VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi – 590018

A Project Report on

"DESIGN AND CONSTRUCTION OF AN INTEGRATED DOMESTIC ORGANIC WASTE COMPOSTING DEVICE"

Carried out by

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Submitted in partial fulfillment for the award of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

Under the Guidance Of

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DEPARTMENT OF MECHANICAL ENGINEERING

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2018-19

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CERTIFICATE

This is to certify that the project work entitled **"DESIGN AND CONSTRUCTION OF AN INTEGRATED DOMESTIC ORGANIC WASTE COMPOSTING DEVICE"** is a bonafide work carried out by

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In partial fulfillment for the award of **Bachelor of Engineering in Mechanical Engineering** from**Visvesvaraya Technological University**, Belagavi during the academic year 2018-2019. It is certified that all the corrections/suggestions indicated for the internal assessment have been incorporated in the report deposited in the department. The project has been approved as it satisfies the academic requirements.

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Signature of Guide	Signature of HOD	Signature of Principal/Director
(Mr. Umashankar M)	**(Prof.Umashankar M)**	**(Dr. T.V Govindaraju)**

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DECLARATION

We, PRAMOD M G, RAGHU BHARADWAJ R, RAM NARAYAN G S, SAGAR S students of 8^{th} semester B.E, Mechanical Engineering, K.S. Institute of Technology, Bengaluru hereby declare that the project report entitled **"DESIGN AND CONSTRUCTION OF AN INTEGRATED DOMESTIC ORGANIC WASTE COMPOSTING DEVICE"** embodies the record of the project work carried out by us, for the fulfillment of the course requirement for the award of Degree in Bachelor of Engineering in Mechanical Engineering, Visvesvaraya Technology University, Belagavi during the academic year 2018-2019. Further, the matter embodied in dissertation has not been submitted previously by anybody for the award of any Degree or Diploma to any other University.

Signature of the candidates

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Place: Bengaluru

Date:

ACKNOWLEDGEMENT

The sense of completion and elation that accompanies the successful completion of this work would be incomplete without the names of the people who helped us in accomplishment of this project to its culmination point, people whose constant guidance, support and encouragement resulted in realisation.

We take this opportunity to thank **Dr. T.V GOVINDARAJU**, Principal/Director, **K S Institute of Technology** for providing the guidance and healthy environment in college which helped in concentrating on project.

We sincerely thank with utmost gratitude to **Prof. Umashankar M, H.O.D, Department of Mechanical Engineering** who is also our project guide for providing us a abundance of support during the course of project, we express our sincere gratitude for his unfathomable and never ending support that he has given us, during the entire course of the work.

Last but not the least, we would like to thank all the teaching and non-teaching staff of **K S Institute of Technology, Bangalore,** our parents, friends and all those who stood by us in the hour of greatest need in helping us directly or indirectly during the completion of the project.

Thank You,

Pramod M G

Raghu Bharadwaj R

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ABSTRACT

Waste management is a huge concern in today's world. The problem of waste is alarming and is becoming enormous. In all the cities and places, organic waste is dumped or disposed in a landfill or discarded, which causes the public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences. So the best course of action is to treat the household organic waste at its rudimentary stage thereby help in curbing of escalation of organic waste drastically.

There are few composting machines which are used at industrial levels which are gigantic and are not ideal to be kept at the home due to its enormous size and by the sheer space it occupies. Currently, problems are encountered when potential customers are shut out of the composting technologies owing to expensive, space as well as time-consuming and complicated methods of composting solutions offered by large vessel capacity organic composters as opposed to what is normally required by a household. The months-long composting processes are time-consuming and require regular maintenance for a good level of compost.

Shredding machine is used for shredding and converting macro organic waste products into small or micro easily decomposable form, which can be easily be decomposed using the aerobic composting process. Organic waste shredder designed should be perfect to shred all kinds of organic kitchen waste products. The organic waste shredded will be in small pieces to enable a higher rate of decomposition and hence a faster-composting process. This shredder can be operated with a VDC motor

For the organic waste to be shredded into the micro-organic matter of about 5-10mm in diameter it is essential to design and fabricate the shredder for the same. The shredder and cylinder assembly are made out of stainless steel as it is non-corrosive, durable and doesn't react with organic materials to give toxic chemicals. The design is based on many iterations that were performed during the designing phase, the most suitable design of all the iterations is considered for further fabrication. As for the other necessary parts are concerned food grade plastic is selected to collect the compost so that no reaction happens between the compost and the collector. The cabinet covering and the frame has been done with the help of Mild still due to its better structural properties and strength. TIG welding is incorporated as it gives good weld depth and good weld finish. The entire process is semi-automated with the help of Arduino Uno, the bioculum, and sanitreat which are the necessary ingredients for the composting process as they increase the rate of decomposition and reduce the odor released

during the composting process respectively are sprayed for a definite interval of time based on their requirement as set in the Arduino. The temperature is regulated with the help of water screen that is sprayed on the cylinder chamber and also a fan is incorporated to remove heat from the cabinet, all the spraying actions are achieved with the help of submersible pumps which are placed inside the containers which cradle necessary materials to be sprayed in it. The shredder runs at a high rpm first few minutes to serve the process of shredding later the speed is reduced to serve the process of stirring necessary for aeration, all this is achieved with the help of variable DC motor(VDC).

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INTRODUCTION

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INTRODUCTION

1.1 Waste escalation in environment

Waste is essentially any material that is discarded after its primary usage. Be it an artificial product or an organic matter after they are deemed redundant and they are castoff. Nowadays due to exponential outbreak off population, there is seemingly very high need for essential products such as organic matter and also man made products therefore due to this drastic growth of population waste being collected is also increasing escalating.

Since there is a need to curb the growth of waste in environment it is necessary to segregate the waste into many divisions so that they can be treated based on the type of waste that is being generated segregation is necessary because electronic waste cannot be treated the same way as that of organic waste.

On an average let alone in a city like Bangalore the amount of solid waste that is being generated is tremendous and is about 3000 tones- 3500 tones according to a survey by BBMP. According to another survey by Times of India which states that 64% of the total solid waste comprises of wet waste which is biodegradable in nature.

Types of wastes:

- Municipal waste
- Industrial waste
- Biomedical waste
- Hazardous waste such as radioactive waste

Fig1.1 Municipal waste

Fig1.2 Industrial waste

Fig1.3 Biomedical waste

Fig1.4 Radioactive waste

1.2 Organic waste Management

Since there is an enormous need for the management of waste yielding to its exponential boom in the environment. We somehow have to curb the amount of organic waste that is entering the environment, so rather than pushing the waste till the point of culmination it is better to treat the organic waste at its inception so that it indirectly reduces the organic waste output at dumping grounds.

Organic waste takes prominence because these organic matters may help in the growth of disease causing bacteria and viruses which are then carried away by carriers. Hence decreasing the amount of organic waste output also reduces the chances of getting diseases like cholera, malaria etc.

Organic waste management(OWM) involves naturally occurring bacteria, worms, fungi and many other processes to decompose the organic matter so as to release the organic waste back into the soil in the form of nutrients which is rather beneficial as it enriches the quality of soil and hence promotes agriculture and backyard farming owing to its nutritive quality.

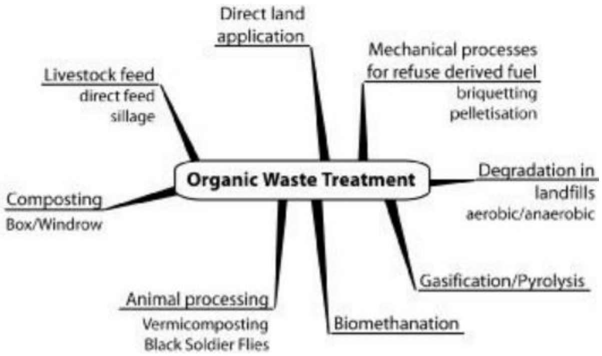

Fig1.5 Organic waste treatment/ management

1.3 Material selection

The material of selection for the cylinder and the shredder is entirely based on the way the selected material would react with the organic matter, also considering the economic liabilities and the material properties of the selected material.

Considering all the factors it has been found that stainless steel 316 grade is most suitable for the processing of organic waste. Since it is corrosion resistant, durable, easy to fabricate, heat resistant and cleanability hence it is more practical and economic to consider steel as the rightful material for shredder and cylinder parts.

