An-Najah National University

Faculty of Engineering & Information Technology

Department Of Computer Engineering

Graduation Project II

The Art of Gypsum

Prepared By:

Jumana Saif

Jullnar Alhajja

Supervised by: Dr. Raed Al-Qadi

Presented in partial fulfillment of the requirements for Bachelor's Degree in Computer Engineering

18 Sep 2025

Acknowledgments

We would like to express our sincere gratitude to our supervisor, Dr. Raed Qadi, for his continuous guidance during the semester and for always being ready to provide us with valuable academic support. Our appreciation also goes to all the professors in the Computer Department for their encouragement and knowledge throughout our years of study. Finally, we warmly thank our families and friends, whose support, trust, and encouragement have been a constant source of motivation for us.

Disclaimer

Jumana Saif and Julnar Alhajja have written this report as requirements for Bachelor's degree in Computer Engineering Department. No one modifies or corrects it because it will be evaluated by professors at An-Najah National University. It is worth mentioning that An-Najah National University does not have any responsibility for any word in this report.

Contents

List of Figures

Abstract

In recent years, handicrafts have become more popular, and many people have started working with gypsum to make decorative molds and artistic designs. To make this process easier and faster, we decided to design a machine that helps in producing gypsum molds with different shapes and colors.

Our project focuses on preparing gypsum mixtures from basic ingredients: water, gypsum, and colors. The process begins by adding water first, then gypsum, and mixing them well. After that, colors are added to the mixture, where the user can choose any color using RGB control, or even create marble-like effects by blending two colors together. Once the mixture is ready, it is poured into molds (with the ability to work on two molds at the same time) and then dried inside the machine until it is ready for use.

This project supports small-scale craft makers and home-based businesses by providing an automatic way to produce decorative gypsum molds. While handmade gypsum products are becoming more common, our system makes the work simpler, faster, and more creative by allowing different designs and color options.

Chapter 1

Introduction

Recently, the number of people working from home in handmade crafts has been increasing, especially in making gypsum molds and decorations. From this need, the idea of creating a machine that produces gypsum molds with less effort was developed. This machine helps in preparing mixtures with water, gypsum, and colors, allowing the creation of different designs and even marble-like effects, making the process easier, faster, and more creative.

1.1 Problem Statement

The main problem lies in the effort and health risks involved in manually making gypsum molds. Direct contact with gypsum powder and coloring materials can cause irritation to the skin and hands. In addition, the manual process requires significant time and effort, as each step mixing, coloring, pouring, and drying must be done carefully and repeatedly. By using an automated machine, these risks can be reduced, and the time required to produce molds can be minimized, making the process safer, faster, and more efficient.

1.2 Objectives

The main objective of this project is to build a machine that automatically prepares gypsum molds by measuring and mixing the required quantities of water, gypsum, and colors. This reduces the need for manual labor and makes the process easier, faster, and more consistent compared to handmade production.

This machine introduces several features as follow:

1. **Dual mold system**: The ability to prepare and pour mixtures into two molds at the same time.
2. **Automatic dispensing**: Adding water first, followed by gypsum, in the correct ratios.
3. **Mixing system**: Thoroughly mixing the materials to prepare a uniform base mixture.
4. **Coloring system**: Allowing the user to select any color using RGB control, with the option to create marble-like patterns by combining two colors.
5. **Pouring system**: Automatically pouring the prepared mixture into the molds.
6. **Drying system**: Ensuring the mixture solidifies inside the molds quickly and efficiently.

1.3 Scope of Work

1. Control the quantities of water, gypsum, and colors pumped from the containers according to the user's demand.
2. Develop a system that works sequentially to add the materials in the correct order (water first, then gypsum, then colors) and track the mixing stages at the appropriate time.
3. Testing and validating the system to ensure reliable performance and safe operation.
4. Provide a user interface that allows the operator to select the number of molds (up to two at a time), choose desired colors through RGB control, and even apply special effects such as marble-like patterns.

1.4 Significance

The growing interest in handmade crafts and home-based decoration projects, especially the production of gypsum molds and artistic designs, highlights the need for more efficient and creative production methods. Traditional mold-making is time-consuming, requires continuous manual effort, and often exposes individuals to direct contact with gypsum powder and coloring materials, which may cause irritation or health risks.

This project provides a simple and effective solution by automating the main steps of mold production—dispensing materials, mixing, coloring, pouring, and drying. The system reduces both the physical effort and the time required while also minimizing direct contact with raw materials. This makes the process safer, faster, and more consistent.

In addition, the ability to create a wide range of colors through RGB control, as well as decorative effects such as marble-like patterns, expands the creative possibilities for small-scale producers. By enabling easier and higher-quality production, the machine not only supports hobbyists but also contributes to the growth of home-based businesses and the wider handicraft industry.

1.5 Organization of the report

The report starts with the introduction, included the problem statement, the objectives of the project, the scope of work, significance.

The second chapter takes the limitations and constraints the forces us during work on the project, also the standards we use and the programs we used in coding and application, finally the earlier coursework.

The next chapter takes the literature review, In that chapter, relevant work and results are included.

Then, the chapter of methodology, which goes deeply on the project, its structure, components used to build it, the electronic hardware components, and talking specifically with details about how the system works.

