DESIGN AND DEVELOPMENT OF FOOD WASTE COMPACTOR

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DECLARATION

I hereby declare that the work in this report is of my own except for summaries and quotations which have been duly acknowledged.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion, this report is sufficient in terms of scope and quality for the award of the degree of.

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Dedicated to my beloved family

ABSTRACT

Increasing effects of global warming could be easily traced throughout the continents. Natural disasters such as tsunamis, hurricanes and earthquakes are flooding the world news each day. Sadly, human race is the main contributor of global warming but there is always a silver lining, human is also the only solution to the global warming problem. Food waste produced by human is one of the major reasons of global warming because the food waste released methane gas, a type of greenhouse gas, and the a amount of energy needed to process the food waste starting from houses and restaurants until landfills is staggering, making it dangerous to the environment. Thus, by controlling the amount of food waste thrown away will greatly reduce the effects of global warming. The main rational of this project is to help reduce the amount of food waste that ends up in landfills by compressing the food waste into a more manageable form so it could be used as compost or livestock feed for example. In this project, five concepts for the food waste compactor that suits the customers demand, shown using the Product Design Specification (PDS), are generated and then, the best design is chosen by concept selection method. Then, final design undergoes structural analysis to see the structure reaction under practical application. Finally, prototype is fabricated for the sake of testing its working principle.

ABSTRAK

Kesan dari pemanasan global boleh dilihat di seluruh pelusuk benua, di mana bencana alam seperti tsunami, ribut taufan dan gempa bumi dilihat sentiasa memenuhi berita-berita dunia tiap-tiap hari. Umat manusia adalah penyebab utama pemanasan global tetapi, berita positif dari fakta tersebut adalah manusia juga merupakan satu-satunya jalan penyelesaian bagi masalah pemanasan global ini. Sisa makanan yang dihasilkan oleh manusia merupakan salah satu penyumbang utama dalam pemanasan global kerana sisa makanan akan mengeluarkan gas methane yang merupakan salah satu dari gas rumah hijau. Selain itu, sisa makanan juga mengunakan jumlah tenaga yang banyak untuk dilupuskan, bermula dari rumah dan restoran, sehinggalah ke tapak pelupusan sampah. Jadi, apabila jumlah sisa makanan yang sampai ke tapak pelupusan sampah dapat dikurangkan, kesan pemanasan global dapat dikurangkan dengan drastik. Rasional utama disebalik projek ini adalah untuk mengurangkan jumlah sisa makanan yang terpaksa dihantar ke tapak pelupusan sampah, dengan menjadikan sisa makanan tersebut kepada bentuk yang lebih mudah untuk diuruskan. Sisa makanan yang telah diuruskan mengunakan pemampat sisa makanan boleh digunakan sebagai bahan kompos atau makanan untuk haiwan peliharaan. Untuk projek ini, lima konsep rekabentuk yang bersesuain dengan kehendak pelanggan telah dilukis dan konsep terbaik akan dipilih mengunakan kaedah pemilihan konsep. Kemudian,konsep rekabentuk yang terpilih akan melalui proses analisis reka bentuk untuk melihat kelakuan struktur konsep jika dibuat dan diguna secara realiti. Selepas itu, prototaip untuk pemampat sisa makanan di buat untuk menguji kebolehgunaan prinsip kerja yang digunakan.

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LIST OF SYMBOLS

$\mathbf{CO_2}$	Carbon Dioxide
N	Newton
$\mathbf{TiO_2}$	Titanium Dioxide
F	Force
m	Mass
$\boldsymbol{g}$	Gravity

LIST OF ABBREVIATION

MSW	Municipal Solid Waste
FW	Food Waste
QFD	Quality Function Deployment
HOQ	House of Quality
CAD	Computer Aided Design
FEA	Finite Element Analysis
FEM	Finite Element Method
PDS	Product Design Specification
MYR	Malaysian Ringgit

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The latest Malaysian's population is estimated at around 30 million people. It has steadily increased yearly for the past ten years (Anonymous A, 2014). This positive growth in population has induced rapid urbanisation, change of both in lifestyle and in living standard. Due to this, it is only right to assume that it will cause the increase of waste produced.