Table 1.1 Composition of 316 grade Stainless Steel

Element		Percent by Weight
		316 Stainless
C	Carbon	0.08 max
Mn	Manganese	2.00 max
Si	Silicon	0.75 max
Cr	Chromium	16.00 - 18.00
Ni	Nickel	10.00 - 14.00
Mo	Molybdenum	2.00 - 3.00
P	Phosphorus	0.045 max
S	Sulfur	0.030 max
N	Nitrogen	0.10 max
Fe	Iron	Bal.

Table 1.2 Properties of Stainless Steel 316 grade

Yield Strength 0.25% Offset psi MPa	 30,000 205
Ultimate tensile strength psi MPa	 75,000 515
Percent Elongation in 2in. or 51mm	40
Hardness Max. Brinell RB	 217 95
Yield Strength 0.25% Offset psi MPa	 30,000 205

1.4 Aerobic Composting Process

The aerobic composting process starts with the formation of the pile. In many cases, the temperature rises rapidly to 70–80 °C within the first couple of days. First, mesophilic organisms (optimum growth temperature range = 20–45 °C) multiply rapidly. They generate heat by their own metabolism and raise the temperature to a point where their own activities become suppressed. By the end of the composting process the material becomes dark brown to black in colour. The particles reduce in size and become consistent and soil-like in texture.

1.5 Factors affecting aerobic composting

1.5.1 Aeration

Aerobic composting requires large amounts of O, particularly at the initial stage. Aeration is the source of O, and, thus, indispensable for aerobic composting. Where the supply of O is not sufficient, the growth of aerobic micro-organisms is limited, resulting in slower decomposition. Moreover, aeration removes excessive heat, water vapour and other gases trapped in the pile. Heat removal is particularly important in warm climates as the risk of overheating and fire is higher. Therefore, good aeration is indispensable for efficient composting. It may be achieved by controlling the physical quality of the materials, pile size and ventilation and by ensuring adequate frequency of turning.

1.5.2 Moisture

Moisture is necessary to support the metabolic activity of the micro-organisms. Composting materials should maintain moisture content of 40–65 percent. Where the pile is too dry, composting occurs more slowly, while moisture content in excess of 65 percent develops anaerobic conditions. In practice, it is advisable to start the pile with moisture content of 50–60 percent, finishing at about 30 percent.

1.5.3 Nutrients

Micro-organisms require C, N, phosphorus (P) and potassium (K) as the primary nutrients of particular importance is the C: N ratio of raw materials. The optimal C: N ratio of raw materials is between 25:1 and 30:1 although ratios between 20:1 and 40:1 are also acceptable. Where the ratio is higher than 40:1, the growth of micro-organisms is limited, resulting in a longer composting time. A C: N ratio of less than 20:1 leads to underutilization of N and the excess may be lost to the atmosphere as ammonia or nitrous oxide, and odour can be a problem. TheC: N ratio of the final product should be between about 10:1 and 15:1.

1.5.4 Temperature

The process of composting involves two temperature ranges: mesophilic and thermophilic. While the ideal temperature for the initial composting stage is 20–45 °C, at subsequent stages with the thermophilic organisms taking over, a temperature range of 50–70 °C may be ideal. High temperatures characterize the aerobic composting process and serve as signs of vigorous microbial activities. Pathogens are normally destroyed at 55 °C and above, while the critical point for elimination of weed seeds is 62 °C. Turnings and aeration can be used to regulate temperature.

1.5.5 pH value

Although the natural buffering effect of the composting process lends itself to accepting material with a wide range of pH, the pH level should not exceed eight. At higher pH levels, more ammonia gas is generated and may be lost to the atmosphere.

1.6 Arduino Uno

Arduino is an open source microcontroller which can be easily programmed, formatted and reprogrammed at any given point of time.Based on simple microcontroller boards, it is an open source computing platform that is used for fabricating and programming other electronic devices. It can also act as a mini computer just like other microcontrollers by taking inputs and controlling the outputs for a variety of electronics devices this is the very purpose that this microcontroller has been incorporated in this project so as to vary the speed of VDC motor and also make use of temperature control module when temperature rises. Arduino uses a hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development Environment).

These microcontrollers can be programmed easily using the C or C++ language in the Arduino IDE. This development board gives us the opportunity of uploading a code by as simple as uploading with the help of a USB. The Arduino Uno uses ATmega328 16MHz clock speed microcontroller. Hence it is fast and can respond to the incoming signals quickly with appropriate output signals as per the written code which is uploaded to the board previously.

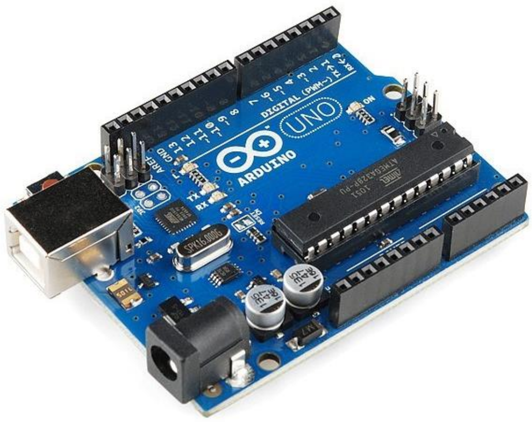

Fig 1.6 Arduino Uno

1.7 Submersible pumps

Submersible pumps are the mechanical components that are used to pump the fluids from its container to the required chamber, with the help of rotary vanes. The pump is immersed inside the fluid and the mechanical energy of the vanes is converted to the kinetic energy of the fluid.

Fig 1.7 Submersible pump

1.8 Variable DC motor

Variable DC motor is a mechatronic device which is generally used for high Speed and high torque requirements. The variation of the speed and torque is linear and the two factors are inversely proportional to each other. These factors greatly influence the necessity of the project as there factors is crucial in obtaining necessary shredding speed and also high torque required to churn the mixture of organic matter.

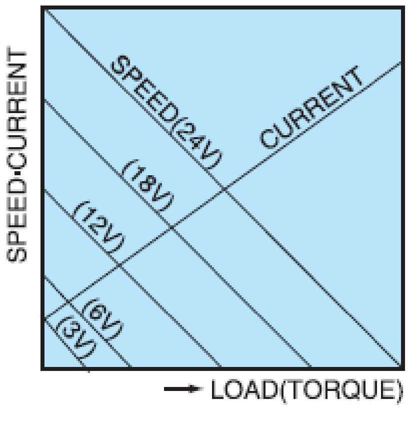

Fig 1.8 Torque vs. Speed relation

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW AND OVERVIEW

2.1 Literature review

1. **Stainless Steel for Dairy and Food Industry: A Review by Dewangan AK, Patel AD and Bhadania AG**

   Stainless steels (SS) were invented to overcome the problem of **corrosion** which is a major concern of food and many other industries. Dairy and food industries are concerned with reliability of equipment and **product purity.** To achieve these, stainless steels are often the **economical and practical** materials of choice for process equipment.

   It is suggested that there are six major reasons for the widespread use of stainless steel in the food and dairy industry: **corrosion resistance**; **durability**; **ease of fabrication**; **heat resistance**; **flavour and colour protection**;and **cleanability.**

2. **Optimum Design for Multi-angle Kitchen Grater Mechanism for Biodegrading Kitchen Waste by Zol Bahri Razali, Abdul Rahim, Abdul Hasim and Mohd Hisam Daud**

   The Stainless Steel is the one classified as the **“Food Grade”** type. Where the applications involve with high temperatures, the non-hardened ferritic and austenitic types of stainless steel which having the higher duplex strength is the **most suitable to be used In case of organic kitchen waste** the highest strength is for a chicken bone. **The force required to break a chicken bone is 275.8Mpa**

3. **Stainless Steels for the Food Processing Industries by British Stainless Steel Association**

   The “316” grades (1.4401 / 1.4404) are often referred to as the “food” grades. There is no known official classification for this and so, depending on the application, the equally common 1.4301 and 1.4016 types may be suitable for food processing and handling

4. **On farm Composting methods by R.V. Misra, R.N. Roy and H.N. Hiraoka**

Where the supply of Oxygen is not sufficient, the growth of aerobic microorganisms is limited, resulting in slower decomposition. Moreover, aeration removes excessive heat, water vapour and other gases trapped in the pile. Heat removal is particularly important in warm climates as the risk of overheating and fire is higher. Therefore, good aeration is indispensable for efficient composting. The natural buffering effect of the composting process lends itself to accepting material with a wide range of pH; the pH level should not exceed eight. At higher pH levels, more ammonia gas is generated and may be lost to the atmosphere.

