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Grader: Peter Westin
STS 1500

Compost Based Water Heater Provisional Patent Application

Preamble

We, Priti Patel, Ben Kuster, Nick Wu, Andrew Li, and Gwen Powers, engineering students at the University of Virginia in Charlottesville, Virginia, have invented a method to make a more efficient process of heating liquid from an aerobic composting process by combining parts for a new, streamlined take on the process. The design is a system of interconnected, mechanical parts that intends to substantially reduce the amount of human labor required in the process of extracting heat energy from an aerobic composting process.

Advantages over Prior Art

Composting systems often waste usable heat generated through chemical reactions during aerobic composting. This mechanism for capturing heat during the composting process transforms excess heat directly into usable preheated water. Prior designs of capturing this heat use less efficient heat storage compounds, like air instead of water, or do not directly exchange heat from compost to a water tank, instead using intermediate heating like solar heating. This makes the output energy less applicable for use in large communities due to increased complexity. For example, the process for capturing heat during aerobic compost described by John Crockett (Pat. US20050257585A1, 2004) forces airflow through the compost and "routing the hot off-gas from forced aeration which has gone through the active compost, through a heat exchanger"[1]. This method produces heated air as an output, which itself is not useful and must be then fed through a heat exchanger which invariably loses some heat energy in the process. This method also requires a system for removing moisture from the air to prevent it from clogging the mechanism, which further wastes heat energy that was captured from the composting process.

Other methods of capturing heat from aerobic composting that use water to capture and store the heat combine solar heating to preheat water. For example, the compost water heater and method described by John E. Fiarkoski, Sr. (Pat. US5144940A, 1990) primarily uses a solar-heated water tank as a heat exchanger for input water. While the solar-heated water uses coiled copper piping as a heat exchanger, the compost-heated water doesn't make direct contact with the compost tank, reducing heat loss by conduction.

In the past, composting machines require the compost to be manually mixed before being placed into the main composting housing. For example, a composting machine design described by Rosario Loggia, et. al (Pat. CA3002252, 2016) utilized a handle mechanism to mix the compost. There is a mixing chamber located on top of the main composting chamber that serves as the housing of the compost. On top of the mixing chamber, there is a handle that has to manually be turned by the operator to mix the compost. In order to minimize the manual aspect, this design also included a handle coupling feature that allowed the handling portion to be manipulated so that multiple machines can be operated by one handle. The composting design by Li Baosheng, et. al (Pat. CN208166874, 2018) did not include a mixing chamber. Rather, it required the compost to be already mixed manually by other means before being placed into the machine, which requires extra time.

Our design solves:

- Common inefficiencies of composting mechanisms including:
    - Heat capture of normally wasted heat
    - Eliminates the manual aspect of mixing compost
- UN SDGs:
    - Goal 7: Affordable and Clean Energy - Provides clean, hot water to communities.

- Goal 11: Sustainable Cities and Communities - Provides a more sustainable composting system that exports a constant flow of water to the community.
- Goal 12: Responsible Consumption and Production - Provides an efficient method of composting food waste.

Our method for both capturing heat through water and eliminating the manual aspect of mixing compost is preferable over previous designs described above because it provides a more sustainable, efficient system. Our method uses water provided by a main water source to store heat exchanged by tubing flush with the composting tank. This maximizes contact surface area and minimizes wasted heat to the environment. Water combines both high heat capacity and a directly usable output, simplifying the process and reducing the need for intermediate steps to convert energy. By eliminating the manual aspect of mixing, less time and labor has to be put into the process, increasing the output.

Technical Description

Form Description

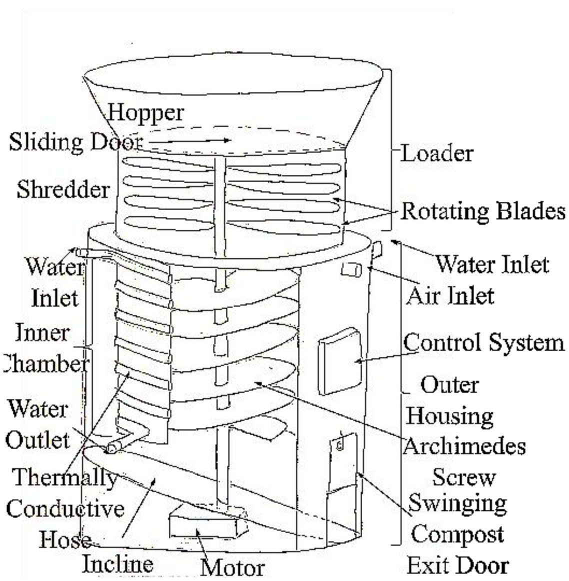

Figure 1: Cross Section Views

The device has five main sections: a loader, an outer housing, an inner chamber, an exit chamber, and a control system. The loader has a cone shaped hopper and a shredder below. At the bottom of the hopper is a sliding door which moves along a groove. Beneath the sliding door is a shredding unit that consists of a rotating blades. The shredding unit connects directly into the inner chamber.