The fifth chapter includes the results and analysis, then the conclusion and discussion chapter, which give the summary of the project, and the future work that can be done to the project.

Chapter 2

Constraints and Earlier Coursework

2.1 Constraints and limitations

1. The main problem was in found the perfect ratios for making the gypsum bold correctly.
2. Ensuring of insulation of the connections of pipes and pumps connected with the ingredients, to prevent leaks and electrical short circuits.
3. One of the challenges faced was that gypsum powder often got stuck and accumulated inside the funnel, making it difficult to flow down smoothly. To solve this issue, a mixer was added to prevent clogging and ensure proper dispensing.
4. Moving the container (that holds the mixture) on a belt without vibration.

2.2 Standards / Codes

1. We developed our code using the Arduino IDE, enabling us to control the hardware via the Arduino platform.
2. For communication, we utilized MQTT as our protocol, enabling clients to control the device through a specialized mobile application.
3. We created the mobile application using the App Inventor platform that providing the ability for the users to control the system remotely.

2.3 Earlier Coursework

1. Microprocessor and Microcontroller courses, we gained a knowledge of how to control the hardware components in our project.

2. The critical thinking course, which helps us to search through researches on some issues, in addition of helping in documentation and writing re- ports skills.
3. Wireless and networks courses played a vital role on understanding the communications between nodes, which help us in connecting the application with our system via connecting esp with Arduino.
4. Electronics course that provides instruction in various aspects of electronic systems and technologies.
5. Self-learning via YouTube Arduino courses, and different researches.

Chapter 3

Literature Review

In recent years, there has been a noticeable growth in small-scale handicraft industries, particularly in the production of decorative items such as gypsum molds and artistic designs. This trend is driven by economic needs, increasing interest in handmade products, and the flexibility of working from home. While these activities offer creative and economic opportunities, they also present challenges related to time, effort, and consistency in production.

One of the main challenges in manual gypsum mold production is the difficulty of handling materials such as gypsum powder and coloring agents. Gypsum powder can be messy, prone to clogging, and requires careful mixing and pouring to achieve uniform and high-quality molds. Additionally, producing artistic effects, such as marble-like patterns or custom colors, demands precision and patience, making the process labor-intensive and time-consuming.

Automation has been explored in various craft and small-scale production applications to improve efficiency, precision, and safety. Studies on automated systems for mixing, pouring, and handling materials in small-scale industries show that these technologies can significantly reduce manual effort, minimize errors, and improve consistency in the final product. For gypsum crafts, automation can control the ratios of ingredients, mixing speed, color blending, and mold filling, enabling more uniform and aesthetically pleasing results.

In summary, while handmade gypsum molds are highly valued for their artistic quality, automation offers a practical solution to overcome the challenges of labor intensity and material handling. Implementing automated systems can increase productivity, improve product quality, and support the growth of home-based or small-scale craft businesses.

Chapter 4

Methodology

4.1 System Structure

4.1.1 External structure of gypsum mold making machine

This structure was made of wood to facilitate drilling operations and fixing the pieces used in the project. It looks like a box from the outside, considering that the machine does not see the operations taking place inside it. What is important is the Gypsum it produces, as illustrated in the image that describes the model. As in figure 4.1 it's the project's design on solid work to know all the measurements and how the frame would be.

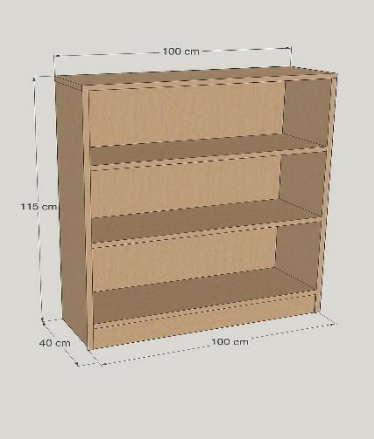


Figure 1 Machine frame design.

And after designing the frame ,we made it to wood frame on a carpentry .

4.1.2 Control system

The gypsum manufacturing machine features an advanced control system that enables operators to precisely configure production parameters through an intuitive interface. Using a keypad and LCD display, manufacturers can select the quantity of molds—either single or double production—and choose from an extensive color palette based on an RGB mixing system. The system allows optional addition of marble effects with secondary color variations for customized aesthetic finishes. Once parameters are set, the control system automatically manages the precise proportions of raw materials, including gypsum powder, water, and additives, ensuring consistent product quality. The entire manufacturing process—from material dispensing and mixing to mold filling, finishing, and drying—proceeds automatically after confirmation. Real-time monitoring provides statistics on material levels and production counts, while integrated cleaning cycles maintain optimal operational efficiency. This comprehensive automation streamlines gypsum product manufacturing while maintaining flexibility for custom orders.

Figure 2 control system

4.1.3 Adding water

The pumping system draws water from their storage containers and delivers it directly into the mixing bowl at precisely controlled moments during the production cycle.

Figure 3 Pumping for water and colors

4.1.4 Dispending Gypsum

Via the NEMA 17 motor, and using a coupler with a mixer, we made it mix inside the gypsum powder box so that the gypsum dispenses into the container.

