DISASSEMBLABILITY EVALUATION METHOD (DEM) FOR GREEN PRODUCT

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This Master Project Report is submitted to the Faculty of Mechanical Engineering as a partial fulfillment of the award of Master Degree in Mechanical Engineering

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

Mac, 2003

Dedicated to;

my lovely wife,

Rosmawati Bte Ma'arof,

my mother,

Che Gayah Bte Salleh

and my father,

Yusof Bin Awang.

ACKNOWLEDGEMENT

Several people have played a role in making this report a reality.

Foremost amongst them is my supervisor ***Dr. Ariffin Bin Abdul Razak*** for his guidance and encouragement. For his understanding during the difficulties I faced at the initial stages of this research, my appreciation is immeasurable.

I would also like to thank ***Mr. Rashid*** for helping me to make a drawing, my colleagues at KUiTTHO, my course mates at UTM for their support.

I am very grateful to my lovely wife ***Rosmawati Ma'arof***, who taught me patience and supports willingly during my study.

I am very grateful to my mother, ***Che Gayah Salleh***, my father, ***Yusof Awang*** for their full love and spirit.

Last but not least to all the people who contribute directly or indirectly for helping me to complete the thesis, thank you very much.

YUSRI YUSOF

ABSTRAK

Ceraian komponen merupakan proses yang penting bagi sesuatu produk untuk dikitar semula. Aktiviti ceraian ini digunakan dalam banyak operasi termasuk operasi pembuatan semula, kitar semula dan pelupusan. Kaedah reka bentuk untuk ceraian dapat mempertingkatkan kualiti pembuatan dan mengurangkan kos. Rancangan ceraian yang berkesan penting untuk mendapatkan turutan ceraian yang paling optimum dalam reka bentuk sesuatu produk. Dalam kata lain, reka bentuk untuk ceraian ini dapat menentukan kekuatan sesuatu produk untuk diceraikan komponennya, dan menghasilkan cadangan yang baik untuk mereka bentuk produk tersebut. Kaedah Penentuan Ceraian ini telah diperkenalkan oleh syarikat Hitachi, Jepun, bagi menganalisa apabila beberapa perkara diketahui seperti bilangan komponen, jenis komponen, turutan ceraian yang optimum, bentuk komponen dan hubungkait penceraian. Kaedah ini dapat memberi panduan kepada pereka bentuk untuk menentukan reka bentuk awal bagi mengurangkan kos dan masa. Dalam kajian ini penyelidik mengkaji secara mendalam kaedah tersebut untuk mendapatkan turutan ceraian yang optimum dan menentukan mata bagi setiap komponen. Beberapa cadangan dikemukakan bagi mempertingkatkan lagi reka bentuk produk. Kajian ini dijalankan dengan sebuah peralatan elektrik iaitu pemerah jus, bagi membandingkan beberapa kriteria pada reka bentuk asal dan baru. Dua parameter utama yang digunakan ialah mata penentuan ceraian dan nisbah kos operasi ceraian. Perbandingan reka bentuk asal dan baru ini menunjukkan peningkatan dan penurunan dalam beberapa aspek.

ABSTRACT

Disassembly is a fundamental process needed for component reuse and material recycling in all assembled products. Disassembly activities take place in various recovery operations including remanufacturing, recycling, and disposal. Disassembly is often a labor intensive and costly process. Techniques such as design for disassembly (DFD) have been reported in an attempt to lower the high cost of disassembly. Disassembly planning is concerned with finding the optimal sequence of disassembly for a given design. On the other hand, DFD examines the given design to evaluate its "fitness" for disassembly, and where appropriate, to provide high level suggestions to redesign the components so that they are easy to be disassembled. Introduced by Hitachi, Disassemblability Evaluation Method (DEM) analysis is performed when the design details are known (the parts number, types, optimal disassembly sequences, shapes of components and their disassembly relationships). DEM is used to guide the designer in the search for a best initial design to reduce the time and cost. As a result, the researcher investigates detail of the DEM approach from determined the disassembly sequences and determined the score for each part of the original design and give some suggestions to improve the design, finally redesign the product. In this paper, the researcher proposes the case study of the green product, electrical appliance home product to evaluate and to compare the original design and the new design with several parameters. Two main parameters to indicate this evaluation are the E index, (Disassemblability Evaluation Score) and the K index (Disassembly operation cost ratio). Comparison results of the case study had shown the percentages of improvement and reduction of several parameters for the original and new design.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Green Product

