GNG 1103

Design Project User and Product Manual

User Manual: Hydroponic Raft Cleaning

Submitted by:

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Table 1. Acronyms

Acronym	Definition
CAD	Computer-aided design
Psi	Pound-force per square inch
UPM	User and Product Manual
UX	User Experience
J.A.D.	Just A Dishwasher

1 Introduction

This User and Product Manual (UPM) provides the information necessary for Growcer company to effectively use the design J.À.D and its prototype documentation. This design was developed in order to clean hydroponic growing plant boards by also decreasing the time required for labour. As a result, this document informs the techniques used and the steps taken to prototype the design. With that, a detailed description of the prototype testing and a BOM of materials is documented. Overall, while this concept design is yet to be an implementation it is still a work in progress.

2 Overview

The problem that team J.À.D. was presented with is to "design a time-efficient cleaning project for Growcer's hydroponic plant growing boards that is easy to use without any experience, reduces manual labour time, space efficient and is safe for humans, plants and the environment." This is important due to the fact that if the boards are not properly cleaned, the algae will become overgrown and result in the crops becoming infected with all of the algae's harmful bacteria. A successful implementation of this product will help Growcer dramatically cut down costs from labour time as well as increase workers productivity.

The day to day user of the product must be able to lift approximately 15lbs (twice the hydroponic board weight) and carry an object that is 24" x 32". This user must also be able to locate and press the start button as well, in the event of an emergency or malfunction this user must locate and be able to press the stop and emergency stop buttons. Finally, the daily user must be able to listen or stay vigilant for a rushing water sound or an orange light meaning that the system is in the process of cleaning as well as listen for a "ding" sound or look for a green light meaning that the cycle is done.

The design created by J.À.D. features a completely brushless clean which results in easier, less cluttered maintenance as well, due to this, the design requires less frequent cleaning. The element of heating up the water before use coupled with the high pressured water spraying results in an overall 93% cleanliness rating. This design also features 3 other extremely simple systems that make up the entire design. The heating system that was already mentioned is a simple clip in/ clip out method of replacement. The draining system simply optimises the use of gravity in order to have all the algae slide down the system rather than build up in the corners. The sanitol emitting system uses a simple set of code and a simplistic mechanical design that is already used in dishwashers globally which allows for the user to get the exact and same amount of sanitol in each cycle. The final system that allows the design to function is the rail system. The use of solid rails at the entrance and exit slits of the design and mesh rails spanning the length of the design allow for a seamless experience when placing the board in and taking the board out as well, this lowers the error rate.

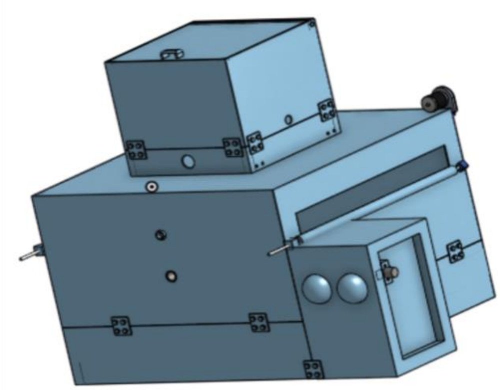

Figure 1: Final CAD prototype design

The design made by J.À.D. is very much derived from that of a dishwasher. This being said, the 4 main systems that are used in this design are the aforementioned heating, draining, rail and sanitol distribution systems. The heating system features a quick swap heating element that can be ordered from amazon and easily replaced. This is meant to heat the water to a temperature of 60℃ so that even if the algae is not off of the board, the user is assured that the algae is dead. The drainage system quite simply optimises the use of gravity by using a 30° angle in order to funnel the water and rinsed off algae to the bottom of the system where it is then drained out into the sewage system. The railing system is quite simply a normal rail near the entrance and exit, however, the design features a seamless and supportive mesh rail spanning the whole length of the design in order to keep the board supported while still receiving a full clean. The sanitol distribution system is a pre existing system that is already seen in dishwashers around the world. The only tweak made to this system is a small piece of code that allows the user to set the amount of sanitol that gets dispersed into the water for each cycle.

Upon receiving the design, it has been made to be able to fit into the average sized door which allows for the user to simply bring the box into the Growcer Pod. Once near the position where it will be placed, begin unpacking the box. The heating system will be pre attached to avoid any leaks however the pressurising system on the side will utilise hooks and a few screws to secure it. After this, all that remains is attaching the supply pipes to the water line, the drainage pipes to the septic system and finally, attaching it to power. After this is done be sure to test the system to ensure there were no damages in delivery or any manufacturing errors. J.À.D. has constructed a fully metal design with six subsystems including a feeding system, washing system, sanitol dispensing system, control system, heating system as well as a draining system. In testing ensure that all six of these subsystems work flawlessly as described later in this report. As well, make absolute certain that you ensure that the start and stop buttons work along with the visual and auditory aids for people with and without disabilities.

2.1 Conventions

There is the use of a step system within section 3.3, documenting the chronological order of the actions required to complete a task. In the case of 3.3, it is the instructions of how to set up J.A.D.

2.2 Cautions & Warnings

- It is recommended that the user keeps their hands and anything other than the boards a minimum of 15 cm away from the entrance and exit of the machine.
- It is imperative that the user keeps their hands away from the entrance and the exit of the machine while it is turned on. Especially when the machine is performing a cycle.

- The user should refrain from wearing loose fitting and dangly clothing while operating this machine. To avoid the risk of anything becoming stuck in the feeding mechanism of this machine.
- Do not force the growing boards in or out of the machine. If a board becomes stuck, turn off the machine, drain the water, and carefully remove the jammed board after the machine' temperature has cooled down to 40°C.
- Do not touch the machine while it is running to avoid burns, as the water in the machine is running at high temperatures. The metal facade of the machine will reach a very similar temperature that will burn the user if touched.
- When cleaning the machine the user must make sure that the machine is off. Do not put anything other than the growing boards into the machine unless it is turned off.
- When performing any type of maintenance or inspection turn the machine off, drain the water, and let its temperature cool down to at least 40°C.

3 Getting started

While the design is in function, it will first drag the board into the inside. Then, a light will turn on to signal that the machine has started. As a result, the board is found inside the design. Then, the sprayer from the top and the bottom will eject hot water that will be pressurised at 160 psi. The water will create a moment around both bottom and top sprayers since they would be ejected at an inclined angle see Figure 2. Combined with the water, a quantity of Sanitol will exit through the centre of the top and bottom sprayers. At the same time, the sprayers on the sides of the machine will initiate in order to clean the sides of the boards. Then, the design would automatically move the board until the end of the design and return it to the starting point to restart the washing cycle. This process will be done 6 times over a period of 10min. After the washing cycle ends, the board will exit from the other side and the light will turn off. During this process, the algae and the water used to clean the board will be drained through the draining system. Also, the water heating tank component will be filling up during the cleaning process of the boards.

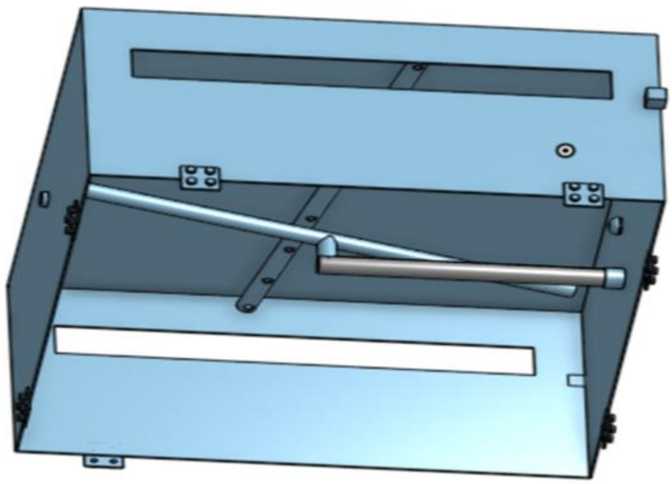

Figure 2 Washing system of J.À.D

The described process above demonstrates the steps taken by the design to function. However, before those steps, it is required that the user places the raft into the machine. Then, they need to press on the button found on the small box to the right of the design. The first button to the left is required to be pressed to start the machine and the second button on the right is to stop the machine for security reasons such as terminating the washing process due to a malfunction see Figure 3. Hence, after placing the board, it is required to press on the start button. Finally, when the design has completed its task of cleaning the raft, the user needs to take the raft that is exited from the machine.

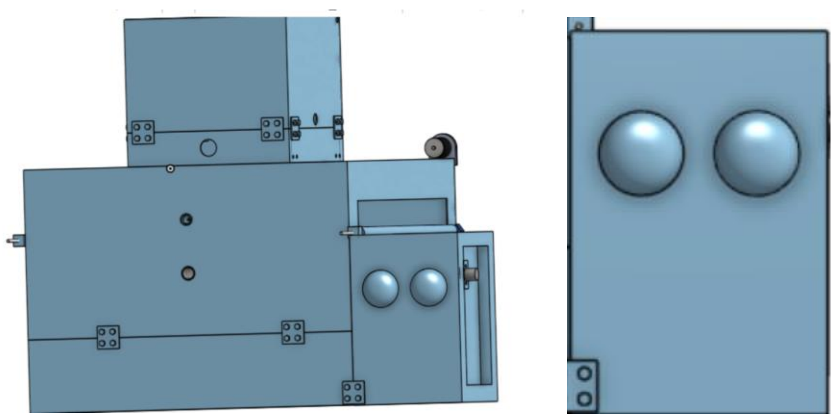

Figure 3 Button for controlling system

3.1 Configuration Considerations

3.1.1 Equipment:

The main equipment present in the system are the soap dispensary system *(Figure 4)*, the feeding rollers *(Figure 5)*, the heating element *(Figure 7)*, the microcontroller *(Figure 8)* equipped with an on and off button *(Figure 3)* and the 2 spinning washers *(Figure 2)*.

