



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN ANALYSIS OF A CHILDREN'S SCOOTER
USING DFMA (BOOTHROYD DEWHURST) METHOD**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Manufacturing Engineering Technology (Product Design) (Hons.)

by

GUE SEY YANG

B071110136

880811-01-5061

FACULTY OF ENGINEERING TECHNOLOGY

2015

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design analysis of a children's scooter using DFMA (Boothroyd Dewhurst) method.**

SESI PENGAJIAN: **2014/15 Semester 1**

Saya **GUE SEY YANG**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. ****Sila tandakan (✓)**

- SULIT** (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
- TERHAD** (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
- TIDAK TERHAD**

Disahkan oleh:



PENYELIA PSM

Alamat Tetap:

NO. 1130, Taman Cempaka,

72100 Bahau,

Negeri Sembilan.


Tarikh: 21/1/2015

Tarikh: 21/01/2015

**** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.**

DECLARATION

I hereby, declared this report entitled “Design analysis of a children’s scooter using DFMA (Boothroyd Dewhurst) method.” is the results of my own research except as cited in references.

Signature : 

Author’s Name : GUE SEY YANG

Date : 21/01/2015

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) (Hons.). The member of the supervisory is as follow:



.....

Project Supervisor

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) (Hons.). The members of the supervisory committee are as follow:



Principal Supervisor

—

Co-Supervisor

ABSTRAK

Objektif utama bagi projek ini adalah untuk menganalisa skuter kanak-kanak jenis lipatan yang berada di pasarandan meningkatkan rekabentuk menggunakan kaedah Boothroyd Dewhurst DFMA. Rekaan baru inia kanmeliputimengurangkankomponen-komponenkos, masa, dan proses bagi pembuatan dan pemasangan untuk menghasilkan kecekapan rekabentuk yang tinggi. Untuk mencapai objektif, setiap maklumat berkaitan dengan skuter kanak-kanak dan kaedah Boothroyd Dewhurst DFMA dikumpul bagi member lebih pemahaman tentang prinsip kerja sesebuah skuter kanak-kanak. Sumber-sumber maklumat ini mungkin diperolehi dari buku-buku, jurnal-jurnal, internet, dan perpustakaan.

ABSTRACT

The objective of this project is to analyze an existing design of a selected the manually children's scooter with foldable and to improve the design using the Boothroyd Dewhurst DFMA method. The new design will contain reduce component, cost, process for manufacturing and assembly to get highest design efficiency. In order to achieve the objective, any information about children's scooter and Boothroyd Dewhurst DFMA method were gathered to get a better insight on how it works. This all information may come from books, journals, the internet, and the library.

DEDICATION

To my beloved parents
Especially to my beloved parents,
My lovely brothers,
My respectfully lecturers,
Also my faithfully friends,
Your prayers always with me every way that I went...

ACKNOWLEDGEMENT

In this great opportunity, I would like to acknowledge with appreciation to all those people who helped me numerously during completing this project.

In a particular, I would like to convey my sincere thank you to my supervisor Mr Mohd Fa'iz Bin Wahid, for giving me chance to do the project under his supervision. I also would like to thank to him for teaching me more in DFMA subjects especially works for my topic. He also guided me and given advised based on his experience during my progress of this project. His constant encouragement and guidance had brought me to completing my project.

Not to forget, I would also like to express my appreciation to thank to all my friends especially class of 4 BETD for being kind and helpful to me until the project done. Finally, thank to my beloved parents who had given me encouragement until this project done. Thanks for your guidance and cooperation.

TABLE OF CONTENT

Abstrak	vi
Abstract	vii
Dedication	viii
Acknowledgement	ix
Table of Content	x
List of Tables	xix
List of Figures	xv
List Abbreviations, Symbols and Nomenclatures	xxi
CHAPTER 1: INTRODUCTION	1
1.1 Introduction	1
1.2 Problem statement	1
1.3 Objective	2
1.4 Tittle	2
1.4 Scope	2
1.6 Expected result	3
CHAPTER 2: LITERATURE REVIEW	4
2.1 Designs for Manufacture and Assembly (DFMA)	4
2.1.1 Advantages	5
2.1.2 DFMA Guidelines	5
2.1.2.1 General DFM Guidelines	6
2.1.2.2 General DFA Guideline	7
2.2 DFMA Approaches	8
2.2.1 Lucas Method	8
2.2.2 Hitachi AEM Method	9
2.2.3 Boothroyd-Dewhurst Method	11
2.2.3.1 General Guidelines for Part Handling	11
2.2.3.2 General Guidelines for Insertion and Fastening	13

