



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**IMPROVE PRODUCT SUSTAINABILITY THROUGH DFE
APPROACH on DESIGN of HOME APPLIANCES:
A CASE STUDY on ELECTRIC IRON**

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

By

NELSON WONG WYE LEONG

FACULTY OF MANUFACTURING ENGINEERING

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Alamat Tetap:
10, Jalan Setia Impian U13/4P,
Setia Alam Seksyen U13 40170,
Shah Alam, Selangor.

Disahkan oleh:

(
TAJUL ARIFFIN BIN ABDULLAH
Ketua Jabatan (Rokabentuk Pembuatan)
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Hang Tuah Jaya,
Ayer Keroh, 75450 Melaka.

Cop Rasmi:

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.....
Tajul Ariffin bin Abdullah
(Official Stamp of Supervisor)

ABSTRACT

The development of electronic equipment and sustainability are a recent combination of conditions that come from the recognition of the importance of design, production, and material selection, kind of product, use and final disposal which are having impact on the environment. These urge manufacturers to consider environmental aspects at all stages of the product development process and increase resources efficiency at all phases of product life cycle. This report demonstrates the application of Design for Environment (DFE) concept to develop a sustainable product. The objectives are to integrate Design for Environment (DFE) tools into product design and development process; to carry out Sustainability analysis on product design to reduce environment load; and to carry out Life Cycle Assessment (LCA) study and compare the environmental performance of the new product with the benchmark product using the SimaPro software. The methodology carried out in this report is by developing an existing product as a benchmark and implementing DFE tools and guidelines to design a new sustainable product. Based on the evaluation of available benchmark product and analysis of the product, a new sustainable redesign product was developed accordingly to environment variables. Finally, the evaluation and comparison of environment impact and human health of the existing product and sustainable redesign product is carried out with the life cycle assessment (LCA) method. The environment impact is analyzed by mean of SimaPro software which is one of the LCA widely used software. After thoroughly analyses on environmental impact and detailed evaluation of the benchmark product performance, a new sustainable product is redesigned or improved in a way of environmental perspective. The sustainable product is expected to cause the lowest environmental impact throughout its life cycle.

ABSTRAK

Perkembangan peralatan elektronik dan kemapanan adalah kombinasi dari kondisi baru yang berasal dari pengetahuan terhadap pentingnya rekabentuk, produksi, pemilihan bahan, jenis produk, penggunaan dan pelupusan akhir yang memberi kesan terhadap persekitaran. Ini menggesa semua pengilang untuk mempertimbangkan semua aspek alam sekitar pada setiap peringkat pembangunan produk dan meningkatkan penggunaan kecekapan bahan mentah pada setiap peringkat kitaran produk bermula dari pengekstrakan bahan, pembuatan, pembungkusan, pengangkutan, penggunaan produk dan kitar semula. Laporan ini menunjukkan penerapan konsep Rekabentuk untuk Persekitaran (DFE) untuk membangunkan produk yang mapan. Objektif projek ini adalah untuk mengintegrasikan konsep DFE dalam rekabentuk produk dan proses pembangunannya; mengendalikan analisi untuk mengurangkan kesan terhadap persekitaran dan akhir sekali menggunakan kaedah LCA untuk membandingkan produk baru dan produk penilaian tanda aras dari segi aspek persekitaran. Metodologi yang akan dijalankan dalam laporan ini adalah dengan mengembangkan produk yang sudah ada sebagai penanda aras dan menerapkan alat DFE serta panduan untuk membangunkan produk baru yang mapan. Berdasarkan penilaian tanda aras produk dan bancian ke atas produk, sebuah rekabentuk semula produk mapan yang baru akan dibangunkan bersesuaian dengan pembolehubah persekitaran. Akhirnya, penilaian dan perbandingan kesan persekitaran dan kesihatan manusia terhadap produk sedia ada dan rekabentuk semula produk mapan yang baru dilakukan dengan menggunakan kaedah LCA. Kesan persekitaran ini dianalisis oleh perisian SimaPro yang mana ia merupakan salah satu daripada kaedah LCA yang digunakan secara meluas. Selepas analisis yg teliti terhadap kesan persekitaran dan penilaian prestasi produk penanda aras sebuah rekabentuk semula produk mapan yang baru akan dibangunkan dari sudut persekitaran.