3.1.2 Communications:

The communications present within the system are all the microcontroller communicating with all the subsystems individually as well as receiving input from the temperature sensor in the heating chamber.

3.1.3 Configuration:

The configuration of the system is that all subsystems are connected and controlled by the microcontroller. The timing for all systems are programmed within the microcontroller. It is set up so that all subsystems can be started and run simultaneously as well as stopped if needed.

3.1.4 Input/Output:

The only input and output that this device receives is the boards that must be input by the operator at one end and then after the cycle has run its course it is output at the other end.

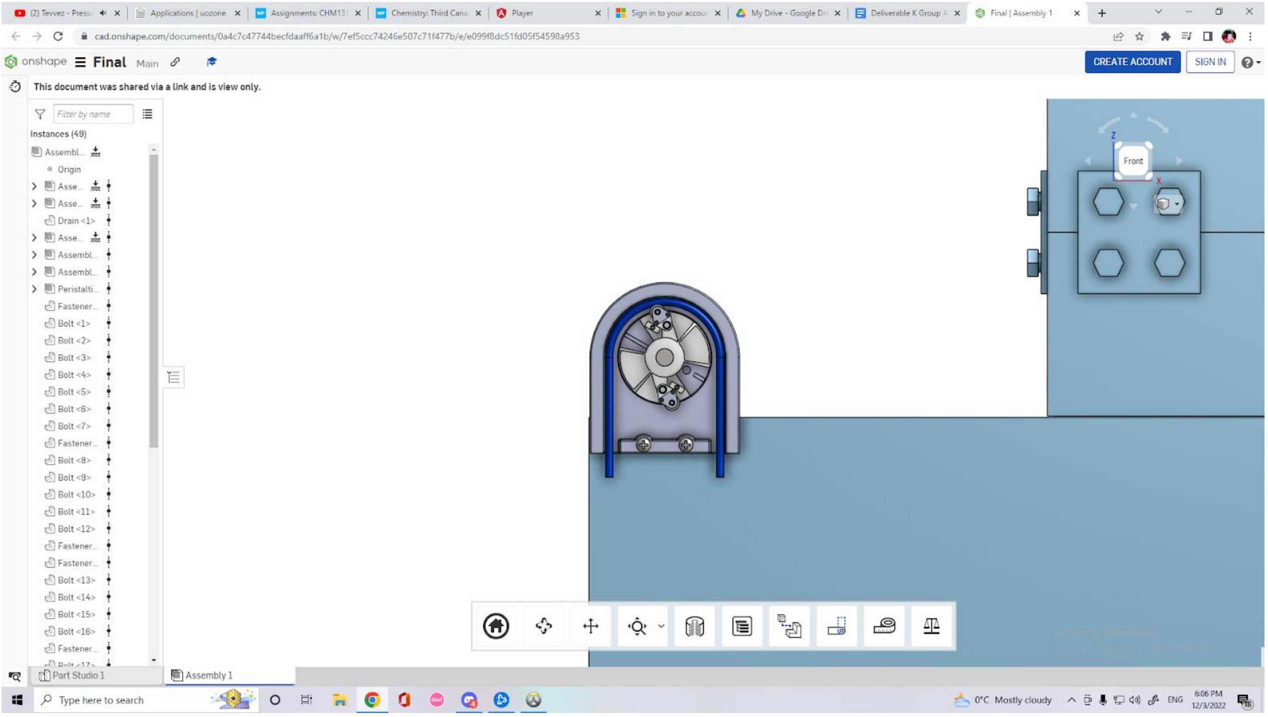

Figure 4 Soap ispensary system

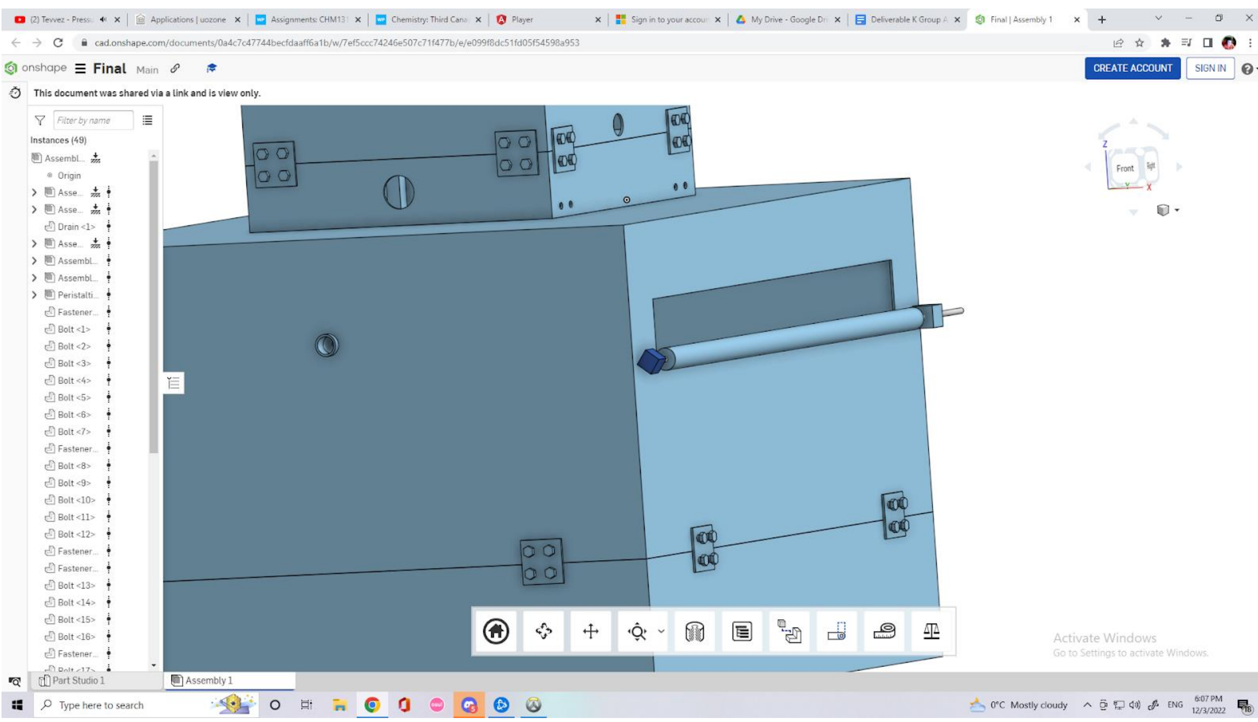

Figure 5 Feeding rollers

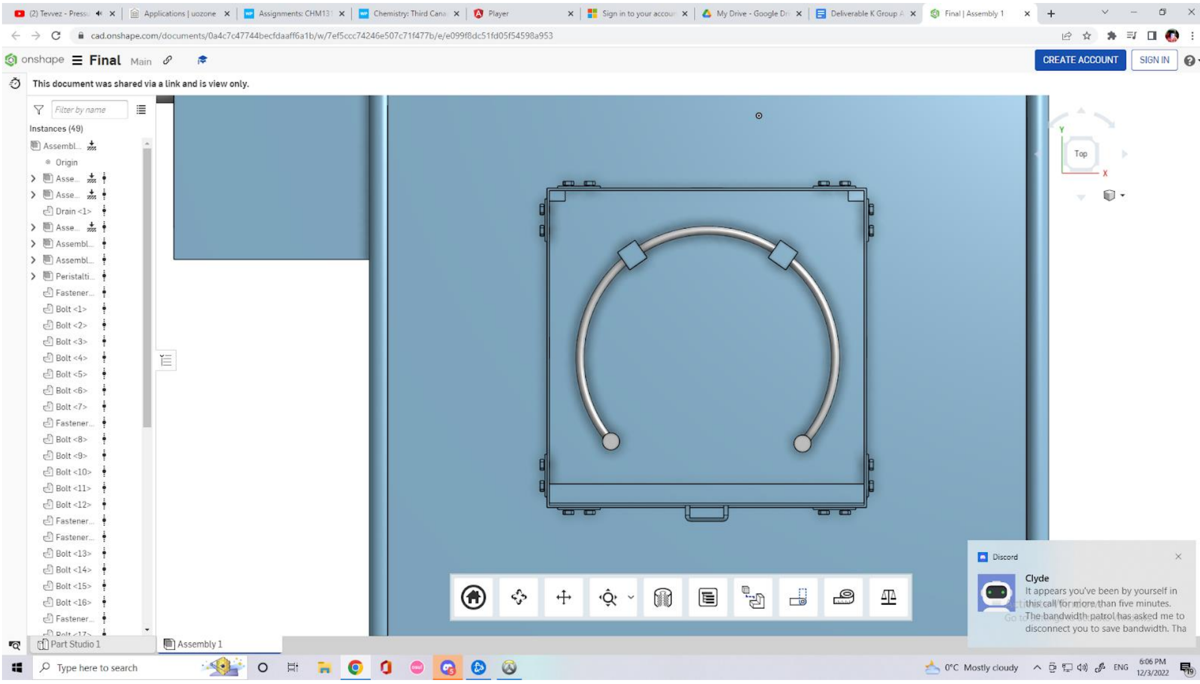

Figure 6 Heating element

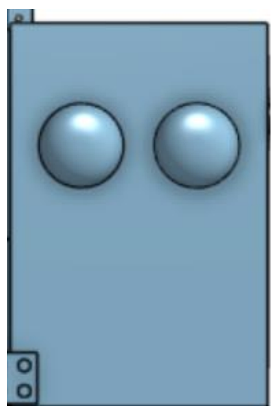

Figure 7 Buttons for controlling system

Figure 8 Microcontroller (Arduino Uno)

