.

Project Green Can

Team 1

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ECE 445: Senior Project Design

Contents

1. Objectives and Background

1.1 Problem

[1]According to an article by the National Association of Convenience Stores (the Value of Can and Bottle Recycling), crushing cans before recycling saves space, providing more recyclable material per container and makes transportation more efficient.

However, the average person's means of crushing cans before recycling neither has a system to prevent the crushing of non-empty nor a safety guard for its users– what happens if a hand gets stuck in front of the crushing surface some metal shards fly around during the crushing? Some concerned threads outline these concerns in a discussion forum (Health and Safety Tips).

So the problem is apparent: improving our current system of recycling cans with safety in mind.

1.2 Solution

We intend to make an Aluminum can recycling machine that prevents the recycling of non-empty Aluminum cans and keeps track of how many cans have been recycled for documentation purposes at larger organizations. This solution encourages large-scale recycling through a user-safe system that prevents the recycling of non-empty and/or pressurized cans.

The machine will use a latch sensor (similar to those used to turn the light on or off in refrigerators) to tell when the can-crushing enclosure's door is shut and a load cell to tell when an empty aluminum can (weighing from 12g to 16g) has been inserted into the machine. When, in addition to the previous two conditions, there is no overload of cans detected in the collection system (i.e. as long as there are not too many cans in the machine's collection bin), and the start button is also pressed, a PCB will send a signal to the motor, which will crush the can. The motor will proceed to crush the can until a potentiometer attached to the motor indicates to the PCB that the can has been crushed to the point where, if the motor retracts, it will fall into the can disposal chute. If, before this point, the current monitor attached to the motor indicates that an irregular amount of current is being exerted to crush the can, the motor will be retracted immediately to prevent damage to the machine. Assuming the can is sufficiently crushed, it will be allowed to fall into the disposal chute by the retracting motor, breaking the beam of an IR sensor placed at the bottom of the chute, and sending a signal to the PCB. The can will proceed to fall into the disposal bin below the device, while the PCB will internally increment its count of the number of cans recycled and display the current number on a small display.

To ensure only empty cans are crushed, our system will monitor two values: the weight of cans placed into the crushing cubicle and the current drawn from the motor. If its weight exceeds the

[1] Advancing Convenience & Fuel Retailing. "The Value of Can and Bottle Recycling." *NACS*, https://www.convenience.org/Topics/Sustainability/Can-Bottle-Recycling/Can-Bottle-Recycling. Accessed 30 January 2023.

weight of an empty can or the current crosses an experimentally determined threshold, a red LED will glow (indicating to the user that the machine will not crush the can placed inside, sending the machine into a do not accept state). There will be a collection bin for the crushed cans.

At any point in time, the system is one of four internal states: A start state (which it will be frozen in temporarily if it detects an invalid can on the load cell, a can blocking the disposal chute due to a full disposal bin, or an open door to the can insertion area) where the machine can be asked to crush a can, a crush state (which will only be triggered from the start state if none of the freezing conditions are true and if the go button is pressed) where, assuming no problems are detected, the can will be crushed by extending the crushing piston and retracting it once the can has been crushed small enough to fall into the disposal chute, a retraction state (which only occurs to immediately retract the piston if the door is suddenly opened or if the current is detected to be to unsafe) to implement safety measures during crushing, or an increment state (which occurs after the crush state assuming a can is detected by the disposal chute as the piston is retracted) to increment the recorded number of cans crushed and continue retracting the piston. The current state of the machine, including which of the four internal states it is in and the presence of problematic signals (too much weight, too much current, too many cans, can door open) might also be indicated by a set of LEDs.

1.3 Goals and Benefits

- Provides a user-safe method of can-crushing for recycling by shielding users from metal shards and stopping the can-crushing platform if the protective covering is removed.
- Collects can-recycling data for study when employed as a communal amenity.
- Encourages can-recycling in areas where people do not have can-crushers at home.
- Prevents recycling of non-empty cans.

1.4 High-level requirements

- The system crushes only non-pressurized empty cans when they are inserted into the can-crushing space.

- The crushed cans are collected in the collector until it is full/ the collection duct is obstructed (in this case, the machine goes into a mode where it must be serviced to continue operation)

- The system keeps track of how many cans have been crushed in between service cycles.

2. Design

2.1 Visual Aid

As shown below, our project is designed to lay down with a can disposal chute facing a collection bin. It comprises three main subsystems: a can-crushing, collection, and control system.

The can-crushing system revolves around the motor: controlled by the pcb, it moves a can-crushing surface that pushes a can (initially placed on a load cell that detects it weight to ensure that can is empty and valid for crushing) against the opposite surface effectively crushing it which makes it small enough to go through the disposal chute into the collection system which increments the crushed can count by 1 via the IR sensor and the pcb and updates total cans crushed internally and displays this number via the Arduino serial display. As seen from the top view, there is also a door for can entry which serves as a safety component to prevent people from accidentally placing their hands in the machine while a can is being crushed and getting hurt. This door comes with a door sensor that communicates with the pcb, indicating when the door is shut and safe for the commencement of crushing.

For the internals of both the top and side view, a linear motor piston is seen with a crushing block mounted to its head which is key in the process of crushing the can. We also see a can detection IR beam for the purpose of detecting when a can has been placed on the crushing platform which houses the load cell.

