Deliverable F - Prototype 1 and Customer Feedback

GNG1103 - Engineering Design
Winter 2024

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Introduction

In this deliverable, our team presents prototype 1. A culmination of our designs and testing phases. This document focuses on both the assembly and testing processes of our first prototype. We define the independent variables and test conditions, provide a thorough description of each component and subsystem, including their functions, and detail the dimensions of critical elements such as the aluminum shaft and shaft coupling. In addition, this deliverable includes feedback from our second client meeting and how we have integrated this valuable input into our design iterations. Through analysis, we received feedback from former CNL engineer Jim Mitchel, as well as a dean's list mechanical engineering Sohan. Finally, we have developed vital criteria that our system must complete in order to achieve reliable test results.

Objective

To develop and evaluate our first prototype, formulating, and creating a positive test plan to guide the development of subsequent prototypes. This requires collecting and integrating customer feedback to improve our design.

Client Feedback

Canadian Nuclear Laboratories (CNL) appreciated the simplicity and effectiveness of our first erosion test system design, particularly praising the circular tank and the motor holder/protector that ensures the safety of the electrical components. However, CNL raised concerns about our initial proposal to use acid in the slurry water and were reluctant about the feasibility of the rotating rock tumbler test system depicted in some of our sketches.

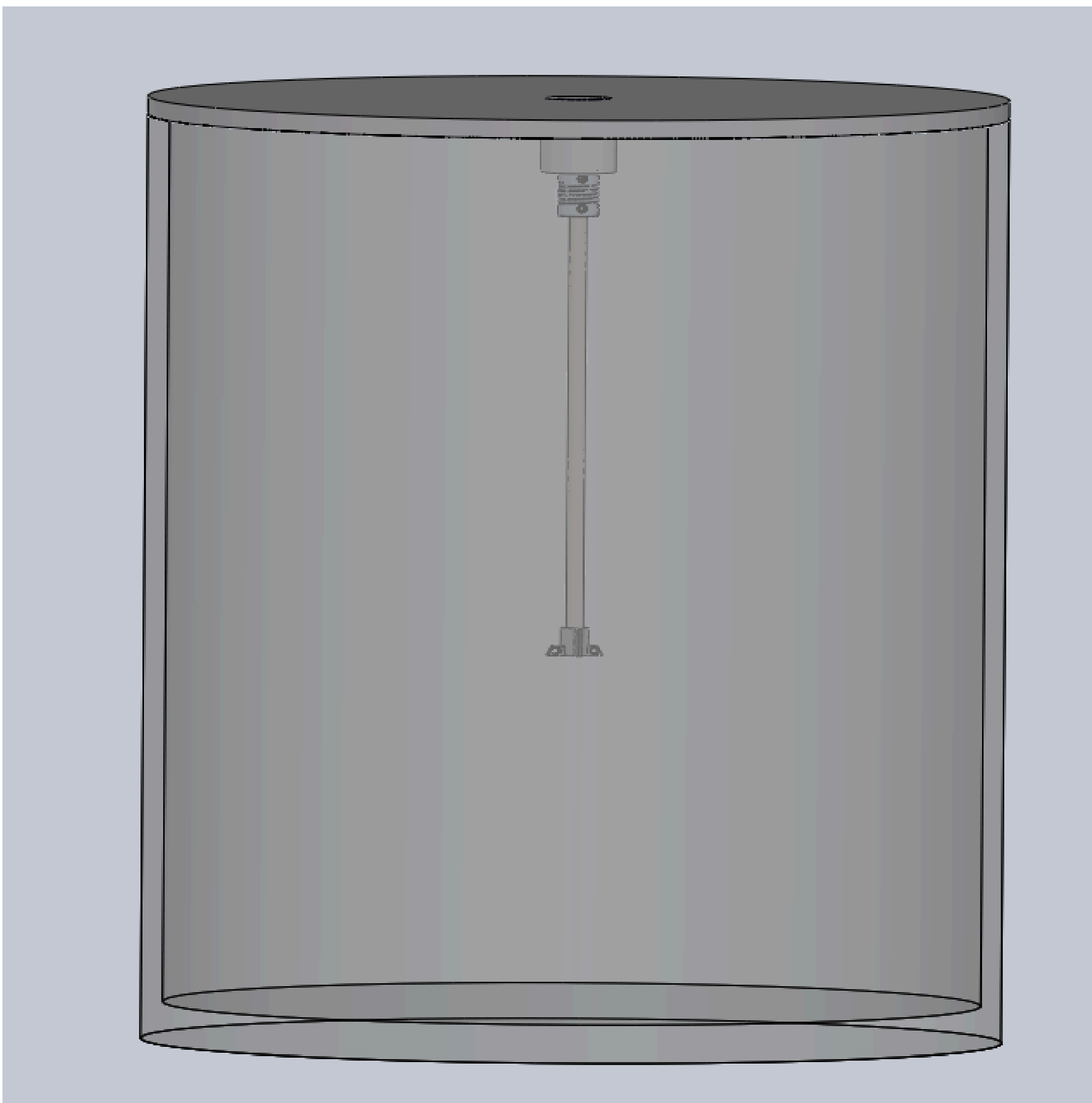
In response to CNL's feedback, we have refined our approach, opting for a straightforward yet adaptable design that promises to deliver reliable results. We decided against incorporating acetic acid into our slurry water due to potential safety risks and compatibility issues with certain test materials. Instead, we will use plain water (H_2O), possibly adding some salt, and will introduce harsher conditions through the use of two types of abrasives: silica sand and rock tumbler grit. This adjustment aligns with our commitment to safety and effectiveness while maintaining the integrity of our testing process.

