‘I approve that I have read this thesis thoroughly and in my opinion, this thesis has fulfilled the criteria covering all the aspects of scope and quality and satisfied to be awarded for Bachelor of Mechanical Engineering (Design and Innovation).’

Signature :…………………………
Supervisor :…………………………
Date :......................................

DESIGN IMPROVEMENT USING DESIGN FOR MANUFACTURE& ASSEMBLY (DFMA) APPROACH

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This report is written as a partial fulfillment of terms in achieving the award for Bachelor of Mechanical Engineering (Design and Innovation)

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“I admit that this report is all written by myself except for the summary and the article which I have stated the source for each of them.”

Signature	:……………………….
Writer	:……………………….
Date	:.....................................

DEDICATION

To beloved family, friends and lectures who supported me throughout this project.

ACKNOWLEDGEMENT

In this great opportunity, I would like to thank Allah for providing me strengths to finish up this project and finally it was completed. Here, I would like to acknowledge and appreciate all those people who helped and guided me till this phase of this project.

In a particular, I would like to express my gratitude to my supervisor, Mr Mohd Rizal B. Alkahari for giving me a chance to do the project under his guide and attention. I also would like to thank all of my colleagues whether in UTeM or not for their contribution in sources, journal and a whole lot of studying tools provided by them. I am gratified to the Head of Department of Mechanical Engineering (Design and Innovation) and the members of the staff at the University the constant encouragement and the valuable inputs from time to time throughout the completion of this report.

In this semester where PSM subject had take place, I had gain a lot of valuable experience and knowledge that cannot be learnt inside a classroom only. Teamwork and endurance with an addition of creativity is a must in getting through the real life of an engineer and that is what I had learnt throughout all the completion of this PSM report and it will be forever be kept as a message deep in my heart and my mind.

Finally, I would like to express my appreciation to everyone especially to all my family and friends who helped and supported me. Thanks for your guidance and cooperation. May Allah bless all of you. Amin.

ABSTRAK

Reka Bentuk Untuk Pembuatan dan Pemasangan (DFMA) adalah satu proses atau garis panduan yang dibangunkan bagi memastikan produk yang dicipta memudahkan dan teratur ketika dikilangkan kemudian dihimpunkan dengan seminimum penggunaan tenaga, masa, dan kos. Produk yang direka dengan menggunakan prinsip-prinsip DFMA sepatutnya mempunyai kualiti dan kebolehharapan yang lebih tinggi dari yang dibangunkan dengan menggunakan kaedah rekabentuk tradisional. DFMA juga memastikan bahawa peralihan dari fasa merekabentuk ke fasa pengeluaran berjalan dengan secepat dan selancar yang mungkin. Di dalam tesis ini, DFMA diaplikasikan pada Mesin Pemadam Kebakaran. Mesin Pemadam Kebakaran merupakan sebuah kenderaan yang digunakan untuk membantu ahli bomba memadam kebakaran. Bilangan bahagian di dalam mesin ini dikurangkan tetapi masih berfungsi seperti keadan asalnya. Dengan yang demikian, kos turut dapat dikurangkan. Semua proses DFMA diterangkan dengan terperinci dalam tesis ini. Perbandingan untuk megenalpasti bahagian mesin memadam kebakaran yang diubah dilakukan dengan menggunakan simulasi DFMA dan analisis DFMA secara manual.

ABSTRACT

Design for Manufacturing and Assembly (DFMA) is a set of product evaluation tool developed to ensure that a product is designed so that it can be easily and efficiently manufactured and assembled with a minimum effort, time, and cost. Products designed using DFMA principles should have higher quality and reliability than those developed using traditional design methods. DFMA also ensures that the transition from the design phase to the production phase is as smooth and rapid as possible. In this project, DFMA is applied to Fire Fighting Machine. Fire Fighting Machine is a vehicle that used to help fireman to extinguish the fire. The numbers of part in this machine are reduced but the function is still the same as before improvement, thus the cost of this machine decreases. In this project, all the process of DFMA clearly stated. The comparisons to verify the part changed on fire fighting machine were made between DFMA simulation and by manual DFMA analysis.

