DESIGN FOR ASSEMBLY AND APPLICATION USING BOOTHROYD DEWHURST METHOD

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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Date: April 2010

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This paper shows a detailed study to investigate the efficiency of Boothroyd Dewhurst Design for Assembly (DFA) method that was applied to improve the product design process. In today competitive world, companies try to cut down the manufacturing cost and at the same time increase their profit. In order to be a competent player in the market, the product should arrive into market within a short time and reasonable price. Assembly cost is one of the major operations in manufacturing but always ignored during designing stage. In this study, comparative analysis was done between current and alternative design. The design was done by using Solidwork software and analyzed by using manual and DFA software analysis to get the efficiency of current design. Then, by applying Boothroyd Dewhurst DFA method guideline, alternative design was generated and analyzed using the same method to compare the effectiveness of this new alternative design. From the study, it was found that the design efficiency increased from 16.7% to 46.4% when Boothroyd Dewhurst DFA method was applied. The time of assemble also decreased from 193.09 seconds to 58.48 seconds per product. From the result, it was proven that this Boothroyd Dewhurst DFA method was able to improve the design in terms of design efficiency, product assemble time and labor cost. This method can be applied in manufacturing company in order to improve their design effectiveness.

ABSTRAK

Kajian ini menunjukkan tentang kajian lanjut untuk mengkaji kecekapan kaedah Boothroyd Dewhurst Rekabentuk untuk Pemasangan (DFA) yang diaplikasikan untuk menambahbaik proses pemasangan rekabentuk. Dalam persaingan dunia masa kini, syarikat-syarikat berusaha untuk mengurangkan kos pengeluaran produk dan pada masa yang sama mereka cuba untuk meningkatkan keuntungan syarikat. Untuk bersaing di pasaran dunia, produk yang dihasilkan mestilah berada dipasaran di dalam masa yang cepat dengan harga yang berpatutan. Kos pemasangan adalah salah satu operasi penting dalam bidang pembuatan tetapi selalu diketepikan semasa proses mereka bentuk. Dalam kajian ini, analisis perbandingan telah dibuat antara produk semasa dengan produk yang dicadangkan. Rekabentuk dilakukan dengan menggunakan perisian Solidwork dan dianalisis dengan menggunakan perkiraan manual dan juga perisian analisis DFA untuk mendapatkan kecekapan bagi rekabentuk semasa. Kemudian, dengan mengaplikasikan panduan kaedah Boothroyd Dewhurst DFA, rekabentuk cadangan dihasilkan dan dianalisis dengan menggunakan kaedah yang sama untuk membandingkan keberhasilan rekabentuk cadangan ini. Daripada kajian, telah didapati kecekapan rekabentuk meningkat dari 16.7% kepada 46.4% apabila kaedah Boothroyd Dewhurst DFA diaplikasikan. Masa untuk pemasangan juga telah berkurang dari 193.09 saat untuk setiap produk kepada 58.48 saat untuk setiap produk. Daripada hasil kajian, telah terbukti bahawa kaedah Boothroyd Dewhurst DFA ini mampu untuk meningkatkan rekabentuk dari segi kecekapan rekabentuk, masa pemasangan produk dan juga kos tenaga kerja. Kaedah ini boleh diaplikasikan dalam syarikat pembuatan bagi meningkatkan kerberhasilan rekabentuk.

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α	Rotational symmetry of a part about an axis perpendicular to its axis of insertion
β	Rotational symmetry of a part about its axis of insertion
s	Second
mm	Millimetre

LIST OF ABBREVIATIONS

DFA	Design for assembly
DFMA	Design for manufacturing assembly
CAE	Computer aided engineering
AEM	Assemblability evaluation method
NSF	National Science Foundation
CAD	Computer aided engineering
RM	Ringgit Malaysia
NM	Total Theoretical minimum part
CM	Total assembly cost
TM	Total assembly time

