Project Deliverable H: Prototype III and Customer Feedback GNG 1103 – Engineering Design

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Abstract

This report details the progression and evaluation of a high-fidelity erosion testing prototype designed to analyze the effects of mass on torque of a motor. The purpose of the prototype is to make improvements from our last design and to confirm the validity of the design approach, minimize potential risks, and collect input for further enhancements. We utilized a targeted prototyping strategy that involved assessing feasibility, analyzing critical subsystems, and facilitating effective communication to iterate on improvements. Through meticulous documentation, thorough analysis, and feedback from users, our objective is to deepen our understanding of how water erosion impacts core samples and move towards developing a more resilient solution.

During the third prototype development phase, we made enhanced modifications and constructed a proof of concept. We connected our motor and Arduino and tested the code. Erosion tests were conducted by submerging the core sample in water and observing changes in mass loss. The prototype effectively validated both feasibility and functionality while also providing valuable insights for refinement.

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1 Introduction

Regarding our ongoing project investigating water erosion on core samples, we've completed the construction of our first and second prototypes and are in the process of crafting our third prototype with modifications tailored to address the specific objectives outlined in our project blueprint. The primary objective of this prototype is to create a final prototype to present for the client's design day and to validate the effectiveness of our approach while minimizing risks and gathering essential feedback for further enhancement. Our prototyping strategy is focused on achieving predetermined objectives, including viability analysis, thorough examination of subsystems, and facilitating efficient communication to foster incremental advancement. Through meticulous documentation, and user input, we anticipate deepening our understanding of water erosion's impact on core samples, thus propelling us closer to the development of a more robust solution.

1.1 Objective

Our central focus in the development of our third prototype is aimed at refining our design compared to the previous prototypes and to enhance feasibility and effectiveness to a product capable for design day. This third prototype is a closer and more of a final representation of our innovative erosion analysis device, showcasing its pivotal features and components. Our objectives for validating and testing the prototype includes the following:

- ☐ Validate the feasibility and functionality of the Core Sampling System prototype.
- ☐ Gather easily accessible and cost-effective materials and components for testing, including a Stepper Motor, and a motor driver.
- ☐ Validate our code and assess compatibility with our motor, while also soliciting feedback to enhance our understanding of the prototype.
- ☐ Gather feedback and insights from potential users or clients to refine the design.

Testing Procedure - To achieve these goals, we have devised specific testing procedures:

- ☐ Conduct power distribution testing to ensure compatibility and functionality.
- ☐ Evaluate structural integrity by subjecting the prototype to rotational forces.
- ☐ Assess the functionality of the sampling mechanism and its real-time visualization capabilities.
- ☐ Implement Arduino-based RPM modulation to control the stepper motor's dynamic manipulation, thereby validating our code and achieving our objectives.
- ☐ Gather feedback from potential users or clients through demonstrations.

Stopping Criteria - The testing process will conclude when:

- ☐ All key subsystems of the prototype demonstrate functionality and feasibility.
- ☐ Feedback from potential users or clients is collected and analyzed to guide design refinements.

2 Testing plan and Results

2.1 What

Our plan involves creating a key third prototype that has been improved from our last design to replicate the essential functions of the Core Sampling System. This prototype will center on critical subsystems including power distribution, Code effectiveness, and the seeing all .

2.2 Why

The process of prototyping plays a crucial role in validating our design concept, pinpointing possible challenges, and soliciting input from prospective users or clients at an early stage of development. Through prototyping, our objectives include risk reduction, design enhancement, and assurance that our eventual product aligns with the requirements and anticipations of our intended users.

2.3 When

The final design development will start immediately after finalizing the design specifications and objectives. It will be completed within 1 week to align with project deadlines and testing objectives.

2.4 Third Prototype Design

Firstly, to test our theory of our prototype design we need to gather materials and components that are easily accessible and cost-effective. We gathered a Stepper Motor, a clear container, and a motor driver for our third prototype design to test whether or not our code will work and we will be able to achieve our objectives.Implement Arduino-based RPM modulation: The focal point of this prototype involved the utilization of Arduino programming to control the dynamic manipulation of the stepper motor's RPM.