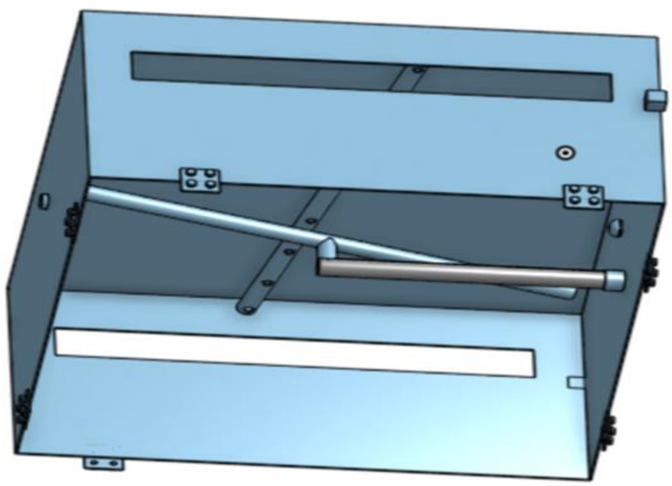

Figure 9 Washing system

3.2 User Access Considerations

The different users that would be able to use the product consist of any human person with the ability to lift the hydroponic raft that is 24” x 32” and are able to reach the insertion point. A person with a physical disability resulting in them being in a wheelchair will remain able to use the system as long as they are still able to place the board appropriately in the insertion point and are able to reach the on, off and emergency stop button.

A person who is diagnosed with dwarfism would remain able to use this product but may require the use of a step stool of sorts in order to reach the insertion point and the on/ off buttons.

Any person diagnosed with a hearing disability will remain able to effectively use this product due to the included lights that signal when the system is off (no lights) running (orange light) as well as a light to signal the washing cycle is done (green light). The option to enable these lights to flash is also included with a slight tweaking of code. However, it does not come in the standard model in order to enable people diagnosed with forms of epilepsy to continue using the product.

Any person diagnosed with a visual disability will also remain able to use this product due to the intentional slim design allowing for the rushing water sounds to protrude through the casing signalling the system is running as well as a ringing sound that informs the user that the cycle is completed. The main complication that one would face if diagnosed as a person who is blind is their ability to find the insertion slot. In this case the farmer can decide if they would like to include guiding touch points which would allow for the person who is blind to easily find not only the insertion point but on, off and emergency stop buttons too.

3.3 Accessing/setting-up the System

3.3.1 Installation and setup of the plumbing system

Step 1: Connect the drainage system to a pipe connected to the septic system. To install the pipe, connect the drainage system's exterior pipe to the farm's septic system system. Regarding this instance, it is preferable that the septic drainage system is installed by someone with plumbing experience.

Step 2: Adhesively seal the pipes and its connection to the water intake system. Sealing the washing machine's connection to the water intake system will reduce any potential issues like leaks that may occur.

Step 3: Connect the water input system to the water tank. To install the water intake, connect an exterior pipe from the water tank to the washing machine. Regarding this instance, it is preferable that the water intake system is installed by someone with plumbing experience.

Step 4: Adhesively seal the drainage system's connection to the septic system. Sealing the drainage system to the septic system prevents the drainage system from improperly removing the algae soap water from the system, reducing potential issues such as leaks.

3.3.2 setup and use of the electrical system

Step 1: ensure the machine is plugged into an electrical outlet. If the system is not plugged into an electrical outlet, insert the plug into an outlet. This can be achieved through multiple means. There is the possible option of inserting the plug into a nearby electrical outlet; however, if the length of the cord is too small, electrical cord extensions may be applicable to optimise distance.

Step 2: Once the electrical has been plugged into an electrical source, The user is now able to use the system. Pressing the left button will start the machine while pressing the right button will stop the machine.

3.4 System Organization & Navigation

3.4.1 Organisation:

The main component of the system is the washing system *(Figure 2)* connected to this main system is all the other components. Firstly, the heating system *(Figure 6)* is connected via stainless steel pipes that will supply the hot water to the washing system. Secondly, the soap dispenser *(Figure 4)* is connected to the washing system via plastic tubing. Thirdly, The feeding rollers *(Figure 5)* that are bolted to either side of the main body of the system. These allow for the input, output and control of the board. The drainage of the system is integrated directly into the main body, consisting of a sloped surface leading to a hole at the bottom of the dishwasher that sends the water out the connected pipe.

3.4.2 Navigation paths/connections:

All components are connected together using either plastic tubes, stainless steel piping or bolts. All components are connected to a single microcontroller present within the control box *(Figure 3)* this links all the components together and allows them to work in unison. This microcontroller is controlled by 2 buttons that are on the face of the box which will either start or stop the machine respectively.

3.4.3 System function:

3.4.3.1 Washing system:

The washing system consists of 2 spinning washers as well as 2 point washers on either side which is in charge of washing off the algae of the boards using high pressure water.

3.4.3.2 Heating system:

The heating system uses the heating element *(Figure 7)* to heat up 4.2 gal of water to a temperature of 60 C which is then fed to the washing system.

3.4.3.3 Soap dispenser:

The soap dispenser uses suction to pull soap from a bucket below the system and then send it into the washing system to be mixed in when the washing cycle takes place.

3.4.3.4 Feeding rollers:

The feeding rollers are used to receive the input of the boards, outputting the boards once the washing cycle has finished and controlling the boards, moving them back and forth as the cycle is ongoing.

3.5 Exiting the System

When your board cleaning needs are complete for any given session, it is recommended that you follow this shutdown process to minimize maintenance needed. As well as avoid potential breakdowns of this machine.

1. Complete one full cycle without a board running through the machine

2. Turn off the machine with the main OFF button

3. Drain all the water from the system of the machine and allow it to cool down before touching any metal components

    1. Be sure to check that the heating chamber is also empty of any water as well

4. Open the machine to visually inspect that the interior and any surfaces are free of algae

1. Surfaces to specifically check are: sprayers, interior walls, feeding rollers, and an overall scan of everywhere else

    1. If there is algae attached to any surfaces manually remove the algae with your hands or by rinsing with water

5. Thoroughly check that the drainage system is free of algae too

6. Leave the machine open to allow for it to dry fully. Preventing and mould growth.

4 Using the System

This section entails the process the user should follow when using this machine to wash the growing boards.

1. While the machine is OFF, inspect the cleaning chamber, sprayers, heating chamber, rollers, and drainage area. These areas should be clear of debris. Also check that the container feeding the soap pump is not empty. If it is, change or refill the container with more Sanitol.

2. After this initial inspection make sure all the chambers are closed off and press the ON button to turn on the machine. Now that the machine is on let it start a cycle to allow the machine to heat up the water required for a cycle. During this initial cycle it is helpful to make sure that the soap pump is actually pumping Sanitol into the machine. As well as to make sure all the sub systems are working normally.

3. Once the startup is carried out you may start cleaning your growing boards. Gently place a board at the entrance to allow it to be caught by the rollers. The board will move through the machine forwards and backwards a total of six times over a 10 minute cycle. During this cycle the user is free to work on other tasks at hand. When the cycle is complete the machine will play an audio to notify the user of completion.

4. Step three can be repeated as many times as necessary until there are no more boards to be cleaned

5. When all of the boards are clean and the user wishes to shut down the machine refer to section 3.5 to successfully shut down the system.

5 Troubleshooting & Support

5.1 Error Messages or Behaviors

5.1.1 Improper board cleaning:

5.1.1.1:

A cleaned straight vertical line on the boards might indicate an error within the jets, specifically a lack of rotations occurring with the jets. The inability to rotate such jets would be tied to a lack of pressure distributed from the pressurizer due to the jet's reliance on water pressure to allow the jets to rotate.

5.1.1.2:

Lack of algae physically removed; however, the boards are warm to the touch may imply low pressure. The implications of low pressure may be tied to the pressurizer

5.1.1.3:

Residual algae residue and lukewarm to cold water may imply a lack of heat. The implication of low temperature may be tied to the hot water tank.

5.1.2 Boards not properly exiting the washing machine:

5.1.2.1:

The Boards being elevated; however, not aligned with the exit slot may imply a faulty or damaged rail within the guide rail system.

5.1.2.2:

The Boards not being elevated, sloped onto an angle may imply a faulty or damaged rail within the guide rail system, causing the board to slowly slip and wedge into the drainage system in the process.

5.1.3 Electrical Malfunction:

5.1.3.1:

Left or Right Buttons are faulty may imply damage to the electrical circuit. First, grab your key to the electrical box and unlock the box. Afterwards, assess the areas where potential damage may have occurred like damp circuit boards, implicit of water damage

5.1.3.2:

Roller’s inability to feed boards through the system may either imply that the motor has defected or potential damage to the electrical circuit. Troubleshoot the motor first followed by troubleshooting the circuit system if the motor is proven not defective.

5.1.4 Water is leaking or making a mess within the surrounding area:

5.1.4.1:

Water leaking near the water intake section of the washing machine may imply improper sealing and installations regarding the washing machine’s connection to its water intake system.

5.1.4.2:

Water over pouring with soapy algae water may imply algae buildup, blocking the drainage system.

5.1.4.3:

Dirty soap and algae water leaking at the base of the machine may imply an improper sealing and installation of the drainage system’s connection to the septic system.

5.2 Special Considerations

5.2.1 Boards not properly exiting the washing machine

5.2.1.1

If the board is ever elevated but not aligned with the exit slot, press the right button and turn off the machine, then unplug the electrical source. Afterwards, grab a pole or a stick large enough to slide into the exit slot of the machine. Drag the board back onto the non faulty guide rails and push the board out through the entrance slot.

