Faculty of Manufacturing Engineering (Industrial Engineering)

DEVELOPMENT OF FRAMEWORK FOR ALUMINUM CANS RECYCLING MANAGEMENT USING ANALYTICAL HIERARCHY PROCESS

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DECLARATION

I declare that this thesis entitle "Development of Framework for Aluminum Cans Recycling Management using Analytical Hierarchy Process" is the result of my own research except as cited in the references. The project has not been accepted for any degree and is not concurrently submitted in the candidature of any degree.

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APPROVAL

I hereby declared that I have read through this project report and in my opimion this project report is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Industrial Engineering)

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DEDICATION

This project is dedicated to my beloved mother Rabia Hamza and father Alarbi Hamza, to my supervisor who never failed to teach and guide me, to my family who supports me in everything, to my friends who helped me finished this project, and most of all to the Almighty Allah who gives me strength and good health while doing this.

ABSTRACT

This research focuses on the establishment of a new framework an efficient used aluminum cans management system in the context of sustainable development based on Melaka situations. The Analytical Hierarchy Process (AHP) a multi-criteria decision making analysis was evaluated using a quantitative data generated from survey on solid waste management company in Melaka (SWM Environment Sdn Bhd and Tzu chi Foundation). Quantitative weightings from the AHP were used to identify alternative systems that have similar outcomes in meeting the aluminum cans management objective were evaluated based on multiple criteria comprising technology, economics, quality, environment and management which were used to validate the appropriateness of the three aluminum cans management models which are recycling model, reuse and disposal model that were used. The result showed that reuse model (37.0 %) and recycling model (37.0 %) ranked first and lastly disposal model (26.0 %). The present research finding can be used to optimize aluminum cans management practices in Melaka with respect to the criteria that were evaluated.

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LIST OF ABBREVIATIONS

Abbreviation	
AHP	Analytical Hierarchy Process
EU	European Union
GHG	Green House Emissions
IEA	International Energy Agency
UBC	Used Beverage Cans
SWM	Solid Waste Management

CHAPTER 1

INTRODUCTION

1.0 Background

Recycling remains an attractive area because of its low-cost relative to new production. Aluminum is the most abundant metallic element in the earth's crust after oxygen and silicon. By mass, it is the third most abundant of all elements in the earth's crust and constitutes about eight percent of the earth's crust by mass (European Aluminum Association, 2008). Recycling of aluminum requires ninety five percent less energy than production from raw materials and were often advocated on their economic ground (Chen et al., 2011). Recycling of aluminum cans saves large amount of energy and help control environmental pollution associated with aluminum mining and an increase in energy use.

Disposal of unwanted aluminum products exposes the environment to problematic impurities such as Silicon, Magnesium, Zinc, lead, iron, Copper and Manganese (Lundqvist et al., 2004; Das, 2006; Gesing, 2006; Gesing and Harbeck, 2008; Gaustad et al., 2011). One of the most effective ways to eliminate the negative impact of these impurities is to initiate effective recycling of used aluminum cans. However, level of deteriorating impact of the disposal of aluminum cans to the living environment depends on their level of its exposure (Coker et al., 2009; Patwary et al., 2009a). Since the disposal

of aluminum cans are not appropriate for landfills and cause skin infection and pollution when incinerated (Coker et al., 2009). These health impacts can be controlled through the recycling of used aluminum products.

However, recycling of aluminum cans is challenging due to limited recycling facilities, lack of awareness on the importance of recycling, lack of appropriate recycling framework to control the increasing volume of aluminum cans disposal. The Study found that limited availability of waste recycling management option obstructs waste management efforts and led to illegal dumping and burning of reusable materials such as aluminum cans (Sawalem et al. 2009). This study will provide information on current management practices of aluminum cans recycling in Melaka using the proposed framework.

1.1 Statement of the Purpose

The purpose of the present study is to investigate various aluminum recycling practices in Melaka using a newly developed framework. The framework comprises three models that were justified based on five important waste management criteria which was used to evaluate the aluminum cans management practices and to rank the models in the order of effectiveness using the overall result that were obtained from the elements that were tested.

