GNG 1103

Design Project User and Product Manual

Submitted by:

G11 - Group 11

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Table of Contents

List of Tables

List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
DC	Direct Current.

1 Introduction

This User and Product Manual (UPM) provides the information necessary for scientists and engineers to effectively use the Accelerated Erosion Testing Machine (AETM) and for prototype documentation. The Accelerated Erosion Testing Machine is a device that will help in simulating the effects of running a given part for a long time while it is submerged in a fluid. This manual will help the reader navigate the process of the testing for this product as well as the product usage. The different sections of this device include the overview, the setup, using the system, troubleshooting, product documentation, and conclusion. The sections are ordered in a logical manner to ensure that other engineers and scientists are able to make a prototype and replicate the results we have presented. The overview discusses the inception of the project and what we prioritized while making a design. Getting started, gives a detailed description of the different subsystems in the design and how they fit together. Using the system elaborates on the design as a whole explaining its functionality. Troubleshooting details some common mistakes that could occur from product usage. Finally, the product documentation shows how the product was designed to allow the reader to build their own prototype. Readers should be warned that the design uses a high speed motor that is potentially dangerous if not handled with caution.

2 Overview

Canadian Nuclear Laboratories explores various aspects of nuclear science and technology in Canada. They study a variety of materials to help improve design features, however using new material comes with uncertainty and potential challenges. The goal of this project is to help alleviate some of this uncertainty in materials testing by creating a device that can be used to test the degree to which erosion parameters affect a given material/part. This device will be used by Canadian Nuclear Laboratory scientists to determine whether and how long a given material will be suitable for a predetermined application.

Canadian Nuclear Laboratories already has an erosion testing device that functions by rotating samples at high rpm in hot water. Nevertheless, the client has expressed concerns about the time it takes to generate results (over one year) and the accuracy of those results in reflecting real-world erosion rates (the actual product erodes at a faster rate than the test suggested prior). They expressed that they are already working at a very high speed and high pressure so they would like to pursue other efficient avenues for accelerated erosion.

Table 2: Prioritized Client Needs

#	Need Statement	Importance
1	The device is low risk to its users.	1
2	The device is able to accelerate the erosion of a variety of materials.	1
3	The device is able to produce results after a short run-time.	1
4	The device is able to simulate at least one isolated factor causing erosion without increasing the speed of material.	1
5	Within the parameters that are being tested, the device is able to be adjusted to test with the different measurable intensities of these parameters.	2
6	The material used for the device is durable enough to withstand the erosion testing from its internal processes.	2
7	The material used for the device is accessible and inexpensive.	2
8	The device is portable.	4
9	The device is aesthetically pleasing.	5

Table 3: Target Specifications

Target Specifications	
Minimum size	25 cm x 25cm x 25cm
Maximum weight (dry)	10kg
Rotating speed (constant)	100 rpm to 1000 rpm
Maximum fluid temperature	30°C
Maximum size of abrasives (diameter)	0.01mm
Maximum pressure of the system	1 atm (not pressurized)
Data collecting instruments	Thermometer, stop watch, display (optional)

Ability to test more than one material	Yes

Problem Statement: Canadian Nuclear Laboratories needs a safe and cost-effective accelerated erosion testing device that produces measurable results after a short runtime to test different parameters causing erosion on various materials.

The key differentiator for our product is the simplistic design which allows for easy usage for beginners; Unlike the other products, usage does not require knowledge of coding or any hardware technical knowledge, thus allowing novices to use it safely.

Key Features:

1. **Adjustability of speed**: The AETM is equipped with an adapter capable of controlling the speed of the motor by varying the voltage input. This user-friendly interface allows for easy and safe control of the speed of the part getting tested.
2. **Versatility in Tested Parts**: the loading apparatus is capable of holding parts that are a variety of widths and heights.
3. **Consistency in the Results**: The AETM gives consistent and reliable results, so it is able to be used as an analytical testing device.