Figure 4 Gypsum Dispending

4.1.5 Mixing mechanism

After pouring the basic ingredients into the container, we need to mix the mixture to get a homogeneous consistency, which are the basic ingredients for making Gypsum. In this process, we need a mixer and a motor to move it up and down until it enters the container, and we also need a motor for the mixing process.

Figure 5 Mixing

4.1.6 Adding colors

After the initial mixing process, the colors are added through their dedicated pumps according to the user's choice, and then the mixture is blended again to ensure uniformity. If the user requests a marble effect, the system first performs the normal base mixing and color blending, but then it reintroduces the selected colors once more, followed by a shorter mixing time to create the desired marble texture without fully blending the colors.

Figure 6 Colors

4.1.7 Container moving system along the production line

We used two cylindrical columns and a scraper to help move the heater by the motor to the right and left, so that the container stops at the bottom of each tube.

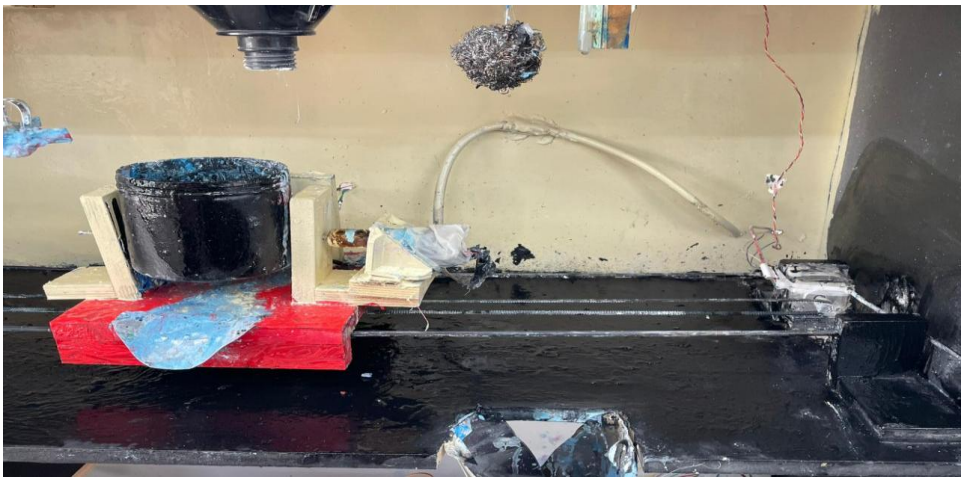
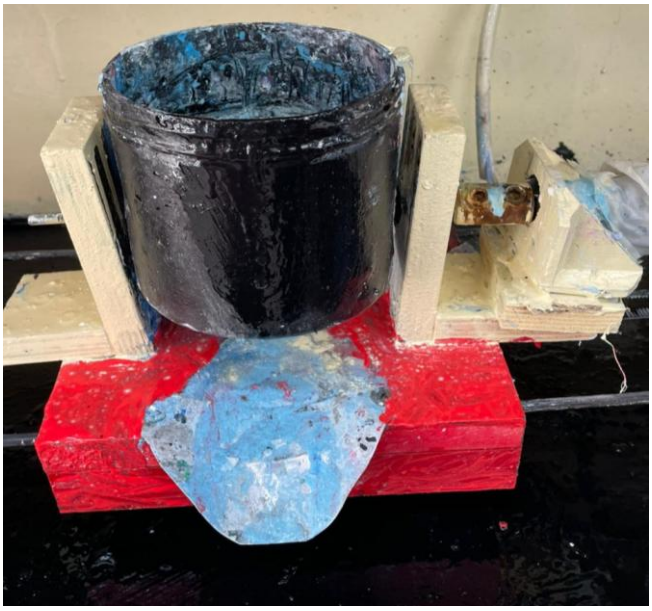


Figure 7 Container moving system along the production line

4.1.8 Mixture casting process

The pouring process is done by moving the container at a 90 degree angle using a motor. After the container contents are emptied of the mixture into a mold , the container rises at the same angle to return to its upright position.



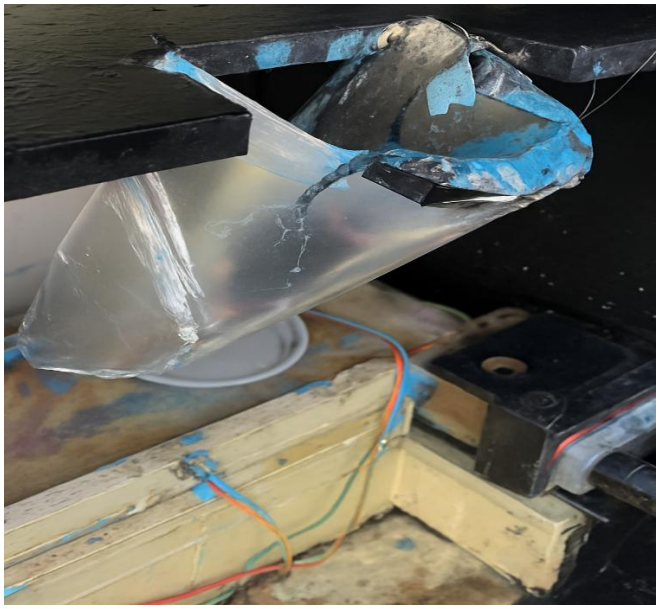


Figure 8 Mixture casting process

4.1.9 Mold preparation stage

On the second production line, a laser and an LDR are installed on the track. When a mold is detected, the mixture is then poured into the mold.

