Down to Earth (DTE):
The Electric Food Composter

Senior Design 2021/2022

Team LANCE

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Functional Specifications

3/29/21

Down To Earth – Electric Food Composter

The device will be able to breakdown food waste into usable compostable ready to use fertilizer in as little as 24 hours to reduce landfill waste.

1. The device will have three main subsystems. They are the heating chamber where food waste will be dehydrated, the grinding chamber where the dehydrated food will be turned into fertilizer, and the storing chamber where the customer will be able to retrieve the ready to use fertilizer.
2. The device will be effective in reducing the mass of food waste
3. The device will be safe to be around as there will be no methane production created.
4. The device will be a self-contained unit and requires a wall powered outlet
5. The device will be maintainable and easily monitored by users with minimal training
6. The project design will be documented in such a way that it will allow for easy replication and adaptation to different regions.

GOALS

1. USER FRIENDLY (UF)

The device will be easy to use and have limited maintenance. The user will have easy access to input food waste into the device and be able to retrieve the final product with little to no problems. Users of the device will be provided with materials detailing how to properly operate and care for the device.

UF001: **There will be an operation handbook included with our electric composter**. This handbook will detail proper operational procedures and user responsibilities. This includes Ikea level instructions such as how to replace the carbon filter from our system as well as where to place the processed food waste. This will also include a basic maintenance schedule.

UF002: **Our electric composter shall not require expert maintenance work more often than 1 time per 12-month period if user operation guidelines are followed properly. Our composter should not require expert maintenance more often than 1 time per 24-month period if user operation guidelines are followed properly**. It is not realistic to assume that families in developing nations to be able to afford or have access to experts. Therefore, our system must require minimal expert maintenance for it to be a practical option for the market. This will have to be measured through reliability specs of major individual components in our system such as our heater, blender, temperature sensor, motors, and exhaust fan. Out of these five components, the heater, exhaust fan, and motors have the highest risk of failure. Therefore, the heater has a heating life of 3 years, but the exhaust fan was given with no life expectancy other than a limited warranty of a year. Also, the temperature sensor has no reliability specification as well, but this may be our most reliable component as we are working with relatively low heat and the sensor is waterproof. Furthermore, the motors do not have a

reliability specification but due to the heat that we are working with, the motor attached to our agitator may be the main risk for maintenance.

2. SAFETY (S)

Safety is the number one concern so that our device will not harm the customer at all. The device has many moving parts, but all parts will be secure and ensure proper operation for the user. For added safety protocols, we will place an emergency stop button should the user wants to stop the composting process.

S001: **Our electric composter will be equipped with some form of an emergency stop button in case our composter malfunctions**. For example, if our blades in our blending chamber do not stop or are running hazardously, the user will be able to stop the process immediately. This will be measured through testing whether our integrated emergency stop button will work.

S002: **Electric composter will be equipped with a safety latch on the input and output doors, so that when opened, power will be unable to flow to electrical components.** To ensure the safety of the user, opening any door will shut the power off to all electrical components. This will be measured through testing to see if opening the input and output doors stops the functions of our electrical components.

S003: Methane **Emissions shall be less than or equal to 15,000 ppm (parts per million) and should be less than or equal to 5,000 ppm.** This is crucial to our project as we are designing our system in such a way that it does not produce hazardous amounts of methane. However, we are still in our testing phase so we will test methane production using a methanometer at the duct where air will escape our system.

S004: **The device will be labelled with clearly visible warning signs.** International symbols for things such as fire, gas, and other danger warnings will be placed on our electric composter so it is clear from a distance caution must be taken around this device. Additionally, we will be adding custom labels for the emergency stop, shock risks near the plug, notices around the blender for proper removal, warnings for the heating chamber and indicators for the input and output hatches. This will be measured through visual inspection of whether there are clear and visible warning signs present on our electric composter.

3. RELIABILITY (R)

We want our design to be reliable, meaning that we want our design to perform consistently well. Although we have some components, such as the carbon filter, that need to be replaced every so often, we want the rest of our system, such as our heating chamber, to work without fail for an extended period.

R001: **Our heating chamber will be tested with food waste of all kinds, except large bones**. Our testing will include various amounts of food waste of various kinds in which we will have the food waste resting for various times to determine the best amount of food waste and the various times it takes to get our desired fertilizer. Furthermore, this test will ensure that all components involved in our heating chamber are effective and that they will be able to be used

multiple times. The measurement of this is simply testing our heating chamber with various amounts and types of food waste. This will include combinations of all vegetables, all fruits, half meat & half vegetables, half chicken/fish bones and half vegetables, all bread, half bread & half vegetables. Each food combination will be tested 2-3 times. These food combinations and amount of testing trials will be the standard for validating relevant specifications.

