MECH 45X Final Report: Design and Build of Tote Washer for UBC Farm

Doug Downing, Michael Jewett, Lindsay McInnes, Evan Meyer

University of British Columbia

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Doug Downing [redacted]

Michael Jewett [redacted]

Lindsay McInnes [redacted]

Evan Meyer [redacted]

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1.0 Objectives

1.1 Client Requirements

The objective of our project was to design and build a tote washing device for Andrew Rushmere and the UBC farm. Our team's primary objective was to build a device that would cut down the amount of time farm staff and volunteers spend cleaning totes. There were 5 main evaluation criteria our team strived to meet while designing and building the tote washer. They were:

1) Tote washing speed
2) Mobility
3) Water Usage
4) Variety of items that can be washed
5) Maintenance

With our final product, we managed to decrease the tote washing time from around 1 minute to less than 30 seconds, for a tote with average dirtiness. The entire setup is made of 3 stations, each of which can be moved with 2 people. The water usage has been cut down from ~1.3 gallons per tote to <0.5 gallons per tote. The device can soap and rinse any object that fits inside the Soaper and Rinser, and it can scrub any item that is durable enough to withstand the rotating brushes. The maintenance on the device is fairly minimal. The oil in the gearbox should be changed annually. Any additional maintenance is outlined in Appendix E – User Manual.

1.2 Other Requirements

The tote washer was required to clean totes to pass a visual inspection. Some totes are used as part of the Community Supported Agriculture (CSA) program which uses totes to transport foods. Any produce sold in the tubs however, is not sold as "ready to eat." As such it was not necessary to disinfect the totes above the level that can be achieved using dish soap. All of the 120V electrical components on the tote washer are CSA approved. This includes the motor, solenoids, Estop, footswitch, relays, electrical box and connectors.

2.0 Design and Testing

2.1 Design

The final prototype consists of three machines. A tote is first placed into the "Soaper" machine. This machine has 6 spray nozzles which apply soapy water to the interior and exterior surfaces of the tote. Soap is introduced to the water through a venturi injector and the machine is activated using a button that connects to a microcontroller which switches a solenoid valve on and off. The second machine is the "brusher". This machine features two vertical counter rotating brushes which protrude approximately one foot above the surface of the machine box. These brushes are spaced such that a tote can fit overtop of the brushes and all of the interior surfaces can be cleaned. A tote lid can also be placed between the brushes and cleaned. The final machine is the "Rinser". The "Rinser" is identical to

the “Soaper” except that it does not have a venturi injector. These three machines’ sensors and electronics are connected to a control box located on the back of the “brusher” box.

