Automatic Can Crusher

A Baccalaureate thesis submitted to the
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College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science

in Mechanical Engineering Technology

by

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Problem Statement

As the world is becoming increasingly environmentally conscious, the familiar trend of recycling is one that both businesses and consumers return to in order to make an impact. However, a problem that many people face, is that they don't have easy access to recycling programs, particularly in apartment buildings and office spaces. For my senior project, I feel as though a necessary and helpful device would be an automatic can & bottle crusher. This device would make it easier to transport large amounts of cans & bottles to recycling facilities by reducing their volume and make it as easy as simply taking out the trash; all you do it dump your cans or bottles into a bin and the device will sort, crush, and deposit them into an easily removeable container.

Research

Background of the Problem

For the past several years, recycling has been on an upswing of popularity. More and more people are participating in recycling programs across the world. In fact, the number of recycling services offered by the waste industry has seen a 150% increase in just the past three years (1). Regardless, there is a gap between the number of people participating and the number of opportunities they are given to do so, and when it comes to environmental consciousness, there is always room to improve and participate more.

Impact

While people are generally not directly negatively impacted by the problem of recycling resources, society at large is. Resources that offer convenience and speed for recycling are not widely available at the moment (2); if they were, as is being proposed, it is expected that there would be an increase in participation that would lead to an overall benefit for the whole of society and provide a benefit for the greater good.

Why address it

As stated above, individual people are generally not negatively impacted by not participating in recycling programs, but society is. Pollution is one of the biggest issues that the world faces, and it is taking its toll on the natural world. In the United States, there is still about 20% of the population that only 'sometimes' recycles or doesn't recycle at all (3). If recycling can be made more convenient for the consumer, more people would participate.

Current Situation

Currently, there are less than 68% of US citizens with access to recycling programs that fall within the categories of curbside pickup, automatic recycling, opt in programs, subscriptions, or drop off programs (4). Therefore, there are opportunities to improve these statistics and increase the number of people engaged in recycling activities. By expanding these programs, the share of aluminum and steel cans to be recycled has the potential to increase from its current standing of 54.9% and 71.3% respectively (5).

State of the Art

Current Technology

1) Manual Single Can Crusher

Figure 1 - Manual Single Can Crusher

How it works: Place a can on the ledge, and pull the handle downward quickly and forcefully.

Pros: Easy to use, can crush can with less manual force

Cons: Manual labor, can only crush one can at once, have to reload after every can, not a consistent crush size, danger of can shooting out if not loaded properly.

2) "Automatic Aluminum Can Crusher" US Patent no. 5,967,029 (6)

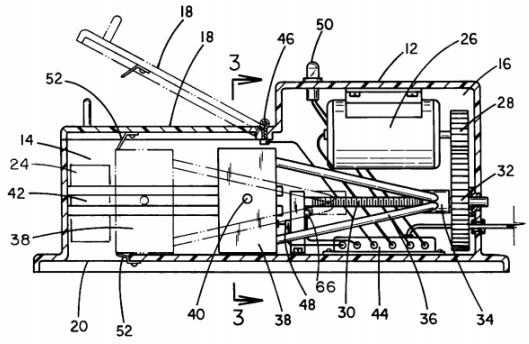

Figure 2 - Automatic Aluminum Can Crusher

How it works: It is a motor drive gear that drives a piston that slides forward and back. The crushed cans drop into a collection bin below.

Pros: Motor operated (no manual labor), easy to use, powered by electricity.

Cons: Have to manually load every single can, has to be set on a table (not freestanding / easily moved), no real safety features beyond a cover tray.

3) "Electrically Actuated Can Crusher" US Patent no. 4,570,536 (7)

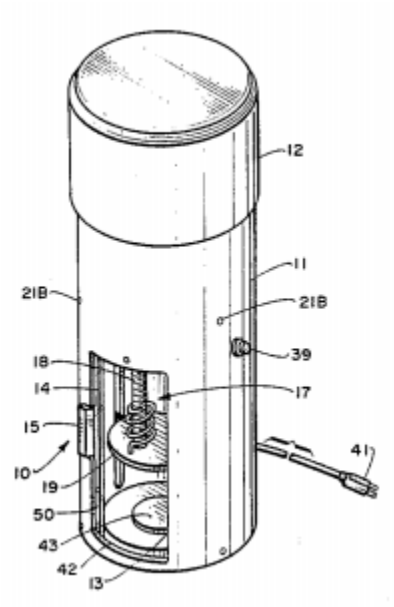

Figure 3 - Electrically Actuated Can Crusher

How it works: A motor powered, geared shaft pushes a plate downward to crush a can. Each can needs to be individually loaded and removed.

Pros: Motor operated (no manual labor), easy to use, powered by electricity.

Cons: Have to manually load each can, have to manually remove each crushed can (does not automatically drop into containment box), has to be set on a table (not freestanding / easily moved), no real safety features beyond sliding door.

Overall Conclusion

This new device needs to be mechanically driven by a motor that drives gears, or by a hydraulic or pneumatic press. This will cut out all manual labor as well as make the device easier to use. The device also needs some sort of auto-feed so the user does not need to insert each can individually, and it should have a collection bin that the crushed cans will fall into. It is important that this device have a safety feature so that it cannot be operated while a door or tray is open. The press / crusher aspect should not be accessible while in operation. The device also needs to be mobile, meaning that it shouldn't need to be placed on a table or bench, it should be a standalone device on wheels, tall enough for a large collection bin underneath.

End User

The end user of this product will simply be everyday people. While this product will be marketed more towards companies / apartment buildings, the end user will be the everyday individual. The idea is that people living in apartment buildings, or people that work in office buildings, that typically don't have access to recycling programs, will be able to easily participate in recycling.

Summary of Research

What is missing in the current technology? Too complex / expensive?

What's missing in the current technology is convenience, ease of use, and speed. There aren't any readily available products to tackle the issue for our specific end user. There are small

‘single family’ type device without discarded can storage, and there are large industrial devices that are used at recycling depots. Though, as stated in the ‘End User’ document, we are trying to accommodate the everyday individuals that live in apartment buildings or work in offices that don’t currently offer recycling programs. We can do this by making it easier for the user to operate and making is easier the builder owner / office manager to participate in recycling.

We think we can tackle these issues by building a device that has a high capacity (meaning less time emptying), high speed, and is easy to operate. The device can be attached to a moveable cart, or mounted in a cabinet or wall. We think the best solution is to use a motor driven gear and piston, but are also exploring a pneumatic piston option as well. The device can be operated by pushing a single button to start, with a timer to turn off after a set amount of time, or when it senses there are no more cans to crush. If the device needs more electronic control than simple switches and buttons, we will use a Raspberry Pi or Arduino to program controls, thus keeping the cost low.