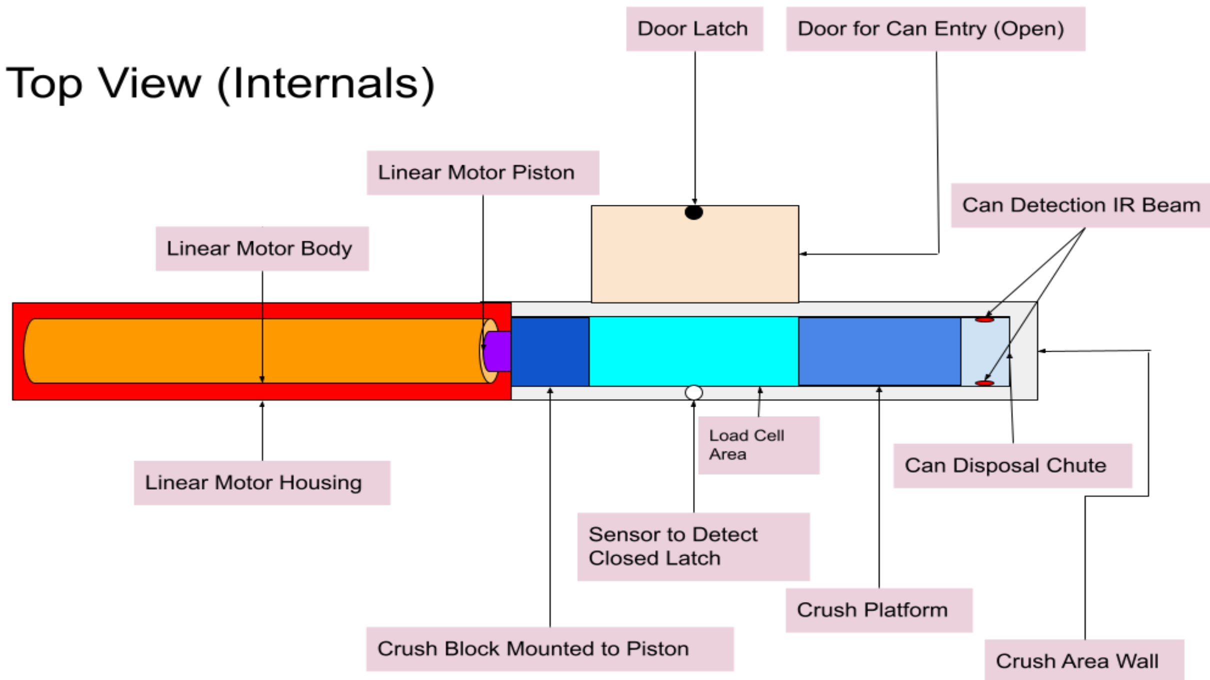


Figure 1: Top View of GreenCan (Internals)

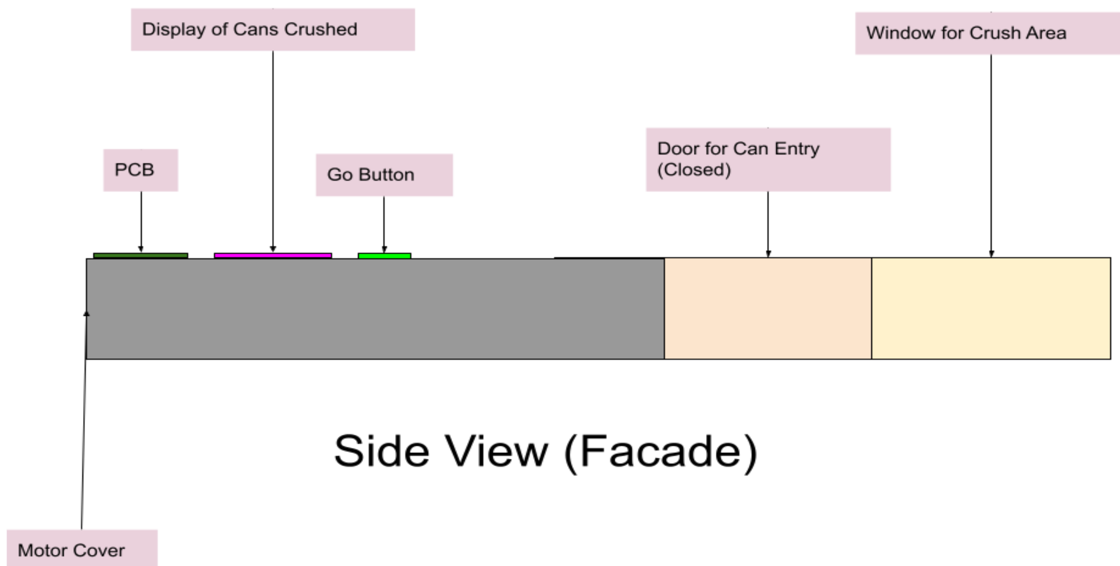


Figure 2: Side View of GreenCan (Facade)

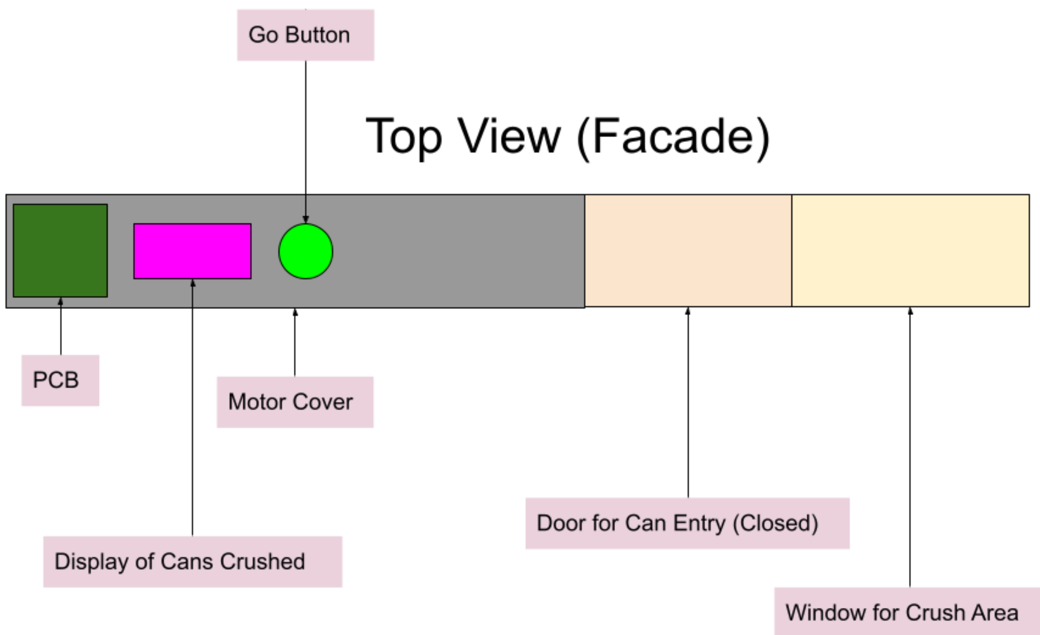


Figure 3: Top View of GreenCan (Facade)