In the past two decades environmental concern has focused on production processes, and environmental regulation has concentrated on pollution from industry. However, there is growing awareness that this may not be sufficient and it is increasingly recognized that the use and disposal phases, as well as the production phase of the product life cycle, are important. Environmental regulation and consumer pressure are forcing manufacturers to become more responsible for the safe disposal and recycling of used products. This requires a new approach to product design, one which results in a product designed for all the stages of its life-cycle.

Environment consciousness is rapidly becoming the fundamental of product design [Boothroyd, 1994]. It has prompted for many concepts and ideas such as 'design for environment (DFE)', 'design for product retirement, environment conscious manufacturing', and 'end of life strategies'. These concepts involves the life cycle of the product, from conceptual design to final delivery, ultimately to the end of life disposal, recycling or remanufacturing of the products, such that it can greatly reduce

waste generation, thus increase product environment friendliness. Global markets now were increasing of competition, manufacturers always looking for a way to beat their competitors. If the public is more likely to buy a product from a company that they believe cares for environment, it will increase the competitive advantage of that particular company in the market. As consumers become more aware of the problem of waste disposal and the need for recycling, they may begin to demand more products that have been designed with these issues in mind. In order to capture the share of the market, manufactures need convince consumers that their product will cause less harm to the environment and will be more recyclable than the competition. This can be done in a number of ways, for example launching a green product, taking back old products at the end of their lives or introducing a new recycling initiative [Dowie, 1995].

Figure 1.1 shows the product life cycle, the time from product conception to final product disposal; includes production, inspection, and all phases of a product's life. What happen when the product at the end of product life cycle or at the product retirement stage? Thinking the environment performance, reuse, recycle and remanufacturing are very import in Design for Environment (DFE). To support DFE, design for recyclability, design for disassembly needs to be addressed. The most part is to dismantle the product to reuse, recycle or remanufacturing. Therefore Design for Disassembly enhances maintainability or serviceability of a product, and it enables recycling of materials, component parts, assemblies and modules.