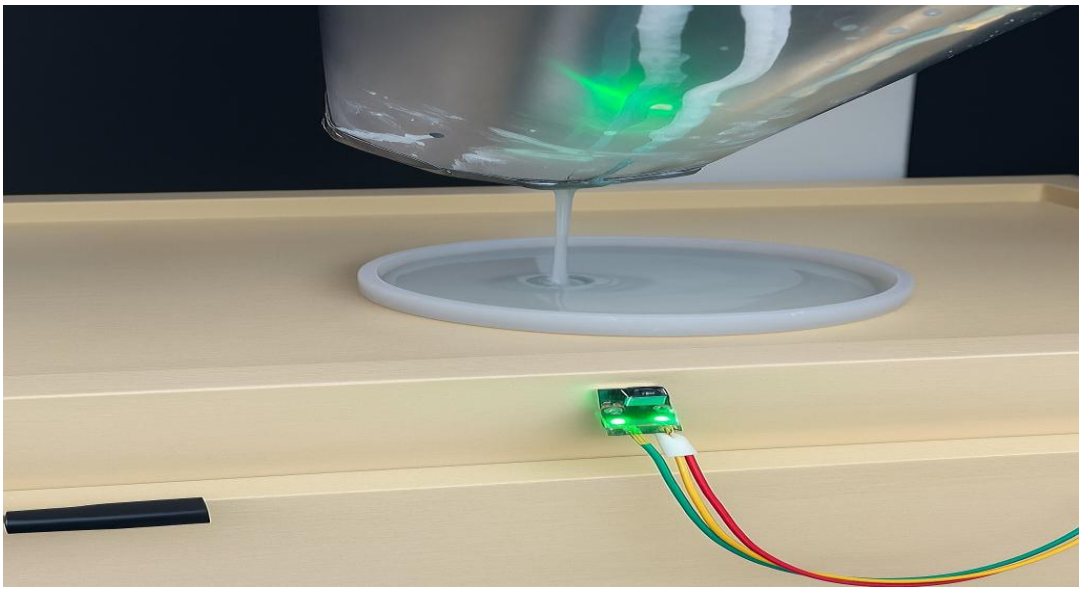


Figure 9 molds in the production line

4.1.10 Vibration System

We use two servo motors. After the mold reaches a certain position, one servo with an attached piece of wood stops in place, while the other servo pushes the mold toward the servo with the fixed wooden piece.

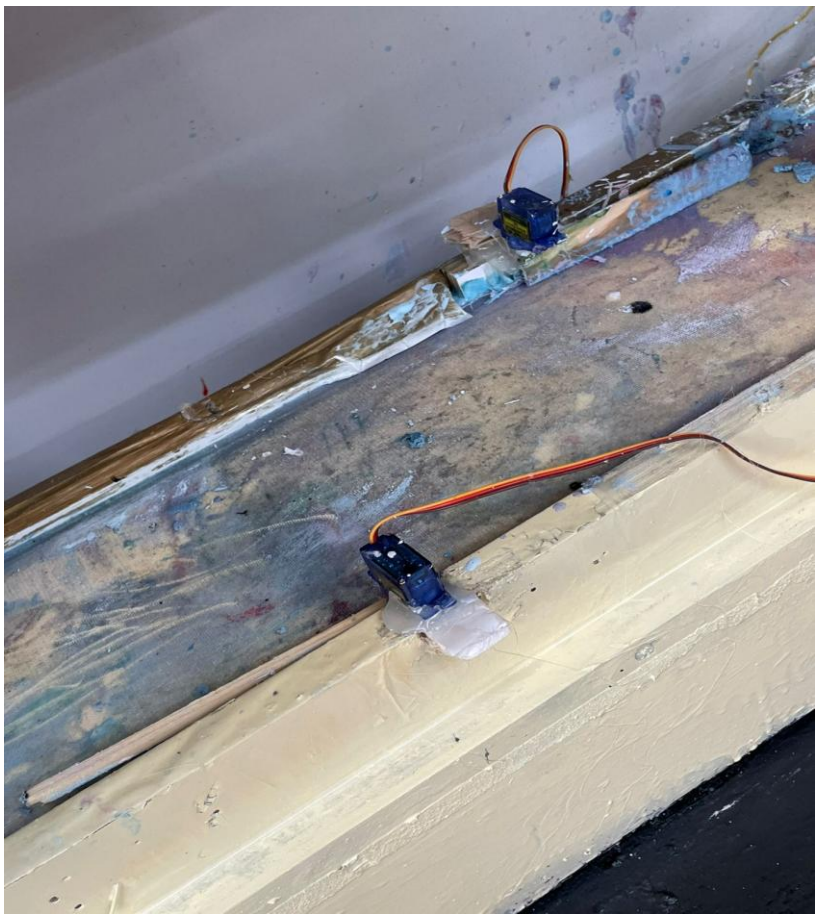


Figure 10 molds in the production line

4.1.11 Ventilation system

After the pouring process is completed, the fans start working, thus helping in the process of cooling the gypsum until it freezes and becomes ready for use.