5. **Aerobic and anaerobic decomposition of organic matter in marine sediment: Which is fastest? By Erik Kristensen Saiyed I. Ahmed and Allan H. Devol**

The test was considered by means of incubation techniques. Rates of CO2 evolution in diatom chambers showed that aerobic carbon mineralization was 10 times faster than anaerobic process.

6. **Methodologyfordesign&fabricationof portableorganicwastechopping machinetoobtaincompost–areview by A.A.Deshpande and Ajinkya S. Hande**

The study specifies factors influencing the organic waste chopping process and recommends a number of design options for chopping machine. These are based on a systematic study of the organic waste chopping process and testing of a portable model of chopping machine By shredding the storage volume could be reduced approximately 5.0 times.

7. **Composting byRobert E. Graves**

Larger particles are desirable to promote the flow of air, but they also diminish the surface area of the particles. Because the majority of the microbial activity occurs on the surface of the compost particles within a thin liquid layer, the greater the amount of surface area exposed, the greater the amount of decomposition. The first several days of the active composting period are characterized by a drop in pH to levels between 4 and 5 the ideal range for microbial activity is between 6.5 and 8.0. Acidic conditions are generally detrimental to aerobic micro-organisms, particularly bacteria, and slow the composting process. Composting will not stop; however, because a population of organisms, mostly fungi, eventually develops that can use the acidic compounds as a substrate. The pH value can be regulated by the addition of superphosphate.

8. Experiences on using Arduino for laboratory experiments of automatic control of robotics by F. A. Candelas, G. J. García, S. Puente, J. Pomares, C.A. Jara, J. Pérez, D. Mira, F. Torres

This Integrated Development Environment (IDE) is open and free, as well as easy to get, start and use. C/C ++ is used as programming language, which enables user to create from a simple program based on procedures in a single file. To a complex object-oriented program in multiple files. Other relevant aspect of the Arduino platform is the big amount of information available about it, ranging from the basic documentation in the official web site, to full books for different application fields.

9. Working principle of Arduino and using it as a tool for study and research by Leo Louis

Main advantages are fast processing (16 MHz) and easy interface (Simple UI). Today, with increasing number of people using open source software and hardware devices day after day, technology is forming a new dimension by making complicated things look easier and interesting. These open sources **provide free or virtually low costs, highly reliable and affordable technology**

10. Chicken Bone Stiffness and Elastic Modulus Testing: Differences in Axial and Flexural Properties by Orrin G. Meyers

Comparing the strength and mechanical properties of bones in these different directions can help characterize what forces put bones at risk when applied in a given direction. Human cortical bone is often modeled with common avian bone like chicken bone which can be found at any grocery store. Experience with chicken femurs in BE 210 Experiment 4 has produced results such as bone **stiffness of 0.08113±0.01882 kN/mm.**

11. Optimizing your Spray system by spraying systems co.

To achieve long-term, efficient, optimal performance and keep operating costs as low as possible, you need to consider your spray system in its entirety and develop a plan for evaluating, monitoring and maintaining it. If you don't already have a spray system optimization program in place, you could be wasting significant amounts of chemicals, water, energy and time and risking process and product quality

12. A TIG Welding Process- A Review Paper by Bhavin Shah, Bhavik Shah

The Tungsten Inert Gas (TIG) welding process (or GTAW) is used when a good weld appearance and a high quality of the weld are required. TIG welding helps in increasing the depth of penetration in single pass and to also increase depth to width ratio of the weld pool, thereby increasing the productivity of the process and also it helps in achieving better mechanical properties.

13. DC Geared motor by TSUKASA ELECTRIC CO.,Ltd

The relationship between torque vs. speed and current is linear as the load on a motor increases, speed will decrease. A DC motor can be used at a voltage lower than the rated voltage. Speed reduction by means of a gear box results in increased torque. The reduction/increase is determined by the gear ratio and efficiency of the gear box.

2.2 Overview

- Composting in its natural form generally takes about 50 days. Using Bioculum we can achieve the same in 21 days.
- Anaerobic composting takes 10 times more time when compared with aerobic composting.
- Due to the respiration of the microbes the temperature raises up to 60-70ºC. For faster decomposition the temperature range should be brought around 25-35°C.
- When microbes act on the organic waste it generates ammonia which has a pungent odour.
- Shredding of organic waste gives larger surface area for the microbes to act hence decreasing the time for composting.
- Continuous circulation of air is essential for faster rate of decomposition.
- The strength required to break a chicken Bone is 275.8Mpa.

- Vertical shredders are used since it doesn't need pre-sorting and waste can be fed at any point of time.
- Since the composting chamber might react with the organic waste and biocolum to release harmful toxins which might further result in Bio-Magnification, stainless steel of food grade can be used to reduce this risk to a large extent
- VDC Motor can deliver higher torque or higher speed based on necessity by changing the amount of voltage supplied to the motor with the help of drive.
- Arduino series micro-controller can be used to do the required automation work. Since it uses embedded C it's easy to program the controller.

CHAPTER 3

PROBLEM DEFINITION

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PROBLEM DEFINITION

Organic waste takes a whopping 50 days in order to get converted into compost under untampered condition. With the use of bioculum, the organic waste turns into compost within 21 days. This project mainly aims in cutting down the lead time required for the composting process.

3.1 Problems related to shredding

- To cut-down the lead time for the process of composting, the process of shredding plays a vital role. As it provides larger surface area for the microbes to act on thereby increasing the speed of the composting process drastically.
- The organic waste must be shredded approximately from larger sizes to 0.5 to 1.5 centimeters to make the process more efficient.
- The process of organic decomposition releases ions which can react with the shredding chamber therefore a food grade material has to be selected for maximum efficiency.
- The blade must have the capacity to cut small chicken bones and hence must have the capacity to bear a force of not less than 275.8MPa.

3.2 Problems related to stirring

- This project uses aerobic decomposition process and hence sufficient amount of air is required for faster decomposition.
- The shaft and the blade must act as a stirrer for the proper circulation of air, there must be no separate arrangement for the purpose of stirring due to space and economic constraints.

3.3 Problems related to temperature control

- For efficient working of microbes, two major requirements are air and surrounding temperature. The microbes were more efficient under the temperature ranging from 27 to 35 degree Celsius.
- During the process of decomposition the temperature rises above 35 degree Celsius, therefore the temperature must be brought down for efficient working.
- The temperature control module must be an automated process as it must be user friendly.
- This project uses an atomizer to cut-down the temperature; therefore a drain arrangement must be incorporated to drain the sprayed water.

3.4 Problems related to chemical catalyst and odour

- In order to cut down the lead time chemical catalyst such as bioculum must be used.
- The bioculum solution which is mixed with water must be sprayed using a spray mechanism into the composting chamber to receive efficient output.
- The process of decomposition releases bad odour therefore an herbal solution of sanitreat must be used in order to cancel out the bad odour.
- The sanitreat solution must be sprayed using a spray mechanism into the composting chamber.
- The spray mechanism for both bioculum and sanitreat solution must be automated at regular interval of time to attain maximum efficiency.

3.5 General problems

- The completed product must be poured from the composting chamber into the storage box; therefore there is a requirement of an opening and closing mechanism at the bottom of the composting chamber.
- The motor must run at two different speeds as the blade shaft performs dual operation such as shredding and stirring.