5.2.1.2

If the board ever falls on an angle within the system, press the right button and turn off the machine, then unplug the electrical source. Afterwards, grab a pole or a sick large enough to slide into the slot of the machine where the upper part of the slope is the closest to. Use the stick to re-elevate the board back onto the guide rail, followed by pushing the board out through the opposite end where the stick entered.

5.3 Maintenance

Due to the fact that this system is not self sustaining, there are a few regular maintenance pieces that the user or owner should follow up on in order to reduce the risk of failure.

The first and perhaps most important thing to check is checking if the drain is clogged and if it is to clear it. Ensure that you have gloves on and the system is unplugged first. Once you have this done, feel free to reach your hand into the shell of the system and down to the mesh drain and remove and dispose of whatever algae may have collected there. As well, be sure to check the pipes every few months and run cleaning fluid down the pipes to ensure there are no blockages. The user should also check the drainage ramps to ensure that all the algae slides down the side and into the drain properly and efficiently to ensure full cleaning of the board.

The user should also consistently check to ensure that the soap dispensing system is consistently fully replenished in order to ensure there is enough soap for each cycle. The user should restock the soap system after each full day of use.

The user should also be aware of parts that are likely to wear out or break such as the heating component. This is something that can be simply fixed and does not require a technician to do so. The system used simply requires the user to order a new part off amazon, clip out the old part and clip the new part back in place of the old. After this, let it run a test cycle and you are good to go.

5.4 Support

In the event of an emergency J.À.D. has a fully functioning 24 hour cell phone number and various email addresses that one can use to get the proper help.

In the event that your product stops working and you do not know why, please call 819-208-0920 and ask for our Director of Staff and Operational Manager, Giovanni Abbruzzo, or send a detailed email to gabbr085@uottawa.ca with subject line "J.À.D. Unknown System Malfunction" please include any and all potentially helpful details and images.

In the event that your heating system stops working, please call 819-208-0920 and ask for our Chief Systems Designer, Kalan King or send a detailed email to kking023@uottawa.ca with subject line "J.À.D. Heating System Malfunction" please include any and all potentially helpful details and images.

In the event that your feeding system (conveyor belt system) stops working, please call 819-208-0920 and ask for our Chief Systems Designer, Kalan King or send a detailed email to kking023@uottawa.ca with subject line “J.À.D. Feeding System Malfunction” please include any and all potentially helpful details and images.

In the event that your sanitol dispensing system stops working, please call 819-208-0920 and ask for our chief systems designer Kalan King or send a detailed email to kking023@uottawa.ca with subject line “J.À.D. Sanitol Dispensing System Malfunction” please include any and all potentially helpful details and images.

In the event that your draining system stops working, please call 819-208-0920 and ask for our Head of Physical and Technological Designs, Ali Elmawazini or send a detailed email to aelma032@uottawa.ca with subject line “J.À.D. Draining System Malfunction” please include any and all potentially helpful details and images.

In the event that your controlling system stops working, please call 819-208-0920 and ask for our Head of Physical and Technological Designs, Ali Elmawazini or send a detailed email to aelma032@uottawa.ca with subject line “J.À.D. Controlling System Malfunction” please include any and all potentially helpful details and images.

In the event that your washing system stops working, please call 819-208-0920 and ask for our Director of Staff and Operational Manager, Giovanni Abbruzzo or send a detailed email to gabbr085@uottawa.ca with subject line “J.À.D. Washing System Malfunction” please include any and all potentially helpful details and images.

In the event that the lights, ring or other miscellaneous problems arise, please call 819-208-0920 and ask for our Director of Staff and Operational Manager, Giovanni Abbruzzo, or send a detailed email to gabbr085@uottawa.ca with subject line “J.À.D. r Miscellaneous Problem*(s)* System Malfunction” please include any and all potentially helpful details and images.

6 Product Documentation

To build the final design, we have done many prototypes in order to represent each subsystem. As a matter of fact, we have begun doing a detailed design through a CAD program. Then, we built a physical scaled model as a proof of concept. After, we went on to prototype the subsystems such as the draining system, the feeding system, the controlling system, the heating system and the washing system.

6.1 Subsystem 1 CAD

The overall goal of this first prototype was to get everyone in the group on the same page when it comes to our design. This drew a lot of confusion as even though we had made drawings and visuals in the past, there was nothing fully built allowing for everyone to see the big picture. Thus, we made our CAD model. We were able to make a fully fledged design which conformed to the allotted area as well as our final design dimensions (30”x45”x30”) as well as confirming that this would fit into our given space being the table space inside of each portable (30”x96”x36”). Members of J.À.D. were also able to give various parts animations in order to increase the clarity within our team.

6.1.1 BOM (Bill of Materials)

Material/ Platform	Description	Quantity	Cost ($)	Added cost ($)	Total Cost ($)	Link
1. OnShape	It is a CAD website	1	0.00	0.00	0.00	link
2. Computer	Computer (laptop or desktop) capable of running OnShape	1	150.00 - 3,000.00	20.25 - 405	0.00	link
3. Key board	Allows you to in put items using OnShape	1	10.99 - 200.00	12.47 - 227.00	0.00	link
4. Mouse	Allows you to have better control of OnShape	1	7.99 - 120.00	1.08 - 16.20	0.00	link

6.1.2 Equipment list

In the making of this prototype there was no equipment needed. Team J.À.D. already had all of the required materials listed in the above B.O.M. The team only had to simply connect the mouse and keyboard to their laptop and log into OnShape and they were able to begin working on the prototype.

6.1.3 Instructions

Various members of team J.À.D. were able to make use of their previous years experience in CAD modelling and were able to produce a fully functioning 3D render of the proposed design.

This was done through many tedious steps and re-learning from various YouTube videos as well as tutorial videos featured on the OnShape website. After countless hours of work, the final functioning 3D model is shown below.

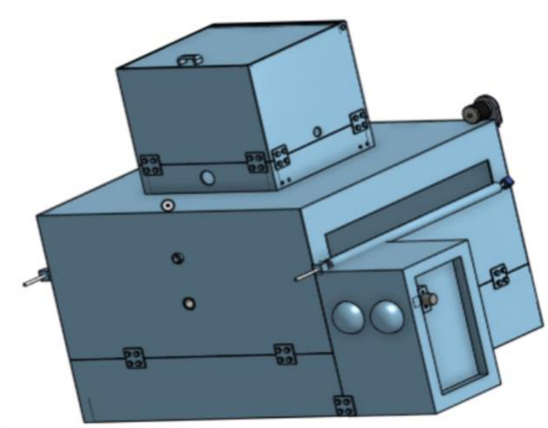

Figure 10 Final CAD prototype design for team J.À.D

6.2 Subsystem 2: Proof of concept Box

6.2.1 Objective:

The main goal of this prototype was simply to see whether or not we would be able to pass a board through the entire system without any problems. However, we did run into a major problem with the board falling through the shell. In our final design this would result in a catastrophic failure where the board would come in contact with the spinning water jet on the bottom resulting in a possible breaking of both the board and the machine.

6.2.2 BOM (Bill of Materials)

Material/ Platform	Description	Quantity	Cost ($)	Added cost ($)	Total Cost ($)	Link
1. Cardboard	Various types of cardboard were used, some from that of a TV and some from that of a Cheerios box.	$12ft^2$	0.00	0.00	0.00	Recycling bins
2. Hot glue gun	Dispenses hot glue through use of a trigger.	1	16.99	2.29	19.28	link
3. Hot glue gun sticks	Becomes liquid glue when paired with a hot glue gun.	40	0.00	0.00	0.00	Was included with the above purchase
4. Styrofoam	Came with the cardboard from the TV.	$2ft^2$	0.00	0.00	0.00	Recycling bins
5. Roll of Duct Tape	Is used to combine/ connect one or more items.	1	6.79	0.92	7.71	link
6. Ruler	Is used to measure distances and as a straight edge	1	1.99	0.27	2.26	link
7. Scissors	Used to cut various materials	1	7.77	1.05	8.82	link

6.2.3 Equipment list

The equipment required to construct this prototype was a pair of scissors and a hot glue gun.

6.2.4 Instructions

For this prototype, J.À.D. set different people on different tasks. The first group was tasked with the making of the 10”x10”x10” box with two 8” slits in opposing sides. This group carefully measured each four 10”x10” thick pieces of TV box cardboard, cut out two 8”x1.5” slits on either side and pasted the box together using a mix of hot glue and tape. The team decided, after testing that the addition of rails is necessary in order to have a functioning design. With that, two more strips of cardboard were cut (10”x2”) and taped on as rails. As well, extra 3”x2” pieces of cardboard were added to enhance the structural integrity of the design.

While the first group was doing this, the other group worked on the construction of the model board. This was done by cutting out a piece of styrofoam that was 10 inches long, 8 inches wide and 1.25 inches tall. Since styrofoam is very brittle, these members of J.À.D. added a thin layer of cardboard that covers the top and bottom faces (10”x8”) and width ends (8”x1.5”) of the box.

Figure 11: Final prototype 2 - cardboard and Styrofoam model for team J.À.D.

6.3 Subsystem 3: Draining system

Objective:
In this next prototype, we are testing the functionality of our draining system. This test will be a physical and focused prototype. Indeed, in order to demonstrate a good functionality of the draining system, we need to have a physical concept to generate test results. Also, we will only be testing this subsystem separately to determine if the chosen draining system of our design is adequate to carry out its objective which is to drain the algae and the water out of the design. As a matter of fact, the draining system is created with two inclined planes. The goal of this prototype is to determine the required angle of inclination in order to drain all of the water and the algae. Indeed, if the algae is as adhesive as our client describes, we will need to avoid having any algae sticking to the draining system. Hence, the goal that we have implemented has a learning objective and a reducing risk objective. The learning objective in this test is to have a proper idea of how the inclined plane will affect our system.