The device uses a motor at the top design and spins the part rather than spinning the fluid around the part. It is made of a plastic can with a metal motor on top and a threaded shaft inside to hold the part.

2.1 Conventions

There are no special conventions for the device

2.2 Cautions & Warnings

The device works with an electrically powered motor which has the capacity to run at high speeds so users should ensure that there is no water or fluids on the motor while it is operational.

3 Getting started

The system is designed to accelerate erosion on the sample. Please follow the instructions to avoid any unwanted results

1. Prepare a sample roughly 10 cm in diameter with a hole in its center roughly 8mm in diameter.
2. Adjust the top nuts to desired height and place them in the first washer.
3. Place in the sample and tighten the nuts below. Make sure the sample is not free to rotate.
4. Fill the container to the mark with fluid of your choice. Weigh and add suitable abrasives to the fluid.
5. Close the lid tightly. Use moderate force to click the lid in place.
6. Connect the power adapter to the power port and the other end to the circular connector on the device.
7. Use the knob on the adapter to set a desired voltage and start the timer. Observe the device for 2 minutes to ensure safe operation.

   a. If the display goes blank or the motor stops, refer to part 5 of this document.

8. Turn off power and unplug the device before opening to check on the sample.

3.1 Configuration Considerations

1. The system must always be kept upright while functioning (the motor should always be on top).
2. Keep electrical cables and outlets away from liquids or moisture to avoid the risk of electric shock.
3. The system is equipped with overcurrent protection, if the motor stalls or in case of short circuit, the system turns itself off. To resume operations simply unplug from the electrical source and set up again.
4. Do not use radioactive or corrosive substances.
5. The ideal sample size is a disk 10 cm in diameter and a hole in its center which is 8mm in diameter not exceeding 15 grams in weight. If too heavy, try reducing the sample size without reducing the center hole.
6. The motor is noisy, do not use in spaces where noise is restricted

3.2 User Access Considerations

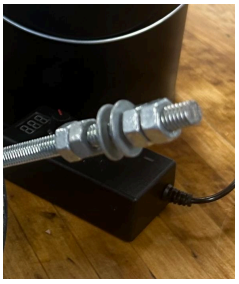
No restrictions on the use of the system for any users.

3.3 Accessing/setting up the System

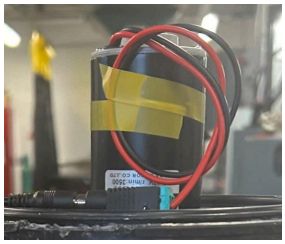
1. Find the lid with motor attachment and threaded rod.

2. Place the bottom container on a flat horizontal surface.

3. You may use the nuts to adjust the elevation of the sample by turning them to the required height.



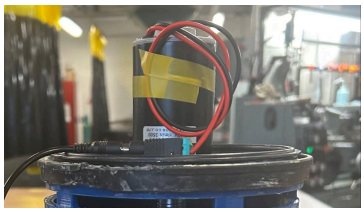
4. Check all wires for damage, signs of corrosion or short circuits. If any issue is found, do not use the system.



5. Follow instructions above to load and use the device.

3.4 System Organization & Navigation

1. **Motor**
   The motor is the main component of the system. It sits on top of the lid secured and well insulated. It has a power connector which accepts power through a barrel connector. The power is delivered by a DC variable power adapter which comes with overcurrent protection.



2. **Loading**
   It consists of a threaded shaft of size 5/16-18 and suitable washers and nuts. The nuts can be adjusted to user specific heights and washers prevent the sample from slipping off. This subsystem is attached to the motor via a flexible shaft coupling.

3. **Container**
   The container holds fluid and provides a means of isolating the system from its surroundings. It provides a leak proof system to accelerate erosion in a controlled way.

3.5 Exiting the System

After use,

1. Remove the adapter from the outlet and from the barrel connector. Leave the motor connection intact.
2. Clean any residue in the container and on the loading apparatus. You may remove the threaded road by unscrewing the coupler. Do not use any liquid to clean the motor or electric components.
3. you may close the lid and leave any small parts in the container and store it in a cool dry place away from any moisture or corrosive substances.