CHAPTER 4

METHODOLOGY

CHAPTER 4

METHODOLOGY

4.1 Technologies used

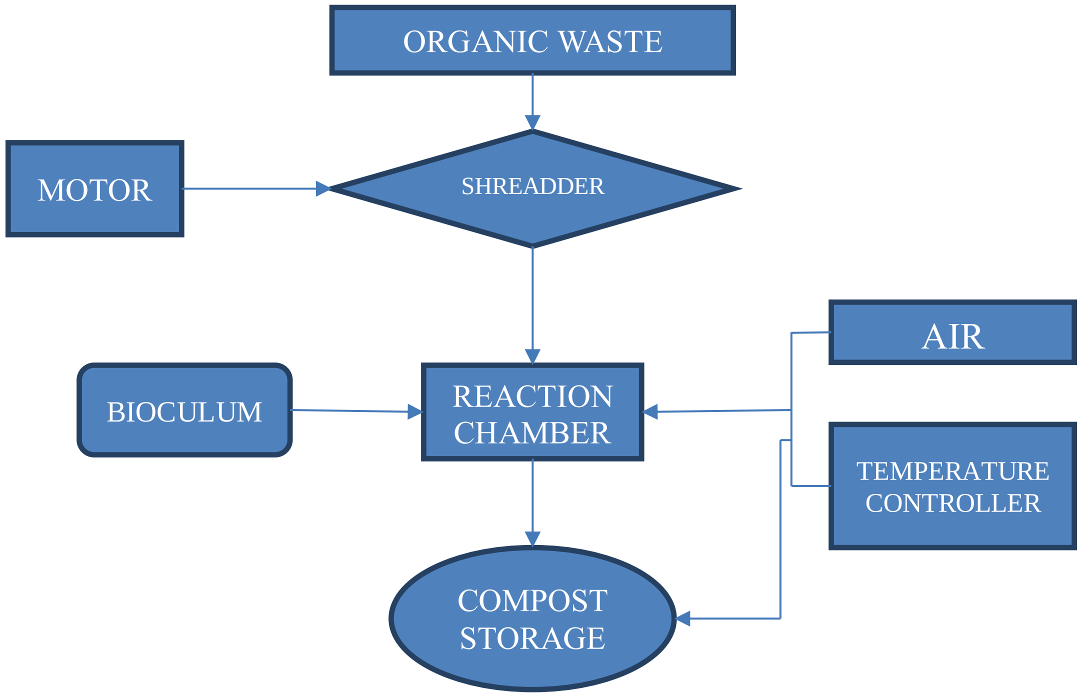

Fig 4.1 Flowchart table representing technologies used.

- The organic waste will be first fed into the shredder where the waste will be converted into finer particles.
- As soon as the process of shredding completes the spraying of the bioculum and sanitreat will get initiated.
- The blade after shredding will act as a stirrer with 10rpm so as to facilitate the continuous circulation of air which is required for the aerobic composting.
- A temperature control system is installed which initiates the automiser and a fan when the temperature increases above 28 degree Celsius.

4.2 Project process

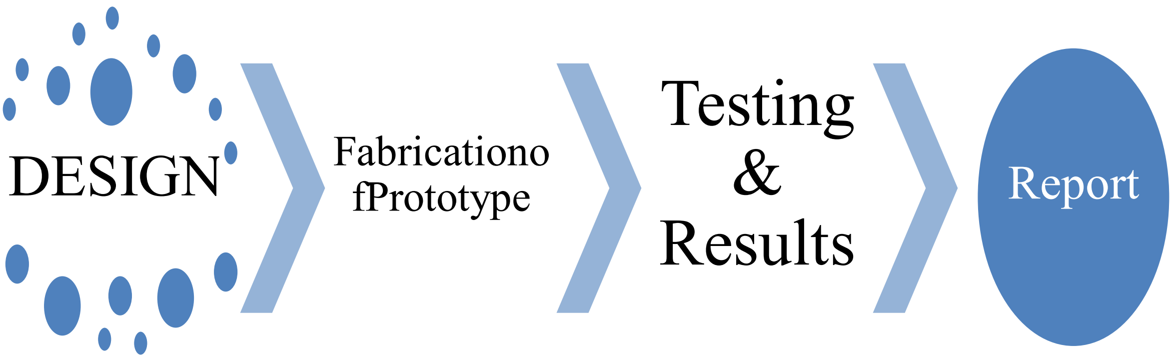

Fig 4.2 Project process flowchart

4.2.1 Design

- The design of the blade and the cabinet done after iterations as there were no previous reference. Several iterations were performed in order to select the optimal design.
- The shredder was designed so as to be compact and compatible with the blade design.

4.2.2 Fabrication

- Arduino Uno is used to automate the process of spray mechanism and temperature control system.
- Manufacturing blade and constructing cylinder is made of stainless steelbecause the material is non-reactive with the reaction.
- Constructing three tanks with food grade plastic with three submersible pumps.

4.2.3 Testing and results

- Stress and fluid flow analysis of blade design comparing the NPK values of compost.
- The analysis of the blade was done in ansys keeping in mind all the consideration.

CHAPTER 5

EXPERIMENTAL PROCESS

CHAPTER 5

EXPERIMENTAL PROCESS

5.1 Design of Shredder blades

The blade was designed based solely on three purposes

1. The pre-compost had to be shredded to a size of 50-150mm.
2. The pre-compost needed to mixed will with both bioculum and sanitreat.
3. To incorporate air within the pre-compost by stirring, as the composting process was aerobic as mentioned above.

To accomplish this blade design was done in several iterations. There was no initial drawing or a blueprint to with the design could be based on. Thus the initial design was a collective idea from all the available shredders in the market.

The next step in designing of the blade was that it needed to mix the mixture of pre-compost and a combination of bioculum and sanitreat. To achieve these blades were given a certain degree of inclination. The pre-compost may consist of very hard materials such as small chicken bones, thus must be able to withstand the load of cutting it.

The pre-compost needed to aerated so as to provide the microbes the necessary air to accelerate the composting process. The blade is designed in such a way to facilitate this process.

The modeling of blades was done under in three iterations. In each iteration, the best feature was selected was carried on to the next iteration until a design that was ideal and which suffices all the required purpose was obtained.

The modeling was done in CATIA V5 software. It chosen was its was familiar, easy to work with and good interface. The modeling of the blade in each iteration was carried out in this software.

The following shows the sets of iterations of blade design;

5.1.1 Iteration I

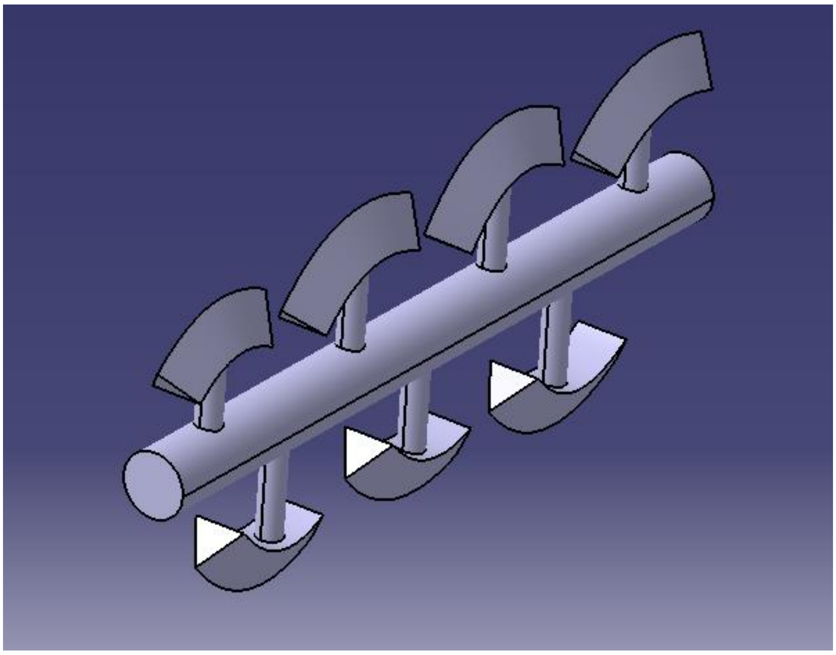

Fig 5.1: Isometric view

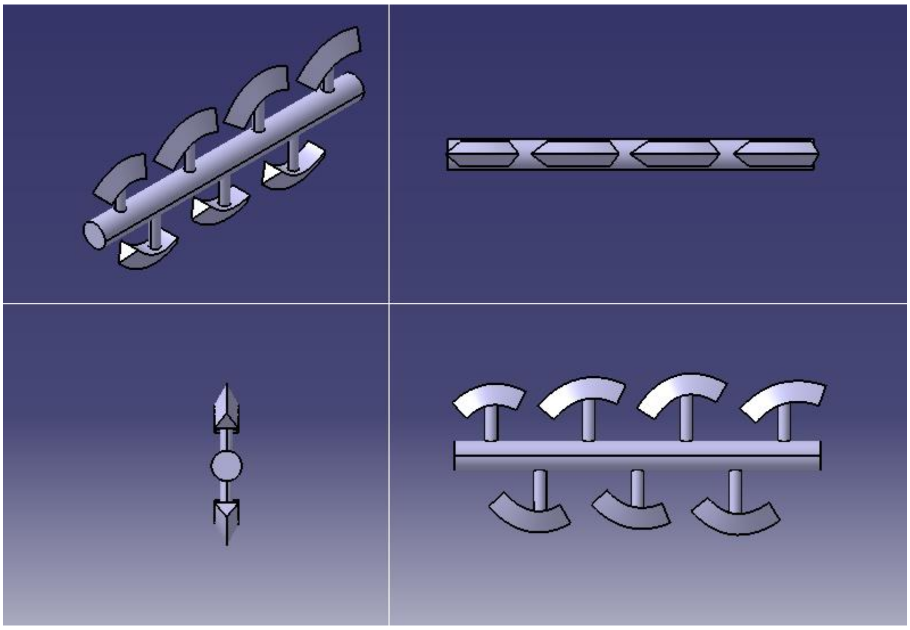

Fig 5.2: Four views of the blade along with the shaft

In this model, the major flaws was that the material wasn't being shredded into desired size also no proper mixing of compost.