Figure 11 Ventilation system

4.1.12 Cleaning system

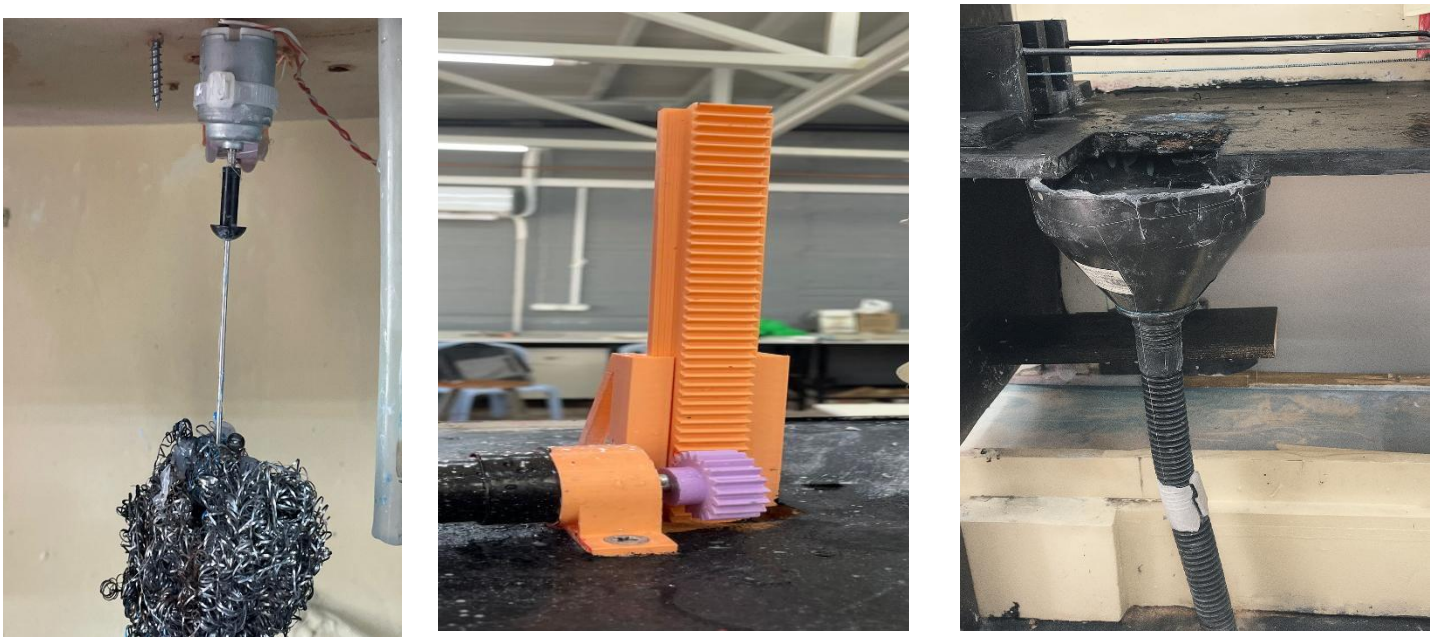


Figure 12 Cleaning system

4.2 Hardware components

4.2.1 Arduino MEGA

The Arduino Mega 2560 is a powerful microcontroller board designed for more complex and demanding projects. It is built around the ATmega2560 micro- controller, offering a larger number of input/output pins and more memory compared to other Arduino boards like the Uno. Specifically, it has 54 digital I/O pins, 15 of which can be used as PWM outputs, and 16 analog input pins, making it suitable for handling multiple sensors and actuators. The board also features 256 KB of flash memory, 8 KB of SRAM, and 4 KB of EEPROM, allowing for the storage of more complex programs and data. With 4 hardware serial ports (UARTs), it supports multiple communication channels simultaneously. Operating at a clock speed of 16 MHz, the Mega 2560 is equipped with a USB port for easy programming and communication, as well as a power jack and reset button. It is widely used in larger projects requiring more resources, such as robotics, automation, or multi-sensor systems, and is compatible with the Arduino IDE, making it accessible for developers of all levels.

Figure 13 Arduino MEGA.

4.2.2 Computer Power Supply

A computer power supply (PSU) converts AC power from an external source into the low-voltage DC power required by internal computer components. It provides different voltage levels like 3.3V, 5V, and 12V to power the mother- board, CPU, graphics card, and storage devices. The PSU's wattage rating determines how much power it can supply, and it comes with various connectors for different components. Many PSUs are 80 PLUS certified for energy efficiency and feature built-in fans for cooling. They also include safety protections such as over-voltage and short-circuit protection to ensure system stability and prevent damage.

Figure 14 Power Supply

4.2.3 Water Pump

High Pressure DC 12V 3.7A Water Pump. We used it to pump water forcefully from place to place. It used to pump water and RGB colors.

Figure 15 Water Pump

4.2.4 Ultrasonic sensor

Ultrasonic Sensor that measures the distance to an object using ultrasonic sound waves. In this project we used two ultrasonic sensors to measure the height of the cans of the water and gypsum level in the containers.

