COMPARATIVE STUDY ON DIFFERENT APPROACH OF BOOTHROYD DEWHURST (B-D) DESIGN FOR ASSEMBLE (DFA) TECHNIQUE

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To Beloved Mother and Father

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ABSTRACT

Boothroyd Dewhurst (B-D) Design for Assembly (DFA) is method used to measure the assembly efficiency during assembly process in industry. There are two approach in B-D DFA which are manual approach and software approach. Both approaches have their own standard on the assembly evaluations which have cause differences in the results. The software approach is systematically formulated from the manual approach. Therefore the DFA of design efficiency is supposed to be equal or at least a little error percentage between them. The percentage error might be due to misjudgement during part assembly. Therefore the study the factor that affect the percentage error of design efficiency between manual approach and software approach of Boothroyd Dewhurst (DFA) perform and analyse in order to understand the function of these method in evaluate the product. The Manual approach follow the table in "Product Design for Manufacturing and Assembly " third edition by G. Boothroyd, P. Dewhurst and W,A, Knight. (copyright Boothroyd Dewhurst 1999, Inc) .The software approach use the Boothroyd Dewhurst (DFA) Design for Assembly 9.3(2006).The result than analyse and compare to evaluate the percentage difference and determine the reason for the difference to occur.

ABSTRAK

Boothroyd Dewhurst (BD) Rekabentuk untuk Pemasangan (DFA) adalah kaedah yang digunakan untuk mengukur kecekapan pemasangan semasa proses pemasangan diindustri. Terdapatdua pendekatan dalam B-D DFA iaitu pendekatan manual dan pendekatan perisian. Kedua-dua pendekatan mempunyai standard yang tersendiri pada penilaian pemasangan yang mempunyai meyebabkan perbezaan dalam dapatan kajian. Pendekatan perisian dirumuskan secara sistematik merujuk pendekatan manual. Oleh itu DFA kecekapan rekabentuk sepatutnya sama atau lebih kurang peratusan ralat sedikit di antara mereka. Kesilapan peratusan mungkin disebabkan oleh salah tafsir semasa perhimpunan bahagian. Oleh itu faktor yang memberi kesan akan dikaji tentang ralat peratusan kecekapan rekabentuk antara pendekatan manual dan pendekatan perisian Boothroyd Dewhurst (DFA) untuk melaksanakan dan menganalisis bagi memahami fungsi kaedah ini dalam menilai produk. Pendekatan Manual mengikut jadual di dalam "Design Produk untuk Pembuatan dan Dewan" edisi ketiga oleh G. Boothroyd, P.Dewhurst dan W, A, Knight. (hakcipta Boothroyd Dewhurst 1999, Inc) .Manakala pendekatan perisian menggunakan perisian Design Boothroyd Dewhurst (DFA) Design for Assembly 9.3(2006) . Kaedah ini akan dianalisis dan dibandingkan untuk menilai perbezaan peratusan dan menentukan sebab berlaku perbezaan dalam peratusan.

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LIST OF SYMBOL

α	Alpha = orientation of part in X-axis
β	Beta = orientation of part in Y-axis
DFMA	Design for Manufacturing and Assembly
DFA	Design for Assembly
B-D	Boothroyd Dewhurst
N_{min}	Theoretical Minimum Number of Parts
t_{ma}	Total Manual Assembly Time
t_a	Basic Assembly Time for One Part Standards
E_{ma}	DFA Index

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CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT:

Design for Assembly is a tool or method for industry to reduce time and cost of assembly product in the same time can improve the quality of the product. Design for Assembly as the basic concurrent engineering studies to provide guidance to the design team in simplifying the product structure, to reduce manufacturing and assembly cost, and to quantify the improvement because before this most of them using an over the wall approach. Design for assembly also as a benchmarking tool to study competitor's products and quantify manufacturing and assembly difficulties

There are two approaches in Boothroyd Dewhurst (B-D), Design for Assembly (DFA) evaluation namely manual approach and software approach. The software approach is systematically formulated from the manual approach. Therefore the DFA of design efficiency is supposed to be equal or at least a little error percentage between them. The percentage error might be due to misjudgement during part assembly.