As we progress, we are committed to applying all of our clients' feedback, concerns and desires in every design decision. Our plan involves iterating prototype 1 twice; while obtaining feedback & analysis in-between each step.

Prototype Development

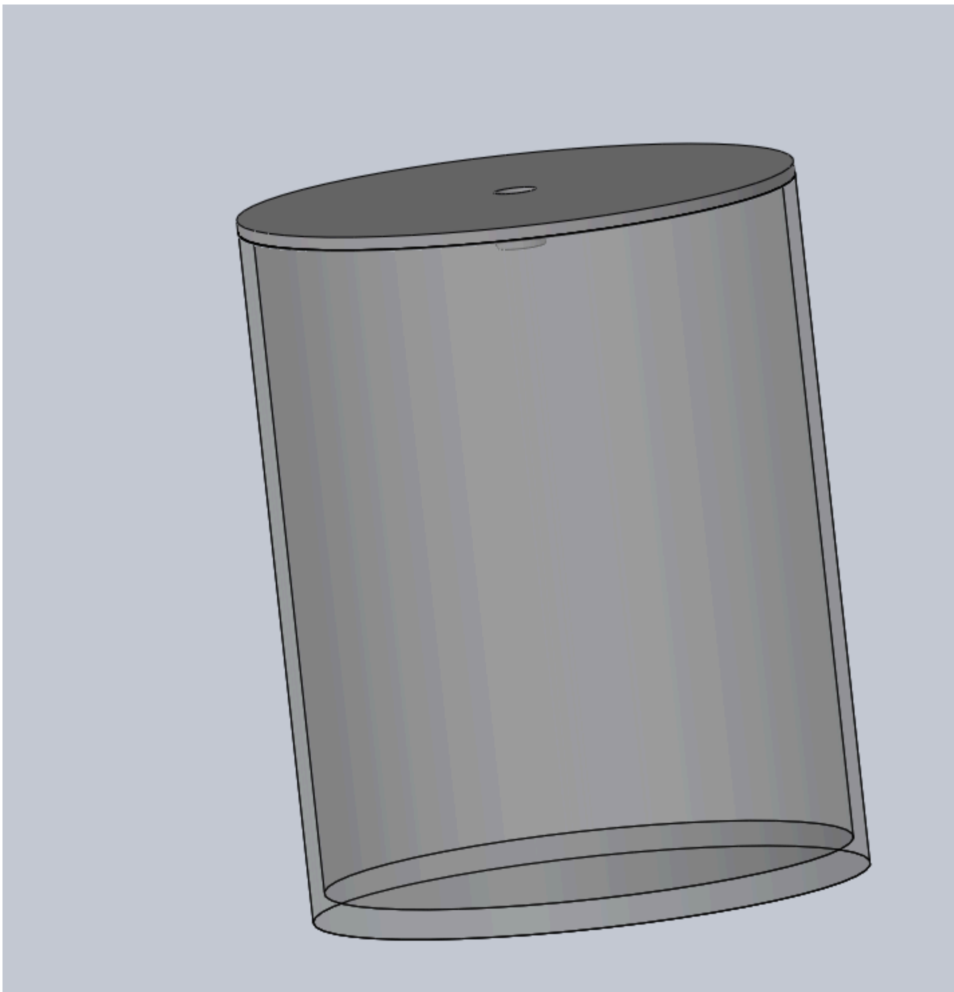
CAD analytical prototype:

Critical component analysis:



Prototype 1 (excluding the top half)

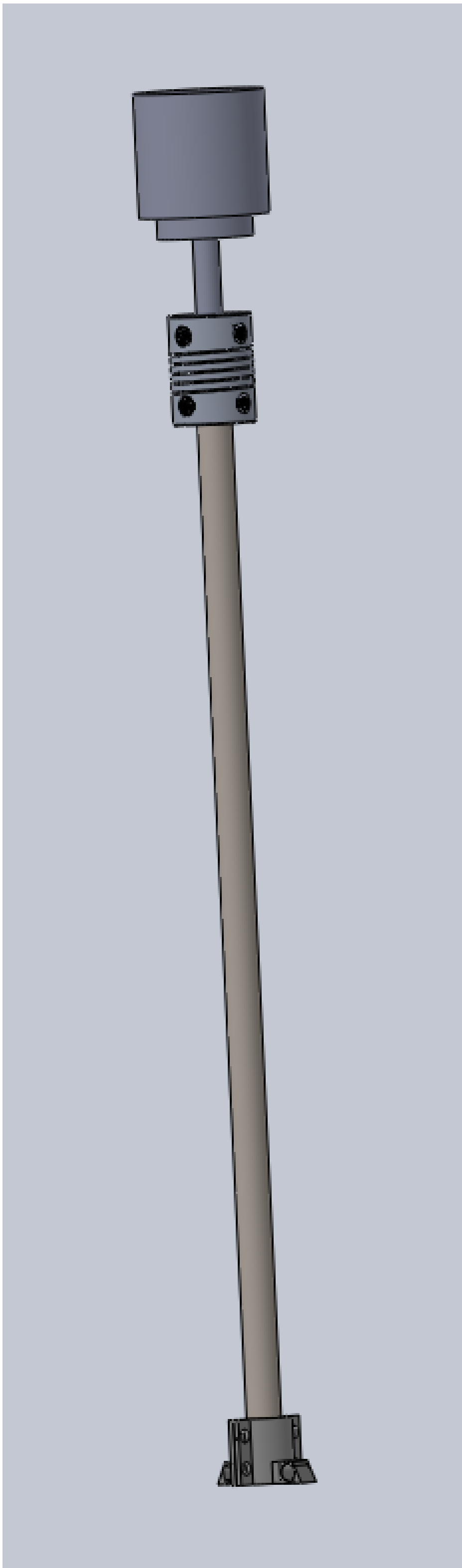
Tank:
The tank is a container vessel that holds both the material being tested and the abrasive particles used to simulate erosion. It provides a controlled environment for the erosion test, ensuring that the conditions remain consistent throughout the testing process. The tank's design may vary depending on the specific requirements of the erosion test, such as size, material, and shape. It should be robust enough to withstand the erosive forces generated during the test without leaking or deforming.



Motor: The motor plays a crucial role in the erosion test setup by driving the mechanism responsible for generating erosive forces within the test. It provides the power necessary to create turbulent flow or abrasive action within the tank. The motor's torque and speed characteristics are important considerations to ensure that it can effectively drive the erosion mechanism and produce the desired erosive conditions.

Material Holder: The material holder serves to securely hold or position the test material inside the tank during the erosion test. It ensures that the test material remains in the desired orientation and location throughout the test duration.

Shaft & Motor Case:



Prototype Test Plan

Test ID	Test Objective (why)	Prototype Used (what)	Test Method (how)	Results to Be Recorded (how)	Estimated Time (when)
1	To determine the efficiency of the test system environment in providing accelerated erosion results.	Initial Prototype (tank, motor, shaft, material clamp)	The main test method will be used. Below these sections more details can be found.	1)Mass of test materials before and after. 2)Time taken for erosion. 3)Observations on material compatibility.	4 hours
2	Asses the temperature control	Initial Prototype (tank, motor, shaft, material clamp)	1)Measure the initial temperature of the system. 2)Adjust the system to maintain a temp of 15-40 degrees celsius. 3)Record the temperature fluctuations using a temp sensor.	1)Temperature fluctuations 2)Observations of the systems ability to maintain the temperature.	4 hours
3	Test systems compatibility with different materials.	Initial Prototype (tank, motor, shaft, material clamp).	1)Test different materials (e.g., styrofoam, chalk, sandstone) under normal conditions. 2) Observe the erosion	1) erosion rates and effect on different materials. 2) Observations on material compatibility.	4 hours