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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TABLE OF CONTENT

Abstract	i
Abstrak	ii
Dedication	iii
Acknowledgement	iv
Table of Content	v
List of Figures	viii
List of Tables	x
List of Abbreviations, Symbols, Nomenclatures	xi
1. INTRODUCTION	1
1.1 Background	1
1.2 Project Background	2
1.3 Problem Statement	3
1.4 Objectives	3
1.5 Scope	4
1.6 Boundaries	
2. LITERATURE REVIEW	5
2.1 Background of Design for Environment (DFE)	5
2.1.1 Definition of DFE	6
2.1.2 Aims and Benefits of DFE	7
2.2 Design For Sustainability	8
2.3 Green Manufacturing	9
2.3.1 Green Manufacturing as an Option	10
2.4 Product Life Cycle	13
2.4.1 Reuse	17
2.4.2 Remanufacturing	18
2.4.3 Recycle	18

2.5	Implementation DFE Guidelines, Technique and Rules	18
2.6	DFE Tools	20
2.7	Life Cycle Assessment (LCA)	22
2.8	Description of Product Case Study (Electric Clothing Iron)	24
2.8.1	The Electric Iron	25
2.8.2	Parts of Electric Iron	26
2.8.3	Electric Iron Working Principle	30
2.9	Literature Review on Design for Sustainability	31
3.0	Summary	40
3. METHODOLOGY		41
3.1	Methodology Flow Chart	41
3.2	Detail Description of Methodology Flow Chart	44
3.2.1	Literature Review	44
3.2.2	Benchmarking of Competitor's Product	44
3.2.3	Material Analysis	45
3.2.4	Detailed Design	46
3.2.5	Assessment and Comparison of Environment Performance	47
3.3.6	Result & Discussion	47
3.3.7	Conclusion & Recommendation	47
4. RESULT AND DISCUSSION		48
4.1	Product Benchmarking	48
4.1.1	Product Specification	49
4.1.2	Product View Structure	51
4.1.3	Product System Level Design	53
4.1.4	Product Tree Structure	55
4.2	Material Analysis on Benchmark Product	59
4.2.1	Analysis on National Electric Iron – Handle	60
4.2.2	Analysis on National Electric Iron – Cover	62
4.2.3	Analysis on National Electric Iron – Soleplate	63

4.3	Material Selection for Sustainable Product	65
4.3.1	Sustainable Product Part – Handle	66
4.3.2	Sustainable Product Part – Cover	71
4.3.3	Sustainable Product Part – Soleplate	72
4.4	Material Choice for Sustainable Electric Iron	74
4.4.1	Sustainable Product Part – Handle	76
4.4.2	Sustainable Product Part – Cover	81
4.4.3	Sustainable Product Part – Soleplate	84
4.5	Sustainable Electric Clothing Iron Target Specification	89
4.6	Detailed Design of Sustainable Electric Iron	90
4.6.1	Detailed Design of the Handle	90
4.6.2	Detailed Design of the Cover	91
4.6.3	Detailed Design of the Soleplate	91
4.6.4	Detailed Design of the Dial Temperature	92
4.6.5	Assembly of the Sustainable Electric Iron	93
4.7	Sustainable Electric Clothing Iron Tree Structure	95
4.8	Technical Comparison with National Electrical Clothing Iron	96
4.9	Life Cycle Assessment	98
4.9.1	Life Cycle Assessment of National Electric Clothing Iron	99
4.9.2	Life Cycle Assessment of Sustainable Electric Iron	101
4.9.3	Comparison of Life Cycle Assessment	102
	5. CONCLUSION AND RECOMMENDATION	105
5.1	Conclusion	105
5.2	Recommendation	106
	REFERENCES	107
	APPENDICE	
A	Gantt Chart	
B	Detailed Drawing of sustainable electric clothing iron of product	