Figure 16 Ultrasonic Sensor

4.2.5 LDR Sensor

An LDR, or photoresistor, is a passive electronic component that modifications its electrical resistance due to varying light intensity. In the presence of light, LDR's resistance lessens; when hidden from light, its resistance intensifies. By harnessing their light-sensitive properties. It was used to sense the absence of the mold in order to prevent pouring the mixture when no mold is in place.

Figure 17 LDR Sensor

4.2.6 NEMA 17 Stepper Motor

There is a wide spread popularity of the NEMA17 stepper motor because of its small size as well as its great torque output, which makes it to be used in many places. It needs 200 steps to complete a revolution and these steps have an accurate angle of 1.8 degrees per step. Its coils can take a maximum current rating of 3.5 A each and one can also apply voltage inputs that range from 3 to 12 volts. It was used for moving the container forward and reverse, for rotating the mixer to mix the gypsum and water, and also for driving the mechanism inside the container to push the gypsum powder down from the funnel into the container.

Figure 18 Stepper Motor

4.2.7 SG37BL-A DC Brushless Gear Motor

A 12-volt DC Motor is used when both a high starting torque and good speed regulation is needed. In this project we used 3 DC motors to move the mixer up and down, as well as for controlling the vertical movement of the cleaning mechanism. The cleaning mechanism consists of a metal rod with a brush attached, which moves up and down to reach the container, and for the production line.

Figure 19 DC Motor

4.2.8 L298N Motor Drive Controller Board Module Dual H-Bridge

The H-bridge configuration is usually utilized to reverse the polarity /direction of the motor but sometimes it's also possible to use it for 'braking' the motor

i.e. when its terminals are connected together, the motor abruptly stops.

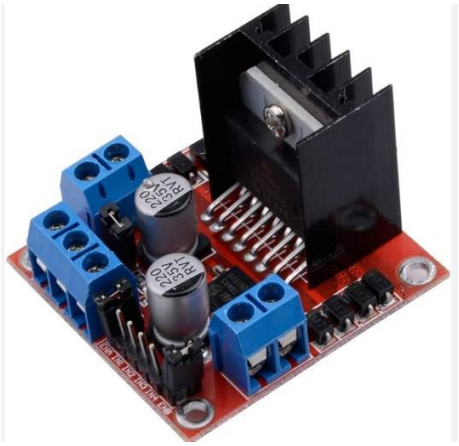


Figure 20 H-bridge

4.2.9 MicroStep TB6600 driver Stepper Motor Driver

The TB6600 driver was used to control the stepper motors in the project. It is a reliable and widely used stepper motor driver that supports both forward and reverse rotation with precise step control. The driver allows adjusting the current and micro stepping settings, which provides smoother motion, reduced vibration, and better accuracy for positioning. By using the TB6600, the stepper motors in the system were able to perform stable and efficient movements required for mixing, container positioning, and powder feeding.

Figure 21 TB6600 driver Stepper Motor

4.2.10 Relays

Relay is a device which is electrically controlled to initiate and end electrical connections, or activate and deactivate operation of other appliances within the same or different electrical network. We used active low relays to turn on/off the pumps and fans.

Figure 22 Relay

4.2.11 Stainless Steel Rods

Stainless steel round bars are utilized in the manufacture of structures, appli- ances, and machinery. We used it to put the heater above it to move on also the belayas.

Figure 23 Rods

4.2.12 4 x 4 Matrix Keypad

The 4 x 4 Matrix Keypad Module is a non-encoded matrix keypad consisting of 16 keys in parallel. The keys of each row and column are connected through the pins outside – pin R1-R4 as labeled beside control the rows, when L1-L4, the columns, we used it to make it as the controlling system of the machine to choose number of molds, colors and to show statistics for admin and to choose if need to do the cleaning process.

Figure 24 4 x 4 Matrix Keypad

4.2.13 Intercom Wires

We used them for wiring and connecting different components together.

Figure 25 Intercom Wire

4.2.14 Arduino Wires

To be able to connect the components to the Arduino.

Figure 26 Arduino Wires

4.2.15 Servo Motor

A servo motor is a type of motor that allows precise control of angular position, speed, and rotation. It is commonly used in applications where accurate movement is required, such as robotics, automation, and control systems. In this project, the servo motor was used to operate the gate of the gypsum funnel. It is connected to a small wooden plate acting as a door. When gypsum powder needs to be released into the container, the servo rotates to 90° to open the gate. When the flow needs to stop, the servo returns to 0°, closing the gate. This allows precise and reliable control of the powder dispensing process.

Figure 27 Servo

4.2.16 20x4 LCD screen

Being a popular alphanumeric display type, a 20x4 LCD screen can showcase up to 20 characters arranged into 4 columns. Widely used in electronic projects and devices, computing can display data/message via alphanumeric characters in devices such as thermometers, clocks, and interfaces. It displays all the choices that the admin can choose to make a gypsum mold and the statistics of the machine.

Figure 28 LCD Screen

4.2.17 I2C LCD Driver

I2C LCD Display Adapter is specially designed to drive LCD Display using only 2 data pins. This module uses the I2C serial bus to communicate with microcontroller like Arduino. Normally it requires minimum 6 data pins to use a lcd display. It creates a problem when multiple sensors and is module is using with Arduino at the same time. Because Arduino has limitation of I/O pins. This I2C LCD Display driver will help to reduce the uses of pin of your Arduino and makes the project easier. You can use this module with other I2C supported device on the same line and at the same time.

