UNIVERSITI TEKNIKAL MALAYSIA MELAKA

E-RECYCLE SYSTEM MODEL: A STUDY ON PLASTIC, PAPER AND DISC

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotic and Automation) with Honours.

by

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FACULTY OF MANUFACTURING ENGINEERING

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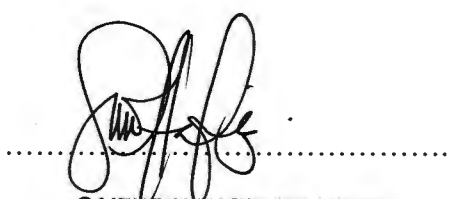

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ABSTRACT

Over this recent year, Malaysians have been generated wastes at an alarming rate, for instance, discs, paper and plastics. On top of that, the conventional recycling systems that have been constructed in Malaysia are not widely marketed and lack of practical applications. This research is mainly focus on the E-recycle system model basically on the study on discs, papers and plastics, with the aim to design and illustrate the simple concept of an E-recycle system model on discs, papers and plastics. The research comprises introduction of recycling systems background, problem statement, research objectives and research scopes. Based on the defined problem statement, an E-recycle system model that interconnection with high technologies of material separations and merit point incentivized system is constructed. The research also consists of the studies on history, recycling processes, facilities of material separations, refuse collection system, recycling cost model and future challenges and opportunities. To achieve the objectives, "in-house" programming using C++ language, CAD (Solidwork) design on the E-recycle model and construction of E-recycle solid model are also carried out in this research together with the methods and planning are presented in Chapter 3. Apart from that, concept design and selection of E-recycle system model is carried out in order to determine the limitations of conventional recycling systems and hence overcome it in this E-recycle system model. Results of E-recycle CAD design model and solid model are presented in Chapter 5, as well the output of the C++ programming for merit point incentive system. In addition, discussions and analysis such as stress analysis, fatigue analysis and benefit and cost analysis of E-recycle system model have been carried out based on the results obtained. Last but not least, conclusion and recommendations are also included in this research.

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ABSTRAK

Dalam beberapa tahun kebelakangan, warganegara Malaysia telah menghasilkan sisa sampah dalam kadar yang amat membimbangkan, sebagai contoh, disk, kertas dan plastik. Selain itu, sistem kitar semula tradisional yang terdapat di Malaysia tidak dipasarkan dengan meluasnya dan penggunaan praktikal yang tidak mencukupi. Penyelidikan ini adalah terutamanya fokus pada *E-recycle system model: A study on paper, plastic and disc*. Penyelidikan ini meliputi pengenalan kepada latar belakang sistem kitar semula, penyataan masalah, objektif dan skop pengkajian. Daripada penyataan masalah didapati, satu *E-recycle system model* yang berteknologi canggih dalam pengasingan bahan dan berinsentif telah dibina. Penyelikan ini juga melingkungi pengurusan sisa, proses kitar semula, pengasingan bahan system kitar semula, sistem pengumpulan sisa dan kos model kitar semula. Untuk mencapai objektif-objektif yang dinyatakan, *"in-house" C++ programming*, rekabentuk *E-recycle system model* dan *E-recycle solid model* bersama dengan cara-cara dan perancangan juga dilaksanakan dalam Bab 3. Selain itu, konsep rekabentuk dan pemilihan untuk *E-recycle system model* telah dijalankan untuk menyatakan kelemahan sistem kitar semula tradisinal dan dengan itu dapat mengatasinya dalam *E-recycle system model.* Keputusan untuk *E-recycle CAD model* dan *solid model* telah ditunjuk dalam Bab 5, sekali dengan keputusan daripada *C++ programming* untuk *merit point incentive system.* Tambahan pula, perbincangan dan analisis seperti *stress analysis, fatigue analysis* dan *benefit and cost analysis of E-recycle system model* telah dibincang atas keputusan yang deperolehi, akhirnya, kesimpulan dan rekomen-rekomen juga termasuk dalam kajian ini.

