CONCEPTUAL DESIGN OF A KITCHEN FOOD WASTE COMPOSTER

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DECLARATION

I declare that this project entitled "Conceptual Design of A Kitchen Food Waste Composter" is the result of my own work except as cited in the reference.

Signature :.....
Name :.....
Date :.....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : ……..

Supervisor's Name : ……..

Date : ……..

ABSTRACT

This report details the conception and design of a kitchen food waste composter to improve the kitchen food waste management in Malaysia. The current solid waste management system in which most of the waste generated goes to landfills is non-environmentally friendly and is inadequate to handle the drastic increase in the food waste generation. Therefore, the aims of this report are to conceptually design a kitchen food waste composter using theoretical formula, to model the kitchen food waste composter using CATIA software and to perform finite element analysis on the designed kitchen food waste composter. Research are carried out on developing operating conditions such as composting temperature and capacity for an ideal composting process as well as determining suitable operating mechanisms for maximum performance of the kitchen food waste composter. A kitchen food waste composter is formed with major working mechanisms which includes shredding and composting processes with automated interval mixing mechanism. The morphological chart and PUGH method are implemented for design generation and evaluation of the kitchen food waste composter. The positive outcome of this report is recommended to be applied in Malaysia as an alternative for handling food waste at household level and reducing the impact of food waste to the environment.

ABSTRAK

Laporan ini memperincikan konsep dan reka bentuk alat pengomposan sisa makanan dapur untuk menambahbaik kaedah pengurusan sisa makanan dapur di Malaysia. Sistem pengurusan sisa pepejal semasa di mana sebahagian besar sampah yang dihasilkan ditanam di tapak pelupusan sampah adalah tidak mesra alam dan tidak mencukupi untuk menangani peningkatan pengeluaran sisa makanan secara drastik. Oleh itu, tujuan laporan ini adalah untuk merancang konsep alat pengomposan sisa makanan dapur dengan menggunakan formula teori, untuk memodelkan alat pengomposan sisa makanan dapur menggunakan perisian CATIA dan melakukan analisis elemen hingga pada alat pengomposan sisa makanan dapur yang direka. Penyelidikan dilakukan untuk mengetahui keadaan operasi yang sesuai untuk proses pengomposan yang ideal seperti suhu dan kapasiti alat pengomposan serta untuk menentukan mekanisme operasi yang sesuai untuk prestasi maksimum pengomposan sisa makanan dapur. Alat pengomposan sisa makanan dapur adalah terdiri daripada mekanisme kerja utama yang merangkumi proses pencincangan dan pengomposan dengan mekanisme pencampuran selang automatik. Carta morfologi dan kaedah PUGH dilaksanakan untuk penghasilan dan penilaian reka bentuk alat pengomposan sisa makanan dapur. Hasil positif dari laporan ini disarankan untuk diterapkan di Malaysia sebagai alternatif untuk menangani sisa makanan pada peringkat isi rumah dan mengurangkan kesan negatif penghasilan sisa makanan terhadap alam sekitar.

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QFD	Quality Function Deployment
HOQ	House of Quality
FEA	Finite Element Analysis
EPA	Environmental Protection Agency

LIST OF SYMBOLS

π	=	a mathematical constant which approximately equals to 3.14159
r	=	inner radius of the cylinder
h	=	height of the cylinder
T	=	force moment to rotate the composting chamber about an axis
F	=	force which equals to the mass of composting capacity
ω	=	angular displacement per unit of time
N	=	number of revolutions
P	=	power consumption of motor
P	=	yield stress of kitchen food waste
Q	=	heat generated
M	=	mass of the heating coil
C	=	Specific heat capacity of air
T_s	=	force moment to rotate the shredder blade about an axis
T_1	=	initial temperature of heating coil
T_2	=	final temperature of heating coil
ρ	=	Density of the Nickel-Chromium heating coil (1.225 kg/ m^3)
V	=	Volume of the Nickel-Chromium heating coil
A_s	=	cross-sectional area of shredder blade
F_s	=	force required to overcome the yield strength of a bovine trabecular bone

r_s	=	radial distance from centre point to the tip of the shredder blade
T_m	=	torque needed to operate the motor at a constant velocity
r_1	=	driver pulley radius
F_a	=	total axial force to move the loads
η	=	efficiency of belt drive system
m	=	total mass of external loads and belts
g	=	gravitational acceleration
μ	=	coefficient of friction
m_f	=	mass of kitchen food waste
F_f	=	distributed force due to the mass of the kitchen food waste

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Solid waste is always one of the major environmental problems and concerns throughout the world in order to ensure the sustainability of nature and life within its capacity. In 2018, the amount of solid waste generated by Malaysians recorded a total of 38, 142 tonnes per day, which is nearly doubled of 2005 with a figure of 19, 000 tonnes waste generated daily. Out of the solid waste collected, food waste was the largest composition which comprised 44.5 % of the total amount (Mohd Pauze, 2019). As food waste are produced in various levels of the food systems such as farming, processing, transporting, retailing, cooking and consuming, the increasing trend of food waste produced should be controlled and reduced as the decomposing of these organic waste will emit greenhouse gases such as methane which in turn contributes as the main cause of the changes in climate (Anon., 2017). However, the standards of waste management in Malaysia still have a long way to be improved despite the massive amount of waste generated (Anon., 2019). Thus, the main intention and commitment of this project is to design a kitchen food waste composter as an alternative to help in decomposing and utilising the massive amount of food waste generated as well as to reduce the impact of food waste on the environment.