CHAPTER 1

INTRODUCTION

1.1 Introduction

Design for analysis or design for assembly was done in the early 1970. These designs actually are done in several stages and include several persons. This process starts from designers who are design the product and follow up by making prototype. After prototype was been construct then the process is follow up by testing it and wait for the approval. These designs for analysis not only finish until there but it continues by manufacturing team by conduct the manufacturing plant. These planes are to make sure the product have same functionality and produces in large amount of production. This plans is to change the. This plans included the tools use, using different materials and different components. Designs for assembly also are the integration of product design and process planning into one common activity. The goal is to design a product that is easily and economically manufactured. The importance of designing for manufacturing is underlined by the fact that about 70% of manufacturing costs of a product are determined by design decisions, with production decisions responsible for only 20%. These designs for assembly is important in improving the quality in design, cut of cost of manufacturing of product and increase efficiency of product produces

For this study, design for assembly is differ into three types which are Hitachi AEM method, Lucas method, and Boothroyd Dewhurst method. These 3 methods are the most usable method in any design process. The different of these 3 methods will be discussed further in literature review. The practice of DFA as a distinct feature of designing is a relatively recent development, but many companies have been essentially doing DFA for a long time. For example, General Electric published an internal manufacturing producibility handbook in the 1960's as a set of guidelines and manufacturing data for designers to follow. These guidelines embedded many of the principles of DFA without ever actually calling it that or distinguishing it from the rest of the product development process.

It wasn't until the 1970's that papers and books on the topic began to appear. Most important among these were the publications of G. Boothroyd that promoted the use of DFA in industry.

1.2 Objective

For this project, the main objectives are:

- To study and apply Boothroyd Dewhurst method in design for assembly
- Redesign a product using Boothroyd Dewhurst method.
- Evaluate the original design efficiency over new design efficiency.

1.3 Scope of study

- Study on Design for Analysis together with Boothroyd Dewhurst methodology.
- Evaluate a product as a case study, analyze and redesign the product using Boothroyd Dewhurst method.
- Verification and validation on the method use.

1.4 Important of study

This study is important to simplify the product so that the cost of assembly is reduced. Applying design for analysis also usually to improved quality and reliability, and a reduction in production equipment and part inventory. These secondary benefits often outweigh the cost reductions in assembly.

1.5 Problem statement

A manufacturing system is composed of a large number of distinct processes which all influence product cost, product quality and productivity of system. This problem will cause a company major losses in their business. Other than that, mostly lot of product nowadays consist a lot of fasteners and unnecessary features. As a result, it will increase the time to market. By the time reach to market, the design is already outdated and finally it will lose its competency.

One of the methods used to overcome this problem is by using Boothroyd Dewhurst DFA method. The advantage of this method is the problem regarding of manufacturing can be detected in the early stage of design. This method also suggested the best possible way to assemble a product by eliminating fasteners to other type of assemble such as snap fit, press fit and etc. Other than that, this method also suggested to combine a part or eliminated the unnecessary part. By applying this method, time of assemble can be lesser and more product can be produce. This method also estimated the product cost of assemble and design efficiency of the product in the early stage of design, designers in manufacturing system always can estimated their efficiency and labor cost of their design before the product been produce

This study is aim to improve the design and reduce the assembly parts as well as its cost. Lesser parts mean lesser time needs to assembly the product as well as the cost.

1.6 Summary

This chapter described about overall introduction of this project. Background of this project will discuss after defining problem statement. Then, scopes and objectives of this project are determined as guidelines of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Design for assembly

2.1.1 Introduction of design for assembly (DFA)

The development of the original design for assembly method is early on 1960s on automatic handling. A group technology classification system was developing to catalogue automatic handling solutions for small parts. This shows that classification system could help the designers to design parts that would be easy to handle. This continue in the mid of 70s when U.S National Science Foundation (NSF) awarded a substantial to extend this approach to the general areas of design for manufacturing and design for analysis. University of Salford in England also was awarded a government grant to study product design for automatic assembly in the middle 70s (G.Boothroyd, at. all., 2002).

Also in the 1960s there was much talk about designing product so they could be manufactured so easily. Recommendations commonly known as productibility guidelines were develop. Figure 2.1 shows typical design guidelines that show how to simplifying the individual parts. But it has made a wrong assumption that single complex parts are less expensive to manufacture compare to the assembly part. This shows in Table 2.1 how the author is made a wrong assumption (G. Boothroyd, at. all., 2002). Reflex with the figure and table on the next page.

