جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

Fall 2016-17

Senior Design Project Report

Design of Compost Machine

In partial fulfillment of the requirements for the

Degree of Bachelor of Science in Mechanical Engineering

Team Members

	Student Name	Student ID
1	Alharith Almuhaimeed	201101004
2	Abdullah Alnaim	201103040
3	Hadi Alkatheri	200901740
4	Othman Alamoudi	201200510

Project Advisors:

Advisor Name: Dr.Nader Nader

Co-Advisor Name: Dr.Ali Chamkha

Abstract

Organic waste and especially Food waste is a worldwide problem, it cost to be disposed and nothing is gained from it, on the contrary, it causes the emission of harmful gases such as methane. In Saudi Arabia 35 percent of the garbage is a food waste. One of the major problems that faces Saudi Arabia nowadays that there are no serious moves towards solving the food waste issue. In 2030 vision, one of their targets is to focus on the pollution and the causes of it. Composting has proven to be a valid solution to this problem but not entirely explored. The objectives of this project are to design a composting machine with certain parameters for the design, Process time, Easy to use, odorless and power saving. The designed food waste decomposition system is designed for rapid composting performance. It can be used by households, restaurants, hotels, schools, apartment buildings, communities, offices and cafeterias depending on the capacity of the machine. The system employs high temperature, microorganisms to decompose food waste and organic matter. The machine was built with an agitation motor with rated power input of 36W and an exhaust fan with 9.5W rated power input and a heater with 200W rater power input in addition to temperature sensor and humidity sensor and printed circuit board to control the process. The prototype was able to decompose organic waste in a time frame of 38 to 50 hours with minimum harmful gases emissions and odors, and it's almost a plug - play machine but with an average power consumption rate of 484 watt.

Acknowledgment

We would like to express our gratitude for everyone who helped us during the graduation senior project starting with our advisor Dr. Nader Nader and our Co-advisor Dr. Ali Chamkha who did not keep any effort in encouraging us finish the project, providing our group with valuable information and advices to overcome every obstacle. Thanks are extended to our senior project course instructor Dr. Nader Sawalhi for providing us with all the requirements needed and helping us to finish on time based on our project plan. Final thanks is greatly due to a friend and a major mate Mr. Khalid Almutairi who helped us with CAD and SOLIDWORK.

Table of *Contents*

1. Introduction

1.1 Project Definition

The designed machine is a fully automatic and highly compact composting machine, which uses special microorganisms to break down and decompose all kinds of organic waste into compost within 24 hrs with a volume reduction of 85-90%. The entire process is natural and biological. The microorganisms we use thrives in high temperature and are effective even in high acidic or salty conditions. The machine has a U-shaped composting tank, with a humidity sensor, heater, mixing blades and an exhaust system.

When organic waste is added to it, moisture is sensed by the humidity sensor, due to which the heater turns ON and the composting tank gets heated. Due to this, the water content in the organic waste is evaporated and it goes out to the atmosphere as water vapor through the exhaust system. As any organic waste contains 70-80% water content, we achieve 70-80% volume reduction at this stage itself.

At the same time, our special microorganisms then decompose the organic waste into compost, and this happens within 24 hours. That is how we achieve 85-90% volume reduction. The process is noiseless as there is no crushing or grinding involved. The blades are just for evenly mixing the waste.

1.2 Project Objectives

The project objectives are:

1. Study the different factors within the composting process
2. Learn how to make the machine as energy efficient as possible.
3. Increase public awareness on food waste and how to handle it.

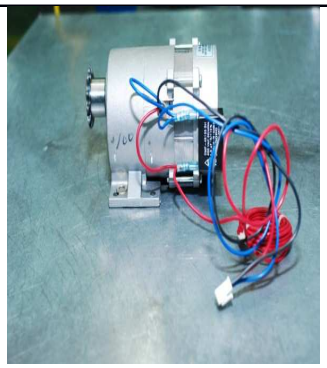
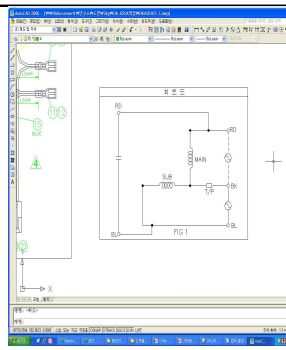
4. Learn about sensors and control system.

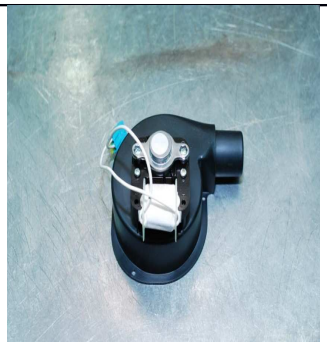
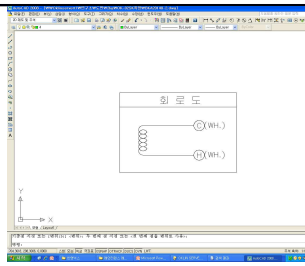
5. Study the effects of bacteria on the composting process.

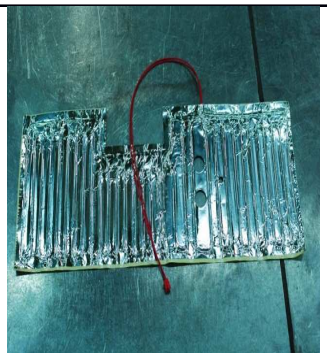
1.3 Project Specifications

Table1.1: (Main components)

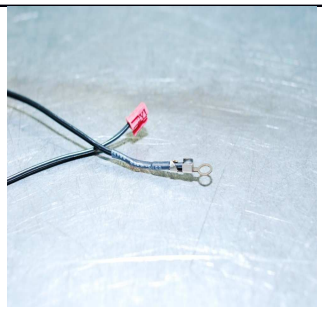
<table>
<tr>
<td>Agitation motor

1.1(a)</td>
<td>  </td>
<td>
<table>
<tr><th></th><th>Specification</th></tr>
<tr><td>Power rating</td><td>AC 220V
60Hz</td></tr>
<tr><td>Rated power input</td><td>36W</td></tr>
</table>
</td>
<td>  </td>
</tr>
<tr>
<td>Exhaust fan

1.1(b)</td>
<td>  </td>
<td>
<table>
<tr><th></th><th>Specification</th></tr>
<tr><td>Power rating</td><td>AC 220V
60Hz</td></tr>
<tr><td>Rated power input</td><td>9.5W</td></tr>
</table>
</td>
<td>  </td>
</tr>
<tr>
<td>Heater

1.1(c)</td>
<td>  </td>
<td>
<table>
<tr><th></th><th>Specification</th></tr>
<tr><td>Power rating</td><td>AC 220V
60Hz</td></tr>
<tr><td>Rated power input</td><td>200W</td></tr>
</table>
</td>
<td></td>
</tr>
<tr>
<td>Main PCB (Printed Circuit Board)

1.1(d)</td>
<td>  </td>
<td>Temperature sensor

1.1(e)</td>
<td>  </td>
</tr>
</table>

1.4 Product Architecture and Components

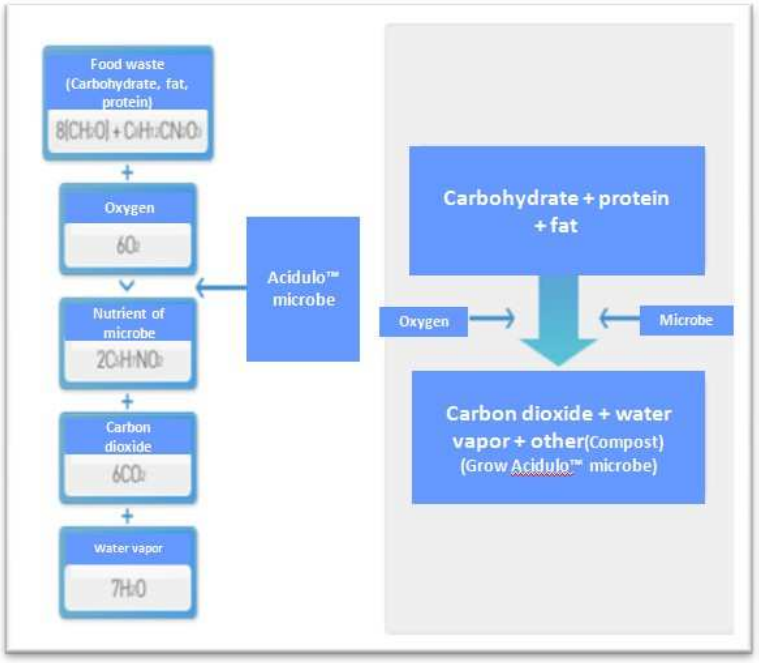


Figure (1.1): Chemical process for the machine

Figure (1.1) illustrate the chemical process inside the machine. Organic waste consist of carbohydrate, protein and fat, it is mixed with oxygen and microbes inside the tank with the add heat from the heater to get broken down into carbon dioxide, water vapor and the compost.

