PROJECT DELIVERABLE K
USER AND PRODUCT MANUAL.

GNG 1103

GROUP 10 - DESIGN DYNASTY

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Acronyms

Table 1. Acronyms.

ACRONYMS	DEFINITIONS
CNL	Canadian Nuclear Laboratories.
RPM	Revolutions per Minute.
UPM	User and Product manual
MOSFET	Metal-Oxide Semiconductor Field Effect Transistor
BOM	Bill of Materials

Glossary

Table 2. Glossary.

TERMS	ACRONYMS	DEFINITIONS
Design Dynasty	-	Our official team name throughout the semester.
TurboRosion	**T**	The official name of our final product.

Introduction

The Design Dynasty team was tasked by our client, CNL, to create an erosion testing device for **quick** and **efficient** evaluation of materials' **erosion rates**. It must allow **controlled variation** of fluid **abrasives**, **viscosity**, **temperature**, and impeller **RPM** within set **safety limits**. Budget constraints necessitate creative acceleration to simulate **four years** of erosion in a shorter time frame of at most **one week**.
TurboRosion is an efficient and accurate accelerated erosion testing device that can test the rates of Erosion on any chosen substance under a very small time frame.

This UPM provides the information necessary for Engineers, Governments, Farmers, and any other Erosion-related Stakeholders to effectively use TurboRosion and for prototype documentation.

Overview

In approaching the problem, we went through different stages to ensure we did a thorough and efficient job for CNL.

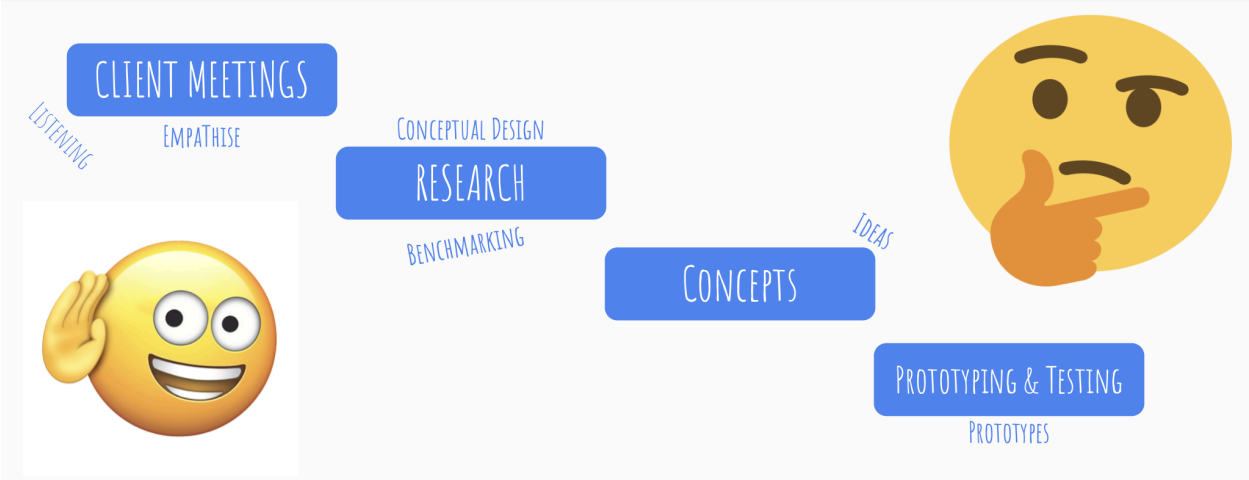

Figure 1.

What is the Problem?

Having consulted our Client representative and some other potential clients (some of our seniors in Agricultural Science, Material Engineering, and Civil and Environmental Engineering), we came up with a problem statement to broadly capture the exact needs of our Client:

"**Canadian Nuclear Laboratories** seeks an erosion testing device for **quick** and **efficient** evaluation of materials' **erosion rates**. It must allow **controlled variation** of fluid **abrasives**, **viscosity**, **temperature**, and impeller **RPM** within set **safety limits**. Budget constraints necessitate creative acceleration to simulate **four years** of erosion in a shorter time frame of **two days**."

We concluded that the vital and immediate needs were:

- Easy Repeatability.
- Short Time of Function.
- Low Cost.
- Safety.
- Efficiency.

What did we Create?