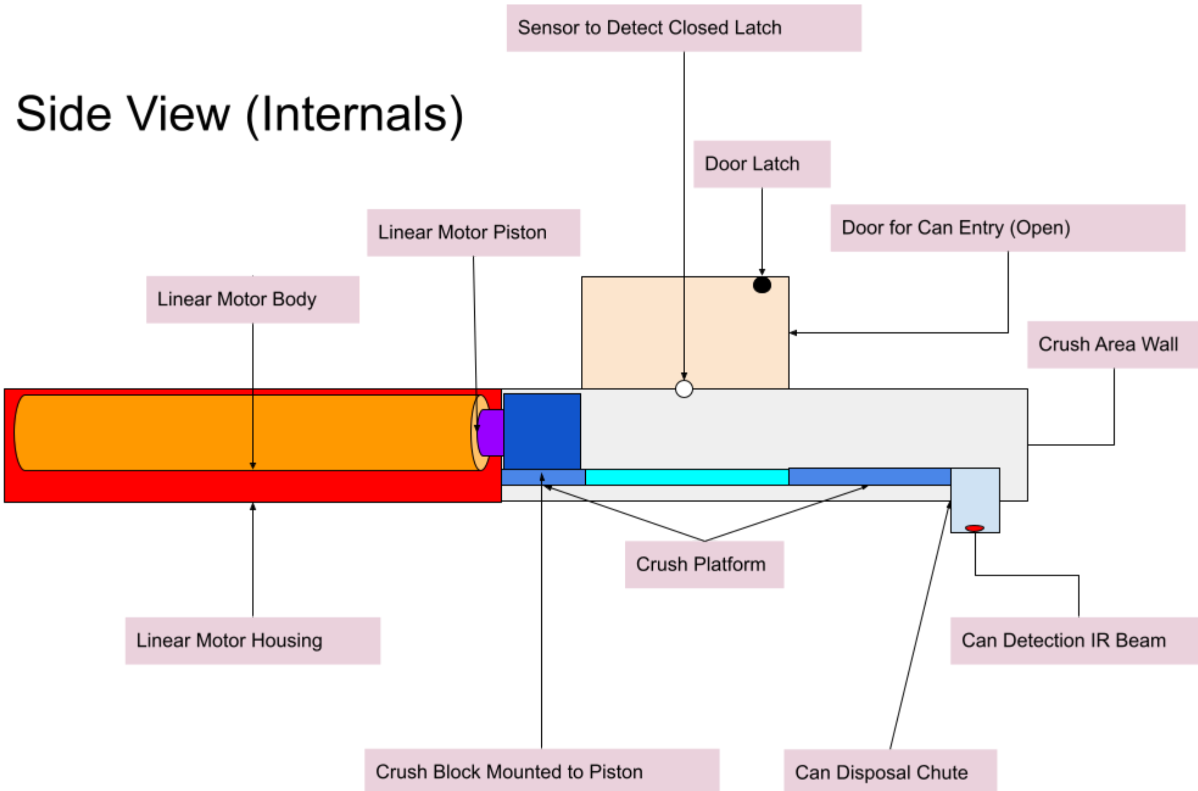


Figure 4: Side View of GreenCan (Internals)

2.2 Block Diagram

The block diagram contains the three main systems for the machine; the can-crushing system, the control system (PCB), and the collection system. The can-crushing system has multiple subsystems, including the door sensor, which communicates to the PCB the door status– either opened or closed– which the PCB uses to decide if it is safe to begin the can-crushing process, so that subsystem is solely to promote safety. The load cell resides on the crushing platform and communicates to the PCB the weight of a can be placed on this platform to help the PCB realize that this can is empty and is ready to get crushed and recycled. The linear motor has 12V supplied to it and contains the potentiometer (with 5V provided to it) as well as the current monitor, which communicates current readings to the PCB, which the PCB uses to send back retract/extend signals to the motor in order to use just enough force to crush the can and not too much or too little.

The control system (PCB) contains the state machine, which uses the signals from the subsystems mentioned above in the can-crushing system. This state machine is displayed via LEDs. The PCB also takes the signal from the IR sensor in the can collection system and increments the internally kept number of cans crushed and sends this number to the can collection system to be displayed on the Arduino display.

The can collection system contains an IR sensor to detect when a can has been crushed and collected through the disposal chute into the collector. This IR sensor then sends a signal to the PCB indicating that a can has been collected so that the PCB increases the number of cans crushed internally. The can collection also contains the Arduino display to display the number of cans crushed as communicated by the PCB.

Note that the **5 V being fed into the h-bridge is to tie the reset pin high** (the reset pin is active low and we never want the reset pin to reset. The 12V is for actual chip power.

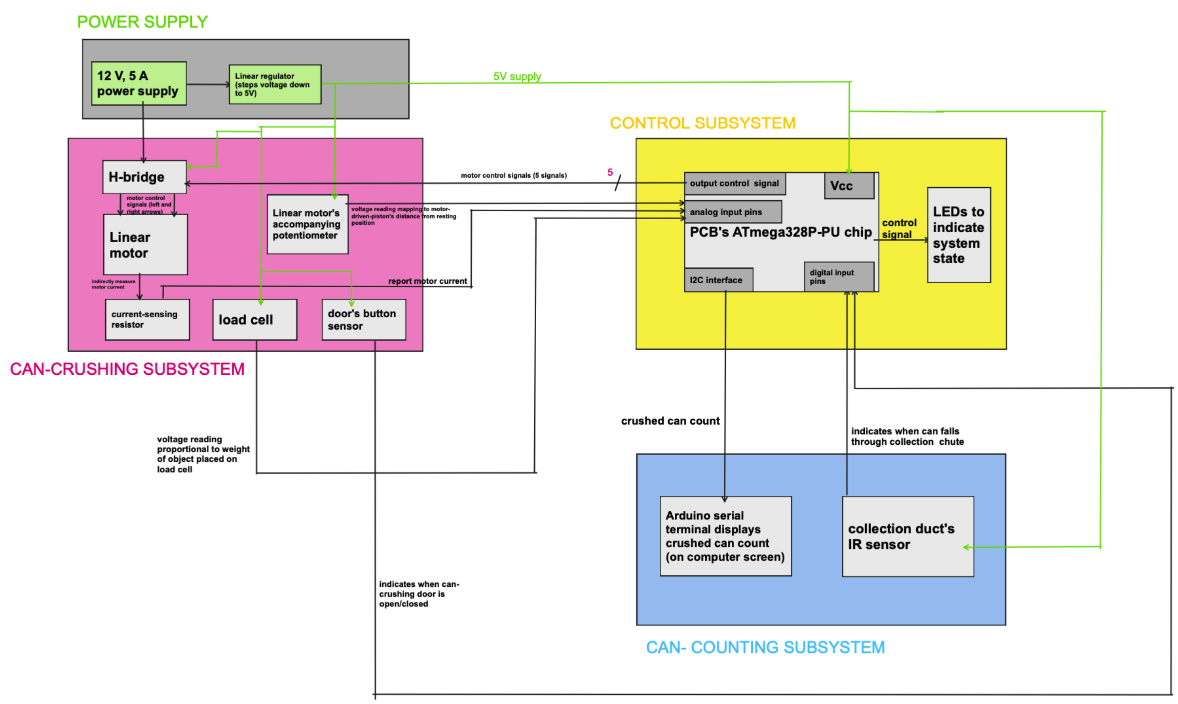


Figure 5: Block Diagram

2.3 Subsystem Overview

- **Can-Crushing System with built-in protection from recycling full cans**

Once in the can-crushing state, the opening through which one places the can must remain shut unless the motor will stop moving the can-crushing platform (there is a button the door should hold down to tell if the door remains shut). The motor will also only move the piston to crush the inserted can if the weight sensor beneath the can does not sense that the can weigh outside the acceptable 12 to 16 g range. Once crushed, gravity pulls the crushed can through an open chute which leads to the collector subsystem.