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DEDICATION

Specially dedicated to my beloved father Choong Khay Hoe and my mother Chan Kooi Foar @ Chen Kooi Foar who are very caring, understanding, patient and supporting. Thanks for everything to my supervisor, Mr. Saifudin Hafiz bin Yahaya for his constructive guidance, encouragement and patient in fulfilling our aspiration in completing this research. I also would like to express my sincere thanks to Mr. Tajul Ariffin bin Abdullah for his kindness, helpfulness and sharing do to me.

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LIST OF ABBREVIATIONS

BEM	-	Boundary Element Method
C&D	-	Construction & Demolition
CAD	-	Computer-Aided Design
CD	-	Compact Disc
CD-R	-	Compact Disc – Recordable
DSS	-	Decision Support System
DVD	-	Digital Versatile Disc
ECS	-	Eddy Current Separator
EEE	-	Electrical and Electronic Equipment
FEA	-	Finite Element Analysis
FEM	-	Finite Element Method
HDPE	-	High-Density Polyethylene
ID	-	Identification
MRF	-	Material Recovery Facility
PE	-	Polyethylene
PET	-	Polyethylene Terephthalate
PP	-	Polypropylene
PVC	-	Polyvinyl Chloride

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CHAPTER 1
INTRODUCTION

This chapter presents the general ideas of the research which provides an overview of the E-recycle system model on discs, papers and plastics. Basically, it consists of four main sections, such as background, problem statement, research objectives and research scopes which describe the overall operating of this E-recycle system model research.

1.1 Background

Nowadays, solid waste management has been considered as a vital topic for Malaysian government and owing to major issue. As the result of alarming rate of waste generated due to the increase in population, affluence and changing lifestyles in Malaysia, the environmental restrictions have been encountered which included the stringent control of waste disposal sites, resource restrictions such as emphasizing the awareness of the public about the depletion of natural resources, the natural disasters issues such as global warming that caused by the green house effect. In other perspective, the improper waste managements will face serious biohazards, in some cases, it might even cause death. All of these issues have been addressed as roadblock toward the government's efforts to attain sustainable development approach vision 2020. In the meantime, the demand for recyclable consumer products is ever-increasing while supplies of raw materials are eventually being reduced. Saidatul Suhaila (2009) had mentioned that it is estimated that the overall solid waste generated per day is 18000 tonnes in Malaysia, sadly most of the wastes generated are dumped illegally and disposed in landfills. If such a concern is the

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fact, then the waste and recycling issue will requires an urgent action to be taken. Henceforth, recycling is an alternative solution instead of landfilling, however, the public awareness toward recycling is alarmingly low, and the future outcomes of our country didn't even cross their mind. Likewise, Saidatul Suhaila (2009) also reported that an average of 0.8 kilogram of waste is generated by an individual per day which a kilogram of the recyclable material is cost at 20 cents. Consequently, it has shortened the lifespan of landfills and caused a massive loss to our country economic, as the simplest measure of the acceptance of recycling is economical that pointed by Billatos and Basaly (1997). A waste should not be treated as a waste until it was confirmed useless. Waste management is a vital issue that needs the effectual solutions and recycling is always viewed as a crucial aspect of an effective and efficient solid waste management system.

As a conclusion, recycling plays a major role in term of conserves the natural resources and prolongs the lifespan of landfill sites around the world. In the same time, it will reduces global warming and pollutions which beneficial to publics.

Figure 1.1: Almost all of the landfills in Malaysia are open dumps that have no pollution control measures (Tan 2004).

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1.2 Problem Statement

By the intensifying growth of the population in Malaysia, the amount of waste generated in daily life has indicated the escalating growing patterns where publics constantly dumped the wastes without think properly. The conventional recycling systems that have been constructed are not widely marketed and lack of practical applications. On top of that, they are also not environmental friendly. Henceforth, it has been the barrier for encouraging the publics to recycle.

1.3 Research Objectives

The main objective is to design an E-recycle system model on discs, papers and plastics, which supported by subsequent objectives as follows:

i. Encourage public to participate in government's recycling campaign
ii. To create an "in house" programming using C++ language for merit point incentive system of E-recycle system model.
iii. To illustrate the simple concept of an E-recycle system model which appropriate for the business fields such as offices and banks.
iv. To design an E-recycle system model by using CAD tools.
v. To build an E-recycle solid model.

