UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Design and Development of Grass Cutting Machine using DFMA Methodology

Thesis submitted in accordance with the requirements of Universiti Teknikal Malaysia Melaka for the Bachelor's degree in Manufacturing Engineering (Manufacturing Design) with Honours

By

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APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering Manufacturing (Design). The members of the supervisory committee are as follows:

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ABSTRACT

This project describes about the implementation of redesign the grass cutting machine by using the application of Design for Manufacturing and Assembly (DFMA) methodology. The scope based on the existing grass cutting machine and the appropriate of DFMA methodology. The method used for gaining the data is from the reassembled the existing grass cutting machine. From the data achieved, it can be classified into several categories to be studied. Data will be analyzed by using Lucas Hull method to verify the design efficiency, handling ratio and fitting ratio to achieve. The tools that used is TeamSET software. The new proposed design of grass cutting machine drawn using SolidWorks software based on TeamSET result achieved. Result shown that the design efficiency for redesign grass cutting machine obtained better percentage rather than the existing design. From the study, the total part, handling ratio fitting ratio and cost of existing design is reduced. Eventually, the improvement of redesign grass cutting machine finally will be able to meet user requirements and satisfactions.

ABSTRAK

Kertas kerja ini menghuraikan tentant perlaksanaan dalam mereka bentuk semula mesin pemotong rumput dengan menggunakan aplikasi DFMA (Design for Manufacturing and Assembly). Skop projek adalah memfokus kepada rekabentuk asal mesin pemotong rumput dan disertakan dengan aplikasi DFMA. Kaedah yang digunakan untuk mendapatkan data adalah daripada memasang semula mesin pemotong rumput. Hasil data yang diperolehi akan dikelaskan kepada beberapa kategori sebelum analisa dilakukan. Kemudian, kesemua data tersebut akan dianalisa dengan menggunakan kaedah Lucas Hull untuk menentukan kecekapan rekabentuk, nisbah pengendalian, nisbah perhimpunan sebagai pencapaian objektif projek. Perkakasan yang terlibat adalah perisian TeamSET. Rekabentuk mesin pemotong rumput yang baru akan di lukis menggunakan perisian SolidWorks berdasrkan keputusan yang dicapai daripada perisian TeamSET. Keputusan menunjukkan bahawa kecekapan reka bentuk untuk rekabentuk semula mesin pemotong rumput memperolehi peratusan lebih baik daripada rekabentuk yang asal. Daripada kajian, bahagian terjumlah, nisbah pengendalian, nisbah perhimpunan dan kos telah dikurangkan. Akhirnya, peningkatan rekabentuk semula mesin pemotong rumput akhirnya akan dapat bertemu keperluan dan kepuasan pengguna.

DEDICATION

For my beloved mother and father

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TABLE OF CONTENTS

Abstract……i
Abstrak ……ii
Dedication…….....iii
Acknowledgements……iv
Table of Contents……v
List of Figures……ix
List of Tables…….....xi
List of Sign and Symbol……xii

1. INTRODUCTION…….....1
1.1 General Introduction…….....1
1.2 Problem statement……2
1.3 Objective……..3
1.4 Scope of study……..3

2. LITERATURE REVIEW……...4
2.1 Introduction……..4
2.2 Design for Manufacturing and Assembly (DFMA)…….5
2.3 Boothroyd Dewhurst DFA method……..7
2.4 The Lucas DFA method……...8
2.4.1 Functional Analysis……..10
2.4.2 Handing Analysis…….....10
2.4.3 Fitting Analysis…….....12
2.5 The Guidelines of DFA…….....13
2.5.1 A DFA guideline……...13
2.5.2 Design Guidelines for Part Handling…….....14

2.5.3 Design Guidelines for Insertion and Fastening……14

2.6 Types of Assembly……15
2.7 DFA Process……..16
2.8 Design for Manufacture Guidelines……...17
2.8.1 General Principles of manufacturability……...17
2.9 TeamSET……...19
2.10 Application of DFMA in industry……...21
2.10.1 Application of DFMA in aerospace industry……21
2.10.2 Application of DFMA in automotive industry……...24
2.10.3 Application of DFMA in medical instrument industry……..26