The problems need to understand and clarify to prevent the error or optimize it by identify the capabilities or limitation of both software and manual approach.

1.2 OBJECTIVE

To study the factor that affect the percentage error of design efficiency between manual approach and software approach of Boothroyd Dewhurst (DFA). Therefore, both approaches need study, perform and analyse in order to understand the function of these method in evaluate the product.

Therefore by carrying out the study, the understanding Boothroyd Dewhurst method either manual approach or software approach needs to be study, understand and carry out by study a product. The action need to be follow by referring a reliable source such of books, journals, experience person and reliable internet resources

1.3 SCOPE

The scopes of these studies are:

1. To evaluate the existing product design efficiency using manual approach of B-D DFA.
2. To apply DFA software analysis on the same existing product design.
3. To compare both approaches product design efficiency.
4. To study the factors that contributed to the design efficiency error.
5. To re-evaluate the design efficiency based on the identified contributed factors.
6. To redesign the product by referring the B-D DFA guideline.
7. To Re-evaluate the redesign product using manual and software of B-D DFA.

1.4 SIGNIFICANT OF PROJECT

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

The purposes of Design for Assembly (DFA) are to make the process of fabrication and assembly easier, and reduce the cost. It will also simplify the product and also make the product become more reliable. If the engineers carry out their design in order to achieve Design for Assembly (DFA) analysis, they can protect product function and will know and determine that there is little chance that function will be seriously impaired.

There are several methods that widely used in industry to achieve Design for Assembly (DFA). The most widely used in industry nowadays is Boothroyd Dewhurst method, Hitachi Assembly Evaluation Method, Effort Flow Analysis and Lucas Hull method. However, in this project will only focus on Design for Assembly using Boothroyd Dewhurst methods which consist of manual approach and software approach product design efficiency comparison.

The case study of this project is more on product design efficiency analysis on both method of manual approach and software approach by using easy storage trolley. The target of this analysis is to evaluate score product design efficiency for each part before and after redesign. The product will be redesign with the same function and shape with simpler assembly method. It will make comparison become clearer.

1.5 SUMMARY

This chapter have described about overall introduction of the study of manual approach and software approach of B-D DFA. Significant of this project will discuss the study after defining problem statement. Then, scopes and objectives of this project are determined as guidelines of the project.

CHAPTER 2

LITERITURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide information and review about the Design for Manufacturing and Assembly (DFMA). This chapter will discusses about the following sub-chapters; design for manufacturing and assembly, theory of manual and software approach, review on previous case studies and perspective approach.

2.2 Design for Manufacturing and Assembly of Boothroyd Dewhurst.

Design for Manufacturing and Assembly (DFMA) method is introduced by Geoffrey Boothroyd since 1960s on automatic handling. The method of Design for Manufacturing and Assembly (DFMA) can be used to redesign a product. DFMA is the combination between Design for Manufacturing (DFM) and Design for Assembly (DFA). DFM is manufacturing of individual component parts of a product or assembly while DFA is addition or joining of parts to form a complete product. DFMA can help us to simplify the product structures, reduce the assembly and manufacturing costs and assembly time. By using this method, the quality of existing product can be improved and cost can be reduced.

The main activities of the DFMA are concurrent engineering to provide guidance to design team in simplifying the product structure, to reduce manufacturing and assembly costs and to qualify improvements. Besides, it is also used as a benchmarking tool to study competitors' products, and as a should-cost tool to negotiate contract with the supplier as shown figure 2.1.