The motor's potentiometer reports the piston's location to the PCB, which, in turn, sends back control signals to the motor.

For safety reasons, the motor's current is also reported to the PCB. If the motor stalls for any reason (for example, squishing a small animal that crawled into the can-crushing space, crushing a human body part if the door was opened and the button's feedback to the control system is too late, or the motor is trying to crush an empty to pressurized can which could explode under compression, etc.) this creates a spike in the current drawn by a motor (stall current). This spike is noticed by the control system, which reverses the direction of the motor.

Please note that the system states mentioned are displayed under the Software Design section.

Requirements	Verification
Motor drives can-crushing platform to crush cans be a **as thin as 0.28cm (with an allowed error on ± 5%)**	Any empty can fed into the can-crusher must be crushed thin enough for the crushed can to slide through the collection chute (which is 0.28 cm in width). Two empty cans will be fed to the machine. After the cans are crushed, they must fall through the chute to show they have been crushed to satisfaction.
Only empty cans are crushed with an **accuracy of at least 90% percent**– with our trial of 10 cans, at least 9 cans should set the machine into the expected state as outlined on the right.	Ten Aluminium cans (five completely empty, five full) will be individually fed into the machine. The crushing door remains closed once they are fed into the machine. Only the empty cans will be accepted and crushed; the other items will sit in the machine uncrushed, with the system staying in the REJECT state until they are removed.

Opening the door stops the motor from its crushing motion **within 5 seconds.**	Opening the crushing door at any point in time should halt crushing within 30 seconds and send the system into REJECT state (which can be escaped from by first removing the can). Two empty cans will be fed into the machine: one can's crushing will be interrupted before the motor starts crushing the can and the other's crushing will be interrupted while the can is being crushed. Both experiments should put the machine in REJECT state until the cans are removed. Both cans will then be placed back into the can-crushing unit and left to be crushed uninterrupted. Now, the cans should be completely crushed.

- **Collector subsystem**

The collector chute has an IR sensor that monitors when crushed cans fall into the collector below. If, for some reason, the chute becomes blocked (this could happen when the crushed cans pile too high or a crushed can do not fit down to the chute properly), a signal is sent to the control subsystem, which puts the system in a state where no more cans will be accepted until the system is serviced. Additionally, the IR sensor acts as a counter for the can-counting done by the PCB in the control subsystem.

Requirements	Verification
Blockages in the collector chute are reported to the control system as a flag to stop accepting cans (**within 5 seconds**) till the blockage is removed. After blockage is removed, the system must be able to accept cans **within 5 seconds.**	Blockages in the collector chute put the machine in SERVICE state until they are removed. A crushed can or small rock will then be placed into the collected chute to simulate an obstruction the chute might encounter when launched on organizations' campuses. The system must accept no more incoming cans and stay in the SERVICE state until the obstruction is removed.
Sends can-count increment signal to PCB every time a can is crushed and sent down the chute. This count increment must be made within **5 seconds.**	Two empty cans, after being crushed and collected in the collection bin, must trigger the can counter to increment by exactly two units. The time between either can dropping

	and the can count increment must be 30 seconds (we will check this with a timer).

- **Control subsystem**

This comprises the PCB and the Arduino serial output terminal. Using inputs from the can-crushing subsystem (load cell weight, motor potentiometer, and the motor current readings), the PCB outputs control signals to control the direction of the motor. The button under the door of the can-crushing area also sends a signal to the PCB to stop the motos if the door is opening during can-crushing.

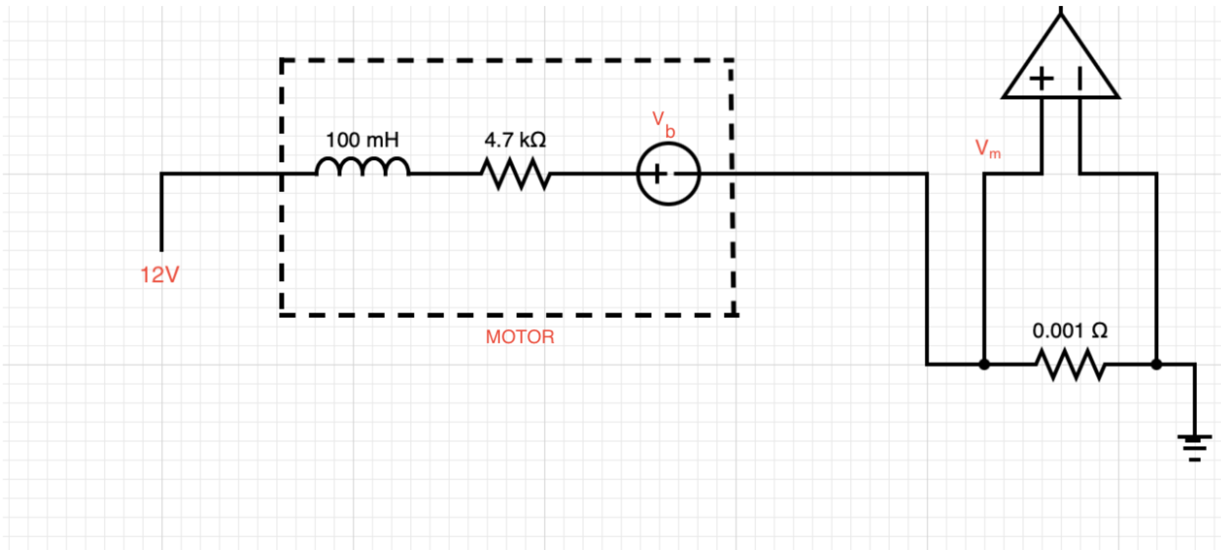
The PCB, upon receiving a signal from the collector chute's IR sensor, increments the can count and displays this using the Arduino's serial output terminal.