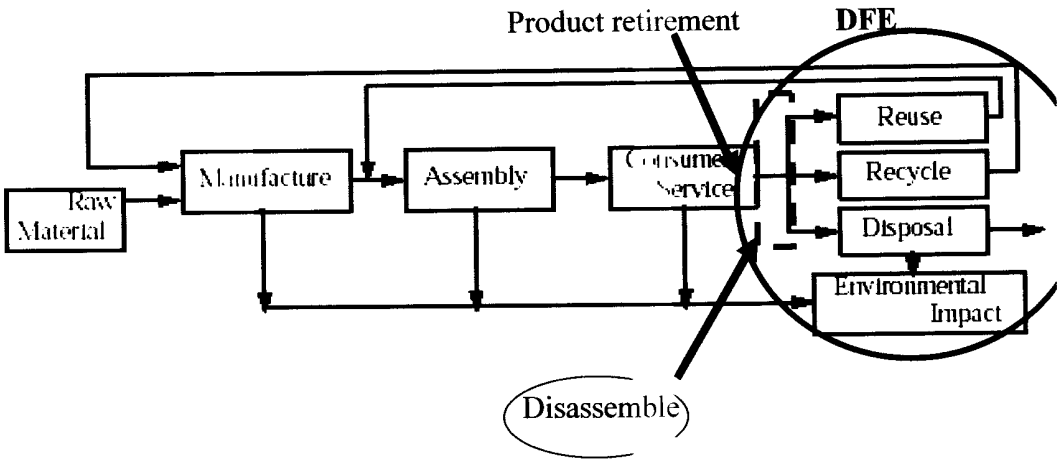

Figure 1.1: Product Life Cycle

1.2 Problem Definition

Traditionally issues considered in design have related only to function, appearance and financial concerns. As the decisions made by designers have a direct effect on the amount of raw material used, the amount of energy consumed and pollution produced by a product during its lifetime it is important that designers are given the right information and tools to enable them to minimize the effect their products will have on the environment. This is where the discipline of Design for the Environment (DFE) has an important role to play.

The manufacturing industry is facing environmental issues in various aspects; energy consumption and CO_2 emission, environmental pollution, waste problems and etc. An important counter measure for these problems is to establish a sustainable, closed loop circulating society. To achieve this, an advanced recycling system for end of life products is very important. One further aspect is the importance of establishing economically feasible methods to conduct recycling. "Economically" means that the measure or policy must be executed in a manner that the society can bare financially. Economically acceptable for the society is another important factor to realize a sound or

stable sustainable society. For the manufacturers, basically two strategies can be apply, developing efficient recycling processes and easier to recycle product in order to reduce the environmental load caused by end of life.

The success in realizing the recycling of end of life products greatly depends on whether the recycling process can be economically feasible. The reduction of product disassembling time is important in order to realize economically feasible recycling. In order to make products easier to disassemble, it is necessary to take the ease of disassembly into consideration at the design stage. Cost elements and product life cycle in figure 1.2 shows the activities involved in life cycle cost and the stages of product life cycle from raw material until the end of product life. The goal of product life-cycle engineering is to maximize the values of the manufacturer's line of products, while containing its costs to the manufacturer, the user, and society. Engineers and Designers must consider performance, costs, and environmental impact. In the past decade, researchers around the world have proposed various systematic methodologies that apply to the early stages of product development in integrating life-cycle quality [Ishii, 1995].