The primary aim of this prototyping test plan is to validate our code and see if our Arduino is compatible with our motor, soliciting feedback to enhance the comprehension of our Prototype

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Test Components:

- Arduino
- Efficiency of the stepper motor
- Investigate practical applications and contextual relevance

Here's a breakdown of what our findings suggest:

- **Code:** Our code successfully enabled RPM adjustments, allowing us precise control and optimization of motor speed to meet our requirements.

- **Efficiency of Motor:** After attaching the motor to the shaft and observing its behavior with the clamp, we noticed a decrease in speed, necessitating an increase in RPM to sustain the desired flow rate.

Data Collection and Documentation:

In this experiment, we coded the Arduino testing procedure to ensure we gathered accurate and well-organized data for further analysis. Here's our detailed plan for data collection and documentation:

Test Parameters

- Programmed Arduino to control RPM (Revolutions Per Minute) of motor.
- RPM varied in increments of 250.
- Conducted experiments by increasing mass in increments of 100g.
- Observed effects on motor torque with each mass variation.

Decreased Torque:

As we continue to increase the mass being handled by the motor, so does the demand placed upon it. This increase in load necessitated the motor to exert more effort to counteract the applied resistance. Furthermore, this additional strain resulted in a reduction in the motor's torque output, as it dissipated the energy to overcome the amplified challenge.

Motor Heating:

We observed a decreasing torque curve in our stepper motors as the load increased, indicating potential influences such as thermal effects, magnetic saturation, or voltage constraints. Understanding these factors are critical for optimizing motor performance and ensuring reliable operation in our applications.

Documentation

We created a dedicated logbook (or a digital spreadsheet) to record all the data points in an organized manner. This includes:

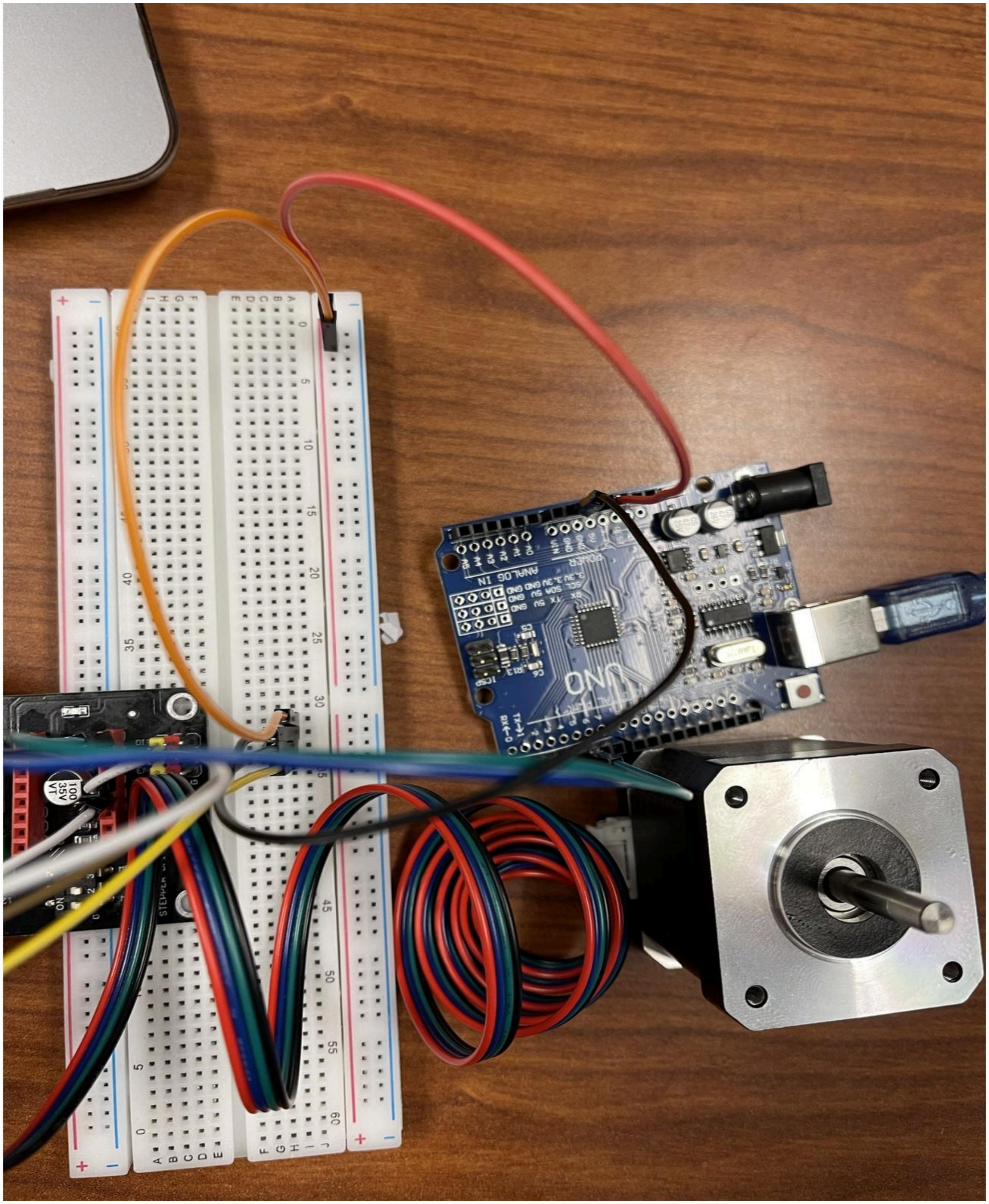
- Rotation speed of the Motor (RPM)
- Variation of Mass (load)