LIST OF FIGURES

2.1	Potential Environment impact across the entire product life cycle	14
2.2	Methodology for sustainable manufacturing at stages of product lifecycle	16
2.3	Common parts of electric iron	26
3.1	Methodology flowcharts	35
3.2	X-Ray Diffraction (XRD) machine used for this case study	45
4.1	National Electric Iron	49
4.2	Overall structure of the National Electrical Clothing Iron	51
4.3	System level design of National Electric Clothing Iron	53
4.4	Bimetallic strip in electric iron as temperature regulator	54
4.5	Main tree structure of National Electric Clothing Iron	55
4.6	Handle unit structure of National Electric Iron	56
4.7	Plate Cover unit structure of National Electric Iron	57
4.8	Weight unit structure of National Electric Iron	57
4.9	Iron base unit structure of National Electric Iron	58
4.10	Iron base unit structure of National Electric Iron	58
4.11	Illustration of XRD technique	59
4.12	The graph analyze view of Handle	60
4.13	The graph analyze view of Cover	62
4.14	The graph analyze view of Soleplate	63
4.15	Material Selection Process Flow	65
4.16	Handle	66
4.17	Aluminium Cover	71
4.18	Soleplate	72
4.19	Pie Chart Environmental Impact of ABS	77
4.20	Pie Chart Environmental Impact of PC	78
4.21	Pie Chart Environmental Impact of PP	79

4.22	Pie Chart Environmental Impact of Aluminium	82
4.23	Pie Chart Environmental Impact of Polycarbonate	83
4.24	Pie Chart Environmental Impact of Stainless Steel	85
4.25	Pie Chart Environmental Impact of Aluminium Metal	86
4.26	Isometric view of the Handle	90
4.27	Isometric view of the Cover	91
4.28	Isometric view of the Soleplate	92
4.29	Isometric view of the Dial Temperature	92
4.30	Isometric view of the Sustainable Electric Iron	93
4.31	Sectional view of the Sustainable Electric Iron	93
4.32	Exploded view of the Sustainable Electric Iron	94
4.33	Main tree structure of Sustainable Electric Clothing Iron	95
4.34	SimaPro software tree structure wizards for the National Electric Iron.	99
4.35	SimaPro Impact assessments for the National Electric Iron.	100
4.36	SimaPro software tree structure wizards for the Sustainable Electric Iron.	101
4.37	SimaPro Impact assessments for the Sustainable Electric Iron.	102
4.38	SimaPro impact comparisons (weighting).	103
4.39	SimaPro impact comparisons (single score).	103
4.40	SimaPro impact comparisons (damage assessment).	104

LIST OF TABLES

2.1	Example of DFE Tools and its Function	21
4.1	Benchmark and target sustainable product handle of properties	68
4.2	Data Sheets Properties for Thermoplastic	69
4.3	Summary of Sustainability Results on Environment Impact	80
4.4	Advantages Comparison between Stainless Steel and Aluminium Metal	84
4,5	Summary of Sustainability analysis for electric iron	88
4.6	Technical Comparison of Sustainable and Benchmark electric iron	96

LIST OF ABBREVIATIONS

ABS	-	Acrylonitrile Butadiene Styrene
AC	-	Alternate Current
Al	-	Aluminium
CAD	-	Computer-Aided Design
CO ₂	-	Carbon Dioxide
CR	-	Customer Requirements
DFA	-	Design for Assembly
DFD	-	Design for Disassembly
DFE	-	Design for Environment
DFMA	-	Design for Manufacturing and Assembly
DFS	-	Design for Sustainability
ECQFD	-	Environmentally Conscious Quality Function Development
EIA	-	Environment Impact Assessment
EIS	-	Environment Impact Statement
EM	-	Engineering Matrices
EOL	-	End-of-Life
EPA	-	Environmental Protection Agency
FU	-	Functional Unit
GHG	-	Green House Gas
GMAT	-	Green Management Assessment Tool
GWP	-	Global Warming Potential
ISO	-	International Standard Organization
LCA	-	Life Cycle Assessment
LCC	-	Life Cycle Cost
LCD	-	Life Cycle Design
LCI	-	Life Cycle Inventory
LED	-	Light Emitting Diode
MJ	-	Megajoule

N	-	Nitrogen
PC	-	Polycarbonate
PF	-	Phenol Formaldehyde
PO ₄	-	Phosphate
PP	-	Polypropylene
Pt	-	Point
QFD	-	Quality Function Development
SO ₂	-	Sulfur Dioxide
SS	-	Stainless Steel
UV	-	Ultraviolet
WEEE	-	Waste Electronic and Electronic Equipments
XRD	-	X-Ray Diffraction

CHAPTER 1

INTRODUCTION

1.1 Background

The world is facing problem with limited resources, serious environmental impacts and escalated disposal rate of product, hence this trigger the importance of living a more sustainable life style. The problem arise is not only designers' and manufacturers' but also responsibility for every inhabitant to overcome these environmental problems. During last century, the environmental problem faced at the end of life cycle of certain product during disposal or recycling. But today the environment performances of a product are taken into consideration in very early stages of product design and development.