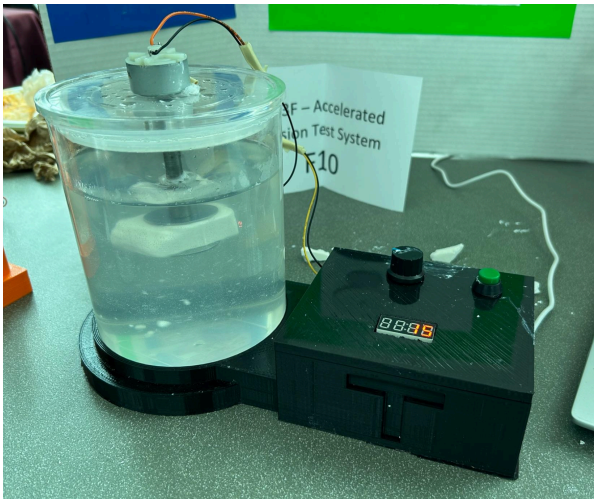

Figure 2.

We created a device that erodes any chosen substance by spinning that substance in any chosen fluid (preferably water) in which abrasives can be added. The device allows for controlled RPM and temperature monitoring. TuboRosion is made up of only 3 subsystems namely: Fluid Drum, Motor House, and Control box. The base and the control box are made from 3D printed PLA while the Fluid Drum is made of transparent plastic.

What is so Unique about TurboRosion?

- It is very Easily Repeatable.
- It is Compact & Portable as its subsystems can be easily detached.
- It has a Percentage RPM Display Feature.
- It is very Cheap to make.
- It is Efficient as it can run at 100% for over 4 hours non-stop without any damages.

Cautions & Warnings.

During the development of our system, safety was a primary focal point. We diligently ensured that the system's design maintained simplicity to mitigate major safety risks for users. Nevertheless, it's essential to note that our system employs an Arduino and an electrically wired board, alongside the utilization of water or other liquids for erosion purposes. Users must exercise caution to prevent any inadvertent contact between these liquids and the electrical wiring, as such contact could lead to potential short circuits or, in extreme cases, pose a risk of electrocution.

Getting Started

Equipment List

- DC motor
- Arduino
- Breadboard
- Cylindrical container
- Wires
- Metallic rod
- Computer (for coding purposes)
- ON/OFF switch
- 100k ohm potentiometer
- MOSFET
- 10W Power Supply
- TM1637 4-digit 7 segment display

Configuration Considerations

The configuration of the system requires a connection of the arduino and the motor using the breadboard, the arduino contains the code that controls the motor speed. With all the wires in place, the only tools that are needed are an allen key, that is used to drive the screw in the rod in order to keep the sample locked in place and does not move.

Accessing/Setting up the System

1. Ensure that the potentiometer is set to 0
2. Remove the chamber from the mount and fill it with the required fluid
3. Put the chamber back on the mount
4. Unscrew the bolt that is at the end of the motor shaft
5. Feed the bolt through the sample with washers between the sample.

6. Hand tighten the bolt back onto the motor shaft and use an allen wrench to gently tighten it further
7. Set the lid back onto the chamber
8. Connect the system to power using a 10W power supply
9. Press the green button and verify it has turned on by seeing if the motor is spinning and that the display is on
10. Turn the potentiometer to the required power output

System Organization

Chamber

The chamber is mounted on a support to prevent any tipping if knocked. The motor is directly connected to the chamber lid by two screws and driven by the components from the electrical box. The sample is mounted onto the motor by a detachable bolt and washers.

Electrical Box

The electrical box covers all the electronics to prevent water from potentially damaging them.

Potentiometer

A 100k potentiometer communicates with the arduino through one of the analog pins and measures how much amps the potentiometer is sending.

Push-Button

A green push-button is also mounted on the box which allows for a quick shut-off of the motor.

Display

The arduino communicates with a TM1637 display that is mounted to the box to show how much power is being put into the motor, 100% being the max rated RPM of the motor.

Arduino

The arduino translates the amperage that the potentiometer is sending and puts it on a PWM (pulse-width modulation) signal. The signal is then amplified by a MOSFET and a 10W power supply. The signal is fed directly to the motor which results in variable RPM.

Exiting the System

Our system was designed with utmost simplicity and meant to be user-friendly.
To exit the system:

1. Turn the speed down to zero
2. Turn off the system by clicking on the green button.
3. Unplug the electrical wire.
4. Empty the liquid and clean the container.
5. Store the system.

Using the system

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

1. Fill the container with the desired liquid.
2. Add abrasives as necessary
3. Cut the simple in a circular shape with a diameter not exceeding 10 cm
4. Drill a hole in the center of the sample.
5. Put a washer on each side of the sample
6. Insert the screw in the center of the sample just as the sample is “sandwiched” between the two washers
7. Using an allen key or screwdriver, drive the screw in the rod making sure the sample is fixed in place.
8. Insert the whole composed system in the container and make sure the lid is closed properly, avoiding any leakage.
9. Clicking on the green button, turn the system on.
10. Slowly, turn the speed dial slowly , to increase the speed as desired.
11. Leave the sample rotating the liquid for the desired amount of time.
12. When done, turn the speed down to zero and turn off the system
13. Unplug the system to make sure there is not electrical circuit.
14. Take the lid off, using the screwdriver/allen key remove the screw to allow the retrieval of the sample.

