Project Deliverable G: Prototype II and Customer Feedback GNG 1103 – Engineering Design

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Abstract

This report details the progression and evaluation of a medium-fidelity erosion testing prototype designed to analyze the effects of water erosion on core samples. 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 second prototype development phase, we made enhanced modifications and constructed a proof of concept using easily accessible materials such as a milk frother motor, transparent container, test sample (glycerin soap), and elastic band. 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 concerning the study of water erosion on core samples, we have built our first prototype and are in the process of crafting a second prototype with modifications tailored to the specific goals delineated in our project blueprint. The primary objective of this prototype is to substantiate the soundness of our devised approach while mitigating risks and soliciting crucial feedback for refinement purposes. Our prototyping strategy is focused on meeting predetermined goals, including viability analysis, close examination of subsystems, and encouraging efficient communication to enable incremental progress. By means of comprehensive documentation, rigorous examination, and user input, we anticipate deepening our comprehension of the impact of water erosion on core samples, thus advancing towards the development of a more resilient solution.

1.1 Objective

Our primary aim in developing the second prototype is to make modifications compared to our last prototype to improve the feasibility and effectiveness of our proposed design. This prototype will serve as a tangible embodiment of our innovative erosion analysis tool, highlighting its essential features and components. The objectives for validating the prototype and conducting testing procedures include:

- ☐ Validating the feasibility and functionality of the Core Sampling System prototype.
- ☐ Soliciting feedback and comments from potential users or clients to refine the design.

Testing Procedures:

- ☐ Perform 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.
- ☐ 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 fundamental second 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, structural robustness, and the sampling mechanism.

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 prototype development will start immediately after finalizing the design specifications and objectives. It will be completed within 2-3 weeks to align with project deadlines and testing objectives.

2.4 Second 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 milk frother (motor), a clear container, a test sample (glycerin soap), and an elastic band for our second prototype design to test the hypothesis of our plan whether or not erosion will occur. We constructed the chamber using the plastic container, ensuring there are no holes for leakage of eroding fluid. Attach the core sample to the motor and bearing with the elastic band. Integrate the variable-speed fan motor into the chamber, ensuring compatibility for speed modulation.

We conducted erosion tests with the core sample and emerged it into the water and observed changes in loss of mass of the initial sample.

The primary aim of this prototyping test plan is to empirically validate the impact of water erosion on a designated core sample, solicit feedback to enhance the comprehension of erosion effects, and gauge the feasibility of proposed solutions for erosion mitigation.

Test Components:

- Core Sample Preparation:

- We selected a piece of glycerin soap, initially measuring (4.20cm x 2.30 cm), as our core sample, and utilized tap water mixed with about 60 g of sea salt for your erosion testing.

- Erosion Impact Analysis:

· The measurements (3.80 cm x 1.80 cm) show a reduction in size due to erosion. The smoothed edges are another strong indicator of erosion by wind, water, or even fragmentation.

Here's a breakdown of what our findings suggest:

- **Size reduction:** glycerin soap losing dimension signifies material loss due to erosion.
- **Smoothened edges:** This is a classic sign of erosion. Wind, water, or even physical breakdown can wear down the sharp edges, creating a smoother profile.

Data Collection and Documentation:

In this experiment, we refined my glycerin soap erosion testing procedure to ensure we gathered accurate and well-organized data for further analysis. Here's our detailed plan for data collection and documentation:

Sample Information

- We started with glycerin soap samples measuring **4.20 cm x 2.30 cm**
- Using a calibrated balance with a precision of at least 0.001 g, I meticulously measured the initial weight of each sample. The initial weight of one sample was **7.50 g** (record the initial weights of all your samples here).

Test Parameters

- I maintained a consistent water temperature of **20°C** inside the testing Container throughout the experiment using a reliable thermometer.
- The stirrer was set to a constant rotation speed of **1500 RPM**.
- Each glycerin soap sample underwent erosion testing for a total duration of **10 minutes**. I might consider replicating the test with multiple samples at this duration for more robust data.
- A simulated environment was established using **3.5 liters** of deionized water to which **60 grams** of sea salt was added.

Erosion Measurements

Weight Loss:

After the erosion test, I precisely measured the final weight of each sample using the same balance. Well then calculate the weight loss by subtracting the final weight from the initial weight and recording the value in grams (g).

Surface Imaging:

- We captured high-resolution digital photographs of the glycerin soap sample surfaces before and after the erosion test. We ensured consistent lighting and maintained the same picture orientation for all images for accurate comparisons.
- We standardized the image resolution (e.g., megapixels) and magnification level to capture consistent details across all samples.
- To aid in size comparison during analysis, we considered including a reference scale (ruler or grid) in each image.

Documentation

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

- Date of testing
- A unique serial number or identifier for each sample
- Initial dimensions (length, width, thickness) of each sample (cm)
- The initial weight of each sample (g)
- Water temperature (°C) during the test
- Rotation speed of the stirrer (RPM)
- Duration of the erosion test (minutes)
- Final weight of each sample after testing (g) (recorded after measurement)
- Calculated weight loss for each sample (g) (replace with your calculated value)

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

Digital Photos:

- We organized the high-resolution images of the glycerin soap samples (before and after the test) in a designated folder on my digital storage system.

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.


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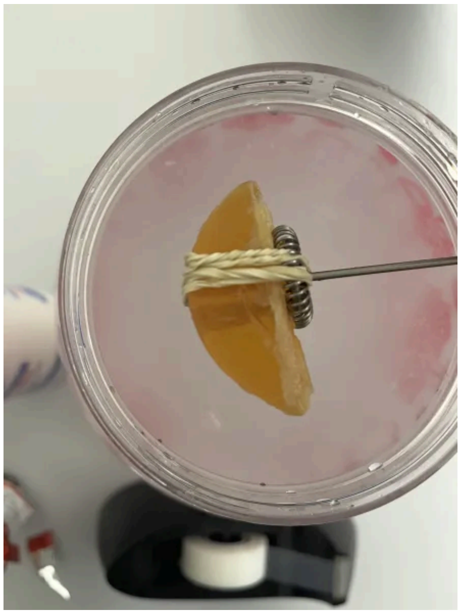

Analysis and Evaluation:
This information helps solidify the case for erosion. With the original dimensions being 4.2 cm x 2.3 cm and the current measurements at 3.8 cm x 1.8 cm, we can calculate the amount of material eroded.

Running the calculations again:

- Length loss: 4.2 cm (original) - 3.8 cm (current) = 0.4 cm
- Width loss: 2.3 cm (original) - 1.8 cm (current) = 0.5 cm

Therefore, the glycerin soap eroded by 0.4 cm in length and 0.5 cm in width. The larger width loss compared to the length loss suggests erosion might have impacted the wider side more.

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 iteration of the prototype. For our future prototype we can put more of an investment towards making a mount to attach the core sample and the design together.This project proposes investigating the feasibility of using stepper motors on our further prototypes.While coffee frother motors offer a functional solution, stepper motors hold the potential to deliver superior control and customization, leading to a more consistent and user-friendly experience.

5 Reference

1. *Pears Transparent Soap ingredients (Explained)*. (2020, November 11). INCIDecoder.

   https://incidecoder.com/products/pears-transparent-soap