UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DESIGN ANALYSIS OF A VACUUM CLEANER 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) with Hons

by

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I hereby, declared this report entitled "Design Analysis of A Vacuum Cleaner Using DFMA (Boothroyd-Dewhurst) Method" is the results of my own research except as cited in references.

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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's Degree in Manufacturing Engineering Technology (Product Design) with (Hons). The member of the supervisory is as follow:

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DEDICATION

To my beloved parents thankyou for your continuos support from the beginning until I managed to finish my Final Year Project. Thankyou for all the sacrifice and supports that both of you gives and your strength makes me stand further to achieve my dreams. Thankyou very much.

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ABSTRACT

Design for manufacturing and assembly (DFMA) methodology are being implemented to analyze the house appliances (vacuum cleaner) in the aspects of assembly, handling and insertion, part of the assembly and manufacturing process. The problems identified for this vacuum cleaner are there are too many parts of the vacuum cleaner. Also, there are too many difficulties involved in an assembly process. The objectives of this project are to reduce part while maintaining the function of a vacuum cleaner, to increase the DFA index of the vacuum cleaner 3 in 1, to draw the new design after the analysis, to reduce manufacturing cost for the vacuum cleaner and reduce the assembly time. The study has proven to save assembly time by 282.53 s, which is 42% more efficient than the original design. Besides the total cost per product for manufacturing has saved 2.80 $. The number of parts is also reduced from 87 parts to 40. The DFA index is improved from 4.2 to 10.0 too. The study result has revealed the DFMA methodology benefits of the final product (vacuum cleaner 3 in 1).

ABSTRAK

Reka bentuk untuk proses dan pemasangan adalah satu kaedah yang digunakan untuk menganalisa alatan barangan rumah dalam aspek kesusahan semasa pemasangan dan pengendalian. Masalah yang didapati terhadap pembersih habuk ini adalah terlalu banyak bahagian yang perlu dipasang dan diproses. Objektif projek ini adalah untuk mengurangkan masa pemasangan, mengurangkan kos pemasangan untuk pekerja, meningkatkan indeks DFA untuk produk ini, dan untuk mencadangkan reka bentuk yang baru untuk pembesih habuk. Melalui kajian yang telah dibuat, terbukti dengan menggunakan kaedah ini, kos pemsangan dapat dikurangkan sebanyak 282.53 s, 48.5% lebih bagus daripada yang sebelumnya. Kos untuk satu bahagian juga dapat dikurangkan sebanyak $2.08. Bilangan bahagian juga dapat dikurangkan daripda 80 bilangan sehingga ke 40 bilangan sahaja. Indeks DFA juga meningkat daripda 4.2 sehingga 10.

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List Abbreviations, Symbols and Nomenclatures

DFMA	—	Design for manufacturing and assembly
DFA	—	Design for assembly
DFM	—	Design for manufacturing
CE	—	Concurrent engineering
AEM	—	Assembly evaluation method
E	—	Assembly evaluation score ratio
K	—	Assembly cost ratio
A	—	The number of essential components
B	—	The number of non-essential components
tm	—	Total assembly labor time
Nmin	—	Number of minimum part

CHAPTER 1

INTRODUCTION

1.1 General Introduction

The recent developments in design for manufacturing and assembly, the need for improving quality and reducing the manufacturing, we need a more structured and flexible design approaches. This can be done or achieved by using software called as DFMA. Design for Manufacturing and Assembly (DFMA) is an approach to design that focuses on ease of manufacture and efficiency of the assembly. It is a well-established approach in sectors such as the automotive and consumer products industries that are driven by the need to produce large numbers of consistently high-quality products efficiently. For this project, a 3 in 1 vacuum cleaner was modeled using the software, Solid works and all the data was imported to DFMA. DFMA analysis was performed and computes all the essential requirements and the most optimal design can be achieved throughout the analysis.

Much of the early research work on Design for Manufacturing and Assembly (DFMA) was done in the early 1970 by Boothroyd Dewhurst. Boothroyd Dewhurst and team were studied many of the component and came out with the idea of composing a systematic methodology. The main objective for this system is to relate to the Product design, Assembly operation and Assembly method in details. Others than Boothroyd, they are the company that works similarly with this concept called as The Hitachi Evaluation Method that was developed at Hitachi in Japan. The basic idea for the reduction of cost by simplification of its design includes:

a) Reduction of number of components
b) Ensuring that the parts are easy to assemble
c) Increasing the use of standardized parts across entire product range.
d) Designing with widest possible tolerance
e) Material selection must be considered manufacturing, not just function.

