AN INVESTIGATION ON PRODUCTS SELECTION FOR RECYCLING USING PRODUCT RECYCLING DESIRABILITY MODEL AT MALAYSIA

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Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

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Tajuk: **AN INVESTIGATION ON PRODUCTS SELECTION FOR RECYCLING USING PRODUCT RECYCLING DESIRABILITY MODEL AT MALAYSIA**

Sesi Pengajian: **2019/2020 Semester 1**

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Author's name   : Evelyn Justin

Date   : 30 December 2019

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of University Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committees are as follow:

………………………………………………

(**TS Dr Al Amin bin Mohammed Sultan**)

ABSTRAK

Kajian ini dijalankan untuk menyiasat keutamaan produk pengguna untuk di kitar semula menggunakan Ideal Pemilihan Produk untuk Model Kitar Semula semula yang dicadangkan dalam kajian ini. Kajian ini lebih tertumpu pada pemilihan produk untuk kitar semula oleh pengguna di Malaysia dengan mencadangkan model kitar semula untuk membantu pihak berkepentingan untuk mengutamakan produk untuk kitar semula melalui kaedah matematik berdasarkan factor-faktor kritikal kitar semula yang wujud dalam produk pengguna Malaysia. Tujuan kajian ini adalah untuk mengenal pasti faktor kritikal untuk mengitar semula produk pengguna. Pengenalpastian faktor kritikal disenaraikan berdasarkan kertas penyelidikan akademik dan meringkaskan faktor kritikal yang dilakukan dengan memilih hanya dua hingga tiga faktor kritikal yang sesuai dengan kitar semula dalam konteks Malaysia. Perumusan persamaan matematik berdasarkan faktor kritikal yang telah dikenalpasti. Faktor kritikal yang dikira telah berubah menjadi faktor kitar semula yang dikehendaki menggunakan komposisi bahan produk pengguna teladan untuk membangunkan indeks keinginan kitar semula. Selepas pembangunan indeks keinginan kitar semula telah dilakukan, penerapan model matematik kepada produk pengguna telah dilakukan dengan menggunakan graf dan indeks dalam membentangkan model kitar semula
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ABSTRACT

This research was conducted to investigate consumer product requirements of product selection for recycling using the recycling model proposed in this study. This research was more focused on product selection for recycling by consumers in Malaysia by suggesting a recycling model to help stakeholders to prioritize products for recycling through mathematical methods based on critical factors inherent in Malaysian consumer products. The purpose of the study is to identify critical factors for recycling of consumer product. The identification of critical factors was listed based on the academic research papers and the summarization of critical factors were done by selecting only two to three critical factors that suited the recycling in Malaysia context. The formulation of the mathematical equation based on the critical factors is identified. The calculated critical factors were transformed into the desired recycling factors using the material composition of the exemplary consumer products to develop the recycling desirability index. After the development of recycling desirability index were done, the application of mathematical model to the consumer product were done using the graphical representation and indices.

DEDICATION

Only

my beloved late father, Justin Jimbun

my appreciated mother, Siantim Sumpiou

my sibling, Evint, Ellen and Evarina

my supportive friends Ain Fateha, Elisha, Eric

for moral support, cooperation, encouragement, financial support and understandings

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LIST OF ABBREVIATIONS

UN	-	United Nation
MSW	-	Munipal Solid Waste
MHLG	-	Ministry of Housing and Local Government
TRL	-	Technology Readiness Level
CI	-	Critical Index
MSI	-	Material Security Index
RDI	-	Recycling Desirability Index
EU	-	Europe United
RR	-	Recycling Rate
GHG	-	Green House Gas
WCED	-	World Commission on Environment and Development
IPI	-	Industrial Production Index
ODEC	-	Organisation of Economic Co-Operation
EF	-	Exposure frequency
ED	-	Exposure duration
AT	-	Average Time
ADD	-	Average Daily Dose