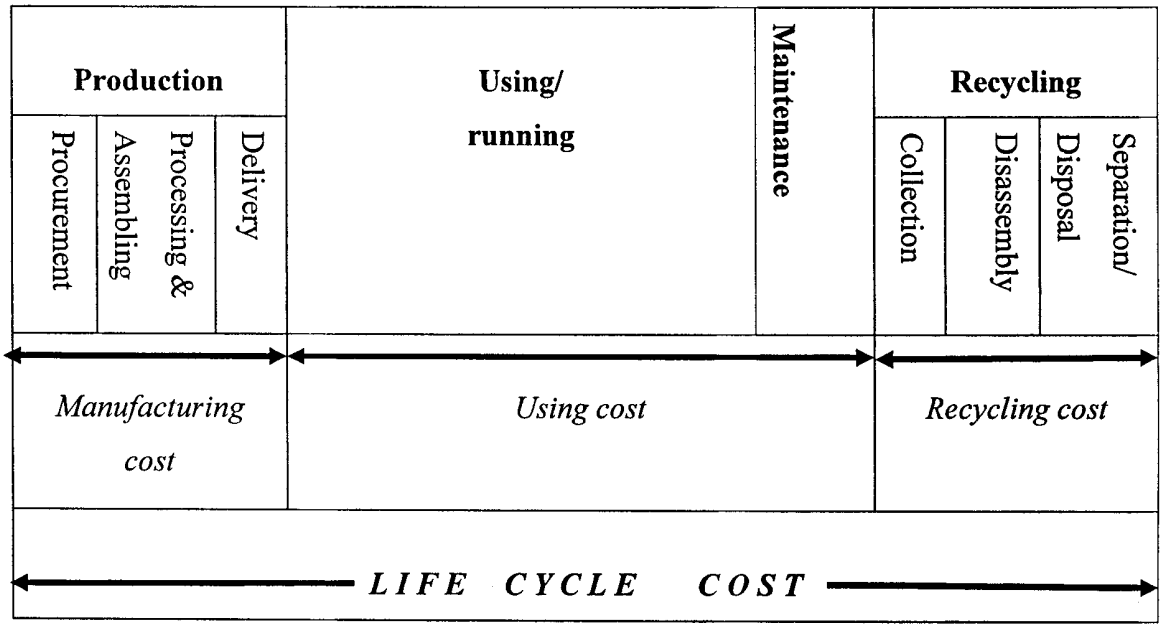

Figure 1.2: Cost elements of product life cycle

1.3 Objective of Study

The objective of this project is to evaluate the disassemblability for products based on reducing the environmental load caused by end of life products and improve recycling efficiency.

1.4 Scope of Study

The scopes of study for this project consist of;

i. Review on existing procedures for disassembly sequences generation.
ii. Study and understand on the Design for Disassembly (DFD) concepts and Disassemblability Evaluation Method (DEM) technique.
iii. Select on green product as the project case study.
iv. Analyse the existing product.
v. Make a modification for design improvement.
vi. Analyse the new design.
vii. Compared the new and old design.

1.5 Methodology of Study

This research is divided into two parts; part one is done in first semester and part two in second semester. Activities for part one consist of literature review on Design for Disassembly (DFD) and focus on the Disassemblability Evaluation Method (DEM) by Hitachi, understand on DEM approach and the application on this technique, green product case study selection, analysis the potential product, and determine the disassembly evaluation score. Part two consists of modification consideration to improve the product, redesign using 3D AutoCAD, analysis on the design, result finding and comparison, discussions and conclusion to complete the thesis. The details

flow chart for both semesters is shown in figure 1.3. Appendices A1 and A2 show the Gantt chart for the project schedule for first semester and second semester, respectively.

1.6 Significance of Finding

The researcher will come out the new design of the product with consideration of disassembly sequence for mechanical parts at the end of this research. Hopefully at the end of this, the researcher can achieve the score and percentage for the criteria listed as;

a) Improve the *E* index, (Disassemblability Evaluation Score) > 80.
b) Decrease the *K* index (Disassembly operation cost ratio) <0.7 or 70%.
c) Reduce the product components about 30% from the original design.
d) Reduce the disassembly time about 30% from the original design.

1.7 Report Structure

This report consists of eight chapters. Chapter I; Introduction, introduces the research area and is therefore rather general to its nature. The research method used to approach the research problem is outlined. Chapter II; Literature Review, presents what other researchers have done within this area. Related work is used to position the research in this thesis since a lot of research effort has been put in related areas. Material from this part is then used to build the foundation for the proposed method in Chapter III; Methodology for Disassemblability Evaluation Method (DEM), explains the approach for the proposed method as well as describes the requirements. Chapter IV; Product Case Study, is the part for detailing proposed as the case study in DEM approach. Chapter V; Original Design Analysis discusses the solution described in this part, also critically reviews the results. Further modification for improvement design is finally suggested. Chapter VI; Design Modification and Improvement, presents the detail modification, the reason for modification and the detail design modification.

Chapter VII; Comparison for Original and New Design, discusses about the disassembly evaluation for the original design and the suggestion based on the analysis result. Finally, Chapter VIII; Conclusion, concludes the project and proposes some recommendations for the future research.

1.8 Summary

In this chapter researcher present the overview of the study such as, green product, introduction to the research area, objective of study, scope of study, methodology of study and significance of findings. The next chapter will discuss the literature review of design for disassembly and Disassemblability Evaluation Method (DEM) has done by several researchers.