3. METHODOLOGY……27
3.1 Method of Study……27
3.2 TeamSET process flow……..29
3.3 TeamSET database process……....30
3.4 DFA analysis for existing product……34
3.4.1 Flow chart of existing product…….....34
3.4.2 Flow chart of base part…….....34
3.4.3 Flow chart of upper tunnel part……..35
3.4.4 Flow chart of lower tunnel part……..36
3.4.5 Detail drawing of existing product……37
3.4.6 TeamSET analysis for existing product……37

4. RESULT AND ANALYSIS……...39
4.1 Introduction of analysis……..39
4.2 Draw design using SolidWork software……40
4.2.1 Detail drawing of first redesign……40
4.2.2 Detail drawing of second redesign……41
4.3 Analysis using TeamSET software……42
4.3.1 DFA analysis for first redesign……..42
4.3.1.1 Flow chart of first redesign……44
4.3.1.2 Flow chart of upper tunnel part after first redesign……...44
4.3.1.3 Flow chart of lower tunnel part after first redesign……...45
4.3.1.4 Flow chart of base part after first redesign……46
4.3.1.5 TeamSET analysis for first redesign……..47
4.3.2 DFA analysis for second redesign…….....48
4.3.2.1 Flow chart of second redesign……...49
4.3.2.2 Flow chart of base structure part……...49
4.3.2.3 Flow chart of cylinder blade part……...50
4.3.2.4 Flow chart of tunnel part……50
4.3.2.5 Flow chart of pulley system part……51
4.3.2.6 TeamSET analysis for second redesign…….51
4.4 Material and process selection…….53
4.4.1 Shaft blade and shaft connector…….53
4.4.2 Cylinder blade……54
4.4.3 Base structure…….55
4.4.4 Tunnel……56

5. DISCUSSION……57
5.1 Comparison of existing design with first and second redesign……..57
5.2 Safeguards for prevent from mechanical hazards……..59

6. CONCLUSION & FUTURE WORKS ……...61
6.1 Conclusion…….61
6.2 Future works……..62

REFERENCES……63

APPENDIX

A Gantt chart for PSM 1 & 2
B Detail drawing for redesign Grass Cutting Machine

LIST OF FIGURE

1.1	The grass cutting machine	2
2.1	Flow chart of Lucas Hull method	9
2.2	Show DFA analysis	20
2.3	Show view of Longbow Apache Helicopter	23
2.4	Explode view of existing design of overhead luggage rack	24
2.5	Explode view of new design of overhead luggage rack	25
2.6	BagEasy III	26
3.1	Flow chart of Planning of the Study	28
3.2	The process flow in developing TeamSET database	29
3.3	The product maintaining projects, products and design scenarios	30
3.4	Product Breakdown Structure	31
3.5	Assembly Window	32
3.6	DFA analysis for assembly parts	33
3.7	A flow chart of existing product main part	34
3.8	A flow chart of base part	35
3.9	A flow chart of upper tunnel part	36
3.10	A flow chart of lower tunnel part	36
3.11	View of the existing product	37
3.12	TeamSET analysis for existing product	38
4.1	View of first redesign	40
4.2	View of second redesign	41
4.3	A flow chart of first redesign main part	44
4.4	A flow chart of upper tunnel part after redesign	45
4.5	A flow chart of lower tunnel part after redesign	45

4.6	A flow chart of base part	46
4.7	TeamSET analysis for improvement design	47
4.8	A flow chart of final design main part	49
4.9	A flow chart of base structure part	49
4.10	A flow chart of cylinder blade part	50
4.11	A flow chart of V-belt part	51
4.12	TeamSET analysis for second redesign	52
4.13	Drawing of shaft blade and shaft connector	53
4.14	View of cylinder blade	54
4.15	View of base structure	55
4.16	Cross section view of tunnel	56
4.17	Isometric view of tunnel	56
5.1	Part for accessories	59
5.2	View of the second redesign after installation accessories	60
6.1	Shows the comparison between existing product and second redesign	61

LIST OF TABLE

2.1	Lucas DFA method - Manual Handling Analysis	11
2.2	Lucas DFA method - Manual Fitting Analysis	12
2.3	Pilot's Instrument Panel Estimate Summary	23
4.1	Quantity List of a first redesign	43
4.2	Quantity List of a second redesign	48
5.1	Comparison of existing design with fisrt redesign	58
5.2	Comparison of existing design with second redesign	58