LIST OF SYMBOLS

C_i	-	Material mass fraction
H_m	-	Complexity separating materials
N	-	Maximum number in a product
M_i	-	Mass of the discrete material in a product or component
M_T	-	Total product Mass
R_i	-	Technology readiness level (recycling) for particular material
R_{Top}	-	Top scale for the TRL scale
H	-	Complexity Measure
H_{Top}	-	Top scale for Material Complexity Index
S_i	-	Score for particular material
R	-	Recycling index
$D_{Desirability}$	-	Desirability recycling index
$D_{Simplicity}$	-	Simplicity Index
D_{MSI}	-	Material Security Index
$D_{product\ scrap}$	-	Scrap value Index
D_{profit}	-	Profit Index
μ_p	-	mean price

CHAPTER 1

INTRODUCTION

This chapter explained about the background of the study, problem statements, objectives and scope while conducting this final year project. The introduction discusses about the necessity of recycling in today's world and the approach that can be developed to help the stakeholders to decide or priorities product/materials for recycling in Malaysia. The product recycling desirability model would be used as a vital guide in executing this project.

1.1 Background of study

This study discussed on creating a new product recycling desirability model in Malaysian Context. This research was focused on developing a new scientific approach for prioritizing of end-of-life products in circular economy. It's also identified the sustainable way in handling the end-of-life products Nowadays, human being or living things are very dependent on earth resources. Although, in our daily life they need these resources to survive but it will not last longer. In recent time, there's a lot of environmental issues exist on the surface of media. For example, pollution, natural resource depletion and waste disposal. The natural resource depletion such as fossil fuel consumption causes the production of greenhouse gaseous which contribute in global warming and climate changing. Improper waste disposal activity and uncontrolled plastic production creates huge problem to the environment globally.

The fast growth of economy and the rise of urban population has become an alarming to the society nowadays which contribute to as one of the challenges in sustainable development (Abas and Wee 2016). This rapid development of growth both economy and population unknowingly contribute in the integrating the wastes. Sustainability should be implemented

in coping with the problem that was faced by the society especially consumer. The aim of sustainability is to reuse the renewable resources that already exist, instead of throwing waste in the garbage we can try to recycle it and recycle are connected. In order to conserve and sustain the environment from waste pollution, the government especially the consumer should consider that recycle the waste product into something useful to lessen the production of waste in our country.

Sustainability is introduced to balance the environment, social and economic aspects (Samsudin and Don 2013). In order to implement sustainability while managing the wastes, there are many challenges faced by Malaysia waste management industry in achieving sustainability (Sin et al. 2012). The important part of the sustainability is that it lessens the human impact on the environment and lowered the pressure of the usage of the natural resource.

Other counter measure that need to be highlighted, the implication of the usage of landfill in Malaysia. As one of developing country in southern-east Asia, Malaysia has been applied the control dumping and sanitary landfill in disposing solid wastes (Zhang, Santha, and Binti Shahul Hamid 2012). The low management of dumpsite or landfill brings bad implication to environment and human health (Zhang, Santha, and Binti Shahul Hamid 2012). This shows that Malaysia still struggling in managing the waste dumping. It also shows that sanitary landfill and dumpsite is not environmental-friendly disposal. The practice of landfilling is one of easiest and economical technology that can be used, since there are certain low or middle country that faced financial constraint.

Landfilling may be financially economics in handling the waste dumping, but it harms the environments in long way run even with the proper abatement measure in landfills, there are no certainty that the environments isn't polluted (Ismail 2013). Most of the landfill exist in Malaysia are open air which lead to contaminated soil and ground water due to its direct contact with the land surface. The landfill and illegal landfill such as open burning also bring another pollution which the air pollution, the air pollution creates unpleasant odour and generate greenhouses gaseous just by conducting an open burning.

Based on these facts, it portrays that landfilling is not the best choice in dealing with waste dumping and landfilling can be dangerous over time. Therefore, Malaysia government should take developed county like European country, United State of America and Canada as an example in coping with landfill problem. One of their effort toward zero waste target, is execute ban landfilling and landfill tax (Eunomia Research & Consulting 2012). The main driver of changing the managing the Commercial and Industrial waste by landfill tax. The landfill ban

is implemented to apply the source separation and application of product stewardship policies (Eunomia Research & Consulting 2012).

