OPTIMIZATION OF CONCEPTUAL MANUAL WHEELCHAIR DESIGN USIGN INTEGRATED QFD AND DFMA

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

by

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2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **OPTIMIZATION OF CONCEPTUAL MANUAL WHEELCHAIR DESIGN USING INTEGRTATED QFD AND DFMA**

SESI PENGAJIAN: **2015/16 Semester 2**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the Degree of Manufacturing Engineering (Engineering Design) (Hons.). The member of the supervisory committee is as follow:

.....

(Prof. Madya Dr. Hambali bin Arep@Ariff)

ABSTRAK

Projek ini adalah untuk menunjukkan Fungsi Kualiti Penyebaran (QFD) dan Rekabentuk Pembuatan dan Penyambungan (DFMA) bersepadu dalam mengoptimumkan reka bentuk konsep produk. Dalam projek ini, kerusi roda manual dipilih apabila produk untuk untuk digunakan dalam proses integrasi QFD dan DFMA. Objektif projek ini adalah untuk mendapatkan input dari pelanggan menggunakan QFD dan memperbaiki reka bentuk kerusi roda menggunakan DFMA dengan berpangkalkan permintaan pelanggan dan keperluan. QFD digunakan untuk menterjemahkan Suara Pengguna (VOC) kepada Suara Jurutera (VOE). Sebaliknya, DFMA digunakan untuk mengoptimumkan reka bentuk dan terutamnya bagi mengurangkan kos. Dari QFD, bahagian yang perlu diminimumkan dikenal pasti dan DFMA dilaksanakan untuk menukar keinginan pengguna ke dalam reka bentuk konseptul yang baru. Manual DFMA digunakan untuk analisis reka bentuk yang sedia ada dan reka bentuk baru. Kecekapan semula reka bentuk dan reka bentuk yang direka juga diterapkan dalam projek ini. Dari 96 bahagian dari reka bentuk asal telah diminimumkan kepada 63 bahagian. Hasilnya, kecekapan reka bentuk dalam istilah nombor alat ialah 34.37% dan kos diminimumkan kepada 32%. Ia menunjukkan bahawa kaedah intgrasi dengan jayanya menyelesaikan konflik antara pelanggan dan keperluan teknikal dan mengurangkan bahagian kos.

ABSTRACT

This project is to demonstrate the integrated Quality Function Deployment (QFD) and Design Manufacture and Assembly (DFMA) in optimizing the conceptual design of a product. In this project, a manual wheelchair is chosen as the product to show the integration process of QFD and DFMA. The objective of this project is to obtain customer input using QFD and improve the wheelchair design using DFMA based on customer demand and needs. QFD is used to translate the Voice of Customer (VOC) to Voice of Engineer (VOE). On the other hand, DFMA is used to optimize the design and mainly to reduce the cost. From QFD, the parts that need to minimize are identified and DFMA is implemented to convert user desire into the new conceptual design. DFMA software is used to analyze the existing design and new design. The efficiency of re-design and new proposed design are also covered in this project. The part had reduced from 96 parts to 63 parts. As a result, the design efficiency in terms of part number is 34.37% and the cost minimizes to 32%. It showed that the integration method has successfully resolving conflict between customer and technical requirement and reducing part cost.

DEDICATION

To my beloved parents, Zulkifli bin Baharin & Rohanum binti Buyong and my siblings.

ACKNOWLEDGEMENT

First of all, I am grateful to Allah S.W.T for His Blessings and strength that He's given to me to complete this research successfully. Thousands of sincere thanks have to go to my supervisor, PM. Dr. Hambali, for his help with the tremendous amount of patience in trying to teach me about everything from A to Z, and make this report possible.

Also, big thanks to my friends, especially to Nur Muhaizyan, Sahida, Khairunnisa and Nizam for always be by my sides and keep pushing me to make sure to complete this thesis.

Thus, I would like to take this opportunity to say thank you, goes to the lecturers, technicians, classmate and the entire person that's involved directly or indirectly, in order assisting me to complete this research. Lastly, I hope that this thesis may useful as a reference for future works.

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LIST OF ABBREVIATIONS AND SYMBOLS

ABS	-	Acrylonitrile-Butadiene-Styrene
BOM	-	Bill Of Material
CAD/CAM	-	Computer Aided Design/Computer Aided Manufacture
DFA	-	Design for Assembly
DFE	-	Design For Environment
DFM	-	Design For Manufacturing
DFMA	-	Design for Manufacturing And Assembly
EDM	-	Electric Discharge Machine
etc	-	Et Cetera
FMEA	-	Failure Mode Effect Analysis
HOQ	-	House Of Quality
LH	-	Left Hand
NO	-	Not Okay
NO	-	Number
OD	-	Optimization Design
OK	-	Okay
PBT	-	Polybutylene Terephthalate
PMMA	-	Poly(Methyl Methacrylate)
PSM	-	Projek Sarjana Muda

