Project Schedule and Cost

Vidvath Tanjore

Wesley Savage

Andrew Bettin

Connor Rennie

Andrew Walisser

University of Ottawa

GNG 1103 - Introduction to Engineering Design

Mr. David A. Knox

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Introduction

The purpose of this report is to present a detailed design of the prototype device. As outlined in previous reports, the primary goal is to create a device that will enable the EMED team at Canadian Nuclear Laboratories to safely collect a 30-80 gram sample of metal from inside a fuel channel that supplies uranium fuel to a CANDU reactor.

In earlier reports, the project needs were identified and categorized based on their importance, design criteria for each need were established, and conceptual design concepts were developed. This report aims to finalize the design of the prototype and provide a comprehensive list of materials required for its construction, including the cost of each item. Additionally, a schedule for both the construction and testing phases of the prototype will be outlined.

Design

Parts modeled using Onshape:

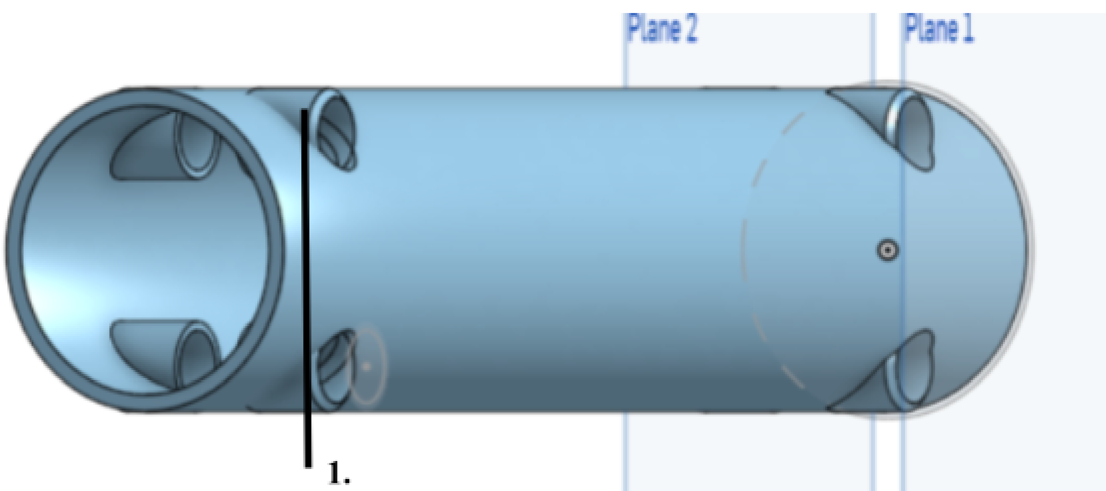

Figure 1: Main body of the device.

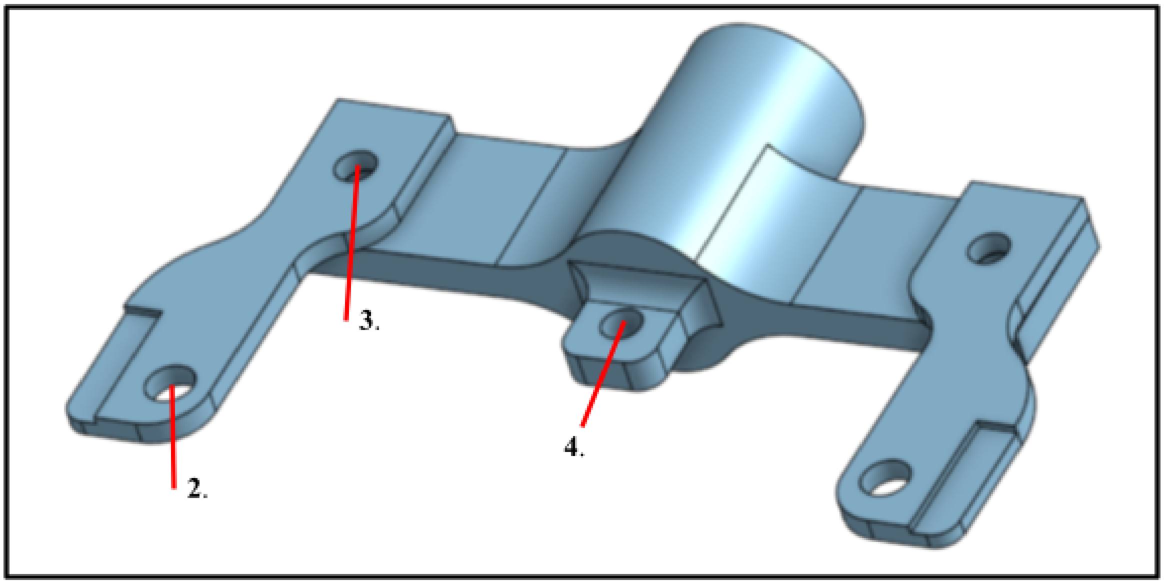

Figure 2: Assembly of the scraping blade holders and the part that is connected to the DC motor.