			rates and effects on different materials		

Main Test

Preparation

1. Assemble Materials: Gather Styrofoam, Chalk, and Sandstone for the test.
2. Prepare Samples: Create two identical samples of each material for both normal and harsh conditions.
3. Define Conditions:
    a. Normal Conditions: Room temperature, 750 rpm, zero abrasives
    b. Harsh Conditions: Abrasives included, 1000 rpm, temperature increased to 30℃

Test Execution

Test 1: Normal Conditions

1. Perform testing under normal conditions.
2. Post Testing:
    a. Dry the samples and measure their mass.
    b. Record test duration, temperature, rpm, and mass in Excel.
    c. Create a graph depicting mass vs.time with independent variables (abrasion, rpm, temperature).

Test 2: Harsh Conditions

1. Repeat tests with harsh conditions.
2. Post Testing:
    a. Dry samples and measure their mass.
    b. Record test duration, temperature, rpm, and mass in Excel.

c. Create a graph showing mass vs. time, integrating the independent variables (abrasion, rpm, temperature).

Analysis

1. Expected Outcome: If the tests are successful, the harsh conditions should accelerate erosion faster compared to the normal conditions.
2. Comparison & Prediction:
    a. Compare erosion rates under normal and harsh conditions
    b. Asses the consistency of acceleration in erosion rates across materials
    c. If acceleration rates are consistent, predict erosion rates for additional materials and assess how much faster the system erodes under harsh conditions.

Additional Considerations

- Data collection: Follow the advice on mass measurements before and after testing for accurate results.
- Material Compatibility: Ensure materials used in testing are compatible with the system to avoid unwanted reactions.

External Feedback & Insights

- Clarification on RPM changes was made clear by CNL during our first one-on-one client meeting (this was not made clear at the start).
- The tumbler design idea would not reflect turbine material spinning in water.
- No need to worry about having a turbine on the bottom to mix the grit because if the grit is fine enough, it should stay mixed in the water.
- The idea of using acetic acid might cause a toxic chemical reaction when working with aluminum, so we should stick with just using abrasions.
- More to come (waiting for feedback from our personal contact at CNL).

Target Specifications Update

Category	Specification	Details	Metrics/Targets
Functional	Erosion Acceleration	The system must accelerate erosion testing efficiently	-
	Temperature Control	Ability to maintain a controlled temperature environment within the system.	15-40℃, ±2℃ accuracy
	Material Compatibility	Compatibility with a wide range of material for testing without causing damage.	-
	Data Storing	Compatibility with a wide range of materials for testing without causing damage.	-
	Structural Stability	Ensure the system maintains stable under operational conditions	-
Non-Functional	Portability	The system should be easily movable and set up in different locations	-
	Aesthetics	The system should have a visually appealing design without compromising functionality	-
Constraints	SAFETY	Priority on operator and environmental safety throughout	-

		the design and operation.	
	Temperature Limit	Must not exceed 40℃ to ensure safety and material integrity.	Maximum 40℃
	Atmospheric Pressure	Operation at atmospheric pressure to prevent safety hazards.	101,325 Pa
	Target Weight	Need to define an optimal weight	TBD
	Target Dimensions	The tank and rotating disk should facilitate efficient testing.	Tank: ~100mm Disk: ~80mm
	Rotational Speed	Adjustability of the motor's speed to simulate various erosion conditions.	0-3000 rpm *currently having delays with ordering the motor.

***Side Note Part Measurement changes:**
-Linear motion rod shaft:
8mm x 350mm

-Tumbler Grit:
2 lbs

-Shaft Coupler Connector:
8mm x 10mm

Conclusion

By combining feedback from customers and experts in the field, we have refined the model to address practical and safety issues in erosion testing. This is a testament to our team's ability to develop systems that not only meet, but exceed our customers' needs. Erosion testing system requirements. With a commitment to continuous improvement and incorporating feedback into the design process, we are confident in our approach to developing our next model.