1.2 Problem Statement

The aluminum can recycling management in Melaka has no detailed information concerning that explains the appropriateness of various management measures that are adopted for aluminum cans. This makes it difficult to recommend the best management

practice that explains an efficient and complex range of control techniques for Melaka. Along the protracted progression leading from aluminum dross and scrap into raw material, a variety of management processes are needed, each of which has tight criteria of quality and giving rise to high added values for the end products. It is in fact dealing with a chain of the transformation process with the end product of one process serving as incoming material for the next process down the line (Puga et al. 2009). The added values benefiting the end product in some cases amount to several times the cost of the incoming material. Good control not only ensures the productivity of the process and the quality of the product, it also makes better use of high-capital equipment and lengthens its active life (Verran and Kurzawa, 2008).

Management of aluminum cans in Melaka is considered important in the present study because it offers attractive characteristics such as its strength and its light weight which are useful for many technological applications (Abdul and Abdul, 2007). Aluminum is a very good electrical conductor, resistant to corrosion and is used for packaging in food, beverages and soft drinks. It becomes important to evaluate the waste management model in order to enhance management practices (Kelkar et al., 2001). Aluminum beverage cans among aluminum beverage cans provided the largest sources of recycled aluminum and can be a source of income if a sustainable management practices is developed. Used aluminum cans can be reconstructed for interior and exterior applications such as window frames, roofing, siding, heating and air conditioning (Plunkert, 2004). Aluminum usage is very important in electrical sector where has replaced copper for electric transmission wiring and in the construction of machinery and consumer durables such as cookware.

Aluminium cans that are disposed of in the landfill represents a potentially valuable source of reproducible raw materials for the aluminium industry and a source of income to the people that disposes it. The economic value of recovered aluminum cans depends on

the quality and shape of the aluminum material as well as its collection rate. Recycling aluminum scrap requires five percent of the total expended energy required for producing new aluminum cans (Puga et al., 2009) therefore; it is imperative that various recycling practices of aluminum cans in Melaka should be evaluated however, the development of a new framework could facilitate effective management recycling practices of used aluminum cans.

1.3 Research Aims

This research is aimed to address aluminum recycling technique that is compatible with a different environment setting as an attempt to enhance to enhance existing processes process. In order to optimize the existing aluminum recycling existing processes, it is important to identify factors that influence aluminum cans recycling using a new framework. The developed framework was used to produce consistent information on aluminum cans recycling. The developed framework was used to determine the appropriateness of certain aluminum cans management measures in order to control and improve the quality recovery feature (Chmura and Gronostajski, 2006). Quantitative analysis were conducted to change the settings of the various process parameters and to evaluate the appropriateness of the new framework. To achieve the aims of the research, the following research questions will be answered. The research questions are:

1. What are the aluminum cans management processes in Melaka?
2. What is the best model for aluminum cans management practices in Melaka?
3. How is the management framework for aluminum cans developed and ranked?

1.4 Objectives of the Study

The objectives of the study are as follows:

1. To investigate aluminium cans management practices in Melaka, Malaysia.
2. To analyze and choose the best aluminum cans management framework to ensure effective management processes.
3. To develop and rank aluminum cans management models.

1.5 Significance of the Study

The following are the significance of the present study:

a. Recycling is an economical way to minimize illegal deposal of useful materials aluminum cans (Gao et al. 2009).
b. Processing of fresh aluminum generates considerable amounts of waste in the form of chips and comprises about 3–5% of the casting weight (Chmura and Gronostajski, 2006).
c. Modern technological dimension necessitates for reduction of the primary aluminum use, control of pollution and the development of a sustainability policy measure for the modern industrial societies (Gao et al. 2009).
d. Recycling of aluminum cans is associated with high energy savings are associated and requires below five percent of the total energy needed for the production of primary aluminum (Verran and Kurzawa, 2008).
e. Enforcement of aluminum can recycling programs will help in keeping the living environment neat.
f. Recycling one aluminum can saves energy to keep a 100-watt bulb burning for almost four hours or run a television for three hours.

g. Aluminum has a high market value and continues to provide an economic incentive to recyclers.

h. To the body of knowledge, it will provide suitable options to efficiently manage used aluminum cans in Melaka.

i. To the researcher, it will provide useful hint on the usefulness of recyclable material that otherwise could have been considered as waste (Puga, et al, 2009).

j. In Melaka, recycling of aluminum cans is very important because it will create job opportunity to the citizens.