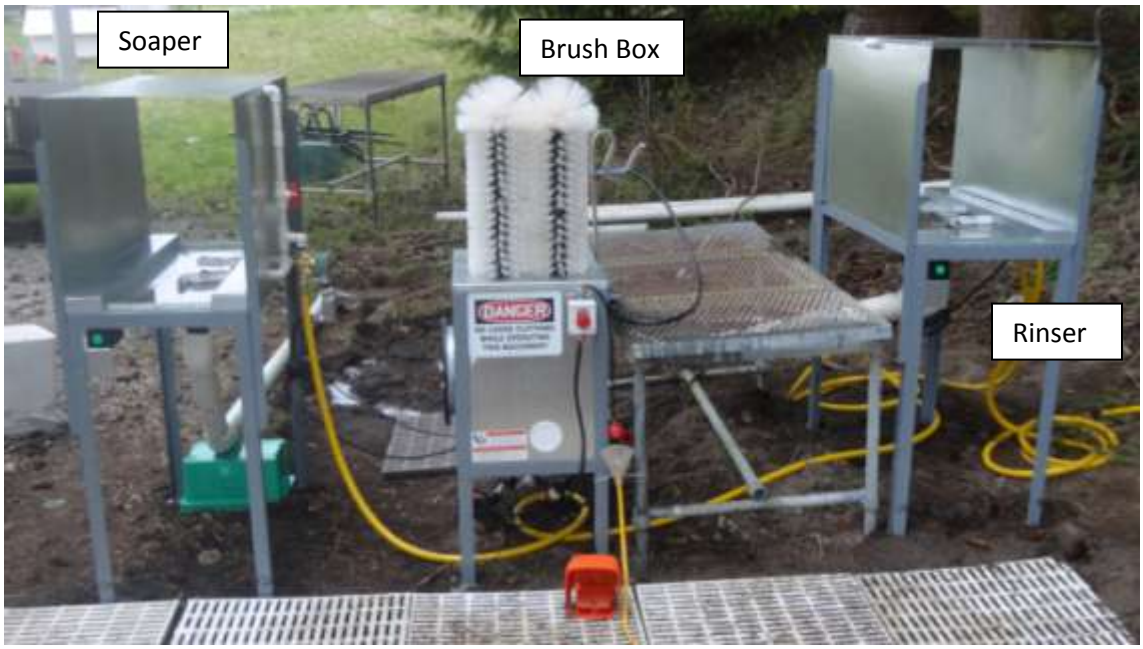

Figure 1: Completed Tote Washer installed at UBC Farm

2.2 Testing

Two major factors were tested for during the verification and validation process. The first was whether the machine enabled a worker to clean totes in a shorter amount of time than was previously possible. The second was whether the machine was an environmentally friendly alternative to the previous tote washing method. Our results show that with the machine, a worker can wash a tote in fifteen seconds as opposed to the forty-five seconds or more that were previously required. Further testing by the UBC Farm will determine whether the machine is ergonomic and can stand up to regular use in the outdoor environment. The second criteria was measured quantitatively based on water consumption. Previously, washing one tote used 4.9 liters of water. The new machine only requires 1.1 liters per tote. Other factors were tested both qualitatively and quantitatively such as electricity usage, leakage, safety feature operation etc. More details of the testing procedure and the results that were obtained can be found in *Appendix A – Final Product Testing*.

The main deficiencies that we found during testing were drainage from the Rinser/Soaper, the soap venturi setup, and the infrared (IR) sensor reliability. After the Rinser/Soaper had been running for a few cycles, water droplets remained on the IR sensor window and caused the sensor to become unstable, switching on and off radically. With more time we may have been able to alter the programming such that it would work more effectively, but in the end, the IR sensor was replaced with a push button because it was not reliable enough. The soap venturi was likely meant for lower pressures and did not work well with the high hose pressure at the farm. We will be replacing it with a better model in the near future. Lastly, the drainage out of the Rinser and Soaper is difficult since the rails that the tote rests

on are very flat and there is only a slight slope to the drain at the bottom. This results in water flowing down the legs. This is undesirable as more water may build up in the area, but it does not harm the effectiveness of the Soaper or Rinser.

3.0 Conclusions

As described above, the UBC Farm tote washer has been installed at the UBC Farm and is now operational. The testing has identified a few aspects that could be improved; however none of these issues limit the effectiveness of the machine's function. Overall we are happy with the tote washer's performance during testing, though we realise that it will take some time in operation at the farm before we can make definitive conclusions about its long-term performance.

Over the past eight months we feel that we have learned a significant amount about project management. If we were to repeat the process we would likely approach it slightly differently. Some of our main adjustments would include the following:

- Document regularly and often (keeping track of expenses, design changes, suppliers etc.)
- Produce detailed designs as soon as possible so there is time to iterate and make design changes with your client and supervisors
- Start building as soon as possible in order to spend more time troubleshooting
- Have a schedule which is updated constantly and used to designate tasks, deadlines and progress for all team members. Use this to keep everyone on track and on the same page.

There were also many aspects of this project that worked well for us. We communicated with our Client fairly often, especially in the initial stages of the process when we were determining the project requirements. We were fortunate enough to have help from UBC Plant Operations as well, which significantly improved the final product. UBC Plant Operations was able to assist us in fabricating our sheet metal boxes which formed the main structure of the machine. This allowed us more time to focus on designing internal components and the electronics. We also worked with UBC Plant Operations electricians who were vital in making sure our final product was safe from an electrical point of view, an extremely important requirement for us as the machine operates in a very wet environment.

Building the tote washer also gave all of us valuable hands-on experience designing and building a product using our mechanical engineering knowledge. Being part of a project from the initial stages to the final testing allowed us to better understand the importance of being able to communicate effectively with suppliers, customers, experts, supervisors and each other.

4.0 Recommendations

We feel that the Tote Washer has been a successful project and hope that it will be useful to the farm for many years. The appendices following this report detail the design, components, and user manual which should be used to assist in maintenance, repair, or even re-design of the Tote Washer in the future.

The two main issues that were discovered during product testing were related to drainage and the soap dispenser venture as discussed above. If this is very undesirable we recommend redesigning the bottom to allow for a steeper slope to the drain or drilling holes through parts of the bottom where water pools which can connect to the drain piping. The soap venturi seems to be working but does not stand up very well to the high hose pressure. We have ordered a better dispenser and hope to install it in the near future.

Some of the parts in the internal components of the Tote Washer are custom-made, namely the HDPE water-jet cut gears and the brushes. We have included drawings of both the gears and the brushes to assist with replacement. Replacement gears can be cut out from the water-jet machine in the UBC Mechanical Machine Shop or elsewhere.

The brushes were made by J.F.K Brushes in North Vancouver. The hemispherical ends were custom made by our team, however if they need to be replaced a flat top can be used instead which J.F.K brushes can fabricate. The brush for the handheld is currently a modified toilet brush. We recommend finding a larger brush if desired by the farm. We have looked into finding a more appropriate brush but are still waiting to hear back from suppliers. One option was found at Carlisle Food Service Products in the USA. It is a 5” diameter, 6” length brush that may work well as a handheld brush. Details of this brush can be found at:

http://www.carlislefsp.com/food-processing/sparta-spectrum-valve-and-fitting-brushes/4000802

Lastly, we recommend consulting with certified electricians before doing any maintenance, repairs, or re-design of the electrical components.