2.2.3.3	Codes and subsequent times	16
2.2.3.4	Symmetry	17
2.3	Children's scooter	17
2.3.1	Patent of the children's scooter	18
2.3.2	Design research in the market	20
2.3.3	Manufacturing and assembly process of the product	22
2.3.3.1	Welding process	22
2.4.4.2	Stamping process	23
2.4.4.3	Rivet process	24
2.4.4.4	Roll Forming Bending Process	26
CHAPTER 3: METHODOLOGY		27
3.1	Identify the product	29
3.1.1	Identify the part and material	30
3.1.3	Identify the manufacturing and manual assembly process	43
3.1.4	Assembly Fixture	45
3.1.5	Product structure tree for manual assembly process	48
3.2	Measurement of dimension	49
3.3	CAD software	49
3.3.1	Exploded drawing	50
3.4	Analysis of the Existing Design	53
3.4.1	Boothroyd Dewhurst DFMA software	59
3.4.1.1	Boothroyd Dewhurst DFA software aid method	59
3.4.1.2	Boothroyd Dewhurst DFM software aid method	64

CHAPTER 4: RESULT & DISCUSSION	68
4.1 Approach DFMA Analysis	
for current Design	68
4.1.1 Approach DFA Analysis	
for current design	68
4.1.1.1 DFA Software analysis	69
4.1.1.2 DFA Manual analysis	70
4.1.1.3 Discussion of the	
DFA Manual Analysis	78
4.1.1.4 Comparison of DFA Analysis	79
4.1.2 DFM Analysis for the new design	80
4.1.3 Total DFM cost for the current design	80
4.2.0 Analysis of the DFMA	
Result (Current Design)	81
4.2.1 Analysis of the	
DFA Result (Current Design)	81
4.2.2 Analysis of the	
DFM Result (Current Design)	85
4.2.2.1 Machine's Specification	87
4.2.2.2 Material cost	91
4.2.2.3 Machining Process	92
4.3 Suggestion for new design	94
4.3.1 Suggestion for DFA new design	94
4.3.1.1 Redesign for cover fork assembly	95
4.3.1.2 Redesign for fork assembly	100
4.3.1.3 Redesign for t-tube assembly	108
4.3.1.4 Redesign for back wheel assembly	113
4.3.2 Suggestion of DFM new design	118
4.3.2.1 Redesign for baseboard	119
4.3.2.2 Redesign for cover fork	122
4.3.2.3 Redesign for fork	125
4.3.2.4 Redesign for t-tube	129
4.3.2.5 Redesign for brake	132

4.3.2.6	Redesign for handlebar	134
4.3.2.7	Redesign for L-Bracket	136
4.3.2.8	Redesign for cover front baseboard	138
4.3.2.9	Redesign for snap-fit knob	140
4.4.0	Approach DFMA for new design	142
4.4.1	Approach DFA Analysis for new design	142
4.4.1.1	DFA Software analysis for new design	142
4.4.1.2	DFA Manual analysis for new design	143
4.4.1.3	Comparison of DFA Analysis	146
4.4.2	DFM Analysis for new design	147
4.4.2.1	Total DFM cost for the current design	147
4.5	Comparison between DFMA result	151
CHAPTER 5: CONCLUSION AND FUTURE WORK		153
5.1	Conclusion	153
5.2	Future work	154
REFERENCES		156
APPENDIXES		159
APPENDIXES A- Exploded Drawing (Current Design)		159
APPENDIXES B- Exploded Drawing (New Design)		165
APPENDIXES C- Comparison DFA Analysis		170
APPENDIXES D- PSM Gantt Chart		172

LIST OF TABLES

2.1	Design Research in the market	21
3.1	The list of parts in children's scooter	32
3.2	The list of hardware in children's scooter	35
3.3	Functional of Fixture	47
3.4	The list of DFM analysis part	53
3.5	The list of DFA analysis part	54
4.1	DFA software analysis result of the current product	70
4.2	DFM cost for the current product	80
4.3	DFM cost for the new design	147
4.4	The list of purchases part	148
4.5	Comparison of DFA Analysis Result	151
4.6	Comparison of DFM Analysis Result	152

LIST OF FIGURES

2.1	General DFMA Method	4
2.2	General Lucas Hull Method	9
2.3	General Hitachi AEM Method	10
2.4	The features are affecting part handling	12
2.5	The characteristic need to be avoid	12
2.6	Incorrect geometry can allow part to jam during insertion	13
2.7	Provision of air-relief passage to improve insertion into blind	13
2.8	Design for ease of insertion – assembly of long stepped bushing into counter bored hole	13
2.9	Provision of chamfer to allow easy insertion	14
2.10	Standardize parts	14
2.11	Single axis pyramid assembly	14
2.12	Provision of self-locating features	15
2.13	Design to aid insertion	15
2.14	Common fastening methods	15
2.15	The example rotational symmetries for different parts	17
2.16	Perspective view of children scooter	18
2.17	Exploded view of a shock absorbing	19
2.18	Types of welding joints	22
2.19	Types of welding positions	23
2.20	Die design for stamping process	23
2.21	Metal stamping products	24
2.22	Rivet and its parts	24
2.23	Riveting operation	25
2.24	Type of rivet head	25
2.25	Roll forming bending process	26
2.26	List of formed shapes	26

