University of Ottawa

GNG 1103: Engineering Design Project

Deliverable H: Prototype III, and

Customer Feedback

Group Members:

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Introduction

In this deliverable, we have concluded and assessed the need to pivot our chosen design. As of November 14th, the group ran our first tests using a fluid and the hardware construction from the last deliverable. These tests concluded that there was interference with the plexiglass windows, and the initial design was unusable. In response to this challenge, we decided to run some tests using a different sensor and received successful readings. In order to meet the design day deadline, we are now working to modify and adapt existing aspects of our design in order to implement the use of a new sensor. the refined aspects from our last deliverable, as well as producing readings from our sensor. The goals for this deliverable are to: relocate the sensor window in the tube, test for waterproof capabilities and cleanability, 3D print the sensor housings and clamp, connect the Arduino and sensors, and finally conduct tests to produce an ultrasonic reading through the tube and fluid.

Updated Project Plan

Task	Owner	Duration	Due Date
Prototype 1	Group	7 Days	November 6th
Prototype 2	Group	7 Days	November 13th
Prototype 3	Group	7 Days	November 27th
Final Prototype	Group	7 Days	November 30th
User manual	Group	2 Days	December 7th
Design Day	Group	1 Day	December 1st

Updated Client Meeting Feedback

Our team sought out to meet with Professor Knox to discuss our need to pivot in the project as of November 14th. We determined that as a knowledge professional with real industry experience, his insight could be helpful to the challenges we were facing. After bringing our issues to his attention, we discussed with him our options. Firstly, we could order a new waterproof sensor at a high price, compromising our budget, and relying on fast shipping. Our other option was to order multiple of the non-waterproof variant and run tests in water knowing that our sensor could break. Professor Knox explained the risk in ordering the new sensor, or even pivoting our entire design to using a different sensor. Despite this we concluded that the research and development that had been invested in our existing prototype couldn't go to waste. With the advice from Professor Knox, and knowing that our previous water submerged tests in a cup yielded a 30% inaccurate, however scalable reading. We proceeded with the second option.

Prototype III Test Plan

Objective

The objective of prototype III is to assess existing systems and modify them to fit new sensors. Test the waterproofing capabilities of the new sensor. Produce tests using the tube and liquid. Create a data output method. And test fit and all the hardware components.

Test ID	***Test Objective (Why)***	***Description of Prototype used and of Basic Test Method (What)***	***Description of Results to be Recorded and how these results will be used (How)***	***Estimated Test duration and planned start date (When)***
1	Test waterproofing of the new Ultrasonic Sensor	A case has been created and a thin piece of plastic is being used to seal the sensor. The sensor is being placed in water.	If the sensor keeps working, it is waterproof. If this is true, we will be able to use our design as opposed to buying a waterproof sensor.	November 15th (1 hour)
2	Test reading accuracy from the sensor with saran wrap	Further detail and development on CAD case. A case has been created and a thin piece of plastic is being used to seal the sensor. The sensor is being placed in water. Knowing the speed of sound in water, the reading will be compared with the known value to determine accuracy.	Knowing the speed of sound in water, the reading will be compared with the known value to determine accuracy. This will also determine the need for the ultrasonic sensor.	November 15th (20 minutes)
3	Output speed of sound readings to MS Excel	Test live readings to Excel	Confirms a backup plan to display data if Bluetooth app doesn't work.	November 16th (Couple of Hours)

4	Relocating a slot on the tube to accommodate for the new sensor, must be waterproof.	A new window will be placed further down the tube, on the opposite side the tube will be routed for a sensor case. This will be tested for waterproofing, by capping the ends and filling it with water.	The tube will be observed for water leakage.	November 16th (20 minutes)

Specific demands

1. The Location of the Ultrasonic Window has been moved to the end of the pipe, allowing for room to clamp and fit the sensor housing overtop, in addition to the new sensor window and reflection surface.
2. The ultrasonic device must get a reading that is accurate to 2 or 3 decimal places (which means it needs to be able to tell difference between water and thicker liquid) because the speed might not have an observable difference if the accuracy is deficient.
3. The whole test project can be covered with waterproof material, but it must be 100% waterproof and it cannot affect the spread of the ultrasonic wave.
4. Make sure the pipe's shape creates as little echo as possible, if the echo is affecting the receiver's reading, then the outcome will create a considerable number of errors.
5. The parts of the prototype III must be able to easily be removed, the box will need to detach from the tube in order to perform modifications or maintenance on the project.
6. The test readings have been achieved and a reading is produced
7. The mathematical equations to determine specific gravity have been completed and produce a value for specific gravity.

Stopping criteria

Specific demands	A comparable accurate reading has been achieved	Water has inhibited the function of the pipe, electronics or sensor	Minimum of three tests	Clamp or housings fail in stress testing	3D Prints fail
Points (1-5)	3	5	5	4	2

Prototype III

The third prototype is much more comprehensive than the previous prototypes. It includes the clamp, pipe, Arduino cause and a slot to put the ultrasonic sensor. This prototype can be used to

show what the finished product may look like and makes a base to test the different systems and observe errors caused by their interaction.

The clamp is 3D printed and is thick enough to absorb any physical chocs induced in the busy environment of a brewery. It contains a pipe and can be removed or clamped with the help of 4 bolts.

The pipe now has caps so testing with liquid in the pipe can proceed as well as holes so that the ultrasonic sensor can be inserted and removed. The window on the pipe has since been scraped as it no longer serves a purpose.

A case to hold the Arduino that is mounted on the clamp has also been 3D printed but its dimensions make it difficult to use so a new case will be printed.

