NVD Technical Report:

Centralized Dog Waste and Bag Separator

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1.0 REQUIREMENTS

At the outset of this course, our New Venture Design group set out to pursue a business that was centered on the problem of dog waste being thrown in landfills within Metro Vancouver and all over North America. Throughout the course, our team, Kurb'd, made various pivots, and in the end, we determined that a service-based model was the best solution. The idea required us to work with municipalities in order to implement dedicated dog waste-only bins in parks and around high canine traffic areas. Afterwards, this dog waste would be transported to a dog waste processing facility operated by Kurb'd.

The task of the engineering team was to design the technical solution within this facility that would process this dog waste, so that we could, first and foremost, divert dog waste from landfills, and then potentially have additional revenues from composting the dog waste and/or recycling the used plastic bags. Below, the features and behaviors of our technical solution is discussed in more detail.

1.1. Features and Behaviors

Our technical solution must have the following features:

- Be fully automated
- Separate dog waste from dog bags
- Dispose of or treat dog waste in a safe manner

Our solution must be fully automated so that it is scalable to other regions and eventually all over North America. It is expensive for humans to manual process the dog waste, especially since dog waste is considered a biohazard. Manual processing is definitely not the most appealing job either, so automation is necessary to keep costs down. The dog waste must be separated from the plastic bags in order to be properly processed. Whether the waste is disposed of in the wastewater treatment system of eventually composted, plastic bags cannot be present, as it will contaminate the wastewater treatment or composting processes. Lastly, the dog waste, once separated, must either go to the wastewater treatment system without further human contact to reduce health hazards, or be neutralized as part of the composting system so that the end users of the compost will not be subject to health hazards.

Additional features that were identified as desirable, but not absolutely necessary, were the following:

- Cleans plastic bags post-separation for recycling or repurposing
- Neutralize bacteria and viruses in dog waste and compost

The end goal of the Metro Vancouver region is to have no waste at all. They perceived our solution as an intermediate solution to divert dog waste from landfills, but the amount of plastic bags being used for dog waste purposes is also a big problem. The feature of cleaning plastic bags would eventually need to be considered as part of the technical solution so that we are not

only addressing one part of the problem. Once the bags are separated and cleaned, they can be repurposed or recycled, either for additional revenue or simply for the sake of being more sustainable. In addition, composting the dog waste would reduce the amount of strain on the already strained waste water treatment system. This composted dog waste, though not high in nutrients, could be sold as peat, which is an important soil addendum for farmers, along with other uses, as an auxiliary revenue source. In addition, this completes the full life cycle by returning the neutralized dog waste back to the earth in a safe and neutralized manner.

2.0 SYSTEM OVERVIEW

2.1. Intended Final Product

Initial interpretations of the final Kurb'd product were very simple. As mentioned previously, the device was expected to be an industrial machine capable of autonomously and efficiently separating dog waste from the plastic bags which enclose it. The dog waste containing bags would be fed into one end of the machine which would then separate the two components. The dog waste would be fed into a composter capable of neutralizing the waste and the plastic bags would accumulate in an easily accessible collection bin.

Figure 1 below presents a rendering of the envisioned final product.

