IMPLEMENTATION OF DESIGN FOR MANUFACTURING AND ASSEMBLY (DFMA) METHODOLOGY TO ANALYZE ANTITHEFT DEVICE SYSTEM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) with Honours.

by

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EN TAJUL ARIFFIN BIN ABDULLAH
ABSTRACT

Profit is a very important element in running a company. It can only be obtained when the expanses are managed to be coped up by the total gaining. What is more important and more interested by company is not to discuss on how to obtain the profit but is on how to multiply the profit by reducing the cost of the production. As more companies struggle with competitive markets to produce low cost products, the attention of many companies has naturally turned to cost reduction. One virtually untapped source of reduced costs was assembly and the most effective method of reducing assembly cost is through good product design. With references to this one of the most powerful tool for reduce manufacturing costs has been introduced, which is the Design for Manufacturing and Assembly (DFMA). This study focuses on DFMA method to analysis the antitheft device which is steering wheel lock which emphasis on cost reduction and parts count reduction. The purpose of this study is to improve the current design of steering wheel lock. Implementation of DFMA software is also represented in this study.
ABSTRAK

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<td>DFC</td>
<td>Design for Cleaning</td>
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<td>DFMA</td>
<td>Design for Manufacturing and Assembly</td>
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<td>ECN</td>
<td>Engineering Change Notice</td>
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<td>DFM</td>
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<td>Design for Assembly</td>
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<td>Cf</td>
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<td>Ci</td>
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<td>Minimum number of parts</td>
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<td>$F_m$</td>
<td>Maximum feed rate</td>
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<td>$F_r$</td>
<td>Assembly rate</td>
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CHAPTER 1

INTRODUCTION

The first chapter of this report presents the general idea of the project. It is include five sections in this chapter which is background, problem statement, objectives, research methodology, and scope of the project. The background section presents an introduction about manufacturing design. Certain problems of product design and the problems that attempt to address in this project will state in problem statement section. The target of this project is present in objective section. The last part in this chapter is scope of the project which elaboration from the objectives section.

1.1 BACKGROUND

Nowadays, people are more demanding on something that simple and less costly in their daily requirement. In order to meet customer needs, more companies struggling with competitive markets to produce low cost products with high quality and faster to market. Many researches have been carried out that focusing on increasing the efficiency and simplify the operation especially both assembly and manufacturing process and cost.

The design specifications are found as the result of systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints (Clive and Patrick, 2000).
There are some techniques and tools that can be used to sustain the creativity and to help designers or manufacturers to think logically so that the design specifications are organized and smart development. Engineering design can be rewritten as organized and smart development and estimation of detail description for new objects that have specific shape and geometry and brings some special purpose that reaches the goal without going against any particular restrictions.

Improvement in many company’s operation is made by using a specific method. Usually, in industry the improvement they made are based on reduction cost. The reduction of cost could be made in early stage of design cycle. This is mean that cost estimation is an essential aspect in design stage. Moreover, this is accepted that over 70% of final product costs are determined during design stage which is shown in Figure 1.1 (Boothroyd, 2002).

**Figure 1.1:** Influence of product design in the product development (Boothroyd *et al.*, 2002)
In the past, design and manufacturing exist independently which is sequential approach to design the product. In sequential approach, a number of distinct phases are divided. A product flows from one department in an organization to another and possible to repeat to ensure that the product will still function adequately (Kalpakjian and Schmid, 2006).

The design process begins with generation of a product concept (Kalpakjian and Schmid, 2006). Innovative and creativity is greatly needed at this stage to lead to major savings in material and production costs. Understanding of the functions and the performance expected of the product is required in the design stage.

There are various design guidelines are available which has known as Design for X. Each design guideline addresses a particular issue that is caused by, or affects the characteristics of a product. The design guidelines itself propose usually an approach and corresponding methods that may help to generate and apply technical knowledge in order to control, improve, or even to invent particular characteristics of a product. X represents anything such as Design for Environment (DFE), Design for Sustainability (DFS), Design for Cleaning (DFC) and many more. Among of them is Design for Manufacturing and Assembly (DFMA).