4 Using the System

The following subsections provide detailed, step-by-step instructions on how to use the various functions or features of the Accelerated Erosion Testing Device.

4.1 Power

Power system delivers power to the motor to spin the sample in clockwise direction.

4.1.1 Speed Variation

Speed of the system can be controlled by turning the knob present. The voltage reading correlates to the speed of the motor.

4.1.2 Over current protection

The power system is equipped with built-in over current protection. The adapter lights blink and the motor stops when over current is detected. When it occurs, refer to part 5 of this document.

4.2 Loading

This system holds the sample in place securely.

4.2.1 Adjustable loading height

You can use the nuts on the threaded rod to adjust the height the sample will be while the system is running. Turn the nuts to set the desired height before loading the sample.

5 Troubleshooting & Support

Should an error occur, please carefully read this part to check whether you can resolve the problem by yourself or if a trained technician is needed.

5.1 Error Messages or Behaviors

Table 4: List of Errors

	Errors	**Potential Causes**	**Solutions**
1	The motor is not rotating properly	The sample is too large in size	Replace with a smaller sample
		The fluid's viscosity is too high	Pour out the current fluid and replace with the one having a lower level of viscosity (less amount of abrasive substance
		The voltage is set too low (creating low RPM)	Low RPM might not give enough inertia for smooth operation → Increase the voltage
		Power input is not sufficient	Check the power input and make sure the device is connected to a 120 V - 60 Hz stable outlet
		The lid is not closed properly	Fully close the lid until it is flat and there's no bum on the edges
2	Motor gets hot	The motor is overpowered	Check the power input and make sure the device is connected to a 120 V - 60 Hz stable outlet
		The fluid's viscosity is too high (preventing the motor to rotate)	Pour out the current fluid and replace with the one having a lower level of viscosity (less amount of abrasive substance
3	Water is splashed out	The "crown" is still installed	The 3D-printed "crown" is only uses for visual purpose of the inner operation → Remove the crown

			when not needed for ordinary operations
4	The container vibrates vigorously	The under surface is not flat or there is an obstacle	Make sure the surface under the device is fully flat without any obstacle
5	The sample got damaged/broken around the shaft area	Over Compression due to overturned nuts	Adjust the nuts to an appropriate level to avoid any damages to the sample

5.2 Special Considerations (Technician recommended)

For your safety, any device's circumstance relating to electricity should be handled by a trained technician. The user should first shut down the room's circuit breaker and then call a technician. These circumstances may include but are not limited to:

- Short circuit
- Fluid got splashed/spilled to electrical parts/wires
- …

5.3 Maintenance

Users are advised to practice maintenance procedures to prolong the product's life span:

- Pour out all liquid and substances inside the container after use
- Cleaning the container, lid, shaft, and nuts with water and dish soap is recommended
- Let every part of the device get naturally dried and store them in a dry environment

5.4 Support

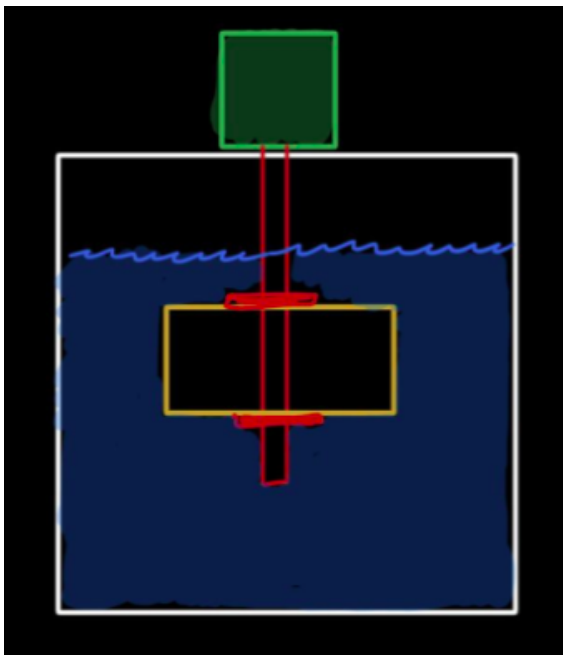
In case of an emergency, call 911 (or any emergency number of the current country or region) immediately.