There are many alternatives exist to solve these problems and one of them is recycling the waste. Recycling can be defined as the restoration of waste that was reuse either for the original usage or other usage (Md Zain et al. 2012). Recycle enable us to sustain the resource that exist now. This method already exists for so long but unable to implement it into their daily life due to lack of morality and concerned towards our environment. Recycle gives advantages to the environment and economy compare to landfilling. Economically it creates more job opportunities. It's also reduced energy consumption and it's environmentally saved. Recycle enable the reduction of the usage of natural resource and helps to preserved it by creating something useful from the waste instead of disposing it to the landfill without using it.

Recycle reduces the usage of landfill, less trashes were sent to the landfill since the preservation of resources is implemented by recycling it. The lack of awareness of the importance of recycling among Malaysia gives bad impact to the Malaysia's environment. Recycle begins at home, instead of throwing away old products. Action is needed for consumer to start utilizing the waste into something useful.

Thus, the proposal of product recycling desirability model is developed in assisting the stakeholders in prioritizing the selection of product for recycling. By conducting this research, the identification of critical factors is crucial in developing this model.

1.2 Problem Statement

Due to the increasing of rate of economic growth, the of Malaysia has been increasing significantly from over 21 million people in 2000 to over 28 million people in 2010/11 (Innocent Jereme, Md. Mahmudul Alam, 2014). While in Malaysia, the choices of method practised for the disposal of waste s through the landfill and many of the sides are open dumping area (Samsudin, 2013). Almost 95% of waste collected is brought to landfills for disposals and the rest were sent to small incinerations plants, diverted to thrown illegally (Periathamby & Fauziah, 2010).

Thus, by comparing Malaysia to developed country like European country, they execute landfill ban and landfill tax policy in achieving zero waste target. Towards achieving zero

waste and landfills band in Malaysia, the product selection recycling desirability model is introduced.

The Product Selection for Recycling was already developed mainly focuses in the United Kingdom, (UK) context based on the identification of three critical factors that were formulated and calculated. However, the Product Selection for Recycling that already exist cannot be used in Malaysian context due to the existing of one critical factor that was formulated were not suitable to Malaysian context. Therefore, the extended of simple product selection for recycling model is suggested in assisting the stakeholders to prioritize the products for recycling towards achieving landfill ban in Malaysia.

1.3 Objectives

The objectives were achieved for the research needed to be done. The objectives of this study were:

i.   To identify the critical factors for recycling of consumer products.
ii. To formulate the mathematical equation based on the critical factors.
iii. To apply the mathematical model to the consumer product.

1.4 Scope

The scope of the research is as follow:
a) Focuses on the selected consumer product selection that significant to Malaysia economy and consistent with previous research.
b) Study duration for final year project 1 & 2 in conducting this research is limited.
c) Formulation of mathematical equation based on the important factors in Malaysian perspectives.
d) Development of generic model of product selection for recycling.

1.5 Significant of study

The significant study are as follows:

a) Improve the knowledge of sustainability and recyclability in Malaysian context.
b) Utilize the suitable formulation of mathematical equation based on the summarized critical factors.
c) Developed an extended product recycling desirability model to assist the stakeholders in prioritizing the end of life product for recycling.

1.6 Summary

Chapter 1 consists of 7 sub-chapter which are the background of the study, problem statements, objectives, scope, the significant of the study, organizational of the final year project and the summary. Background of study explains about the scenario of recycling and sustainability globally to Malaysia's scenario in effort creating a new product recycling desirability model. Next sub-chapter is problem statement, in order to go thru deeply of the research, it's important to have a solid problem statement based on the real situation problems in Malaysia country or industries. Then, there are 3 main objectives that must to be achieve by the end of the study. As for the scope, it describes the priority things in developing a new desirability recycling model that it should be focuses on while conducting this research. The significant of the study describes the important point of this study. Lastly, the organization explains the overview.

