ASSEMBLABILITY DESIGN EFFICIENCY (ADE) ANALYSES FOR DESIGN FOR AUTOMATIC ASSEMBLIES

BAIZURA BINTI ZUBIR @ ZUBAIR

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To my beloved husband and daughter, thank you for your patients and loved

To my beloved father, thank you being a good father

To my mother, I will always miss you

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ABSTRACT

The ability to quickly develop new products, which are of the lowest cost, the highest quality and the fewest environment impact, is a key factor to meet the global market demand. Design for Assembly (DfA) has been most widely applied in industries with most impressive achievements. Since the prevalence of three well known DfA tools – Boothroyd-Dewhurst DfA methodology, Hitachi Assemblability Evaluation Method (AEM) and Lucas-Hull DfA method – in industries, significant developments have been attempted in several directions not only by manual assembly but also by automatic assembly. The purpose of this project is to determine the Assemblability Design Efficiencies (ADE) by implementing the assembly analyses on the selected mechanical product for Design for Automatic Assemblies (DFAA) methodology. The results from the analyses will be used for further design improvements.

ABSTRAK

Keupayaan untuk menghasilkan produk baru yang mempunyai ciri-ciri seperti mempunyai kos yang rendah, tinggi kualiti dan dapat menghasilkan impak yang minimum pada persekitaran merupakan faktor utama di dalam memenuhi pasaran antarabangsa. Pemasangan untuk Reka bentuk (DfA) telah banyak diaplikasikan di dalam industri dan telah menghasilkan pelbagai kejayaan. Sejak kewujudan tiga alat DfA yang ternama – kaedah Boothroyd-Dewhurst DfA, kaedah analisis Hitachi Assemblability (AEM) and kaedah DfA Lucas-Hull– di dalam industri, banyak pembangunan penting telah dijalankan samada secara pemasangan insani ataupun pemasangan automatik. Tujuan projek ini dijalankan ialah untuk menentukan Kecekapan Keupayaan Pemasangan (ADE) dengan mengimplikasikan analisis pemasangan pada produk mekanikal yang terpilih untuk Kaedah Pemasangan Automatik bagi Reka bentuk (DFAA). Keputusan daripada analisis ini akan digunakan untuk penambaikan reka bentuk akan datang.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xiv
	LIST OF FIGURES	xvi
	LIST OF SYMBOLS	xviii
	LIST OF APPENDICES	xix
1	**INTRODUCTION**	**1**
	1.1 Problem Statement	1
	1.2 Objective of Study	3
	1.3 Scope of Study	4
	1.4 Methodology of Study	4
	1.5 Significance of Findings	7
	1.6 Report Structure	8
	1.7 Summary	9

2	**LITERATURE REVIEW ON DESIGN FOR MANUAL ASSEMBLY METHODOLOGY**		**10**
	2.1	Introduction	10
	2.2	Design for "X"	11
	2.3	Approaches for Implementing DFA	13
		2.3.1 Hitachi Assemblability Evaluation Method (AEM).	13
		2.3.2 Boothroyd-Dewhurst (B-D) DFA	14
		2.3.3 Lucas DFA	15
	2.4	Assemblability Measures	17
		2.4.1 Hitachi Assemblability Evaluation Method (AEM)	17
		2.4.2 Boothroyd Dewhurst DfA	18
		2.4.3 Lucas DFA	20
	2.5	Examples of DFA Methodologies	22
		2.5.1 Redesign of a simple product using Hitachi Assemblability Evaluation Method (AEM).	22
		2.5.2 Redesign of a simple product using the Boothroyd-Dewhurst DFA method	25
		2.5.3 Redesign of a drain pump assembly using Lucas DFA	29
	2.6	Summary	32
3	**DESIGN FOR AUTOMATIC ASSEMBLY (DFAA) METHODOLOGY**		**33**
	3.1	Introduction	33
		3.1.1 Fixed/ Hard automation	34
		3.1.1 Robotic Assembly/ Soft automation	35