Requirements	Verification
Stop the motor when it is stalling within **5 seconds.**	The current of the motor is indirectly monitored by the control subsystem. When an experimentally determined threshold is reached before a can is crushed, the system notes that the motor has encountered an object too hard to be an empty, recyclable can. This item must be rejected. A rock, water bottle, and empty can will be put into the crushing enclosure, and only the empty can be crushed: the motor must retract within 30 seconds of trying to crush the rock and water bottle, sending the system into REJECT state.
Keeps count of how many cans have been crushed between service sessions, with an **accuracy of 100%** (assuming only cans are fed in).	Two empty cans, after being crushed and collected in the collection bin, must trigger the can counter to increment by exactly two units. This data must remain visible on the display until a SERVICE state is reached.
Does not allow the motor to run if the load cell detects full cans in can-crushing space.	An empty can and full can/rock will be placed in the can-crushing container. Only the empty can should be crushed; the rock/full can should be rejected by the machine and

The detection of full cans must **be 100%** accurate.	rejected.

2.4 Hardware Design

The main hardware components of our system are found in the can-crushing subsystem. The collector subsystem uses an IR sensor as input into the program running on our PCBs microchip (outlined in the software development section), and the control subsystem is the program that sends out control signals to the rest of the system (also outlined in the Software Development section).



[23]Figure 6: Motor Circuit Mock Up and Motor Current Monitoring (Vm)

[2] Girr.org. "Motor Current." *Motor Current*, http://www.girr.org/girr/tips/tips5/motor_current.gif. Accessed 30 January 2023.

[3] Girr.org. "An Ideal Motor." *An Ideal Motor*, http://www.girr.org/girr/tips/tips5/ideal_motor.gif. Accessed 30 January 2023.

Figure 7: A Picture of the Motor-Driven Can-Crushing Platform

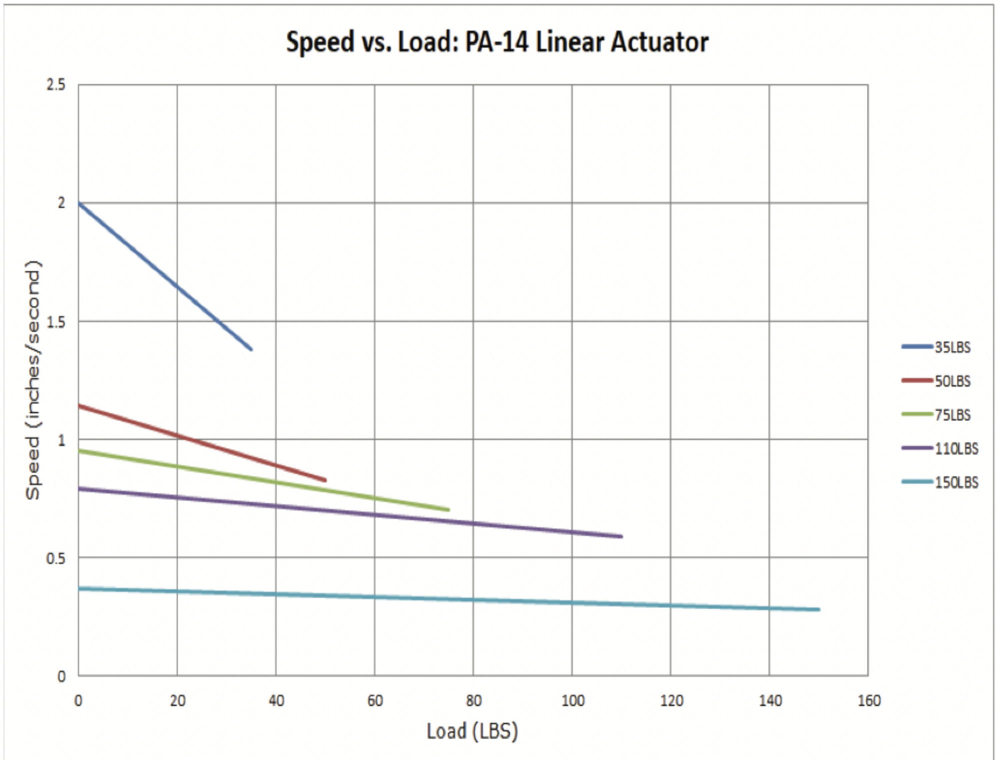


Figure 8: Graph of Motor Speed vs. Load

The focal point of the can-crushing subsystem is the DC motor which drives a can-crushing surface (as shown in Figure 7). Powered by a 12 V source and operating on 5 Amps, it has in-built potentiometer feedback, which is monitored by the PCB's microchip, which controls the motor's direction and power status via an H-bridge.

To ensure only empty cans are crushed by the machine (this is a safety measure as well), V_m is also monitored by the PCB's microchip. This indirectly gives the motor current:

$$I = Vm/0.001\Omega$$

The motor current (I) is what is indirectly measured by the PCB microchip's program. It reaches a critical value when it stalls. This is because Vb (the back EMF) is proportional to the angular velocity of the motor (ω):

$$Vb \propto \omega$$

From the circuit drawn in Figure 6, one may see that, as Vb drops to zero, the voltage across the current sensing resistor rises; the motor current rises. This will be the case when the motor stalls, then the can-crushing platform is pressing against something it should not encounter in its path.

Left unchecked, the current might be too much for the motor (as the trend in Figure 9 suggests). However, we will experimentally determine the stalling current for our motor and ensure the system REJECTS the item placed in the can-crushing enclosure.

It was important we kept the value of the current sensing resistor small to reduce power loss due to it, following the power equation:

$$P = IR^2$$

Note that 0.001Ω is only a placeholder value. Our actual current sensing resistor has a power rating of 0.0625 W.

Also shown in 7 is our load cell. The Wheatstone bridge circuit in our load cell is used to measure the change in resistance of the strain gauge(s) bonded to the metal structure of the load cell. When an external force (such as a can) is applied to the load cell, the metal structure deforms slightly, causing a change in the resistance of the strain gauge(s). This change in resistance causes an imbalance in the Wheatstone bridge circuit, which generates a small electrical signal that is proportional to the applied force. We will experimentally determine the threshold signals which are proportional to 12 g and 16 g objects.

The IR sensor is the input to the can-counting subsystem. We will be using a single-element IR sensor, which works by detecting changes in the infrared radiation emitted from objects. These sensors typically consist of a photodiode that is sensitive to infrared radiation and converts it into an electrical signal. When an object emits or reflects infrared radiation, the radiation is absorbed by the photodiode, which generates an electrical signal proportional to the intensity of the infrared radiation. This signal is then processed by the sensor circuitry to detect the presence of an object or to measure its temperature. This signal is simply fed into the control; the signal for processing and the IR's circuit is a simple one that connects it to power and ground (with a small resistor to keep form shorting).