1.6 Scope of the Study

The scope of this study focuses on the recycling practices of aluminum cans in Melaka, Malaysia. To evaluate various recycling activities, data was generated from recycling centers in Melaka using a newly developed framework and analyzed to provide a recycling management scenario of aluminum cans. The recycling activities will be evaluated based on some important criteria such as economy, environment, quality, technology and management.

This analytical technique was used to evaluate and rank various aluminum cans management models considering and their cost-effectiveness, environment impact of various practices, quality, technology and the management strategy that were employed. This information is important in that it will provide an overview of various recycling practices in Melaka. This approach will provide a positive step towards reducing the amount of used aluminum cans that are disposed at various dumping sites and will serve as a catalyst to provide job opportunities and promote healthy living environment.

1.7 Structure of the Study

The importance of aluminum stretches through manufacturing sector to food industries, building and construction and major many other economic-sustaining sectors. Owing to the relevance of aluminum to a growing environment, the present study explores the recycling practices in Melaka and the development of a new framework for efficient and effective recycling of aluminum cans. To investigate aluminum recycling practices in Melaka, the present study is structured as follows:

Chapter 1 presents an overview of the study, the problems of aluminum recycling, importance of recycling, scope and rationale of the recent study. The chapter highlights the key significance of the study in such a direction that meets its objectives.

Chapter 2 present literature review developed from previous related studies on aluminum cans recycling within the study context. The chapter explains the recycling processes, the key practices and the need for efficient management practice based on the developed framework.

Chapter 3 depicted the methodology that is used to collect and analyze data from Melaka. The developed framework will be explicitly analyzed quantitatively AHP base on which research finding and recommendation were made to encourage the use of best management practice especially for valuable materials such as used aluminum cans.

Chapter 4 presents result analyzed using AHP and research findings base on which further studies on aluminum recycling can be generalized while Chapter 5 concludes, reported the research findings and recommends viable aluminum cans management practices in the Melaka using tested developed models based on the criteria.

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

This chapter reported previous literature studies on aluminum cans management practices. The literature review provided an in-depth understanding of various practices, different purification and sorting techniques and the implication of illegal dumping of aluminum cans within the living environment. The information obtained from various literature studies will be used to enhance aluminum cans recycling practices in Melaka, Malaysia.

2.1 Waste Management Practices in Malaysia

Solid waste generation represents imperfect utilization of raw materials and financial loss for a particular product consumed (Koroneos and Nanaki, 2012). There are numerous definitions of what constitutes solid waste and many classifications attempt to categorize solid waste materials. Waste constitutes scrap material, effluent or unwanted substance that has no further use from process operations (EU Framework Directive on Waste, 2002) although they can be transformed into other useful form especially for material such as aluminum that requires huge amounts of energy for their procession.

The population of Melaka is estimated at 180671 based on the information obtained from the GeoNames geographical database. Melaka is located at 2.196 latitude in degrees, 102.241 longitude in degrees at an altitude of meters. The average elevation of Melaka is -

9999 meters. There is no detailed study on the recycling of used aluminum cans in Melaka however, studies showed that Malaysia government are committed to improving waste recycling practices in Malaysia (Nadzri, 2008; Department of Environment Malaysia, 2006).

Per capita solid waste generation at an average rate in Malaysia in 1995 was 0.77 kg/person/day and has been on a steady increase in the economic and population growth. About 3.9 million tonnes for 1 kg per capita daily was generated in 2000 (Agamuthu, 2001). Although, local government authorities are responsible for waste collection services waste collection in Malaysia is requires a new framework that is compatible with various waste recycling practices.

In an attempt to reduce problems illegal dumping waste, local government authorities in Malaysia initiated privatization of waste collection in 1996 so as to efficiently improve the quality of the living environment and further encourage the reuse of resource as well as minimization of waste (Mourato, 1999). The current privatization mode is currently regarded as a transition period pending the approval of the proposed Parliamentary SW Act.

The Malaysian government has increased campaign on the need for recycling of used aluminum cans and the minimization of illegal dumping. A study estimated that three percent of the generated waste in Malaysia are recyclable with used aluminum cans as among the most valuable material (Othman et al. 2004).