Quality Function Deployment

Customer Features

- Safety: It is very important that a machine like this is safe to operate. Being that there is a mechanical crushing motion, we need to be sure that the user cannot access any of the internal parts, particularly while it's in operation.
- Efficiency: This machine needs to be efficient to the point that if the user has a large amount of cans to deposit, they aren't standing around waiting for long periods of time. This means having enough buffer space to accommodate their needs, and making the machine operate quick enough to handle larger loads in a shorter amount of time.
- Ease of Use: This machine needs to be, essentially self explanatory. It is very easy to simply throw cans into the garbage, so it needs to be easy enough to use that it won't dissuade someone from using it because it is too complicated.
- Load / Capacity: This is a more precise feature related to efficiency. As stated above, the machine needs to have a large enough buffer space to accommodate larger loads. The machine also needs to have a large deposit area for crushed cans so it doesn't need to be emptied daily.
- Noise Level: Simply put this machine needs to be relatively quiet. In an apartment building it needs to be quiet enough as to not wake up any residents if someone were to use it in the night. And in an office building (most likely a cafeteria) it needs to be quiet enough to not disturb anyone.
- Required Labor: Similar to Ease of Use, there shouldn't be much labor involved in operating this machine. If it is too laborious then it will dissuade someone from using it.

Engineering Characteristics

To meet the 'safety' feature, the entire crushing & depositing mechanism will be enclosed in a box that cannot be accessed by the user without a key. It can also only be accessed when the machine is turned off.

To meet the 'efficiency' feature, we will engineer the machine to operate quickly, and make sure it is able to handle an adequate number of cans to accommodate a range of users.

To meet the 'ease of use' feature, this machine will either operate at the push of a button or be fully autonomous. To be fully autonomous means that the machine will recognize when a can has been dropped into the chute / tray and will automatically turn on and crush the can / cans and remain on until it no longer senses a can. The machine will subsequently deposit the crushed can into the container below.

To meet the ‘load / capacity’ feature, we will simply make a receptacle large enough to hold enough cans so that it doesn’t need to be emptied daily. Though in office settings, trash receptacles are typically emptied daily.

To meet the ‘noise level’ feature, we will most likely need to add a sound dampening insulation to the inside wall of the case of the machine. It will go on the inside to maintain a nice outside aesthetic appeal. We will most likely only need to do this if we use a pneumatic piston.

To meet the ‘required labor’ feature, the machine will simply do all the work. The most work that the user will need to do is load their cans and push a button.

House of Quality

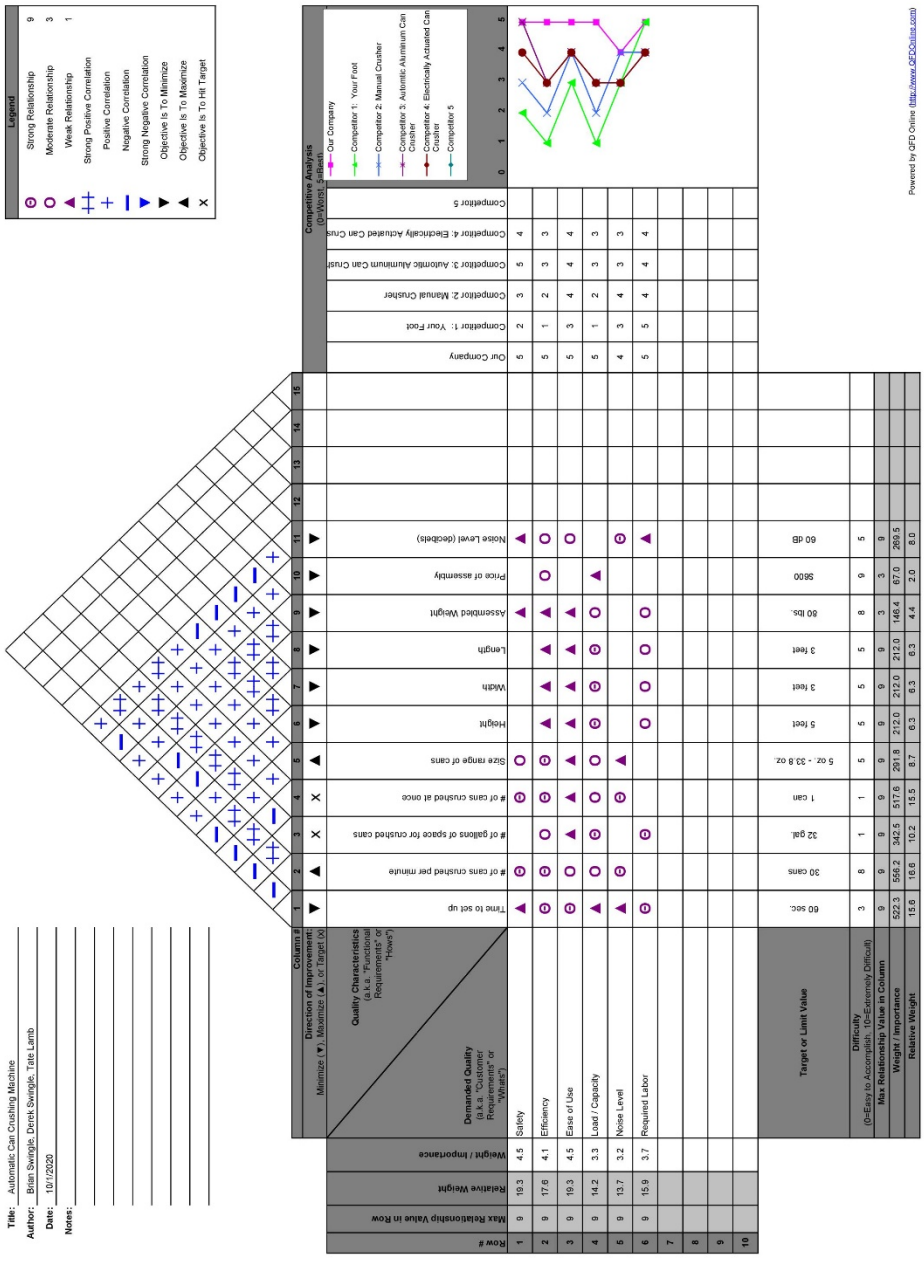

Figure 4 - House of Quality

Customer Satisfaction

Based on our customer's desired features and correlations in the house of quality, my groups automatic can crusher is the overall best rated. Using the high level of safety, efficiency, ease of use, capacity and the labor that is required we shall easily outperform our competition. The only thing that our customers desire for out can crusher is that we could improve is the overall noise it produces. It is the only low in an overall well rated automatic can crusher.

Product Objectives

Safety: 4.51/5 = 90.2%

Given that safety is clearly a high priority based on our surveys this is of highest priority for us to create a safe product for our end user. We plan to enclose the entire crushing mechanism in a box that can only be accessed with a key which is set to kill power to the machine if unlocked. The encasing will include all moving parts and the spaces in which they move.

Efficiency: 4.08/5 = 81.6%

This was the third most important aspect to our survey group, to meet their demand we will engineer the machine to operate quickly and make it able to handle a reasonable number of cans to meet a range of user needs.