Additionally, we ensured that crushing the can would take a reasonable amount of time. The motor we acquired applies 150 LB to crush the can. In experiments, we verified that can-crushing takes about 6 seconds (as figure 8 suggests) since average aluminum cans are 12 inches long.

2.5 Software Design

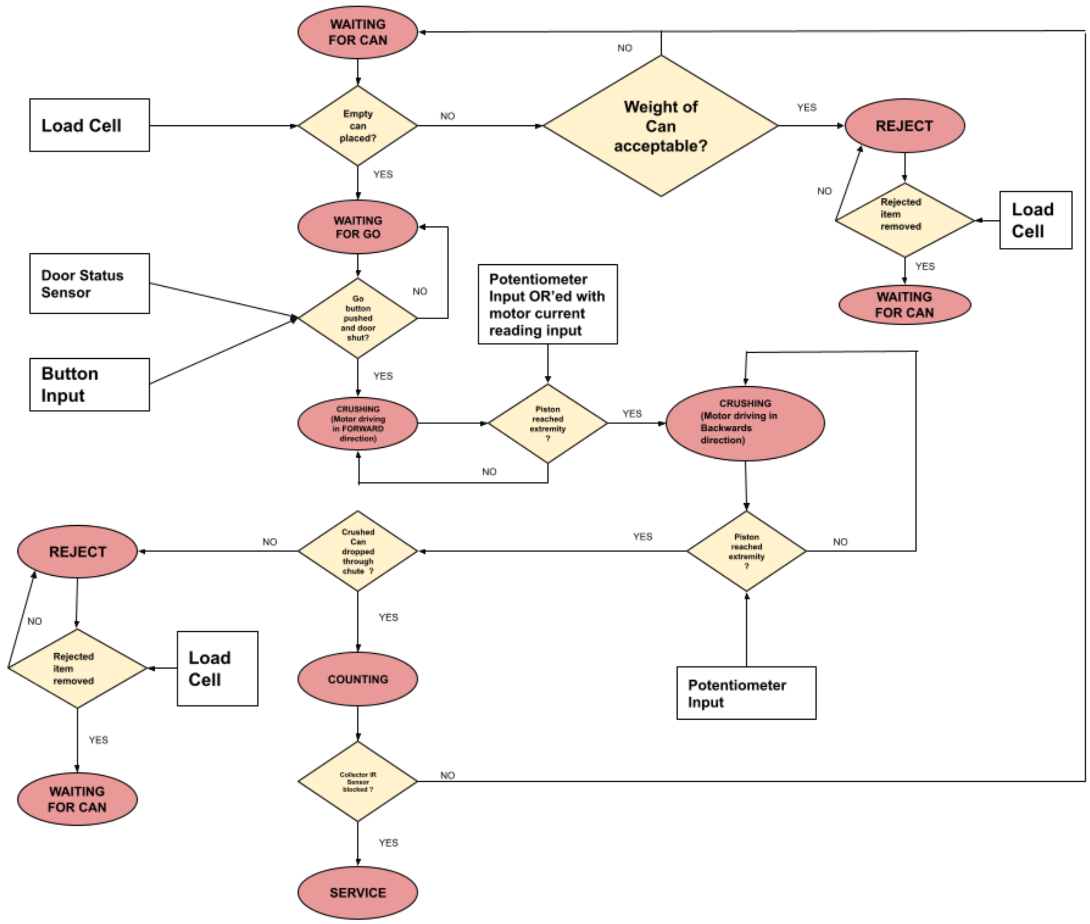


Figure 10: State Machine Diagram of Project

The PCB microchip will run a program that keeps the system in one of seven states at every point in time. These states will be indicated by LEDs on the machine and are outlined below:

- WAITING FOR CAN: The initial starting state of the system. The motor is kept off, and the piston is kept reeled in. When the Load cell reads in voltage corresponding to an item weighing between 12 and 16 grams, the system progresses to the WAITING FOR GO state. If the item placed is beyond 16 grams, the system goes into REJECT state. Although this is not shown in Figure 10, items weighing below 12 grams leave the system in the WAITING FOR CAN state.

- REJECT: When items weighing over 16 g are fed into the machine, this state is reached. This is to ensure items like rocks and non-empty cans are not recycled by the machines and later delivered to recycling centers. Once the overweight items are removed, the system goes into the WAITING FOR CAN state.

- WAITING TO GO: this state serves as a safety mechanism as we do not want the can-crushing platform being driven forward by the motor while a user's hand is still in its path of motion. To proceed with can crushing, users press a go button.

- CRUSHING (MOTOR GOING IN FORWARD DIRECTION): at the start of the can-crushing process, the motor drives the can-crushing platform forward. To know when the extremity is reached (whether the can-crushing platform is pressing against a hard surface or the piston has been extended to its full extent), the PCB's program monitors the motor's potentiometer's reading and the V_m of the motor (V_m is explained in the Hardware Design section).

- CRUSHING(MOTOR GOING IN BACKWARD DIRECTION): the second part of the crushing process is after the piston's direction is swapped when it has reached the extremity, the motor drives the can-crushing platform backward. When the piston reaches the extremity a second time, and the can is thoroughly crushed and falls into the collector chute as detected by an IR sensor, the system goes into the COUNTING state. If, however, the collector's IR sensor did not sense a can dropping through the collection chute, the system progresses to the REJECT state.

- COUNTING: in this state, the system internally increases the number of cans it has crushed. Also, the system checks if the collector's IR sensor has been blocked for too long. If this is the case, the system goes into the SERVICE state; if not, the system goes back to the WAITING FOR CAN state.

- SERVICE: in this state, the humans would interact with the collector bin in an attempt to unblock the IR sensor. The block could result from the collector bin being too full and overflowing with crushed cans, or a can could just be positioned to block the IR sensor.

3. Tolerance Analysis

We have ensured that our system is a closed loop: assuming what is likely an empty, non-pressurized can is placed into the can-crushing container (detected by the load cell, which feeds into the control subsystem), the control subsystem PCB microchip program sends out a control signal which drives the motor to crush it; the motor then retracts (when its potentiometer indicates the piston has been fully extended or V_m indicates a motor stall in the PCB microchip program) and, as the crushed can slip through a collection chute, the system increases the can count and either go into SERVICE state (if there is now an obstruction in the collection chute) or returns to the initial WAITING FOR CANS state.

One major point of concern is the control of the motor– what happens if it pushes the crushing platform too far?

We choose to discuss this part of the project as its correct operation is crucial to the successful operation of the project. Without a successfully crushed can, nothing goes down our collection chute, no can count is kept, and our control subsystem stays in the initial state indefinitely.