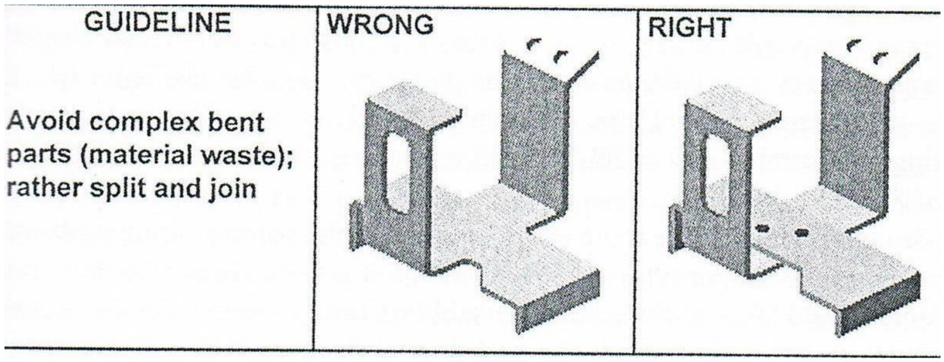

Figure 2.1: Misleading productibility guidelines (G. Boothroyd, at. all., 2002)

In Table 2.1, it shows that the right design is more expansive compare to the left design. This shows how the author is made a wrong assumption according to the implementation of DFA.

Table 2.1: Estimated cost for 2 products regarding applying DFMA
(G. Boothroyd, at. all., 2002)

	Wrong	Right
Setup	0.015	0.023
Process	0.535	0.683
Material	0.036	0.025
Piece part	0.586	0.731
Tooling	0.092	0.119
Total manufacture	0.678	0.850
Assembly	0.000	0.200
Total	0.678	1.050

Design also would be detailing of materials, shapes, and tolerances. Therefore, not only is it important to take manufacture and assembly into account during product design, but also these considerations must occur early as possible in the design cycle. This is illustrated qualitatively in Figure 2.2 which is showing that extra time spent early in the design process is more than compensated for by savings in time when prototypes takes places. Thus, in addition to reducing product cost the application of design for assembly shortens the times to bring product to the markets (G. Boothroyd, at. all., 2002).

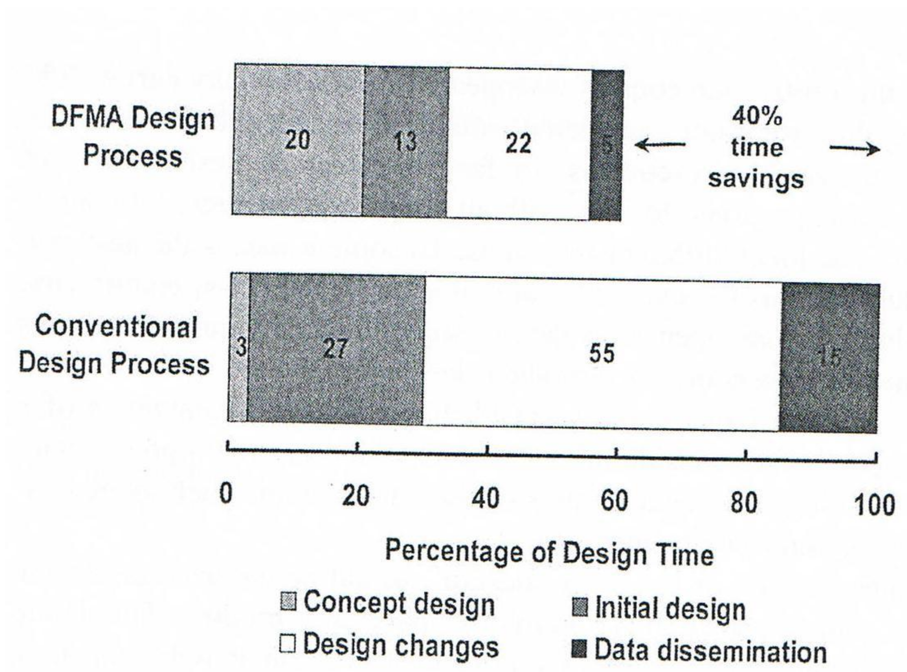

Figure 2.2: DFMA shortens the design process

(G. Boothroyd, at. all., 2002)

Other than that, Figure 2.3 also shows effect of design for assembly on cost product.