6.3.1 BOM (Bill of Materials)

Material	Description	Quantity	Cost ($)	Added cost ($)	Total Cost ($)	Link
1. Egg cardboard box	To support the draining system	1	0.00	0.00	0.00	My recycle bin
2. Hot glue sticks	To connect all parts together	5	0.00	0.00	0.00	Link
3. Plastic surface	To simulate the draining system	1	0.00	0.00	0.00	link

6.3.2 Equipment list

The equipment used in this prototype was scissors to cut the cardboard and a hot glue gun to connect and stick the support together. Also, we used a protractor in order to measure the angle of inclination. As for spraying water, we used a shower head.

6.3.3 Instructions

The first step in building this prototype was to cut the egg box in half with scissors. Then we stuck both ends of the egg box together with hot glue in order to have a 90 degrees angle. After letting the glue dry, we placed a plastic plane on it to simulate the draining system. Then, we took 10 toilet paper pieces and soaked them with water. This allowed them to be heavy and sticky which simulated the algae. After that, we randomly placed them on the plastic plane. The next step done was that we took a protractor and measured the angle of inclination. Finally, we used a shower head at a very low pressure to spray on the inclined plane in order to simulate the draining of water. Then, we restarted these steps for each angle tested. The first angle tested was at 10 degrees, the second angle was at 30 degrees and the third angle was at 40 degrees.

Figure 12: Draining system

Figure 13: Draining system with wet paper tissues

6.4 Subsystem 4: Heating

6.4.1 Objective:

The objective of this Focused/analytical prototype would be to see if our heating system in its current state would be able to contain an appropriate amount of water and what the power usage of the system would be in order to heat our water within the allotted 10 minute time window. If our heating system is able to meet said specifications, this would give us insurance that in our real world product the heating system would be able to function with the rest of our subsystems to create a fully functioning model.

For the analysis we decided to do a focused and analytical prototyping of our heating system. It will be important to establish a few metrics/criteria as well as target specifications. This will allow us to determine whether or not our current heating system will allow us to adequately clean the algae of the boards when coupled together with the other subsystems. A few criteria that will be important to us in this regard will be the overall temperature of the water, the quantity of heated water and the time necessary to heat said water. For these 3 criteria it will also be important to specify the target specifications. Seeing as our overall design is extremely similar in make and functioning to a standard dishwasher, we are able to establish general target specifications based on current existing dishwasher models.

6.4.2 Calculations:

Table 1: Quantity of water per cycle based on dishwasher size

Company:	Model	Size (in^3)	Water usage (gal)	gal/in^3	Links:
Amana	ADB1300AF	19872	3.5	0.0001761272142	Link
Beko	DDT38530	19872	3	0.0001509661836	Link
Beko	DIT29430	19872	2.4	0.0001207729469	Link
Bosch	SHEM78WH#	19872	2.9	0.0001459339775	Link
Bosch	SHPM865Z5#	19872	3.5	0.0001761272142	Link
Frigidaire	FGID2476	19872	2.7	0.0001358695652	Link

KitchenAid	KDTE304G	19872	3.5	0.0001761272142	Link
LG	LDT780#	19872	2.9	0.0001459339775	Link
Samsung	DW80R2031	19872	3.5	0.0001761272142	Link
Whirlpool	WDF518SAHB	19872	3.1	0.0001559983897	Link
Avanti	DW1832D1BE	19872	3.1	0.0001559983897	Link
Electrolux	E24ID75	19872	2.7	0.0001358695652	Link
Maytag	MDB8959SK	19872	3.5	0.0001761272142	Link
Average:		19872	3.1	0.0001559983897	
J.A.D	1	27000	4.211956522	0.0001559983897	
Data: Link					

This first table tells us our target specification when it comes to the amount of water that will be needed per cycle within our product. Thus, indicating the amount of water that our heating system will have to be able to contain. The calculations were done by taking the most common dishwasher models and calculating the quantity of water needed per cycle, this was then averaged. We also took the average size of the dishwashers. Dividing the quantity of water by the size this then gave us an average for gal/inch^3 for common dishwashers. Taking this average we then modified the size to the dimensions of our current model being 30x30x30=27000 in^3 giving us a 4.2 gal per cycle estimate.

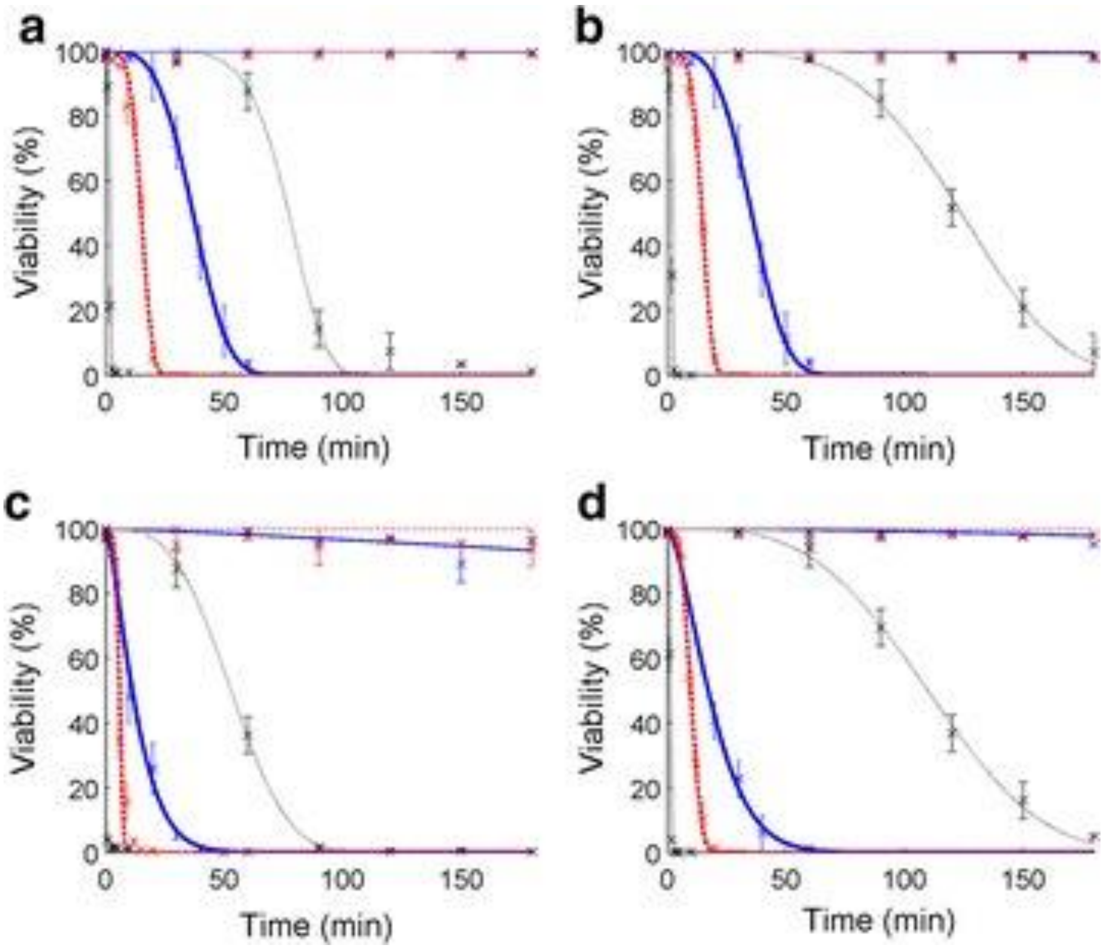

Figure 14: Salination levels

“Evolution of *D. salina* viability with time of exposure to high temperatures (Marker/Incubation time: **a** erythrosine/1 h; **b** FDA/1 h; **c** erythrosine/6 h; **d** FDA/6 h; *crosses* experimental data; *line* Weibull model; *Thin blue line T* = 41 °C; *Thin red dash line T* = 42 °C; *Thin black point line T* = 43 °C; *Thick blue line T* = 45 °C; *Thick red dash line T* = 50 °C; *Thick black point line T* = 60 °C). *Error bars* represent 95% confidence intervals. The 100% viability measured in the tubes non-exposed to heat (t = 0) shows that experimental conditions (no agitation, dark conditions) did not impact algal viability over the duration of kinetic studies”(U.S. National Library of Medicine 2017)

This table was taken from a research paper done on the percent of viable D.Salina cells based on the temperature. D.Salina is a form of green microalgae that grows within mineral rich lakes and areas. This makes it very similar to the algae being removed in our case as it is a green algae growing in a mineral rich environment. Thus , an assumption is being made that the percentage of viable D.Salina cells will be closely representative of the percentage of our given algae. The tables reveal that exposed to a temperature of T = 50 °C there was a rapid decline in the viability percentage and at T = 60 °C there was a near instant drop to 0%. Thus, the target specification for the heat of our water should strive to be around the 50 - 60 °C range.

As for time to heat the required volume, our estimated time per cycle would be around the 10 min mark. As precise in the paper it would take only a matter of a minute or two for just about all the algae to be killed off. Thus, in order to guarantee that all the algae would be cleaned off we are allowing for an additional few minutes of safety, as well, this time would allow the worker to work on separate tasks while the cycle runs therefore increasing the users experience and allowing for very little wasted time. Thus, our heating system would need to be able to heat the designated volume within a time frame of 10 minutes to have it ready for the next cycle once the current one is finished.