The outer housing, which surrounds the inner chamber, contains fluid (air and water) inlets and outlets and thermally conductive hosing. The air pump inlet is located at the top of the outer housing. It connects an external air pump unit to the inner chamber through a rubber tube. There are two water inlets located at the top of the outer housing and one water outlet located at the bottom. There are standard screw type connectors on the inlets and outlets. In the outer housing, thermally conductive hosing is linked to a water inlet and outlet by a standard connector and is coiled around the inner chamber so that it makes direct contact with the wall.

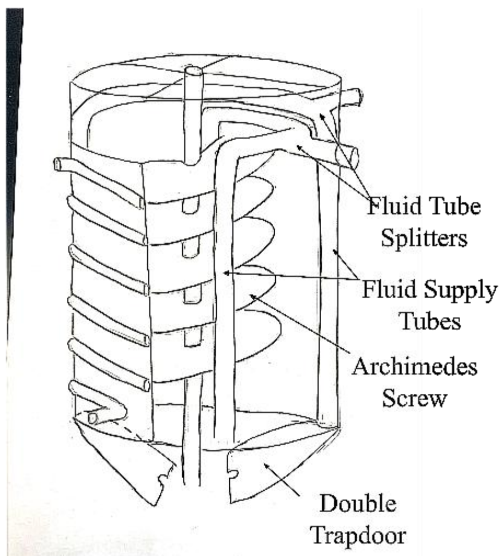

Figure 2: Inner Chamber

Within the inner chamber, there is a large Archimedes screw, fluid supply tubes, and fluid tube splitters. The Archimedes screw runs the length of the inner chamber and is held in place at the top of the inner chamber by a ring that is mounted to the sides of the inner chamber by a set of beams. Along the sides of the inner chamber are 4 fluid supply tubes, two for water and two for air, which are welded to the sides of the chamber in 90 degree increments. The air tubes are located directly across from each other. The water tubes are also located directly across from each other. All four tubes are connected to their respective inlets with splitters attached so that one inlet of each fluid can reach two pipes. On each of the tubes are small pinholes from which the water and air can exit into the inner chamber.

The exit chamber, located below both the inner chamber and outer housing, contains a motor, incline, double trapdoor, and a swinging compost exit door. The double trapdoor connects the inner chamber to the exit chamber. The incline is an angled plate of metal above the motor. Through both the incline and the double trapdoor are singular holes, through which a shaft connects the motor to the Archimedes screw. The incline is held up by internal supports near the motor. The swinging compost exit door connects the exit chamber to the outside of the machine. The swinging compost exit door is manually opened and closed with the removal or addition of a pin respectively.

The control system consists of a small digital display with an embedded touchscreen and keypad. It has three main menus on the home display. The three main menus are labeled "Loading", "Operation and Monitoring", and "Unload". Each of the three menus has a collapsible submenu with certain context actions. The "Loading" submenu contains a toggle button labeled "Turn on Shredder" or "Turn off Shredder" based upon whether the shredder is active or not. The "Operation and Monitoring" submenu displays four readouts, each labeled "Input Temperature", "Output Temperature", "Core Temperature", and "Core Humidity". There is also a button labeled "Set turning / watering intervals" that initiates a dialog where the user may input data into blank fields using the keypad. The "Unload Submenu" contains two buttons: an "Unload" button and an "Emergency Stop" button. If the user selects the "Unload" button, a "Yes/No" dialog appears asking for confirmation on the process. The "Emergency Stop" button is colored bright red. The keypad consists of a number pad, a green "Enter" button, and a red "Back" button to the side.

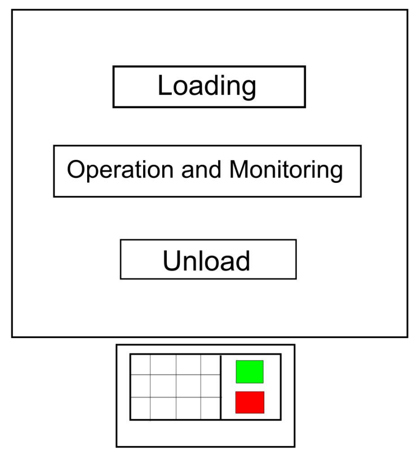

Figure 3: Control System

Process Description

There are three distinct phases of operation of the device: the loading phase, the operation phase, and the unloading phase. Each phase has its own individual series of steps that must be performed in order to operate the device properly.