We also included a designated section in our logbook for any observations or notes during the testing process, such as unexpected occurrences or equipment malfunctions.

Digital Photos:

- We have attached the picture of our code and analytical along with a physical Prototype.

  We used a clear and consistent naming convention for the image files that incorporates the sample identifier, pre-test/post-test designation, and date.

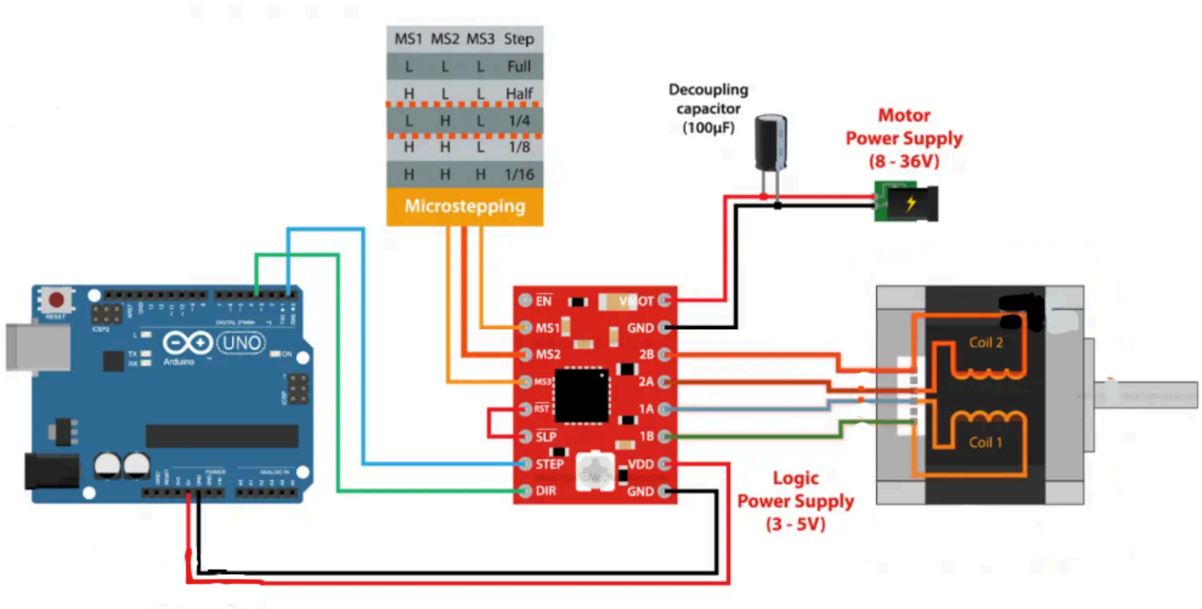


For efficient organization and annotation of the photographs, we might consider using image management software.

```
// defines pins
#define stepPin 2
#define dirPin 5

void setup() {
  // Sets the two pins as Outputs
  pinMode(stepPin,OUTPUT);
  pinMode(dirPin,OUTPUT);
}
void loop() {
  digitalWrite(dirPin,HIGH); // Enables
  int y = 800; // This value changes how
  for(int x = 0; x < y; x++) {
    digitalWrite(stepPin,HIGH);
    delayMicroseconds(700);    // by cha
    digitalWrite(stepPin,LOW);
    delayMicroseconds(700);
  }
  delay(1000); // One second delay
}

```



Analysis and Evaluation:

This information helps solidify the case for erosion analysis tool development. Through the thorough testing and documentation of our prototype, we've gained valuable insights into its performance.

Our findings reveal that the utilization of Arduino-based RPM modulation effectively allows us to control and manipulate the stepper motor's RPM. Our experimentation with varying masses and observing the motor's response highlights the importance of understanding torque output under different load conditions, mirroring the effects of erosion on core samples.

Our successful implementation of the Arduino integrated with the stepper motor, shows the effectiveness of our code. This achievement reaffirms our confidence in the feasibility of our erosion prototype development.

This analysis identifies the significance of our prototype's capabilities in simulating erosion and provides a solid foundation to put together and assemble our development towards the final prototype design.

3 Analysis of Critical Components and Systems

Our solution has 3 key components and subsystems that make up the overall design, these are the motor system, the axle system and the container. Each of these systems will be combined to create our solution.

3.1 Motor System