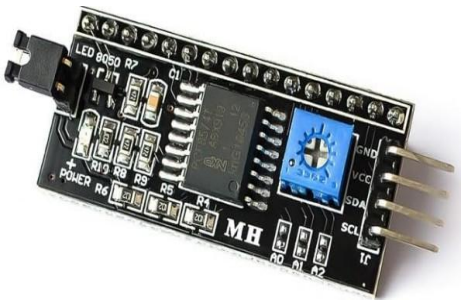


Figure 29 I2C LCD Driver

4.3 How the system works?

Since the Arduino mega and esp8266 connected to the power, and the application is now opened and the WIFI network is the one for the Esp, the system starts, and all components are stopped, waiting for the user to choose what process he need, the processes are as follow:

4.3.1 Start the system (Pumping, Filling, Mixing, Pouring, Vibration, Ventilation)

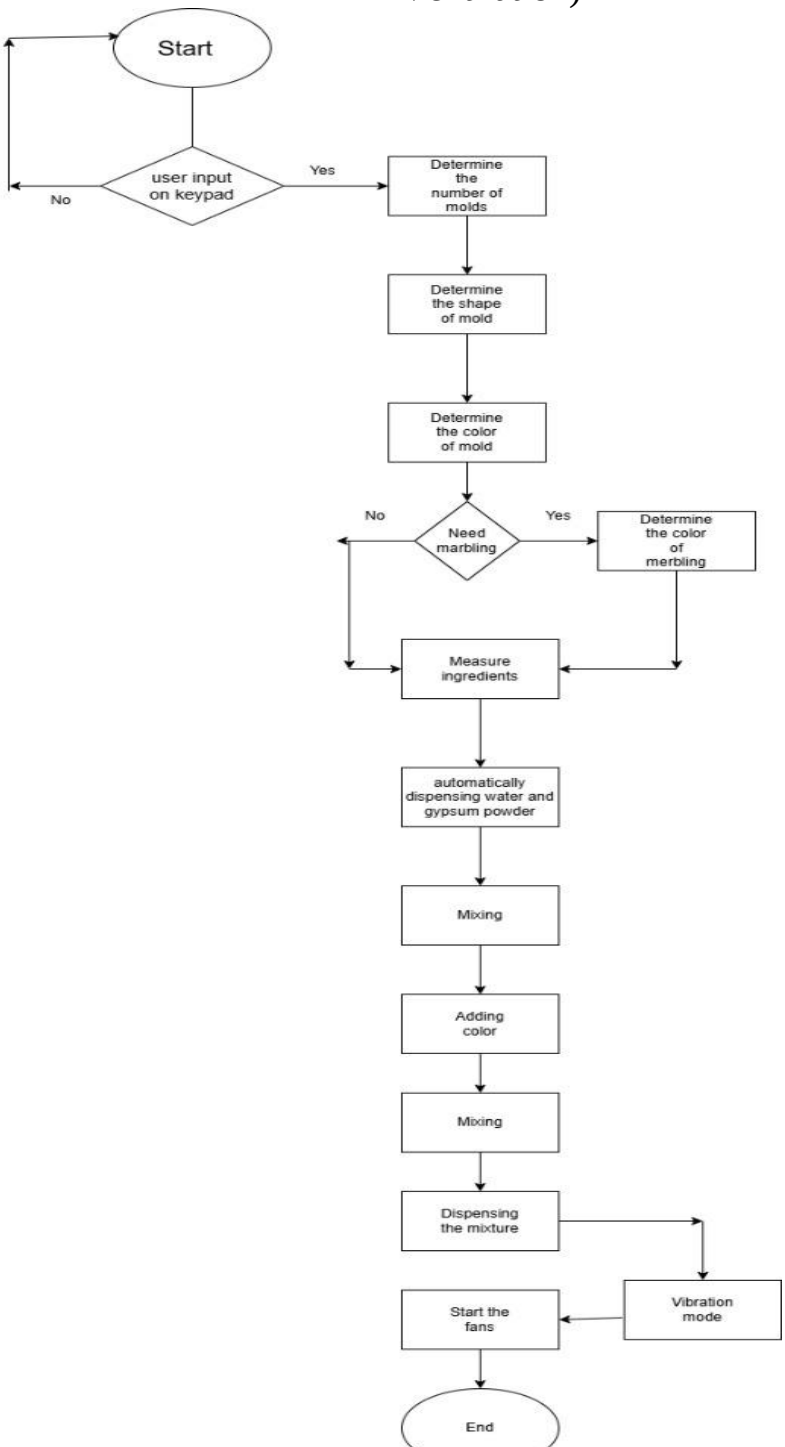


Figure 30 Making Gypsum Flow chart

1. Start
2. User input on keypad
3. Choose how many molds
4. Choose which mold
5. Choose color
6. Choose if marbling is needed
7. Start the process
8. Dispense the water
9. Dispense the gypsum
10. Mixing
11. Add color
12. Mixing
13. Return to color step if marbling is selected
14. Dispense the mixture
15. Vibrate
16. Ventilation (fan)
17. Final result

selects how many molds to use and which specific mold will be filled. Next, the user chooses the desired color and decides whether marbling is required. After the selections are made, the process starts automatically. The system begins by dispensing water and gypsum powder, followed by mixing. The selected color is then added, and mixing continues to ensure uniformity. If marbling is required, the system returns to the color step to apply the marbling effect. Once mixing is complete, the mixture is dispensed into the molds. The molds are then vibrated to remove air bubbles and ensure proper filling. Finally, the molds are moved to the ventilation stage with fans, leading to the final result.