PVC	-	Polyvinyl Chloride
QFD	-	Quality Function Deployment
RM	-	Ringgit Malaysia
TRIZ	-	Theory Of The Resolution Of Invention-Related Tasks
UTeM	-	Universiti Teknikal Malaysia Melaka
VOC	-	Voice Of Customer
VOE	-	Voice Of Engineer
%	-	Percent
>	-	More than
-	-	To/until
s	-	Second
°	-	Degree
Ø	-	Diameter
α	-	Alpha
β	-	Beta
L/R	-	Left/right

CHAPTER 1

INTRODUCTION

1.1 Background

Manual wheelchair is equipment that had been used for the consumer to help human moves. Wheelchair occupied with two wheels, handle, arm rest, brake system, rim, footrest, seat and backrest. Wheelchair helps user that had a difficulty with mobility to move around independently. Manual wheelchair generally could be in founded at hospital, folk's home, and even at the airport, and etc.

From the journal title History of Wheelchair, the earliest inventor was in the year 1595 by unknown inventor who build it for the use to king Philip II of Spain. The wheelchair called 'invalid chair'. And then, on the year 1655, the paraplegic watchmaker, Stephen Farfler invents a wheelchair for himself on the age of 22. The wheelchair called 'self-propelling chair'. On the year 1783, the wheelchair maker, John Dawson had invented a wheelchair called 'bath chair because it is develops in Bath, England. Bath chair had outsold during early 19^{th}. During 19^{th} century, many improvements were made to design of wheelchair. Inventor added hollow rubber on metal rim (similar use on bike) on year 1867 until year 1875. On year 1881, push rim was invented for self-propulsion. Until year 1990, the push rim design standard was set. Starting on 1990s, a standards wheelchair invented similar to

a bicycle, and few year later more advanced wheelchair was designed. In year 1932, Harry Jennings had invented the first folding chair (similar to what use today, tubular steel wheelchair). He built it for a paraplegic friend called Herbert Everest (Bellis, 2009).

For this project, title *Optimization of Conceptual Manual Wheelchair Design Using Integrated QFD and DFMA* is proposed. Wheelchair had many compartment, component and joint mechanism. All this stuff used may lead to increase of cost and weight. Thus, by using method of QFD and DFMA, the design of the product can be change according to the methods use (Emmer, 2011).

1.2 Problem Statement

Wheelchair occupied with two wheels, handle, arm rest, brake system, rim, footrest, seat and backrest. Wheelchair helps a user that had a difficulty with mobility to move around independently. The weight of the wheelchair can be increase due to the joint part of the folding part. Almost 90% of the manual wheelchair is foldable, but this moving part will give more weight (Emmer, 2011). Besides that, the folding part can have vibration and loss energy. This is less efficient when user push the wheelchair forward and backwards. If the joint parts are fixed, the weight will reduce and the ergonomic design can produce (Emmer, 2011). If this problem did not fix, the user will feel uncomfortable with the condition of the wheelchair because they will use it for a long period of time. The issues always occur when user had to sit on the wheelchair independently and larger forces are needed to propel the chair forward. Users commonly happen to have a friction on the elbow and wrist during use the pushrim (Koontz et al.,1998). The assemble of the wheelchair had to design to ease the user, so that the assemble and dissemble time of the chair can be reduce besides giving them more ergonomic design and can load in the car easily and ease of transfers.

1.3 Objectives

The main objective of the project is to optimize the conceptual manual wheelchair using integrated QFD and DFMA at the conceptual design stage.

The other objectives are specific as follows:

(a) To obtain the customer inputs by using QFD technique

(b) To minimize number of parts of wheelchair using DFMA

(c) To develop the best conceptual design based on product analysis and customer requirement.

1.4 Scope

This project comprises the *Optimization Conceptual Manual Wheelchair Design Using Integrated QFD and DFMA.* Quality Function Development (QFD) is done to correlate the customer demand with engineer specification. A questionnaire are done to reach the customer wants, and then House of Quality (HOQ) is use to interpret the user demand and relate it with engineering specification. Customer needs are main objectives of new conceptual design of manual wheelchair, besides minimize the number of part using Design for Manufacturing Assembly (DFMA). From QFD, the part that need to minimize are identified and DFMA are implemented to convert the user desire into new conceptual design by taking factor such as cost, design specification and minimize lead time. The original design manual wheelchair will re-design using DFMA method using CAD/CAM software. For DFMA part, the original design and re-design are compared by the Bill of Material (BOM), Assembly work sheet (α and β), Boothroyd Dewhurst DFA method and the material requirement of DFM. The efficiency of the original design and new design will also include in this report.