Basically, there are four environmental challenges need to be faced and overcome by the mankind which are over-consumption, resources utilization, pollution and over-population. Over-consumption means that the use of various type of material to produce a product which demands for higher utilization of transportation. Thus, increases the energy consumption around the world. Resources utilization requires a product not to be “over-designed” over having unnecessary parts. As for pollution is a common challenge in industry resulting from emissions. Lastly, over-population refers to ever increasing world inhabitants that demand for less consumption for resources or energy, otherwise the mankind will face an exhaustion of those resources and energy.

Besides meeting the customers' needs for better quality and price demands and employees demand for economic competitiveness, the design engineers also have to take into consideration the environmental impact during designing phase of a product. Fundamentally, it is impossible to design a product which has zero impact on

environment and human health. However, this drawback can be solved by implementing Design for Environment (DFE) at early stages of product design and development.

Design of product according to DFE enables companies or firms to be recognized according to International Standards Organization 14001 for Environmental Quality System. Adopting DFE into their product actually benefits the companies in many areas such as broadening market access; expediting permits, reducing liability, improve public acceptances of the product, decreasing pollution and conserve energy or natural resources.

1.2 Project Background

As for this project, a benchmark product will be chosen to be analyzed its performance and environmental impact. The product then will be developed using DFE tools to obtain a sustainable product with less environmental influential. At the end, the performances of the product developed will be analyzed with LCA method by comparing to the benchmark product.

The aim of the sustainable product will be designed to reduce a product process energy consumption, material usage, recycle-ability or toxicity compared to its originally designed performance level by the implementation of DFE. The expected outcome for this project is the sustainable product that will have less impact than the benchmark on environment and mankind.

1.3 Problem Statement

At the beginning of a designed and introduced in the current market product, the environment value of the product is given a less priority. Thus, this has led to a lack of environmental friendly products in market. Every such product in the market will eventually face the risk of disposal difficulties at the end of the products life. Hence, this led to the raised of a product cost due to the disposal difficulties. The emission and waste produced during the manufacturing phase and service of a product will eventually harm the environment and health of product users. Aside from those mentioned issues, another crucial issue is the ever depleting nature resources and material urging the necessity to produce environmental friendly goods. This project will look into implementation of DFE method and tools to obtain a sustainable product that will have less impact on the environment and human health than benchmark product.

1.4 Objectives

The objectives of this project are:

- a) To identify a current product as a benchmark for sustainable product development and make necessary study and analysis about the product for sustainable improvement.
- b) To integrate Design for Environment (DFE) tools into product design and development process.
- c) To carry out Sustainability analysis on product design in order to reduce environment load.
- d) To carry out Life Cycle Assessment (LCA) study and compare the environmental performance of the new product with the benchmark product using the SimaPro software.

1.5 Scope

The product design and process development is based on the DFE guidelines, method and tools obtained through literature studies. The benchmark product will be analyzed for its material composite and new material will be suggested to replace those non-environmentally friendly former materials of the product. The environmental performance of the products is evaluated with SimaPro which is software for LCA studies. As for the new product detailed design will be produced by using CAD software SolidWork.

1.6 Boundaries

The restraint of this project is that the electrical and electronic of the product will not be analyzed. Heat energy is also excluded from the studies. Thus, this leaving behind material selection and design of the product to be analyze. Others area in such; electricity, transportation, manufacturing process of the product and cost are not included in the field of this project.

CHAPTER 2

LITERATURE REVIEW

A literature review is a body of text that aims to review the critical points of current knowledge on a particular topic. Literature reviews are secondary sources, and as such, do not reports any new or original experimental work. Literature search was to perform studies, implementation, design and analyzing the sustainable product through the implementation of Design for Environment (DFE) tools and methods. This particular study also includes the areas of the product design and development of the sustainable product. This chapter will explain all the terminology used and certain of important definition.