Chapter 5

Results and Discussion

The foray into the creation of the gypsum production machine has produced highly encouraging developments. This section outlines the key results we have achieved and how they may shape the future of gypsum processing, both for household and small industrial use, as well as other perspectives.

Efficiency in Production

One of the most significant results was the dramatic reduction in the time required for gypsum preparation and molding. Traditionally, preparing gypsum manually was a labor-intensive process that consumed hours of continuous work and effort. With our machine, the sequence of pumping, mixing, coloring, and pouring has been streamlined, saving both time and energy. This is not only about saving a few hours; it is about allowing workers to use their time more productively, making the process of gypsum production more efficient and less exhausting.

For workers and small manufacturers handling gypsum alongside other responsibilities, this time-saving factor is truly revolutionary. The machine not only accelerates the entire workflow but also enables higher production output without increasing the physical effort required. This improvement creates opportunities for small producers to expand their operations, meet higher demands, and achieve better quality results with ease.

5.1 Safety Improvements

As stated above, safety was a critical concern for this project, and we believe we are right in saying that the machine significantly reduces

the amount of manual work required when dealing with gypsum powder and chemical color additives. During the mixing and pouring stages, we have integrated automation technology, which minimizes the need for the operator to come into direct contact with these materials. This makes the process considerably safer for the user.

This improvement in safety is particularly valuable for small workshops or individuals who work from home and may not have access to advanced protective equipment. Since the machine performs the most risky operations—such as dispensing the powder, mixing, and pouring—the health of the user is better protected, and the chances of respiratory issues, injuries, or long-term health concerns are greatly reduced. This marks an important step forward in making gypsum production processes safer, more user-friendly, and aligned with modern health and environmental standards.

5.2 Customization Capabilities

A part from the core process, we also integrated a color selection system, which allows the user to choose any desired color for the gypsum products from a wide range of options. This feature enables the creation of custom-made molds with unique colors, introducing possibilities that were not previously available in the market. During testing, this feature received positive feedback as it encouraged creativity and experimentation from the users.

Customization provides a competitive edge in a market where consumers appreciate personalized and aesthetically pleasing products. It allows small-scale gypsum producers to cater to niche markets and offer alternatives to standard, mass-produced items. This feature not only makes the products more appealing and marketable but also adds a personal touch that end-users value and enjoy.

5.3 Consistency in Production

Over the years of developing the gypsum production machine, one of the most significant accomplishments has been the ability of the

machine to produce gypsum products of consistently high quality. Thanks to the automated mixing, color integration, and controlled dispensing systems, each batch is expected to meet the same standards, which is crucial for building and maintaining customer trust.

Maintaining quality control is essential in any production process, including small-scale or artisanal manufacturing. A systematic and cyclical approach to preparation ensures that every gypsum mold or product meets the required specifications. This reliability not only reassures customers about the consistency of the products but also encourages repeat purchases, helping small producers establish a strong reputation and competitive standing in the market.

5.4 Reduction in Labor

The workload that the gypsum production machine handles helps to take physically demanding tasks away from the user, thereby reducing the amount of manual effort required. Operations that previously demanded constant attention—such as mixing, pouring, and monitoring the process—have now been automated.

For many operators, especially those managing multiple responsibilities or working in small workshops, easing the physical strain during gypsum preparation is a significant improvement. This not only helps preserve the user's health but also makes the overall production process more convenient, efficient, and enjoyable.

5.5 User Interface and Control

We designed a mobile application to control the machine such that even the non-technical people will find it easy to use. The app lets the user define the quantity of bars to be made, the colors, the fragrances, and the entire process through a smartphone.

Aside from the costs of general acceptance of technology, the general interface and mobile app should be designed to have the additional layer of ease of use for all people. The mobile app also integrates with the busy lifestyles of the users. It has control of the

cabinet within the Gypsum production cycle, thus making it more flexible for the users.

5.6 Challenges and Limitations

Bumpy roads aside, it should be noted that challenges were not absent during the development of the gypsum production machine. One of the main difficulties was managing the correct ratios of gypsum powder, water, and color additives to achieve the desired consistency. Additionally, controlling the timing and sequence of mixing and dispensing to ensure uniformity presented occasional obstacles.

While the operation of the machine was generally smooth, there were instances where manual adjustment was needed to achieve the optimal mold fill or texture, reflecting the varying degrees of malleability caused by differences in the mixture's composition. These challenges provided valuable insights into refining the machine's automated processes and improving overall product quality.

5.7 Future work

Make the admin have the flexibility to choose the mold he wants and to put it on the production line using an arm.