DESIGN IMPROVEMENT OF WIRA'S DRIVER SEAT USING INTEGRATED DFA AND VE

MGT ARNAZ BIN MGT RAMLI

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Faculty of Mechanical Engineering
Universiti Malaysia Pahang

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ABSTRACT

Wira driver's seat is a complicated product that consist hundred of part and the material representative are from steel to rubber. Some of the part is easy to assemble and some of it is difficult to assemble. Parts that are difficult to assemble could cause a rise of cost in terms of labor and time. The objectives of this project are to improve the design of Proton Wira driver's seat by using integrated Value Engineering (VE) and Design for Assembly (DFA) and to make the comparative analysis between current design and proposed design in terms of assembly effectiveness. The flow of this project is started from collecting Wira seat information and using VE approach to identify the function identification and implement function analysis. Then, the alternative design will be generated and the best alternative design will be evaluated using Pugh method. After that, the proposed design will be compared with current design of Wira seat using DFA approached. The result shows that the DFA Index for the proposed design of Wira driver's seat is higher than current design that is 4.7 compare to 4.4. Hence, it can be concluded that the integrated of VE and DFA method can improve the design of Wira driver's seat in terms of assembly effectiveness.

ABSTRAK

Kerusi pemandu bagi kereta Wira adalah suatu produk yang komplek yang komponennya membabitkan beratus komponen dan bahannya yang terdiri dari besi sehingga getah. Sesetengah dari komponennya adalah senang untuk dipasang dan sebahagiannya susah untuk dipasang. Komponen yang susah dipasang akan meningkatkan kos dari segi buruh dan masa. Objektif utama projek ini adalah untuk memperbaiki reka bentuk kerusi pemandu kereta Wira menggunakan gabungan Kejuruteraan Nilai (VE) dan rekabentuk untuk pemasangan (DFA) dan untuk membandingkan analisis antara reka bentuk yang sedia ada dengan reka bentuk yang telah dicadangkan dari segi pemasangan yang lebih baik. Perjalanan projek ini bermula dengan mengumpul informasi tentang kerusi kereta Wira dan menggunakan kaedah VE untuk mengetahui fungsi setiap komponen dan menjalankan fungsi analisis setiap komponen. Selepas itu, rekaan alternatif akan dibuat dan rekaan yang terbaik akan dinilai menggunakan kaedah Pugh. Reka bentuk yang dicadangkan akan dibandingkan dengan reka bentuk kerusi asal kereta Wira menggunakan kaedah DFA. Keputusan menunjukkan indek DFA untuk rekaan kerusi yang dicadangkan lebih tinggi daripada reka bentuk kerusi yang sedia ada iaitu 4.7 jika dibandingkan hanya 4.4. Oleh itu, kesimpulannya gabungan kaedah VE dan DFA boleh memperbaiki reka bentuk kerusi pemandu kereta Wira dari segi pemasangan yang lebih baik.

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DFA	-	Design for Assembly
VE	-	Value Engineering
DFM	-	Design for Manufacture
DFMA	-	Design for Manufacture and Assembly
T_{actual}	-	Total estimated assembly time
N_{min}	-	Theoretical minimum number of parts
FAST	-	Function Analysis System Technique
PVC	-	Polyvinyl chloride

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Automotive industry is one of the largest and competitiveness industries in the world. The major global company are headquartered in France, Germany, Italy, Japan, South Korea, and the United States. Every manufacturer has their own strategies to market their product. One of the strategies is sell a product in the low price to the customer.

In the automotive industry, the pressure to reduce prices is present at all levels, from the vehicle manufacturer (OEM) through to the lowest level of the supply base. Most first and second tier suppliers are faced with contractual performance or productivity clauses which require annual downward price adjustments of 3 to 5% on the products they provide to the OEM.

Faced with these pricing constraints and continuing cost pressures, the suppliers and OEM's alike have resorted to a multitude of formalized techniques designed to meet the challenge. These include VE and DFA. The Boothroyd Dewhurst DFA method is enhance the outcomes of Value Engineering (VE), resulting in significant savings in materials, design costs, tooling, and processing of parts and assemblies.

