DESIGN FOR SERVICEABILITY EVALUATION OF CAR DOOR

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A report submitted in partial fulfillment of
the requirements for the award of the degree of
Bachelor of Mechanical Engineering
with Manufacturing Engineering

Faculty of Mechanical Engineering
University Malaysia Pahang

PERPUSTAKAAN
UNIVERSITI MALAYSIA PAHANG
No. Perolehan
030500
Tarikh
30 MAY 2008
No. Panggilan
TL
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2007
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Thesis

NOVEMBER 2007

ABSTRACT

Serviceability is the capability to perform effective problem determination, diagnosis, and repair on a system or a product. The main problem of Kancil's car door is the service cost and time are less consideration due to its uneasy disassemble and complexity procedures to service a car door. Design for serviceability evaluation of car door is aim to search for shorter car door service cycles and lower cost has led to the emergence of DFA and DFS. Through this project, DFS is a tool that will allow estimating the times and the cost for the service tasks which carrying out on the products. DFA will be analysis the optimization design to ease for assembly. DFA and DFS is the practice whereby the design needs to simultaneously consider various downstream activities throughout the entire product service life cycle, in addition to meeting the products' functions. Furthermore, Pugh method is concerned with finding the optimal and evaluate redesign concepts and thus to meet the serviceability requirements. A car door redesign has been presented to demonstrate the feasibility of the proposed scheme based on the easiest defect components on car door. The result shows that the service time of the current design, for instance door latch is 609.90s and after modification the service time reduces to 353.70s. While the service cost calculated with hourly labour rate before the modification is Rm20.85 and after modification is Rm20.49. Thus it can conclude that the proposed method can be applied on evaluating the product design at the early phase of the design.

ABSTRAK

Kebolehan memperbaiki adalah keupayaan untuk melaksanakan penentuan masalah, diagnosis, dan membaiki dalam sistem atau produk dengan berkesan. Masalah utama pintu kereta Kancil adalah kos dan masa untuk membaiki pintu kereta Kancil adalah kurang ditimbangkan kerana kesukaran untuk nyahhimpun dan prosedur-prosedur kerumitan untuk membaiki pintu kereta. Matlamat menilaikan DFS pada pintu kereta adalah untuk mencarikan masa untuk memperbaiki pintu kereta lebih pendek dan kos rendah dengan memperguanakan kaedah DFA dan DFS. Melalui projek ini, DFS adalah satu alat yang akan membenarkan menganggarkan masa dan kos untuk tugas memperbaiki produk. DFA akan menganalisis reka bentuk yang optimum untuk kerja pemasangan balik komponen-komponen. DFA dan DFS ialah amalan di mana reka bentuk perlu untuk serentak menimbangkan pelbagai kegiatan pembaiki sepanjang kitaran hayat dengan memastikan fungsi produk tidak terjejas. Tambahan pula, kaedah Pugh adalah untuk mendapatkan optimum rekabentuk dan menilai konsep-konsep rekabentuk semula dengan memenuhi syarat-syarat kebolehan pembaiki. Satu rekabentuk baru pintu kereta berdasarkan komponen-komponen paling senang rosak di pintu kereta telah disampaikan untuk menunjukkan kemungkinan memenuhi skop penyelidikan. Hasil untuk masa memperbaiki pintu terkini, misalnya selak pintu adalah 609.90s dan selepas pengubahsuaian ia menurunkan kepada 353.70s. Manakala kos perkhidmatannya mengira dengan menurut jam kadar buruh adalah Rm20.85 untuk sebelum pengubahsuaian dan selepas pengubahsuaian adalah Rm20.49. Kesimpulannya, kaedah yang dicadangkan dapat digunakan di atas menilai rekabentuk produk pada fasa awal reka bentuk.

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LIST OF SYMBOLS/ABBREVIATION

DFA	-	Design for Assembly
DFS	-	Design for Service
DFD	-	Design for Disassembly
+	-	Plus Score
-	-	Minus Score
Ø	-	Diameter

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter gives a short description of the project background including several approaches. It then introduces objectives, scopes, problem statement of this project on design for serviceability evaluation for car door.

1.2 Project Background

Most of the product in nowadays was focusing on functional of the product and cost targets but neglect of long-term, life-cycle costs. Studies show that conceptual design accounts for only 4% of product cost and results in 70% of the total life-cycle costs. Other studies suggest that an additional 5% invested in improving part design can lower lifetime maintenance costs by 25%. (Barkai, 2005). A product's design and serviceability qualities should be considered and been made early in product development that will strongly influence life-cycle costs.