Please contact us through email: group11.gng1103.uottawa24@gmail.com for any further support/feedback/report.

6 Product Documentation.

6.1 Subsystems of prototype

This acceleration erosion testing device can be further divided into three subsystems, namely; the shaft/loading, the motor, and the housing/container.



The model above describes the finalized concept of this prototype using the said three subsystems.

- **Motor Subsystem**: The standards for choosing a motor for this new concept were; cost, energy intake, and rotations per minute. Hence resulting in our choosing CONQUERALL 775 DC Motor DC. Its resulting alternating 12V- 24V allows for easy access controlling the speed and rotations per minute, which is 6000-12000 RPM, of the motor. It was also the cheapest choice to performance ratio.
- **Container System**: A crucial element of the erosion testing device is its housing, and hence careful considerations must be taken before choosing it. These considerations include; durability, strength and price. With all these elements taken into consideration group 11 has opted for a metal housing, preferably being aluminium. It is also to be noted that being able to purchase the cylindraical shape is the key to success, as currently we have no means of bending the aluminum.
- **Loading Apparatus**: We believe the loading/shaft is still up to debate. As there are many pros and cons for each subsystem, collectively decisions must be made with specification matters at mind. And hence the decision of what material to utilise for the erosion testing

device will be subject to the budget and careful consideration over the period of the production of our device.

6.1.1 BOM (Bill of Materials)

Table 5: Bill of Materials

Erosion Testing Device Budget					
BUDGETED AMOUNT	TOTAL COSTS	DIFFERENCE			
$100.00	**$120.27**	**-$20.27**			
Description	**Material**	**Type**	**QUANTITY**	**COST**	**TOTAL**
Paint Container **[1]**	Metal (aluminum)	Container/Housing	1	$7.99	$7.99
Motor **[2]**	Metal	Torque Mechanism	1	$36.67	$36.67
Threaded Shaft **[3]**	Metal	Loading/Shaft	1	$11.27	$11.27
CaOH **[4]**	Calcium Hydroxide	Abrasives	1	$16.50	$16.50
Adapter **[5]**	Electronics	Power Supply		$19.19	$19.19
Shaft Coupling **[8]**	Aluminum	Shaft Connection	2	$4.80	$9.60
Nuts **[6]**	Metal	Material Security	4	$0.27	$1.08
Washers **[7]**	Metal		4	$0.16	$0.64
MDF**[9]**	MDF	Insulator	1	$3.50	$3.50
SUB TOTAL					**$106.44**
TOTAL					**$120.27**

6.1.2 Equipment list

1) Container (Metal Paint Container)
2) Motor
3) Threaded Shaft: Metal
4) Abrasives: CaOH & Sand
5) Gasket
6) Nuts/Washers
7) Arduino uno
8) Laptop
9) Tablet (displays)
10) Arduino IDE
11) CodeBlocks
12) Power Supply (outlet)

6.2 Testing & Validation

There were a total of three prototypes made and tested. While prototype one was a proof of concept, due to logistical problems, prototype two was a simple test of the subsystems. Therefore leaving prototype three the finalized concept of the accelerating erosion testing device.

Table 6: Prototype One Test Results

ID	Test Description	Results
1	Leakage	There was no visible leakage.
2	Stability	The motor does fluctuate slightly. However, the container stays stable.
3	Loading capacity	The loading mechanism is undamaged while handling a small and light sample (<20g).
4	Loading capability	The loading mechanism can visibly withstand low RPM and low viscosity (tap water).
5	Software	Software was not used for this prototype.