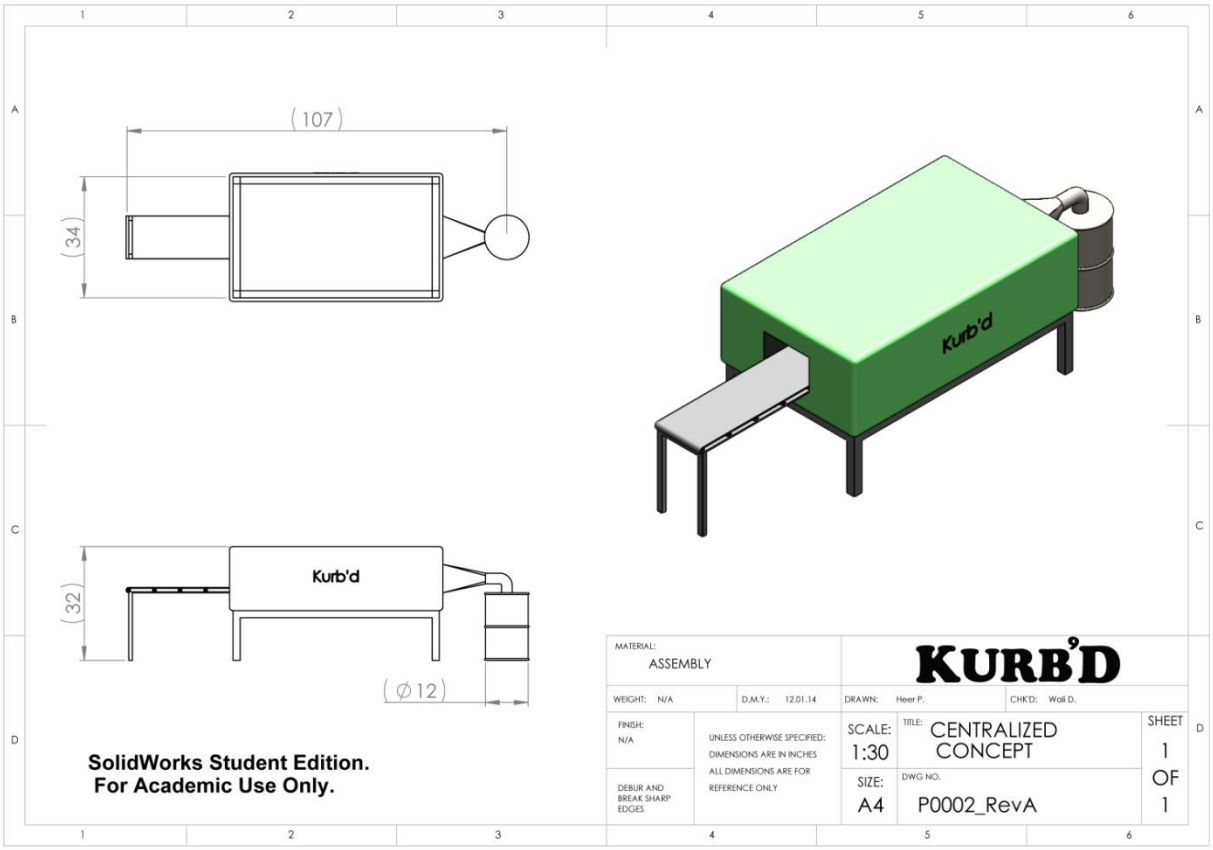

Figure 1: Intended Product

2.2. Prototype

2.2.1. Vision

The constructed critical function prototype does not encapsulate all aspects of the intended final product. The purpose of the prototype was to allow Kurb'd to quickly and easily test the device functions that carried the greatest uncertainty.

Ultimately, the function that carried the most uncertainty was deemed to be the ability to separate a given plastic bag from the unique type and amount of dog waste contained within it. The final device is required to be able to separate bags of all sizes containing waste of varying amounts, sizes, and consistencies among other things. The lack of standardization of the bags and their contents posed a challenge to the team.

Evidently, the prototype, unlike the final product, is not capable of composting the separated dog waste. It was determined that this aspect of the device did not carry much uncertainty. Research showed extensive amounts of literature on the procedure and also existing products capable of neutralizing and composting the dog waste. As a result, this function was not considered to be critical during the construction of the prototype.

2.2.2. Design

The completed prototype consists of 2 distinct components: the shearing component and the separating component. Figure 2 below presents an image of the completed prototype.