Therefore in this project present the car door is approach to DFS analysis that may be applied in the conceptual design stage. Design for service (DFS) is a method of inferring service operations of a mechanical system based on its candidate design. DFS has the objective of aiding the designer in making choices promoting the development of products prearranged for service intention. (Makino et al, 1993). Besides that, another famous method Design for Assembly (DFA) analysis is also applied to assist with the designs to improve assembly ease and reduce assembly time. (Boothroyd and Dewhurst, 2002). That wills enables to minimize the number of components of a product and select the most economic technique for that specific product. Further more evaluation of the multiple constraints from manufacturing, assembly, services, etc. at the design stage.

A major improvement in product serviceability would be beneficial to both the manufacturer and their customer. For instance, the car door's panel undergoes side impact accident and deformed, that will cost to replace it and can not be change for the certain part. There even a minor body damages that would cost prohibitively expensive for repairs and maintenances, even though there is an anticipated part of normal product use. This is because that the car door labor cost of service consider the subassemblies can be exchange as quickly and easily as possible which is depends on the ease of assembly and disassembly of car door's components.

The purpose of this project is to show the way of improve the car door using the DFS, DFA approaches. Through this project, DFS is a tool that will allow estimating the times and the cost for the service tasks which carrying out on the products. DFA will be analysis the optimization design to ease for assembly. The balance among the cost service and reduction of parts design should be concentrated on car door redesign. In fact, car door which continues service involve replacement of various item should have DFA,DFS applied during the first stage design , that would easier to service help boost profitability and lower both maintenance and total cost of ownerships .

1.3 Project objective

The objectives of the project are to:

1. To evaluate Kancil 's front door with application of DFS, DFA
2. To identify and optimum serviceability of Kancil 's front door
3. To redesign a serviceability car door approach the DFS,DFA analysis

1.4 Scope of Project

In order to achieve the objectives of this project, the scopes are created as below:

1. Literature review and information gathering of DFS,DFA and car door (Pro Dua Kancil) components function.
2. Modeling current Kancil car door with solidworks software.
3. Analysis and Evaluate current car door with the DFA software.
4. Analysis and Evaluate current car door with the DFS software.
5. Design the new improvement of the Kancil car door.
6. Evaluate and analysis the new improvement of the Kancil car door.
7. Comparative analysis with the current and proposed design.

1.5 Problem Statement

The problems have been identifying of the current Kancil's front door.

1. Serviceability, assembly ability and disassembly ability are not taken into account

during the car door design.

2. Cost and time are less considered during the service and maintenance.
3. The complex and uneasy to unmount components are increase the time and cost of service.
4. A certain minor part damage will cause changing of an new car door.

1.6 Summary

Chapter 1 has been discussed generally about project, problems statement, objective and the scope of the project in order to achieve the objective as mention. This chapter is as a fundamental for this project and as a guidelines to complete the project research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 2 discusses Design for Assembly, Design for Service and Design for Disassembly in general, with a specific focus on product design to ease serviceability. The work is based on three fundamental areas of research – principles, guidelines and advantages. Further more, Pugh Method used to choose the best alternatives of concept design also been study. Chapter 2 presents research initiatives in each of the fields that have been integrated and form the basis of this work.

2.2 Boothroyd – Dewhurst DFA Method

Design for assembly (DFA) means to analyze the product designs to improve assembly ease and reduce assembly time (Boothroyd et al, 2002; Stone, 2003). DFA considered all the design stage especially at the early stage of the design process. Basically, the assembly systems consists of three types which there are manual, special-purpose machine, and programmable machine assembly. It is obviously apply that for manual and automated assembly. Hence, DFA is one of the effective methods to reduce assembly costs were those applied during design; manufacturing and production changes have less impact on product cost. DFA can lead to improvements in serviceability, reliability, and quality of the end product (Kim, 1997). DFA is used for activities (Boothroyd et al, 2002):

1. As basis for concurrent engineering studies to provide studies to provide guidance to design team in simplifying the product structure, to reduce manufacturing and assembly cost and quantify the improvements.
2. As benchmarking tool to study competitors' products and quantify manufacturing and assembly difficulties.

2.3 The Advantages and Benefits of DFA

The advantages and benefits of DFA are (Boothroyd et al, 2002; Chiabert at el, 1998):

1 An important manufacturing tool that can significantly guide the engineers to reduce the costs attributable to assembly.

