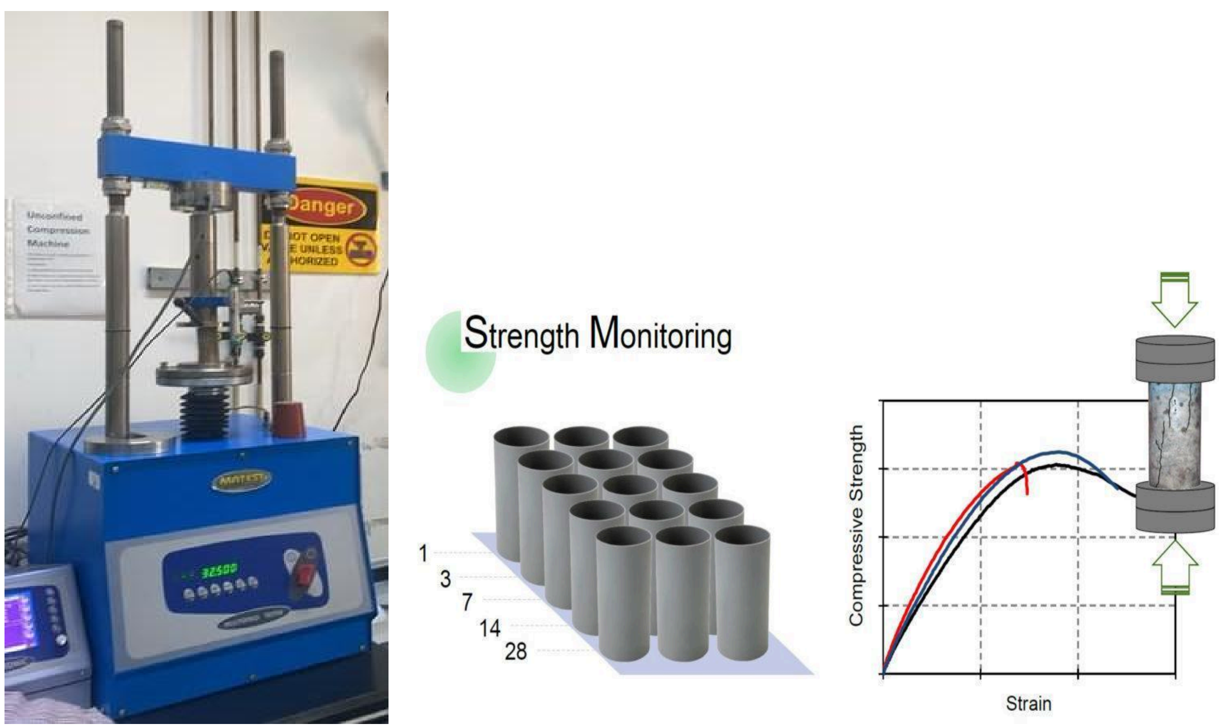



*Figure 41 Compression strength test*

**Mechanism of Action**:
The operational mechanism of the Pottery Cups Machine was rigorously tested to validate its seamless integration and efficiency. Key processes such as cutting the clay into suitable quantities, shaping it using press forming, carving intricate designs, and performing precision finishing were evaluated. User interaction through the keypad with an LCD and a mobile application was tested for ease of operation and flexibility.

**Performance Evaluation**:
To appraise the performance of the Pottery Cups Machine, several experiments were carried out, among other things:

- **Production Rate**: The average time taken for creating one clay cup from start to finish was taken-preparations, forming by pressing, carving, and precision finishing.
- **Quality Control**: Consistency in* the size, shape, and design of pottery cups across multiple production cycles.
- **User Experience**: Feedback from users on the ease of operation, customization options, and satisfaction with the final product.

The results suggest that the machine is functioning very well, producing high-quality pottery cups and exhibiting a consistent design and size with minimum errors.


*Figure 42 Result Cup*

# ❖ Chapter 5: Discussions

The fusion of automation into ancient pottery production procedures presents a significant milestone in the process of upgrading this ancient craft today. Automation of the usual tasks means that our machine reduces dependence on skilled labor, improves the efficiency of production, and ensures that handcrafted pottery is nowadays made with the same quality and standards. There are two modes of operation, local control via a keypad, and remote control via a mobile app, which can emphasize user engagement and flexibility in operation.

This invention shall be of benefit to both small artisans and large manufacturers offering a scalable and cost-effective solution to address the growing demand for sustainable pottery. The market demands this technique for high-end industries like artisan shops, pottery studios, and education establishments.

The initial cost of setting up the machine, maintenance, and assurance of stable power supply are conundrums to be taken into consideration for a viable long-term solution.

# ❖ Chapter 6: Conclusions and Recommendation

## 6.1 Conclusion

In regard to this, the project seeks to transform pottery-making from its traditional practice by developing an automated mechanism for the making of clay cups which are mostly hand-made. The efficiency of this process will overshadow human skill, thus maintaining artisanal conventionality for handmade pottery. Automation of substantially manual operations was undertaken through advanced technologies, including clay cutting, shaping through press forming, design carving, and precision finishing.

There were also two modes in which the actual control took place: The first mode consisted of using a keypad with an LCD for local control, and remote operation was enabled through the other mode by connecting a mobile application via ESP.

These features provided flexibility and ease with which different users could use the features easily. Automation of such processes ensured that the traditional craftsman's art merged with modern automation, meeting scalable and cost-effective solutions.

The experience from this project is that of learning how the integration of microcontroller-based systems takes place for hardware control items such as stepper motors, sensors, and displays. This enhanced our understanding of circuit design and programming, better preparing us for work in automation and system design.

## 6.2 Recommendations

We spent a significant amount of time learning the language of Arduino and how it's used in automation prior to the actual beginning of this work. A great deal of our time was used in procuring all electronic components and acquiring substantial knowledge regarding their usage. Such foundational knowledge became very useful during our project work. We highly recommend that future students invest in acquiring this knowledge right at the inception of their projects to avoid unnecessary hindrances.

Another factor that helped much in bringing about success to our project was choosing the idea well in advance of the semester scheduled for the graduation project. In this regard, we could give full concentration on implementation and smooth the workflow. We encourage the students to select the idea as early as possible and plan for it, putting maximum details to enhance the possibility of achieving their goals.

In building from the successful construction of an Automated Pottery Cups Machine, note the following improvements and iteration work that should be considered for future development:

- **Automatic Oil Spraying Tool:** To prevent clay from sticking to the press and mold during each pressing cycle, an automatic oil spraying system can be integrated. This adds to the efficiency of the production process, minimization of material wastages, and longevity of working components, which include the press and mold.

- **Color customization ability**: through painting/glazing of pottery cups during their making to help make it more personalized or of better aesthetics.

- **Inclusion of a Kneading machine:** This automates the making of the clay to perfection before cutting it into pieces and rolling it out.

It will further modernize the system, expand its functionality, and increase its appeal to a wide market.

# ❖ References


1. **Elettrondata**. (2025). *Automation for Ceramics Manufacturing*.
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