1.4 Research Scopes

Chapter 1 will explain about the background of conventional recycling systems, problem statement, research objectives and research scopes. Background of conventional recycling systems evaluates the causes and flaws of the current recycling systems. By identifying and pinpointing the problem statement, research can be launched in order to improve and upgrade the conventional recycling systems. On top of that, research objectives play a significant role in the success of the whole research. Research scopes

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provide an overview that is essential to the success of this research. All those elements become the initial step before go through this research.

Furthermore, Chapter 2 will discuss about the literature review related with recycling systems such as introduction of recycling systems, evolution of solid waste management, recycling processes of discs, papers and plastics, facilities for material separation, handling and moving of recycling systems, refuse collection system, recycling cost model and future challenge and opportunities. In this section, it is mainly involved the study of journals, books, research papers and online resources. Throughout the study, evidences can obtain to support the facts stated in the research.

In addition, Chapter 3 will evaluate on the research methodology that will implements in response to create the entire E-recycle system model. In this chapter, it is generally consisted of process flow charts and methods used to construct the research. The process flow charts such as flow of the process in completing the research, operation processes of the improved recycling system throughout the tools utilized will discuss in this section later. This chapter will also explain the way to achieve objectives of E-recycle system model on discs, papers and plastics. Apart from that, tools like C++ language programming and CAD (Solidworks) will utilize to construct the entire E-recycle system model research.

Besides, Chapter 4 will include the concept development and selection of the E-recycle system model on discs, papers and plastics. In this section, history and limitations of conventional recycling system are studied and concept design is developed to design an E-recycle system model. Concept selection is performed by choosing the suitable design and ideas in order to construct an environmentally friendly recycling system.

In Chapter 5, it will explain about the results of the research after the design and construction of the E-recycle model is completed. Solidworks is the major tool that will use to design the E-recycle CAD model. Other than that, the output of operation flow of the merit point incentive system will illustrate through the C++ programming

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constructed. An E-recycle solid model is also will presented in this section. The results obtained are relevant to the research objectives stated.

Moreover, Chapter 6 will discuss on the COSMOSXpress analysis and fatigue analysis of the component in the E-recycle system model. Analysis is crucial to support the results and to convince public awareness toward the importance of recycling and the development of country. Other than that, benefits and costs analysis between the conventional recycle systems and E-recycle system are also carried out in this chapter. By the way, an environmental friendly recycling system will greatly avoids the unhealthy hazards toward publics.

Last but not least, Chapter 7 will describe on the summary of main findings throughout the E-recycle system model on discs, papers and plastics. Beside that, it also provides brief recommendation for further study.

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CHAPTER 2

LITERATURE REVIEWS

This chapter provides an overview on the conventional solid waste recycling systems in the communities. The study also conducts on the evolution of solid waste management and the recycling processes on discs, papers and plastics involved. Facilities used for material separation, handling and moving to build up an E-recycle system model are also included. Other than that, refuse collection system and recycling cost model will discuss in this section as well. Last but not least, future challenges and opportunities are studied in order to up-to-date with the rapid development of our country.

2.1 Introduction of Recycling Systems

There are several definitions of recycling can be found from different type of resources. One of the most common definitions of recycling described by Billatos and Basaly (1997) is recycling is reuse of products in the same capacity for which they were originally manufactured. Tchobanoglous *et al.* (1993) mentioned that recycling involves three main steps, those are (1) the separation and collection of waste materials, (2) the preparation of these materials for reuse, reprocessing and remanufacture and finally (3) the reuse, reprocessing and remanufacture these materials. While recycling is one the methods to recover those generated waste where it plays an important role especially in the rise in population and the increase of urbanization and industrial growth in saving energy and reducing pollution which then aid in slow down the global climate change.. However, Agarwal (2007) stated that the most common way of waste disposal in Malaysia is landfilling where on an average per person generation of solid waste is 1kg

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per day which approximately 26 million people in the country produce 26 million kilos of solid waste every single day. Davis and Marten (2004) pointed that recycling involved two alternatives, those are closed loop recycling and open loop recycling where closed loop recycling or primary recycling is the use of recycled products to make the same or similar products whereas open loop recycling or secondary recycling is the use of recycled materials to make new products with different characteristics than the originals.