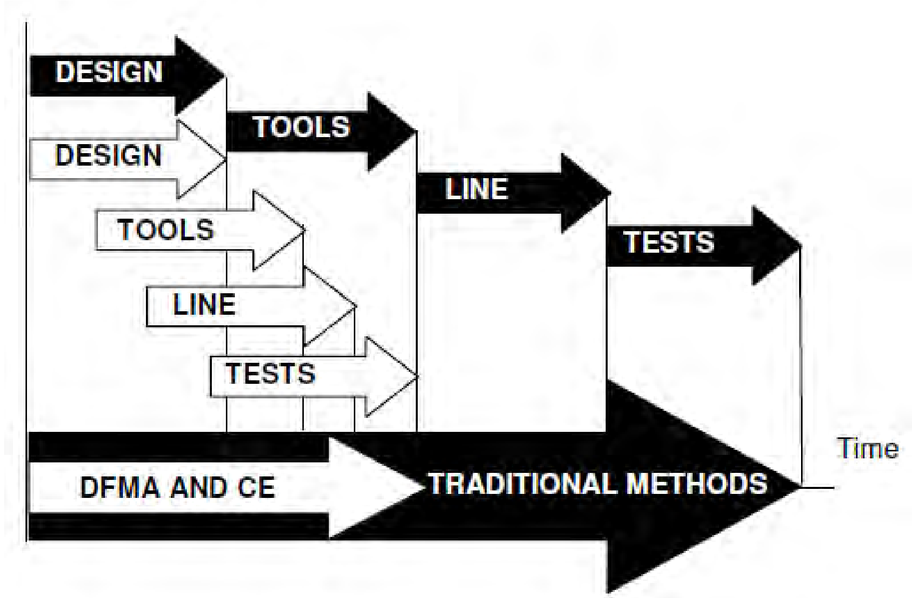

Figure 2.1: Time to Deliver Comparison between DFMA + Concurrent Engineering (CE) and the Traditional (Pedro (2006)

Tian Hong Luo (2007) have define the DFMA is a method can improve the integration between designer and manufacturer, speed up the productivity cycle, reduce the cost, improve product quality and reliability, to shorten lead time, to increase productivity and fulfil the customer's requirements. Hence, DFMA is a method to reduce the design and assembly cost to simplify the structure of the product, improve the quality and reliability to compare with the existing product. This method must be done at the earliest state to avoid from the overhead cost under the consideration of design team, the spirit of the co-operation is very important in this process.

Boothroyd.G, (1992) have stated. “We design it, you build it." This attitude has now become known as "over-the wall" design which means the designer did not care about the manufacturing engineer, they think that their responsibility is to draw and design the drawing then after that throw all the drawing to aside for manufacturing engineer as shown in figure 2.2. They are facing a lot of manufacturing problem because they were not involved in design effort

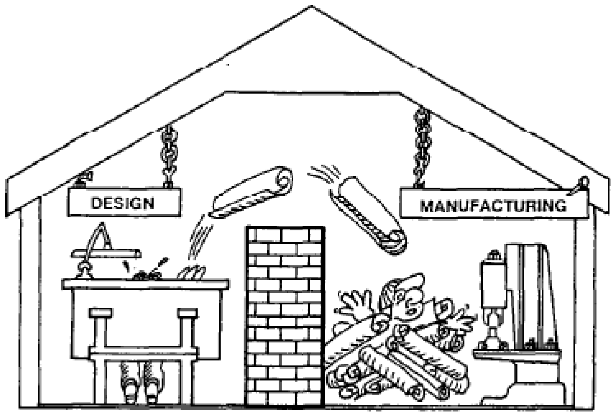

Figure 2.2: “Over the Wall Design” (Boothroyd.G ,1992)

Boothroyd (2002) have said that product design manufacturing and assembly (DFMA), it have been developed and discovered applied in industry particularly U.S. industry. In fact, it can be said that the availability of these methods have created a revolution in the product design business and helped to break down the barriers between design and manufacture; it has also allowed the development of concurrent or simultaneous engineering as shown in figure 2.3 and figure 2,4.