5.1.2 Iteration II

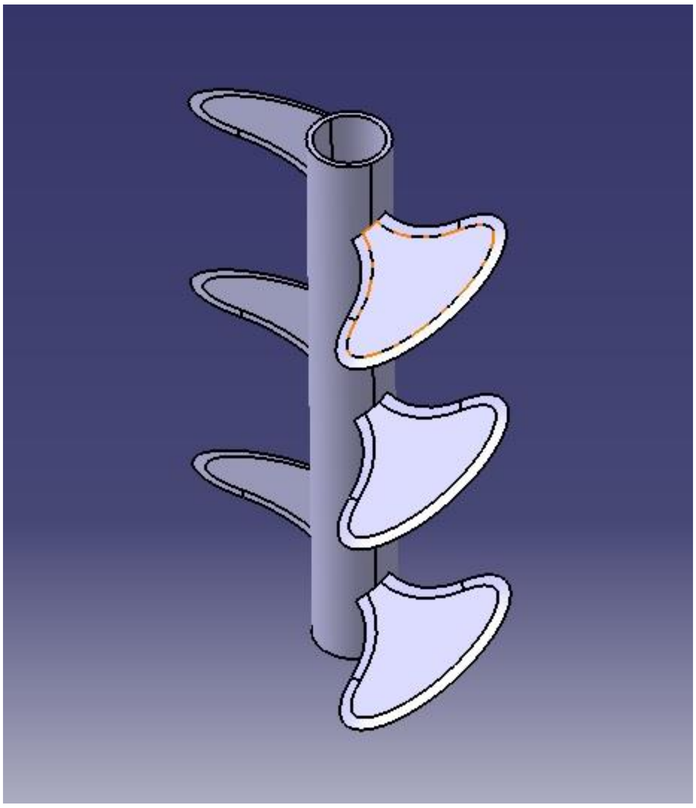

Fig 5.3 Isometric view

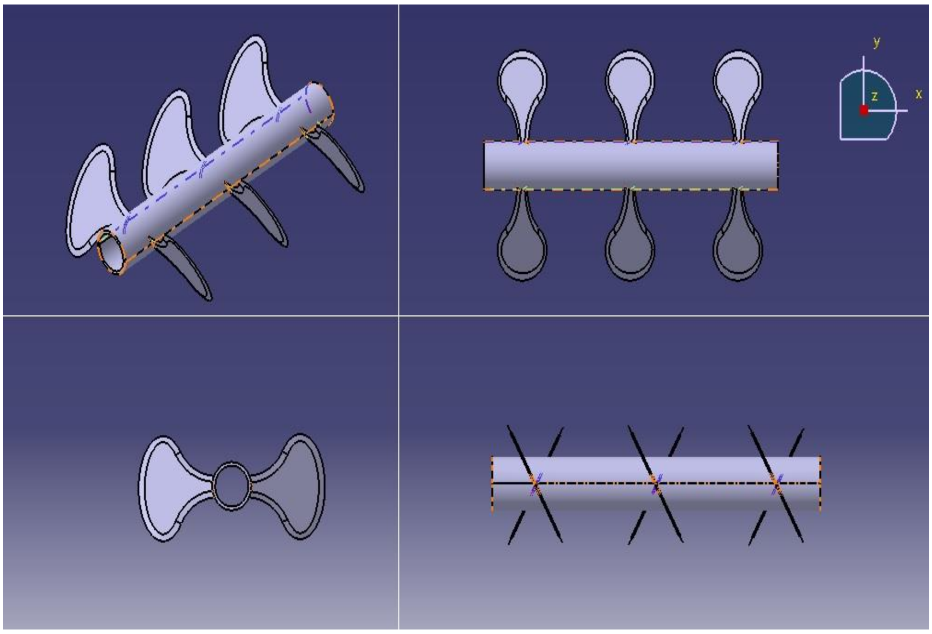

Fig 5.4 Four views of the blade along with the shaft

In this model, there was sufficient shredding action, but no proper mixing of the compost

5.1.3 Iteration III

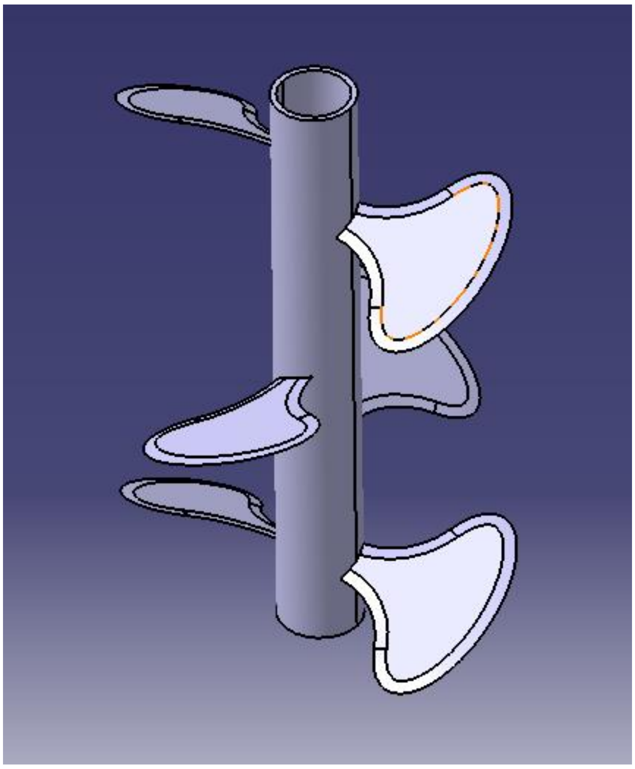

Fig 5.5 Isometric view

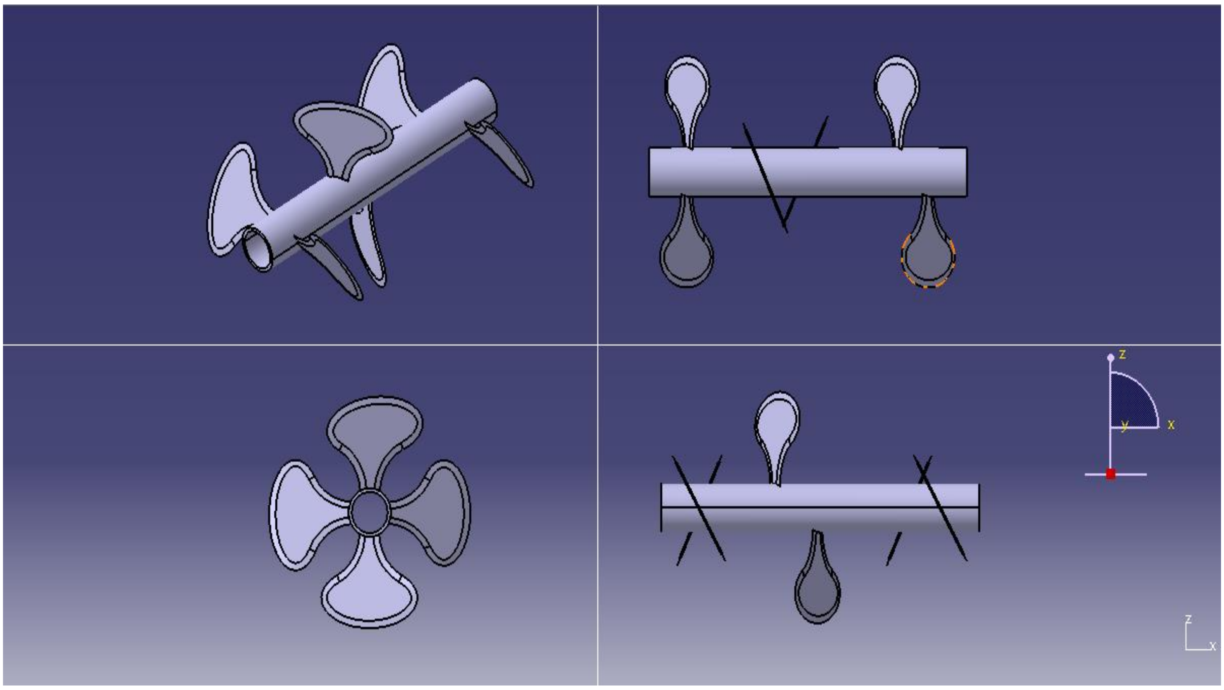

Fig 5.6 Four views of the blade along with the shaft

Proper shredding and mixing was noted in this model, thus selected.