Ease of Use: 4.51/5 = 90.2%

Ease of use was tied for the most important aspect for our survey group. In today's times of immediate gratification and no non-sense expectations we plan to make our machine fully operational at the push of a button. We will work to make if fully autonomous so that it can rapidly crush a feed of multiple cans in a row. The machine will recognize when a can has been dropped in the chute and will crush it and will remain on until it no longer senses a can. The crushed cans will fall through a slit at the back wall to not clog up the machine.

Load / Capacity: 3.27/5 = 65.4%

The surveys tell us that our customers are most likely not looking for industrial sized can crushers here which makes sense given we are aiming for office buildings and apartment buildings. However, we still must be able to handle a larger volume of cans. To ensure we can meet this challenge we plan to be sure that the process is repeatable and the receptacle holding the crushed cans is large enough to not need often emptying.

Noise Level: 3.23/5 = 64.6%

Our surveys tell us this is the least important aspect for our end users; however, we must recognize the noise level is still an issue to be dealt with. We plan to implement so kind of sound dampening insulation to the inside walls of our casing for the machine. This will be especially important if we end up using a pneumatic piston since they are very loud.

Required Labor: 3.65/5 = 73%

Surprisingly the required labor was only ranked fourth. This will be easy to meet given that it is the whole reason for our project, to make crushing cans and recycling easier and more efficient. The machine will be doing nearly all the work the consumer will just need to load the cans and press a button.

Concepts Drawings

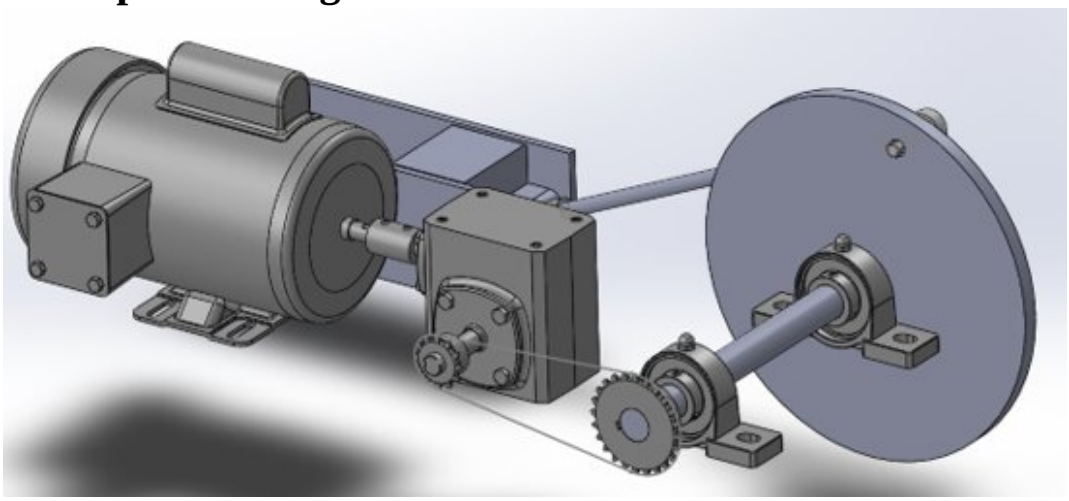

Figure 5 - Crushing Chamber Design 1a

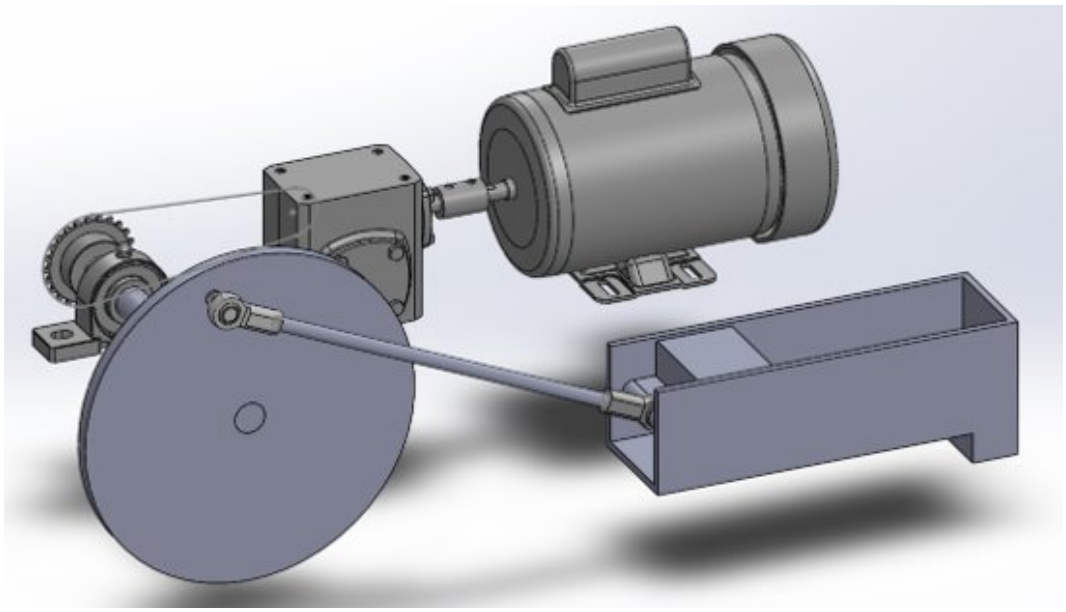

Figure 6 - Crushing Chamber Design 1b

For this concept we will use a 1 hp motor with a 50:1 gear box speed reduction and a further reduction by sprocket and chain. Depending on the rpm of the motor this will equate to a full cycle rotation being completed in about 2 seconds. This means we will be able to crush about 30 cans / minute. We could increase the speed of the crusher, but since the cans will be gravity fed, we need to allow time for the next can to fall in place. The gearbox is attached directly to a rotating gear with a connecting rod attached to a piston that crushes the can. The can is crushed against the wall on the left, then when it piston pulls back, the can falls down the chute into the storage container. The actual design will be more closed, but for the purposes of explanation, I decided to leave it cutaway. One concern with this design is that it may be difficult to keep different sized cans oriented correctly.