TABLE OF CONTENT

	TITLE	PAGES
	DECLARATION	i-ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRAK	v
	ABSTRACT	vi
	CONTENT	vii
	LIST OF TABLE	x
	LIST OF FIGURE	xii
	LIST OF APPENDICES	xiv
CHAPTER 1	**INTRODUCTION**	**1**
	1.1 Problem Statement	2
	1.2 Objective	2
	1.3 Scope	2
CHAPTER 2	**LITERATURE REVIEW**	**3**
	2.1 Introduction	3
	2.2 Assembly Evaluation Method (AEM)	4
	2.2.1 The Evaluation Procedure	5
	2.2.2 The Hitachi's AEM Method Example	7
	2.3 The Lucas Method	8
	2.4 The Boothroyd – Dewhurst Method	9
	2.4.1 Procedure of DFMA	10
	2.4.2 DFMA Software	16
	2.4.2.1 DFA Software	17
	2.4.2.2 DFM Software	18

		2.4.3 Boothyord – Dewhurst DFMA Example	19
	2.5	Application of DFMA	24
		2.5.1 Directed Technologies, Inc. (DTI)	24
		2.5.2 Texas Instruments	26
	2.6	The Firefighting Machine	28
CHAPTER 3	**METHODOLOGY**		**30**
	3.1	Introduction	30
	3.2	Project Outline	31
		3.2.1 Literature Review	32
		3.2.2 Selection Design	32
		3.2.3 CAD Drawing (Detail Design)	32
		3.2.4 Manual DFMA Analysis Approach	33
		3.2.5 Computer Aided DFMA Analysis Approach (DFA and DFM software)	35
		3.2.6 Comparison	35
CHAPTER 4	**MANUAL DFMA ANALYSIS APPROACH**		**36**
	4.1	Introduction	36
	4.2	Analysis of the Current Design (Manual)	36
		4.2.1 Assembly Flow Chart	38
		4.2.2 The Process and Material Selection	39
		4.2.3 Theoretical Part Count and Symmetrical Analysis Table	50
		4.2.4 Handling and Insertion Time	54
		4.2.5 Costing (Current Design)	76
	4.3	Analysis of the Improvement Design (Manual)	78
		4.3.1 Assembly Flow Chart	79
		4.3.2 Theoretical Part Count and Symmetrical Analysis Table	81

	4.3.3	Handling and Insertion Time	85
	4.3.4	Costing (Improved Design)	100
CHAPTER 5	**COMPUTER AIDED DFMA ANALYSIS APPROACH**		**102**
	5.1	Introduction	102
	5.2	Analysis of the Current Design (Software)	102
	5.2.1	Design for Manufacture (DFM) Concurrent Costing	103
	5.2.2	Design for Assembly (DFA)	108
	5.3	Analysis of the Improved Design (Software)	111
	5.3.1	Design for Manufacture (DFM) Concurrent Costing	111
	5.3.2	Design for Assembly (DFA)	113
CHAPTER 6	**DISCUSSION**		**115**
	6.1	Introduction	115
	6.2	Comparison between DFMA Manual and DFMA Software	115
	6.3	Parts Count	117
	6.4	Part Removed	119
	6.5	Improved Part	122
CHAPTER 7	**CONCLUSION AND RECOMMENDATION**		**128**
	7.1	Conclusion	128
	7.2	Recommendation	129
	7.3	References	130
	APPENDIX		131