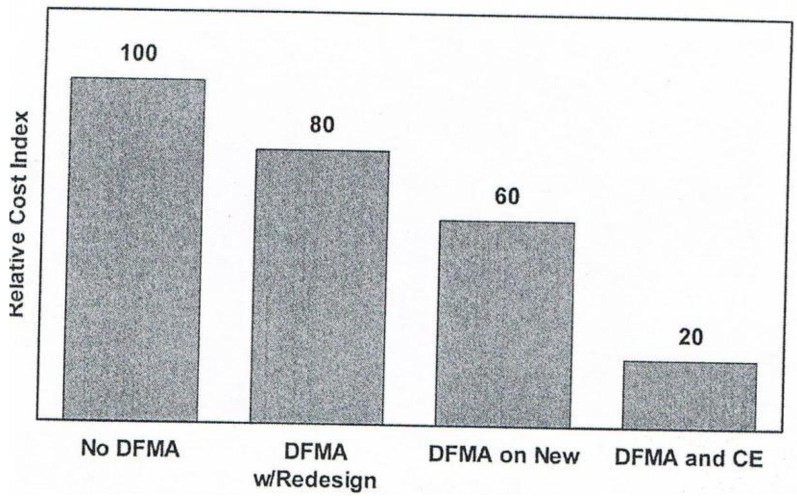

Figure 2.3: Effect of DFMA on cost product

(Boothroyd at. all., 2002)

2.1.2 Comparison of Assembly Methods

Assembly methods can be divided into three major groups. In manual assembly, parts are transferred to workbenches where workers manually assemble the product or components of a product. Hand tools are generally used to aid the workers. Although this is the most flexible and adaptable of assembly methods, there is usually an upper limit to the production volume, and labor costs. Fixed or hard automation is characterized by custom-built machinery that assembles one and only one specific product. Obviously, this type of machinery requires a large capital investment. As production volume increases, the fraction of the capital investment compared to the total manufacturing cost decreases. Indexing tables, parts feeders, and automatic controls typify this inherently rigid assembly method. Sometimes, this kind of assembly is called "Detroit-type" assembly. Soft automation or robotic assembly incorporates the use of robotic assembly systems. This can take the form of a single robot, or a multi-station robotic assembly cell with all activities simultaneously controlled and coordinated by a PLC or computer (Vincent Chan, at. all., 2003). Although this type of assembly method can also have large capital costs, its flexibility often helps offset the expense across many different products. Graphically, the cost of different assembly methods can be displayed as in Figure 2.4 show the non-linear cost for robotic assembly reflects the non-linear costs of robots. The appropriate ranges for each type of assembly method are shown approximately in Figure 2.5. Assembly methods should be chosen to prevent bottlenecks in the process, as well as lower costs.

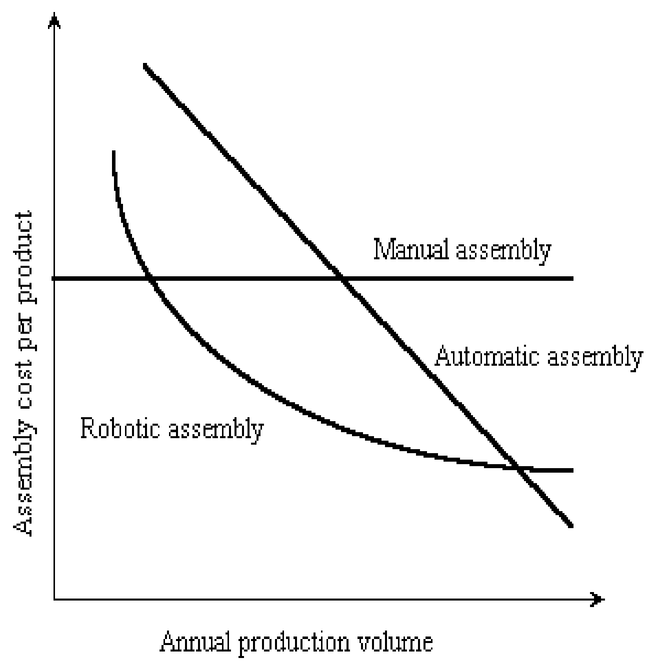

Figure 2.4: Relative costs of different assembly methods by type and production volume. (Vincent Chan, at. all., 2003)