Project Flow Chart

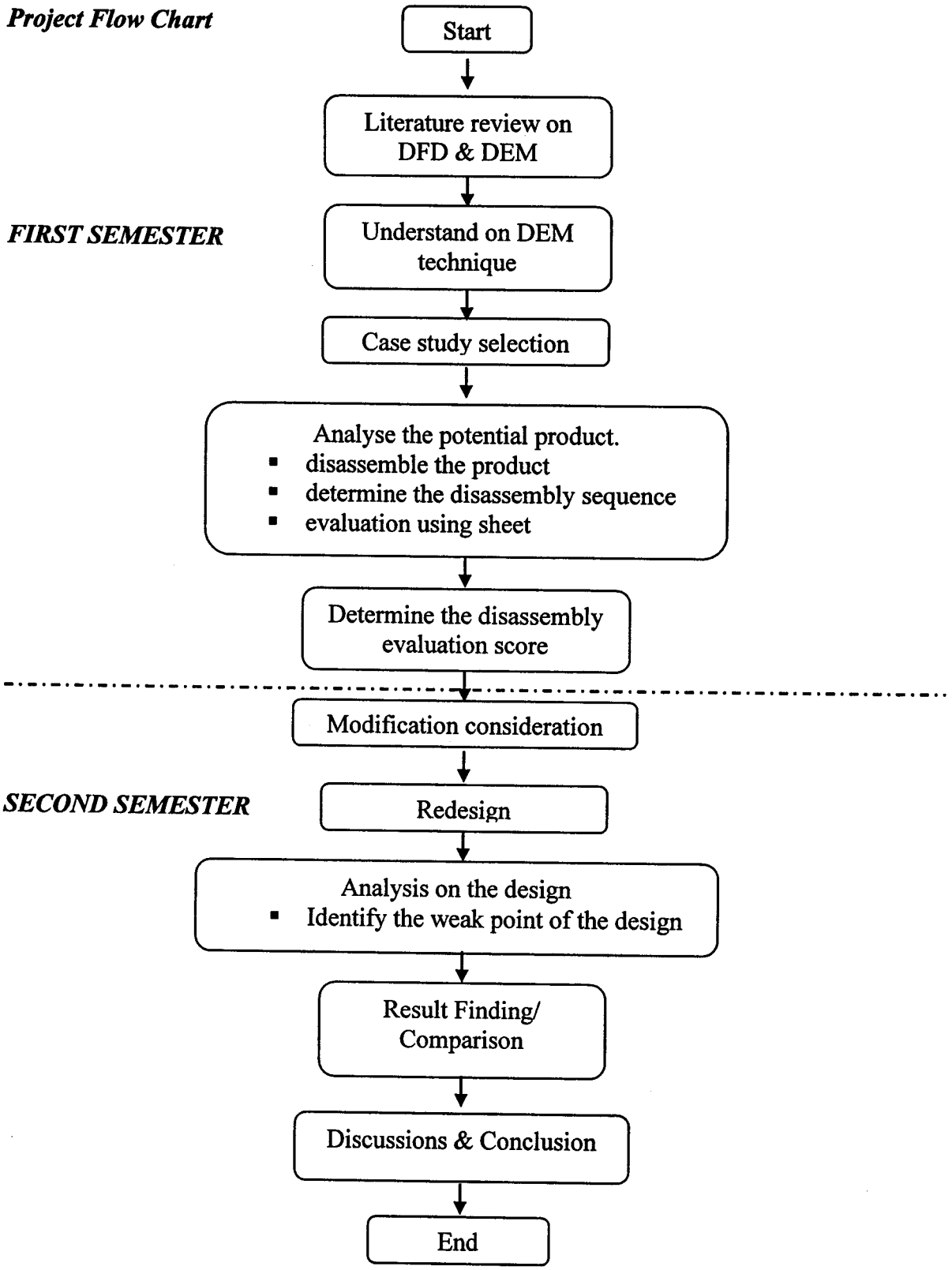

Figure 1.3: Project flow chart

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