<u>**LIST OF TABLES**</u>

NO.	TITLES	PAGE
2.1	For One Hand Manual Handling	13
2.2	For One Hand with Grasping Aids Manual Handling (second)	13
2.3	For Two Hand Manual Handling	14
2.4	For Two Hands or Assistance Required For Large Size	14
2.5	Manual Insertion (Part Added But Not Secure)	15
2.6	Manual Insertion (Part Secure Immediately)	15
2.7	Manual Insertion (Separation Operation)	16
2.8	Evaluating the design efficiency of Piston	21
2.9	Evaluating the design efficiency of the re-designed piston	23
2.10	Results of DFMA redesign of reticle assembly	28
3.1	Table for computation of Design efficiency	34
4.1	Fire Fighting Machine Body Theoretical Part Count	50
4.2	Fire Fighting Machine Strut Theoretical Part Count	52
4.3	Symmetrical Analysis	53
4.4	Handling and Insertion Time	55
4.5	Costing of fire fighting machine current design	76
4.6	Fire Fighting Machine Body Theoretical Part Count	81
4.7	Fire Fighting Machine Strut Theoretical Part Count	83
4.8	Symmetrical Analysis	84
4.9	Handling and Insertion Time	86
4.10	Costing of fire fighting machine after improvement	100
5.1	Total manufacturing cost of current design	105
5.2	Total manufacturing cost of improved design	111
6.1	Result for Manual DFMA Analysis Approach	115
6.2	Result for Computer Aided DFMA Analysis Approach	116

6.3	The number of current parts and new parts	117
6.4	Description of parts removed	119
6.5	Description of modification parts	122

LIST OF FIGURES

NO.	TITLES	PAGES
2.1	The Hitachi's AEM procedure	5
2.2	Assemblability evaluation and improvements	7
2.3	The Lucas DFA procedure	9
2.4	Typical steps taken in a DFMA study using DFMA software	10
2.5	Example the value of α and β are calculated.	12
2.6	Example DFA software applications.	17
2.7	Example DFM software applications.	18
2.8	A piston-assembly design	20
2.9	An improved piston design	22
2.10	Exploded view of a fuel cell stack	24
2.11	Illustration of the manufacturing process for creating the gas diffusion layer (GDL)	25
2.12	Original design for reticle assembly for thermal gunsight	26
2.13	An Improved Piston Design	27
2.14	The Firefighting Machine	28
2.15	Fire Fighting Machine Classification	29
3.1	Process Flow Chart	31
4.1	Assemble drawing before Improvement	37
4.2	Fire Fighting Body and Fire Fighting Strut	37
4.3	Assembly Chart for Fire Fighting Machine Body	38
4.4	Assembly Chart for Fire Fighting Machine Strut	39
4.5	Process for Cutting, Bending, Welding	40
4.6	Process for Cutting, Stamping, Bending	41
4.7	Process for Cutting and Bending	42
4.8	Process for Cutting and Welding	43

4.9	Process for Cutting	44
4.10	Process for Injection Molding	45
4.11	Process for Cutting, Metal Forming	46
4.12	Process for Powder Metallurgy	47
4.13	Process for Welding	48
4.14	Process for Inspection and Attach	49
4.15	Assemble drawing after Improvement	78
4.16	Fire Fighting Body and Fire Fighting Strut after Improvement	78
4.17	Assembly Chart for Fire Fighting Machine Body	79
4.18	Assembly Chart for Fire Fighting Machine Strut	80
5.1	Step in DFM Concurrent Costing	103
5.2	Library Operations	104
5.3	Result for Nozzle Header	105
5.4	DFA classification	108
5.5	Analysis total for DFMA software (Current Design)	109
5.6	Analysis total for DFMA software (Improved Design)	113

LIST OF APPENDICES

NO.	TITLES
A	Manual Handling Table
	Manual Insertion Table
B	Analysis Total Current Design
	Analysis Total New Design
C	Assembly (Current Design)
	Assembly (New Design)
	Exploded View (Current Design)
	Exploded View (New Design)
	Current Design Drafting
	Improvement Part

CHAPTER 1

INTRODUCTION

Design for Manufacture (DFM) is a systematic approach that allows engineers to anticipate manufacturing costs early in the design process, even when only rough geometries are available on the product being developed. Design for Manufacture provides guidance in the selection of materials and processes and generates piece part and tooling cost estimates at any stage of product design. DFM is a critical component of the DFMA process that provides manufacturing knowledge into the cost reduction analysis of Design for Assembly.