It is due to its importance that we ensure, through simulation, we will achieve acceptable fault tolerance from the motor: in the worst case, the motor's forward driving signal from the control subsystem is slightly too powerful. This could damage the load cell or crush the can too quickly (prematurely triggering the collection chute's IR sensor in a state where its input is not considered by the PCB).

By monitoring the current of the motor, we ensure the PCB reels the motor back to its original position before the can is crushed too thinly (causing the second issue mentioned in the preceding paragraph). By separating the load cell from the actual can-crushing platform (as shown in the visual aid), we avoid the first issue mentioned in the preceding paragraph.

This ensures our high-level requirements are met because, by preventing the damage of our load cell, cans outside the allowed weight range can be rejected in future uses of our system and, by preventing premature triggerings of the collector chute's IR sensor, its readings will be available in states when they are used in can-counting and obstruction detection. Additionally, monitoring the motor's current prevents the motor from attempting to crush items that are not empty non-pressurized cans (such as hollow rocks and human parts) which may bypass the load cell's weight restrictions.

Other points of concern are the progression of machine states. They are outlined in the Software Development section, and we have taken time to ensure the system is not stuck in any state indefinitely:

WAITING FOR CAN progresses to WAITING FOR GO once an item 12 g to 16 g is detected. Any item under 12 g keeps the system in the WAITING FOR CAN state, and any item over 16 g sends the system into REJECT state when placed on the load cell.

WAITING FOR GO progresses to CRUSHING (MOTOR GOING IN FORWARD DIRECTION) once the go button is pressed, and the crushing door must remain shut (monitored by a button the door must hold down) during either of the CRUSHING states unless the system will go into REJECT state.

CRUSHING (MOTOR GOING IN FORWARD DIRECTION) progresses to CRUSHING (MOTOR GOING IN BACKWARD DIRECTION) once the motor potentiometer indicates the crushing piston has been fully extended or V_m indicates the motor has stalled.

CRUSHING (MOTOR GOING IN BACKWARD DIRECTION) progresses to COUNTING once the motor has fully retracted and the collector chute IR sensor signals that a crushed can has fallen through the collection chute. If, however, the collector's IR sensor did not sense a can dropping through the collection chute, the system progresses to the REJECT state.

COUNTING progresses to WAITING FOR CAN if the IR sensor does not indicate a blockage in the collection chute. Else, it progresses to the SERVICE state until the can is removed– this will be indicated by the IR sensor readings– allowing the system to finally progress to the WAITING FOR CAN state.

The REJECT state also loops back to the start state: once the load cell senses the rejected item has been removed, the system progresses to the WAITING FOR CAN state.

4. Cost and Schedule

The total cost for parts as seen below in Table 4.1 including shipping and sales tax is $164.06. We can expect a salary of $41.67/hr (around the average salary of an electrical engineer in the US) ×2.5 (overhead factor) ×84 hours worked = $8,750.70 per team member. We need to multiply this amount with the number of team members, $$8,750.70 x 3 = $26,252.10 in labor cost. For the machine shop that worked on the mechanical aspect of the design, we expect $22/hr for a total of 48 hours spent producing the mechanical component, $22 x 48 = $1,056.00. This comes out to be a total cost of $27,472.16.

4.1 Cost

Number needed	Part name	Model or Part number	Manufacturer	Total part(s) cost in USD ($)	link
1	[4]Linear actuator with potentiometer feedback	PA-14P-2-35	Progressive Automations	145.00	link
1	H bridge	DRV8829	Texas Instruments	5.00	link
1	Molex Male terminal crimp	39000040	Molex	0.04	link
1	Molex mini fit	39013063	Molex	0.48	link
1	Current sensing resistor	RL73K1ER82JTD	TE Connectivity	0.14	link

[4] Progressive Automations. "Home." *Progressive Automations*, https://www.progressiveautomations.com/products/linear-actuator-with-potentiometer?variant=18277322555459. Accessed 30 January 2023.

1	Load cell	SEN-13329	SparkFun Electronics	9.69	link
1	IR sensor	TMCS1108A4UQDRQ1	Texas Instruments	2.50	link
2	buttons	PTS645TM43-2 LFS	C&K	0.26	link
1	op-amp	595-TL972IP	Texas Instruments	0.95	link
3	Labor (Group)	N/A	N/A	26,252.10	N/A
1	Labor (Machine Shop)	N/A	N/A	1,056.00	N/A
Grand Total				$27,472.16	

4.2 Schedule

Week	Objectives	Person
2/20	Start PCB design (testing sensors with protoboard)	Everyone
	Supervise the software and hardware done by Michael and Matt so it can be integrated into the final design	Ifesi
	Secure parts for testing such as Arduino, switches, LEDs, and a protoboard along with new parts for the machine shop like a mountable button. Create a debugging setup with switches to simulate inputs to board and LEDs to simulate outputs on board. Check at the machine shop. Look into PCB design with TA.	Matt
	Work on Arduino Code for testing setup	Michael
2/27	PCB Design Finalization	Everyone

	Ensure all parts we need are ordered and all testing with protoboard is complete	Ifesi
	Assist in testing on protoboard and prototyping of the PCB, check on Machine Shop to make sure production is smooth	Matt
	Assist in creation of PCB schematic and begin planning to order PCB	Michael
3/6	PCB Ordering	Everyone
	Make sure current PCB design will meet every high level requirement our project has	Ifesi
	Continue to check with the machine shop on physical design and finalize the PCB design	Matt
	Ensure that PCB is properly ordered	Michael
3/13	Control subsystem focus: PCB microchip programmed	Everyone
	Ensure that every possible case is covered by the code for the PCB, try to ensure that all subsystems can be controlled in the way we expect as long as the PCB gives the outputs we expect	Ifesi
	Plant out how to bring our PCB work together with the mechanical component from the machine shop, systems integration	Matt
	Responsible for testing code on the present PCB or prototype pcb if it’s not here yet and making sure that the code will give the outputs we expect if the PCB functions as expected.	Michael
3/20	Control subsystem focus: PCB set up tested with a breadboard to avoid permanent connections to the mechanical parts of project before testing is done	Everyone
	Make sure set up PCB with outputs based on debugging stimuli performs the same way the arduino performed with them, with any added components for end goal	Ifesi
	Look for possible weaknesses/improvements with the current fabricated PCB design, connect to actual mechanical design if everything is as intended	Matt
	Assist in transporting and connecting mechanical design, document all progress to demonstrate any functionality project currently has	Michael
3/27	Interfacing of control subsystem inputs with can-crushing subsystem sensors: Motor’s potentiometer sensor, Motor current readings, door	Everyone