2.2 Aluminum Recycling

Aluminium (Al) is a chemical element and belongs to the boron group with atomic number of 13. It is silvery white and insoluble in water under standard temperature and pressure. Aluminium comprises eight percent by weight of the solid surface of the Earth's

and it is chemically reactive and are limited to the extreme reducing environment. It combined with over 270 different minerals (Shakhashiri, 2008) with the major ore as bauxite. Aluminium has low density and resist corrosion, malleable and has high ductile strength making it suitable for various applications across different innovative industries.

There has been a significant increase in the use of aluminum in transportation industry, aerospace, building, packaging and electrical engineering due to its versatile properties. The production of aluminum from its ore (bauxite) requires much energy than many other metals and causes the release of the greenhouse gas (GHG) into the atmosphere (Norgate, 2009). Aluminum production contributes to about one percent of the annual GHG emissions (IEA, 2009). Energy conservation and emissions reduction of emission have become a key concern for sustainability of aluminum industry.

Aluminum is a durable and sustainable metal and two-thirds of the total aluminum ever produced are in use today (von Falkenstein et al. 2010). An average of 113,204 aluminum cans is recycled globally and the newly recycled aluminum cans take up 95 percent less energy making it possible for more recycled cans to be produced using less energy than needed to produce fresh cans using virgin ore.

Theoretically, aluminium is one hundred percent recyclable without losing its natural qualities. Recovery of the metal through recycling is common and has become an important route for aluminium production (Koroneos and Nanaki, 2012). The growing use of aluminium beverage cans has created public awareness on the importance of recycling in Malaysia. Recycling of aluminum cans comprises the melting down of the scrap requiring only five percent of the energy used to produce aluminium from its ore. Primary production of aluminum requires huge energy with high tendency of environmental

pollution from greenhouse gasses. Figure 2.1 depicted global warming potential for primary production of aluminum products to gross energy required.

Recycling of aluminum can save energy to keep a 100-watt bulb burning for four hours or run a television for three hours. 54 billion of aluminum cans can be recycled saving energy equivalent to 15 million barrels of crude oil in America's entire gas consumption per day. Disposing of aluminum cans into landfills means wastage of energy and material (Koroneos and Nanaki, 2012).

In 1972 about 24,000 metric tons of aluminum used beverage containers were recycled. In 1998, the amount increased to over 879,000 metric tons. In 1972, it took about 22 empty aluminum cans to weigh one pound. Due to advances in the technology to use less material and increase durability of aluminum cans, in 2002 it takes about 34 empty aluminum cans to weigh one pound. The average employee consumes 2.5 beverages a day while at work. The empty aluminum can is worth about 1 cent. In Europe, forty two percent beverage cans, eighty five percent of construction materials and ninety five percent of transportation vehicles made of aluminium are recycled (Chen et al., 2011).

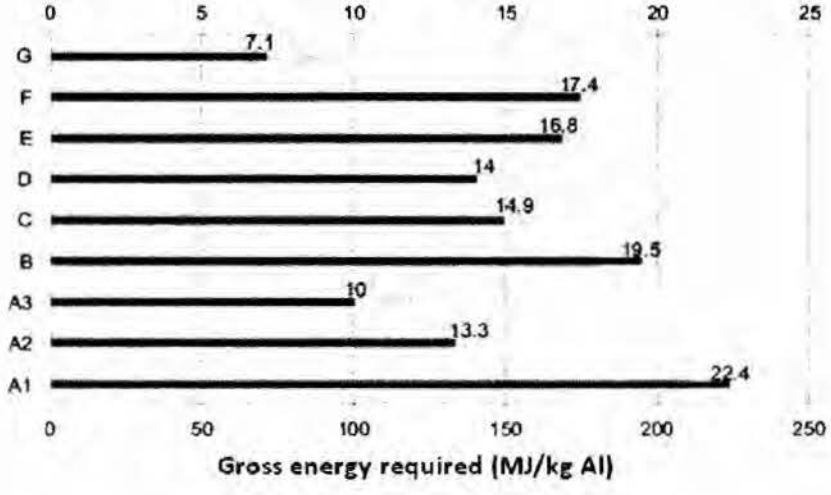

Figure 2.1 Gross energy required for aluminum recycling