3.2 Structure of DFAA 38
3.2.1 Product Level 38
3.2.1.1 Reduce Number of Parts 39
3.2.1.2 Unique Parts 40
3.2.1.3 Base object 41
3.2.1.4 Design base object 41
3.2.1.5 Assembly directions 42
3.2.1.6 Parallel operations 43
3.2.1.7 Chain of tolerances 44
3.2.1.8 Disassembly 44
3.2.1.9 Packaging 45
3.2.2 Part Level 45
3.2.2.1 Need to Assemble Part? 47
3.2.2.2 Level of Defects 48
3.2.2.3 Orientation 48
3.2.2.4 Non-Fragile parts 49
3.2.2.5 Hooking 50
3.2.2.6 Centre of Gravity 50
3.2.2.7 Shape 51
3.2.2.8 Weight 52
3.2.2.9 Length 52
3.2.2.10 Gripping 54
3.2.2.11 Assembly Motion 54
3.2.2.12 Reachability 55
3.2.2.13 Insertion 56
3.2.2.14 Tolerances 56
3.2.2.15 Holding Assembled Parts 57
3.2.2.16 Fastening Method 58
3.2.2.17 Joining 58
3.2.2.18 Check/Adjust 59

	3.3	Applications of DFAA	59
		3.3.1 Design and Evaluation During Early Product Development	59
		3.3.2 Redesign and Evaluation of an Existing Product	60
	3.4	Evaluation Philosophy and Criterions of DFAA	61
	3.5	Summary	62
4	**PRODUCT DETAIL FOR OLD DESIGN**		**63**
	4.1	Introduction	63
	4.2	Product Specification	64
	4.3	Product Structure	66
	4.3	Product Assembly Operation Sequences	67
		4.3.1 Base Part	67
		4.3.2 Cover Part	69
	4.4	Summary	72
5	**EVALUATION OF THE ORIGINAL DESIGN**		**73**
	5.1	Introduction	73
	5.2	Product Level Evaluation of The Old Design	74
		5.2.1 Reduce Number of Parts	74
		5.2.2 Unique Parts	75
		5.2.3 Base Object	75
		5.2.4 Design Base Objects	75
		5.2.5 Assembly Directions	76
		5.2.6 Parallel Operations	76
		5.2.7 Chain of Tolerances	78
	5.3	Part Level Evaluation of The Old Design	78
		8.2.1 Base Socket	79

8.2.2 Switch On/Off 80
8.2.3 Spring 80
8.2.4 Panel 3 Pin 80
8.2.5 Cover Socket 80
8.2.6 Life Plate 81
8.2.7 Life Clamp 81
8.2.8 Life Screw ϕ6 X 11 81
8.2.9 Life U Plate 81
8.2.10 Connector Panel 3 Pin 82
8.2.11 Plate Switch On/Off 82
8.2.12 Earth U Plate 82
8.2.13 Earth Plate 82
8.2.14 Earth Clamp 83
8.2.15 Earth Screw ϕ6 X 11 83
8.2.16 Neutral U Plate 83
8.2.17 Neutral Clamp 83
8.2.18 Neutral Screw ϕ6 X 11 84
8.2.19 Screw ϕ5 X 12 84
8.2.20 Screw ϕ6.5 X 23 84
5.2 Summary 84

6 PROPOSED IMPROVEMENTS ON THE ORIGINAL DESIGN 86

6.1 Introduction 86
6.2 Improvement of The Original Design 86
6.2.1 Eliminating Screws ϕ5 X 12 and Changing to Snap Fits 87
6.2.2 Joining Life Plate, Life U Plate, Panel 3 Pin and Connector 3 Pin 88
6.2.3 Joining Earth Plate, and U Plate 89

6.2.4 Joining Clamp and Screw ϕ6 X 11 90
6.3 Summary 91

7 PRODUCT DETAIL FOR PROPOSED DESIGN 92

7.1 Introduction 92
7.2 Product Specification 92
7.3 Product Structure 94
7.4 Product Assembly Operation Sequences 94
7.4.1 Base Part 95
7.4.2 Cover Part 95
7.4.3 All Parts 96
7.5 Summary 97