5.2 Selection of blade design among iterations

In iteration I the blade did not efficiently shred the waste matter into required size and no adequate mixing capabilities of the blade, thus this design needed to be improved in all the specifications so to perform in the required manner. This led to re-designing of the blade to iteration II. In this iteration, the blade was efficient enough to shred the pre-compost into the required size but unable to achieve proper mixing of the bioculum as well sanitreat into the pre-compost. It was also moderate aerator. Hence this blade design needed to be changed. The iteration III, with its new placement of blades and the new angle in blade inclination proved efficient in all aspects of the conditions, namely.

1. The blades shredded the pre-compost into the desired size.
2. Proper mixing of bioculum and Sanitreat with the pre-compost.
3. Sufficient aeration of the pre-compost.

5.2.1 Specifications of the shredder

Table 5.1 Shredder specification table

Specifications	**Dimensions**
Length of the shaft	300mm
The outer diameter of the shaft	40mm
The inner diameter of the shaft	36mm
The thickness of the blades	1.5mm
Number of blades on the shaft	6
The angle of the blade with respect to the shaft	30^0
Length of shredder cylinder	300mm
The diameter of the shredder cylinder	200mm
Volume of cylinder	$9.42*10^6 mm^3$

5.3 Analysis of the blade design

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. A static structural load can be performed using the ANSYS. The iteration III blade which had satisfied all the conditions was to be tested for its structural integrity at high speeds and also its load bearing capacity.

5.3.1 Specification considered for analysis.

Table 5.2 Considered specification for analysis

Specifications	**Unit**
Material considered	Stainless steel grade 316
Load applied	300MPa
Density of material	8mg/cm^3
Bulk modulus	140GPa
Elastic limit	580MPa

5.4 Construction of shredder blades

The material of choice from which was stainless steel grade 316. A sheet of 1.5mm was laid out on the precision laser cutting machine's workbench. The pattern for the blade design was drafted from the 3D model designed earlier. The pattern was then entered to the laser cutting machine, which cut the sheet as per the pattern.

The blades once cut to the required dimension by the precision laser machine was taken out of the workbench then sent grinding process. In the process, the blades were given an edge to give a required cutting edge on the blade. The blades were sent into the cleaning process to remove any oil and dirt residues, and to prepare it for the next process.

The shaft material selected was also stainless steel grade 316. A pipe of dimensions 40mm external diameter and 36mm internal diameter was cut into a length of 300mm.

The blade and the shafts were TiG welded as represented in the 3D model. The blades were first tag welded into place, later welded without seams to form a perfect and strong weld.

Fig 5.7 Construction of shredder blade

5.5 Nozzle spray test

The bioculum and sanitreat need to be sprayed into the shredder tank for fast and odorless composting. The reagents are pumped for the holding tank via a submersible pump to the nozzle of the atomizer. The liquid is then atomized and then sprayed on to the pre-compost in the shredding tank. The amount of material needed to be specific so that no excess reagents are sprayed on the pre-compost. The atomizer was tested by running it for duration of time. The collected samples were then dried and the remaining dry powder was weighed to analyze the number of reagents being sprayed upon the pre-compost.

The test was done in several iterations and the samples were analyzed. The table below represents the systematic testing done under controlled conditions.

Table 5.3 Optimization of spray mechanism

Trail number	**Duration (sec)**	**Amount of Bioculum sprayed**	**Amount of Sanitreat sprayed**
1.	3	1.8g	2.1g
2.	7	3.2g	4.5g
3.	9	5.6g	6.8g
4.	10	7.3g	7.5g
5.	12	9.7g	10.3g

5.6 Compost observation

Once the organic kitchen is shredded into the required size by the shredder blades, the waste is then sprayed upon with bioculum and sanitreat, the waste is called a pre-compost. This pre-compost should be aerated periodically and it needed to be maintained at ambient temperature so as to boost or amplify the composting action of the microbes present in the pre-compost.

The pre-compost was observed for several days, the observation of the same is given below.

i. **Day one:** there is no change in the color of compost when compared to earlier pre-compost. High moisture content.
ii. **Day two:** aslight change in color of compost, no change in moisture content.
iii. **Day three:** thecolor of compost remains the same, decrease in moisture content. A slight change in texture.
iv. **Day four:** thecolor of the compost gets darker, decrease in moisture content. No change in texture.
v. **Day five:**thecolor of the compost is light brown, a decrease in moisture content. Change in texture.
vi. **Day six:** color and texture of the compost similar to that available in the market, no change in moisture content.

Once the compost generated by the unit reached the color and texture similarities to the compost available in the market, the compost was sent to testing.

Thus ensuring the compost produced is up to the standards set by the Fertilizer Control Order 1985, revised in 2018.

5.7 Compost analysis

The compost once visually analyzed, had to be tested for its nutritional values and its maturity. The quality of the compost is tested against the standards based on the Fertilizer Control Organization 1985, quality control of biological inputs in India. This is crucial as immature or improperly formed compost in very harmful.

5.7.1 Effects of immature compost

1. Biological blockage of available nitrogen by the microbial population
2. Decrease in oxygen concentration.
3. Presence of even small quantity of ammonia is toxic to the roots.
4. Presence of organic acids is also the cause of photo toxicity.

Thus it is vital that the compost produced doesn't have any of the about stated harmful and ill effects.

5.7.2 Different Physical, chemical and biological tests for nutritional value and maturity of the compost

1. **Physical tests :**

   The physical methods are of general importance and can be tested by easy means. These include temperature, odor, texture, and color. Good compost should have a constant temperature, should not have any unpleasant odor.

2. **Biochemical tests :**

   The C/N ratio below 20 is indicative of compost maturity and a ratio of less than 15 is preferable. Also, the available nitrogen, phosphorous (P_2O_5), potassium (K_2O) should be less than 0.5%. The conductivity of the compost should not be more than 4.0 dsm-1. pH is also considered as a good indicator of good compost. The optimal value of the compost is between 7-8.

3. **Biological tests :**

   The compost should be free from phototoxic compounds and should be tested for the same, to ensure the efficacy of the compost for specific usage and should generally not be extrapolated to other different conditions.