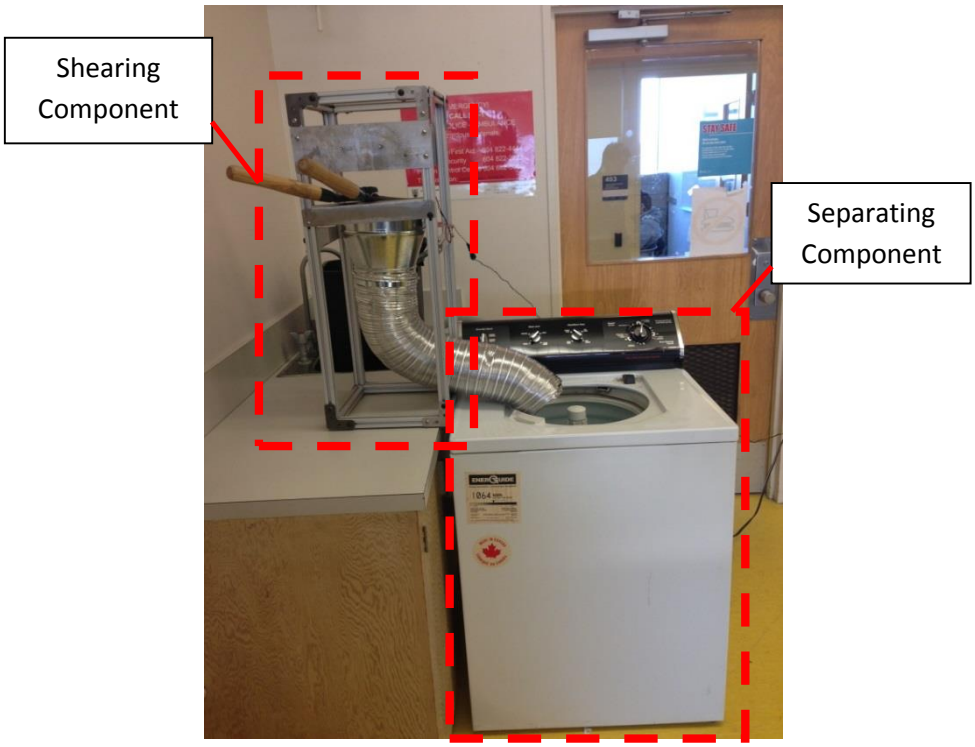

Figure 2: Completed Prototype

The separating component of the prototype is a simple washing machine. It is responsible for separating the waste from the bag. The washing machine was chosen for the separation of the waste from the bag as it was an existing and available solution that required little time to implement.

Figure 3 below presents the shearing component of the prototype. It is responsible for shearing the bag to allow the waste to exit and also pass these two components on towards the separating component. The shearing component is a modular frame that consists of rapidly prototyped components. These components were quickly and cost-effectively machined using equipment accessible to the team.