8 EVALUATION OF THE NEW DESIGN 98

8.1 Introduction 98
8.2 Product Level Evaluation of The New Design 98
8.2.1 Reduce Number of Parts 99
8.2.2 Unique Parts 99
8.2.3 Base Object 100
8.2.4 Design Base Objects 100
8.2.5 Assembly Directions 100
8.2.6 Parallel Operations 100
8.2.7 Chain of Tolerances 101
8.3 Product Level Evaluation of The New Design 102
8.3.1 Base Socket 103
8.3.2 Switch on/off 103
8.3.3 Spring 103
8.3.4 Panel 3 Pin 103
8.3.5 Cover Socket 3 Pin 104

		8.3.6 Life Plate	104
		8.3.7 Life Clip	104
		8.3.8 Earth Plate	104
		8.3.9 Earth Clip	105
		8.3.10 Neutral Plate	105
		8.3.11 Neutral Clip	105
		8.3.12 Screw ϕ6.5 X 23	105
	8.4	Summary	106
9	**DISCUSSION**		**107**
	9.1	Introduction	107
	9.2	Comparison Between The Original Design and Proposed Design	108
		9.2.1 Number of Components	110
		9.2.2 Number of Unique Components	111
		9.2.3 Assembly Index for Product Level	112
		9.2.4 Assembly Index for Part Level	112
10	**CONCLUSIONS AND FUTURE RECOMMENDATIONS**		**113**
	10.1	Introduction	113
	10.2	Conclusions	113
	10.3	Future Recommendations	115
	REFERENCES		**116**
	APPENDICES		**118**

LIST OF TABLES

TABLE NO.	TITLE	PAGE
1.1	Gantt chart for Master Project I	5
1.2	Gantt chart for Master Project II	7
2.1	DFX as lifecycle oriented or ability oriented (WDK, 1993)	12
2.2	DFA worksheet analysis	18
2.3	Evaluation score and the cost ratio of the original design	23
2.4	Evaluation score and the cost ratio of redesign 1	24
2.5	Evaluation score and the cost ratio of redesign 2	25
2.6	Manual assembly worksheet for the original design	26
2.7	Manual assembly worksheet for Redesign 1	27
2.8	Manual Assembly Worksheet for Redesign 2	28
3.1	The evaluation of the part reduced in the product	40
3.2	The evaluation of the unique parts in the product	40
3.3	The evaluation of the base object of the product	41
3.4	The evaluation of the design base object of the product	42
3.5	The evaluation of the assembly directions of the product	42
3.6	The evaluation of the parallel operations of the product	43
3.7	The evaluation of the chain of tolerances of the product	44
3.8	The evaluation need to assemble part of each part	45
3.9	The evaluation level of defects of each part	47
3.10	The evaluation for orientation of each part	48
3.11	The evaluation for non-fragile parts	48
3.12	The evaluation for hooking of each part	49
3.13	The evaluation for centre of gravity of each part	49
3.14	The evaluation for shape of each part	50
3.15	The evaluation for weight of each part	51

3.16	The evaluation for length of each part	52
3.17	The evaluation for gripping of each part	52
3.18	The evaluation for assembly motion of each part	53
3.19	The evaluation for reachability of each part	54
3.20	The evaluation for insertion of each part	55
3.21	The evaluation for tolerances of each part	55
3.22	The evaluation for holding assembled parts	56
3.23	The evaluation for fastening method of each part	57
3.24	The evaluation for joining of each part	58
3.25	The evaluation for check/ adjusts of each part	59
3.26	Evaluation sheet for Product Level	61
3.27	Evaluation sheet for Part Level	62
4.1	Three (3) Pin Wall Socket Specification	64
5.1	Evaluation sheet of product level for the old design of 3 pin wall socket	74
5.2	Evaluation sheet of part level for the old design of 3 pin wall socket	79
7.1	Specification of Three (3) Pin Wall Socket New Design	92
8.1	Evaluation sheet of product level for the old design of 3 pin wall socket	99
8.2	Evaluation sheet of part level for the new design of 3 pin wall socket	102
9.1	Comparison in Percentage between the Original Design and Proposed Design	108
9.2	Comparison between the Number of Components in Original Design and New Design	111