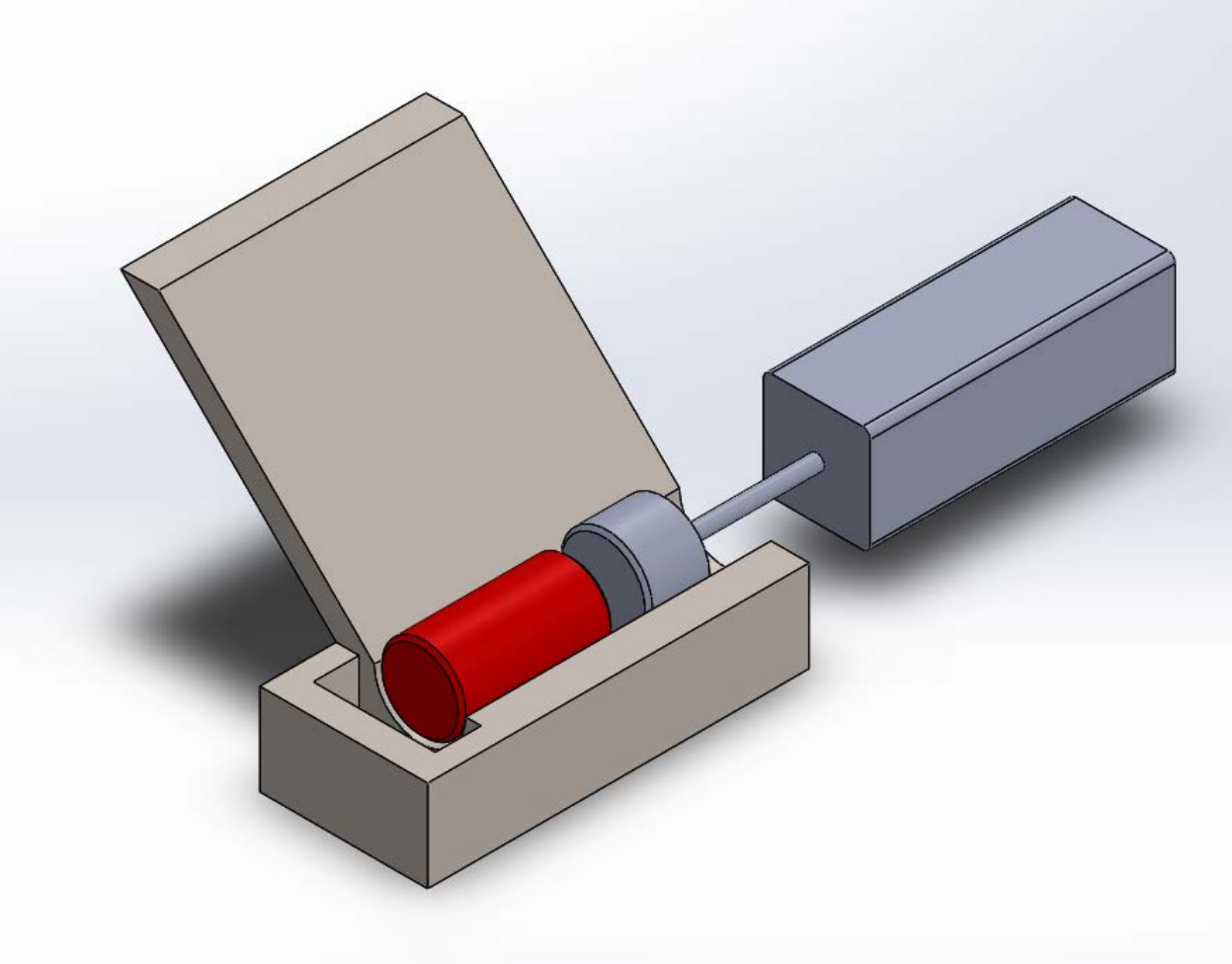

Figure 7 - Crushing Chamber Design 2

Concept 2 is similar to the first concept, where one can drops into the crushing chamber, and is crushed by a piston. However, with this design we will use a pneumatic press. This will eliminate the electric motor, and we will no longer need the gearbox and connecting arm, but we will need a compressor to operate it. This will make the machine louder when it operates, but we can combat the sound level by insulating the container. As with the first design concept, one concern is that it will be hard to keep different sized can oriented correctly.

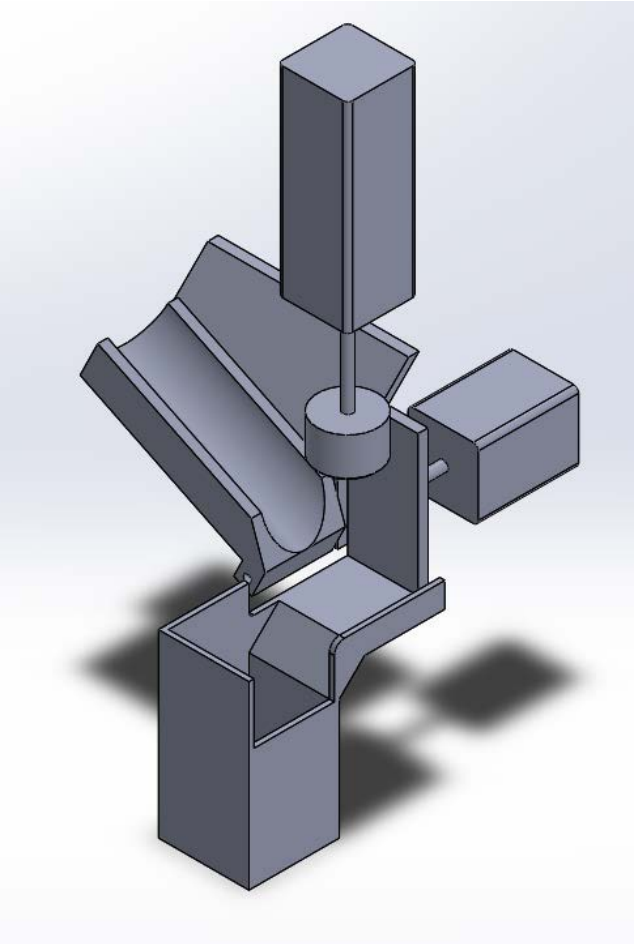

Figure 8 - Crushing Chamber Design 3

The third design concept is designed to do a better job of keep the cans organized so that only one can falls into the crushing chamber at once. A can falls onto the lift, and a stepper motor will lift the platform and reorient the can in a vertical position. This will also make it easier to crush larger cans. A piston will then crush the can from the top down. Then, once the piston pulls away, a second piston pushes forward and slides the can down the chute and into the storage receptacle. As mentioned before, this is shown with a cutaway view, and the final design will be more enclosed to ensure cans cannot spill over the edge, and to keep the user away from moving parts, ensuring their safety.

In conclusion, I feel that all 3 of these concepts can be operated very safely. The crushing mechanisms will be fully enclosed and unreachable by the operator. I think design number 1 will be the most efficient based on the speed we can operate it. All 3 designs will be very easy to use because they will be operated by a simple push of a button that will start the machine, then it will automatically shut after a time period. Concepts 2 and 3 will probably be louder because they are operated by a pneumatic piston, so we will have to do more soundproofing if we decide to use either of those concepts.