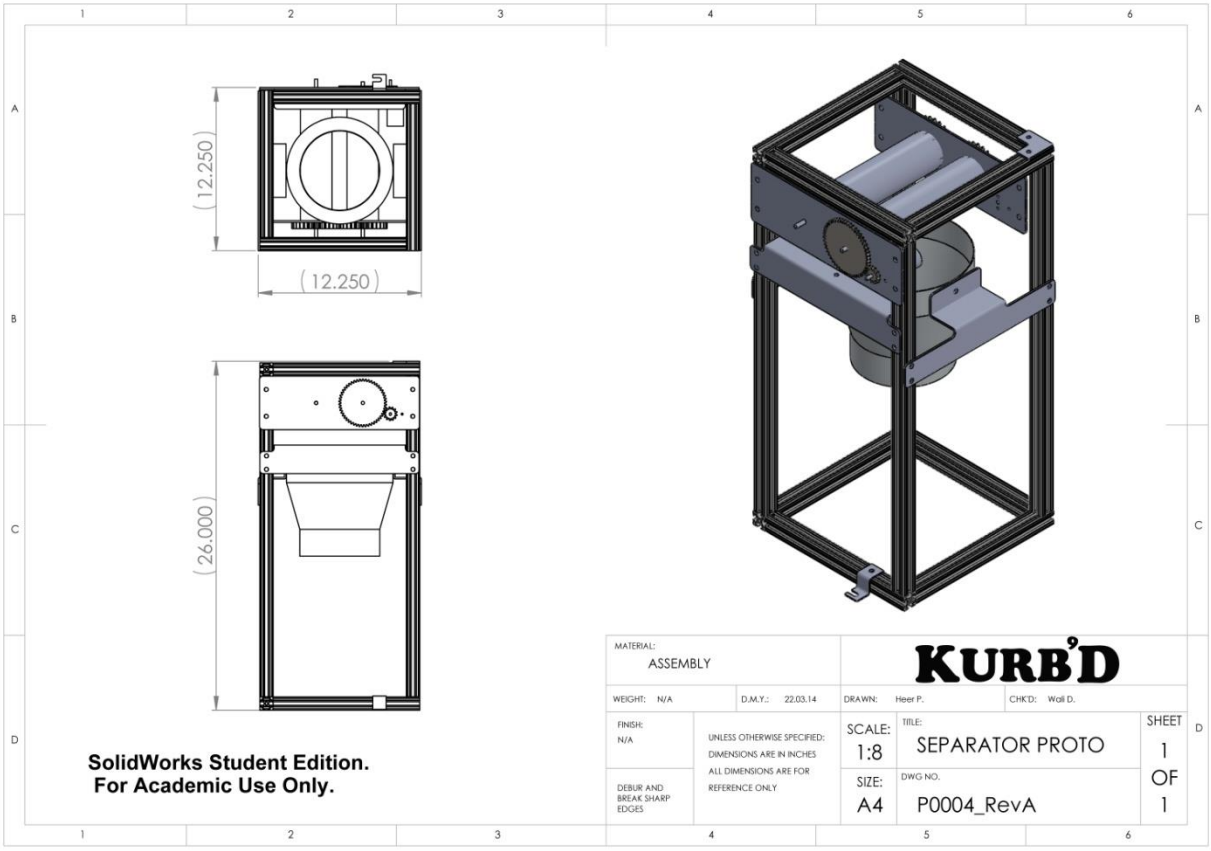

Figure 3: Critical Function Prototype

Please refer to the dossier for the complete selection process for the individual components.

2.2.3. Function

The prototype's overall function can be separated into 3 main phases: Feeding and Shearing, Separating and Agitating, and Filtration.

The Feeding and Shearing phase consists of manually feeding the waste bag into the top of the separator component. The continuously rotating rollers grip onto the input and slowly drop the bag to the level of the shearing mechanism. Once in position, the shearing mechanism must be manually operated to cut the bag and allow the waste to eventually exit the bag. The rollers will continue to rotate and allow the waste and bag to drop below into the ducting. The ducting directs the inputs into the separating component.

The Separating and Agitating phase occurs within the separating component. Once the capacity of the washing machine basin (approximately 20 waste bags) has been reached, the washing machine cycle is started. The cycle begins by filling the basin with water and conducting a swift back and forth motion with the agitator. This motion disturbs the waste and causes it to exit the sheared bags which envelopes it. The motion continues for approximately 20 minutes. The continuation of the motion causes the waste to break into smaller pieces and eventually dissolve into the water. It also cleans the sheared bags of any residues.

The conclusion of the cycle is known as the Filtration phase. Once the agitation portion of the washing machine cycle comes to an end, the washing machine begins to spin rapidly and drain the waste water contained within it. At this point in time, the majority of the waste particles have either dissolved completely or have become small enough to drain out of the washing machine basin with the waste water. At the completion of the Filtration phase, the user should be left with nothing in the washing machine basin aside from residue free plastic bags.

3.0 VERIFICATION AND VALIDATION

As mentioned above, the prototype consisted of three major steps. For each of these major steps, qualitative & usability tests were first done followed by engineering tests. The following section will elaborate on the testing of each of these processes:

3.1. Feeding and Shearing

This section of the process of separating dog waste from plastic bags required the use of automated rollers and a mechanically operated shearer. The main testing required for this section was to see if the rollers would appropriately grip the plastic bag and feed it in a slow enough manner for the shearers to cut it. The following questions were the major ones for the testing of this phase:

a) Will the plastic bags be fed neatly through the rollers in a straight fashion as opposed to being caught on and laterally expanding? If so, what torque and rpm would be necessary for the motor to impart on the rollers, i.e. what should be the gear ratio?

b) Will the shearer have enough time to cut the plastic bags?

c) Will the clearance distance between the rollers be appropriate?

