

PRODUCT DESIGN OPTIMIZATION USING DESIGN FOR MANUFACTURE  
AND ASSEMBLY APPROACHES


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## ABSTRACT

Design for Manufacture and Assembly (DFMA) were developed in order to help designers identify the manufacturing and assembly difficulties during the early stage of designing process. By applying DFMA, the assembly cost and time can be reduced and DFMA also ensure a smooth transition from design to production phase. Based on this fact, this thesis will presents a case study done to a selected product by using two DFMA methodologies that are Lucas-Hull DFA and Boothroyd-Dewhurst DFA methods. Based on the result of the analysis done, a new design will be proposed and both methods will be compared to identify the strength and weakness of each method. It is found from the study that by applying DFMA on the selected product, the product design had been optimized in term of assembly and manufacturing process and material selection.

## TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENTS	III
	ABSTRACT	IV
	TABLE OF CONTENT	V
	LIST OF FIGURES	IX
	LIST OF TABLES	XVI
	GLOSSARY	XVIII
<b>1</b>	<b>INTRODUCTION</b>	
	1.1 INTRODUCTION TO DESIGN FOR MANUFACTURE AND ASSEMBLY (DFMA)	1
	1.2 HISTORY OF DFMA	3
	1.3 BENEFIT OF DFMA	4
	1.4 OBJECTIVE OF PROJECT	5
	1.5 SCOPES OF PROJECT	5
<b>2</b>	<b>LITERATURE REVIEW</b>	
	2.0 INTRODUCTION	6
	2.1 DESIGN FOR MANUFACTURE AND ASSEMBLY	6

2.1.1	DFA System Using Design Principles And Design Rules	7
2.1.2	DFA System Employing Quantitative Evaluation Procedures	7
2.1.3	DFA Methods Employing A Knowledge-Based Approach	8
2.1.4	Computer-aided DFA Methods	8
2.2	DFA METHODOLOGIES	8
2.2.1	The Boothroyd-Dewhurst DFA Method	9
2.2.2	The Lucas-Hull DFA Evaluation Method	12
2.2.3	The Hitachi Assemblability Evaluation Method	15
2.2.4	The Westinghouse DFA Calculator	18
2.2.5	The Toyota Ergonomic Evaluation Method	19
2.2.6	Sony DFA Methods	19
2.2.7	Effort Flow Analysis	20
2.3	CASE STUDY FROM PREVIOUS RESEARCH	23
2.3.1	Stapler Evolution	23
2.3.2	Texas Instruments	25
2.3.3	Digital	27
2.3.4	FASTRAC Turbopump Case Study	29
2.4	INTRODUCTION TO TEAMSET	32
2.4.1	Benefit Of TeamSET	32
2.4.2	The Tool Set	32

2.5	SUMMARY	33
<b>3</b>	<b>METHODOLOGY</b>	<b>34</b>
3.0	INTRODUCTION	34
3.1	LUCAS-HULL DFMA	34
3.1.1	Starting Teamset	35
3.1.2	Using DFA Toolset	38
3.1.3	Lucas-Hull DFMA Analysis	51
	Summary	
3.2	THE BOOTHROYD DFMA METHOD	52
3.2.1	Manual Handling Analysis	52
3.2.2	Manual Insertion Analysis	54
3.2.3	Boothroyd DFA Analysis Result	55
3.2.4	Boothroyd DFM Manual Analysis	56
3.9	SUMMARY	61
	<b>DFA ANALYSIS AND DISCUSSION</b>	<b>62</b>
4.0	INTRODUCTION	62
4.1	THE SELECTED PRODUCT	62
4.2	RESULT AND DISCUSSION FOR THE ORIGINAL DESIGN	71
4.2.1	Analysis on the Original Design Using Lucas Hull DFMA	71
4.2.2	Analysis on the Original Design Using Boothroyd Dewhurst DFMA	74
4.3	THE NEW DESIGN	76