2 Able to produce product with higher quality, increased reliability, and shorter manufacturing time.

3 Encourage dialogue and concurrent engineering between designers and manufacturing engineering, clients and any others who play in determining final product cost during the product design development.

4 The important of the geometric dimensioning and tolerancing approach can be ensuring at the design phase while DFA is applied. The component parts will assemble into the finished product and function as intended. Assembly stacks stack's calculation enables the engineers to analyze the dimensional relationships within an assembly, and create effectiveness designs and open up tolerances to the outer limits permitted by the product function.

5 Assures that considerations of product complexity and assembly take place at the earliest design stage. This will eliminates the danger of focusing exclusively

during early design on product function with inadequate for product cost and competitiveness. Hence, piece parts can be reduced.

6 DFA is establishing a database that consists of assembly time and cost factors for various situation and productions condition.

Hence, DFA leads to product that to easier for service because that product is easy to assemble is usually easier to disassemble and reassemble. In fact, the product that needs continual service therefore that should be strictly during the design stage with DFS approach.

2.4 DFA Principles

DFA analysis focuses on redesigning an existing product through a two principles procedure applied to each part in the assembly. The first step evaluates each part to determine if it is necessary or a candidate for elimination or combination with other parts in the assembly. Hence, reduce the number of assembly operations by reducing the number of parts The second step estimates the time taken to grasp, manipulate and insert the part during assembly. This would make the assembly operation easier to perform, handled such as transported, oriented and positioned and inserted such as places, fastened, etc. Performances of the two steps allow a design efficiency rating to be calculated and used to compare different designs.

The manual assembly design efficiency is obtained by using the formula:

$$EM = 3 \times (NM/TM) \tag{2.1}$$

Where EM is the manual design efficiency, NM is the theoretical minimum number of parts, and TM is the total manual assembly time. The design efficiency was very essential ingredient of the DFA method which shows the DFA index or assembly efficiency of proposed design. The principles of DFA would be affecting the DFA index.

2.4.1 Reduce the Part Count

Part reduction can be accomplished either by the outright elimination of individual component parts or combining several components parts into a single. DFA methodology that provides three criteria against which part must be examined during assembly to reduce and minimum the number of parts for the assembly as shown below. (Boothroyd and Dewhurst, 2002)

1. During operation of the product, does the part move relative to all other parts already assembled?
2. Must the part be of a different material than, or be isolated from all other parts already assembled.
3. Must the part be separate from all other parts already assembled because otherwise necessary assembly or disassembly of other parts would be impossible?

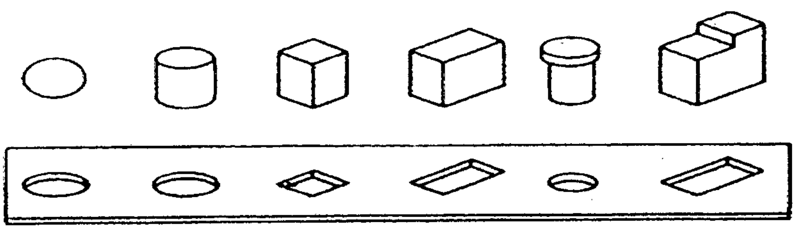
2.4.2 Reduce Handling and insertion time

Assembly operations always involve at least two component parts whether the parts to be inserted and the part or assembly into which the part is inserted. According (Boothroyd and Dewhurst, 2002), a part is easy to handle manually 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 is not required.

2.4.2.1 Symmetric and Orientation

The orientation which classified with respect to rotational symmetry of a part about the axis perpendicular to the axis of insertion denoted by Alpha symmetry, α and about the axis of insertion denoted by Beta symmetry, β (Boothroyd and Dewhurst, 2002). In DFA methodology, α and β symmetry properties defined are required to estimate the orientation and insertion part efficiency in the assembled product and to correctly orient the parts for automated assembly operations. Partial symmetry detection processes can be useful for roughly orienting a part but are not convenient to automated insertion operations since the part must be well oriented.



α	0	180	180	90	360	360
β	0	0	90	180	0	360

Figure 2.1: Alpha and Beta rotational symmetries for various parts (Boothroyd and Dewhurst, 2002)

Perfectly symmetrical parts need no rotation to orient them, completely asymmetrical parts require at most 360° rotation followed by a second 360° to put them in the same position every time. The alpha and beta rotational symmetries been shown as Figure 2.1.

2.4.2.2 Size and Thickness

The thickness and size of part is defined in a convenient way in work factor system. The thickness of cylindrical part is defined as radius whereas for noncylidrical parts the thickness is defined as maximum height of part with its smallest part dimension extending from a flat surface. When the diameter of a part is greater than or equals to length the part is treat as noncylindrical as illustrated in Figure 2.2.