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Types of DFA	2
1.2	Flow Chart Master Project I	5
1.3	Flow Chart Master Project II	6
2.1	Assembly sequence flow chart	21
2.2	Original design	22
2.3	Redesign 1	23
2.4	Redesign 2	24
2.5	Original design	25
2.6	Redesign 1	27
2.7	Redesign 2	28
2.8	Original drain pump assembly design	30
2.9	Redesign using the Lucas DFA method	31
3.1	Classification of Automatic Assembly	33
3.2	DFAA Method	38
3.3	Suggested structure for Product level in the DFAA method (Stephan Eskilander, 2001)	39
3.4	Suggested structure for Part level in the DFAA method (Stephan Eskilander, 2001)	46
4.1	(a) Front view (b) Back view of 3 pin wall socket	63
4.2	Three (3) Pin Wall Socket Structure of the Old Design	66
4.3	Summary of the Assembly Process for Base Part	67
4.4	**(a)** Before assembled **(b)** After assembled for base part	68
4.5	Assembly Sequences for Cover Part	70
4.6	**(a)** Before assembled **(b)** After assembled for cover part	71
5.1	Parallel Operations	77

6.1	The location of screw ϕ5 X 12 on the 3 pin wall socket	86
6.2	The Proposed Design from Screws ϕ5 X 12 to Snap Fits	87
6.3	The Proposed Design from Separate Life Plates to a Life Plate	88
6.4	The Proposed Design from Separate Earth Plates to an Earth Plate	89
6.5	The Proposed Design from Separate Clamp and Screw ϕ6 X 11 to a Clip	89
7.1	Three (3) Pin Wall Socket Structure of the New Design	93
7.2	Summary of the Assembly Process for Base Part	94
7.3	Assembly Sequences for Cover Part	95
7.4	Assembly Sequences for 3 Pin Wall Socket of the New Design	96
8.1	Parallel Operations	101
9.1	Comparison Number of Components in Old and New Designs	109
9.2	Comparison Number of Unique Components in Old and New Designs	109
9.3	Comparison between Assembly Index in Old and New Designs	110

LIST OF SYMBOLS

AEM - Assemblability Evaluation Method

E - Assemblability Evaluation Score

DFA - Design for Assembly

DFAA - Design for Automatic Assembly

DFM - Design for Manufacture

DFE - Design for environment

DFC - Design for cost

DFT - Design for test

DFMA - Design for Manufacture and Assembly

DFX - Design for “X”

TM - Assembly time

CM - Assembly cost

NM - Theoretical minimum number of parts

ADE - Assembly Design Efficiency

K - Estimated Assembly Cost Ratio

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A1	Manual Handling Time (seconds)	118
A2	Manual Insertion and Fastening Time (seconds)	119
B1	Design Samples of 3 Pin Wall Socket (Overall)	120

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Design for assembly (DFA) is a way to improve assembly ease and reduce assembly time. It will also reduce product costs by reducing the number of parts, optimizing manufacturing processes, simplifying parts handling and improving product assembly. Furthermore, the implementation of DFA will encourage the design of products to be produced at minimum cost with maximum quality and reliability. Many leading companies such as Ford, Kodak, General Motors, IBM, NCR, Xerox and more have save millions of money when using DFA analysis in their designs.

DFA indicates the important in analyzing both the part design and the whole product for any assembly problems early in the design process. Furthermore, it can also be defined as "*a process for improving product design for easy and low-cost assembly, focusing on functionality and on assemblability concurrently."*

DFA is classified into two major groups: manual and automatic assembly as shown in **Figure 1.1**.

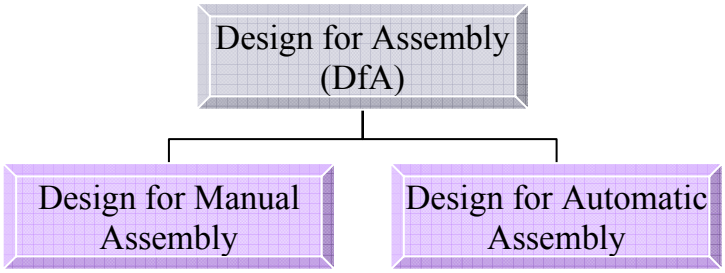

Figure 1.1: Types of DFA

Design for manual assembly involves benches or simple conveyors and the assembly station has bins with un-oriented parts. Besides that, it also has simple jigs and fixtures with manual clamping and simple, light tools with an inexpensive setup costs.