4.4	RESULT AND DISCUSSION OF THE NEW DESIGN	78
4.4.1	Analysis on the New Design Using Lucas Hull DFMA	78
4.4.2	Analysis on the New Design Using Boothroyd Dewhurst DFMA	80
4.5	SUMMARY	82
<b>5</b>	<b>DFM ANALYSIS AND DISCUSSION</b>	<b>84</b>
5.0	INTRODUCTION	84
5.1	DFM ANALYSIS ON LUCAS-HULL DFMA METHOD	84
5.2	DFM ANALYSIS ON BOOTHROYD DEWHURST DFMA METHOD	86
5.2.1	Injection Molding Analysis	99
5.2.2	Sheet Metal Analysis	108
5.3	SUMMARY	118
<b>6</b>	<b>CONCLUSION</b>	<b>119</b>
6.0	INTRODUCTION	119
6.1	COMPARISON BETWEEN LUCAS DFMA AND BOOTHROYD-DEWHURST DFMA METHODOLOGY	119
6.2	CONCLUSION	121
6.3	RECCOMENDATION	122
6.4	SUMMARY	122

**LIST OF FIGURES**

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Example Of Boothroyd-Dewhurst DFA Worksheet	10
2.2	Example Of Tables For Manual Insertion	11
2.3	Architecture of The Lucas DFA system	12
2.4	The Lucas DFMA Procedure	13
2.5	Examples of AEM Symbols and Penalty Scores	15
2.6	Examples of Assemblability Evaluation and Improvement.	16
2.7	Original Design Of Base Sub-Assembly	17
2.8	The Redesign Of Base Sub-Assembly After Applying AEM	17
2.9	The Westinghouse DFA Calculator	18

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.10	Exploded View of Sony Walkman	20
2.11	Example Of Effort Flow Diagram	21
2.12	The Comparisons Of Three Heavy Duty Staplers	24
2.13	The Baseline Design Of The Thermal Gunsight	25
2.14	The Proposed Design Of The Thermal Gunsight	26
2.15	The Original Design Of Mouse	27
2.16	The New Design Of The Mouse	28
2.17	The Baseline Design Of FASTRAC	29
2.18	The Assembly Operation Profile For The Original Design	30
2.19	The Comparison Between The Original And Proposed Design	30
2.20	The Total Assembly Time Comparison Of The Baseline And Proposed Design	31
3.1	TeamSET Main Window	35

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
3.2	New Database Window	35
3.3	Level Selection Window	36
3.4	The TeamSET Main Window After Project, Product And Scenario Have Been Created	36
3.5	Assembly Window	37
3.6	DFA Assembly Window	38
3.7	DFA Window	39
3.8	Naming The Part	39
3.9	The Sub-Assembly	40
3.10	Functional Analysis Window	41
3.11	MA Window	42
3.12	Low Block Geometry	43
3.13	Medium-Low Cylindrical Geometry	43
3.14	High Cylindrical Geometry	43
3.15	Medium-High Cylindrical Geometry	44

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
3.16	Handling Analysis Window	44
3.17	Symbol Selection Menu	47
3.18	Insertion Process Window	48
3.19	Secondary Operation Window	49
3.20	Remove Tool/Disassembly Window	50
3.21	The DFA Analysis Summary Window	51
3.22	Manual Handling Estimates Times Table	53
3.23	Alpha and Beta Orientation Table	53
3.24	Manual Insertion Estimated Times Table	54
3.25	Example of Part	58
3.26	Shape Generations Capability of Processes Table	59
3.27	Selection of Materials and Processes Table	59
4.1	The Overall View Of The Bread Toaster	63
4.2	Plastic Cover 1	63
4.3	Rubber	64

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
4.4	Plastic Cover 2	64
4.5	Indicator	65
4.6	Lift Handle	65
4.7	Side Plate Cover	66
4.8	Top Plate Cover	66
4.9	Plate Core	67
4.10	Heat Conductor	67
4.11	Core Sub-Assembly	68
4.12	Ash Tray Main Body	68
4.13	Ash Tray Sub-Assembly	69
4.14	The Old Design of the Toaster	69
4.15	Analysis Result of the Old Design	71
4.16	The New Design	76
4.17	Analysis Result for the New Design	78
4.18	Exploded Drawing of Original Design	82