Product Documentation

Mechanical

Our final prototype contained 2 main components, the chamber where the erosion takes place and the “black box” with the controls:

The chamber is a clear plastic container that has a lid that closes with a joint. The motor is attached to the lid with two screws, we drilled two holes in the plastic lid allowing the motor to be attached. We used a recycled metal rod that we drilled deep enough allowing the motor’s rod to be inserted and not move. We also added glue for extra holding strength. The metallic rod is drilled from the other side allowing for a screw to be driven in it in order to secure the sample in place.

To hold the chamber secure we 3D printed a station that allowed the chamber to sit in place and be fixed. We also 3D printed the black box that contains all the wiring.

To install the on/off button and the speed dial, we drilled the holes in the cover of the black boxes with the appropriate drilling bits allowing good fittings.

Figure 3.

Electrical

To get the motor running, we needed to connect the system to a source of electricity, but a simple plug was not enough for our needs, so we used a breadboard to allow for different wirings, we needed to use an arduino to control the motor's speed, therefore we connected an electrical wire that will get the electricity from an outlet to the breadboard, then we connected the arduino to the breadboard as well the motor, this wiring allowed for the motor to be turned on and off without the needed to fully unplugging the system and to control its speed.

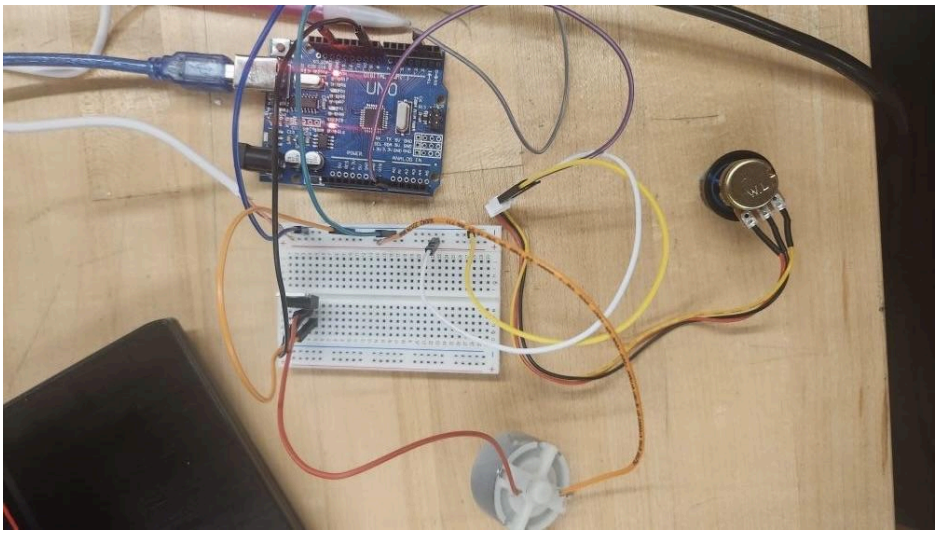

Figure 4.

Software

To get the motor to answer our commands we needed a code to translate them, using an arduino we were able to make the code and store it in the arduino allowing us to not carry a computer around. Allowing us to control the motors speed, therefore controlling the erosion.

Design

In creating the ‘Black Box,’ we made use of 3D printers to ensure that it is cheap, efficient, durable, and accurately dimensioned. Using OnShape (a 3D design software) we made the 3D designs as seen in the images below. The design can be reused or modified using the link to OnShape provided in the list of files at the end of the document.

Figure 5.

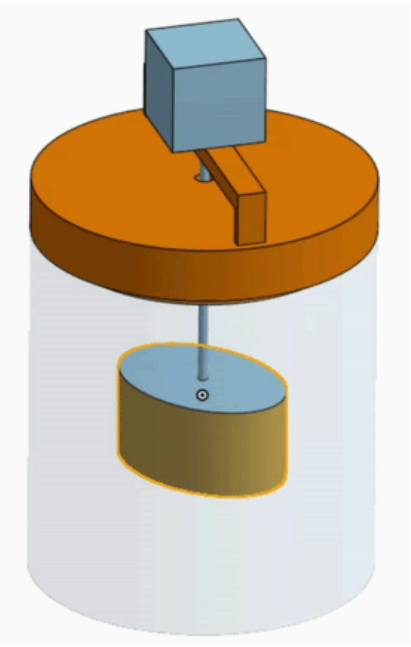

Figure 6.