On the other hand, design for automatic assembly (DFAA), involves any mechanical assembly process which perform assembly operations without human interaction. DFAA is divided into two: high speed (special purpose) transfer assembly and robotic assembly. High speed transfer assembly involved machines that are built to produce specific product. The components are part feeders, single purpose workheads and transfer devices. Meanwhile, the robotic assembly is similar to non-synchronous special purpose assembly stations, except the robots replace the single-purpose workheads.

Between these two types of DFA, the most common practice is manual assembly due to its versatility, flexibility, economical and sensing capabilities of human assembly workers. Meanwhile, for automatic assemblies the characteristics above are difficult to get economically but the advantage is mechanical assembly equipments have the capability to work many hours compare to human assembly workers.

However, when we apply automatic assembly on the product it can also be implemented on manual assembly. Mazka (1985) stated that *"Any product designed for automated assembly will be easier to assemble manually"*. It means that, if a product can be prepared for automatic assembly, it will also be much easier for a human to assemble. According to Herbertsson (1999) in 1960s, when products began to be

redesigned for automatic assembly, it was often discovered that the redesigned product was so easy to assemble manually that automatic assembly was no longer economically feasible.

Due to potential benefits that DFAA have compare to DFA for manual assembly so for this project, we will focus on DFAA to improve the product design of a mechanical product. At the same time, we also have to consider some operations that may be have to be carried out manually, which it is necessary to include also the analysis for manual assembly.

Besides that, in DFA analysis we can compare the assembly efficiency for both DFA for manual assembly and DFAA for automatic assembly. From there, we can make improvements on the product itself that will suit automatic assembly process that in return will give benefits to us.

The product case study of a 3 pin wall socket will clarify the application of DFAA analysis, show the utility of the product structure of DFAA method, and allow the exploration between product evolution of the original design and proposed design for further improvements.

1.2 Objective of Study

The objective of the study is to improve the product design by determining the Assemblability Design Efficiencies (ADE) using Design for Automatic Assemblies (DFAA) methodology for mechanical product.

1.3 Scope of Study

The scope of this study is to use Design for Automatic Assembly (DFAA) methodology in assembly analyses. A case study of a mechanical product will clarify the application of the method with the analyses and percentage of ADE.

1.4 Methodology of Study

The methodology of the study for Master Project I and II were included in session 2006/2007 semester II and session 2007/2008 semester I. The details of this methodology are shown in forms of flow diagrams (**Figure 1.1** and **1.2**) and Gantt charts (**Table 1.1** and **1.2)** which are located by semesters.

For Master Project I, the project was done in semester 2006/2007 (II). The flows of works are shown in **Figure 1.2** and **Table 1.1.**