3.1	Flow chart of the metrology	28
3.2	The existing product- Children's scooter	29
3.3	The exploded drawing and main material of the children's scooter	30
3.4	The lists of part shows at manual instructions sheet	31
3.5	Tool assembly - Philips screw driver	43
3.6	Tool assembly - Alley key	43
3.7	Tool assembly - Snap Ring pliers	44
3.8	Tool assembly – Rivet gun	44
3.9	The customer manual instructions printing at the packing box	44
3.10	Main fixture	45
3.11	Guiding fixture	45
3.12	The product tree structure for existing design	48
3.13	Tool measurement- Digital Vernier caliper	49
3.14	Tool measurement- Measuring tape	49
3.15	Main exploded drawing of children's scooter assembly	50
3.16	Exploded drawing of T-Tube assembly	51
3.17	Main exploded drawing of cover fork assembly	51
3.18	Main exploded drawing of fork assembly	52
3.19	Main exploded drawing of fork assembly	52
3.20	List of information need to fill out	60
3.21	The selection of icon for assembly process	61
3.22	Individual part information	61
3.23	Securing method of the assembly process	61
3.24	Theoretical number of the part	62
3.25	Create the dimension of the part	62
3.26	Identify the symmetry part	62
3.27	Handling difficulties	63
3.28	Insertion difficulties	63
3.29	DFA analysis result	64
3.30	List of DFM information need to fill out	64
3.31	List of DFM information need to fill out	65
3.32	Structure flow of the manufacturing process	65

3.33	List of the process and machine selection	66
3.34	Selection of parameter	67
3.35	DFM analysis Result	67
4.1	Statement Setup and DFA software analysis result of the current product	69
4.2	Manual Handling Table	71
4.3	Manual Insertion Table	72
4.4	DFA manual analysis for Cover Fork Assembly	73
4.5	DFA manual analysis for Fork Assembly	74
4.6	DFA manual analysis for Steering Tube Assembly	75
4.7	DFA manual analysis for T-Tube Assembly	76
4.8	DFA manual analysis for Back Wheel Assembly	77
4.9	DFA manual analysis for children's scooter	77
4.10	DFA manual analysis on fastener part	78
4.11	Comparison of the DFA result for fastener part	78
4.12	The data analysis of tool fetching and tool reposition	79
4.13	Comparison of DFA analysis result	79
4.14	DFM analysis result of the main part	80
4.15	Handling Difficulties Part	80
4.16	Selection of handling difficulties symbol	82
4.17	Insertion Difficulties Part	82
4.18	Selection of insertion difficulties and secured method symbol	84
4.19	Data of DFM concurrent costing responses 1	84
4.20	Data of DFM concurrent costing responses 2	85
4.21	Specification of the CNC Machine	86
4.22	Specification of the CNC Machine	88
4.23	Comparison between CNC machines with conventional milling machines in steering tube production	89
4.24	Comparison of specification of the machine	90
4.25	Manufacturing structure flow tree for a part	91
4.26	Redesign of cover fork assembly	95

4.27	Redesign for cover front baseboard	96
4.28	Redesign for fastener part	97
4.29	Comparison of the assembly flow process	98
4.30	Reduction of redesign	98
4.31	Relationship between labour costs with difficulties part	99
4.32	Relationship between labour costs with assembly part	99
4.33	Redesign of fork assembly	101
4.34	Redesign of fastener part for holding tub	102
4.35	Redesign of absorber part	103
4.36	Redesign of tube part	105
4.37	Redesign of bearing part	105
4.38	Comparison of the assembly flow process	107
4.39	Reduction of redesign	108
4.40	Redesign of t-tube assembly	109
4.41	Redesign of bell part	109
4.42	Redesign of snap-fit knob part	111
4.43	Redesign of handlebar part	111
4.44	Comparison of the assembly flow process	112
4.45	Reduction of redesign	112
4.46	Redesign of back wheel assembly	113
4.47	Redesign of back brake part	114
4.48	Comparison of the assembly flow process	115
4.49	Reduction of redesign	116
4.50	Comparison of main exploded drawing	116
4.51	Product structure tree for the children's scooter	117
4.52	The comparison of the baseboard design	119
4.53	The process flow structure for manufacturing the old baseboard	120
4.54	The process flow structure for manufacturing the new baseboard	120
4.55	The comparison of the result between old and new design	121
4.56	The comparison of the cover fork design	122
4.57	The process flow structure for manufacturing the cover fork	123
4.58	The process flow structure for manufacturing the new cover fork	123