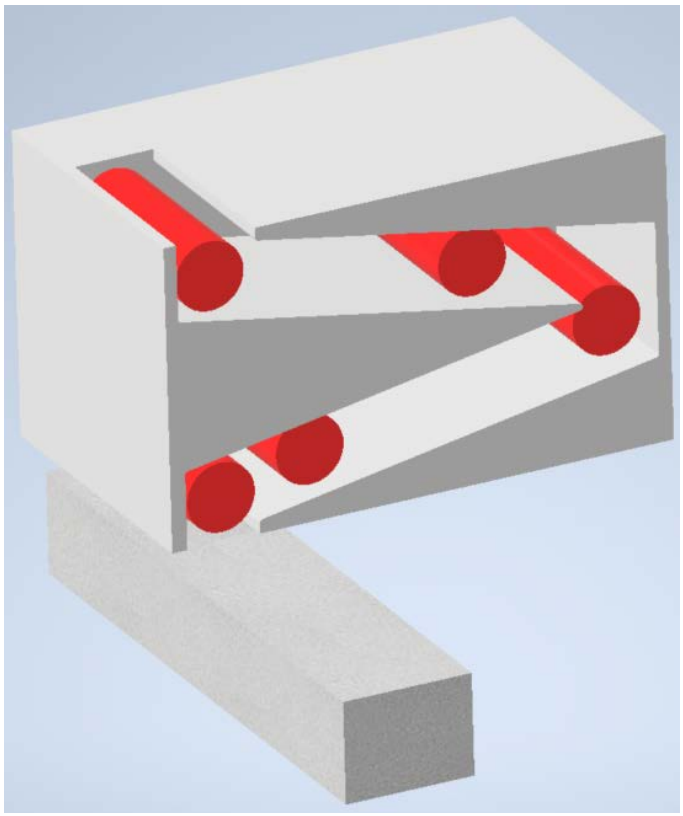

Figure 9 - Chute Design 1

This is the first concept for the feeding mechanism, It is a simple design that works off of gravity. Gravity pulls the cans down a series of ramps towards an eventual drop into the crushing chamber itself. The series of ramps allows for two things, first the cans to be able to fall from gravity pulling one can down not a bunch of cans stacked on one another pushing each other down. Secondly the design allows for more cans to be in waiting as compared to the design in concept number two by using horizontal space not just vertical.

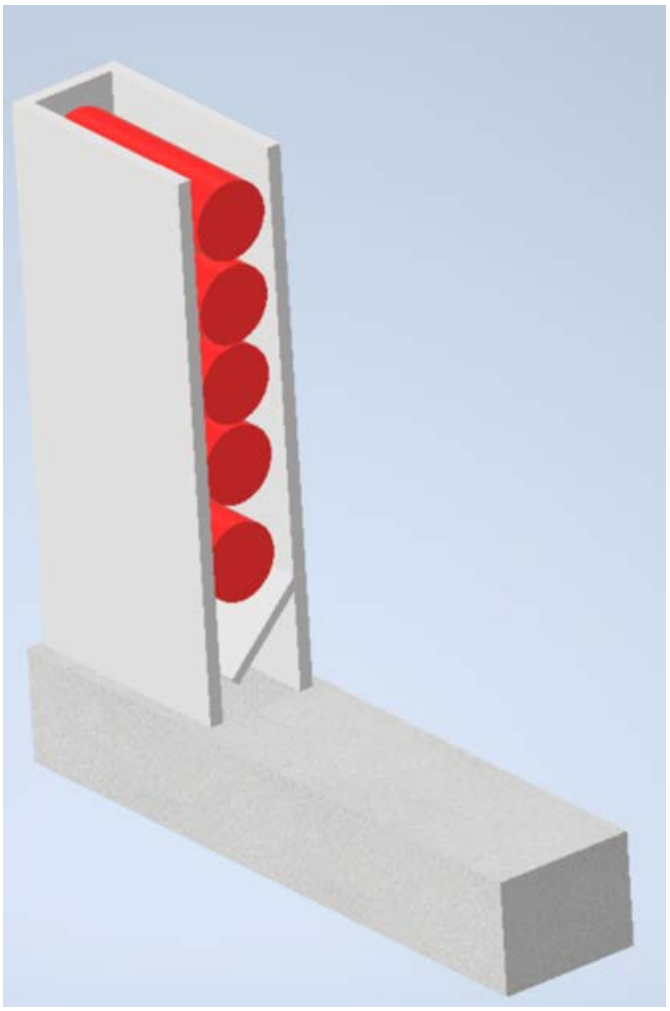

Figure 10 - Chute Design 2

This second design, like the first design feeds working off of gravity but instead of just falling into the crushing chamber a trap door incrementally drops a can down into the crushing chamber. The trap door works off of a simple sensor system to tell when the crushing piston is moving backwards after crushing. When it hits a certain point it triggers the door to drop another can into the crushing chamber so it will have a can to crush and as to not overload the crushing chamber with too may cans causing a potential jam.

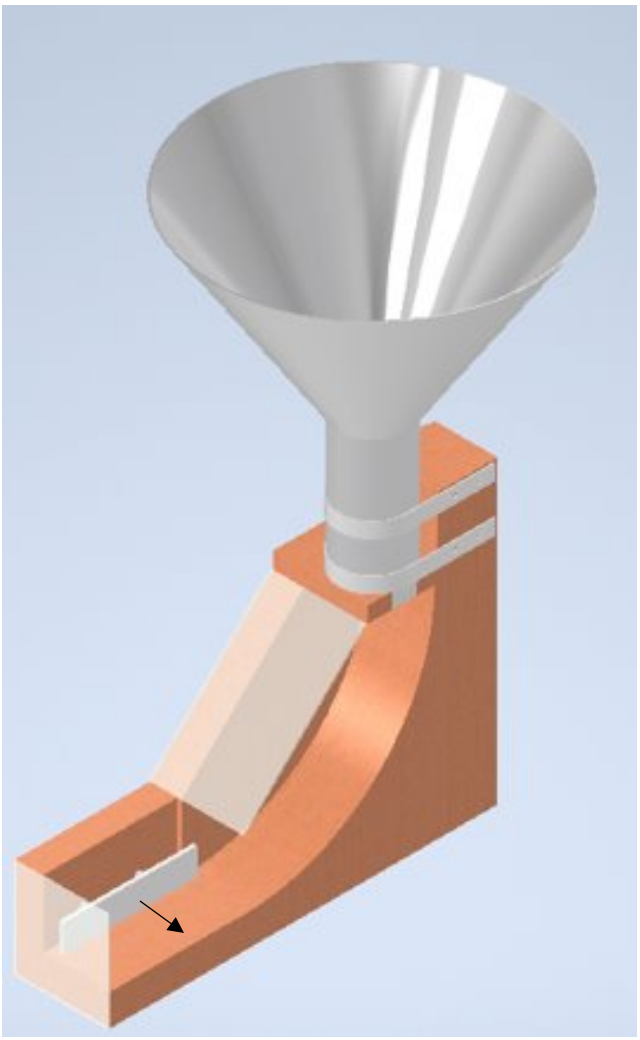

Figure 11 - Chute Design 3

The third design pictured above in figure 6 has a funnel entrance to the chute to allow for easier Loading of the device. A user can theoretically dump a container of empty cans and have them be funneled down vertically into a chute. After a can enter the chute in a vertical orientation the can transfers onto a ramp which transitions the can to a horizontal position where it sits at the bottom of the ramp with a kicker to push the can out into the crushing chamber. The kicker works off of a stepper motor and a raspberry pi, this way the kicker can be programmed on when and how to kick the cans.