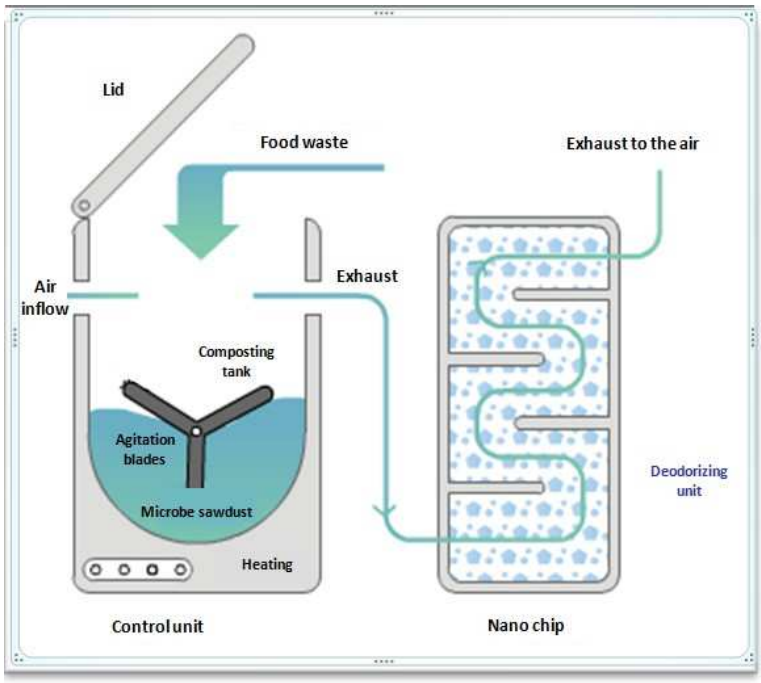


Figure (1.2): Structure of the machine

Figure (1.2) illustrate the structure of the machine and how the machine works.

1.5 Applications

- This machine provides food waste solutions for a variety of commercial uses, from restaurants to large-scale institutions.

- Reduce garbage volume and disposal costs.

- Houses, Hotels, Restaurants, Supermarkets, Municipalities, Canteen / Cafeterias, Shopping Centers, Food Processing Sites.

2. Literature Review

2.1 Project background

Composting is known as a natural process, it occurs by using microorganism under specific condition, which leads to the decomposition of organic waste. As we know, food waste one of the biggest global issues that faces the world nowadays, it could be at home, school, restaurants and any food service sector. One of the recent statistics said that 1.4 billion tons of food is wasted every year [1]. We all know that the waste of food unavoidable, so the best way to makes this food waste useful is by composting the organic waste and returning the nutrients back into the soil to make the cycle of life to continuo which will help protecting of environment[2].

There are two common types of composting process that can be used, one of the types called "aerobic composting" that uses air in composting. In this process the bacteria is growing by high nitrogen waste, which also will make the bacteria create high temperature that makes organic waste breaks down quickly. We can say that aerobic composting is usually happens in nature. The microbes responsible for composting are naturally occurring and live in the moisture surrounding organic matter. Oxygen from the air diffuses in to the moisture and is taken up by the microbes. As aerobic digestion takes place the by-products are heat, water and carbon dioxide (CO2). While CO2 can be classified as a greenhouse gas it’s evolution from the composting process is not counted in emissions. Additionally, CO2 is only 1/20th as harmful to the environment as methane (the main by-product of anaerobic degradation) the heat produced in aerobic composting is sufficient to kill harmful bacteria and pathogens as these organisms are not adapted to these environmental conditions. It also helps support the growth of beneficial bacteria species including psychrophilic, mesophilic, and thermophilic bacteria which thrive at the higher temperature levels [3].This composting process takes 8-10 days.

The second type called “Anaerobic" and this composting process use no oxygen. The composting occurs by making the organic waste piled up and starts breaking down by its self. This process is very slowly and takes many years in order to compost the organic waste [3]. The process is characterized by very strong odors and only a small

amount of heat is generated meaning decomposition takes much longer and does not reach sufficient temperatures to safely kill plant pathogens, weed and seeds. To overcome these limitations external (artificial) heat is normally added.

As the material is broken down by anaerobic digestion, it creates a sludge-like material that is even more difficult to break down. This material, digestate, typically requires aerobic composting to complete the stabilization process [3].

There are several types of bacteria that uses in decomposition, in this project we are using a special bacteria called "Acidulo". As figure (2.1) shows, this bacteria has the ability to withstand very high temperature (above 100C), also can live in a very salty and acidic environment [4]. So these special bacteria can live in a tough environment without losing its efficiency. In order to speed up the composting process we need a specific high temperature that will cause the bacteria to break down the organic waste quickly. By using "Acidulo" our target is to minimize the duration of composting to make it happens in 24 hours

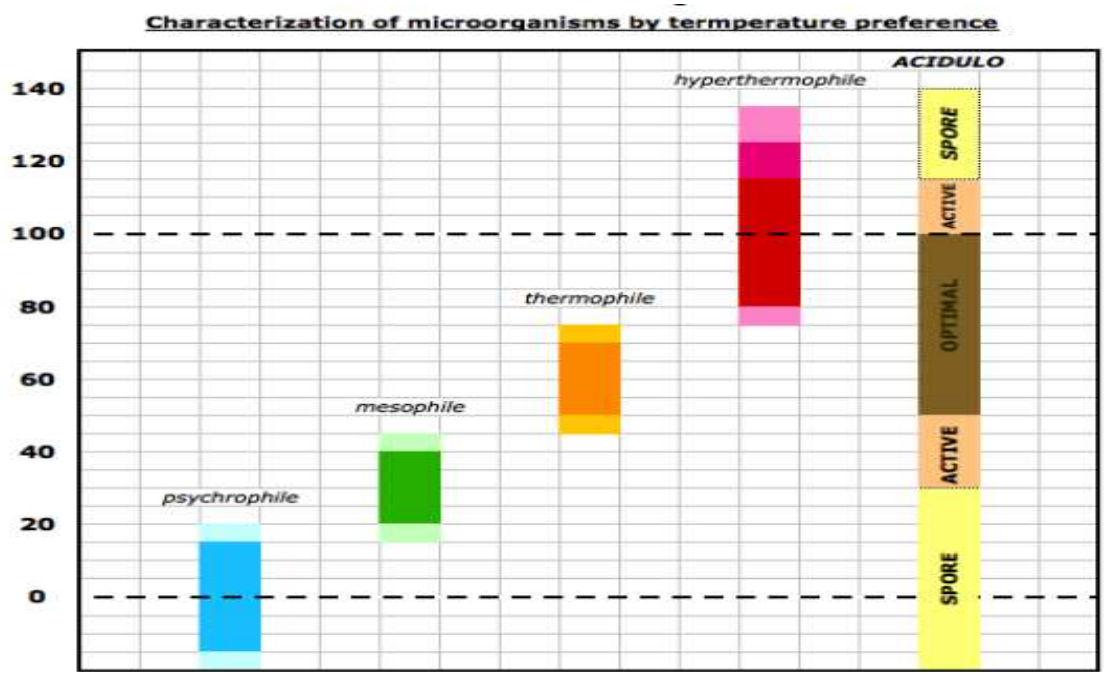


Figure (2.1): shows the characterization of microorganisms by temperature preference

Compost is a valuable soil amendment, as the compost feeds soil. The use of compost is an effective way to improve plant growth. Compost can be used for bioremediation of soil and pollution prevention, reduce erosion and nutrient runoff, alleviate soil compaction. Composting also helps the soil retain much needed moisture, and research has also shown that composting can also assist in enhancing the disease resistance of some plants, like tomatoes and vegetables. This can reduce the amount of crops you lose to disease, which often leads to wasted expenses.

2.2 Previous Work

In this section we tried to look for different composting methods and machines in order to find their capability and how they work, these subsections below are examples of different composting process that we will discuss in details in order to be able to compare them to our designed machine.

2.2.1 WEMI-4000:

Ohio University became the university with the largest in-vessel compost facility in the United states with The (Wright Environmental Management, Inc. WEMI-4000) that was installed in 2009.a 2 ton in-vessel composting system, The tunnel inside the system is controlled for air supply and temperature, a supply and exhaust fan and an air circulation. Figure (2.2) shows that Composting material moves through a set of spinners that act to invert, homogenize, agitate and stack the material into the next zone. Water will be added to the mix during material cross-mixing (if needed) to raise moisture levels into the desired levels. Material remains in the second zone for an additional number of days equivalent to the retention time in Zone 1 (e.g. 7 days in Zone 1 and 7 days in Zone 2 equals 14 retention days) while significant stabilization happens through control of air supply, water and temperature[5].