CHAPTER 6

RESULTS

CHAPTER 6

RESULTS

6.1 Analysis of blade design

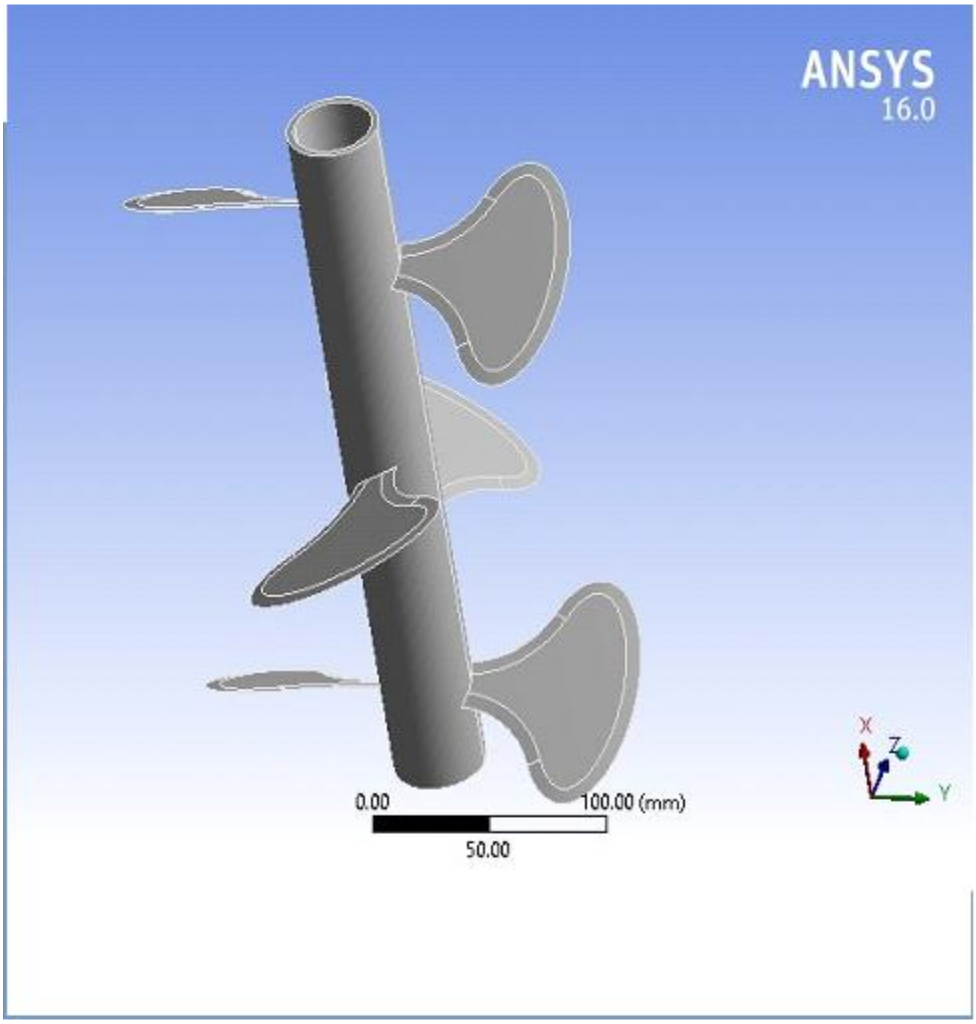

Fig 6.1 Model used in Ansys

The above model was used to conduct all the necessary analytic tests to determine the rigidity and structural integrity of the design. The model used was the Iteration III, as it was the chosen design due to its design specifications.

Table 6.1 Units used for analysis

Unit System	Metric (mm, dat, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s

6.1.1 Statistics

Table 6.2 Statistics tabulation

Bodies	1
Active Bodies	1
Nodes	46688
Elements	23027
Mesh Metric	None

6.1.2 Boundary conditions

Table 6.3 Boundary conditions

Length X	300mm
Length Y	190mm
Length Z	190mm
Volume	$9.42*10^6 mm^3$

6.1.3 Materials properties

Table 6.4 Materials properties

Material considered	Stainless steel grade 316
Density of material	$8 mg/cm^3$
Elastic limit	580MPa

6.1.4 Analysis

Table 6.5 Analysis tabulation

Physics type	Structural
Analysis type	Static structural
Environment temperature	27^0 C
Physics reference	Mechanical

6.1.5 Load distribution

Table 6.6 Load distribution

Force	300MPa
X component	-300MPa (ramped)
Y component	0 (ramped)
Z component	0 (ramped)

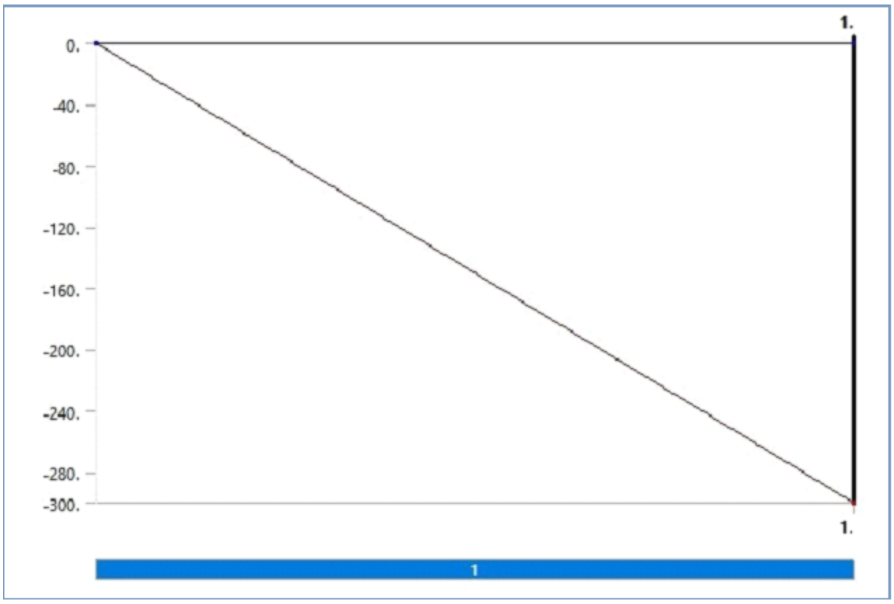

Fig 6.2 Static structural loading.

The graph shows steady loading on the model.

6.1.6 Results of the analysis

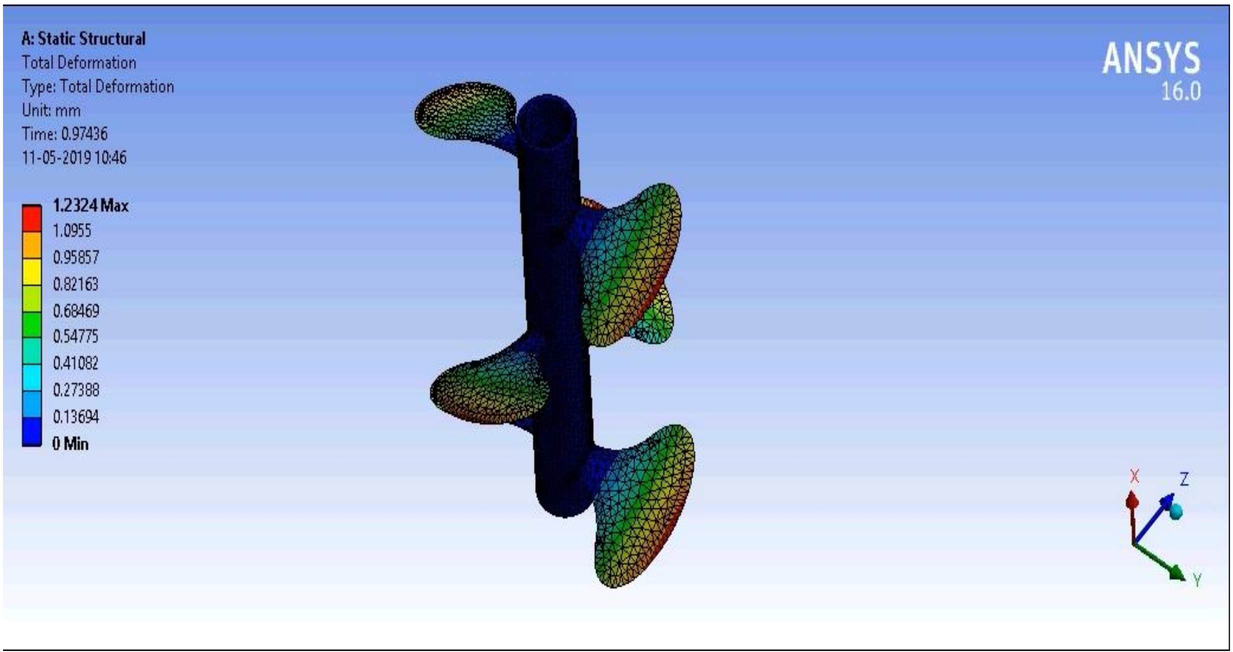

Fig 6.3 Total deformation.

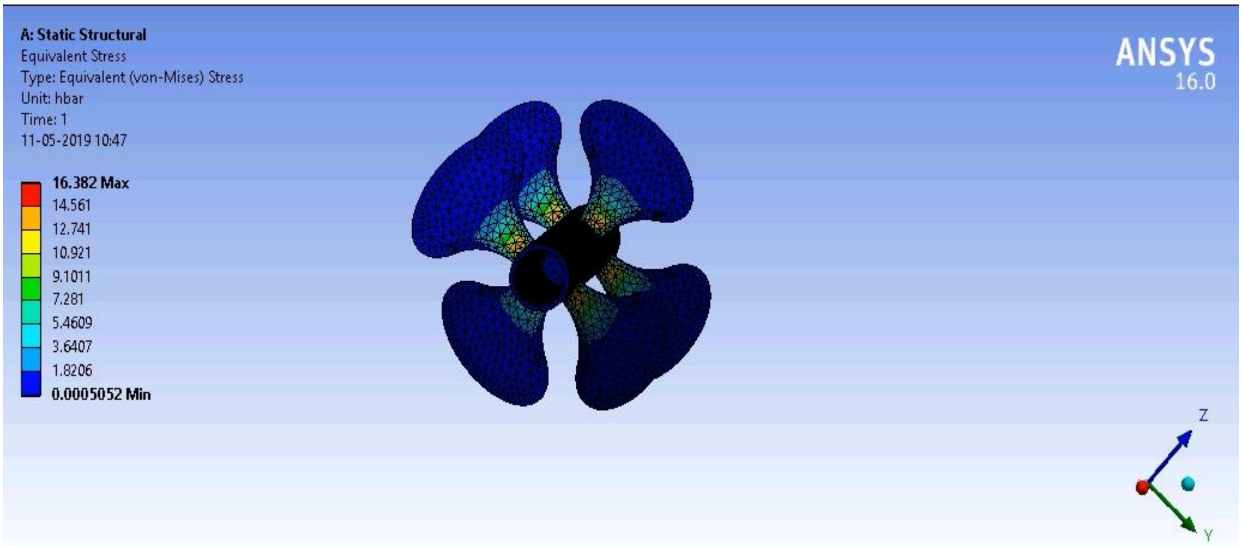

Fig 6.4 Equivalent stress.