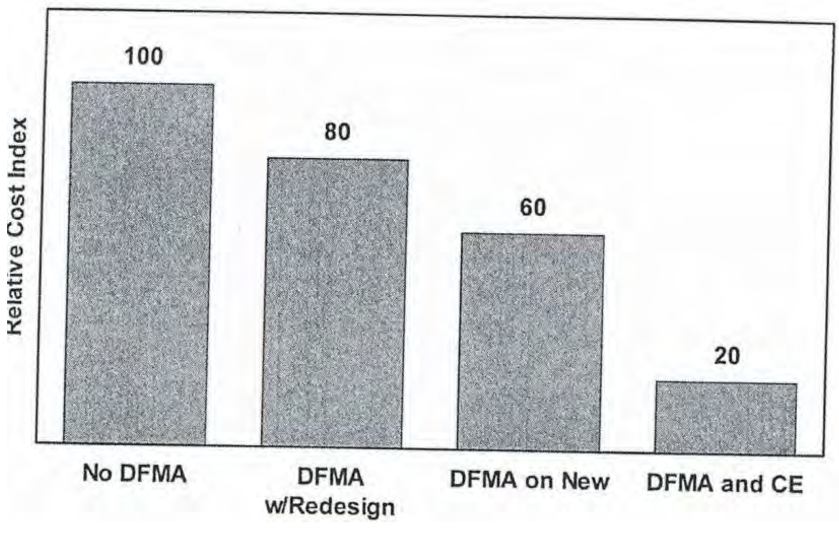

Figure 2.3: Effect of DFMA on cost product (Boothroyd , 2002)

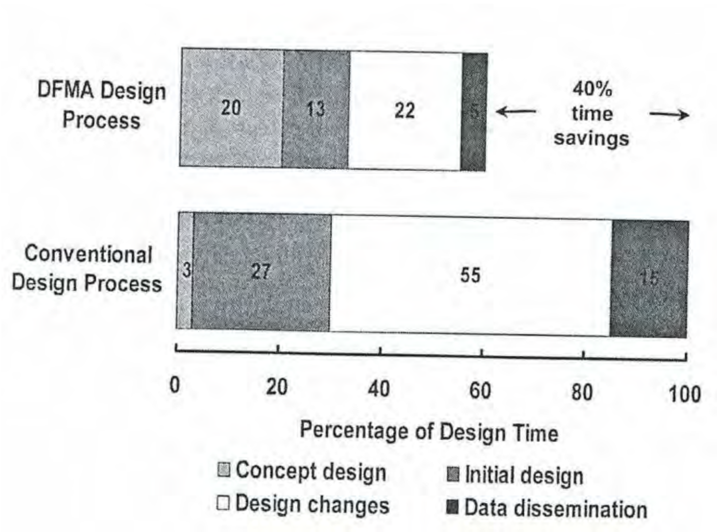

Figure 2.4: DFMA shortens the design process (G. Boothroyd, 2002)

In study of De Fazio T. L. (1993), the DFMA would be a workstation -like environment at which a designer could create a design in terms beyond just geometry, and accessing to capabilities for design trade-off studies, cost reduction studies, reducibility evaluations, design rule checking, and manufacturing and assembly evaluations and recommendations. It will act like a manufacturing expert looking over the designer's shoulder, providing a god suggestions, comments about the design and the defect of the design pattern, and information about fabrication and assembly.

Guidice stated that, (2009) DFMA is a method to analysis and improvement of the existing product, again implemented in commercially available computer software. DFMA developed is possible to optimize manufacturing’s cost, invent a most efficient and economical product. It also allows the analysis of each individual’s component and its assembly in order to define the optimal solutions, facilitating the assembly of subsystems and of the final product. From Boothroyd (2002) said, in the earliest stage, DFMA is able to estimate both assembly and part of manufacturing cost.

2.3 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. University of Salford in England also was awarded a government grant to study product design for automatic assembly in the middle 70s (G.Boothroyd, 2002).

Design is a complex iterative creative process that begin with the recognition of a need desire and terminates with a product or process that uses available resources, energy and technology to fulfil the original need within some set of defined constraint. Assembly is a process of joining components into complex product.

Design For Assembly (DFA) is an approach to reduce the cost and time of assembly by simplifying the product and process through such means as reducing the number of parts, combining two part into one part, reducing or eliminating adjustments, simplifying assembly operations, designing for part handling, selecting fasteners for ease of assembly and minimizing parts tangling.