The best temperature range for composting organic waste in this system is 50 degrees Celsius to 65 degrees Celsius. Any moisture that drains out of the composting material flows into the plenums that run along the base of the tunnel and from the plenums to sump boxes through pipes located at the sides of the tunnel. Leachate is pumped back

onto the composting materials from the sump boxes through pipes located at each sump box[5].

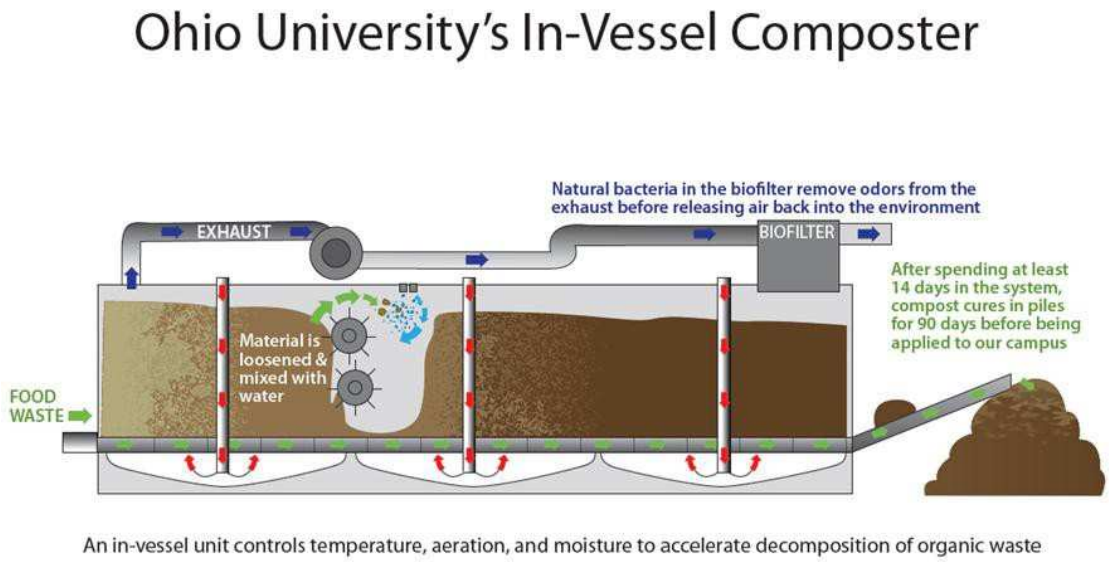


Figure (2.2): WEMI-4000 Process[5].

When the compost is finally removed from the system, the compost needs to cure for at least 90 days. The windrows are turned regularly to offer a more homogenous mix to the compost. The resulting nutrient-rich soil is used on-campus (intramural athletic fields, gardens used by Plant Biology students, Eco house community garden, etc.).[5]

2.2.2 The Earth Flow:

The university has invested in a fully automated composting system called the Earth Flow. This composting machine is located at the Foothills campus. Finished compost is used in landscaping projects on campus [6].

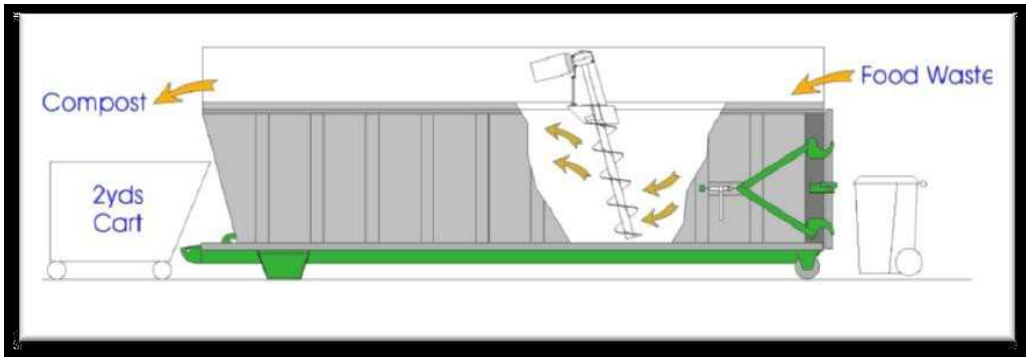


Figure (2.2): The Earth Flow process[6].

The Earth Flow Capacity is up to 900 Kg of waste per day. Figure (2.3) shows that Waste is loaded into one end of the vessel by placing the collection container on an automated tipper. Every time food waste is added, bulking material is added in a 1:2 ratio. Straw, wood chips and horse manure from the Foothills campus are the primary bulking materials. The inclined auger mixes and advances the compost down the vessel with each pass. The control panel allows the operator to select the number of times per day that the compost is mixed as well as automatically adds moisture to the compost [6].

Material composts in 14-21 days inside the machine. The auger discharges the finished compost through an end door of the vessel. The compost is to cure for at least 3-4 weeks before being used in landscaping projects on campus as a soil fertilizer [6].

2.2.3 Ridan Composter:

The Ridan food composter uses natural ingredients and processes to create a warm environment in which food waste (nitrogen) and wood (carbon), can mix with air and water. Unlike other composters, all this happens without the need for electricity, making your Ridan cheap and easy to use [7].

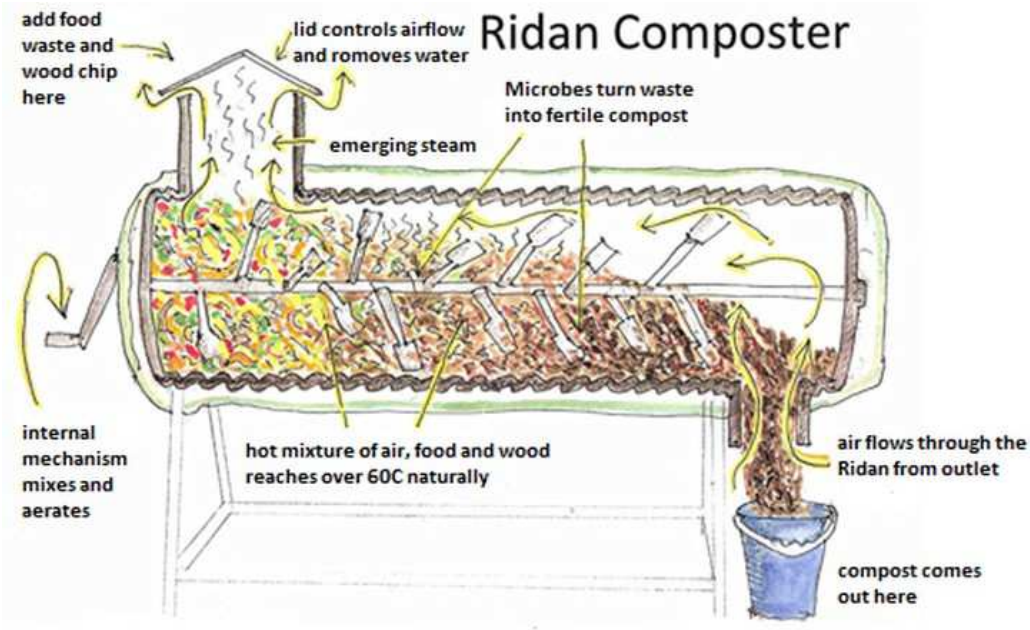


Figure (2.4): The Ridan composter process[7].

Figure (2.4) shows that heat is created when micro-organisms, (including bacteria and fungi) break down the organic matter, bio food waste and wood. The heat attracts even more hyper active microbes, which make the composting process quick and efficient. This creates the perfect composting conditions[7].

The food waste needs to stay inside the composter for a minimum of two weeks before it can be removed from the composter. Depending upon what sort of food is being composted it may be ready to spread straight onto the garden. However, it is usually best to mature the compost for 2-3 months in a maturation Box[7].

2.3 Comparative Study

We have identify many factors that should be looked at when comparing composting systems and machines but we will focus on what makes our designed project considered superior to the other two projects that we have discussed in section 2.2 .

One of the most important parameters in the composting process is the process time, if we took a closer look we can see that the (Wright Environmental Management, Inc. WEMI-4000) system that was installed in Ohio university can process organic waste in no less than 14 days, after that the compost shall cure for at least 90 days before it can be used as soil fertilizer [5], while the Earth Flow composting system that is being used in Colorado university can compost the organic waste in 14 to 21 days, after that the compost needs to cure for about 3 to 4 weeks before using [6]. Further look will show that the Ridan composter needs to compost the food waste for a minimum of two weeks before being removed, after that the compost needs to mature in a maturation Box for 2-3 months[7].If we took a look into our designed project we can see that the process shall not take more than 24 hours to be completed which is a huge milestone compared to the other projects, also the compost can be used immediately which is also wonderful compared to waiting month up to 3 months.