LIST OF SIGN & SYMBOL

DFMA	-	Design for Manufacturing and Assembly
DFA	-	Design for Assembly
DFM	-	Design of Manufacturing
PDS	-	Product Design Specification
QFD	-	Quality Function Deployment
MA	-	Manufacturing Analysis
FMEA	-	Failure Modes and Effects Analysis
DTC	-	Design to Target Cost
ASF	-	Assembly Flowchart
IPD	-	Integrated Product Development
PEP	-	Engineering and Planning
IEFAB	-	Improved Extended Avionics Bay
CAD	-	Computer Aided Design
PBS	-	Product Breakdown Structure

CHAPTER 1
INTRODUCTION

1.1 General Introduction

Product lifecycle is being reduced drastically due to rapid changes in technology and customers requirements. The global marketplace is changing so rapidly that industrialist needs to adopt new strategies to respond customer's requirement and in order to satisfy the market needs more efficiently and quickly. Many companies especially in Japan, USA and Europe have already started to implement techniques and tools that would enable them to respond more quickly to consumer's demand in delivering high quality product at reasonable costs. The delay in time-to-market can be interpreted as a loss in profit (Alan F & Jan Chal, 1994).

Currently, the implementation of Design for Manufacturing and Assembly (DFMA) methodology are applied either manually or computer-aided. Most of the applied interested in implementing DFMA are hindered by lack of clear guidelines or procedures and no integration of isolated design and manufacturing teams. The advantages of the integration are to decrease the number of part design and indirectly to reduce cost and time. At the same time, it fulfills customer's requirement. In this project, DFMA has been applied in design and development the grass cutting machine. The design also must be concerned to the requirement of the DFMA methodology in order to achieve high rank of market selling.

1.2 Problem statement

In developing this project, there are several problems that need to be concerned and the most suitable method that can be used to solve the problems is by applying the Design for Manufacturing and Assembly (DFMA) methodology. In identifying of grass cutting machine problems, the most important aspects that need to be concerned is the design of the grass cutting machine. Some of the part grass cutting machine are being designed quite complicated with accessories and need to be eliminated, in the same time reduced the manufacturing cost and assembly time. Besides that, there are several parts had been recognized that difficult to handle. So, with the application of Design for Manufacturing and Assembly (DFMA) methodology is highly expected in solving these problems to suit the customer requirements and convenient.

Figure 1.1: The grass cutting machine

1.3 Objective

The main objective of this project is using DFMA methodology to design the new grass cutting machine and compare with the existing product. Beside that, other specific objectives include:

a) to develop the grass cutting machine;
b) to design and analysis of original design;
c) to purpose grass cutting machine using DFMA method and TeamSET software;
d) to determine the optimum manufacturing and assembly method for low cost production with short production time.

1.4 Scope of study

a) Case study

A grass cutting machine has been selected as a case study for this project and had the potential to be redesign by applying the Design for Manufacturing and Assembly (DFMA) methodology. The tool selected for drawing the grass cutting machine is SolidWork. User can easily generate drawing from a model. Photorealistic rendering and animation that allow communicating how future products will look and perform early in the development cycle.

b) Design for Assembly (DFA)

DFA is a systematic methodology that reduces manufacturing costs, total number of parts in a product, and etcetera. For this project, the software called TeamSET is used to analyze the design for existing product and redesign product.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

To develop this project, the case study is to apply the Design for Manufacturing and Assembly (DFMA). There are certain important DFMA tools that have been applied such as Design for Assembly (DFA) and Design for Manufacture (DFM). These two important DFMA tools are very useful especially to the industry. This chapter described about the definition of Design for Manufacturing and Assembly (DFMA), Boothroyd Dewhurst DFA method, the Lucas DFA method, the application of DFMA in industry and application of engineering software called TeamSET.

2.2 Design for Manufacturing and Assembly (DFMA)

Design for Manufacturing and Assembly (DFMA) is a design philosophy used by designers when a reduction in part counts, a reduction in assembly time, or a simplification of subassemblies is desired. It can be used in any environment regardless of how complex the part is or how technologically advanced this environment may be. DFMA encourages concurrent engineering during product design so that the product qualities reside with both designers and the other members of the developing team (D-ESPAT, 2007).