The first step in the loading phase is to acquire the proper composting materials. It is recommended to use a balanced mixture of "brown", i.e carbon rich materials like wood clippings and dry leaves; and "green", i.e nitrogen rich materials like grass clippings, food scraps, and manure. The materials are then shredded in the shredder, which directly outputs into the inner chamber of the device. An initial turning and watering step is then initiated by designating an appropriate duration of turning, watering, and aeration by inputting the appropriate numbers into the keypad on the control system. The turning and watering step consists of the screw within the inner chamber rotating counterclockwise to turn the compost, while the tubing on the side outputs air into the turning compost mixture.

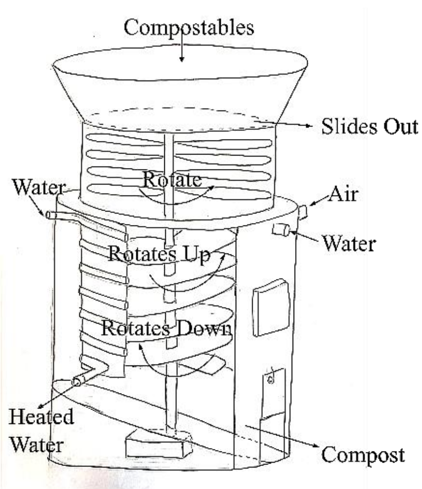

Figure 4: Overview of Process

The operation phase begins immediately after loading, and consists of the user setting watering, turning, and aeration intervals through the control system; monitoring the system, and finally initiating the water heating step. The user navigates to the "Operation" submenu and enters the appropriate values through a keypad. When this has been set, the device will regularly perform turning, watering, and aeration at the given duration and interval designated by the user. The user will regularly monitor the system by reading temperature data from the "Operation" submenu. When an appropriate core temperature has been reached (approximately 140 degrees

Fahrenheit), the user may begin heating water. Water may be pumped into water inlet #1 from a water source. From water inlet #1, the water enters the hose surrounding the inner chamber and is heated through contact with the inner chamber. Heated water is then outputted through the water outlet, which can then be transported directly to a residential location for use or then enter another heating step to heat the water further.

The operation phase continues until the temperature of the compost pile decreases to the point that the water is no longer sufficiently heated (<100 degrees Fahrenheit) or the user determines that the compost pile has failed to produce sufficient heat and another compost pile should be created. At this point, the disposal phase begins. In the disposal phase, the swinging door on the outer chamber is lifted up and latched by the user; the user initiates the unloading process from the control system by entering the "Disposal" submenu; the double trapdoor on the bottom of the inner chamber opens; the Archimedes screw begins to rotate clockwise; and subsequently the compost is pushed out across the incline into an external container. After the compost has been collected in an external container, it will then be used for agricultural purposes.

Alternatives

Our design aims to maximize space usage, containing all aspects of the invention within a cylinder. One plausible alternative configuration would be to switch where the water and compost are housed. Then, the water would be in the inner chamber, and the compost would be in the outer housing. Having the water on the inside would provide a greater volume to contain water so it could output more hot water. However, the compost would need to be changed more frequently. The Archimedes screw would be in the outer housing. Although this configuration would have the same surface area between the compost chamber and the water chamber, it would be less efficient due to heat loss to the outside of the machine. Another reconfiguration would be to house the air and water pumps supplying the compost with necessary components inside of the Archimedes screw. If that configuration was used, more compost could be fit inside of the inner chamber due to the lack of tubes on the sides, but it may not keep the compost on the outside edges of the cylinder fully aerated and hydrated, which would hinder heat generation. A third alternative configuration would be to have one large rectangular tank of compost with multiple smaller water tanks imbedded inside the large compost tank. This configuration would require the compost be changed far less frequently but have the water changed more frequently. The square shape would allow for a large amount of water tanks to be fit inside the compost container. However, the same square shape would cause heat generated from the compost to not be efficiently transferred to the water tanks, as heat would be lost to the outside edges of the container. Also, turning and extracting the compost would be far more difficult in a square container.

On my honor, I have neither given nor received aid on this assignment.

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