When discussing compost an important matter shall be taking into considerations which is odors, if we looked closely to (Wright Environmental Management, Inc. WEMI-4000) system we can see that it filters the exhausted air so that it wouldn't smell bad, but it does not address the issue with odors coming from the compost itself [5]. The Earth Flow composting system does not filter the exhausted air or the compost itself so the area next to the machine and the compost will be filled with odors [6]. The Ridan composter as well doesn't cater to the issue of odors of the compost[7], When looking at our designed project we find that the exhausted air get filtered so that no odors will be on the site also the bacteria we use is able to suppress odors from the compost so we consider our design to have a big lead in this matter.

3. System Design

3.1 Design Requirements, Constraints and Specifications

As we know that food waste is a global issue that need to be deal with. As government and communities try to manage and solve food waste, composting machines is one of the best option in this case, which leads to a reduction in the amount of food waste that happens at home, school, restaurants and any food service sector. Composting machine is the best way to avoid creating pollution, while at the same time creating a high-quality soil amendment which is inexpensive and effective. Economically, compost machine can be useful in many ways such as, eliminating the cost of dumping the organic waste, also getting benefit of the soil amendment by resell it in

markets. Composting is considered as eco-friendly because it is giving back to nature and it reduces the amount of methane emissions in landfill that caused by dumping food waste. There are a lot of development in composting machines in the whole world that fits a wide variety of applications with many different features.

Our compost machine project is a reverse engineer for one of Oklin Company compost machines. We got interested with this design because it has an obvious advantage in processing time which is only 24 hours and that the final product could be used as soon as it comes out of the machine although it would sometimes need to be mixed to soil to be able to use it as soil amendment. Not only that but Oklin has paid great attention to the filtration system within the machine, it uses a Nano filtration system which with the help of microbes inside the machine can make the compost itself and the machine odorless and with a green gas emissions.

For the specifications of our machine, it based on our scale model. We needed an agitation motor with a rate power of 36W to generate the require power to move the blades. We got an exhaust fan with a rate power of 9.5W which makes the process aerobic. To generate a high temperature, we got a heater with a rate power of 200W that will cause the bacteria to start the process. For the sensors, we have three sensing functions on a printed board circuit which are temperature, humidity and overload.

3.2 Methodology:

Figure (3.1) shows the block diagram of our designed composting machine, It shows how the machine works, it also shows the main component of the machine and the parameters controlling the machine.

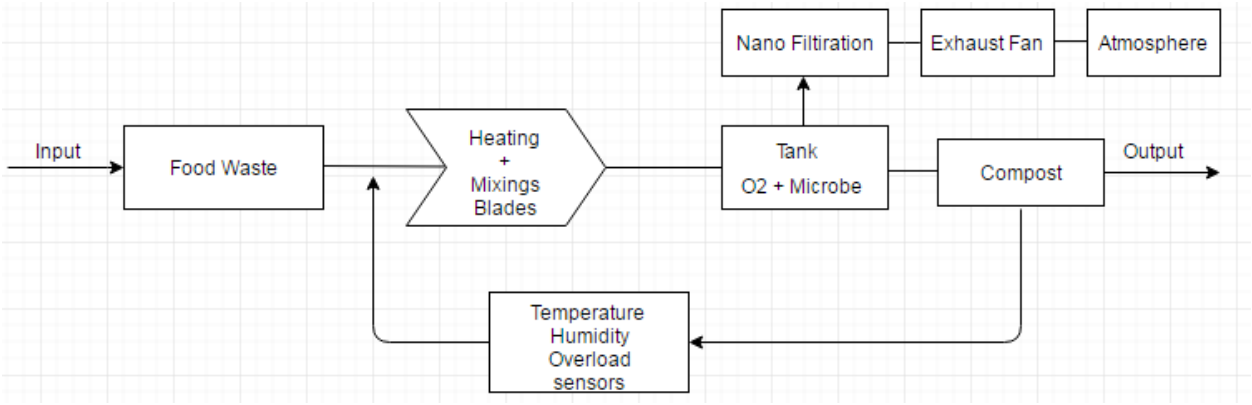
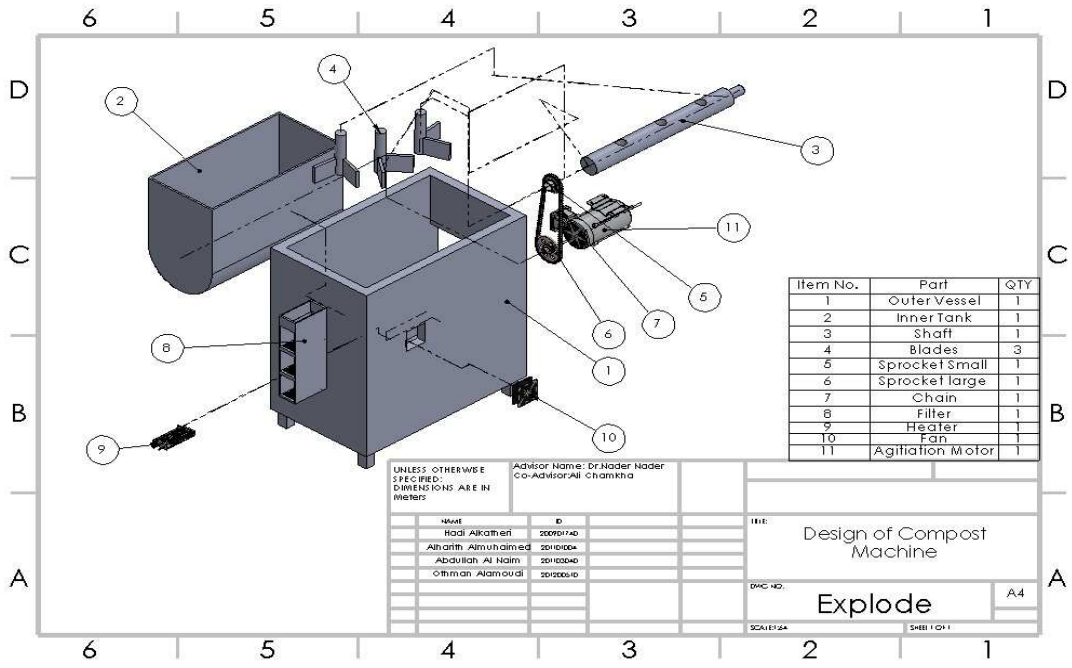


Figure (3.1): The system's block diagram

The approach that we used to complete this project was to divide the project into four main phases that contains multiple tasks within them.



Phase One: Composting development.

Tasks: composting processes and systems, researching composting development.

Phase Two: Machine Design and requirements.

Tasks: Finding an optimum machine design, parts, and workshop.

Phase Three : Machine construction

Tasks: Building the machine, configuring the control system

Phase Four: Testing and analysis.

Tasks: Operating the machine, checking the performance, results.

3.3 Product Subsystems and Components

Figure (3.2): Explode view of the machine.

This figure shows the main components of the machine we used. We chose the specifications based on our calculations and the availability of the components in the market:

Agitation motor: Mixes the microbe sawdust and the food with 36W rated power

Exhaust fan (Type: Blower fan): expel gases (Primarily CO_2 and water vapor) from the unit with 9.5W rated power.

Heater: Controls temperature inside the composting tank with 200W rated power

Temperature sensor: Controls temperature of the heater

Humidity sensor: Senses humidity in the composting tank

Main PCB (Printed Circuit Board): Controls overall operation of the unit

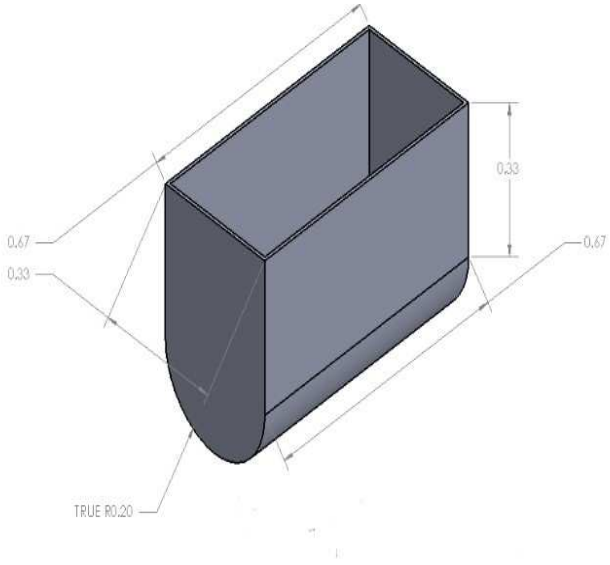
Nano filtration system: Filters all the gasses produced from the composting processes.