Lessons Learned

Looking back at the progression of our project, there's a few lessons to be learnt. Although we have made significant progress so far, and have a somewhat working prototype, there are still a lot of things we could have done differently to produce a more finished outcome in the given time.

One of the things we believe affected our project the most was committing to an idea that we didn't fully look through and understand, rather had more ambition about getting it to work. Given that a slightly bigger budget and more time would produce a very efficient device, we had other ideas that would have been a lot easier to figure out and have working in the given time frame. At times we also did some research later than needed, which ended up costing us in terms of our final prototype.

In conclusion, we learnt to not commit to an idea until you see it thoroughly through. We also learnt that it's important to have at least some tests for more important components earlier on in the project, rather than working on more of the "features", as that would have revealed bigger problems when we had time to address them.

Target Specifications

Updated Bill of Materials

Part #	Part Name	Description	Cost ($)
1	Arduino Uno	Arduino UNO R3 Microcontroller	$9.00
2	PVC Pipe	1ft in of 1 ½in ABS pipe	$2.14
3	Wires	2 packs of jumper cables	$2
4	Plexiglass	0.in x 0.75in x 0.5in thick	$0.10

	3D Prints	-	$8.00
6	Ultrasonic Transmitter	Transmits an ultrasonic signal	$12.18
7	Ultrasonic Receiver	Detects an ultrasonic signal	$12.97
8	Ultrasonic Sensor 5pk	Detects an ultrasonic signal	$23.73
9	Sealant	Clear waterproof sealant	$0.10
10	Arduino IED	IED	$0
11	Arduino libraries	(Newping, SonarI2C, Due Timer)	$0
12	Code Blocks	Secondary IED	$0
13	Tinker CAD	Design software	$0
14	USB Cable (A-B)	Arduino Uno Cable	$7.00
15	Protoboard	Protoboard	$1.00
16	Wi-Fi Module	8266	$4.79
Total			$83.01
Total Used			$83.01
Total Remaining			$16.99

Updated Potential Risks

Issues with the error reading:

Because of the use of saran wrap, readings could be jeopardized or skewed due to the blocking of the ultrasonic waves. The saran wrap could not act as a waterproofing agent for the sensor.

Issue with the power supplies:

The power issue could relate to the waterproof side because there are pipes of liquid going in and out in the factory, so having a waterproof power supply could be very important.

Issue with the reflection of the wave on the pipe:

It could be fixed with an acceptable rate of error that removes the incorrect value from the pipe. A horizontal plate may also be inserted in the pipe to prevent more errors caused by curvature of the pipe.

Categories	Chance	Impact	Contingency
Issue with the error readings	high	low	With an extremely high frequency of income readings, an average of every 3-5 second could eliminate these errors.

Issue with the power supplies	low	low	The power of the unit could be provided by the extended line in client's factory or using a battery.
Issue with the reflection of the wave on the pipe	high	moderate	Because of how the pipe and the measurement unit are placed, the ultrasonic receiver will receive readings that have a huge difference than our normal readings.

Future Objectives

Future Objective	How?	Why?	Impact?	Contingency?
Ultrasonic Sensor Entry Point Relocation	-Cut new section in piping -most likely center -relocate	The current entry point of the PBS tubing does not fit the Ultrasonic sensor device metrics. Therefore, we must re-evaluate the entry point.	moderate	N/A
Ultrasonic Sensor Specific Gravity Longevity Test	-time the submerged sensor in water -measure how long our results are accurate -repeat -base system demonstration on design day on tests -hope it is that reliable on design day	Depending on whether or not our sensor can survive the water durability test, if it doesn't, we need to know how long it can be in the water before it fries in order to prove on design day that our system works. So, we need to know how long the Sensor can be in water for.	high	-Purchase waterproof sensor
Ultrasonic Sensor Environmental interference test	-go to BTP, ask to experiment this test -implement prototype system in factory environment -see how tests come out just external to the actual tank -see if it causes any changes	In the factory environment, there can be a lot of environmental interference with sound frequencies. We need to make sure it does not influence our results.	moderate	-try and create a case to prevent external sound interference
Back-up Power Source and	-Online research	Shane has requested a way of the system working		-N/A

Source Placement	-Ask Shane for any restraints or constraints. -Search best compatibility with constantly running systems	independently for a short amount of time, in case of any circumstances that may arise. Therefore, a back-up power source independent of its environment would be beneficial.	low	
Factory Implementation Research	-Online material research -new bill of materials -possible restraints and constraints -better sensors that can survive in water without replacement -cost effective	Research for how we can implement our system into the BTP factory floor can prove beneficial when trying to gain a tactical edge over our fellow classmates/ competitors.	moderate/low	N/A
Ultrasonic Sensor Specific Gravity in Multiple Substances	-Place sensory in olive oil and water -show system can tests with both substances to prove the independence from substance. -run tests to test findings	Proves our system is capable of measuring specific gravity of more than one substance, thus proving it is capable of differing between the two and not fake.	high	-If the tests don't work, we will have to go back and redo our code -We are very confident it will work

Conclusion

In prototype III, we refined many hardware problems found in the first deliverable; adapting according to the feedback received in our client meeting. The sensor windows were moved, the CAD housings were refined, and the pipe was tested for waterproofing and clarity. In addition to these advancements, we calculated our mathematical data required to compute readings from our sensor to specific gravity. Additionally, we wired and ran trials for the ultrasonic receiver. In the third prototype, we tested our sensor in a variety of liquids and determined that the pipe tests were inconclusive. We established the difference between the tests performed in a cup of water compared to the tests performed in the physical pipe. We have speculated as to why this didn't work and are now looking forward to creating a more technically advanced model, in addition to demonstrating where our tests went wrong on design day.