	button, IR sensor for can detection, Go button	
	Come up with expected data for machine if it functions as intended	Ifesi
	Test machine one a variety of materials and record performance statistics for everything that is running on it	Matt
	Verify that machine performance matches expected data	Michael
4/10	Write final project document	Everyone
	Responsible for all technical descriptions	Ifesi
	Responsible for all diagrams and citations	Matt
	Responsible for clerical work (what was ordered, stats, etc.)	Michael
4/17	Final Testing	Everyone
	Create final testing protocols	Ifesi
	Carry out final tests	Matt
	Verify that test results are expected, document performance in video	Michael
4/24	Mock Demo	Everyone
	Present for Mock Demo and ensure presentation is up to standards	Ifesi
	Present for Mock Demo and transport machine	Matt
	Present for Mock Demo and transport machine	Michael
5/1	Final Demo	Everyone
	Present for Final Demo and ensure presentation is up to standards	Ifesi
	Present for Final Demo and transport machine	Matt
	Present for Final Demo and transport machine	Michael
5/29	Final Presentation	Everyone
	Present for Final Presentation and ensure presentation is up to standards	Ifesi
	Present for Final Presentation and transport machine	Matt
	Present for Final Presentation and transport machine	Michael

4. Ethics and Safety

Our project is quite straightforward from an ethics and safety perspective. For one thing, ethically speaking, this is a device designed to make recycling cans easier and safer, and to encourage recycling by showing how many cans have been recycled in it, so it could generally be considered a social good. Meanwhile, from a safety perspective, the main feature of our project, aside from counting cans, is that it takes multiple safety countermeasures, including preventing people from injuring themselves or the machine through intentional or unintentional misuse.

During the project, we may be working with reasonably high currents to effectively crush the cans, and also will not have implemented all the safety features before building the basic crushing mechanism, so we will need to be careful that none of us injure ourselves during the testing process. This includes not accidentally crushing our hands or accidentally crushing things that shouldn't be crushed while testing the can rejection system After the project. As far as intentional misuse of our finished project goes, there are some things we won't be able to prevent, like someone putting a mouse in the can-crushing machine, but for the most part, our project protects against most forms of misuse.

[5][6]The IEEE and ACM ethical guidelines, while important, are not particularly relevant to our project. That being said, I am very certain that our group members have upheld, continue to uphold, and will continue to uphold these codes in their academic and professional careers. The only two principles which I think are specifically useful to our project are 1.1 and 1.2 of the ACM ethical guidelines. By making recycling easier, we are contributing to society and human well-being, as recycling is a key part of both making society cleaner and more efficient, and thereby more pleasant for human beings to live in.

The best way to avoid ethical breaches is to ensure that people are familiar with why they need to avoid them. There are numerous ways to do this, including making people aware of negative consequences for them practically or from a long-term awareness of what they'll be missing out on through not being ethical. What we believe will, in particular, ensure the cooperation of our ethical standards team is the fact that we are all too hard working and earnest to ever resort to underhanded or dishonest tactics. This is demonstrably true given our effort to complete all assignments as soon as they have come out, and consistently stay ahead of schedule. Simply put,

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[5] Institute of Electrical and Electronics Engineers. "IEEE Code of Ethics." *IEEE Organization*, Institute of Electrical and Electronics Engineers, https://www.ieee.org/about/corporate/governance/p7-8.htm. Accessed 30 January 2023.

[6] Association for Computing Machinery. "ACM Code of Ethics and Professional Conduct." *Association for Computing Machinery*, 2018, https://www.acm.org/code-of-ethics. Accessed 30 January 2023.

we have no need to be dishonest or unethical. We are also strong proponents of personal accountability and will continue to make sure that we stay on a good track.

[7]The United States Department of Labor's Occupational Safety and Health Administration (OSHA), lists moving parts and unexpected machine startup as two of the three leading issues for workers in recycling of metals, the third being lead, which is not relevant to this project, given that we intend to recycle aluminum cans, and a lead can would most likely be so heavy that it would trip our system anyway. Plainly, OSHA considers amputation from errors in machine use paired with unintuitive machine functions to be significant concerns for its recycling process, meaning that if anything our project will be an asset towards popularizing recycling.

[8]We could not find any relevant federal regulations for our project. We checked the website of the Environmental Protection Agency (EPA) to find that there were no significant concerns surrounding the disposal of crushed aluminum cans. As long as the aluminum is sent to a scrapyard or collection center after being harvested, there should be no concerns surrounding weighting, crushing, and then counting the cans.

[9]As far as industry standards are concerned, we could also not find any which were particularly relevant, even after consulting the website of The Aluminum Association. The main knowledge we gained is that recycling aluminum saves almost all of the energy spent making new aluminum, 95% to be exact, and that if all aluminum soda cans were recycled instead of going to landfills, we could save almost a billion dollars for the US economy. This also helps to support our current Aluminum production, as only 20% of the aluminum already produced isn't recycled aluminum, so if we could just recycle a little more we could have 0 net aluminum waste.

[10]For campus policy, we checked the website for the Facilities and Services (F&S) Waste Management Department, to be informed the aluminum cans are highly recyclable by a facility we have on campus, meaning that the addition of production quality GreenCan units, to various school buildings or campus areas would probably be a great idea that would positively impact the school's reputation as a net 0 campus.

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[7] United States Department of Labor. "Green Job Hazards - Recycling: Waste Management and Recycling | Occupational Safety and Health Administration." *OSHA*, https://www.osha.gov/green-jobs/recycling/waste-management. Accessed 30 January 2023.

[8] United States Environmental Protection Agency. "Regulatory Exclusions and Alternative Standards for the Recycling of Materials, Solid Wastes and Hazardous Wastes | US EPA." *EPA*, https://www.epa.gov/hw/regulatory-exclusions-and-alternative-standards-recycling-materials-solid-wastes-and-hazardous. Accessed 30 January 2023.

[9] The Aluminum Association. "Sustainability – Recycling | Aluminum Association." *The Aluminum Association*, https://www.aluminum.org/Recycling. Accessed 30 January 2023.

[10] UIUC Facilities and Services. "Waste Management and Recycling - Services - Facilities and Services - Illinois." *UIUC Facilities and Services*, https://archive.fs.illinois.edu/services/waste-management-and-recycling. Accessed 30 January 2023.

Given that our project is primarily based around ensuring safety, it is unlikely that our end product will present significant safety concerns. However, the safety concerns regarding the moving motor possibly hurting users is handled by our system since an IR sensor detects if the door closing the can-crushing state can stop the moving motor.

5. Citations

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