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
4.19	Exploded Drawing of New Design	82
5.1	DFM Analysis Window	85
5.2	Core	87
5.3	Heater	88
5.4	Heat Breaker	89
5.5	Lift Bar	90
5.6	Main Body	91
5.7	Indicator	92
5.8	Lift Handle	93
5.9	Ash Tray	94
5.10	Plate Cover	95
5.11	Shape Generation Capabilities of Process	96
5.12	Selection of Materials and Processes Table	97
5.13	The Ashtray	99
5.14	The Molding Machine Size	102

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
5.15	Material Selection Table	108
5.16	Gage Number Selection Table	109
5.17	The Basic Manufacturing Point Graph	111
5.18	The Area Correction Factor Graph	111
5.19	Press Machine Selection Table	117



**LIST OF TABLES**

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Comparison Of Original Design And Redesign For The Thermal Gunsight	27
3.1	General Shape Attributes of figure 3.25	58
3.2	Commonly Used Polymers in Injection Molding	60
4.1	Bill of Materials for the Old Design	70
4.2	Result of Botthroyd DFMA Manual Analysis of the Old Design	74
4.3	Bill of Materials for the New Design	77
4.4	Result of Botthroyd DFMA Manual Analysis of the New Design	80
4.5	Summary of Design Change	81
4.6	Comparison between Original and New Design For Lucas DFMA	83

<b>NO.</b>	<b>TITLE</b>	<b>PAGE</b>
4.7	Comparison between Original and New Design For Boothroyd DFMA	83
5.1	The Selected Processes and Materials for the New Design	98
5.2	Material Selection For Injection Molding	100
5.3	Runner Volumes	101
5.4	Surface Appearances of The Ashtray	106
6.1	The Comparison Between Lucas DFMA and Boothroyd DFMA	121

**GLOSSARY**

DFA	=	Design for Assembly
DFM	=	Design for Manufacture
DFMA	=	Design for Manufacture and Assembly
BD-DFA	=	Boothroyd-Dewhurst Design for Assembly
AEM	=	Assembly Evaluation Method
AREM	=	Hitachi Assembly Reliability Method
FA	=	Functional Analysis
MA	=	Manufacturing Analysis
HAND	=	Handling Analysis
ASF	=	Assembly Sequence Flowchart
QFD	=	Quality Function Deployment
Con-Con	=	Concept Convergence
FMEA	=	Failure Modes and Effect Analysis
DTC	=	Design To Target Cost
PSM I	=	Projek Sarjana Muda I
PSM II	=	Projek Sarjana Muda II
UTeM	=	Universiti Teknikal Malaysia Melaka
ABS	=	Acrylonitrile-Butadiene-Styrene

## CHAPTER 1

### INTRODUCTION

#### 1.1 INTRODUCTION TO DESIGN FOR MANUFACTURE AND ASSEMBLY

In this new era of technology, there are many techniques that are developed and applied by manufacturer in order to improve their product quality along with reducing the cost to manufacture their product. One of the most famous methods is by applying Design for Manufacture and Assembly (DFMA) to the product during the design stage. This project title is "Product Design Optimization Using Design for Manufacture and Assembly Approaches".

DFMA is the combination of Design for Manufacture (DFM) and Design for Assembly (DFA). Roughly, DFMA can be defined as a set of guideline that was used by designers during the early designing stage to produce a product that is easily manufactured and assembled with a minimum cost, time and effort. One of the most important characteristics of DFMA is all factors that will affect the final output of the product will be considered and analyzed as early as possible in the design cycle [1].

Any product design that is using DFMA should have higher quality and reliability than product that is using traditional method because the main goals of DFMA are to make fabrication and assembly easier, less costly, simpler, faster and more reliable. Geoffrey Boothroyd and his colleagues had defined DFM as a design for the ease of manufacture of

the collection of parts of a product. The main objective of DFM is the assimilation of product design and process planning into one common activity by embracing some principles that will help maintaining communication between all manufacturing systems. This will allow the flexibility for the designers to modify the design during any stage of the product's realization [2].

DFM help the engineers in making selection among many different types of technology and materials by identifying the limitations that related to manufacturing at the early stage of the design process. This will also help the designers in estimating the manufacturing time and the production cost rapidly among different schemes. Xiao Fen Xie in her study titled Design for Manufacture and Assembly indicates that the three main goals of DFM are:

1. To decrease the cost including the cost of design, technology, manufacturing, delivery, technical support, discarding and others.
2. To shorten the developing cycle time, including the time of design, manufacturing preparing and repeatedly calculation.
3. To increase the quality of the product in term of design, manufacturing, technology and other important factors.