1.2 Project Objectives

Every project must have their own objectives to achieve their target. For this project, the objectives are:

1. To improve the design of Proton Wira driver's seat by using integrated VE and DFA.
2. To make the comparative analysis between current design and proposed design in terms of assembly effectiveness.

1.3 Project Scopes

One of the most important things in the project is the scopes. The scopes for this project are:

1. Do literatures review of the DFA and VE.
2. Gather information of current Wira driver's seat by;
   - I Modeling
   - II Analysis
   - III Dimensioning
   - IV Part Functions
3. Developed the framework and Gantt chart of this project.
4. Analysis using DFA.
5. Compare redesign with current Wira driver's seat.
6. Documentation

1.4 Project Background

Wira seat consist hundreds of part range from steel to a rubber. Some of the part is easy to assemble and some of it is difficult to assemble. Parts that are difficult to assemble could cause a rise of cost in terms of labor and time. Effective design for lowest cost and fewest components can only be accomplished by a product design and engineering staff that understands the manufacturing capabilities of the plants in which the assembly will be made.

The flow of this project is starting by sketching, and then draws the seat using the Solid Work software. After that, Value Engineering (VE) will be applying to get the product information, assembly function identification and implement function analysis. Then, the alternative will be generated and the best alternative will be evaluated. From the result of VE, it will be compared with Design for Assembly (DFA) result. Lastly, this project will be documented.

In this project, integration of DFA and VE will reduce or eliminate the parts count of the seat. DFA constitute the approach of simplification which results in cost reduction and productivity improvement while VE constitutes approach of cost reduction. This project is aim to maintain all essential functions of the seat while reducing the parts count and assembly time.

1.5 Problem Statements

Wira's driver seat is assembled by welding, riveting, screwing, snapping and swaging. Many of the parts were hidden from view until the assembly was actually cut apart revealing multiple layers of material like tubes inserted within tubes and multi piece plastic subassemblies.

Therefore, the improvement or changes have to make to the various components, parts eliminated through combination with others, and processing and assembly simplified. The most important was to maintain all essential functions of the seat while reducing the parts count and assembly time.

Significant numbers of parts were combined or eliminated by the parts count and assembly time. So, the numbers of parts were combined or eliminated by making minor changes to a relatively few number of related parts.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, all the important information related of this project is stated. The sources of this information are from journal, books and web site. Besides that, the literature review can give a brief explanation about the functions and principles of the DFA and VE. Some of the points in this chapter can give extra information which is useful while doing this project.

2.2 Designs for Assembly (DFA)

The two main factors affecting the assembly cost of a product are (1) the number of parts contained in the assembly, and (2) the ease with which the parts can be handled (transported, oriented, and prepositioned) and inserted (placed, fastened, etc). it is somewhat obvious that if one product has 50 component and if an alternative version of the same product has only 10 parts, then the one with the fewer number of parts will ordinarily cost less to assemble. Thus, the best method available for reducing assembly costs is to reduce the number of parts in the assembly. (Poli, 2001)

The Boothroyd-Dewhurst DFA methods seek to minimize cost of manual assembly within constraints imposed by other design requirement using a systematic, step-by-step implementation of DFA rules or guidelines. The process consists of an analysis phase and redesign phase. (Stoll, 1999)

DFA always coupled with Design for Manufacture (DFM) to form a Design for Manufacture and Assembly (DFMA). DFA has an important characteristic that it addresses the simplification of the product structure since the indicator of the product quality is the number of the parts in a product.

The application of DFA will simplify the assembly process of the product. This can be achieved through shorter assembly time, higher quality of the product, required less tools and fixture, higher potential to be assembled in the flexible and automated system etc. Furthermore, fewer parts are needed to be assembled that will result less parts to be designed, less material used and less inventory load. (Boothroyd *et al*, 2002)

2.2.1 Boothroyd – Dewhurst DFA Method

Design for Assembly Method (DFA) was developed by Boothroyd and Dewhurst. It is aimed at minimizing the cost of assembly within the design constraints imposed by other design requirements. The method considers both manual and automatic assembly.