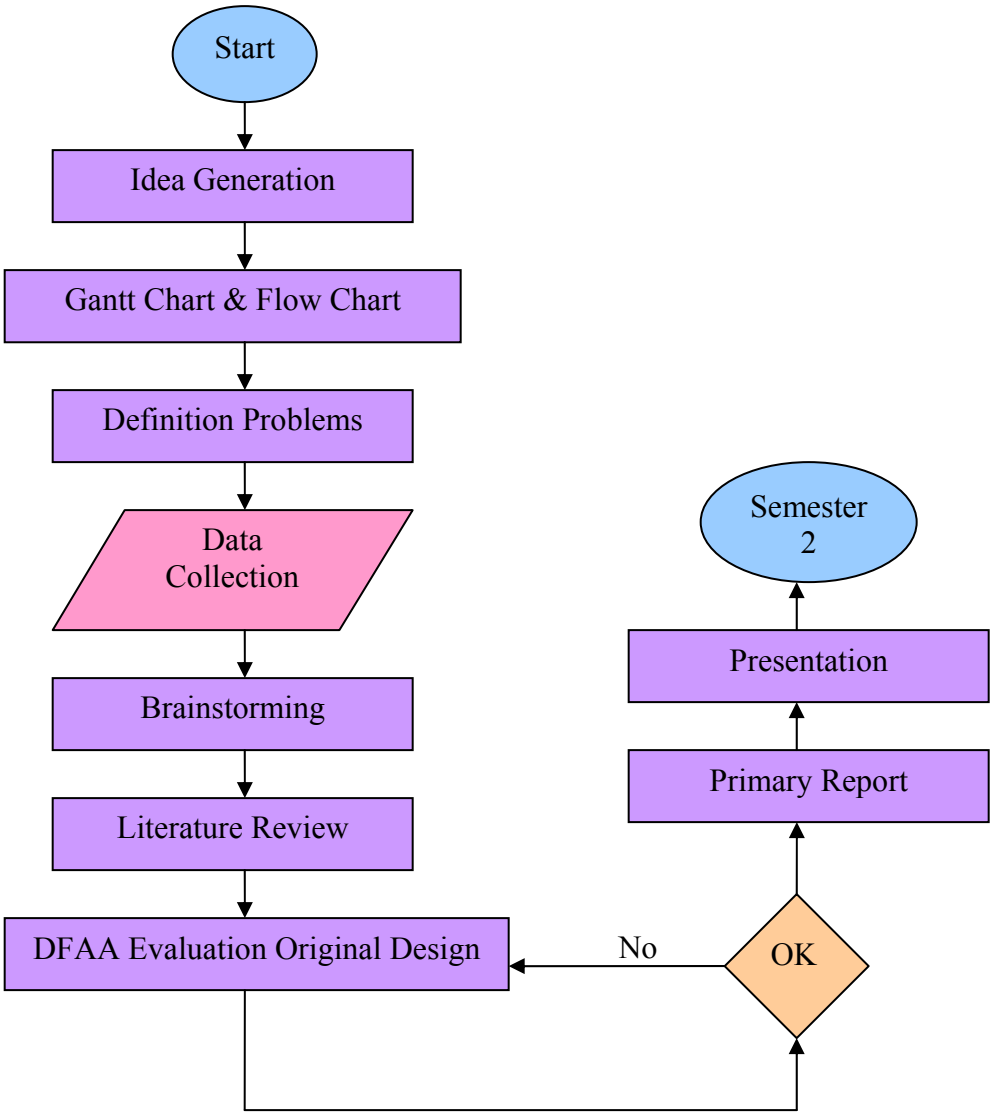

Figure 1.2: Flow Chart Master Project I

No.	Task Descriptions	2006/2007 (II)														
		Dec	January					February				March				April
		26	1	8	15	22	29	5	12	19	26	5	12	19	26	2
1	Problem Definition															
2	Data Collection															
3	Literature Review															
4	Product Description															
5	DFAA Evaluation of the Original Design															
6	Propose Design Improvement															
7	Primary Report															
8	Presentation															

Table 1.1: Gantt chart for Master Project I

For Master Project II, the project was done in semester 2006/2007 (III). The flows of works are shown in **Figure 1.3** and **Table 1.2.**