Grabianowski (2008) argued that although recycling may look like a modern concept introduced with the environmental movement of the 1970's, it's actually been around for thousands of years where long before our growing levels of waste became an environmental concern, recycling was a part of every day life that has become an increasingly crucial part of our more modern society. Nevertheless, in Malaysia, recycling is still at an infant stage as mentioned by Agarwal (2007).

Other than that, recycling is an alternative that beneficial to not only governments but also publics. Grabianowski (2008) mentioned that most of the reasons to recycle are environmental, although some are economical. Among the benefits contributed by recycling are reduces the amount of new materials required to manufacture a new product, creates further benefits for materials where cost of the initial extraction or production is high – economically, socially or environmentally, conservation of natural resources and prolongs the lifespan of landfill sites, for example refilling bottles.

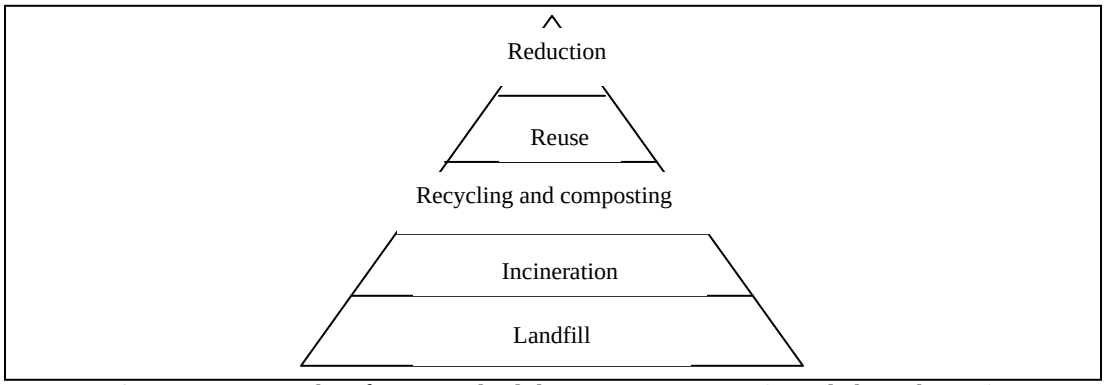

Figure 2.1: Hierarchy of integrated solid waste management (Heimlich *et al.* 2009).

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2.2 Evolution of Solid Waste Management

Tchobanoglous *et al.* (1993) pointed that in early times, humans have used the resources of the earth to support life and to dispose of wastes, yet, it did not pose a significant problem, because the population was small and the amount of land available for the assimilation of wastes was large. However, problems with the disposal of wastes can be traced from the time when countries are undergoing rapid developments. Henceforth, along with the benefits of technology also come the problems associated with the disposal of resultant wastes. In order to understand the nature of these problems, it will be helpful to examine the flow of materials and the related generation of wastes in a technological society and to consider the direct impact of technological advances on the design of solid waste facilities. One of the best ways to reduce the amount of solid wastes that must be disposed of is to limit the consumption of raw materials and to increase the rate of recovery and reuse of waste materials. Although the concept is simple, but effecting this change in the modern society has proved extremely difficult. The problems that concerning with the management of solid wastes in today's community are sophisticated because of the funding limitations for public services in many large cities, the impact of technology and the emerging limitations in both energy and raw materials. As part of 'Vision 2020' the government of Malaysia is looking to enhance environmental protection and integrate its solid waste management, claimed by Agarwal (2007). Besides, Ludwig *et al.* (2003) identified that environment issues around the world are growing everyday. As a consequence, proactive and cost-effective solutions to battle against these environment issues have been taken note. Hasnain *et al.* (2005) mentioned that the implementation of a proper solid waste management program with suitable methods of recycling as an inherent element is important to the alleviation of the problems associated with solid waste generation, handling and disposal, environmental conservation and publics hygiene by identifying the majority of the respondents expressed concerns about recycling where illegal collection, aesthetically displeasing sites and lack of publics awareness were problems of major concern. However, there are many challenges related to waste recycling which are necessary to consider in order making recycling to be succeed, such as separation of recyclable

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