Based on research by Johari et al; (2014), Malaysians produce a total of 25,000 – 30,000 tons of waste daily. All of this waste will then be sent to the landfills, which is a place to dispose waste and unwanted material by burying it with soil, via garbage truck. They also state that most of the waste contains very high percentage of moisture and organic content which promotes bacteria build up and spreading of virus. The moist waste also gives out a distinct bad and pungent smell and could be unpleasant for surrounding community.

Generally, there are two types of common waste that are produced by Malaysian which are recyclable and non-recyclable waste. The recyclable type, it can also be grouped into food waste and non-food waste. Examples of non-food waste are paper, biodegradable plastic…etc. On the other hand, examples of recyclable food waste, which we will be using for this research, are stale bread, rotten vegetable, chicken bones...etc. Few of the problem of this type of waste is that it tend to rot quicker and this process will release unpleasant smell and attracts living organism such as ant, maggot, fly and also stray dogs.

This research aims to design and develop food waste compactor as an alternative solution for these problems. The main function of the compactor is to remove excessive moisture from the food waste using compressive force and the product of the compression can be reused or recycled. This study will help to maximize the usage of food waste rather than ending up at landfill.

1.2 PROBLEM STATEMENT

A staggering 30,000 tonnes of waste are produced by Malaysians daily with 45% of the municipal solid waste are in form of food waste. Malaysia, as of any other developing countries, is in a desperate need of having its own plan on how to tackle the ever increasing waste issue. But the real question is why food wastes? Why don't we focus on other type of waste such as construction waste. The real reason why food waste is the one we should be aiming for is simply because it made up almost half of the total municipal solid waste produce in this country. On top of that, food wastes tend to become bad easier and could cause spreading of numerous illnesses and also could induce greenhouse effect due to methane gas that was released during rotting period . The only way to slow down the rotting period of food waste is by squeezing the moisture out from the waste. A food waste compactor should able to perform the routine and helps in tackling this issue.

1.3 OBJECTIVE

The objective of this project is:-

1. To design and develop an effective food waste compactor for home application

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. The compactor is only designed to remove the moisture of the food waste using compression force. Other act of removing moisture or disintegrating of food enzyme will not be done in this research.
2. The research only covers food waste compactor for home appliances with daily amount of food waste.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the literature reviews on topics related to this project are presented. The reviews include a brief history of compactor and the different type of compactor that had been designed by other researcher. This chapter also discusses the application of compactor at home and the alternative usage of the compactor end product.

2.1 INTRODUCTION

Malaysia, one of the fastest economically growing country in the world, are home to almost 30 million residents called Malaysians (Malaysia Demographic Profile, 2014). With such a big amount of inhabitant, it is almost sure that Malaysia is also facing the same problem as Japan and Korea which is municipal solid waste (MSW) and food waste (FW). In Malaysia, both of these types of waste are treated as one where concept of separation does not exist. Meanwhile in Japan and Korea, both of these wastes are separated because food waste is easier to degrade, lack of landfills area and also difficulty to transport food waste (Kim and Kim, 2010). Based on a research, it is expected that in year 2020, the amount of MSW produced by Malaysian yearly are 10.9 million tons and

60% of the waste will be of food waste (Alias, 2010). The research shows the importance in handling the food waste in proper way.

2.2 RECYCLABILITY OF FOOD WASTE

Based on a research done by Saeed, et al, in year 2009, 48 percent of municipal solid waste produces by Malaysian comes from residential area. In other research done by Chua et al, 43.5 percent of municipal solid waste is in form of food waste & organics. Both of this data shows that in order to reduce municipal solid waste, high amount of food waste came from residential area must first be overcome. In the past, open dumping and burning of waste are the most preferable way to eliminate food waste but nowadays, researchers have proved that both of these options brings more harm than good. This is mainly because both options will release greenhouse gas such as methane and carbon dioxide. The most effective way to reduce is to recycle the food waste. There are a couple of ways of recycling food waste:-

i. In-vessel composting

In this type of food waste recycling, food waste are mix together with farm waste (grass, wheat…etc.) The compost mixture is then kept enclosed for 2-4 weeks to kill off microbes. Then, the compost is dried naturally before being used as soil conditioner.

ii. Anaerobic Digestion

In this method, microorganisms are introduced to the food waste so it can break down the waste anaerobically. The term anaerobic are used to represent the state the food waste are kept, in a tight closed container where supply of oxygen are limited. During the process, methane gas will be produced and collected, where it will then be converted into biogas which is able to generate electricity. Besides that, the product of the breakdown can be used as compost fertiliser in agriculture.

