UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Blender Design Improvement through Lucas-Hull DFA Analysis

Thesis is submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Design)

By

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Faculty of Manufacturing Engineering

May 2007

DECLARATION

I hereby, declare this thesis entitled "Blender Design Improvement Through Lucas-Hull DFA Analysis" is the results of my own research except as cited in the reference.

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ABSTRACT

This paperwork contains the report of design improvement of a blender using Lucas-Hull DFA (Design for Assembly) approach. The aim of this report is to provide optimized solution that better than the existing blender in market based on DFA guidelines after the design efficiency of current blender designs were determined through Lucas-Hull DFA. The current handling and assembly ratio of (Blender B) which requires improvement will be improved to the range of 2.5 to 9.0. Firstly the questionnaires regarding on the current blender design were distributed to the end users in order to identify the problem faced by them. The blender specification will be then determined through obtained response. The two existing blender designs; Hanabishi HA-3018 and Philips Twist 1701 were selected and analyzed using Lucas- Hull DFA approach. The software for Lucas-Hull DFA approach, TeamSET will be used in aiding the analysis of the existing blender designs. The two blenders were compared according to the analysis result and it is found that Philips Twist 1701 model is overall better than the other one and marked as (Blender A). The (Blender A) was made as reference of improvement for (Blender B) which is Hanabishi HA-3018 model. According to Lucas-Hull DFA analysis on two blenders, it is found that the part count could contribute to low design efficiency, high handling ratio and high assembly ratio. Therefore reducing part count is required in order to improve the design efficiency, handling ratio and assembly ratio of the current blender design. The illustration of design improvement is generated by using CATIA V5R16 software. From implementing this approach, it shortens assembly time of the blender parts and minimizes production cost in overall.

DEDICATION

For My beloved family especially for my Mum and Dad and for those who supported me in my studies.

ACKNOWLEDGEMENT

I would like to extend special appreciation to Ms Suriati Bt Akmal, my supervisor who gave her constant guidance over months dedicatedly, my beloved parents and relatives for their encouragement and all my fellow friends for lending their hands throughout this project.

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ABBREVIATIONS AND SYMBOLS

UTeM	-	Universiti Teknikal Malaysia Melaka
DFA	-	Design for Assembly
Qty	-	Quantity
FA	-	Functional Analysis
A parts	-	Parts those are pivotal to product performance in FA
B parts	-	Parts those are less pivotal to product performance in FA
Hand	-	Handling scores on parts
○	-	Work holding process
□	-	Insertion process
△	-	Secondary process
	-	Can assemble wrong way round
	-	Remove tool / Disassembly
	-	Insert tool/ Reassembly
■	-	Assembly and handling scores over specified limit (1.5).

CHAPTER 1

INTRODUCTION

1.1 Introduction

One of the approach practiced in the industries nowadays in order to survive in global rapid changes of market and customer needs they implement Design for Assembly (DFA) approach. That implementation is used for minimizing production cost and assembly cost but maximizing the profit. In electrical appliances industries for example, they periodically come out with new models whether once in three months or once in four months within a year. Besides that, the competitive nature of the international market place has led to short product lifecycles and reduced price margins.

Therefore, one of the DFA approaches, Lucas-Hull DFA is implemented in order to improve the product development process and reduce manufacturing cost. It is because a lot of cost involved in manufacturing and assembly of a product. A significant part of this cost can be attributed to the labour-intensive activities associated with assembly. Therefore that approach is used by the design team in simplifying the product structure, reduce assembly cost and time and to quantify improvements. By implementing the Lucas-Hull DFA approach as mentioned the electrical appliances industries able to survive until today. This report is more focus to one type of electrical appliances which is a blender.

TeamSET software that contains Lucas-Hull DFA method concept is used as tool for analysis for two existing blender design which is Hanabishi HA-3018 and Philips Twist 1701. The Lucas-Hull DFA method was developed in United Kingdom in early 1980's. This method is based on point scale which gives a relative measure of assembly difficulties. The analyses involved in the mentioned method are functional, feeding, fitting and manufacturing analysis.

1.2 Problem Statement

Blenders are not something new because it started to be used from decades ago. Until today, the problems on the existing designs of blender still have been found which involves the product's reliability. Modularity characteristic on the existing blender designs can be identified by comparing the two models of blenders produced by same manufacturers. The DFA approach for this product has been implemented since from decades ago which enables the workers to end users able to assemble and disassemble parts easily.