The product is initially measured on its feasibility to minimize parts by elimination or combination with other parts in the assembly provided that the functional requirements are satisfied. After that, grasp, manipulate, and insert time of the part into the assembly are measured. Design evaluation is done by measuring the design efficiency using the formula below (Boothroyd *et al*, 1994):

$$Design\ efficiency = \frac{"Ideal"\ assembly\ time}{"Actual"\ assembly\ time} = \frac{3\ x\ \min\ parts}{Assembly\ Time} \tag{2.1}$$

The theoretical minimum number of parts is the sum of the number assigned to each separate part in the assembly. The 'ideal' assembly time is calculated assuming an assembly containing the theoretical minimum number of parts. The 'actual' assembly time is the sum of the penalties assessed for handling and insertion difficulties associated with each actual part in the assembly based on compilation of standard time study data as well as dedicated time study experiments.

After evaluation, the part assembled is redesigned for ease of assembly by first eliminating and combining parts using the method from the theoretical minimum number of parts determination (Boothroyd *et al*, 1994).

The basic design for manual assembly procedure is as follows (Stoll, 1999):

1. Obtain the best information about the product or assembly. Useful items include engineering drawings, exploded three-dimensional views, an existing version of the product, or a prototype.
2. Take the assembly apart (or imagine how this might be done). Assign an identification number to each item as it is removed. Initially, treat subassemblies as "parts" and then analyze them as assemblies later.
3. Reassemble the product starting with the part having the highest identification number. As each part is added to the assembly, analyze its ease of handling and insertion and use the three questions to decide if it is a candidate for elimination.
4. When the re-assembly is complete, determine the total estimated assembly time, T_{actual}, the theoretical minimum number of parts, N_{min}, and calculate the design efficiency.
5. Redesign the assembly using the insights gained from the analysis. Analyze the new design by repeating steps 1 through 4 and gage improvements by comparing design efficiencies. Iterate until satisfied.

According to Boothroyd in, among other places, Product Design for Assembly, a part is easy to handle if:

1. it is easy to grasp and manipulate with one hand without grasping tools
2. it is both end-to-end symmetric as well as rotationally symmetric
3. its size and thickness are such that grasping tools or optical magnification are not required.