Meanwhile Design for Assembly (DFA) is a methodology for evaluating part designs and the overall design of an assembly. It is a quantifiable way to identify unnecessary parts in an assembly and to determine assembly times and costs. Using DFA software, product engineers assess the cost contribution of each part and then simplify the product concept through part reduction strategies. These strategies involve incorporating as many features into one part as is economically feasible. The outcome of a DFA-based design is a more elegant product with fewer parts that is both functionally efficient and easy to assemble. The larger benefits of a DFA-based design are reduced part costs, improved quality and reliability, and shorter development cycles. Thus Design for Manufacture and Assembly (DFMA) is a combination of DFA and DFM.

1.1 PROBLEM STATEMENT

Most of the job of the fireman are exposed to danger and can sacrifice their own life. The fireman needs to fast response to the situation without danger they own life. Therefore Fire Fighting machine have been develop at certain country to encounter this problem. In future, this machine may develop in large quantity. It may take a lot cost and time causes by certain complex part in that machine. Current number of part in this machine 61parts (part that same shape and dimension is classified as one part), so that the number of parts need to reduced. Here DFMA method will apply to this machine to encounter this problem. So by the reducing the number of part, it will easier during the manufactured.

1.2 OBJECTIVE

The objectives for the project are:

- To improve current design of fire fighting machine utilizing DFMA approach
- To reduce overall cost of fire fighting machine through design improvement

1.3 SCOPE

There are several scopes for this project which is:

- To conduct literature review of Fire Fighting technology and DFMA application.
- To apply Design for Assembly (DFA) and Design for Manufacturing (DFM) methodologies on Fire Fighting Machine.
- To analyze and compare result before design improvement and after design improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the 1960's and 70's, various rules and recommendation were proposed in order to help designer consider assembly problems during the design process. Many of these rules and recommendations were presented together with practical examples showing how assembly difficult could be improved. However, it was not until the 1970's that numerical evaluation method were developed to allow design for assembly studies to be carried out on existing and proposed design.

The first evaluation method was developed at Hitachi and was called the Assembly Method (AEM). This method is based on the principal of "one motion for one part." For more complicated motions, a point-loss standard is used and the ease of assembly of the whole product is evaluated by subtracting points lost. The method was originally developed in order to rate assemblies for ease of automatic assembly.

Starting in 1977, Geoff Boothyord, supported by NSF grant at the University of Massachusetts, developed the design for Assembly (DFA) method. It is based on timing each of the handling and insertion motion which could be used to estimate the time for manual assembly of a product and the cost of assembling the product on an automatic assembly machine. Recognizing that the most important factor in reducing assembly costs were the minimization of the number of separate parts in a product, he introduced simple criteria which could be used to determine theoretically whether any of the parts in the product could be eliminated or combined with other parts. Then Lucas DFA method have been establish by the cooperation of Lucas Organization and the University of Hull in United Kingdom. Unlike the Boothroyd Dewhurst method, the Lucas method is based on a “point scale” which gives a relative measure of assembly difficulty. Lucas DFA method definitely based on the parts count analysis stage with is known as terms “functional analysis”.

Starting in 1981, Geoffrey Boothroyd and Peter Dewhurst developed a computerized version of the DFMA method which allowed its implementation in a broad range of companies. For this work they were presented with many awards including the National Medal of Technology. [6]

2.2 Assembly Evaluation Method (AEM)

The Assimilability Evaluation Method (AEM) is developing by Hitachi as a result of trying to develop an automatic assembly system for tape recorder mechanism. After years of improvement, Miyakawa (1990) presented the ‘new’ Assembly Evaluation Method from Hitachi. The improvements were e.g. the improvement assembly cost estimate accuracy for individual parts. This methodic formally known as Hitachi’s AEM.

The method does not distinguish manual, automatic or robotic assembly. The reasons are the method is most beneficial when used in early conceptual stage and the manufacturing methods not decide yet.

The method improve design by identify “weakness” in early design process using two indicator. An assemblality index is calculated by summarizing the scores for all parts. [6]

The indicators used in AEM for product evaluation are:

i. Assembly evaluation score, “E”.

- Asses the design by determine difficulties of assembly operation or design quality.

ii. Estimate assembly cost ratio, “K”.

- Used as relative index that compared the redesign to the estimated assembly cost of original design.