DFA is a process to improve a product design for the ease of assembly. Mainly, DFA focused on reducing the parts in a product because the total number of parts in a product plays a big role in product assembly quality. Fewer parts mean less time needed to assemble, thus reducing the assembly cost. In DFA, the designers will use all kinds of method to resolve the possible problems during the early stage of the design so the part can be assembled with high speed, low cost and productivity without affecting the functions of the final product.

Xiao Fen Xie has indicates that DFA can be used in two ways: as a tool for assembly analysis and as a guide for assembly design. DFA can be used as a tool for assembly analysis because by applying DFA, the engineers will make estimation at the beginning of a product design process on all factors that will affect the assembly process.

DFA also can be used as a guide for assembly design because DFA collect the knowledge and experience from many assembly experts and this compilation of knowledge is then used as a design guide. These guides are very important and useful because they helped the engineers to choose the design plan and determining the product construction efficiently.

## 1.2 HISTORY OF DFMA

The history of DFMA starts even before World War II. Henry Ford was one of the first people who consider the assembly process during the design stage. This is the reason why the cars produced by Henry Ford have simpler designs and fewer parts when compared with his competitors. Ford focused mostly on design simplification and standardization; because of this his method was widely used in the US during WWII for the design and manufacturing process of weapons, tanks and other military products.

In WWII, US, Russian and British applied simple standard design such as Ford's method in producing their military products. By applying this method, the product can be produced in a huge quantities and this contrasted sharply with the German's method, which keep improving their current designs thus making the logistic, training and field repair become difficult.

Starting from 1960's, various rules and methods were introduced to help the designers in considering assembly problems during the design process. Most of these methodologies were presented along with practical example to show their effectiveness in analyzing and improving assembly difficulty. Geoffrey Boothroyd and his colleagues, Alan Redford and Ken Swift are the first persons who systematized DFA. This DFA method is later known as The Boothroyd-Dewhurst DFA method and it can be used to estimate the time for manual assembly of a product and the cost of assemblability of the product on an automatic assembly machine.

Hitachi also developed a set of assemblability evaluation method at this time as well. The assembly evaluation method was based on the principle of one motion for one part. For the complicated parts, the evaluation is made by subtracting the penalty point due to difficulty from the base point.

In 1980's and 1990's, a lot of DFMA methodologies were introduced. Among them are: the Lucas DFA Evaluation method, the Westinghouse Calculator, Sony DFA method, Toyota Ergonomics and Effort Flow Analysis. All of these methodologies aim for the same purpose, which is to improve the assemblability of a product.

### **1.3 BENEFIT OF DFMA**

The main reason why DFMA was widely applied in the manufacturing area is because of the benefits that can be gained from the well structured DFMA principles. The most important benefit of DFMA is that it can lower the assembly cost and shorten the assembly time by improving the design and analyzing every increased the reliability of the product and lessen the total time to market the difficulty that will affect the assemblability of the product. This will also indirectly product.

DFMA ensure a smooth and rapid transition from design phase to production phase by providing a systematic procedure for analyzing a proposed design from the point of view of assembly and manufacturing.

DFMA tools will encourage communication between the designers and the manufacturing engineers and other individual that have a role in determining the final product cost; thus teamwork are needed to successfully achieved the concurrent engineering benefit.

## 1.4 OBJECTIVE OF PROJECT

The objectives of this research are:

- To study and analyze the current design of the selected product.
- To understand each DFMA methodologies that was chosen.
- To improve the design of the selected product by using different DFMA methodology.
- To compare Lucas Hull DFMA and Boothroyd Dewhurst DFMA based on case study made.

## 1.5 SCOPES OF PROJECT

Scope of research is an important stage because it is the elements to the researcher to know what actually are the needs in their project. This project's scope can be divided into three, which are using different DFMA approaches to improve the selected product design, presenting the study of existing and new design and comparing different methodology in DFMA. The product that has been chosen for the case study in this project is a bread toaster that was manufactured by MEC and it will be analyzed using two famous DFMA methods that are Lucas-Hull DFMA and Boothroyd-Dewhurst DFMA.