Taking into account all of these target specifications, this now brings us to the question, would our system given the current dimensions and parts be able to meet these specifications and how much power would it take? The actual system in order to meet the target specifications, that being of 140°F (60 °C) every 10 minutes, would need an input of about 7kW through the heating element in order to heat a volume of 4.2 gal. Given an assumption of initial room temperature of 78°F. If the temperature of the water were to be lower this would increase the time needed and vice versa if the temperature of the water were higher.

Pt = (4.2*L*T)/3600

Pt = (4.2 * 16 * (140-78))/3600

Pt = 1.157 kWh

Time = Pt/power usage

Power usage = 1.157/0.167

Power usage = 7kW

The essential of this is that to be able to run our system at optimal efficiency meaning that a board is cleaned every 10 minutes the farm would need to be able to output 7kW, the less power output a farm has the longer the process would take. However, for the sake of the prototype our system, given the correct power output, would be able to contain and heat the water in the appropriate amount of time. For, the dimensions of the heater allow for up to 6.9 gal of water to be stored and the heating element allows for the 7kW of power required to heat the 4.2 gal of water in the allotted time span of 10 minutes.

6.4.3 BOM (Bill of Materials)

There is no BOM since it is an analytical prototype.

6.4.4 Equipment list

The materials needed to reproduce this prototype are a computer and an internet connection.

6.4.5 Instructions

To reproduce this prototype it would simply require calculations for the power required. A few areas that may be important to take into consideration that were not in this prototype. These areas include the amount of time that the water would be in contact with the heating element as well as the surface of contact that the heating element has with the water that would affect the rate at which the water gained heat.

6.4.6 Conclusions:

From these calculations we are able to deduce that a simple standardised heating element would be sufficient for the heating element within our system. As well as stainless steel could be used for the exterior shell of this subsystem for it would be able to handle the heat as well this material would reduce the rusting, this being important due to its contact with water.

6.5 Subsystem 5: Sanitol Dispenser

The majority of Dishwashers that we benchmarked all displayed the functions and uses of soap dispensers. Due to this observable trend, we had assumed that our dishwasher would use a soap dispenser to aid in chemically cleaning off the algae. The soap we had assumed our dishwasher would use would be Sanitol, a disinfectant that our client was using at their hydroponic farms. The Soap dispenser would use a Peristaltic Pump, rotating around the fixed tube, pumping Sanitol into the system's water input.

6.6 Subsystem 6: Washing system

The goal with this focused/analytical prototype was to determine the water pressure needed by the washing system to consistently remove all of the algae buildup on the growing boards. If we can determine a benchmark water pressure that will effectively remove the algae on the growing boards.

6.6.1 BOM (Bill of Materials)

There is no BOM because it is an analytical prototype.

6.6.2 Equipment list

No special equipment was needed to carry out this prototype.

6.6.3 Instructions

To produce the same or similar results that this analytical prototype did, one would need to scour the internet for relevant data and information about algae's surface tension on high-density polyethylene. Further physical prototypes on how much pressure is needed to remove algae stuck to a high-density polyethylene board would be beneficial, as our prototype's results were largely based on the assumption that the water pressure needed to remove the algae would be similar to that of a commercial dishwasher (being around 50 psi minimum).

6.6.4 Conclusion:

At the end of this research we determined that a water pressurizer that has the capability of meeting the 50 psi benchmark, while also being capable of more than triple that pressure (maxing out at 160 psi). This is most beneficial as the pressure can be adjusted as needed. Especially if it turns out to have been a poor assumption to make.

6.7 Subsystem 7: Feeding system

The objective of this prototype was to determine if a cylindrical roller with an adhesive type of material would be able to move a HDPE board forward and backwards as needed.

Figure 15: Physical feeding system prototype

6.7.1 BOM (Bill of Materials)

Part	Material	Amount	Price $	Link
Feeding system	Wood 2X4X8	8	$62.64	Link
	Bolt ¼"	2	$0.20	Link
	Wood dowel	1	$2.10	Link
	Cutting board	1	$13.29	Link

6.7.2 Equipment list

The equipment that was required to put together this prototype was a table saw, a drill and a variety of screws and bolts.

6.7.3 Instructions

Cut out 9, 8x2x1 inch pieces of wood. Next cut 5, 18x2x1 inch pieces of wood. Cut the dowel into a size of 8 inches. Screw all 8x2x1 pieces of wood in between two 18x2x1 pieces of wood. On the fourth opening insert the dowel and then add a bolt on the end of the dowel.

6.7.4 Conclusions:

From this due to the ease of functioning of the prototype we were able to conclude that our rollers in our overall design would be able to function just as the ones in our prototype did.

6.8 Subsystem 9: Controlling system

For this prototype, we are testing the functionality of an automatic feeding system by creating a controlling system. As a matter of fact, The goal of this prototype is to demonstrate that a conveyor belt is able to drag a board through the design. This prototype will be physical and focused. Indeed, the objective towards this prototype was mainly to measure the performance and to reduce risk. As such, we have built a small conveyor belt in order to demonstrate the functionality if it can be implemented into our final design. The prototype is scaled to a measurement of 6 cm long. Also, this prototype was of medium fidelity since there were some issues with the prototype in terms of measurements. If the measurements were exact, the prototype would be of high fidelity since it would demonstrate an exact scaled model of an automatic feeding system. However, the wiring and the coding are of high fidelity since we were able to represent a fully functional motor system that can automise the feeding system.

6.8.1 BOM (Bill of Materials)

Material	Description	Quantity	Cost ($)	Added cost ($)	Total Cost ($)	Link
1. Arduino uno	It is a microcontroller	1	9.00	1.17	10.17	link
2. Jumper cables (male-male)	To connect all parts together	20	2.00	0.26	2.26	link
4. Tactile push switch	To start and stop	1	0.20	0.03	0.20	link
5. Breadboard	To build the circuit	1	2.50	0.33	2.83	link
6. Variable resistor (pot)	To control the current	1	1.61	8.27	9.83	link
7.	To allow a rotation	1	4.00	0.60	4.60	link

DC motor						
8.Nails	For support	12	0	0	0	My garage
9.Wooden board	Base of support	1	0	0	0	Link
10.Hot glue sticks	To stick components	8	0	0	0	Link
11. Mechanical pencil	To simulate rollers	2	0	0	0	Pencil case
12.Rubber bands	To simulate the conveyor belt	2	0	0	0	Link

6.8.2 Equipment list

To build the controlling setup, there was no equipment needed since we had to do it all by hand. However, before building it we used a software called TinkerCad to simulate the wiring. As for the scaled model that represented the feeding system, we used a hammer and hot glue as the equipment to build it.

6.8.3 Instructions

Instructions for wiring setup:

Note: All wires that do not have a specific row assignment, should all be in the same row. Also, for a more precise directory of how we build this setup, below is an image of our setup. This image is a TinkerCad setup that we built.

1. place your L293D IC on the breadboard on F and E. Make sure that the tip with a dent is facing outwards of the breadboard
2. Then, we placed the Pot below the L293 DC IC by 7 terminal strips.
3. Below that, place the tactile push button by skipping 5 terminal strips.
4. Then, we connected 2 wires to the tactile push button. One wire is connected to the Digital pin 7 on the arduino and the other wire is connected to the positive terminal strip of the bread board.
5. We connected 3 wires to the variable resistor. The wire in the middle of the variable resistor is connected to the 0 analog of the arduino. For the 2 others, one of them is

connected to the negative terminal strip of the breadboard and the other one is connected to the positive terminal strip of the breadboard.

6. Furthermore, we connected a wire to the 5V of the arduino to the negative terminal strip of the bread board below the L293D IC of 1 terminal stip.
7. Below that wire, there is another wire connected to the breadboard terminal strip by being aligned to the first connector of the l293D IC.
8. We also connected a wire from the Digital 9 pin of the arduino to the terminal strip aligned to the second connector of the L293D IC.
9. Another wire is connected from the Digital 10 of the arduino to the terminal strip of the breadboard aligned with the 7th connector of the L293D IC.
10. After that, we attached a wire from the 11th Digital pin towards the terminal strip aligned to the 8th connector of the L293D IC.
11. Moreover, a wire is connected from the GND pin of the arduino pin towards the positive terminal of the breadboard. This wire is located above the wire aligned with the 1st connector of the L293D IC.
12. A wire is then connected to the positive terminal strip aligned with the 4th connector of the L293D IC and to the terminal strip of the breadboard aligned with the 5th connector of the L293d IC.
13. The last wire is connected to the negative terminal strip of the breadboard and to the first terminal of row D of the breadboard which is aligned to the 8th connector of the L293D IC.
14. Finally, we connected one motor wire to row G aligned with the 3rd connector of the L293D IC and the other wire of the motor connected to row G aligned with the 6th connector of the L293D IC.