1.2 Problem Statement

In developing this project, there are several problems that need to be concerned. This project has involved the house appliance that is vacuum cleaner. Design for manufacturing and assembly (DFMA) methodology are being implemented to analyze the vacuum cleaner in the aspects of assembly, handling and insertion, part of the assembly and manufacturing process. The problems identified for this vacuum cleaner are there is too many parts of the vacuum cleaner and time to assemble the parts are higher. Also, there is the existing design has more part complexity of the manufacturing process. So,with the application of the Design for Manufacturing and Assembly (DFMA) methodology is expected to solve the problem in order to lower the cost of manufacturing and to ease the process of assembly.

1.3 Objective

The main objective of this project is to analyze the design of a vacuum cleaner by using DFMA (Boothroyd- Dewhurst) method. Besides, the other specific objectives are:

1. To reduce part while maintaining the function of a vacuum cleaner
2. To increase the DFA index of the vacuum cleaner 3 in 1
3. To draw the new design after the analysis
4. To reduce manufacturing costs for the vacuum cleaner
5. To reduce total assembly time for the assembly process.

1.4 Scope of study

This project will involve the consumer product for house appliances. The product that has been chosen is vacuum cleaner.The project will be focusing on how DFMA method plays an important role and how it works for reducing the part for product, reducing the manufacturing cost, reducing the labor cost, making the manufacturing process easier and simplify the manufacturing process. The scope of study are:

1. Using software DFMA name Boothroyd Dewhurst method
2. Focusing on 3 major sub-assembly (vacuum cover sub-assembly, dirt bucket sub-assembly, hard floor nozzle assembly)
3. Using a multipurpose vacuum cleaner (3 in 1 vacuum cleaner)
4. Focusing on mechanical parts only.

CHAPTER 2

LITERATURE REVIEW

2.1 Design for manufacturing and assembly (DFMA)

DFMA can be drawn from an industry point of view as a system by which ways of efficient manufacture and configuration of smaller parts are planned and made possible for their use in making bigger structures by putting them all together. Why DFMA is important? By doing the DFMA process, an industry can save up to 45 percent from the stages of preliminary design, design and details, built and test for re-engineering, and for paperwork's stages. In 1970, there are two things that were changed as many new types of plastics were developed and the process of injection molding technology becomes widely used in the industry.

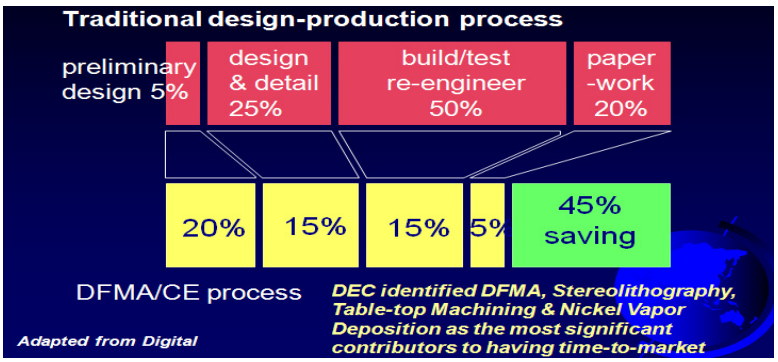

Figure 2.1: Percentage reduces by using DFMA method

These technologies are resulting in the possibility of low cost of plastic components. The advantages of plastic material are that they are providing different material behavior as they can deform without any failure. The advantages of this property are very useful in making snap-fit making components. Thus, the part that made from metal and screwed together could just be made out of plastics and snap fitted. This result leads to reduced time assembly, components and production costs.

Several companies were trying to bring their product faster to the market. This could not be done successfully because there might be changes in the design by the manufacturing engineering and product development was held up. This will hold up waiting the engineer change to be approved by the designer. This process often delays as the designer might be busy doing other works. The concurrent engineering (CE) was being introduced and became popular to simplify the problems.

Concurrent engineering (CE) is the combination of the team of an engineer and management that would be assigned to each new product. This team may consist of different background of the members from any department related including mechanical designer, electrical engineers, software engineers, production engineers, marketing and sales, and management. The production will give the feedback as the design was generated. The sales people would negotiate of product outlook and features. The biggest advantages of the CE was that the product was designed in the way that the manufacturing cost and time will be low in production.