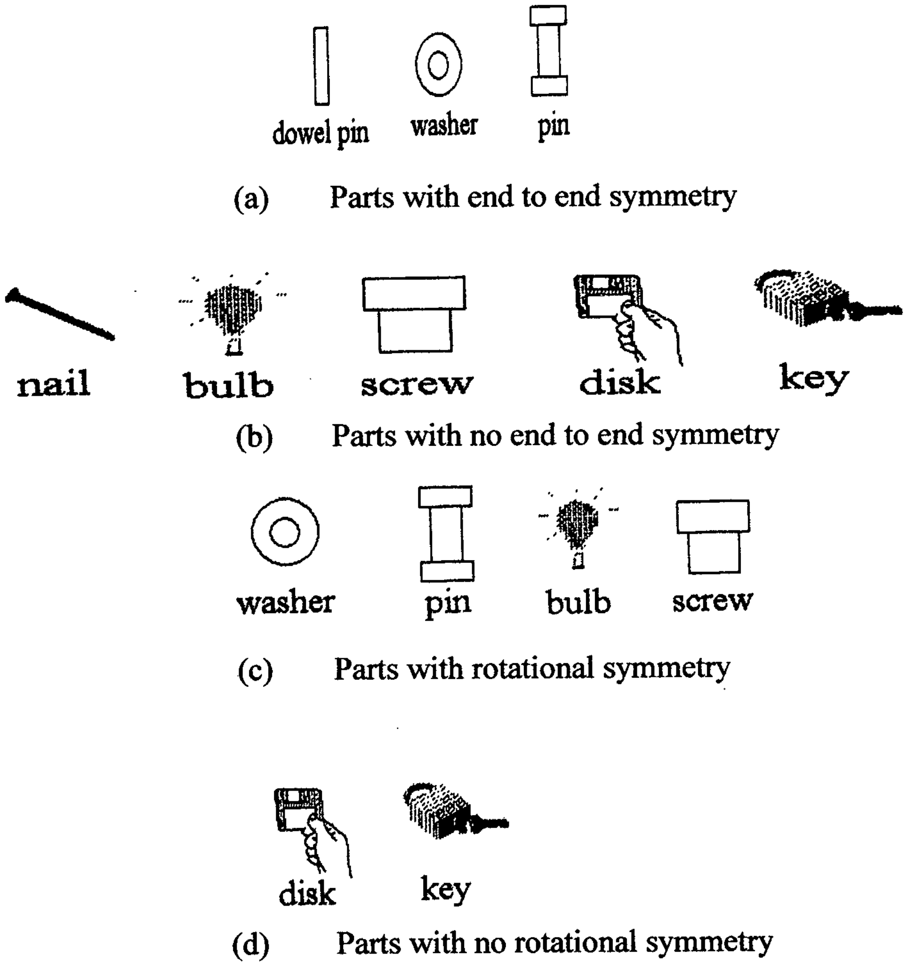

Figure 2.1: The example of end-to-end symmetric and rotational symmetric (Poli, 2001)

The methodology of tolerance design is based on the design-analyze-redesign strategy and consists of the following steps: (Boothroyd *et al*, 2002)

1. Understand: Analyze the existing product or proposed new design for tolerance stack-up.
    I. Identify undesirable interactions.
    II. Identify potential functional and manufacturing problems.
2. Create: Develop alternative redesign proposal that avoid undesirable tolerance stack-ups where possible and reduce information content of those that are unavoidable.
3. Refine: Evaluate the redesign proposals, and select, improve and optimize the alternative that best avoids undesirable interactions, has minimal information content, and also satisfies project criteria for:
    I. Product cost
    II. Product performance
    III. Development cost
    IV. Development time

Ease of assembly is evaluated by analyzing each part for extra information content required to perform the following assembly functions:

I. Handling: the process of grasping, transporting, and orienting components.
II. Insertion: the process of adding components to the work fixture or partially built-up assembly.
III. Securing: the process of securing components to the work fixture or partially built-up assembly. Securing may occur as part of the insertion process (e.g., installation of a threaded fastener) or it may be performed as a separate operation (e.g., heat stake or ultrasonic weld).
IV. Adjustment: the process of using judgment or other decision-making processes to establish the correct relationship between components.
V. Separate Operations: mechanical and non-mechanical fastening process and other assembly operations involving parts already in place.
VI. Checking: the process of determining that the assembly process has been performed correctly.

2.2.2 DFA Guidelines and Principles

The objective of DFA is to integrate the product design and process planning into one common activity. DFA embraces some underlying principles, which help maintain communication between all elements of the manufacturing system and permit flexibility to adopt and modify the design during each stage of the product realization (Boothroyd *et al*, 1994). The principles are (Ullman, 1997):

1. Simplify, integrate, and minimize total number of parts – Fewer parts mean less in everything that is needed to manufacture a product such as total assembly time, product cost, inventory control etc.
2. Standardize and use common parts and materials – standard components require little lead-time, makes the inventory management easy and reduces the tooling time.
3. Mistake-proof product design and assembly – Components should be designed to be assembled in one direction. Notches, asymmetrical holes, and stops can be used to mistake-proof the assembly process.
4. Design parts for handling and orienting – Parts should be designed to be self-oriented when fed into process will reduce the assembly times. Product designs must avoid parts that can become tangled, wedge or disoriented. The designed parts should incorporate symmetry, low centers of gravity, easily identified features, guide surface and point for easy handling.
5. Minimize flexible parts and interconnection – Avoid flexible and flimsy parts such as belts, gaskets, tubing, cables and wire harnesses are more susceptible damage and also to make material handling and assembly more difficult.
6. Design for efficient joining and fastening – Screws require more time to assemble. Therefore, they need to be standardizing to minimize variety and use fasteners such as self-threading screws and captured washers. Consider the use of snap-fit whenever possible.
7. Develop a modular design – Modular design is able to standardize diversity by using different combinations of standard components so that the final assembly

can be simplified due to less part is assembled and each module can be quickly fully checked prior to installation.