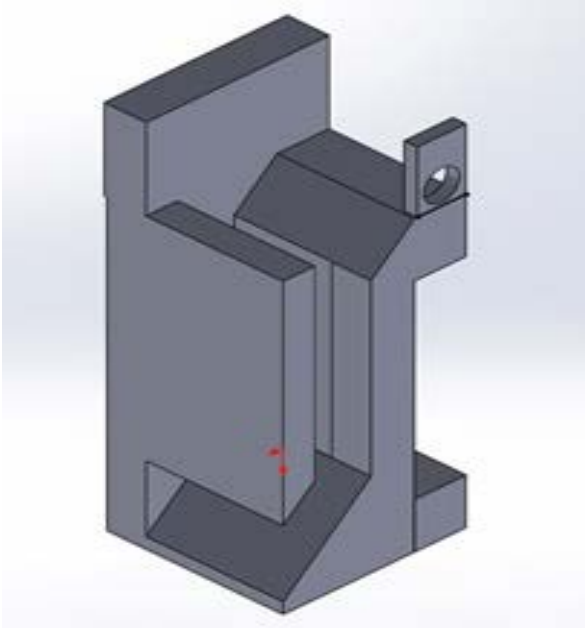

Figure 12 - Casing/Frame Design 1

The 1st concept for the design of the casing shows an open chute system using gravity as a means of transportation one the cans have been smashed. The bored-out hole is where the crushing mechanism will be placed. Parallel to that is an open-faced surface to allow for the attachment of a feeding mechanism. Once the crushed cans travel down the chute, there will be a recycling bin of some sort. Whether it be in your apartment or in your garage.

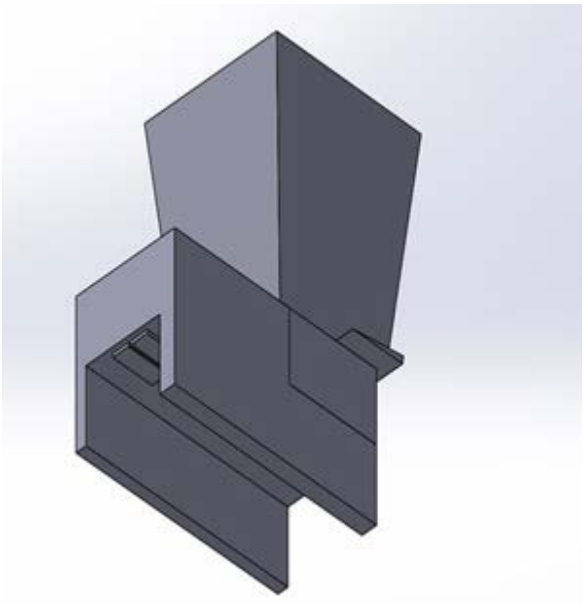

Figure 13 - Casing/Frame Design 2

For the2nd concept design, this a manually fed can crusher. In other words, it will require labor. Manually pouring in large amounts of cans into the open top metal hopper. Once said cans are in the metal hopper. This concept is like the 2nd concept, but the only difference is the overall

size and one less sensor. There are two large trap doors on the bottom that open once the crushing mechanism begins to return to its relaxed position and the process continues until all cans have been crushed.

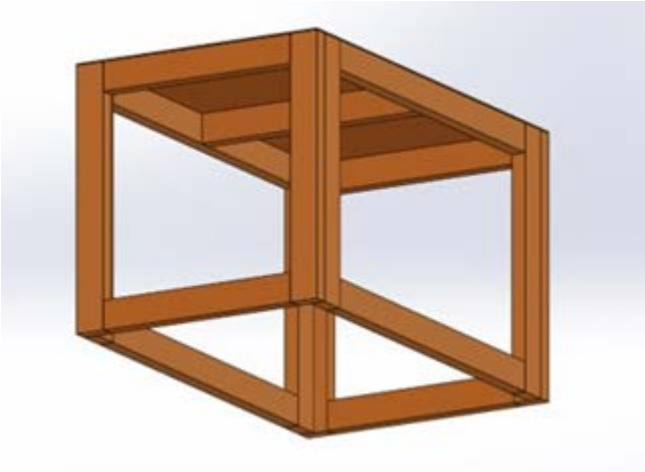

Figure 14 - Casing/Frame Design 3

For the 3rd concept design, the concept we ultimately decided to go with, this is pine-based wood framing. This is simply a skeleton of the frame, but it shows all the necessary parts minus some stress and additional bracing changes. It is a simple box design with the intended purpose of everything aside from the recycling container to be placed on the top surface. The casing would come later and be semi covered in pine wood while the rest were plexiglass windows to see the moving parts. The casing for the frame itself would be large pieces of plywood and there would be a door for both the recycling bin and for all the moving parts.

Project Management

Project Budget Limit: $900 (We ended up going slightly over)

Purchase Order

Item name	Item Description	Vendor	Quantity	Unit Price($	Total Cost($)
Motor	Grizzly Industrial 1 HP	Amazon	1	265.95	265.95
Gear Box	Lexar MRV050 60:1 Worm Gear	Amazon	1	179.99	179.99
Wood Screw	Flat #6 1 1/2" L Steel Wood Screw (QTY 100)	The Home Depot	1	5.40	5.40
Wood Screw	2 1/2" Interior Wood Screw, 5 lb	The Home Depot	1	24.99	24.99
prime whitewood stud	2in x 4in x 96in	The Home Depot	12	4.98	59.76
Pillow Block Bearing	1" Diameter (2) pack	Amazon	1	19.99	19.99
1/2" Plywood	4'x8'x1/2" OSB Plywood	The Home Depot	3	23.15	69.45
Caster Wheels	2" Rubber Swivel (4) pack	Amazon	1	17.49	17.49
Neoprene Rubber Strip	1/8" x 2" x 36" adhesive backing	McMaster-Carr	1	21.28	21.28
Threaded Rod	High Strength Steel Rod	McMaster-Carr	1	12.46	12.46
Keyed Shaft	1" x 12" 1045 Carbon Steel	McMaster-Carr	1	29.83	29.83
Shaft Collar	1" Clamping	McMaster-Carr	1	3.54	3.54
Machine Keys	1045 Carbon Steel (10) pack	McMaster-Carr	1	6.92	6.92
Solid State Relay	SSR-40DA	Amazon	1	10.99	10.99
1" Square Tube	Hot-Rolled Steelx 1/8" Wall	The Home Depot	1	24.99	24.99
Trash Can	Rubbermaid 32 gallong	The Home Depot	1	14.97	14.97
Cabinet handles	H-1105B-HAND	Uline	1	16.00	16.00
Plexiglass	24inx36nx.177in	The Home Depot	1	37.95	37.95
Ball Joint Rod End	7/16"-20 Thread	McMaster-Carr	1	6.22	6.22
Ball Joint Linkage	7/16"-20 Internal Thread	McMaster-Carr	1	7.51	7.51
MDF Board	1/2" x 24" x 48"	The Home Depot	3	12.08	36.24
Various Fasteners	Various Fasteners	The Home Depot	1	50	50.00
Final Running Total					921.92
Total After Tax					974.93

Figure 15 - Purchase Order

Initially our budget was to be right around nine hundred dollars but after some revisions and revaluations of our project we found that our original list of parts needed to be substituted. The parts needed to be switched out because some of the parts we initially had on our list were more costly than we anticipated. Thus, we swapped most of the parts that were initially aluminum and opted for pinewood. While this did bring the overall cost down, we still went over our initial budget and ended up exceeding it by around seventy-five dollars in total after tax.