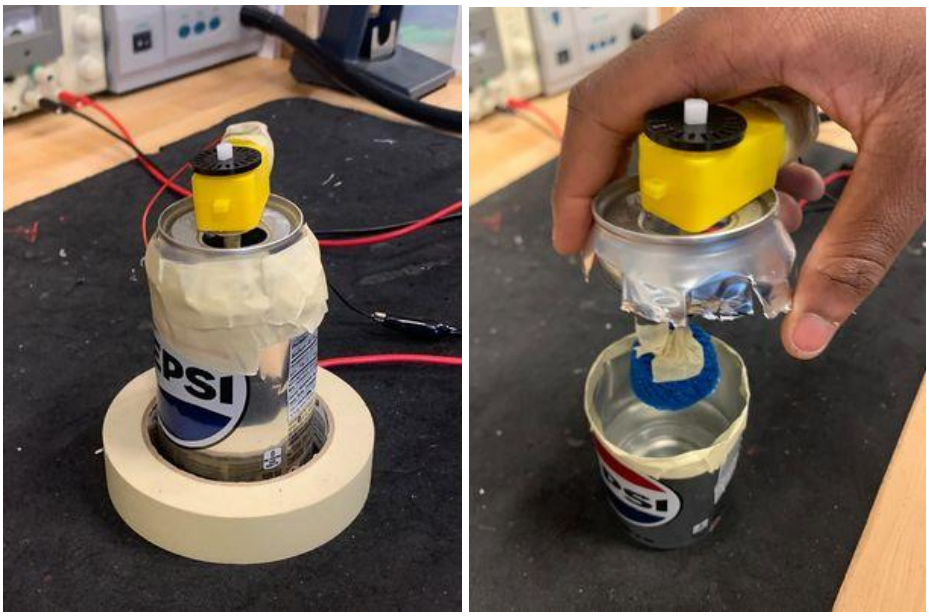


Table 7: Prototype Two Test Results

ID	Test Description	Results
1	Motor's power source	- The motor works well when connected, through the adapter, to an ordinary electricity outlet
2	Motor's controllability	- The power provided for the motor is controllable by using the adapter - The speed is able to be controlled and predicted reliably. An increase in the volts delivered to the motor resulted in an increase in the angular speed of the motor shaft.

Table 8: Prototype Three Test Results

ID	Test Description	Results
1	Leakage	There was no visible leakage.
2	Stability	The motor does fluctuate slightly. However, the whole system stays stable.
3	Erosion test (A styrofoam disk sample was placed and rotated in abrasive liquid, water	The sample's weight before the test was 14g and 13g after the test. This indicates that erosion did happen.

	+ sand, for over an hour. The sample is then cleaned and dried.)	

7 Conclusions and Recommendations for Future Work

In conclusion, we were able to produce a high fidelity prototype of this design which was capable of causing erosion when testing a cylindrical styrofoam part. The results we obtained were qualitative due to the lack of resources to give quantitative data on the visible erosion. Future designers should invest in or borrow an analytical balance to accurately and precisely measure the weight difference after a given run. Further, we experienced some failures in the motor, so in future iterations of the design, a higher torque motor should be used to account for the performance failure.

If we were able to work on the project for a few more months, I would run irregularly shaped samples to further test the robustness of the design. We would also test parts of different densities and hardness to further determine analytical capabilities of the machine and refine its optimum working range. With this manual we hope that the user experience for this product is as smooth as possible and future engineers can improve on our design.

8 Appendix I: Design Files

Document Name	Document Location and/or URL	Issuance Date
Deliverable F	Project Deliverable F: Prototype I a…	03-03-2024
Deliverable G	Project Deliverable G: Prototype II …	10-03-2024
Deliverable H	Project Deliverable H: Prototype II…	24-03-2024
Final Presentation	GNG 1103 Final Presentation	15-03-2024

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