8. Design parts to be multi-functional – Combine function wherever possible. For example, design a part to act both as a spring and as a structure member, or to act both as an electrical conductor and as a structural member.
9. Design for multi-use – Design the parts for multi-use. For example, a spacer can also serve as an axle, lever, standoff, etc.

2.3 Value Engineering (VE)

Value analysis defines a "basic function" as anything that makes the product work or sell. A function that is defined as "basic" cannot change. Secondary functions, also called "supporting functions", described the manner in which the basic function(s) were implemented. Secondary functions could be modified or eliminated to reduce product cost. (Crow, 2002)

Value Analysis and Value Engineering look synonymous but the difference between them is (Stoll, 1999):

1. Value Analysis – A remedial process where the techniques are applied to an existing product with a view to improving its value.
2. Value Engineering – A technique applied when a new product is at the design stage, to ensure no bad value features is included.

Value Engineering provides a systematic approach for design improvement. Typically, a multi-discipline team analyzes the functions provided by the design and the cost of each function. Based on results of the analysis, creative ways are sought to eliminate waste and unneeded function and to achieve required functions at the lowest possible cost. In value engineering, value is defined as (Stoll, 1999):

$$Value = \frac{Function\ (Worth)}{Cost} \tag{2.2}$$

In a complicated product design or system, every component contributes both to the cost and the function of the entire system. The ratio of function to cost of each functions indicates the relative value of functions performed by the product. Obtaining the maximum functionality per unit cost is the basic objective of the value engineering approach. (Stoll, 1999)

The promotes good selection of techniques and good progression in achieving required lower costs to begin to think in terms of three basic steps:

1. Make clear precisely the function
2. Establish the appropriate cost for each function by comparison
3. Cause the required knowledge, creativity, and initiative to be used to accomplish each function for that cost.

Different types of value are recognized by the approach:

1. Use value relates to the attributes of a product which enable it to perform its function.
2. Cost value is the total cost of producing the product.
3. Esteem value is the additional premium price which a product can attract because of its intrinsic attractiveness to purchasers.
4. Exchange value is the sum of the attributes which enable the product to be exchanged or sold.

Most of manufacturers often apply Value Engineering (VE) as one of the effective methods to design *high-valued product*. (Sawaguchi, 2000)

High-valued product – the products, which keep good balance between cost and quality of product from the viewpoint of VE

2.3.1 Value Engineering Methodology

There are six phases in value engineering methodology (Kurt and Martin, 1997); namely:

1. Information Phase – The purpose is to identify the concept and objectives of the designed product before it goes to the next steps. The information is completely gathered, documented and the understanding of it is generated for value study. All information type within the scope of the design activity must be completely studied and reviewed before it enters into the next phase.
2. Function Analysis Phase – The purpose of this phase is to clarify the necessary functions and add missing functions to improve the product value by building a function model such as Function Analysis System Technique (FAST) diagram. There are two kinds of FAST diagrams that are widely used namely 'Technical FAST' and 'Customer FAST' :

   I. Technical FAST – The Technical FAST is a diagram that represents a specific situation such as an assembly process, product, a portion of a construction design and etc. The aim of Technical FAST is to fulfill the specific customer needs or specifications. It tends to use terms or function oriented to the technical activities. Technical FAST has one basic function that then expanded into several secondary functions that form major critical path. The approach of the Technical FAST is based on three fundamental questions that are 'Why', 'How' and 'When'. These questions determine the directions of the Technical FAST. The answers to 'Why' will guide the functions to the basic and highest order function while the answers to 'How' will lead to the lowest order function. The answer of 'When' will indicate the activity of the functions in the major path.