Construction Schedule

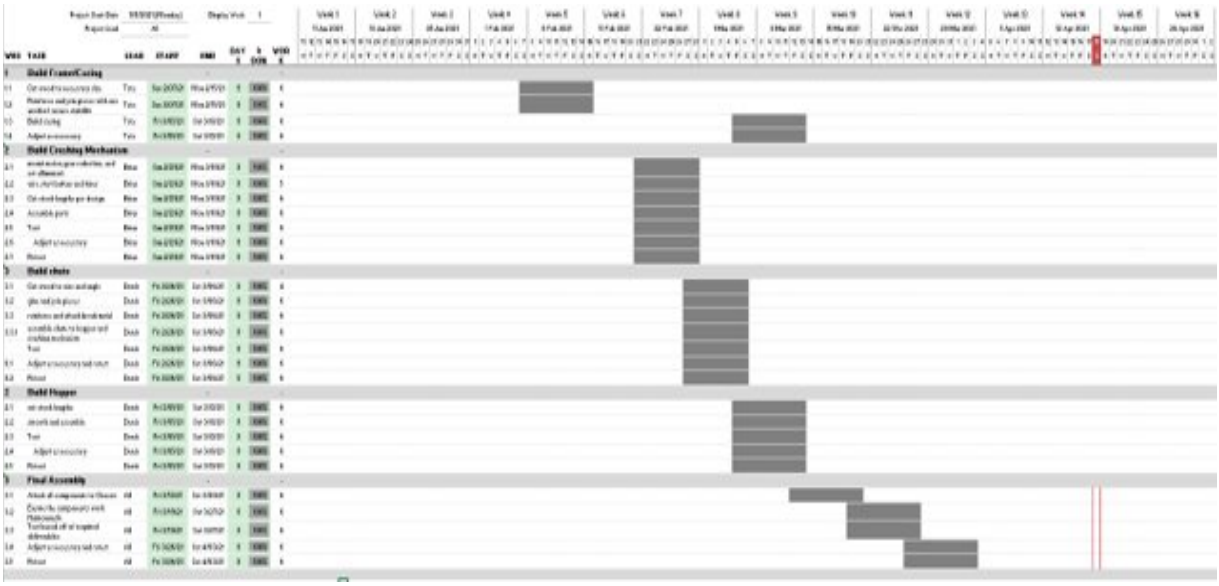

Figure 16 - Gantt Chart

Automatic Can Crusher

Lamb & Swingle Enterprises

Project Start Date: 1/11/2021(Monday) Display Week: 1

Project Lead: All

WBS	TASK	LEAD	START	END	DAYS	% DON	WORK
1	**Build Frame/Casing**			-			-
1.1	Cut wood to necessary size	Tate	Sun 2/07/21	Mon 2/15/21	9	100%	6
1.2	Reinforce and join pieces with enc seothurl ensure stability	Tate	Sun 2/07/21	Mon 2/15/21	9	100%	6
1.3	Build casing	Tate	Fri 3/05/21	Sat 3/13/21	9	100%	6
1.4	Adjust as necessary	Tate	Fri 3/05/21	Sat 3/13/21	9	100%	6
2	**Build Crushing Mechanism**			-			-
2.1	mount motor,gear reduction, and cut allignment	Brian	Sun 2/21/21	Mon 3/01/21	9	100%	6
2.2	wire start button and timer	Brian	Sun 2/21/21	Mon 3/01/21	9	100%	5
2.3	Cut stock lengths per design	Brian	Sun 2/21/21	Mon 3/01/21	9	100%	6
2.4	Assemble parts	Brian	Sun 2/21/21	Mon 3/01/21	9	100%	6
2.5	Test	Brian	Sun 2/21/21	Mon 3/01/21	9	100%	6
2.6	Adjust as necessary	Brian	Sun 2/21/21	Mon 3/01/21	9	100%	6
2.7	Retest	Brian	Sun 2/21/21	Mon 3/01/21	9	100%	6
3	**Build chute**			-			-
3.1	Cut wood to size and angle	Derek	Fri 2/26/21	Sat 3/06/21	9	100%	4
3.2	glue and join pieces	Derek	Fri 2/26/21	Sat 3/06/21	9	100%	6
3.3	reinforce and attach break metal	Derek	Fri 2/26/21	Sat 3/06/21	9	100%	6
3.3.1	assemble chute to hopper and crushing mechanism	Derek	Fri 2/26/21	Sat 3/06/21	9	100%	6
	Test	Derek	Fri 2/26/21	Sat 3/06/21	9	100%	6
0.1	Adjust as necessary and retest	Derek	Fri 2/26/21	Sat 3/06/21	9	100%	6
0.2	Retest	Derek	Fri 2/26/21	Sat 3/06/21	9	100%	6
2	**Build Hopper**			-			-
2.1	cut stock lengths	Derek	Fri 3/05/21	Sat 3/13/21	9	100%	6
2.2	smooth and assemble	Derek	Fri 3/05/21	Sat 3/13/21	9	100%	6
2.3	Test	Derek	Fri 3/05/21	Sat 3/13/21	9	100%	6
2.4	Adjust as necessary	Derek	Fri 3/05/21	Sat 3/13/21	9	100%	6
2.5	Retest	Derek	Fri 3/05/21	Sat 3/13/21	9	100%	6
3	**Final Assembly**			-			-
3.1	Attach all components to Chassis	All	Fri 3/12/21	Sat 3/20/21	9	100%	6
3.2	Ensure the components work Harmoniously	All	Fri 3/19/21	Sat 3/27/21	9	100%	6
3.3	Test based off of required deliverables	All	Fri 3/19/21	Sat 3/27/21	9	100%	6
3.4	Adjust as necessary and retest	All	Fri 3/26/21	Sat 4/03/21	9	100%	6
3.5	Retest	All	Fri 3/26/21	Sat 4/03/21	9	100%	6

Figure 17 - Gantt Chart Expanded

Testing Criteria

Testing Criteria			
Category	**Question**	**Answer**	**Explanation**
Safety	Is it possible for a user to reach a limb or extremity into the product?	No	There is no way for a user to reach a limb or extremity into the machine.
Safety	Is there any dangerous exposed sharp metallic edges?	No	There are no expose sharp metallic or wooden edges.
Ease of Use	Is the failure rate below 1 fail/1000 cans crushed?	Undetermined	On the final iteration of the project only 750 cans were left to be tested out of the 750 cans only 1 can jammed in the system. It is likely the desired 1fail/1000 cans crushed would be hit.
Efficinecy	Can the machine crush 30 cans/minute?	Yes	The gear reduction gives off a RPM of 30 which hits 30 crushed cans/minute.
Load/Capacity	Can the storage bin handle 1000 crushed cans in one load?	Yes	The desired storage bin can handle over 1000 crushed cans.
Required Labor	Must the operator only load cans and press a button?	Yes	The operator only needs to load their cans into the chute and begin the crushing cycle.
Noise Level	Is the noise level below 60 Decibels?	Yes	The machine allows for normal conversation to be held while it is in operation. Normal conversation is held at 60Db thus the machine must be below that value.
Volume Reduction	Does the machine crush a can to 15% or less than its original volume?	Yes	The cans on average were crushed to 13% their original volume.