To answer question a), an earlier prototype constructed in the earlier phases of the project was the basis of going with such a solution to feed plastic bags. It was found that such a method was reliable and fed nicely to the shearer below. That being said, such a solution was never fully automated and herein arose the uncertainty if the motor would get stuck when feeding in the plastic bags due to insufficient torque. Consequently, prior to construction, a calculation of the torque required to roll a plastic bag with 1kg of dog waste (3 times the average amount in one dog waste bag) with the friction of sand paper was done. As a result of this, the appropriate gear ratio from motor shaft to roller shaft was found to be 4:1.

For question b, it was estimated that 1 second would be a comfortable amount of time for the plastic bag to be in the vicinity of the shearer so that it may be cut to ensure the bag is fully opened. The gear ratio selected comfortably satisfied this requirement for small plastic bags (the ones with the least time to be able to shear).

For question c), the initial prototype was again a useful model to work off of where the edge-to-edge distance for the rollers was 2”. This was downsized to 1.5” to allow for the bag to simply not fall completely through.

After all these incorporations to the design, the prototype was tested for multiple batches of plastic bags filled with dog waste and the success rate of bags passing through the rollers and being sheared correctly was close to **93% (28 out of 30)**. This success rate was deemed to be successful by our engineering team

3.2. Separating and Agitating

After the shearing of the plastic bag, the two components had to be separated completely and when separated have the dog waste dissolve with water into a homogenous mixture. To do this, a conventional washing machine was used. The reason being, its agitation motion allowed for the dog waste to become independent from the plastic bag and the constant supply of water allowed the dog waste to be dissolved when constantly agitated.

The initial part of this process, the separation, was something we could guarantee fairly well since the bags were sheared well in the initial stage and the agitation motion of the washing machine was quite strong. That being said, the mixing of dog waste into a homogenous mixture with water was an area of ambiguity prior to testing. Initial testing of dog waste in a household toilet was done and mixed to test its solubility. Dog waste was found to dissolve well in water yet it had to be mixed thoroughly to achieve this. The prototype test was done by running the washing machine on different cycles and seeing how many cycles gave a homogenous mixture. After running the washing machine on three repeated cycles, 90% of the dog waste dissolved entirely with water. This was found by measuring the dog waste left over post- filtration and how much was put in pre-filtration.

3.3. Filtration

The last major portion of the entire process was filtration of the dissolved dog waste via the effluent drain. A major concern was that if the dog waste would go through the filtration holes well and drain out completely via the recirculation pump of the washer. Also having remnants of plastic bags in the washer was important since having the two waste constituents in separate section was a core requirement of our prototype. This, like the agitation, was experimentally tested and found to work well for 90% of the dog waste

4.0 CONCLUSIONS AND RECOMMENDATIONS

The current design of the product carries a number of flaws which would need to be rectified in future iterations of the device.

The final product will not make use of an existing washing machine. A custom device with a greater carrying capacity would be required in order to handle larger amounts of waste. The central agitator within the basin of the machine would also require larger arms to more efficiently agitate the waste and ensure that it dissolves. This device would also have larger drainage holes to ensure that all solid waste is able to exit the device, even if the agitator was not successful in breaking the pieces down.

Moreover, the usage of water could also be optimized in future iterations of the device. Currently, the washing machine requires a certain volume of water within the basin before it will operate. This volume is excessive and results in large amounts of water being wasted. It is desired to design a future iteration of the device to minimize the amount of water used and possibly re-use portions of the waste water.

Future iterations of the device will also require more emphasis on the implementation of the composter.