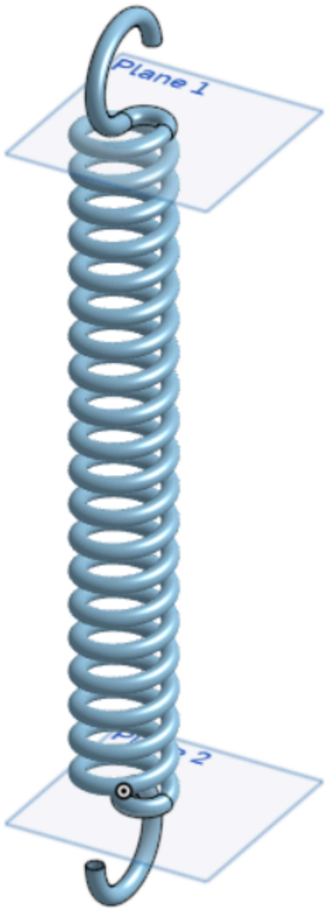

Figure 3: Spring to support the foldable blade holders.

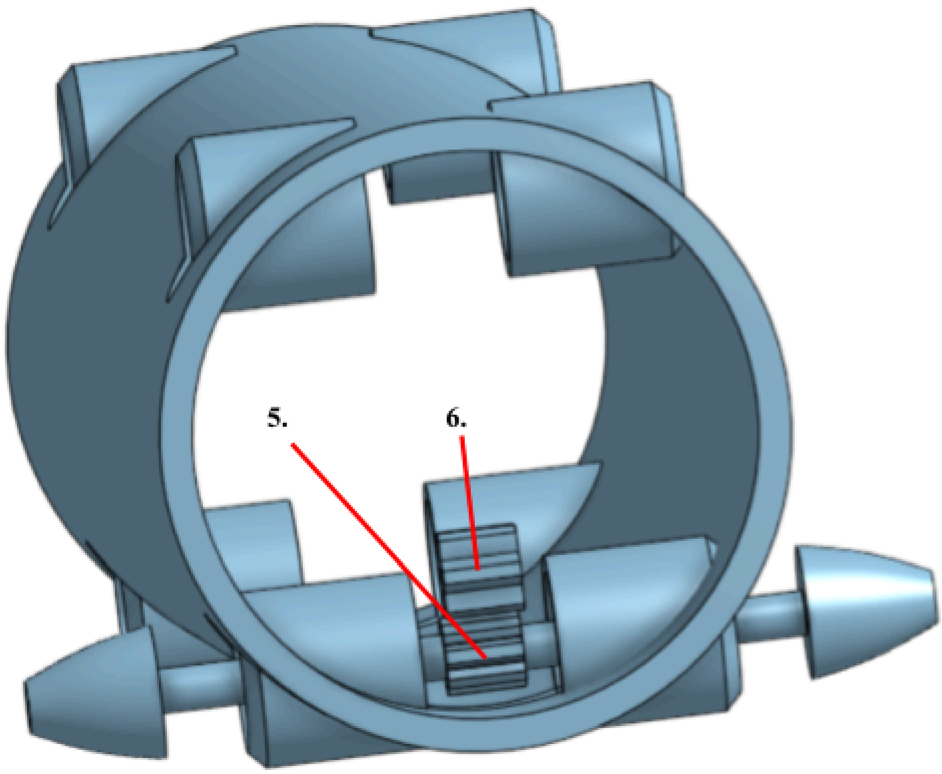

Figure 4: Assembly of the drivetrain.

Click on the following link to access the design of the prototype:
https://cad.onshape.com/documents/9b57c64afa3dbf76f23ef099/w/ddeb314d5428f4f900a5f704/e/fade248d1225ab395951dcfe

<u>Parts that will be purchased:</u>

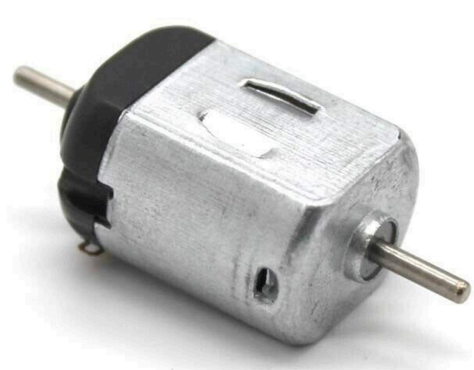

Figure 5: DC motor.

Figure 6: Rotary encoder.

How Does the Prototype Work ?

The device is driven through the tube by a DC motor whose shaft is connected to gear 6, which transfers power to gear 5, which in turn drives the rear wheels. It is important to note here that when the motor is not spinning, the device will not move as the gears are interlocked. Additionally, the shaft of the rotary encoder will be connected to gear 6 and this will allow it to measure the distance travelled.

The rear and front axles pass through wheel bearings that allow for smooth rotation. These bearings are mounted to the ends of the body (part 1).