3.4 - Design Calculations

3.4.1- Composting Drum

Our desired composting drum has U shape. Therefore, in order to measure it we will divide the shape into rectangular and sphere and we will measure the total volume by adding their volumes together:

The composting drum's volume is : = + as give equations 3.1 and 3.2



(equation 3.1)

(equation 3.2)

Figure (3.3): (Drum)

=

3.4.2 - Shaft Diameter

The diameter of the shaft is given in equation 3.3:
(equation 3.3)

= 22.84 Nm

which is maximum torsion moment = 325 Nm (calculated)

combine shock and fatigue applied to bending, 1.6

Kt = combine shock and fatigue applied to torsion, 1.1

Ss = allowable shear stress for shaft with keyways, 42MPa

Using a factor of safety of 1.2 therefore, a shaft of 10cm is selected.

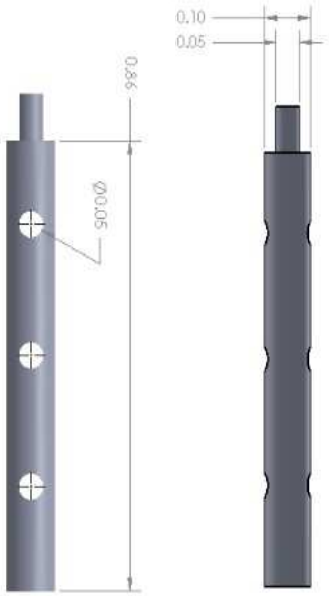


Figure (3.4): (Shaft)

3.4.3 - Shaft Key Design

The shaft key is maximum allowable shear stress.

Width of key is

Thickness of key is

Where, = inner diameter of the shaft to be selected, 10cm

3.4.4 - Volume of Food Waste:

Maximum volume of food is: **(equation 3.4)**

(3 blades)

3.4.5 - Heat Generated and Power Consumed By the Heater:

(equation 3.5)

The initial temperature of coil =

The final temperature of coil =

Specific heat capacity of air =

Mass = Density x Volume of coil

Density =

Volume of heating coil = x

Volume of heating coil =

3.4.6 - Fan Speed Calculation:

The speed of fan is: **(equation 3.6)**

D = diameter of fan = 0.12 m

N = speed of motor in the fan = 180rpm

3.4.7 - Design for the Gear

(equation 3.7)

= Service factor

= Tangential load

Thus, an electric motor of will be selected for the machine.

3.5 - Machine Assembly

Figure (3.5): The sheet plates.

As figure 3.5. display, sheet plates to create the outer vessel. It is a stainless steel plates that have been chose for corrosion resistance. the dimensions of sheets has made by cutting process that based on our calculations. four sheets was welded together to make outer vessel.

Figure (3.6): The exhaust fan.

Figure 3.6 shows the exhaust fan between the vessel and the drum. it has assembled between the vessel and the drum in the right side of the machine in order to transfer the air and odors from the drum to the filtration system inside the vessel. Four screws was used in order to join the exhaust fan between the vessel and drum.

Figure (3.7): The motor.

Figure 3.7 shows the motor. This is the required motor for the machine in order to generate the required power for rotating the shaft. As it shows in the figure, the motor has assembled to a small plate sheet before be fully assembled under the drum. four screws was needed to join the motor to the bottom side of the drum.

.

Figure (3.8): The shaft and blades.

Figure 3.8 shows the shaft inside the composting drum. based on the calculations we needed a shaft with 30mm diameter. it has three blades with a specific angles in order to cover the whole drum while rotating. The shaft has assembled to the in the middle of the drum with dimensions that fit to the blade specifications.

Figure (3.9): The base of motor and the drum.

Figure 3.9 shows the base of motor and the drum. as mentioned before that the motor will be assembled to a plate sheet before be fully assembled under the drum. this shows the location of the base under the drum.

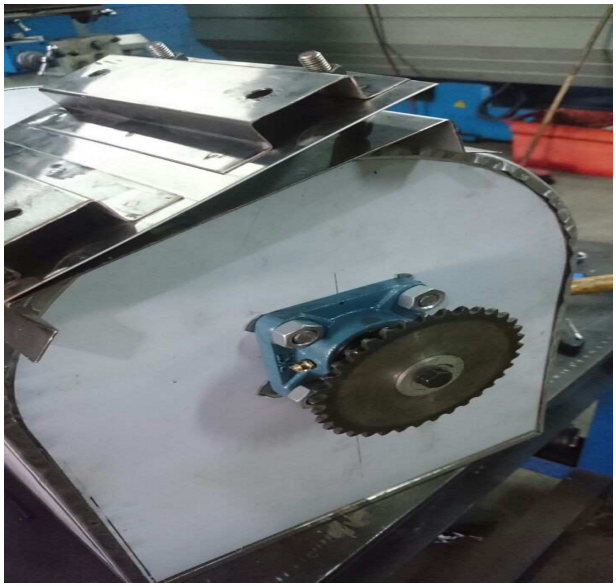


Figure (3.10): The gear.

Figure 3.10 shows the gear in the drum. as it shows that gear has installed the middle side of the drum. the other gear will be installed in the motor under the drum that will be eventually connected together by the chain.

Figure (3.11): The composting machine

Figure 3.11 shows the machine after assembling.

4. System Testing and Analysis

4.1 Experiments

Figure (4.1): The composting machine

As we started experimenting the machine, we searched for what parameters to be focusing on because this process has a lot of parameters to be considered, in order to measure and test for some of the parameters special equipments and knowledge were needed which considered hard to do because it will cost money and time, we decided to stick to certain parameters to test for which were temperature and humidity as they are considered essential to the composting process.

It is worth mentioning that testing didn't start at the desired time due to problems with some part shipment so it delayed the testing process which limited the number of experiments.

Two experiments were conducted with the same sample weight of 1.5 Kg of food waste , the first experiment sample was mixed food not following the 30-1 C:N Ratio and large pieces of food waste, the second experiment sample was a an equal mixing

volume of green plant material with naturally dry plant to balance the ratio of carbon to nitrogen and sample was cut into small pieces.

4.1.1 Experiment 1

Figure (4.2): Different readings for the experiments

Table 4.1shows data recorded from experiment 1

Table (4.1): (Experiment 1 data)

Time / Hour	Temperature /Celsius	Humidity / %
0	23	76%
2	26	65%
4	29	62%
8	31	57%
13	33	54%
18	34	51%
24	36	49%
29	39	45%
34	42	39%
39	44	37%
44	46	26%
48	50	20%
50	52	16%

Table (4.1) shows the variation of temperature and humidity with respect to time, the experiment went for almost 50 hours without adding any additional waste, the food waste was about 1.5 kg of mixed food that has not followed a 30-1 C:N ratio which as could be observed affected the temperature gain and slowed down the process even more with noticing that the heater isn't supplying enough heat. The food waste pieces were of different sizes which could also affect the process time.

Graph (4.1): Humidity over time

Graph (4.1) shows the almost study drop in humidity with time, the less the humidity gets, the more the waste turned into compost.

Graph (4.2): Temperature over time

Graph (4.2) shows the temperature with respect to time, it shows a slow gain in temperature over the course of more than 2 days which considered really slow due to the unbalance ratio of carbon to nitrogen.

4.1.2 Experiment 2

This experiment was conducted under more cautious condition, the C:N ratio of the food waste was more balanced between green and brown food, also every piece of food was cut into small pieces. The total food mass was also 1.5 kg.

Table 4.2 shows data recorded from experiment 2

Table (4.2) :(Experiment 2 data)

Time / Hour	Temperature /Celsius	Humidity / %
0	22	80%
1	24	78%
3	27	73%
5	29	69%
8	33	59%
11	37	51%
14	39	49%
16	39	47%
20	42	43%
24	45	39%
29	50	29%
33	53	21%
38	55	15%

Table (4.2) shows the temperature and humidity with respect to time for the second experiment which was conducted under more careful conditions for the organic waste, it shows a significant improvement in the process time which went from more than 2 days down to a little above a day and a half.

Graph (4.3): Humidity over time

Graph (4.3) shows the variation in humidity over time, even though the starting humidity was higher than the first experiment due to selecting some wastes that are high in moisture. The process ended with less but not much humidity level and the compost was drier.

Graph (4.4): Temperature over time

Graph (4.4) shows the different in temperature with respect to time, the experiment started at low temperature value due to the sample being more moisturized but it gained temperature a lot faster than the first experiment which is due to the consideration of the C:N ratio.