A composting process is a process where biodegradable waste breaks down into organic materials to be recycled and reused in organic farming, gardens, urban agriculture and horticulture. For a composting process to start, the fundamental requirements are air and water supply, optimum temperature and presence of microorganisms which is often found in the soil as shown in Figure 1.1. However, organic matters will decompose naturally on its own instantly as they are generated whether or not they are composted under human control. This is because the soil insects such as earthworms and ant break down the organic matters into smaller particles, therefore increasing the microbial degradation by having a larger surface area exposure. However, human-controlled composting process with absence of soil insects is often facilitated by manual breaking down of particles through grinding, chopping or mashing. With proper regulation and optimisation of human-controlled composting process, a higher efficiency of composting process can be achieved, thus producing end product with desirable level of nutrient content (Chen, L., de Haro Marti, M., Moore, A., & Falen, C, 2011).

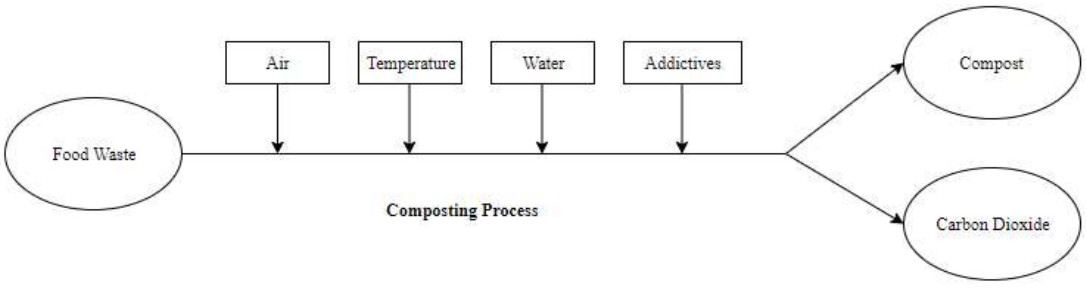

Figure 1.1: Fundamental requirements of natural composting process

Composting is an alternative solid waste management system (Gonawala, Suhas & Jardosh, Hemali, 2018). A kitchen food waste composter is designed to provide a food

waste recycling system at household level by composting food waste like eggshells and vegetable food scraps into nutrient rich compost to be used in gardening and plantation. There is limited kitchen food waste composter to be found in the current market especially in Malaysia. Two products of kitchen food waste composter launched in the market are the Food Recycler FC-30 as shown in Figure 1.2 and the Zera Food Recycler as shown in Figure 1.3. Both of these products are from United States. FC-30 is smaller in size with height of 14" and lighter in weight of 20 lbs compared to the Zera Food Recycler with 33.75" of height, weighing at 125 lbs. From Figure 1.2, it can be seen that FC-30 is designed to use the same bin for the food waste storage and composting chamber which is removable from the product body itself while from Figure 1.3, food waste enters Zera Food Recycler from the top into its composting chamber and the compost is to be collected from the smaller collection bin at its bottom. FC-30 requires no venting, draining or additives to commence the composting process while Zera Food Recycler requires venting and additives to begin the composting process. Both of these products are designed to be kept indoor throughout the composting process. FC-30 is more beneficial in space saving, while Zera Food Recycler is better in providing a higher composting capacity.

Figure 1.2: Food Recycler FC-30

Figure 1.3: Zera Food Recycler

Generally, the main components of a kitchen food waste composter includes a starter chamber where food waste is placed, a composting chamber where the composting takes place, a mixing blade to shred the food waste into smaller pieces for faster composting process and a collection bin where the completed compost is collected. Meanwhile, an installation of motor on the composter is optional based on the design of the composter whether to operate manually by manpower or to run automatically based on electricity supply.

1.2 PROBLEM STATEMENT

In Malaysia, the amount of solid waste produced has been increasing drastically over the years due to the increase of population and economical activities. Of the solid waste generated, food waste was the largest composition. However, the standards of waste management systems in Malaysia are still poor to manage the massive amount of waste produced. In addition, the high amount of food waste could be the main cause of global warming and climate change as the greenhouse gases emitted behave as heat trapping gases within the ozone layer. Therefore, the aim of this project is to design a kitchen food