From the figures 6.1.6 (a) and 6.1.6 (b), it can be concluded that the blade design is structurally sound. The blade can withstand static loading up to 300MPa with a slight deformation of 1.0955mm. The deformation occurs at the edge of the blade due to the shredding action.

6.2 Shredding of organic waste

The shredder blade needed to be tested for its efficacy in shredding the organic waste into size varying from 50mm to 150mm. To test this, a cabbage was places inside the shredder and shredded for about 3mins. The results were as expected. The cabbage was finely shredded into the desired size as shown in fig 6.2.

Fig 6.5 Shredded cabbage

6.3 Nozzle test result

Considering that the average pre-composts weighs around 700-800gms, the required amount of bioculum and sanitreat to facilitate the composting process were to be calculated to be 7gms and 4gms. From observing the table, it was observed that spraying the nozzle for 10seconds in case of bioculum and 7 seconds in case of sanitreat were sufficient in dispersing the required of reagents into the shredding chamber.

6.4 Nutritional value of compost from tests

SNEHA TEST HOUSE

NABL Accredited Laboratory

TEST CERTIFICATE

TC-8309

8 & 28, 4th Cross, Maruthi Nagar, Chandra Layout, 80 Feet Road, Nagarbhavi, Bengaluru - 560 072
Phone : 23390341, 23390737, 23180113
Mobile : 9611324429
E-mail : lab.snehatesthouse@gmail.com
snehahitechproducts@gmail.com
snehanagaraj09@gmail.com
Web : www.sthlab.com

CHEMICAL TESTING

Report No: URL:	TC830919000002447P		
Issued To:	DESIGN AND CONSTRUCTION OF AN INTEGRATED DOMESTIC ORGANIC WASTE COMPOSTING		
Nature of sample:	ORGANIC COMPOST	Sample receipt date:	11.05.2019
Condition of Sample:	Good	Start of analysis date:	11.05.2019
Sample package:	PLASTIC COVER	Completion Date:	13.05.2019
Date of Sampling:	11.05.2019	Report Date:	13.05.2019
Sample collected by:	By Customer	Sampling Protocol No:	NA

TEST PARAMETER	UNITS	RESULTS	LIMITS	TEST METHOD
Organic Carbon	%	20.5	>14.0	FCO 1985:2018 PART D
Available Nitrogen	%	1.8	>0.5	FCO 1985:2018 PART D
Available Phosphorus as P_2O_5	%	1.5	>0.5	FCO 1985:2018 PART D
Available Potassium as K_2O	%	2.6	>0.5	FCO 1985:2018 PART D
C:N ratio	---	11.4	<20.0	FCO 1985:2018 PART D
pH	---	7.1	6.5-7.5	FCO 1985:2018 PART D

Remarks: The given sample meets the limit of FCO 1985: Reaffirmed on Feb 2018 Standards.

Verified By

Authorised Signatory

NARAJ C.E.O

NOTE :
1. Test results refer only to the tested samples and applicable. 2. The Sample will be preserved for a maximum of 10 days on request.
3. This Certificate shall not be reproduce in part or full and cannot be used as evidence in court of law without prior permission in writing.
4. Total liability of our laboratory is limited to the invoice amount. 5. Sample (s) not drawn by us unless otherwise stated.

Fig 6.6 Test Report

The test was conducted at the Sneha test house which is a NABL accredited laboratory. All the tests per preformed to be in accordance to standard norms. As per the test report (fig 6.4) the organic carbon value was to be 20.5%, available nitrogen phosphorous potassium was found to be 1.8% 1.5% and 2.6% respectively. The C:N ratio was found to be 11.4. The pH was stated to be neutral (7.1).

1. Physical test results

The color, moisture and texture had reached to the necessary condition, thus allowing it move on to the next tests.

2. Biochemical test results

The compost was sent for testing to lab accreted to prestigious NABL, thus proving to its authenticity and accurate results. The compost met all the necessary requirements and passed the tests. All the parameters of the compost are well within the range; hence the sample meets the limits set by the FERTILIZER CONTROL ORDER (FCO) 1985, revised in 2018.

3. Biological tests

The compost showed no signs of photo toxicity, thus passing in this parameter.

The above tests shows that the compost produced by the device meets the market standards and is a quality product, which is safe and beneficial to the environment and the society.

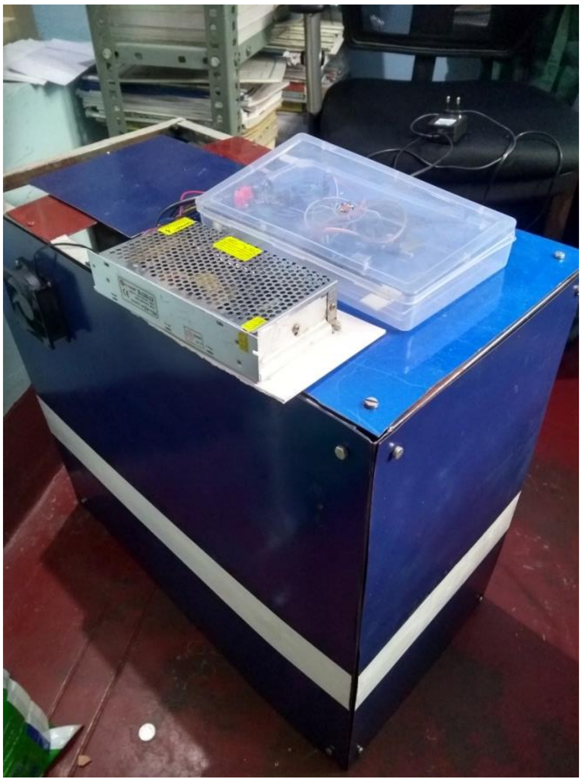

Fig 6.7 Completed isometric view of the device

Fig 6.8 Completed side view of the device

Figure 6.7 and 6.8 are the images of the final assembly along with all the necessary electronic automation and circuits.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 Conclusion

The blade that was designed and fabricated meets the requirement in the field of strength, shredding capacity and stirring process as seen in the analysis of the blades. The temperature control system is under proper working condition which reduces the temperature to required and optimum temperature. The spray mechanism used for the spraying of the bioculum and sanitreat works perfectly as required and sprays the required amount of the respective amount of the solution.

The aerobic composting process usually takes 50 days to convert organic waste into compost, with the use of bioculum the process time can be cut down to 21days. The process of shredding helps speed up the same process, the temperature control system helps the microbes to act faster and reduce the composting process. The lead time of the composting process can be cut down with the use of shredding process, temperature control and the use of bioculum from a whopping 21 days to 6 days.

With the use of three technologies the project has become a success. The aim of the project has been achieved successfully by cutting down the lead time for the process of composting to 6 days.

7.2 Scope for future work

7.2.1 Generation of electricity

As renewable energy sources gain more traction, transforming organic waste into electricity is becoming more popular. When the composting process is performed under controlled environment the generation of electricity can be made possible. The process of electricity generation can be done in several ways among them are the limited supply of oxygen method where the limited supply of oxygen helps generation of methane which can further be converted into electricity.

7.2.2 The use of GSM modules

The use of GSM modules can be implemented in order to easy the operating of the said device, where the GSM modules will help the user to have a remote accesses to the device, once the storage box is filled with the compost a message can be sent to the user to empty the storage box thereby increasing the efficiency of the device.

7.2.3 Automating the chute mechanism

The chute mechanism from in the device is manual as of now which can be automated with the use of weight sensors and the Arduino which can work under the limitation of time. The using of automated chutes helps in the manual work required for the running of the device thereby increasing the efficiency and easing the manual work required.

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