It is worth mentioning that more experiments needed to be conducted in ordered to determine how the machine would work with different conditions, but lack of time limited the ability to conducting experiments as every experiment takes more than 24 hours at minimum. Also more measurement tools were needed to measure different parameters such as moisture level in waste and the C:N ratio. These tools can improve the experiments dramatically. These parameters were measured in a sensing way which is not considered accurate enough to conduct more detailed experiments.

4.2 Overall Results, Analysis and Discussion

Upon testing the machine under different conditions such as the size of the sample, its moisture level, different types of food – green and brown – and other conditions and the observation we came to notice some factors that affects the decomposition process and its efficiency:

The organic wastes will compost best if the pieces were small in range of 5 cm in size. Soft tissue wastes such as orange don't need to be very small because it will decompose fast. Any woody material or bones should be grinded into small pieces before its put in the machine.

To have the composting process as effective as possible, the input waste should have an approximate carbon to nitrogen ratio of 30 to 1.It's not measured easily but experts say that mixing equal volumes of green plant material with equal volumes of naturally dry plant material will equate to the same ratio of 30 to 1.If the c: n ratio is more than 30:1 carbon, heat production drops and decomposition slows. Table (4.3) provides estimates of the C:N ratio for selected composting materials.

Table (4.3): (C:N Ratio)

MATERIAL	C:N RATIO
Corn stalks	50-100:1
Fruit waste	35:1
Grass clippings	12-25:1
Hay, green	25:1
Leaves, ash, black elder and elm	21-28:1
Leaves, pine	60-100:1

Leaves, other	30-80:1
Manure, horse and cow	20-25:1
Paper	170-200:1
Sawdust	200-500:1
Seaweed	19:1
Straw	40-100:2
Vegetable waste	12-25:1
Weeds	25:1
Wood chips	500-700:1

The process will work best if the moisture level of the input waste is about 50 percent. It is also not easily measured. Too much moisture in the input will make a soggy pile and the decomposition process will slow down and it will smell. If the input is too dry the decomposition process will be very slow or might even not occur at all.

The turning blades are playing a big role in the composting process because it prevents the waste from overheating at some point inside the tank and it will be aerated also.

After the process is completed, all weeds and weed seeds are killed, even insects, that is done by the help of the rising temperature.

The use of bio-filtration with charcoal and wood chips has increased the reduction in odors.

5. Project Management

5.1 Project Plan

When we first started working on this project we were eager to make an implantations plan, this plan helped us meet the deadlines and rise our efficiency in gaining proper knowledge about the composting process and the development in it, it also helps with

Time management and to divide the work between group members and actually to work better as a group. Table (5.1) shows our project plan.

Week	Main Task	Description
1-2	Study Composting and its systems	Studying the various types of composting processes and systems.
3	Machine Design	Choosing and modeling an optimum design
4	Market survey	Searching for the parts with minimum cost with good quality
5	First draft presentation and report	Gathering information to make first draft of the literature review and the first presentation

6-8	Purchase and collecting part	Ordering parts from abroad and local stores
10	Locating a Workshop	Searching for a workshop for control system and electrical parts and welding
11-13	Building the machine	Building the machine and configuring control system
14	Testing the machine& data analysis	Testing the performance of the machine & collecting data ((Testing start at the end of week 14))
14	Data analysis	Collecting data
15	Finalizing the final paper	Finishing the collecting and finalizing the thesis

Table (5.1): (Project plan)

5.2 Contribution of Team Members

Table 5.2: states the percentage of work done by each member in respect to the task assigned.

Task	**Hadi Alkatheri**	**Abdullah Alnaim**	**Alharith Almuhaimeed**	**Othman Alamodi**
Studies	**100 %**	**100%**	**100%**	**100%**
Project design	**100 %**	**100%**	**100%**	**100%**
Marketing survey & part collected	**100 %**	**100%**	**100%**	**70%**

Oral presentation & complete literature review & first progress report	**60%**	**100%**	**100%**	**100%**
Solid work	**80%**	**80%**	**100%**	**100%**
Build the Machin	**100 %**	**100%**	**80%**	**100%**
Testing & collecting data	**100 %**	**100%**	**100%**	**100%**
Final report	**100 %**	**100%**	**100%**	**100%**

5.3 Project Execution Monitoring

Meeting with adviser:

We met with Dr. Nader Nader several time to show him the latest update for our work in order to take his feedback into consideration.

Meeting with team members:

We planned to have a meeting twice a week to assure that each team member is doing his task correctly.

Testing:

To complete one experiment the machine needs at least 24 hours to done the composting cycle. And since we faced a delay of arriving some parts we could not do too many testing so far.

5.4 Challenges and Decision Making

Team Problems:

One of the main problems is that we have different class schedule and credit hours. So, we faced some difficulties to manage the time ti be suitable for all team members. Some of us have difficulty in writing reports, therefore we divided the writing work between two of team members and that effect in our capability to meet with the time table.

Building Problems:

The major problem was collecting the parts. Because, some of the parts could not be found in local markets. So, we order some of parts from abroad. After that, we faces another problem with delay of some shipping parts.

Testing Problems:

We faced a problem with the gear system. There were adjustments that needed to be made regarding the location of the motor, because the chain between the gears was a

bit loose which affected the turning process inside the tank and made it harder for the machine to turn heavier samples.

5.5 Project Bill of Materials and Budget

Table (5.3) : Bill of Materials.

	Name of the Part	**Specifications**	**Quantity**
1)	Agitation Motor	Single-phase, 220V 60Hz	1
2)	Humidity sensor wire		1
3)	Digital Centriolar	Single-phase, 220V 60Hz	1
4)	Exhaust fan	Single-phase, 220V 60Hz	1

5)	Metal Sheets		8
6)	Chain		1
7)	Sprocket		1
8)	Bearing holder		2
9)	Filtration system		1
10)	Temperature sensor		1
11)	Heater	Single-phase, 220V 60Hz	1
12)	Shaft		1

Table (5.4) : Budget

	Name of the Part	**Specifications**	**Price**
1)	Agitation Motor	Single-phase, 220V 60Hz	1200SR
2)	Humidity sensor wire		560SR
3)	Digital Centriolar	Single-phase, 220V 60Hz	300SR
4)	Exhaust fan	Single-phase, 220V 60Hz	140SR
5)	Building the machine		2000SR

6)	Control System and wiring		1800SR
7)	Temperature sensor		400SR
8)	Heater	Single-phase, 220V 60Hz	800SR

6. Project Analysis

6.1 Life-long Learning

This project helped us in several ways, it gave us a good experiences in teamwork and gained the ability to work as team to accomplish something. As engineers our work environment needs teamwork skills to do projects and work at fields, so we gained the needed skills for the workplace . We also were able to improve the communication skills by sharing ideas and thoughts which will play good roles in the future job . To build the project we needed several skills, but most of the team had a lack of management skills, so we had tough time to gain these skills during this semester. One of these skills was time management skills which was very needed in order to finish our project in the desired time.

By dividing tasks between group members, each one of the group gained the ability to take responsibilities to done his task in the prober time. At first we faced some delays in some tasks but eventually we could avoid it at the end of project. Doing marketing

survey helped us to increase our knowledge in the costs of common mechanical parts, wielding, cutting and control systems parts. We also gained knowledge in the function of circuit printed bored and how to it is required to apply the control system to our machine. We gained the most skills by doing research in internet by reading about other people experiences in doing projects and also by asking our graduated friends about their experiences in their senior project.

6.2 Impact of Engineering Solutions

As it mentioned before, the project is meant to be eco-friendly and it has a significant benefits for environment. By using the composting machine we can reduce the amount of the organic waste that eventually disposed in landfills. Also by returning the nutrients back to the soil that will make the cycle life of these waste food continuo. By decreasing the amount of the food waste in the landfills which will also decrease the amount of greenhouse gasses that cause the pollution. Spreading composting machine across the country will make the country eco-friendly and green.

This project also has impact on the society, it will educate people about the food waste issue and they will cooperate with the government to solve this issue by decreasing the amount of food they eat daily and how to manage the waste. Also, they may have their own composting machine in their houses which meet the project future goal. It also have impact on the economy, the government will be able to decrease the amount of workers, disposal cost and landfills. That will lead to decrease the expenses that government pay annually for the food waste, it also will make the country use its own fertilizer instead of buying it from other countries.

6.3 Contemporary Issues Addressed

Food waste is one of the most prominent waste streams across the whole world and in Saudi Arabia 35 percent of the garbage is a food waste. One of the major problems that face Saudi Arabia nowadays that there are no serious moves in solving the food

waste issue. In 2030 vision, one of their targets is to focus on the pollution and the causes of it. Since food waste is one of the pollution causes, it has a direct relation to the health and it need to be solved.

Also, by composting the food waste the government will be able to save more money instead of spending it in the disposal. Moreover, the government could sell the compost or use it. Therefore, This project will help the country to manage and sustain the excess food waste that related to 2030 goals, which will show the world that Saudi Arabia is a leading country in recycling.