Design for Manufacturing and Assembly (DFMA) is a method used by designer in a way to reduce part count, reduce assembly time or even during simplify the subassemblies. Two different stages of DFMA implementation process are when existing design need improvement in order to achieve design optimization and in an early stage of new design requirement is established. Besides, in order to implement DFMA, the designer must have a good knowledge of manufacturing process so that no additional unnecessary cost during the design development. Design for Manufacture and Assembly (DFMA) is the process by which designs and assembly sequences and procedures are altered to increase the ease and effectiveness of product assembly and manufacture. However, applying this approach to automation requires a paradigm shift in the approach to manufacturing if it is to be effective.
1.2 PROBLEM STATEMENT

The automobile has always been considered one of the most convenient forms of transportation available to human, whether from home to work, or for shopping. It is one of the most essential vehicles in our daily life. But recently, many vehicle reported has been stolen easily. Therefore, this situation causes the development of antitheft device. A lots of antitheft device has been manufactured such as gear shift lock, break lock, door lock and among these are steering wheel lock which is more popular in the market. However, the design of existing steering wheel lock in the market is quite complicated and causes the manufacturing process and components in the design of a product cannot maximize to be used. Thus, finding better method to manufacture steering wheel lock would be a step towards to design better steering wheel lock.

In order to design a better steering lock, DFMA should be applied in the design of steering lock to obtain the maximum benefit from DFMA. Many examples proved that DFMA analysis is the key to very significant reductions in overall manufacturing cost. Thus, this project will use DFMA method to investigate and redesign the current product which is steering wheel lock.

1.3 OBJECTIVE

The objectives of this project are:

a) To analysis of current product of antitheft device system which is steering lock based on DFMA analysis.

b) To integrate DFMA tools into product design and development process.

c) To make an improvements in order that product ease to manufacture and assemble.
1.4 SCOPE

The product design and process development is based on the Design for Manufacturing and Assembly (DFMA) guidelines, methods and tools through obtained through literature studies. DFMA has been used at several of industries and fields including automotive motor, electronic, internet and others. For that, this project will mainly cover the design for manufacture and assembly approach of antitheft device system which is steering wheel lock. The product needs to disassemble to determine the structures so that it will be easy to study all of each part exist. The detailed design will be produced by using CAD software SolidWorks.
CHAPTER 2

LITERATURE REVIEW

In this chapter, literature review on Design for Manufacturing and Assembly (DFMA) method are explained. There are certain important DFMA tools that have been applied such as Design for Assembly (DFA) and Design for Manufacture (DFM). This chapter described about the definition of Design for Manufacturing and Assembly (DFMA), Boothroyd Dewhurst DFA method, the Lucas DFA method, the application engineering software called DFMA Software and current product which are car padlock systems.

2.1 Previous Design Method

During new product development, combination team of engineers and management (mechanical engineer, electrical engineer, production engineer, sale people and management) to generate the product, has proven to lower the product cost, improve product quality and decrease the development time. In fact, traditionally, the design engineer and manufacturing engineer work individually that is the design engineers have to concept of “we design it, you build it” (Boothroyd et al., 2002).

The designers design the product and construct the prototype for testing. Then, the manufacturing team would construct the manufacturing process for the product, including tool and safety review. After that, the products are manufactured, quality inspected, and go to packaging. Lastly, the products are brought to the marketplaces.
However, once there is a design change made by other department, the design analysis stage has to be repeated leading to product development delay because waiting for the engineering change notice (ECN) to be approved by designer (Kalpakjian and Schimid, 2006).

By using this method, resources, money and more importantly, time is wasted. Moreover, this conventional product development faces major difficulties that are design paradox as shown in Figure 2.1. Design paradox can be determined as the correlation between the designer knowledge about the product and the number of actions to be made during the product development cycle (Bramley et al., 2005).

![Figure 2.1: Design paradox (Bramley et al., 2005)]
2.2 Design for Manufacturing and Assembly (DFMA)

Design for Manufacturing and Assembly (DFMA) is a design philosophy used by designers when a reduction in part counts, a reduction in assembly time, or a simplification of subassemblies is desired. It can be used in any environment regardless of how complex the part is or how technologically advanced this environment may be. DFMA encourages concurrent engineering during product design so that the product qualities reside with both designers and the other members of the developing team (D-ESPAT, 2007).