According to Geoffrey Boothroyd, Professor of Industrial and Manufacturing at the University of Rhode Island, the practices now known as Design for Assembly (DFA), and Design for Manufacture (DFM) had their start in the late 1970's at the University of Massachusetts. Of all the issues to consider, industry was most interested in Design for Assembly. When developing a product, the maximum potential cannot be achieved without considering all phases of the design and manufacturing cycle. DFMA meets this demand by addressing key assembly factors before the product goes on to the prototype stage. These key factors are the product appearance, type, the number of parts required in the product, and the required assembly motions and processes (D-ESPAT, 2007).

The Term “DFMA” comes with the combination of DFA (Design for Assembly) and DFM (Design of Manufacturing). The basic concept of it is that the design engineers apply the DFMA paradigm or software to analyze the manufacturing and assembly problems at the early design stage. By this means, all of considerations about the factors that affect the final outputs occur as early as possible in the design cycle. The extra time spent in the early design stage is much less the time that will be spent in the repeatedly redesign. And meanwhile, the cost will be reduced. DFM is that by considering the limitations related to the manufacturing at the early stage of the design; the design engineer can make selection among the deferent materials, different technologies, estimate the manufacturing time the product cost quantitatively and rapidly among the different schemes. They compare all kinds of the design plans and technology plans, and

then the design team will make revises as soon as possible at the early stage of the design period according this feedback information and determine the most satisfied design and technology plan.

The three goals in DFM are:

1. Increase the quality of new produces during the development period, including design, technology, manufacturing, service and so on.
2. Decrease the cost, including the cost of design, technology, manufacturing, delivery, technical support, and discarding.
3. Shorten the developing cycle time, including the time of design, manufacturing preparing, and repeatedly calculation.

DFA is considering and resolving the possible problems in the assembly process at the early stage of the design which can make sure the part will be assembled with high speed, low cost and productivity. DFA is a kind of design paradigm with which, the engineer use all kinds of methods such as analyze, estimating, planning and simulating to consider all the factors that will affect the assembly process during the whole design process; revise the assembly constructions to satisfied the characteristics and functions of the final products; and meanwhile, lower the cost as most as possible.

DFA is a kind of design method that can be used in two ways. The ways is a tool for assembly analysis and a guide for assembly design. The former usage is that at the time after the beginning of the product design, the engineer makes estimation of assembly possibility by analyzing all the factors that can affect the assembly process, and give suggestions. The second one is that collecting the knowledge and experience from the assembly experts and recording them as design guides. By the help of these guides, the engineer can choose the design plan and determine the product construction such as under the guidance of those experts.

2.3 Boothroyd Dewhurst DFA method

In the history of DFMA, Ford and Chrysler use the DFM philosophy in their design and manufacturing process of the weapons, tanks and other military products. Dr. Geoffrey Boothroyd and Dr. Peter Dewhurst who founded the Boothroyd Dewhurst, Inc (BDI) in 1982 are the first persons doing the research job in this new technology at the beginning in the early 1970's. Actually, the "DFMA" is a trademark of their company. They created and developed the DFMA concept which is used in developing the products of their company --- DFMA software system. Currently these programs are used to help the design in almost all the industrial fields including circuit boards (G. Boothroyd & W. Knight**,** 1993**),** with manual assembly, with robotic assembly, and with machining. They also do a lot of work examining the economic justification of each design revision (G. Causey**,** 1999**)**.

They created and developed the DFMA concept which is used in developing the products of their company such as DFMA software system. Currently these programs are used to help the design in almost all the industrial fields including circuit boards, with manual assembly, with robotic assembly, and with machining. They also do a lot of work examining the economic justification of each design revision.

In generally, Boothroyd Dewhurst DFA method can determine the appropriate assembly method and reducing the number of individual parts to be assembled. This method also can ensure that the remaining parts are easy to assemble. The methods of assembly are classified into three basic categories such as manual assembly, special-purpose transfer machine assembly and robot assembly.

2.4 The Lucas DFA method

Although the Boothroyd-Dewhurst method is widely used, it is based on timing each of the handling and insertion motions. Although tables of data are available, the most accurate numbers are compiled through time studies in particular factories.

The basic construction of Lucas DFA is very similar to the DFA of 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" which is the product of CCI Lucas DFA separates the product design process into three stages: FcA (Function Analysis), HA (Handing Analysis) and FtA (Fitting Analysis). The relations of these three stages are shown in Figure 2.1. 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.