7. Conclusions and Future Recommendations

7.1 Conclusions

At the start of this project we sat our objective and goals into finding a solution for food waste disposal problem, those objectives were that the solution should be eco – friendly and it should help decreasing the garbage volume and the disposal cost, it also should be sustainable and socially responsible. Those objectives were all met choosing composting to deal with the food waste disposal problem. When trying to design the composting machine, objectives were that the machine reduce the

processing time as much as possible which was not more than 48 hours in most of our experiments.

Being easy to use was also one of the design objectives which was met as this machine only require a push of a button to function properly. Power saving was also an objective of the design that it has not been met properly since blades are running the whole time which in the long run consumes a lot of power. Odorless was a main concern and an objective that was achieved with the help of the Nano-biofiltration and the bacteria inside the machine also helped reducing the odors into minimal.

The machine design was inspired by Oklin company, but we add two new features into the design. First was a small display in the outer vessel, it shows the humidity and the temperature inside the composting tank, it also allows the user to easily set the parameters of humidity and temperature so that the user can control the condition that the final product is going to be at. Second feature was changing the filter location to make it accessible for regular users to clean in case it was blocked.

7.2 Future Recommendations

- Using plastic instead of metal on the outer vessel to decrease the weight of the machine.

- Enhancing the mechanism of the gears and motor to enable the blades to withstand larger amount of waste.

- Using wheals in the bottom of the machine to make the machine easier to move.

- Trying to use boiler instead of electric heater and adding nanofluid to it to increase the efficiency of the heating process.

- Adding a safety feature as a switch door sensor that stops the blades when the machine door is open to prevent any accident.

- Attaching a grinder into the machine to be able to handle large bones and such to be composted.

- Installing more powerful heater to raise the temperature faster.

References:

[1] One-third of world's food wasted annually. (n.d.). Retrieved from http://www.un.org/apps/news/story.asp?NewsID=45816#.WBHx8NJ96M8

[2] What is Composting? (n.d.). Retrieved from http://www.recycleworks.org/compost/

[3] Organic Composting. (n.d.). Retrieved from http://www.northernrootsgrowsupply.com/organics/compost.html

[4] Composting Machines. (n.d.). Retrieved from http://www.bfgenergy.org/cm.html

[5] Compost Facility. (n.d.). Retrieved from https://www.ohio.edu/sustainability/programs/compost-facility.cfm

[6] Earth Flow Composter. (n.d.). Retrieved from http://housing.colostate.edu/Data/Sites/1/documents/Composting_Fact_Sheet.PDF

[7] Health Impacts of Composting Air Emissions. Article published in Biocycle 48(11):44-50, 2007.

[8] AEROBIC COMPOSTING VS ANAEROBIC COMPOSTING. (n.d.). Retrieved from http://www.hotrotsolutions.com/pages/anaerobic-composting-vs-anearobic-composting

[9] Food waste recycling with Ridan composters. (n.d.). Retrieved from http://www.ridan.co.uk/

[10] Worker Protection at Composting Sites. Biocycle 53(1):47. By Nellie Brown, 2012.

[11] Hygienic Implications of Small Scale Composting in New York State. 71p report on home compost quality, 2004.

[12] Farm-Based Composting: Manure & More. 38-minute video highlighting 15 farm operations and 6 different composting technologies from low to high tech. YouTube, 2001

Design of Compost Machine

Instructor: DR.NADER SAWALHI
Advisor: Dr.NADER NADER
Co Advisor : Ali Chamkah

Team Members :

Alharith Almuhaimeed	201101004
Abdullah Alnaim	201103040
Hadi Alkatheri	200901740
Othman Alamoudi	201200510

Problem Statement

- Food waste is one of the most prominent waste streams across the whole world, and in Saudi Arabia 35 percent of the garbage is a food waste.

- Food waste is an untapped energy
up rotting in landfills, thereby rel
into the atmosphere which cause t

Problem Solution

Composting!

- Natural and efficient process.
- Simple and effective way for everyone.
- Greener and better world.

What is composting?

- Composting is known as a natural process; it occurs by using microorganism under specific condition which leads to the decomposition of organic waste.

- The process involves decomposition of organic waste into what is known as compost which is a good fertilizer for plants.

Types of composting

- Aerobic composting:
  - Use of air.
  - Bacteria is growing by high nitrogen waste.

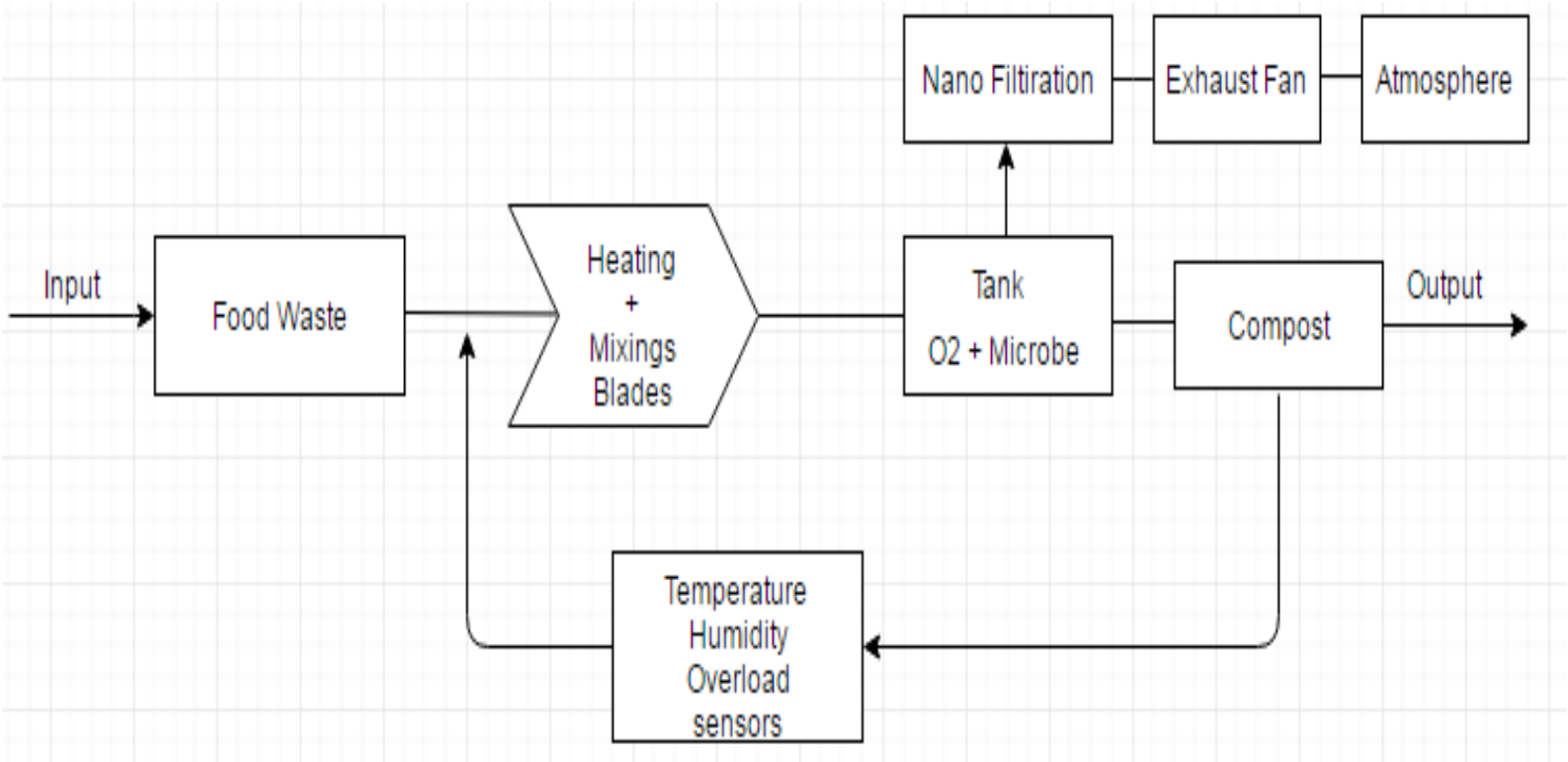
- Anaerobic composting:
  - Use no oxygen.
  - The organic waste piled up and starts breaking down by its self.