With DFA approach the manufacturers able to plummet the manufacturing and assembly cost thus enables them to get more profit. Design improvement on the blender design will be made base on the problems identified considering on Lucas- Hull DFA approach in order to solve the problems faced by end users especially.

1.3 Objective

The objective in this research is:

- To determine the design efficiency of current blender designs through Lucas-Hull DFA.
- To provide optimized solution that better than the existing blender in market based on DFA guidelines.
- To improve current handling and assembly ratio of (Blender B) to the range of 2.5 *to 9.0*

1.4 Scope of Study

The scopes of study for this project are as follows:

- Gather literature reviews on Design for Assembly (DFA) and Lucas Hull DFA approach.
- The distributed questionnaires are more focusing on end users. Their comments or complains on the existing blender design are studied.
- Selecting two blenders in current market and the type of blender that is used for study is the conventional type.
- Analyze the data collected from existing design using TeamSET software which has Lucas-Hull DFA method concept.

CHAPTER 2

STATE OF THE ART

2.1 Introduction

This chapter described about the Design for Assembly (DFA) concept and the drives for industries to implement DFA concept. They are global market changes and consequences of component-oriented design. However, one of the DFA methods, Lucas-Hull only mentioned in this chapter and is implemented throughout this project.

2.2 Design for Assembly (DFA) Overview

Design for Assembly (DFA) is an approach to minimize assembly cost and time by reducing the number of parts or simplify the product. The application of DFA usually brings consequences to product quality and reliability improvement and reduction of production parts and inventory. Those consequences are also the factors of reduced assembly cost. According to Chan and Filippo (2005), DFA can be defined as: *A product design improvement processes for convenient and low cost assembly that focusing on functionality and ease of assembly.*

There are three best-known and also the most well-documented DFA methods. They are the Boothroyd - Dewhurst System, the Lucas DFA Method and the Hitachi Assemblability Evaluation Method (AEM). In general, the designer is guided through the analyses, which are presented in a series of assessment charts. The charts are based on empirical data gathered by knowledge engineering exercises with industrial experts and organised in an easy-to-use worksheet format.

During the evaluation, the designer is required to assess component functionality, form, manufacturing processes and assembly characteristics using values extracted from the charts according to component properties. These numbers are then compiled in tabular format, and calculations performed. In this way, the designer is able to quantify the suitability of the design (www.eng.hull.ac.uk). The Lucas DFA Methodology has been chosen for use within this project because of available facility within UTeM and there are some circumstances found within the other two.

2.3 Drives for DFA Implementation

There are identified two major factors that lead the industries or the companies started to implement DFA. They are global market changes and requirement of proper or convenient assembly in order to raise the rate of delivery to customers and also to improve product development and cost.

2.3.1 Global market changes

The competitive nature of the international market place has led to short product lifecycles and reduced price margins. Therefore, methods to improve the product development process and reduce costs required. It is because a lot of cost involved in manufacturing and assembly of a product. A significant part of this cost can be attributed to the labour-intensive activities associated with assembly. Therefore DFA method is used by the design team in simplifying the product structure, reduce assembly cost and time and to quantify improvements (www.eng.hull.ac.uk).

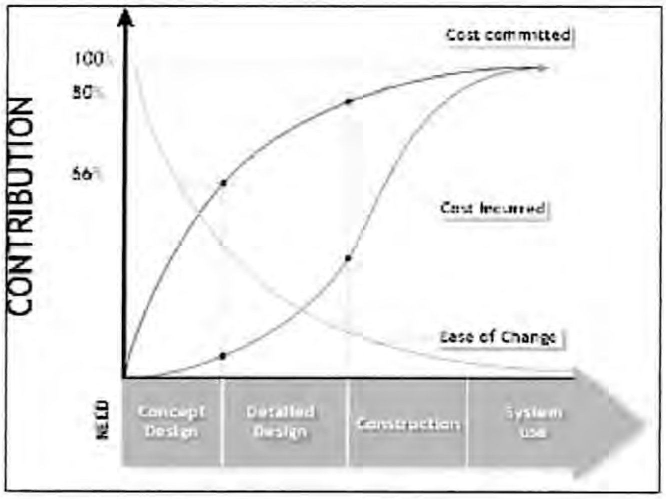

Figure 2.1: Design Change vs. Cost.

