PRODUCT DESIGN OPTIMIZATION USING DESIGN FOR MANUFACTURE AND ASSEMBLY APPROACHES

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A report submitted in partial fulfillment of the requirement for the award of the degree of Bachelor of Mechanical Engineering
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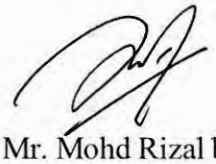
I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the Bachelor of Mechanical Engineering (Design-Innovation).

Signature : 
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I declare that this report entitled "PRODUCT DESIGN OPTIMIZATION USING DESIGN FOR MANUFACTURE AND ASSEMBLY APPROACHES." is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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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.

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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-Sytrene

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 assemblabilty 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 this 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 shorter 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.