2.1 Background of Design for Environment (DFE)

The first consideration of the technical aspects associated with the practice of a design action directed at reducing the environment impact of products appeared in the first half of 1980s. In the early 1990s, these first experiences were followed by a phase of greater understanding of new needs to safeguard resources, which consolidated in a wide diffusion of new ideas and experiences developed with the clear objective of integrating environmental demands in traditional design procedures. In this way a new approach to the design intervention was born, known as Design for Environment (DFE), characterized by the priority objective of minimizing the impact of the products on the environment. (Lindahl,2006)

Another word to portray DFE is an effort to take environmental issues into consideration during the product development stage in every industry. It is also known as eco-design and life cycle design (LCD). It is the aim of integrating environment aspects into product development stage is to reduce the total amount of environment impact of products during its life cycle. (ISO 14062)

Some others strongly relate DFE with Design for Sustainability because its component and field of studies is very identical to each another. Hence, it is grouped Design for Sustainability as a subset of Design for Environment. Another word that strongly related to DFE is the term “Green Manufacturing”. One of the DFE approach or objectives is to produce greener and cleaner product and production process. Thus, Green Manufacturing is the combination of those green and clean product and process of it. (Karlsson, 2006)

The priority objective of DFE is to produce sustainable product that will increase the positive value and decrease the negative values that contribute on the environment impact. At the same time, the product must be able to serve and satisfy human needs and requirement.

2.1.1 Definition of DFE

DFE is a strong influential new term in product design and development due to the awakening of humanity towards the environmental issues lately. Therefore, there are many definitions are phrased to define the concept of DFE by intellectuals around the world. One source define as a general concept that refers to a variety of design approaches that attempt to reduce the overall environmental impact of a product, process or service, where environmental impacts are considered across its life cycle.(Allenby,1994)

Another source defined as a systematic consideration of design performance with respect to environment, health, and objectives over the full product and process life cycle.(Giudice,2006) Others say as reflections on the relationship between technology and the environment evidence the fundamental principles that can serve as the basic for development of more effective methodologies for their complete integration.(Popoff,2000)

DFE referred as a methodology directed at the systematic reduction or elimination of the environment impacts implicated in the whole life cycle of a product, from the extraction of raw materials to disposal. Simplification is that a systematic approach to addressing the entire system of environmental impacts across the whole product life cycle.

As a conclusion, Design for environment is the systematic by which firm design products and processes in an environmentally conscious way based on industrial ecology principles across the entire product life cycle.

2.1.2 Aims and Benefits of DFE

At the beginning of DFE implementation in product development, it is often causes problems in companies rather than benefits as environment assessments tools because they are likely to increase the development cost and is very complicated. After further research and improvement is made on DFE tools and techniques, DFE benefits had gained through good reputation among the customers and better method of cost saving through recycling material.

Manufacturing firms now are beginning to reap benefit from DFE which provide opportunity for cost saving and reduced responsibility for environmental and human health protection. The application of DFE during the product development stages has proved beneficial by reducing manufacturing cycle time and distinguishes products with added value of environment features to provide competitive advantages in the market.

Besides that, DFE raise an opportunity to design and develop sustainable product without much influencing the products market competitiveness and profitability.

From the perspective of customers, practicing DFE benefits the industry itself by widening the market access and customer base, expediting permits. This is done through good reputation to preserve nature. Thus, improves customer acceptance of the product. Aside from that, implementation of DFE reduces record tracking and less inspection. Naturally, DFE decreases emission and pollution, conserve energy and natural resource. Significantly, all these will contribute to economical advantages and ultimately reducing manufacturing cost.

According to DeMendonca (2001), the aims of DFE are to:

- a. Reduce waste at all stages of manufacturing, product usage and disposal.
- b. Overcome expensive disposal problems by adopting environment friendly materials.
- c. Reduce or prevent pollution and emission.
- d. Utilize energy and resources conservation.

2.2 Design For Sustainability

Designing for sustainability requires awareness of the full short and long-term consequences of any transformation of the environment. Sustainable design is the conception and realization of environmentally sensitive and responsible expression as a part of the evolving matrix of nature.

Others saying is that design for sustainability is the process of designing good and services that take into account all the dimensions of sustainable development, and particularly environment, economics, and social factors and some authors said DFS is the superset of the more commonly discussed “Design for Environment”.(Birkeland,2002)