CHAPTER 2

LITERATURE REVIEW

This chapter covers the description of Quality Function Deployment (QFD) and Design for Manufacturing and Assembly (DFMA). House of Quality (HOQ) method in QFD and Boothroyd method from Design for Assembly (DFA) also cover in this chapter. Additionally, this chapter discusses the conceptual design of manual wheelchair, the engineering design standard of wheelchair and previous study done to achieve the objective of this project.

2.1 Quality Function Deployment (QFD)

Quality Function Deployment is one of method that had been used in industry for to translate the Voice of Customer (VOC) to the Voice of Engineer (VOE). QFD was developed by Yoji Akao in Japan in 1996. The method of QFD was demonstrated at Mitsubishi Heavy Industries Kobe Shipyard. As one of the concurrent method, QFD had reduced the development time by one-half to one-third of cycle time (Akao, 1990). There are three main objectives in implement QFD in design stage.

(i) Determine the spoken and unspoken customer needs.

(ii) Translate the needs into technical specification.

(iii) Focus towards customer satisfaction.

2.1.1 House of Quality (HOQ)

The primary planning tool used in QFD is House of Quality (HOQ). The HOQ translate the voice of the customer into design requirement that contain specific target values and matches how the organizations will fulfill the requirement. The QFD chart helped the team to set their target on issue such as the function of product, the color, the assembly, the structure of the product and etc. the raking of the competitor's product also can be ranked by matching the technical and customer benchmarking. For an engineering HOQ is a good method to summaries all basic data that get from customer in a usable form. For marketing, it represents the customer voice and general manager to discover new opportunities (Clausing and Pugh, 1991). The structure of HOQ is as shown in Figure 2.1.

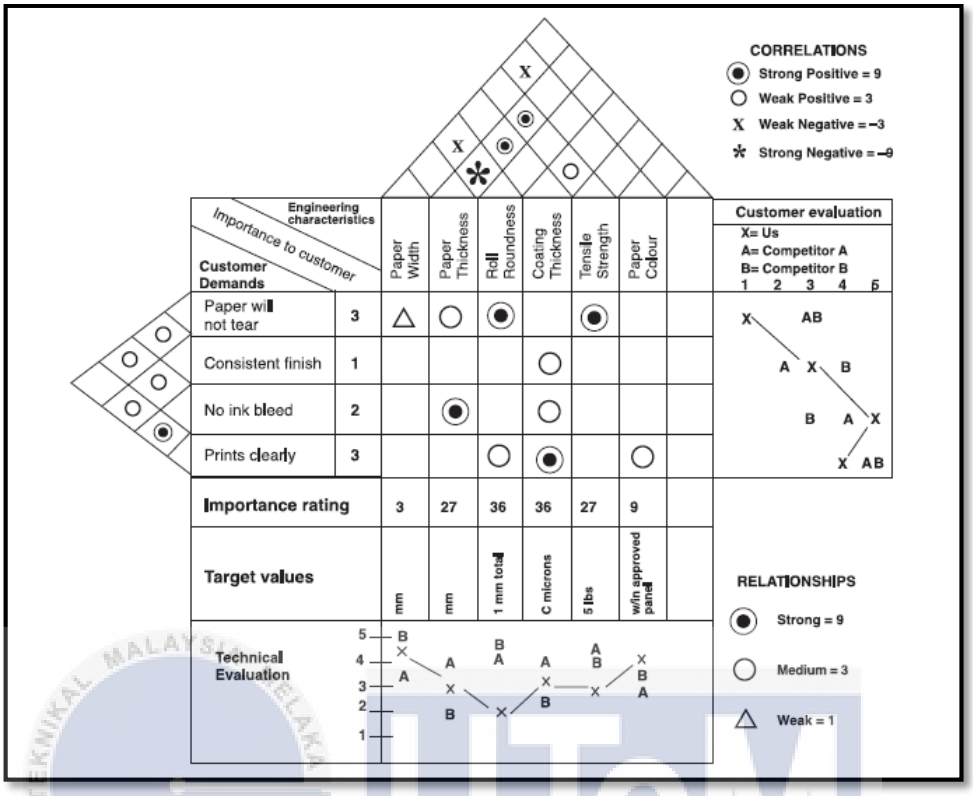

Figure 2.1 : House of quality for a paper-roll manufacturing process, (Bouchereau and Hefin,2000).

2.1.2 Construction of HOQ

HOQ is used to relate the customer requirement (WHATs) and the engineering characteristics (HOWs). The matrix summarize these two components. The six HOQ steps are (Besterfield, 2003);

(i) List out the customer needs (WHATs) and identify the importance to the customer (rank the scale from 1 to 5).

(ii) Customer rating to the competitor. Compare the company to the competitor company.

(iii) Develop the design criteria (HOWs). This is where how the engineer specification will meet the customer specification.