2.3 COMPACTOR

Compactor is either a machine or mechanism applied to a material in order to reduce its size through act of compaction. In Malaysia, there are a total of 230 landfills where most of Malaysian's waste find itself ends up. 50% of the landfill area is being used as open dumping site and to make it even worse, more and more landfills operators have opted to close its business because they cannot keep up with the fact that bulk quantity of waste produced is much faster than natural degradation process (Mohd Idrus, 2008). Compaction of waste used at landfills is the main go-to solution which keeps landfills from running out of space. It also increases the placement efficiency of wastes. Forward a few years further, we can now see the applications of compactor in food waste handling way before it reaches the landfills.

2.3.1 History of Compactor

Compactor had initially been used in other area before its application is applied to waste management. Earliest usage of compactor was done by attaching a roller to a horse and was then replaced by self-propelled steamroller in mid-19th century (Anonymous, 2009). In modern civilisation, compactors are mostly used in the construction area where it is used to compact materials such as soil to increase its density and also in road making where asphalt used are compact down as a road.

2.3.2 Types and Application of Compactor

2.3.2.1 Walk Behind Compactor

This type of compactor is used in smaller scale construction site and can be operated like pushing a cart. The walk behind compactor is mainly used to compact gravel, soil and sand using low impact compression force. It is usually found in small scale road making or compacting a small surface area.

Figure 2.1: Example of Walk Behind Compactor

2.3.2.2 Ride-On Compactor

The most common type of compactor which is widely used in construction or industrial industry. Most structure site will use this type of compactor to flatten out an area or compacting down soil, gravel or asphalt. The name itself shows that this type of compactor is much bigger and need to be operated by skilled operator. Initially used in construction site, but now the application of ride-on compactor had been spread to other place such as farms and landfills. In farms, it is used to compact down soil and small plants while in landfills, solid waste are compact to increase the number if waste landfills can hold.

Figure 2.2: Example of Ride-on Compactor

2.3.2.3 Garbage Compactor

Garbage compactor is a chamber that is used to store and compress bulk waste. Different from previous types of compactor which flatten or compress an area, garbage compactor compacts waste kept in a container where the direction of compression might varies. The method of applying force may also be different whether using hydraulic arm, foot pedal or hand operated. Garbage compactor is mostly installed in densely populated apartment and also garbage truck. (Rae Zimmerman, 2009)

Figure 2.3: Example of Garbage truck installed with a garbage compactor

2.3.2.4 Trash Compactor

Trash compactor is basically the same with garbage compactor, just the quantity of waste is different. Trash compactor hold a much smaller amount of waste making it suitable for home and small business usage such as office and fast food restaurant. It is used to increase the waste efficiency by reducing the amount of plastic bags used and trip taken to throw out garbage bag. Even though it is smaller than garbage compactor, some of the models available in the market have a much complex design and details. Commercial trash compactor such as the Broan Elite, are known for its foot operated opener, odour filter and also removable key-knob controls (Anonymous, 2015). These complex designs are done to compensate the fact that most trash compactor are placed inside a living area.

Figure 2.4: Example of Trash Compactor used at home

2.3.3 Advantage of Compactor

Nowadays, compactors are widely used in all industries and its applications have helps in making their job more efficient. Advantages of using a compactor in construction is that it could compact soil efficiently and this increases the density of the soil making it possible and safe for construction to be done. On top of that, advantages of installation of compactor in garbage truck or apartment are that waste can be properly managed and much more garbage can holds inside the chamber. The sealed chamber also cuts rodents from their food source thus reducing the number of rodents in the area. Besides that, application of compactor saves time and also reducing fuel and vehicle maintenance thus reducingCO_2.

Based on a research by (Kara Culgin et al; 2013), estimation of 80% reduction in the number of trips required to collect garbage if trash compactor are used. The research also shows that lesser trips mean lesser fuel consumed which also means lower CO_2 emissions. Even though, the initial capital cost for application of compactor is high, the overall cost may be reduced with wider analysis of the compactor adoption. Based on a research by (Rae Zimmerman, 2009), the use of compactors in a place that produce high amount of waste is more efficient in terms of transporting waste per unit weight. Without compactor, a garbage truck has to collect garbage weighing 8-12 tons per day using 3-4 workers, but with installation of compactor, a truck could collect over 20 tons of waste daily with only using 2 workers.