BOM

Table 3. BOM.

ITEM NAME	ITEM DESCRIPTION	ITEM QUANTITY	TOTAL COST ($CAD)	SOURCE/LINK
Motor	6V, 4800 RPM, 33mm Diameter. For rotating the sample to aid Erosion of whatever sample	2	8.00	https://www.amazon.ca/3000rpm-6000RPM-12000RPM-Cylinder-Electric/dp/B07CKT5ZQM/ref=sr_1_27?crid=2VOQ0ZJJWMDA4&dib=eyJ2IjoiMSJ9.ZWvkNcHlLymRqYbQmcUBWwOcfBdQTGmRH9l-yy3ktNP1DLDjINL5d-IJCZ5qmI09iJk4Pb3NzqyRgZ6VlA62SyrFIko25jPlbdIwOe_vw-lZOe2urtmZejnlRxI4sYj8QtzgHlbLfXFV_F8LBVH3ngQNhamVjC8SLqJxKs3HFM4D0KsvbmVdMBgpima3fohlpp4TwdGtTgq9KShLc5wqgzsRINrJsor-JjqUR3X_AA-6cl9XhD40QmaM5joObb3ez6Yfq-F9aXKta9WciMXl2RemNpAA_LV-DWJdZ1BlM7M.3hlE_Nl5JsroV9ajPCyKXr15m7jc52uNTT8zyBFDhvM&dib_tag=se&keywords=dc%2Bmotor&qid=1712805753&sprefix=dc%2Bmotor%2Caps%2C82&sr=8-27&th=1 Amazon.
Jumper Cables	For ease of use with breadboard and for interconnecting a electronic components together	20	2.00	https://makerstore.ca/shop/ols/products/jumper-cables-pack-of-10 MakerStore.
Arduino	Arduino uno R3	1	15.25	https://makerstore.ca/shop/ols/products/arduino-uno-r3-clone MakerStore.
USB Arduino Cable	5ft, Black or Blue, For the Arduino connection to a Computer	1	4.00	https://makerstore.ca/shop/ols/products/usb-type-a-b-cables MakerStore.

BreadBoard	For interconnecting Electronic components	1	5.00	https://makerstore.ca/shop/ols/products/breadboard/v/C005-HLF MakerStore.
PVM Controller	Used for regulating and displaying RPM of motor	1	20.00	https://www.amazon.ca/Controller-Regulator-Variable-Control-Circuit/dp/B0BS58SYXW/ref=sr_1_5?crid=1YT9W2P9KZEBE&dib=eyJ2IjoiMSJ9.I6QmppB3u5J5BdfULuQnVm4auyFRbNOWSepw9VtTdMua5ifGVBDKDJMghjW3BbGKF0qhTZuh-fs-6DUweJXNtFHsdM1FR2s9cmIO7pDge_p9qpR1QjrjMsRpdKCerwF4aJFY0RYXgEJmXOhPa5DIDbDgFE59iV6sybEkQy0U8qR9qq4vislpvDq-jPyWiY1gGxmapbM2DEnREKlN21VhMouhyMNi7bNvsJF91XBFgAgHW7bsSApXMSaAX0myY2O-Pezu-l09F5R7b6aUt-7U7EMeGCAXTjS6rQs3xdPAUYQ.xWAkk3AwZtQuBFhHukyQ6pwOVbQXykbgZPk2nW_plBY&dib_tag=se&keywords=motor+rpm+controller&qid=1712805697&sprefix=motor+rpm+controller%2Caps%2C86&sr=8-5 Amazon.
Plastic Container	Cylindrical, Transparent, Diameter 12, For containing fluids being used in the system	1	3.00	Dollarama.
MOSFET	To control electrical conductivity in the circuit (assembly)	1	2.00	Amazon.

Testing and Validation

Before using the system, we need to ensure that it is ready for its purpose. The system needs to be tested to make sure it is ready. After wiring the system correctly to the arduino and breadboard:

1. Plug the system's wire into a source of electricity.
2. Turn on the system by clicking on the green button.
3. Take a look at the breadboard and arduino and visually inspect for any wired touching or smoke.
4. Make sure the motor is well wired to the system and attached to the rod.
5. Increase the speed gradually by turning the dial.
6. Once you reach 100% let the motor run for 30 sec and look for any anomalies.
7. If no problems are observed the system is ready for use!!