2.3.2 Consequences of component-oriented design

There has been a trend towards automated assembly in order to reduce labour costs. However, the potential benefits of automated assembly are limited by the need for flexibility and the ability to respond to product changes and short production runs whereby the most effective form of assembly is often manual assembly. Therefore, automated product assembly process is not necessarily the solution for reducing product development costs (www.eng.hull.ac.uk).

In fact, the design process is the key to reduce product development costs. As shown in Figure 2.1, the overall product development costs are determined during the design stage which is approximately 80%. The high assembly costs are often due to an unnecessarily large number of components in the product and the complex manufacturing and assembly processes that are required due to the design of inappropriate component interfaces. Studies have shown that often, products are still designed with at least 50% excess of parts and greater assembly content than is necessary (www.eng.hull.ac.uk).

The poor design which caused by the designers who designed products according to their intuition highly contributed to assembly problem is still prevalent in many industries. Traditionally or the over the wall approach, different engineering departments perform design, planning and manufacture of the product with no integration or feedback and so assembly problems are identified only at the later stages of production. In order to reduce lead times and product costs effectively, manufacturing and assembly issues must be detected and considered during design or also known as Concurrent Engineering approach. This requires the introduction of 'assembly-oriented design' so that product development and assembly planning can be performed simultaneously rather than consecutively as referred to www.eng.hull.ac.uk (2003).

2.4 Assembly Methods and Processes

Mostly there are two types of basic assembly processes in industries today. They are those performed manually (human) and those performed by mechanism (automated). The comparison between assembly methods are shown in Figure 2.2 and Figure 2.3.

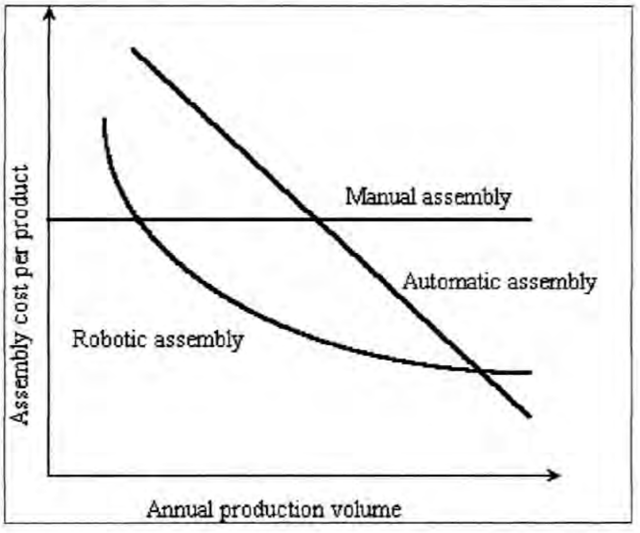

Figure 2.2: Cost comparison between different assembly methods relative with the volume of production.

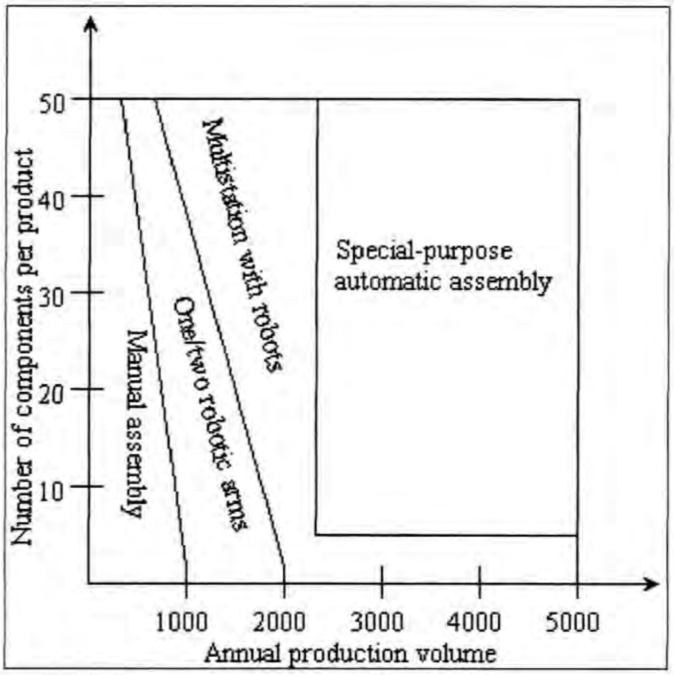

Figure 2.3: Annual production volume for each type assembled by Chan and Filippo (*2005*)