The purposes of DFA are to design a product for easy and economical production and also incorporate product design early in the design phase. Besides, by using Design for Assembly it can improve quality, reduces cost and shortens time to design and manufacture.

2.3.1 DFA Manual approaches

Manual approaches done by referring the classification system for assembly processes is a systematic arrangement of part features that affect acquisition, movement, orientation, insertion, and fastening of the part together with some operations that are not associated with specific parts such as turning the assembly over.

The manual provides cooperatives and other types of self-help organizations with practical guidance that viable. It covers all the steps of project design: from the identification of the evaluation of each part in product, to determine the required time for assembly by referring the evaluation set for each part. For example manual assembly chosen as selected for manual approach time determination, have its own specification been determined that need to follow which same goes to the other type of assembly.

The portion of the classification system for manual insertion and fastening processes is concerned with the interaction between mating parts as they are assembled. Manual insertion and fastening consists of a finite variety of basic assembly tasks (peg-in-hole, screw, weld, rivet, press-fit, etc.) that are common to most manufactured products. If applied properly, these criteria require the designer to consider means whereby the product can be simplified, and it is through this process that enormous improvements in assemble ability and manufacturing costs are often achieved. However, it is also necessary to be able to quantify the effects of changes in design schemes. For this purpose the DFA method incorporates a system for estimating assembly cost which, together with estimates of parts cost, will give the designer the information needed to make appropriate trade-off decisions.

Selected portions of the complete classification system, its associated definitions, and the corresponding time standards are presented in tables in Figs. 3.15 to 3.17. It can be seen that the classification numbers consist of two digits; the first digit identifies the row and the second digit identifies the column in the table. It can be seen that for each two-digit code number, an average time is given. Thus, we have a set of time standards that can be used to estimate manual assembly times that can be refer standard as shown in figure 2.5, figure 2.6, figure 2.7 and figure 2.8.

a. parts that can be lifted with one hand but require two hands because they severely nest or tangle, are flexible or require forming etc

	alpha <= 180		alpha = 360
	size > 15mm	6mm < size <15mm	size > 6mm
	0	1	2
4	4.1	4.5	5.6

Figure 2.5: Selected manual handling time standards, seconds (parts are within easy reach, are no smaller than 6mm, do not stick together, and are not fragile or sharp). (Copyright 1999 Boothroyd Dewhurst, Inc.)

b. part inserted but not secured immediately or secured by snap

		secured by separate operation or part				secured on insertion by snap fit	
		no holding down required		holding down required			
		easy to align	not easy to align	easy to align	not easy to align	easy to align	not easy to align
		0	1	2	3	4	5
no access or vision difficulties	0	1.5	3.0	2.6	5.2	1.8	3.3
obstructed access or restricted vision	1	3.7	5.2	4.8	7.4	4.0	5.5
obstructed access and restricted vision	2	5.9	7.4	7.0	9.6	7.7	7.7

c. part inserted and secured immediately by screw fastening with power tool (Times are for 5 revs or less and do not include a tool acquisition lime of 2.9s)

		easy to align	not easy to align
		0	1
no access or vision difficulties	3	3.6	5.3
restricted vision only	4	6.3	8.0
obstructed access only	5	9.0	10.7

Figure 2.6: Selected manual insertion time standards, seconds (parts are small and there is no resistance to insertion).
(Copyright 1999 Boothroyd Dewhurst, Inc.)

	screw tighten with power tool	manipulation, reorientation or adjustment	addition of non solids
	0	1	2
6	5.2	4.5	7

Figure 2.7: Selected separate operation times, seconds (solid parts already in place).
(Copyright 1999 Boothroyd Dewhurst, Inc.)

I. *Alpha* is the rotational symmetry of a part about an axis perpendicular to its axis of insertion. For parts with one axis of insertion, end-to-end orientation is necessary when alpha equals 360 degrees, otherwise alpha equals 180 degrees.

II. *Beta* is the rotational symmetry of a part about its axis of insertion. The magnitude of rotational symmetry is the smallest angle through which the part can be rotated and repeat its orientation. For a cylinder inserted into a circular hole, beta equals *zero*.