Design of Kitchen Waste Composting Machine: A Smart Approach

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Abstract--In INDIA, approximately 50% Biodegradable Waste is generated in total MSW composition and now the numbers is increasing. So we have come up with idea SMART Composting Machine. Design of machine is such that every day we can process 10 to 15 kg of organic waste

Keywords--SMART Composting

I. INTRODUCTION

The paper is about processing daily Food Waste in such a way that we will get Fertilizer as our product. In this process Organic waste is going to get crushed in semi-powder form and then it will go under continuous mixing and heating process. The process is as follows;

- Only Food Waste (No Plastic) as input.
- Waste material will go into a vessel having shaft inside and blades are attached to it.
- The Motor will run for some time and material get crushed into semi-powder form.
- After some time material will go into homogeneous mixing process at slow speed.
- Now Heating will get ON. As it a biological process it must gone through heating at 60 Degree Celsius for certain time. Continuous Moisture sensing and Heating sensing is going on. Once all Parameters reached to SET POINT, Heating and Motor will turn OFF.

The machine design is automatic and compact in size. This machine processes all types of waste includes in organic waste. This satisfies 3R principle: Reduce, Recycle and Reuse.!!

 Few benefits of using this machine are;

- Savings in costs of collection, transportation & disposal of waste.
- Helps in creating zero garbage cities.
- Preserves landfills space.
- Protects Environment, Protects Economy.
- Prevents global warming.

II. BLOCK DIAGRAM

Above diagram shows Input-Output requirements for the machine to be automated. Now depending upon the size of machine Input-Output requirements are going to change. Motor and Sensor Selection are the key factor as the capacity of the machine to process up to 10 kg kitchen waste. For heating I am going to use heating coil which works on simple Electrical Energy to Heat Energy conversion principle. For display simple16*2 LCD and to indicate particular system ON or OFF I have simple LED notification. Thus, major goal is to automate the machine and make it User Friendly, Eco-friendly with environmentally sound operations and Cost-effective.

III. MACHINE DESIGN

A. Drum Design

It is cylindrical drum to collect organic waste inside. Drum is with shaft inside with blades connected to it. These blades are used to chop organic waste material in semi powder form. Drum have side stands to rest on support frame so that assembly will not vibrate at high speed operations of motor.

B. Support Frame Design (3D)

Support frame is made up MS material. Support frame is designed in such a way that motor, gear box, pulley and other
assembly parts is having individual place. Also place required for collection of final product is also taken into consideration.

IV. TECHNICAL CALCULATIONS AND SELECTION OF MATERIAL

A. Single Phase Induction Motor

Torque (T): \( F \times R \)
\[ : 10 \times 15 \]
\[ : 150 \text{ kg-cm} \]

Angular Speed (\( \omega \)): \( \frac{2 \times \pi \times N}{60} \)
\[ : \frac{2 \times \pi \times 15}{60} \]
\[ : 1.57 \text{ rad/second} \]

Power (P): Torque (T) * Angular Speed (\( \omega \))
\[ : 150 \times 1.57 \]
\[ : 235.5 \text{ watts} \]

Watts to HP:
\[ : 235.5 \text{ watts} = 0.315 \text{ HP} \]
\[ : 1/2 \text{ HP motor is suitable} \]

B. Gear Box

We are using 10:1 reduction gearbox. We require slow speed let’s say 15 rpm. And this could achieve with this gearbox only.

C. Pulley Design

Diameter: 3 Inch
Center Distance: 12 Inch
Belt Length: 3 Inch

D. Electric Heating

An electric heating coil made of Ni-chrome (Nickel and Chromium) is used to heat the inner cylindrical drum where composting takes place, which will require a temperature of 60 degree C.

The amount of heat generated Q, is determined using, \( Q = MC (\theta_2 – \theta_1) \)
Where, M = Mass of heating coil
C = Specific heat capacity of air = 1.0035J/KgK = 1003.5J/gK
\( \theta_2 \) = Final Temperature of heating coil = 60 degree C (343K)
\( \theta_1 \) = Initial temperature of heating coil = 25 degree C (Room Temp.)
Mass = Density x Volume of heating coil
Where,

Density of Nickel heating coil = 1.225kg / m^3
Diameter of heating coil = 0.2 m
Volume of heating coil = Area x Thickness Area (A)=\( \pi r^2 \)
= 3.142 x 0.12 = 0.3802m^2
Thickness of the plate = 0.005m
Volume of heating coil = 0.03142 x 0.005 = 0.0001571m^3
Mass = 1.225kg/m^3 x 0.0001571m^3 = 0.00019245kg = 0.1925g
Heat Generated Q = 0.1925g x 1003.5J/gK x (333 – 298K) = 6761.08J = 6.8KJ

Power consumed P is the heat generated per hour, which is given by:

\[ P = QT \text{ Where T = Time (in seconds) = 3600sec (For 1 Hour) } \]
\[ P = 6800 / 3600 = 1.89KW \text{ An electric heater with rating 2.0KW is selected for this work.} \]

V. SOFTWARE TESTING

Software testing is done on basis of how actual process is going to happen. For Organic Waste to Fertilizer conversion material goes to three different processes; Crushing, Homogeneous mixing and Heating. For these three processes Arduino Coding is done where motor control and automatic heating cut-off is done.

 VI. RESULTS

A. Natural Composting:

It is slowest process of couple of months say one or two. All moisture and Temperature variations are on the basis of environment and how we are setting up the material in bin for composting. Also we need to maintain moisture with addition of Culture Powder and Sand on regular basis manually. So it is the Lengthiest and Slowest one to handle carefully and with NO margin for errors.

That’s why we try to come up with idea of SMART Composting to fasten the process and to get Nutrient Rich Fertilizer.

B. SMART Composting:

Now we have taken the 1.5 kg of Organic Waste sample for our experiment and with the help of moisture sensor we have taken readings of three samples viz. WET, INTERMEDIATE and DRY sample. After keeping wet sample under heating condition for 20 hours we start getting result in terms of change in dryness of material. Dryness got changed from 25% DRY to 75% DRY approximately.

Following Table shows the Serial Monitoring readings on Arduino of WET Material, INTERMEDIATE Material, DRY Material.
SMART Composting will get done within 48 hours max with Nutrient Rich Fertilizer.

1.75 kg of WET Sample lowered down to 1.5 kg of DRY Fertilizer. So there is 14% decrease in weight of material.

Comparative graph of Natural Composting and SMART Composting on the basis of Drying Rate is like,

![Comparative graph of Natural Composting and SMART Composting](https://via.placeholder.com/150)

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**References**