R002: **Our blending chamber will be tested with our dehydrated food waste**. This test will ensure that the blending chamber does not affect other components in our system. Also, this test will allow us to see the varied sizes of bones and shells we could blend to allow us to further stand out in the market. To measure this, we simply need to test our blending chamber to visually inspect whether the rest of our system is being affected as well as how well our food waste is being blended. Also, we will be using the same combinations and amount of testing trials of food waste used in R001.

R003: **The design will include an air flow mechanism to filter air into the system**. Air flow mechanism is necessary as we do not want excess moisture and humidity in our heating chamber. Also, this ensures reliability in parts as we do not want excess moisture lingering in parts such as our ducts, which could lead to replacement. To measure this, we need to use our senses of touch, smell, and eyes for visual inspection during testing. Furthermore, this will be accomplished with two filters attached to our duct work that output air into the environment. We are hoping this will be adequate air flow as existing electric composters use this method as well. Also, this could be the perfect balance of releasing moisture and heat as a single filter may limit the amount of air flow, but two filters may accomplish this balance.

R004: **All exposed materials will be able to withstand the heat created by our heating chamber**. This ensures that the heating chamber will not affect any other components in our design which could lead to maintenance and replacements. This will be measured through touch inspections during testing as well as calculations through thermodynamics.

4. DURABILITY (D)

One of our goals for this device is to be sturdy and long-lasting. Because the device will be used as a home appliance but also be used in small restaurants, our electric food composter will have a comparable life expectancy to other home appliances and small industrial size machines.

D001: **The lifespan of the device shall be at minimum 2 years. The lifespan of the device should be at minimum 5 years**. Since we are catering to developing nations, it would not make sense to completely replace our device as it is not realistic financially or logistically. As there is no definitive way to test this, this will be measured through the life expectancy of our critical components such as our heater, motors, blender, temperature sensor, and exhaust fan. As explained in UF002, most of these do not have reliability specifications. However, our motor connected to our agitator has the most risk of maintenance. Therefore, 2 years is a baseline for the minimal years that this device will last. There is no tangible way to measure this other than building our system so that it is safe, reliable, and sturdy.

5. EFFICENCY (E)

Our electric food composter will be comparable to other electric food composters on the market today. It will be a hybrid electric food composter that can be used as a home appliance, but also a small industrial machine for use in small restaurants.

E001: One Cycle Running Time: **One cycle of operating our electric composter shall be accomplished in less than 15 hours and should be accomplished in less than 13 hours.** One cycle of operating our electric composter simply includes the time it takes to dehydrate the food waste, food to travel, and blending. This requirement will be measured by using a timer during the specified food combination and test trials described in R001.

E002: Mass Reduction: **The processed food waste shall have a mass reduction of at least 50% and should have a mass reduction of at least 70%.** Heating our food for its desired time or cycle will result in the loss of moisture in our food waste, allowing the device to further break down the dried mass into smaller pieces resulting during the blending process. This requirement will be measured by weighing the food waste before and after each cycle of testing our heating chamber.

E003: Fineness of Food Waste without bones: **The processed food particle size shall be 3 millimeters or less and should be 1 millimeter or less after one cycle of operating our electric composter.** We want the food particles to be as small as possible as fine soil particles filling the large pore spaces will allow the soil to hold more water as there is more surface area for the water to cling to. Furthermore, as the particle sizes get smaller, the soil can retain greater amounts of nutrients. This will be measured with a caliper as we are working with small measurements. This specification will be directed towards every relevant combination of food waste without bones, 2-3 times per food combination.

E004: Fineness of Food Waste with bones: **The processed food particle size shall be 1.5 centimeter or less and should be 1 centimeter or less after one cycle of operating our electric composter.** In terms of processing bones, bones are also extremely useful for soil as they release phosphorous when decomposed which is a necessary nutrient for plant growth. Furthermore, having the bones in smaller pieces will also allow for faster decomposition of bones. However, the small bones we are working with, especially chicken bones, will be much harder to get to our desired fineness of 3 millimeters for other food waste. Therefore, we will be working with different requirements for the bones input into the system in which we will be using a caliper to measure. This specification will be directed towards every relevant combination of food waste with bones, 2-3 times per food combination.

E005: Heating Chamber Operating Time**: The heating chamber subsystem shall operate for at most 12 hours which is an ample amount of time for our food waste to completely dehydrate at our specified temperature. The subsystem should operate for at most 8 hours for our food waste to completely dehydrate.** We are using these time constraints as existing electric

composters typically dehydrate their food waste for a cycle of about 4-8 hours. However, due to methane production we are trying to avoid this risk through slower dehydration at a lower temperature range. This requirement will be measured using a timer.