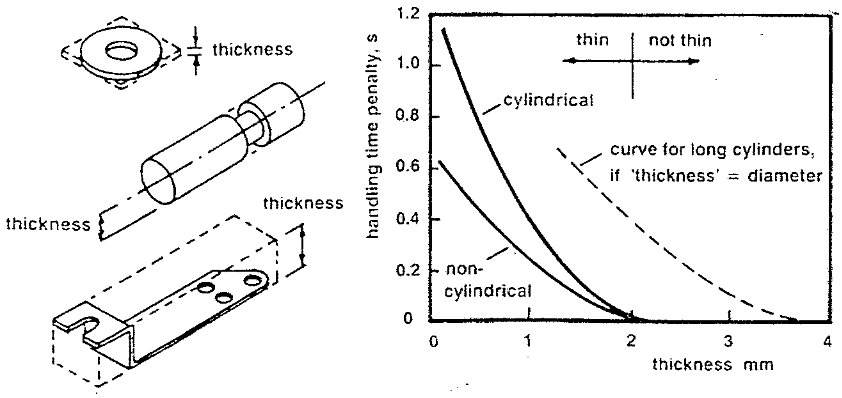


Figure 2.2: Effect of part thickness on handling time (Boothdroyd and Dewhurst, 2002)

The effect of part size on handling time is shown in Figure.2.3. Large parts involve little or no variation in handling time with changes in size; handling time for medium and small parts displays progressively greater sensitive with respect to part size. Tweezers can be assumed to be necessary when size is less than 2mm.

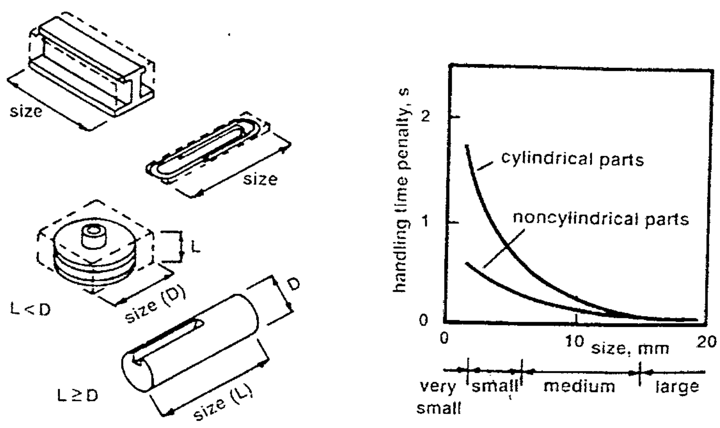


Figure 2.3: Effect of part size on handling time (Boothdroyd and Dewhurst ,2002)

2.4.2.3 Weight.

Work has been carried on effects of weight on grasping controlling and moving of parts. The effect of increasing weigh on grasping and controlling is found to be additive time penalty and effect on moving is found to be proportional increase of the basic time.

2.5 DFA Guidelines

The general design Guidelines develop to consolidate manufacturing knowledge and present them to the designer in the form of simple rules to follow when creating a design. The process of manual assembly can divide into handling (acquiring, orienting and moving the parts) and insertion and fastening (mating a part to another part or group of parts).

The guidelines below are often regarded as the most important, although other criteria exist for the design of parts for ease of assembly. One aspect of DFA is minimizing the number of components in the product. But those parts cannot be made without considering the design for manufacturing processes like sheet metal, injection molding, robot assembly and else. Guidelines are simply as rules provide the engineers to develop a design that easily assembled and to predict to assembly time.

2.5.1 DFA Guidelines for Part Handling

In general, designers and engineer should attempt to following guidelines for ease handling:

1. Parts are end to end and rotational symmetric as much as possible-or else obviously a symmetric.
2. Design parts that where the part cannot be made symmetric, are obviously asymmetric.
3. Provide features that will prevent jamming of parts that tend to nest or stack when stores in bulk. Nesting is one part gets stuck inside another.
4. Avoid features that will allow tangling of parts when stored in bulk. Tangling is the parts get looped together, making them difficult to separate.
5. Parts are designed so that they are easy to grasp and manipulate with one hand using no grasping tools.

2.5.2 DFA Guidelines for insertion and Fastening

For ease of insertion, a designer and engineer should attempt to:

1. Provide chamfer to guide insertion of two mating parts. General clearance should