This subsystem includes the motor and its driver, an arduino, power supply, and a laptop. The way this system works is by connecting the arduino to a laptop and the motor driver, the driver is connected to the motor and a power supply, the motor is also attached to the axle. This setup will allow us to control the motor using the laptop through the arduino and driver. We will also be able to view data during testing on the laptop.

3.2 Axle System

This system will be attached to the motor via an axle and will also include clamps and the testing sample, the axle will connect at the top of the container with the motor. The clamps will attach the sample to the axle ensuring it doesn't fly off during testing. The clamps need to be strong enough to not lose the sample but not so tight it impedes testing.

3.3 Container

The container is a vital component of the solution since it will prevent all the water from leaking or spilling. There are a few different requirements for a container to be effective. First it must be strong enough to hold the force of the water without breaking. The entry point for the axle must be sealed properly to ensure no leaks. The canister also needs to be transparent to allow users to see the interior of the container during testing.

4 Conclusions and Future Testing Plan

The prototype development phase successfully achieved its objectives of validating feasibility and functionality while gathering valuable feedback from potential users or clients. The insights gained from this phase will guide further refinement of the design in preparation for the next and final iteration of the prototype. This project proposes feasibility of our Arduino, the efficiency of our stepper motor and the practical application for our final prototype. For our final presentable prototype for design day, we will put more of an investment towards stabilizing the container and assembling the entire design system together.

5 Reference

Speed - torque curves for stepper motors. (n.d.). Oriental Motor U.S.A. Corp. https://www.orientalmotor.com/stepper-motors/technology/speed-torque-curves-for-stepper-motors.html

Dejan. (2022, October 13). *Stepper Motors and Arduino – the ultimate guide*. How to Mechatronics. https://howtomechatronics.com/tutorials/arduino/stepper-motors-and-arduino-the-ultimate-guide/