Building Changes

Figure 18 - Final Chute Design

Figure 19 - Final Crushing Chamber Design

Above are two pictures showing the final chute design on the left and a shot looking down the crushing chamber on the right. With the chute it was obvious after testing the original hopper design that the cans would not funnel themselves down the chute so that aspect of the design was abandoned. A design without the funnel and just a chute was created however there was issues getting cans of varying sizes to fall into the chamber in the correct orientation. The other problem with this design was the kicker, It could not kick the cans of different sizes into the chamber with any level of consistency. After looking at the other initial concept designs for the chute it was determined a magazine style loader would work best for this application. A bend was added at the top end of the chute to not allow the loading of cans in any incorrect orientation, the chute only accepts cans loaded horizontally. The crushing chamber which is not appropriately depicted in the above picture has metal mounted on the back wall and sides where the cans are being crushed to prevent the cans from digging into the wooden sidewalls of the chamber embedding themselves, which was an issue in the first round of testing of the crushing chamber. There is also mounted wooden fins on the crushing chamber as depicted above which sit in cut channels in the side walls of the chamber which prevent the block from lifting up due to resistance from the can and ensures the block stays in the correct orientation.

Figure 20 - Internal Parts

Pictured above in figure 12 is the contained motor, worm gear reduction, and axel. This is a one horsepower motor that feeds into a worm gear reduction box, originally the design called for a further reduction through a chain and sprocket however it this further reduction was not necessary. The axel is connected to the reduction box through a 1045 carbon steel keyed shaft that is welded to a square tube made of hot rolled steel. The axel is held in place by two pillow blocks fastened to the wood framing allowing the axel to rotate freely. The axel has a hole drilled 4.5 inches away from the center to ensure a 9-inch draw on the crushing block so the machine can accommodate the biggest cans (8 inches in length). It is connected to our crushing block through a 7-inch threaded rod made of A 354 high strength steel.

What We Would Change

- Increase Budget: This project was entirely self-funded. Some of the changes we made were a result of needing to cut costs to stay within budget. Our original intent was to build the entire crushing mechanism (chamber and block) out of machined and welded metal. After starting to order parts we realized that all the metal we would need to buy would nearly double the budget, so we ended up switching to wood. If we were to make this project again, we would increase the budget and machine parts out of metal to tighten the tolerances of the crushing mechanism.
- Sensors: Another change would be to utilize more electronics, mostly sensors. Currently the motor begins operation when the user presses a push button. We would like to have incorporated sensors that detect when a can is deposited down the chute, automatically begin operation, and sense when the chute is empty, then stopping operation. We would also use a sensor that measures when the can is near full, and completely full. When it is near full, an LED would turn orange, then when completely full the LED would turn red, denoting that the can is full, and not letting the machine begin operation.
- Vibratory Feeder: As stated, one of the reasons we moved away from a funnel design with the chute was because in testing, cans would get stuck and not fall down the chute as easily as we predicted. One way to get the cans to easily fall down the chute would be a vibratory feeder that shook mildly until the cans were in the correct orientation to fall down the chute. This is another area where a sensor would be utilized, so the feeder knew when to turn off.
- Weight Sensor: A safety feature that we would use if we were to redesign this project would be an internal weight sensor used in the chute design. Our current machine only accepts 12 oz standard cans and does not allow glass bottles to be inserted into the chute. If we were to use a chute that accepted all sizes of cans, we would need a way to prevent glass bottles from entering the crushing chamber. To accomplish this, we would utilize a weight sensor, or a trap door with light weight springs, that would knock a glass bottle off to the side and down to a separate receptacle. This would also prevent full, unopened cans from the entering the crushing chamber as well.

Compliance & Regulation

- All electrical wiring insulated according to 1910.303(b)(1)(iv) of the Occupational Safety and Health Standards (Administration, 1910.303 - General, 1981)
- All electrical components firmly secured to mounting surface per 1910.303(b)(8)(i) of the Occupational Safety and Health Standards (Administration, 1910.303 - General, 1981)
- Pinch Point signage added near crushing chamber, and near closing point of lid to machine interior per Occupation Safety and Health Standards document “Safeguarding Equipment and Protecting Employees from Amputations (Administration, Safeguarding Equipment and Protecting Employees from Amputations, 2007)

Figure 21 - Pinch Point Warning

References:

Administration, O. S. (1974, 06 27). *1910.211 - Definitions.* Retrieved from OSHA.gov: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.211

Administration, O. S. (1981, 01 16). *1910.303 - General.* Retrieved from OSHA.gov: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.303

Administration, O. S. (2007). *Safeguarding Equipment and Protecting Employees from Amputations.* Retrieved from OSHA.gov: https://www.osha.gov/sites/default/files/publications/osha3170.pdf

Dodd, R. N. (1986, 02 18). *US Patent No. US4570536A.*

Environmental Protection Agency. (2018, 7 24). *Recycling and Compositng Rate of Selected Products in the United States in 2015*. (Statista) Retrieved 9 18, 2020, from Statista: https://www-statista-com.proxy.libraries.uc.edu/statistics/214270/recycling-rates-of-selected-products-in-the-us/

Mayo, D. (1999, 10 19). *US Patent No. US5967029A.*

Moore Recycling, and Resource Recycling Systems. (2016, 8 1). *Population with and without Available Beverage Container Recycling Programs in the United States in 2016, by Material (in Thousands)*. Retrieved 9 18, 2020, from Statista: https://www-statista-com.proxy.libraries.uc.edu/statistics/590955/availability-of-recycling-programs-for-beverage-containers-us-by-material/

Moore Recycling, and Resource Recycling Systems. (2016, 8 1). *Share of Population with Available Beverage Containers Recycling in the United States in 2016, by Program Type*. (Statista) Retrieved 9 18, 2020, from Statista: https://www-statista-com.proxy.libraries.uc.edu/statistics/590985/percent-of-population-with-recycling-for-beverage-containers-available-us-by-program/

Statista Survey. (2017, 4 1). *Share of Consumers Who Participate in Recycling in the United States 2017, by Age Group*. (Statista) Retrieved 9 18, 2020, from Statista: https://www-statista-com.proxy.libraries.uc.edu/statistics/695457/americans-participating-in-recycling-in-the-united-states-by-age/

Waste360. (2019, 7 7). *Recycling Services Offered by the Waste Industry in the United States from 2016 to 2019*. Retrieved 9 18, 2020, from Statista: https://www-statista-com.proxy.libraries.uc.edu/statistics/1016216/recycling-services-offering-us/