The scraping blade holders shown in figure 2 are connected to a part that is connected to a DC motor. When the DC motor moves, the blades scrape the sides of the cylinder to collect material. It is important to note that the blades are movable in order to prevent contact with the wall of the tube while the device is moving. This movement is achieved by a system that involves a cable connecting part 2 with a servo motor. As the servo motor rotates, the tension in the cable builds and this pulls the blade holder inwards and keeps it away from the surface of the pipe. When the tension is released, the spring (figure 3) that connects part 2 and part 4 ensures that the blade returns to its original position.

The blades used to scrape the sample are mounted on the depression in the blade holder.

Components such as the motors, sensors, batteries, and bearings will be mounted to the body using superglue as this ensures a strong bond, and avoids the need to use brackets and screws to hold things in place. However, the markings for these positions have not yet been completed as the exact dimensions of each part is not known.

Project Risks and Contingencies

As with any design prototype, it is crucial to account for potential risks and contingencies. One such risk involves the actuation system of the blade, which is driven by a spring and cable mechanism. This system has not been used in previous designs, so there is a possibility that it may fail during testing.

Additionally, the use of a vacuum pump to collect the scraped sample introduces another area of uncertainty. There are concerns regarding the vacuum pump's ability to effectively suction the sample, which will need to be tested to ensure its functionality.

Both of these concepts require careful evaluation to ensure they perform as expected. Appropriate contingencies should be in place to address any potential failures during testing.

Another risk in this project is reliability. The electrical components, including the motor, batteries, and sensors, have been selected as the most affordable options available on the market to keep the project cost within the $100 budget. However, this may impact their reliability, and there is a possibility that they may not perform as expected over time.

Bill of Materials

Table 1: Bill of Materials

Item	**Quantity**	**Total Cost**
Bearings	4	$ 8.40
DC motor	2	$ 4.00
Arduino Uno R3	1	$ 32.99
Rotary encoder	1	$ 4.00

Jumper cables	25	$ 2.95
12V battery	3	$ 3.00
Battery holder	1	$ 2.50
Vacuum pump	1	$ 8.34
Tubes for vacuum pump	4 ft	$ 4.05
Dowel pins	2	$ 0.00
Servo motor	1	$ 2.50
Springs	2	$ 5.50
Blade for scraping.	2	$ 0.00
Cables for the blade actuator mechanism.	1 set.	$ 2.07
Total Cost (exclusive of tax and shipping)	$ 80.30	

Note - The items that are priced at $ 0.00 are those that the team already possesses or those that are available for free at stores such as IKEA or Home Depot.

Plan for Prototype 1

Table 2: Tasks for Prototype 1

No.	Task	Description
1.	Collect client and TA feedback.	Consider feedback regarding the prototype from the client or the TA, and make the necessary changes.

2.	Define stopping criteria for tests.	Tests will be stopped when the desired result is achieved. For example, the test will be stopped when the team is certain that the blades are able to scrape the sample, and the vacuum pump is able to efficiently collect it.
3.	Feasibility study.	Determine if the prototype is feasible considering money, time and physical constraints.
4.	Purchase items.	The items approved by the TA will have to be purchased and reimbursed.
5.	Testing.	Five tests will be conducted. They are as follows: 1. Ensuring that the written code has no errors and is correctly executed by the Arduino. 2. Ensuring that the DC motor is able to drive the rear wheels using the differential system, and the wheels are able to grip the surface of the pipe. 3. Ensuring that the scraping blade actuation system works as required, and the DC motor is able to provide enough power to scrape the material. 4. Ensuring that the vacuum pump is able to efficiently collect and store the sample. 5. Ensuring that the rotary encoder is able to accurately measure the

		distance travelled by the device.
6.	Testing errors.	Analyse all the errors that occurred during the tests, and make the necessary changes.
7.	Presentation of prototype.	The prototype will be presented to the TA or the client, to seek approval, and make changes where required.

Schedule for Testing

<u>Table 3: Schedule for Testing of Prototype 1.</u>

No	Task	Start date	Finish date	No of days
1.	**Test case design.**	**25th Feb**	**28th Feb**	**8**
1.1	Design function tests for each part.			
1.2	Define test acceptance criteria for each test.			
1.3	Review design and make necessary changes.			
2.	**Prototype build**	**29th Feb**	**2nd Mar**	**4**
2.1	3D print all the plastic parts.			
2.2	Make markings for the mounting points of devices such as the motors, sensors, and vacuum pump.			
2.3	Assemble prototype.			
3.	**Arduino test.**	**29th Feb**	**2nd Mar**	**4**

3.1	Test the Arduino code and fix any bugs.			
4.	**Test prototype.**	**29th Feb**	**2nd Mar**	**4**
4.1	Conduct all the designed tests and based on the results, make the necessary changes.			

Conclusion

In this report, the final design for Prototype 1 was outlined and explained, and the tasks and schedule for the prototype build and test were outlined. The outlined tasks will be completed in future deliverables.