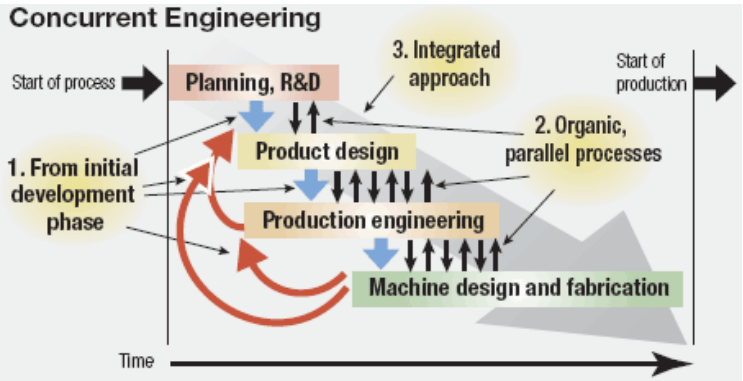

Figure 2.2 : Concurrent Engineering (CE)

Boothroyd and the team were analyzed over hundreds of products and suggested the design improvements for manufacturing and assembly ease. They developed a very large guideline on the design,estimation whether the design was designed well in manufacturing point of view and the potential methods to improve the design. The idea of Design for Manufacturing (DFM) and Design for Assembly (DFA) in subsequent years were extended to include design for the environment and design for maintenance. The basic idea for the reduction cost of a product

through simplification of its design. It can achieve by the reduced number of components, parts that are easy to assemble, use standard parts, designing widest possible tolerance and material selection must be considered for manufacturing also, not just function.

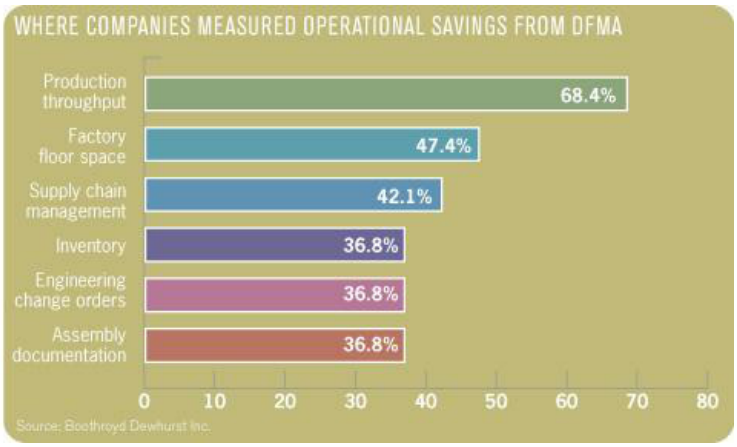

Figure 2.3 : The percentage savings of DFMA method to industry

2. 2 Design for Assembly (DFA)

The aim of design for assembly (DFA) is to simplify the product so that the assembly process can be reduced. DFA notice the need to analyze both of the part design and the whole product for any assembly problem early in the design process. DFA also defined as a process for improving the product for easy and low cost assembly and it is focused on functionality and concurrent assembly. By applying DFA, it is not about the reducing part, also its include the improvement of quality and reliability. Many companies have been essentially doing DFA for a long time. Top companies are applying DFA in their product to achieve 3 main goals :

a) Improve their products while reducing cost.
b) Increase competitive advantage.
c) Hold suppliers accountable.

The Boothroyd-Dewhurst method includes the preliminary design, selection of assembly method and design or redesign of product for the selected method. The selection for the best method of DFMA must be done early in the stages of the design process. The assembly method consist of three types that are widely used in the industry. The types are manual assembly, robotic assembly and fixed and hard automation assembly. For manual assembly, the volume to produce are less than 1000 parts per year. Fixed or hard automation needs the high volume that is more than million parts per year while for somewhere in between these limits, and based on some other considerations either for labor cost and technical requirements, robotic assembly may be optional.

For manual assembly, part is transferred from workbenches where the workers manually assemble the parts or components for the products. The workers will use hand tools to do the works. This is the most flexible, adaptable of assembly methods, but there is an upper limit to the production volume and labor cost. The characteristics of manual assembly are benches or simple conveyors are involved. Most of the time, inexpensive set up cost and assembly cost are nearly constant, and independent volume.

Figure 2.4 : Operator doing manual assembly method

Fixed or hard-automation is characterized by a custom-built machine that assembles one and only one specific product. This type of machinery requires a large capital investment. As production volume increases, the fraction of the capital investments compared to the total manufacturing cost decreases. Sometimes, this kind of assembly called as 'Detroit-type' assembly. The characteristics of fixed and hard automation assembly are the components involved are parts feeders, single purpose work heads and transfer devices. It is very expensive and time-consuming to build, very high production rate and down time due to defective parts may be a severe problem.

Figure 2.5 : Fixed or hard automation assembly method

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. The characteristics of the robotic assembly are similar to non-synchronous special propose assembly stations, excepts robots replace the single-purpose work heads and its use of robots allows flexibility in product types and production rates. Although this type of assembly method can also have a large capital cost, its flexibility often helps offset the expenses across many different products.