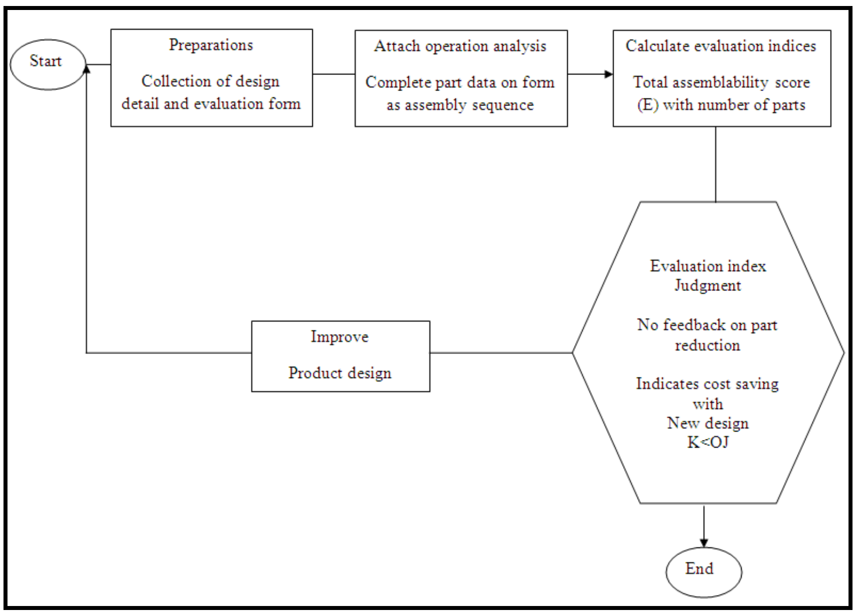


Figure 2.1: The Hitachi’s AEM procedure

(Source: http://www.ami.ac.uk/ami4813_dfx/u03/s01/index.asp)

2.2.1 The Evaluation Procedure

The Hitachi AEM procedures are as per following sequence:

i. The analysis start by determine and categorized the assembly task sequence according by standard operation, that approximately 20 standard assembly task.

ii. All the parts tasks are receiving the penalty score, which subjects to difficulty of the assembly. The ideal operations are rewarded 100 points, which receive zero on penalty score. The score of 100 points represents the assembled with only downward motions.

iii. All score for the parts will summarize, then modify it by attach coefficients and subtracted from the best score.

iv. The totals then divided by the total number of parts. This may be able to consider a measure of design efficiency where a score of 100 would represent a perfect design.

v. Then the cost ratio, k is estimated continuously by compared to current assembly cost ratio with new design.

vi. Hitachi consider that an overall score E of 80 and higher is acceptable and overall assembly cost ratio K of 0.7 or greater is acceptable. [6]

2.2.2 The Hitachi's AEM Method Example

The following Figure 2.2 is the example of assimilability evaluation and improvement of part.

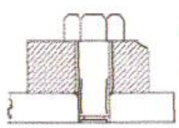
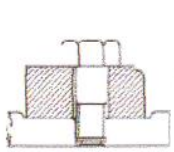
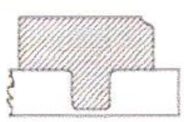
	Product structure and assembly task		E; part assembly evaluation score	E; assemblability evaluation score	K; assembly cost ratio	Part to improved
Structure 1 (current design)	 C(↓∩) B(↓...) A(↓-)	Set chasis A	100	73	1	B
		Bring down block B and hold it to maintain orientation	50			
		Fasten screw C	65			
Structure 2	 C(↓∩) B(↓...) A(↓-)	Set chasis A	100	88	0.8	C
		Bring down block B (orientation is maintain by spot-facing)	100			
		Fasten screw C	65			
Structure 3	 B(↓...) A(↓-)	Set chasis A	100	89	0.5	B
		Bring down block B and press fit block B	100			

Figure 2.2: Assemblability evaluation and improvements

(Source: Redford Alan, J. Chal, 1994)