CHAPTER 2
LITERATURE REVIEW

This chapter explained the summary of related articles, journals, websites and books that has been done by the previous researchers. The sub-topic that is included in this chapter which are sustainability, landfill, waste in Malaysia, recycling, product recycling desirability model and qualitative interview.

2.1 Sustainability

Sustainability in recycling is important. Recycle enable to sustain the resources that exist. Malaysia supposed to developed sustainable ways of handling waste management, for the time being recycle can be considered as a sustainable solution to reduce waste (IA. Jereme, Siwar, and Alam 2014). According to Harlem Brundtland commission or the World Commission on Environment and Development (WCED) that was convened by the United Nation 1983. The report "Our Common Future" suggested the concept of sustain development as an ideal for global economy and corporation. The commission stated that sustainability ca be defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their needs. (Commission, n.d.)

Based on the groups of professional, sustainability can be described when there's effort to maintain and improve the materials and social conditions for human health and the environment over time without exceeding the ecology without support them (Franklin 2008). Sustainability also can be known as the inspiration from the teaching of nature in seeking to optimize the flows of resources characterizing the whole industry system the life cycle of the products (Emas, 2015).In the year 2018, the estimated world population is 7.7 billion people. Population related to our consumption and waste as by-product of our consumption needs. The idea of sustainability does not compromise the benefits of future generations with

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the existing consumption habits before deteriorating the planet in an irreparable and irreversible way (Ak and Braida 2015).
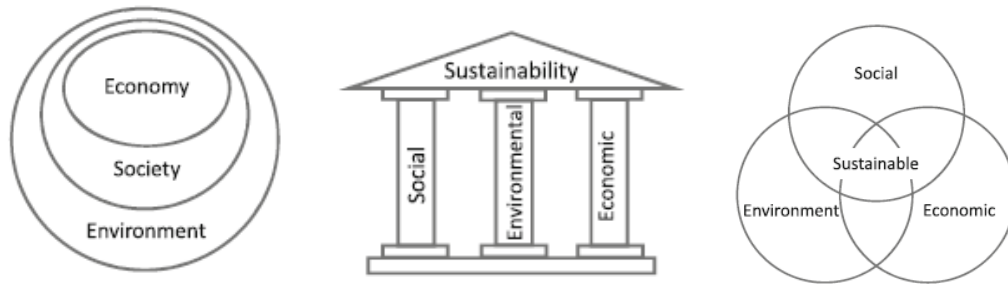
2.11 Important of sustainability

Figure 2.11 (left) typical representation of three pillars of sustainability, (centre) literal pillars of sustainability, (right) concentric pillars of sustainability.

Sustainability is crucial for many reasons. In accordance with achieving healthy communities, it is requiring better air quality, abundant natural resource and non-toxic environment. The three pillars of sustainability can identify as the multidisciplinary and solution-oriented method in developing sustainability based on three important roles (Suhaily et al. 2012). The triple bottom line can determine as the sustainability's potential and its main objectives. Sustainability engaging the three interconnected of pillars (Gibson 2006). The pillars showing economic, social and environmental (ecological) which all these terms are mainly used interchangeably and as the inclination for "pillars" is largely arbitrary.

This three pillars description is usually, but not often presented in figure 2.21. The graphic presentation can be identified in various form as a descriptor of "sustainability" which can be influenced by the academic literatures, policy presentation, business and other resources that related to it(Purvis, 2018). The three pillars approach usually guided by an assumption that sustainability is about balancing, which contrast both the key idea related to the interdependence of factors and the mutually supporting advances on all fronts. It's also strengthened an emphasis on making trade-offs, which may often necessary, but which should always be the last resort, not the assumed task in sustainability assessment(Gibson, 2006). If we are prepared to overlook the lack of semantic clarity and confusion of competing terms, it can be argued that the 'three-pillar' conception of 'sustainability' is a dominant interpretation within the literature. Yet the conceptual origins of this description, and the

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