The term “DFMA” comes with the combination of DFM (Design for Manufacturing) and DFA (Design for Assembly). DFA means the design of the product for ease of assembly while DFM gives mean the designs for ease manufacture of the collection of parts that will form the product after assembly process (Boothroyd et al., 2002).

The objective using of DFMA is to minimize the number of parts count in an assembly or product and to maximize the use of manufacturing process. It is described that DFMA is an organized procedure for analyzing proposed designs from the perspective of assembly process (Edwards, 2002).

The basic concept of it is that the design engineers apply the DFMA paradigm or software to analyze the manufacturing and assembly problems at the early design stage. By this means, all of considerations about the factors that affect the final outputs occur as early as possible in the design cycle. The extra time spent in the early design stage is much less the time that will be spent in the repeatedly redesign. Meanwhile, the cost will be reduced (Xiaofan Xie, 2004).

DFMA also has been described as a methodology for evaluating part designs and the overall design of an assembly and its manufacture. It is a quantifiable method to identify unnecessary parts, and then simplify the product concept trough reducing part counts (Emerald Group Publishing Limited, 2005).
2.2.1 History of Design for Manufacturing and Assembly (DFMA)

According to Geoffrey Boothroyd, Professor of Industrial and Manufacturing at the University of Rhode Island, the practices now known as Design for Assembly (DFA), and Design for Manufacture (DFM) had started in the late 1970’s at the University of Massachusetts USA. With this issue, industry was most interested in Design for Assembly. When developing a product, the maximum potential cannot be achieved without considering all phases of the design and manufacturing cycle (Boothroyd et al., 2002). DFMA meets this demand by addressing key assembly factors before the product goes on the prototype or production stage. These key factors are the product appearance, type, the number of parts required in the product, and the required assembly motions and process (D-ESPAT, 2007).

Starting in 1977, Geoffrey Boothroyd, supported by an NSF grant at the University of Massachusetts USA, developed the Design for Assembly method (DFA), which could be used to estimate the time for manual assembly of a product and the cost of assembling the product on an automatic assembly machine. Recognizing that the most important factor in reducing assembly costs was the minimization of the number of separate parts in a product, he introduced three simple criteria which could be used to determine theoretically whether any of the parts in the product could be eliminated or combined with other parts. These criteria, together with tables relating assembly time to various design factors influencing part grasping, orientation and insertion, could be used to estimate total assembly time and to rate the quality of a product design from an assembly viewpoint. For automatic assembly, tables of factors could be used to estimate the cost of automatic feeding and orienting and automatic insertion of the parts on an assembly machine (Boothroyd et al., 2002).
Besides that, other DFMA method called Hitachi method is developed in 1960 by Myakawa and Ohasi in Japan. It was called the Assembly Evaluation Method (AEM). This method is based on the principle of "one motion for one part." For more complicated motions, a point-loss standard is used and the ease of assembly of the whole product is evaluated by subtracting points lost. The method was originally developed in order to rate assemblies for ease of automatic assembly (Parsaei and William, 1993).

In the 1980s and 90's variations of the AEM and DFA methods have been proposed, namely:

- The GE Hitachi method which is based on the AEM and DFA;
- The Lucas method,
- The Westinghouse method and several others which were based on the original DFA method. (Vincent and Salustri, 2005)
2.3 DFMA Approaches

During development stages of a new product, cost deserves careful consideration. A good strategy to support systems for product design must be provided so that the product development time can be prolonged and product can be improved without increasing cost. There are some approaches that offer the ability to use during the product development cycle to analyze the cost effect and manufacturing process of design, which are:

(i) Lucas method
(ii) Hitachi AEM method
(iii) Boothroyd-Dewhurst method

2.3.1 Lucas Method

The development of the Lucas DFA method is the result of the cooperation of Lucas Organization and the University of Hull in U.K. in the early 1980 (Vincent and Salustri, 2005). Now, the logic of Lucas DFA has been integrated in the engineering analysis software “TeamSet” which is the product of Computer Science Corporation (CSC). Lucas DFA separates the product design process into three stages: FcA (Function Analysis), HA (Handling Analysis) and FtA (Fitting Analysis) as shown in the Figure 2.2. This is a kind of process to change the engineering specifications into the real design and the meanwhile, all the requirements should be satisfied (Vincent and Salustri, 2005).