As illustrated in figure 2.2, the structure 1 shows an assembly task of the current design. The assembly evaluation score is 73, after sum of part score and divided by number of operation, 3. The result in product assemblability evaluation score is 73 is below than acceptable score of 80. The improvement designs shown in structure 2, which improvement on part by remove the holding. It must spot-facing the chassis down. This gives assemblability evaluation score, E as 88; the assembly cost ratio, K as 0.8 the structure 3, the bolt is removed and block attached to chassis by using press fit. The assemblability evaluation score, E is 89; the assembly cost ratio is 0.5. The significant improved of the of the cost ratio because the reduced number of parts. [6]

2.3 The Lucas Method

The basic construction of Lucas DFA is very similar to the Design for Assembly (DFA) of Boothyord Dewhurst Inc. (BDI), it is the result of the cooperation of Lucas Organization and the University of Hull in U.K. Now, the logic of Lucas DFA has been integrated in the engineering analysis software “TeamSet”. Lucas DFA separates the product design process into three stages: FA (Function Analysis), HA (Handing Analysis) and FA (Fitting Analysis). The relations of these three stages are shown as Figure 2.3.

Before the manufacturing and assembly process, the PDS (Product Design Specification) occurs which change the requirements of the customs into engineering specifications. After that, the design engineers perform the design job according to this information. This is a kind of process to change the engineering specifications into the real design and meanwhile, all the requirements should be satisfied. The Function analysis in Lucas DFA theory is to separates all the parts of the product into the essential parts and the non essential parts that employs very similar adjustment standard used by DFA.

Following the function analysis, comes the analysis of handing. Same as the function analysis, Lucas DFA separated the handing analysis into the automatic handing analysis and the manual analysis. During the fitting analysis, the sequence of parts assembly will be determined first, and then according to the assembly flow chat, analyze the gripping and the fitting process. After finishing the whole DFA analysis process mentioned above, the inadequate of the design will be highlighted, the revisal job occurs at this time. [10]

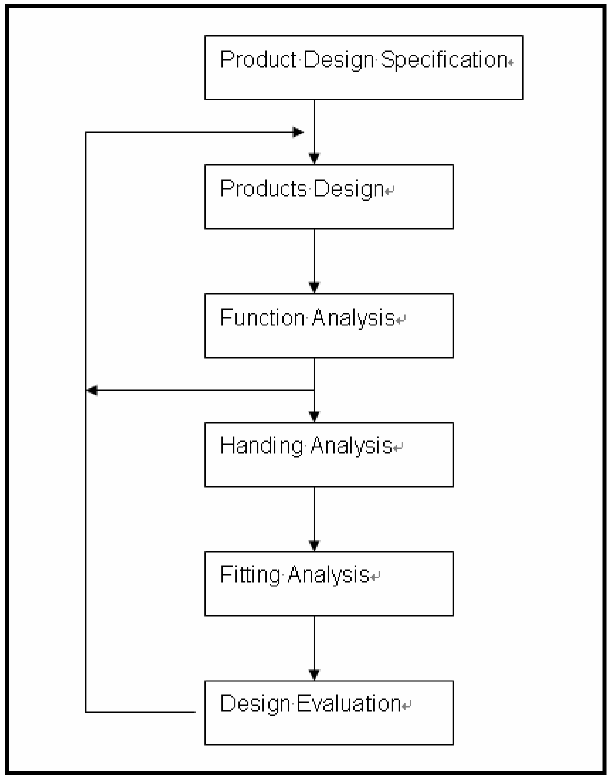


Figure 2.3: The Lucas DFA procedure
(Source: Xiaofan Xie, 1995)

2.4 The Boothroyd – Dewhurst Method

Boothyord Dewhurst method design for manufacture and assembly is the well-known DFMA method that applicable for industry. The Boothyord-Dewhurst DFMA develops by Geoffrey Boothyord and Peter Dewhurst since 1982. The methods generally applied in industry particularly U.S industry. The methodology is well known for the industry especially US industry. The term “DFMA” is actually a trademark for Boothyord Dewhurst Inc. (BDI) the companies have created and develop the DFMA concept that used for their product development, the DFMA software system.