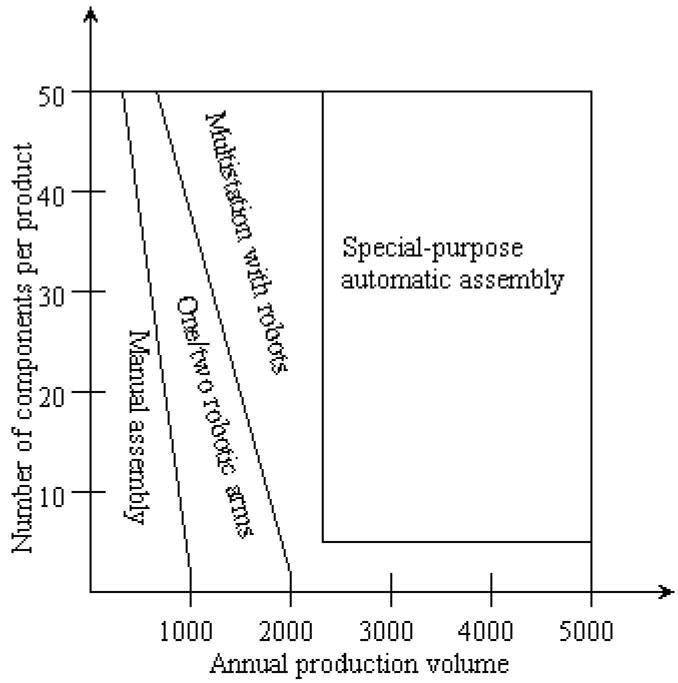

Figure 2.5: Production ranges for each type of assembly method
(Vincent Chan, at. all., 2003)

2.1.3 DFA Guidelines

Differrent books described DFA Guidelines in different ways. Some authors list many guidelines and described it with detail while other authors categorised it with few list before divided the main principle to another few principle. But surely the main objectives for all guidelines remain same, to reduce the cost of assembly. The principles of DFA are:

1. Reduce the parts count. The objectives of this guidelines is to minimize the total number of parts. There is two ways how this objectives can be achieved: First, design for minimum number of parts and second, minimize number of fasteners and their components.

2. Design for minimun number of parts. Focussing on the main parts, when number of parts is decreasing, the cost the assembly and whole product will also decreasing. There is 3 factors that should be considered. First, reduce the number of parts, second, remove non

essential components with its functions still achieved and third, combine several parts into one components and manufactures as an integral multifunctional component.

3. Minimize number of fasteners and their components. Screw and washers can increase the cost and time to assembly. Other alternatives fasteners can be used to replace the screw and washers, such as snap fits, press fits and molded hinges, straps or hook. It seems obvious with this technique (reduce parts count), the assembly costs would be less, but the question remains whether the overall manufacturing costs have been reduced. Next guidelines will show how to reduce overall cost (Poli, 2001).

Figure 2.6 show example of product with hook-under. This design is use as a replacement of screw without sacrifice the function.

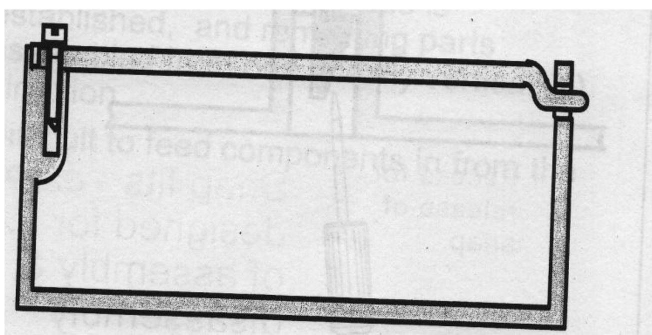

Figure 2.6: Hook- Under (Poli, 2001)