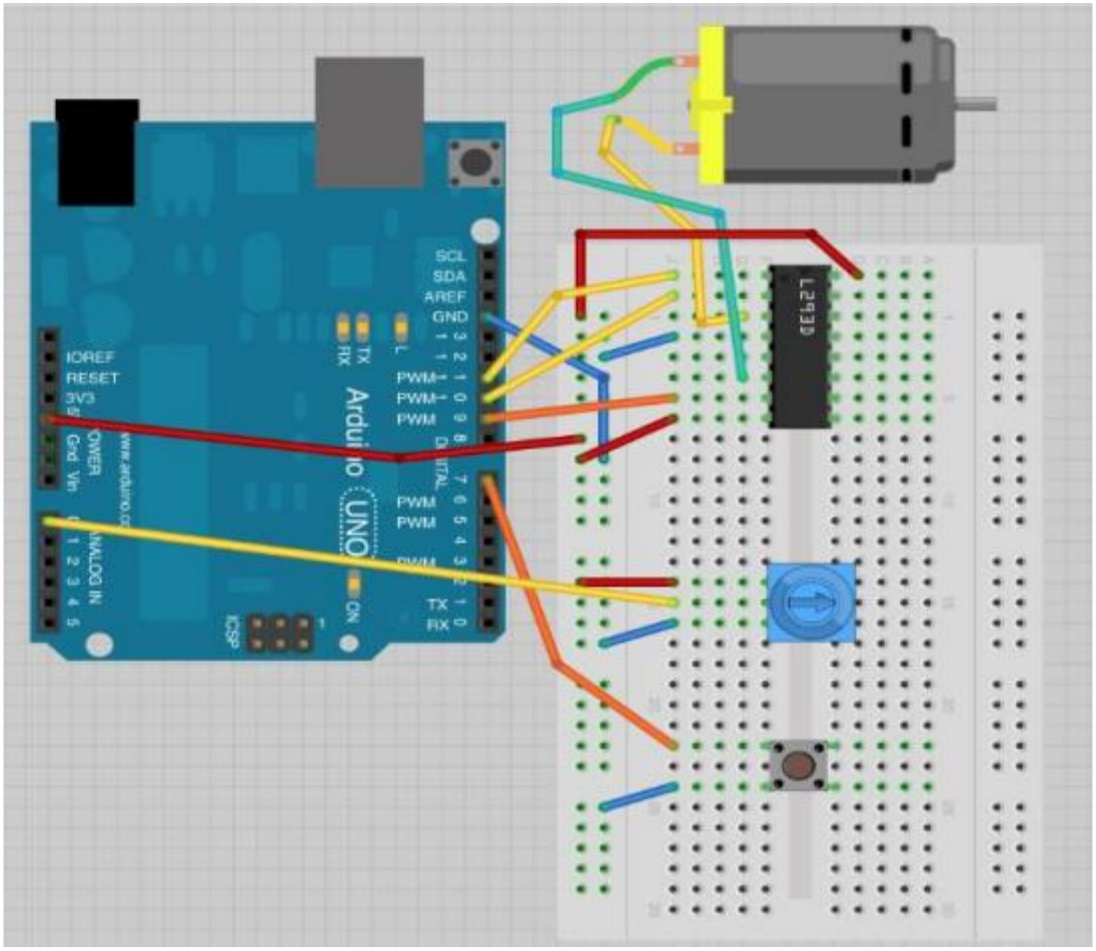

Figure 16: Arduino Setup

Instruction for scaled feeding system prototype:

1. We took the wooden board and placed the motor and the 3D printed tubes 6 cm away from each other.
2. We stuck the motor with hot glue to the wooden board.
3. We stabilised the motor with 2 nails on each side of it.
4. We created a support for the 3D tubes by locking it down with nails.
5. Then we added hot glue into the tubes
6. Before the hot glue solidifies, we place a nail in the centre.
7. To have the tubes at equal height of the motor, we added pieces of crayons to increase the height of the tubes.
8. We then stuck the tip of the motor to one of the 3D tubes with hot glue.
9. Finally, we added 2 elastic rubber bands to connect the 3D tubes together in order to simulate a conveyor belt.

The figure below represents the prototype of the scaled feeding system.

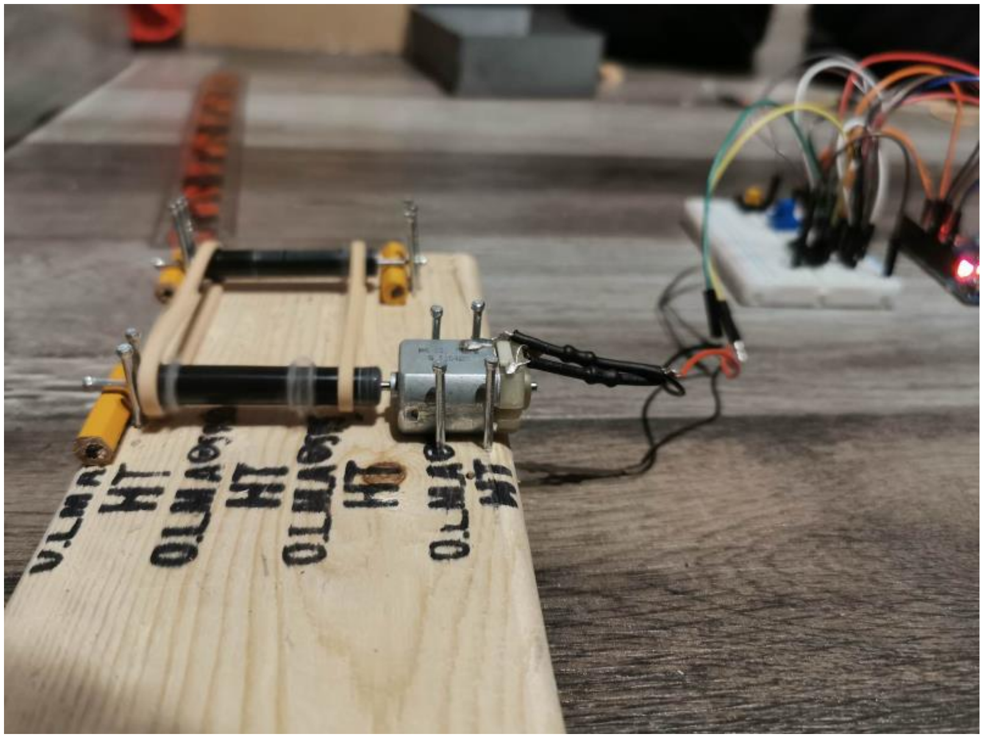

Figure 17: Scaled feeding system prototype

For the code that makes this setup function, we have created it on the arduino code software. This code essentially directs the motor to turn while the tactile button is pressed. When it is pressed, the motor does many cycles of going back and forth. If the tactile button is pressed while the motor is functioning, the motor will stop. This represents our controlling system. However, instead of having 2 buttons, where one would start and the other one would stop, we only have one button that accomplishes both tasks for the prototype. Below is the entire code.

```
/*
Adafruit Arduino - Lesson 15. Bi-directional Motor
*/
int enablePin = 11;
int in1Pin = 10;
int in2Pin = 9;
int buttonPin = 7;
int potPin = A0;
int buttonState = 0;
int lastButtonState = 0;
int x = 0;
```

```
void setup()
{
  pinMode(in1Pin, OUTPUT);
  pinMode(in2Pin, OUTPUT);
  pinMode(enablePin, OUTPUT);
  pinMode(buttonPin, INPUT_PULLUP);
  pinMode(potPin,INPUT);
  Serial.begin(9600);
}
void loop()
{
  buttonState = digitalRead(buttonPin);
  if (buttonState != lastButtonState){
    if (buttonState == 0){
      if (x == 0){
        Serial.print("On");
        x = 1;
        x = cicle(x);
      }else{
      Serial.print("off");
      x = 0;
      }
    }
  }
  lastButtonState = buttonState;
}
void setMotor(int speed, boolean reverse)
{
  analogWrite(enablePin, speed);
  digitalWrite(in1Pin, ! reverse);
  digitalWrite(in2Pin, reverse);
}
int cicle(int x){
  int y = 0;
  int tmp = 0;
  int speed = 0;
  while (x != 0){
    buttonState = digitalRead(buttonPin);
    if (buttonState != tmp){
      if (buttonState == 0){
        break;
      }else{
        tmp = buttonState;
      }
    }
    if (y < 4){
      if (y % 2 == 0){
      long currentm = millis();
      while (abs(millis()-currentm) <= 2500){
```

```
      buttonState = digitalRead(buttonPin);
      if (buttonState != tmp){
      if (buttonState == 0){
        break;
      }else{
        tmp = buttonState;
      }
      }
      setMotor(225,1);
   }
   y +=1;
   }else{
    long currentm = millis();
    while (abs(millis()-currentm) <= 2500){
      buttonState = digitalRead(buttonPin);
      if (buttonState != tmp){
      if (buttonState == 0){
        break;
      }else{
        tmp = buttonState;
      }
      }
      setMotor(225,0);
   }
   y += 1;
   }
   }else{
    break;
   }
  }
   digitalWrite(in1Pin, 0);
   digitalWrite(in2Pin, 0);
   Serial.print("off");
   return 0;
}
```

Figure 18: Arduino Code

6.9 Testing & Validation

6.9.1 Physical Prototype 1

When constructing our first physical prototype we constructed a model of the board that we are trying to clean as well as a ⅓ scale simplistic model of our final design. We began tests by first attempting to push the board through our design. Upon doing this, we were able to notice quite a few things that would be pertinent to our final design and its functioning. Firstly, when inserting the board, gravity would tend to make the board fall forward at first and then would fall inwards upon inserting it further. This would present a massive problem for our later design as this would interfere with the spinning bar below as well as inhibit the passing of the board itself through the system.

Figure 19:Final prototype 2 - cardboard and Styrofoam model for team J.À.D.

To fix this issue, in our final system, we are going to have to add guide rails within our cleaning system to support the board as it passes through the cleaning system. This was under the assumption that the board would not get shaken from side to side or upwards due to the guide rails only being on the bottom. However, the first assumption proved to be incorrect upon conducting further testing, we saw that the board got stuck on the sides of the opening. In order to fix this issue for the final design, we will need to include a slight lip on the side of the guide rails as well as to limit its movement from side to side.

Figure 20: Final prototype 2 - cardboard and styrofoam model for team J.À.D. getting caught on the side

Next, we determined that upon the addition of a guide rail, the rail would interfere with our original idea of having the feeding mechanism contained within the shell of the cleaning mechanism. Thus, we opted to move the feeding bars to the outside of our system to get around this new interference. This would also add a new fixture to the outside of our model to affix the rollers.