2.4.1 Manual assembly

In manual assembly, the parts are transferred from a workbench to another where the workers manually assemble the components into full product or each person responsible for the assembly of only a small portion of the complete unit. In doing this kind of assembly, tools such as screwdriver or any other assembly tools are essential in aiding the workers doing assembly. This kind of assembly is the most flexible and adaptable among the assembly methods. However, there is upper limit to the production Secondary operation analysis may required on certain parts volume, and labor costs which include benefits, cases of workers compensation due to injury, overhead for maintaining a clean, and healthy environment are higher according, (Chan and Filippo, 2005).

2.4.2 Automated assembly

The automated assembly generally divided to another two subcategories. They are Automatic (dedicated assembly) and Robotic (flexible assembly). The following are the elaboration of those assemblies.

2.4.2.1 Automatic/ dedicated assembly

The automatic assembly is characterized by custom-built machinery that assembles one and only one specific product in which ignores multiples of same activities. The cost of machinery required for this kind of assembly involves large capital investment. As production volume increases, the fraction of the capital investment compared to the total manufacturing cost decreases (Chan and Filippo, 2005).

This kind of assembly can be existed in wide variety of different forms; rotary and in-line machine, indexing (synchronized) and free transfer (asynchronous), and there are stopping machines and memory pin machines. Each of the machines mentioned require different design strategies because of the different rework or scrapping policies (Chan and Filippo, 2005)

2.4.2.2 Robotic / flexible assembly

The robotic assembly or soft automation incorporates the use of robotic assembly systems that controlled and coordinated by a PLC or computer. It has capability for more than one assembly activity whereby each element of the assembly system usually responsible for more than one assembly activity. This kind of assembly has even wider variety of equipments. Although this type of assembly method requires large capital costs, its flexibility often helps offset the expense across many different products (Chan and Filippo, 2005).

The cost of different assembly methods can be described in Figure 2.2. The non-linear cost for robotic assembly reflects the non-linear costs of robots (even small ones cost a lot). The appropriate ranges for each type of assembly method are shown approximately in Figure 2.3.

2.5 Lucas-Hull DFA Method

The Lucas DFA method encompasses a functional analysis, manufacturing analysis, handling or feeding analysis and assembly analysis. The method involves the assigning and summing of penalty scores associated with potential design problems similar to the Hitachi method but with the inclusion of handling or feeding as well as insertion (www.lboro.ac.uk).

These penalty factors are combined with an assembly sequence flow chart as shown in Figure 2.4 and generate three assemblability scores. The three scores; design efficiency, feeding/handling ratio and fitting ratio are generated in three stages of the analysis. All components of an assembly undergo functional analysis, categorizing them into an A which represents essential part or B which represents non-essential part. The design efficiency is determined by using Equation 1. A suggested target of 60% - 70% is to be aimed for based on a study of 'good' designs (www.eng.hull.ac.uk).

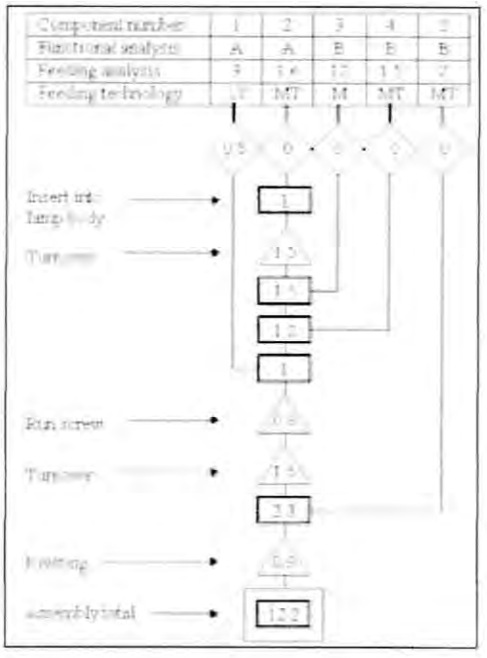

Figure 2.4: Example of assembly sequence flow chart with penalty factors.