E006: Agitator and Heating Chamber: **The agitator and ceramic heating component for the heating chamber will operate at the same time during the heating period.** When the ceramic heater is activated, due to temperature reaching its lower threshold, so will the agitator. Likewise, when the heater is turned off, due to the temperature reaching its upper threshold, so will the agitator. This should be more efficient and effective as activating the agitator while the ceramic heater is turned on will ensure that the food waste will be dehydrated evenly. This requirement will be measured using the temperature sensor, visual inspection, and testing.

E007: Food Waste in Heating Chamber: **The inner heating chamber will have a maximum and minimum fill line to indicate the range of food waste the heater will be able to accommodate**. The minimum indication line allows for enough mass on the trap door to open when the locks disengage after the heating process is finished. The maximum indication line allows the agitator mechanism to work without obstruction from the food waste. This will be measured through visual inspection.

6. POWER CONSUMPTION (PC)

The power consumption will be low as the components used inside the heating chamber do not use a lot of electricity. The heater can generate high heat quickly, however, it will not be active for the entire dehydrating process as it is only used to maintain the temperature inside the chamber. The microcontroller and electric lock use low electricity. Unlike the lock and heater, the microcontroller will always be on to monitor the composting cycle, but our microcontroller uses low electricity. The power consumption of each electrical component can be tested and calculated to know how much power it takes for the composter to complete one cycle of composting.

PC001: Power Consumption: **The power consumption of the device shall be in the range of 0.5 kWh to 2 kWh and should be in the range of 0.9 kWh and 1.4 kWh.** We want to be able to have minimum power use with the maximum output of fertilizer which we want to achieve by utilizing a power consumption range. Also, the insulation inside the heating chamber will help to maintain the temperature inside the chamber and thus make the dehydrating process more power efficient. The average cost of electricity in the United States is around 12 cents. With our food composter, it will cost no more than 18 cents per cycle. Therefore, this will be measured through calculations as well as testing our entire system.

PC002: Internal Heating Chamber Temperature: **The heating chamber subsystem shall be able to generate and keep an internal temperature of 120°F-175°F and should be able to generate and keep an internal temperature of 150°F-160°F.** This is the optimum temperature to dehydrate the contents of the heating chamber safely without producing harmful substances

like methane. Also, we will activate our ceramic heating component when our lower threshold is met and will be deactivated when our upper threshold is met to maintain the temperature inside the chamber. Furthermore, we are using a lower temperature range in our design as we want to avoid the risk of methane production which is created through heating the food waste. This requirement will be measured by using a temperature sensor placed inside the chamber.

7. COST (C)

The cost of our device will be low so that customers will be able to afford the device. With other electric food composters already out there, we hope to stay competitive while also catering to a larger audience.

C001: Total Cost: **The total cost of the electrical food composter shall not exceed $1,000 and should not exceed $500.** Since our system is like other electrical food composters on the market, we want our system to be affordable, however continue to be competitive. Since we are reaching customers in Third World countries, keeping the costs low will help meet that objective.

8. SIZE/WEIGHT (SW)

The size and weight of the device will be reasonable and appropriate for it to be placed in a kitchen at home or a small restaurant. It will be similar in stature to a large trash can and could be easily installed by two people.

SW001: Device volume: **The dimensions of the entire system shall not exceed 47,520 volumetric cubic inches and should not exceed 26,448 volumetric cubic inches.** This size will be large enough to be used in a small restaurant, but small enough where it can be placed in a kitchen. Also, as the system will be better positioned on the floor of a room, we want to focus more on the width and length rather than height as the width and length seem more likely to be the main factors in the placement of the system in a household or restaurant. This requirement will be measured with a tape measure. This will be measured through a measuring tape.

SW002: Device length: **The device length shall not exceed 28 inches and should not exceed 20 inches**. As the length and width of the device seems the most important in the placement of the device in a household or restaurant, we do not want these dimensions to be any longer than necessary. This will be measured with a tape measure.

SW003: Device width: **The device width shall not exceed 19 inches and should not exceed 15 inches**. As the length and width of the device seems the most important in the placement of the device in a household or restaurant, we do not want these dimensions to be any longer than necessary. This will be measured with a tape measure.

SW004: Device Height: **The device width shall not exceed 40 inches and should not exceed 35 inches**. As the length and width of the device seems the most important in the placement of the device in a household or restaurant, we do not want these dimensions to be any longer than necessary. However, the height is also important as we are aiming to have the device to be shorter than an average countertop for maximum comfort and accessibility for the user. This will be measured with a tape measure.

SW005: Device Weight: **The weight of the entire system shall not exceed 150lbs without any food waste and should not exceed 100lbs without any food waste.** With this weight it will ensure our electric food composter to be sturdy but will be able to be moved around easily.