Choosing a design

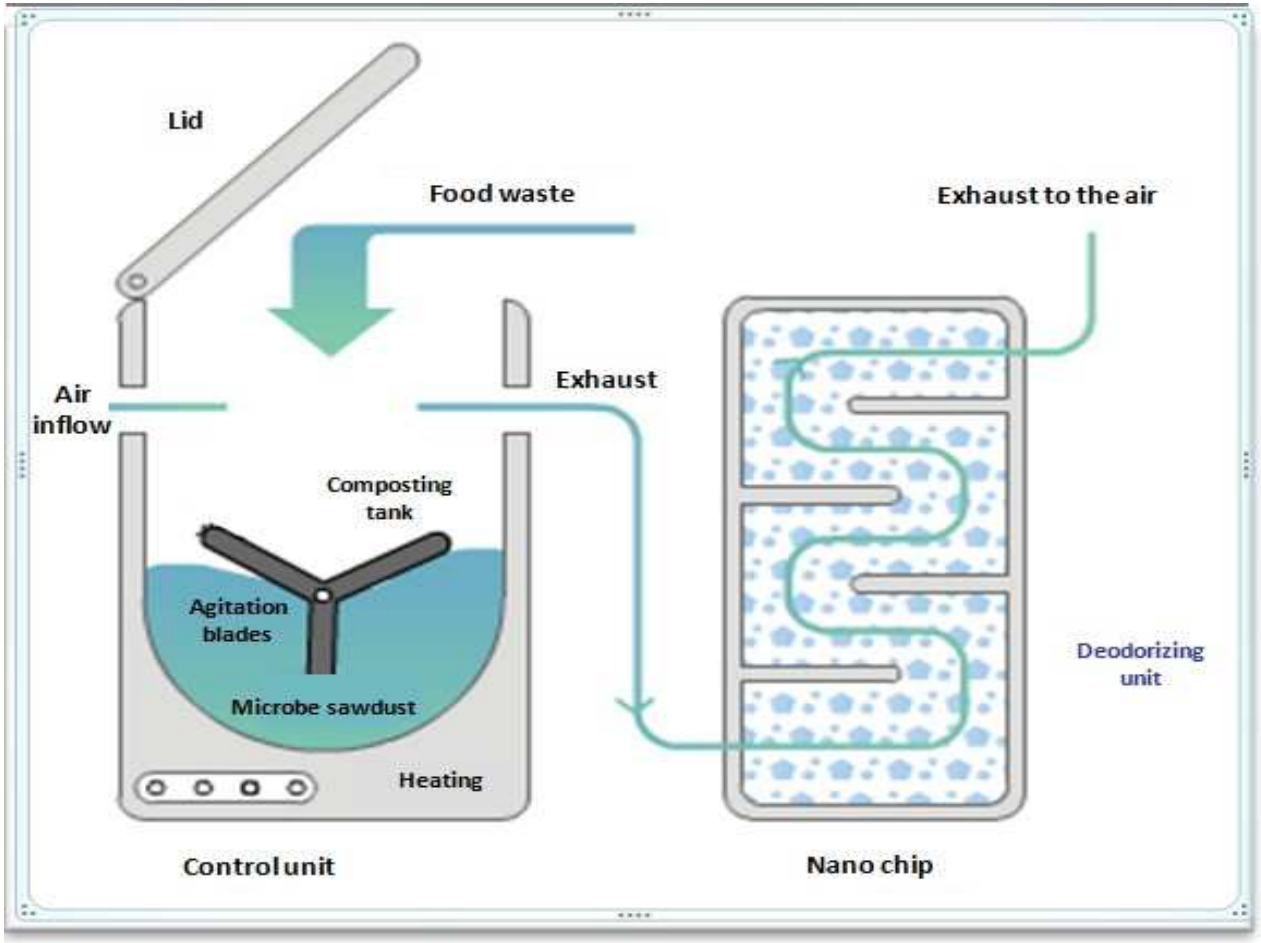
Parameters that was considered:

- Process time.
- Easy to use.
- Power saving.
- Odorless.

Block Diagram



Structure of the Machine



Bill of Materials

	Name of the Part	Specifications	Quantity
1)	Agitation Motor	Single-phase, 220V 60Hz	1
2)	Humidity sensor wire		1
3)	Digital controller	Single-phase, 220V 60Hz	1
4)	Exhaust fan	Single-phase, 220V 60Hz	1
5)	Metal Sheets	stainless steel 316	8
6)	Chain		1
7)	Sprocket		1
8)	Bearing holder		2
9)	Filtration system		1
10)	Temperature sensor		1
11)	Heater	Single-phase, 220V 60Hz	1
12)	Shaft		1

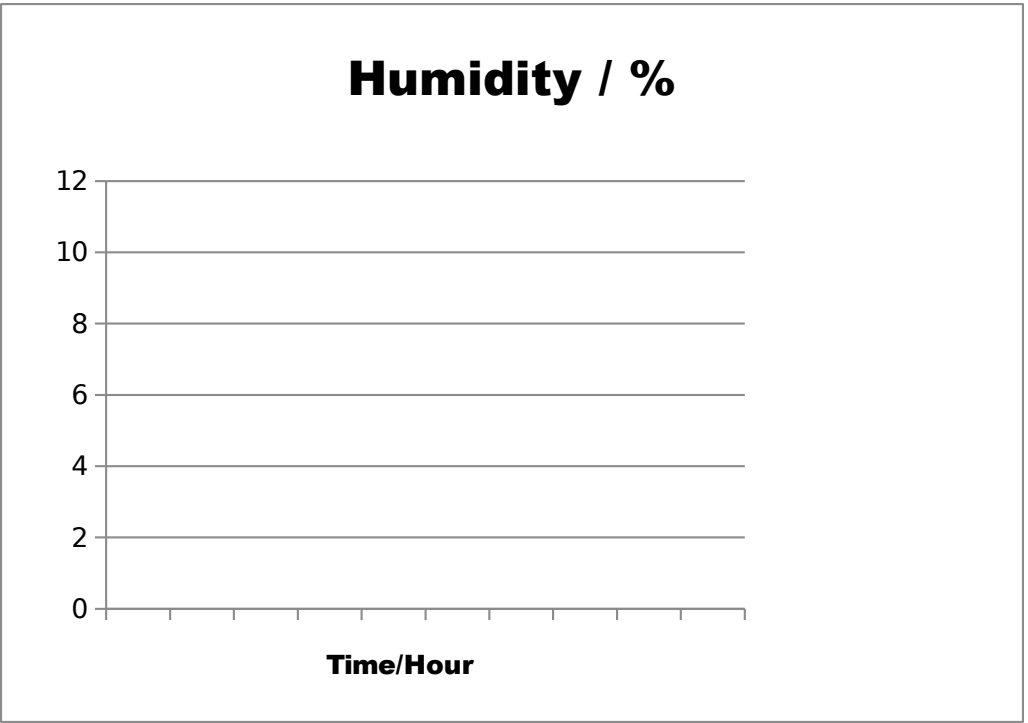
Project Plan

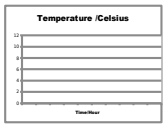
Week	Main Task	Description
1-2	Study Composting and its systems	Studying the various types of composting processes and systems.
3	Machine Design	Choosing and modeling an optimum design
4	Market survey	Searching for the parts with minimum cost with good quality
5	First draft presentation and report	Gathering information to make first draft of the literature review and the first presentation
6-8	Purchase and collecting part	Ordering parts from abroad and local stores
10	Locating a Workshop	Searching for a workshop for control system and electrical parts and welding
11-13	Building the machine	Building the machine and configuring control system
14	Testing the machine& data analysis	Testing the performance of the machine & collecting data ((Testing start at the end of week 14))
14	Data analysis	Collecting data
15	Finalizing the final paper	Finishing the collecting and finalizing the thesis

Experimentation

Experiment 1

- Unbalanced C:N ratio
- Different sample pieces

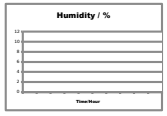


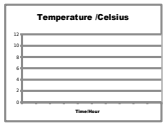


Experimentation

Experiment 2

- balanced C:N ratio
- small sample pieces





Overall Results and Analysis

- Organic wastes will compost best if the pieces were small.
- To have the composting process as effective as possible, the input waste should have an approximate carbon to nitrogen ratio of 30 to 1.
- The process will work best if the moisture level of the input waste is about 50 percent.
- The turning blades are playing a big role in the composting process.
- After the process is completed, all weeds and weed seeds are killed, even insects.

Challenges

- Team Challenges
- Building Challenges
- Testing Challenges

Future Recommendations

- Using plastic instead of metal on the outer vessel to decrease the weight of the machine.
- Enhancing the mechanism of the gears and motor to enable the blades to withstand larger amount of waste.
- Using wheals in the bottom of the machine to make the machine easier to move.
- Trying to use boiler instead of electric heater and adding nanofluid to it to increase the efficiency of the heating process.
- Adding a safety feature as a switch door sensor that stops the blades when the machine door is open to prevent any accident.
- Attaching a grinder into the machine to be able to handle large bones and such to be composted.

Preview Video

THANK YOU