Troubleshooting & Support

Error Behaviors

Below is a list of the possible Errors that may occur in TurboRosion:

False RPM Displayed

If the digital display shows the wrong RPM at any given time, it is most likely as a result of the on/off button being pressed while TurboRosion is still functioning.
To avoid such an error, ensure to properly turn off TurboRosion by firstly turning down the potentiometer to 0 before pressing the on/off button.
In the event when the error has already occurred, it can simply be fixed by firstly turning down the potentiometer to 0, then unplugging the device from the power supply. After these steps have been taken, wait for 30 seconds before plugging TurboRosion to a power supply again.

Burning Scent

Whilst running TurboRosion, ensure to keep checking on the device at every 5 minute interval throughout the run. This is to ensure that there are no errors throughout the run and that the electronic components such as the Arduino and the PVM controller do not burn or blow.
In case you smell any burning scent, stop the run immediately, locate the source of the scent, and isolate the burning component from the rest of the electrical assembly.
It is recommended to replace the burnt parts in TurboRosion , should burning occur.

Total Error

Peradventure the entire system is not functioning, we predict that the following might have occurred:

1. Incorrect Assembly of Electrical Components.
2. A dysfunctional Electronic Component.

3. A damaged Electronic Component.

To solve such issues, we recommend contacting support for advice or consulting a professional (Electrical Engineers) and majority of the errors in TurboRosion source from the electrical aspect.

Maintenance

In maintaining TurboRosion to avoid failures or error messages, carry out the below actions after each run on TurboRosion.

1. Take out the plastic container and clean it thoroughly (preferably using soap and water) in order to ensure that it is clean and to avoid errors in the next run.
2. Equally, using a damp, warm cloth, clean the plastic cover to avoid result errors and to avoid damaging the motor.
3. Check the electrical assembly in the Control Box to ensure that no item is burning.
4. Using a dry cloth, thoroughly clean the Base and the Control Box to remove all forms of fluid that may have spilled on them.

Support

For any form of help & support, any of the individuals listed below can be contacted.

NAME	PHONE NUMBER	EMAIL ADDRESS
Obadje David	+1 873 355 1985	dobad085@uottawa.ca
Dam Adam	+1 226 503 1582	adam096@uottawa.ca
Aduku Ugbede	+1 343 987 9194	uaduk043@uottawa.ca
Amrani Mohamed	+1 514 502 97 85	mamra072@uottawa.ca

Once in contact, follow the following instructions to enhance your support experience:

1. Ensure you have a Notepad and a well functioning Pen with you (a means of writing.)
2. Mention ‘TurboRosion Help’ and state your full name and student number.
3. State the form of support you will require making it as brief as possible, using keywords like, ‘Arduino’ or ‘Control Box,’ e.t.c.
4. Wait and listen attentively (write down key information) to whomever you contacted to solve the issue at hand.

Conclusions

Ultimately, the process of creating TurboRosion was fun and insightful. We learned a lot of lessons from our prototyping stages and from the subject of Erosion. Below are some of the lessons we learned:

- ❖ We learned that it is better to control the RPM of the motor to yield more accurate testing results rather than using the same RPM throughout a series of tests.
- ❖ We learned that Pure Chalk (Calcium Carbonate) is not soluble is water.
- ❖ We learned that a cylindrical shape of the water container yields better water flow rather than a cubic shaped container.

We learned so much!

Although we did a very good job in creating Turborosion, there are a few features we might have added given that we had more time to work with:

- We considered including a temperature monitoring system to help ensure that the temperature of the system doesn't exceed the desired bounds.
- We also hoped to include a timing system to stop runs after a given time to ensure more accurate results and a better human ease of use.
- We also really hoped to add a lot more aesthetics to TurboRosion to make it look more professional and branded.

Design Files

Below are some helpful documents to help in the recreation of TurboRosion:

Table 4. Referenced Documents.

DOCUMENT NAME	DOCUMENT LINK
Design Dynasty Class Presentation	LINK https://docs.google.com/presentation/d/1cfLP6UrN8Y_pZWs7_pvabi80eV4BpdrxIi5CJ-5vsRY/edit?usp=sharing
Design Dynasty Design Day Pitch	LINK https://docs.google.com/presentation/d/1OykdrDbv2sKQyd-wN4FcwZ99wTohXMud-uQnktRRjdA/edit?usp=sharing
Benchmarking/Research	http://www.i-neoplus.co.kr/en/products/linear-reciprocating-wear-test-ufw200/
TurboRosion 3D Models	https://cad.onshape.com/documents/c564661e11712390b1094b27/w/398450bca103bb74b65528ad/e/fd366220eff98f51146cb973
MakerRepo Project	https://makerepo.com/uaduk043/1993.gng-1103-design-dynasty