The functional analysis facilitates part count reduction by evaluation of each component to determine whether it is essential for the performance of the product. Individual components are assessed in terms of their relative motion, material type and the need for removal for replacement or repair, according to nine questions presented in Figure 2.5. Thus, the designer is able to identify parts that may be eliminated, component clusters that may be replaced by single integrated pieces and opportunities for subassembly partitioning (www.eng.hull.ac.uk).

$$\text{Design Efficiency,\%} = \frac{\text{Total No. of 'A' Parts}}{\text{Total Parts} = A+B} \times 100\% \quad \ldots\ldots (1)$$

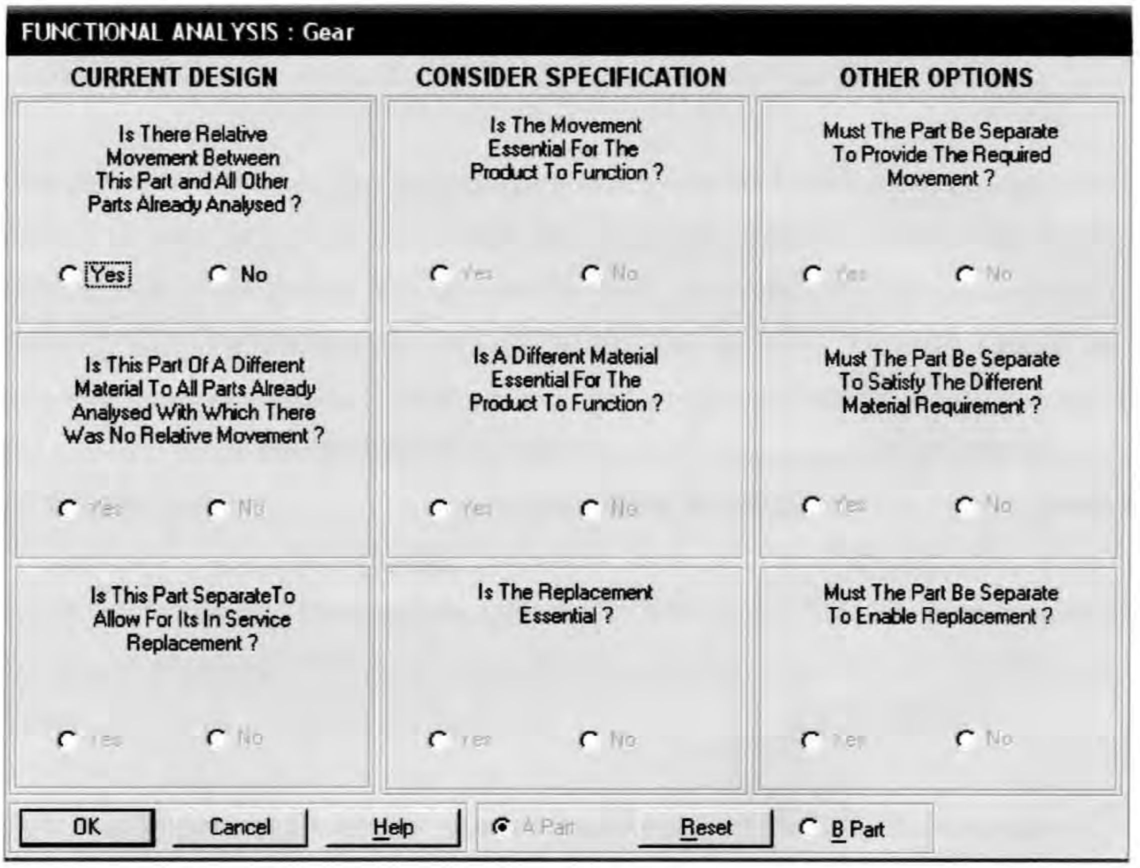

Figure 2.5: Nine questions for consideration on an example part.

The handling analysis evaluates the suitability of a component for manual handling and automated feeding to the point of assembly. The evaluation considers component shape characteristics, size, weight, orientation and mechanical properties. Careful selection of manual handling operations and feeding technology leads to improvements in safety and reduces probability of component damage or incorrect insertions. The main benefits include reduced capital spend on equipment and improved assembly times (www.eng.hull.ac.uk).

The feeding or handling analysis examines each component with respect to a knowledge base to determine a feeding index; these are then summed for the total assembly. The feeding index has a threshold of 1.5 indicating that any greater score be considered for