4.59	The comparison of the result between old and new design	124
4.60	The comparison of the baseboard fork	126
4.61	The process flow structure for manufacturing the old fork	126
4.62	The process flow structure for manufacturing the old steering tube	127
4.63	The process flow structure for manufacturing the new fork	127
4.64	The comparison of the result between old and new design fork	128
4.65	The DFM result analysis of the steering tube	128
4.66	The comparison of the t-tube design	129
4.67	The process flow structure for manufacturing the old t-tube	130
4.68	The process flow structure for manufacturing the new t-tube	130
4.69	The comparison of the result between old and new design	131
4.70	The comparison of the brake design	132
4.71	The process flow structure for manufacturing the brake	133
4.72	The process flow structure for manufacturing the new brake	133
4.73	The comparison of the result between old and new design	133
4.74	The comparison of the handlebar design	134
4.75	The process flow structure for manufacturing the old handlebar	135
4.76	The process flow structure for manufacturing the new handlebar	135
4.77	The comparison of the result between old and new design	135
4.78	The comparison of the bracket design	136
4.79	The process flow structure for manufacturing the old L-bracket	137
4.80	The process flow structure for manufacturing the new U-bracket	137
4.81	The comparison of the result between old and new design	137
4.82	The comparison of the cover front baseboard design	138
4.83	The process flow structure for manufacturing the old cover front baseboard	139
4.84	The process flow structure for manufacturing the new cover front baseboard	139
4.85	The comparison of the result between old and new design	139
4.86	The comparison of the snap-fit knob design	140
4.87	The process flow structure for manufacturing the new snap-fit knob	140

4.88	The DFA result analysis of new snap-fit knob	141
4.89	DFA software analysis result of the new design	142
4.90	DFA manual analysis for Cover Fork Assembly	143
4.91	DFA manual analysis for Fork Assembly	144
4.92	DFA manual analysis for T-Tube Assembly	145
4.93	DFA manual analysis for Back Wheel Assembly	145
4.94	DFA manual analysis for children's scooter	146
4.95	Comparison of DFA analysis result	146
4.96	DFM analysis result of the main part	147

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

DFMA	-	Design of Manufacture and Assembly
DFA	-	Design for Assembly
DFM	-	Design of Manufacture
MM	-	Millimetre
TM	-	Assembly Time
NM	-	Number of Theoretical parts
DFA Index	-	Design efficiency for Assembly
NO	-	Number
QTY	-	Quantity
CAD	-	Computer Aided Design
CNC	-	Computer Numerical Control
LAB	-	Laboratory

CHAPTER 1

INTRODUCTION

A children's scooter is a three-wheeled device that promotes movement from one place to another place. The problem of this scooter is that involved many small fasteners part that to ensuring proper functionality. Furthermore, the scooter also involved some common parts that involved handle bars, the deck, clamps, grips and bar ends, fork, headset, brakes and the wheel. Since the children's scooter involved many parts, these are increasing the number of the component, cost and process for manufacturing and assembly. The purpose of this project is to design analyze a children's scooter using the Boothroyd Dewhurst DFMA methodology and improve the design by removing any unnecessary parts to get highest design efficiency for the current product design.

1.1 Problem Statement

There are several significant problems regarding to the project that exists in the case study:

- The numbers components of children's scooter are too many that involved many fastener parts.
- Too many process assemblies.
- Assembly cost is quite high and complicated.

1.2 Objectives

This project will focus on meeting these objectives:

- To improve and simplify the part's design in children's scooter assembly using the DFMA method.
- To suggest the new design while maintaining the main function of the product.
- To increase 30% of the design efficiency for the current product.

1.3 Title

Design analysis of a children's scooter using DFMA (Boothroyd Dewhurst) method.

1.4 Scope

The scope for this project:

- This research project will focus primarily on the design analysis of a children's scooter using Boothroyd Dewhurst as software of DFMA method.
- The manually children's scooter with foldable is the type of the scooter that will be analyze in this project.
- This project will focus on whole body of the product, and improve the design with less possible components.
- This DFM analysis will focus on the main part of the product, exclude the purchases part (such as screws).

1.5 Expected Result

The result expectation for the project:

- To decrease 10% of the totally manufacturing and assembly cost.
- To reduce 10% of the totally component of the product.
- To increase 30% of the design efficiency for the current product.