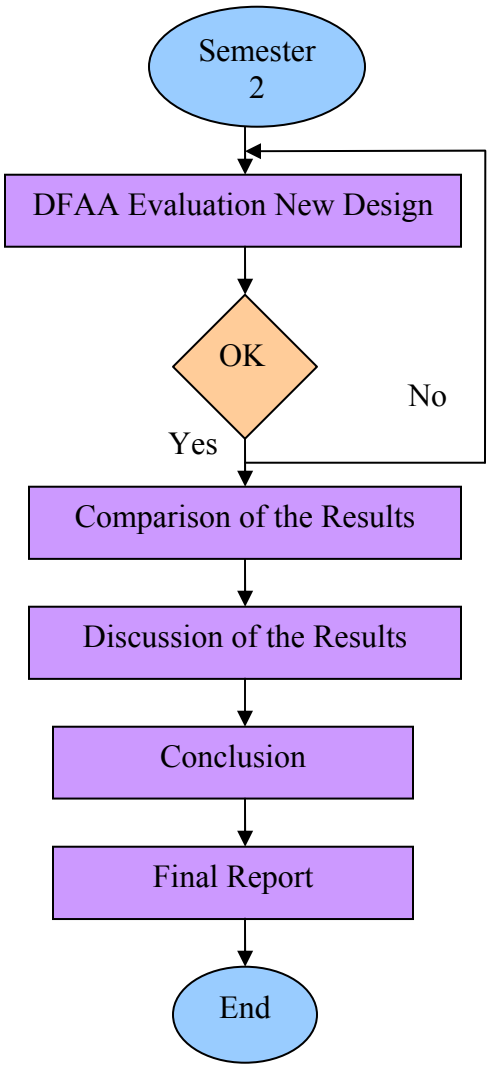

Figure 1.3: Flow Chart Master Project II

No	Task Descriptions	2007/2008 (I)																		
		July				August				September				October					November		
		9	16	23	30	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19
1	Continue Proposing Design Improvements																				
2	DFAA Evaluation of the New Design																				
3	Comparison of the results																				
4	Discussion of Results																				
5	Conclusion																				
6	Final Report																				
7	Presentation																				

Table 1.2: Gantt chart for Master Project II

1.5 Significance of Findings

DFAA is a way to reduce the part count in a design. The way it is done is by using a good design practice rules and guidelines on how the product can be assembled in most efficiently and economically ways. As a result from the approach, it will reduced the product cost, time-to-market and improve product quality.

The analysis of DFAA methodology in this project using ADE on the original and proposed design will improve the product design of this case study. This analysis is evaluative methods that rate or score the assemblability of designs at an early stage in the design process. They use their own synthetic data to provide guidelines and metrics to improve the design in its ability to be assembled. From the result, it can improve the product design for further improvement in future.

1.6 Report Structure

The report of this project is divided into ten (10) chapters which comprises the ADE analyses for DFAA. Consequently, towards developing a better understanding, all the contents were developed in order to meet the knowledge and application of DFAA.

Chapter 1 explores the introduction to the problem which consists the reality of the usage and benefits of DFAA in today's industries. Then, the objective of the project is highlighted together with the scope of the project. Later, the project methodology is shown in Gantt chart and flow chart. Afterwards, the significance of the findings was discussed to give a better view on the impact of the project. Lastly, the report structure is to summarize the contents of the project.

Chapter 2 is on the literature review on design for manual assembly methodology. In this chapter, design for "X" is included to brief the function of "X" as a specific property or a lifecycle phase of the product. Then, the tools use in implementing DFA is then discussed along with the assemblability measures. The tools discussed here were Boothroyd Dewhusrt method, Hitachi Assemblability Evaluation method and Lucas DFA evaluation method. Later, the examples of DFA methodologies were given to provide better understanding on DFA.

Chapter 3 explains on Design for Automatic Assembly (DFAA). It shows the structure and applications of DFAA in industries. Besides that, it also explains on evaluation philosophy along with the design rules and evaluation criterions.

Chapter 4 discusses on the old design of the product where it explained the product specification, material and structure. Then, it describes the function of each component and continued with the product assembly operation sequences. Then, the

weakness of the original design is discussed to make better improvements on the proposed design

Chapter 5 is regarding the evaluation of the original design which is done at product level and part level evaluation.

Chapter 6 illustrates the ideas and sketches of the proposed design. It also includes the minor and major improvements on the original design.

Chapter 7 discusses on the proposed design of the product where it explaines the product specification, material and structure. Then, it describes the function of each component and continues with the product assembly operation sequences.

Chapter 8 is regarding the evaluation of the proposed design which is done at product level and part level evaluation.

Chapter 9 consists of the discussion of the whole project regarding the comparison between the old design and proposed design of the wall socket.

Chapter 10 is the final chapter which is the conclusion of the project and the suggestions for future recommendation of the project.

1.7 Summary

This project concentrated on the improvement of the product design by using Design for Automatic Assemblies (DFAA) methodology. It is done by determining the Assemblability Design Efficiencies (ADE) for a mechanical product.