This requirement will be measured by weighing the system with a scale.

SUMMARY TABLE

Spec ID	Requirement	Threshold (Shall)	Objective (Should)	Validation Method	Notes
UF001	Operations Handbook	IKEA level instructions, such as replacing filters, and maintenance schedule	N/A	10 non-engineering students will read the instructions and gauge their understanding	
UF002	Maintenance	1 time every 12 months	1 time every 24 months	Reliability specifications of all essential components in our system such as heater, insulation, exhaust fan, etc.	Validate with available data

S001	Emergency Stop Button	Integrating a button that can shut down the flow to electrical components	N/A	Cutting operation mid-cycle for all electrical components. If blender is stopped, it will be able to continue its process from where it left off. If the heater chamber is stopped it will require maintenance.	
S002	Input & Output Safety Latch	The power will cut off any time the unit is opened during operations	N/A	opening our input and output doors to visually inspect if the system automatically shuts down the flow to electrical components. Do this test every time the blending chamber is activated and tested with the different variations of food 2-3 times per test.	
S003	Emissions	<=15,000 ppm (parts per million) or 1.5%	<=5,000 ppm (parts per million) or 0.5%	Use methanometer to measure possible methane	

				production for all food variations at least 2-3 times when heating. Each test will consist of periodic testing to determine the methane emissions at a given time	
S004	Warning Labels	Warning labels on our electric composter. Warnings regarding: Heat, sharp objects, and dangerous areas	N/A	Visual inspection	
R001	Variability in Food Waste for Heating Chamber	Testing combinations of all vegetables, all fruits, half meat & half vegetables, half chicken/fish bones and half vegetables, all bread, half bread & half vegetables.	N/A	Visual Inspection and testing all food variations at least 2-3 times	
R002	Variability in Food Waste	Testing combinations	N/A	Visual Inspection and testing all	

	for Blending Chamber	of all vegetables, all fruits, half meat & half vegetables, half chicken/fish bones and half vegetables, all bread, half bread & half vegetables.		food variations at least 2-3 times	
R003	Air Flow Mechanism	Attaching two filters into our ductwork to ensure the release of moisture.	N/A	Visual, touch, and smell inspection as well as testing	
R004	Material Tolerances	Touch inspection, calculations, and testing	N/A	Research all products to make sure they all have a certain heat tolerance. Insulation on our heating chamber and ductwork will ensure lower temperatures for the rest of the system.	
D001	Lifespan	2 years w/ maintenance	5 years w/ maintenance	Reliability Specifications of internal materials and products	Validate with available data

E001	Cycle Running Time	14 hours	13 hours	Use a timer to measure and test all food variations at least 2-3 times which cycle running time depends on the overall blending, heating, and food traveling time.	
E002	Mass Reduction	>= 50%	>= 70%	Use a weight scale before and after food is dehydrated to measure and test all food variations at least 2-3 times	
E003	Fineness without bones	<=3 millimeters	<=1 millimeter	Use caliper to measure all variations of food waste at least 2-3 times when blending process is finished	
E004	Fineness with bones	<= 1.5 centimeter	<= 1 centimeter	Use caliper to measure all variations of food waste at least 2-3 times when blending process is finished	
E005	Heating Cycle	<=12 hrs	<=8 hrs	Use a timer to measure and	

		(this is the overall cycle time, not how long the heater is activated)	(this is the overall cycle time, not how long the heater is activated)	test all food variations at least 2-3 times	
E006	Agitator and Heating Chamber	Temperature sensor, visual inspection, and testing	N/A	The agitator and heater activate when the temperature sensor reads lower threshold limit. Agitator and heater turn off when the temperature sensor reads upper threshold limit. This will be tested with every variation of food waste at least 2-3 times.	
E007	Food Waste in Heating Chamber	Two lines to indicate a maximum and minimum fill line.	N/A	Visual inspection	
PC001	Power Consumption	0.5 kWh – 2 kWh	0.9 kWh – 1.4 kWh	Calculation	
PC002	Heating Temperature	120°F - 175°F	150°F - 160°F	Temperature sensor	
C001	Total Cost	$1000	$500	Calculate overall cost of materials and products	

SW001	Device Volume	47,520 volumetric cubic inches (roughly 36 inches for all sides)	26,448 volumetric cubic inches (roughly 30 inches for all sides)	Tape measure	
SW002	Device length	<= 28in	<= 20in	Tape measure	
SW003	Device width	<= 19in	<= 15in	Tape measure	
SW004	Device Height	<= 40in	<= 35in	Tape measure. Aim at having a height lower than the average height of counters.	
SW005	Device Weight	150lbs	100lbs	Weight scale	