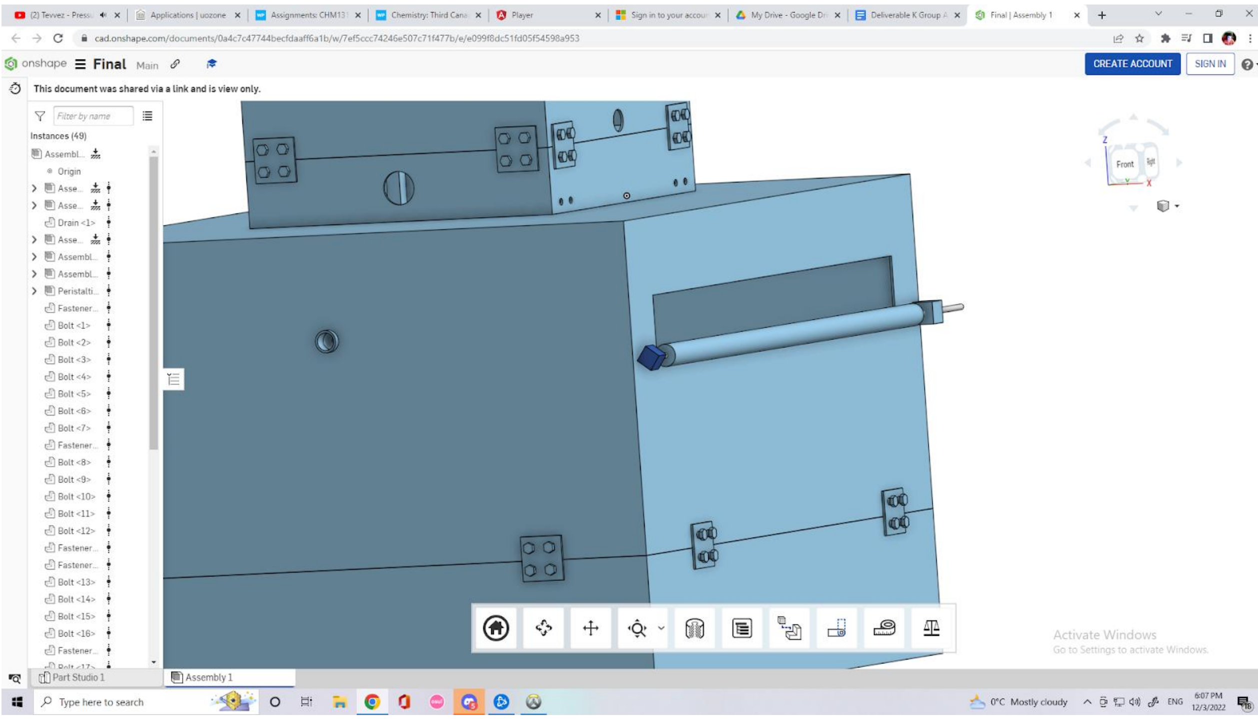

Figure 21: Feeding rollers moved outside of the shell.

6.9.2 Draining system Prototype 2

To test the draining system we have placed 10 pieces of wet toilet plastic planer. As such, we sprayed some water to simulate the effectiveness of the draining system given different inclined angles. The first test with 10 degrees. We analyze that while pouring water from a shower head, only one piece of wet tissue was drained from the inclined plane. Hence, we then adjusted the plane to an angle of 30 degrees. We poured water on the inclined plane and all of the pieces slid from the surface. To make sure, we restarted that test at the angle of 30 degrees and we analyzed that all the pieces have slid off the surface. Finally, we tested the angle at a 40 degrees angle. Similarly to the 30 degrees test, all the pieces were removed from the inclined surface. However, we determined that at a 40 degrees angle, the piece slides faster compared to the 30 degree angle.

Nonetheless, at both 30 degrees and at 40 degrees, the pieces of tissue were able to easily slide down the inclined surface.

However, some issues have occurred during this testing. As a matter of fact, this test proved to be of medium fidelity. Indeed, we tried to have the most accurate angles, however, there is always a percentage of error since the surface itself had a small dent, the protractor might not be 100% aligned with the inclined surface and the support might not be fully straight at a 90 degrees angle. All those factors can affect our results and decrease the feasibility of our drainage system.

Table 1: Representation results of 10 wet tissue pieces drained at various inclination angle for a plane

Test: inclination angles (degrees)	Wet tissue pieces exited (n)	Wet tissue pieces stayed (n)	Success rate (%n/n)
10	1	9	10%
30	10	0	100%
40	10	0	100%

Figure 22: Issues with prototype

6.9.3 Physical Prototype 3

For the controlling system, we have tested multiple codes and setups. One of the codes was to type in a command such as turn left, turn right or stop. We believed that this setup was good since it was functional, however, it did not represent our design. Hence, we updated the setup code to have cycles of moving forward and backward with a press of a button. Also, if the button were pressed while it was functioning, it would stop. Overall, we have tested the setup multiple times and it works every time. Thus, it would have a 100% success rate.

6.9.4 Physical Prototype 4

The test conducted on the fourth physical prototype *(Figure 9)* was putting a HDPE board on the constructed system and then proceeding to turn the attached bolt back and forth and observing that the board moved along back and forth as the rollers spun. This allowed us to conclude that in our final design given a cylindrical roller coated with an adhesive like material (rubber) we would be able to move an HDPE board backwards and forwards as needed.

7 Conclusions and Recommendations for Future Work

One of the lessons learned during the prototyping was that a virtual simulation does not specifically represent a real life implementation. Indeed, in the detailed CAD model, we simulated that a board can pass through the design. However, while doing our first prototype in cardboard to demonstrate a proof of concept, we realised that the board does not pass through the design since it would fall. As a result, we needed to implement guid rails to prevent the board from falling.

Moreover, while testing the needed angle of inclination to drain the algae and the water for the draining subsystem prototype, we have deduced that cardboard and water do not combine well together. Indeed, after a couple of tests, the cardboard used in this prototype started to bend and weaken due to the absorption of water that weakened the material see Figure 21. Thus, we needed to restart some data due to this issue. Therefore, the lesson learned is to not use cardboard with an experiment that contains water.

Figure 23: Draining system prototype

Another lesson learned was for the feeding system. As a matter of fact, we have learned that the measurements should be precise while prototyping. Indeed, since our support had some percentages of errors in the measurements, the conveyor belt had issues turning. So, the tension in the rubber bands needed to be decreased to have a functional prototype see Figure 22

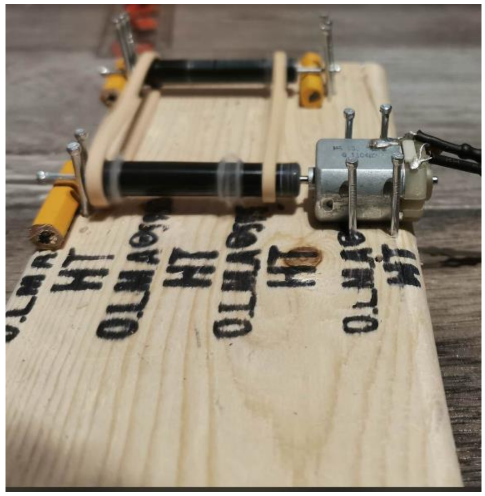

Figure 24: Feeding system motor

Furthermore, an additional issue that we have come by was during the creation of the code and the wiring. We have realised that some of the components for the wiring were not working and some of the code was not properly functioning. To fix this issue, we needed to look at the data sheets for some components such as our L293D to determine the proper inputs and outputs. Overall, the main setup that we were aiming to create was not functional. Thus, the lesson learned from previous experience during this prototyping phase was that we needed a backup plan. So, we created a different code and a different arduino setup for the final design

Overall, we have designed a system that would solve the issue of the Growcer by respecting the constraints, requirements and their needs. Indeed, the purpose of J.À.D is to clean off algae from the hydroponic rafts by decreasing the manual time of labour. Thus, to test the design, we have created a detailed design and multiple prototypes in order to refine and update certain areas of J.À.D. However, the design has not been all physically prototyped. As mentioned in the sections above, the heating system and the washing system have been prototyped analytically since they are standardised products. Hence, for future improvements, we would suggest physical prototyping of the heating system and the washing system to determine if the data collected through research and calculation are correct. These would be the next avenues that we would suggest to work on in order to improve the design. Additionally, we would suggest working on an assembly of all the prototypes in order to improve the entire design. Indeed, by having a fully functional physical prototype design, it will allow a good analysis on the interconnection between all subsystems. Hence, these upcoming avenues of work would help improve the overall design by determining some new risks and the measured performance of the design.

If the team had a few more months to work on the project, we would have done a physical simulation of the washing system. Indeed, with more time, we could have tested how well the washing system works in real life. With this information we could detect the risks and the issues with the design by properly analysing the percentage of cleanliness of the board after being washed instead of doing some calculations that might not 100% represent the quality of the washing system. Additionally, due to not having as much time as we would have wanted, we needed to abandon the soap subsystem. Indeed, we initially had a soap subsystem that would store the sanitol and then distribute a quantity to the washing system while the design is in function. However, we did not have enough time to prototype this subsystem, hence, we assumed that given a normal dishwasher, we would have a similar soap dispenser that would eject sanitol through the design while it is washing a raft. Overall, this would be an important prototype to do since it is the main chemical used to clean the rafts.

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APPENDICES

9 APPENDIX I: Design Files

Table 2. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Design Cad file	Link	October 23 2022
Deliverable C: Technical specification	Link	October 17 2022
Deliverable G: Prototype 2	Link	November 12 2022
Deliverable H: Prototype 3	Link	November 20 2022
Datasheet	Link	November 29 2022
Deliverable I Presentation slides	Link	November 30 2022