



**THROUGH USER REQUIREMENT TO DESIGN WHEELCHAIR
IMPROVEMENT BY INTEGRATED QFD, AHP AND TRIZ
METHOD**



**BACHELOR OF MANUFACTURING ENGINEERING
TECHNOLOGY (PRODUCT DESIGN) WITH HONOURS**

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**Faculty of Mechanical and Manufacturing Engineering
Technology**



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NUR FARHIN BT BAHRUDDIN

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NUR FARHIN BT BAHRUDDIN

**A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Product Design) with Honours**



Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this “ Through user’s requirement to design wheelchair improvement by integrated QFD, TRIZ and AHP method entitled “is the result of my research except as cited in the references. Thesis has that not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature

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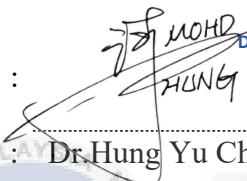


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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

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DEDICATION

This report is dedicated to my beloved cousin who is diagnosed congenital heart disease since she was born and after getting married she got pregnant and this is the high risk for her and baby because of the medicine that she consume for her entire life. When her pregnancy has reach 7 months , she was diagnosed of brain aneurysm and after the operation that took about 10 hours she's survive but the risk of it she's become partially paralyze and the baby was born as premature baby. She's been survive for almost 2 years and started getting better from day by day until 10 May of 2022 that was the 8th Syawal she passed away and left her child and husband. I also thanks to my late grandmother, my parents, special friend, classmates and housemate also not forget my supervisor Dr.Hung Yu Ching @ Muhammad Hung that guided me with patient and always telling that i'am good enough with all the hard work that i've done since FYP 1 until FYP 2. Last but not least i wanna thank me for believing in me. I want to thank me for doing all this hard work. I want to thank me for having no days off. I want to thank me for never quitting. I want to thank me for always being a giver and trying to give more than i receive. I want to thank me for trying to do more rights than wrong. I want to thank me for just being me at all times.

ABSTRACT

Wheelchair is one of the most common used assistive devices to enhance personal mobility for people enjoying their human right and living in dignity. The proper wheelchair allows user to move around freely to engage their physical life doing activities. Wheelchair use and acceptability affect how safe the wheelchair is to carry out activities including having trouble when travel along a bad road that make the wheelchair jump over bumps or uneven surface. Wheelchair is a backbone of a disable person and must strong enough to sustain the loading of human. This project's research steps include a multi-step integrated QFD, TRIZ and AHP technique. To design a wheelchair that meets user's requirement (CR) to product features and problem by enhance product universal feature and function, Quality Function Deployment (QFD) is applied. This method helps us collecting the date and translate into technical characteristic. After that, integrating QFD method with Analytic Hierarchy Process (AHP) and Theory of Inventive Problem Solving also distributed. The first stage of this project is conducting a questionnaire to carried out user's need and ranked based on their technical characteristic by using AHP Pairwise Comparison Matrix. This primary tool is House of Quality (HOQ) which import all the data and calculated inside. The implemented method of QFD is build to know the negative correlation before importing to the TRIZ problem solving to find out the design direction. The problem are solved from the negative correlation using tools in TRIZ 39 TRIZ Parameters and 40 Inventive Principle to identify the best solution for design concept. The concept development is created with 3 concept that followed the user requirement. Next, the completed of HOQ is build to select the final design concept. After select the final design then we started our prototype making and tested the with Design Validation Questionnaire. Based on the survey result, about 50% respondents are choosing Appearance, Function, Wing Design Support and Continuous Footplate for Corvette Wheelchair design concept. This study demonstrated the effectiveness of the three method QFD, TRIZ and AHP approach in reaching new design innovation and the user needs.

Keywords: *Wheelchair, Quality Function Deployment (QFD), Analytic Hierarchy Process (AHP), TRIZ, Design Improvement*

ABSTRAK

Kerusi roda ialah salah satu alat bantuan yang paling biasa digunakan untuk meningkatkan mobiliti peribadi bagi orang yang menikmati hak asasi mereka dan hidup dalam maruah. Kerusi roda yang sesuai membolehkan pengguna bergerak dengan bebas untuk menjalani kehidupan fizikal mereka melakukan aktiviti. Penggunaan kerusi roda dan kebolehterimaan mempengaruhi tahap keselamatan kerusi roda untuk menjalankan aktiviti termasuk menghadapi masalah apabila melalui jalan yang buruk yang menyebabkan kerusi roda melompat di atas bonggol atau permukaan yang tidak rata. Kerusi roda adalah tulang belakang orang kurang upaya dan mesti cukup kuat untuk menampung beban manusia. Langkah penyelidikan projek ini termasuk teknik QFD, TRIZ dan AHP bersepadu berbilang langkah. Untuk mereka bentuk kerusi roda yang memenuhi keperluan pengguna (CR) kepada ciri dan masalah produk dengan meningkatkan ciri dan fungsi universal produk, Penerapan Fungsi Kualiti (QFD) digunakan. Kaedah ini membantu kami mengumpul tarikh dan menterjemah ke dalam ciri teknikal. Selepas itu, penyepaduan kaedah QFD dengan Proses Hierarki Analitik (AHP) dan Teori Penyelesaian Masalah Inventif turut diedarkan. Peringkat pertama projek ini adalah menjalankan soal selidik untuk melaksanakan keperluan pengguna dan kedudukan berdasarkan ciri teknikal mereka dengan menggunakan AHP Pairwise Comparison Matrix . Alat utama ini ialah House of Quality (HOQ) yang mengimport semua data dan dikira di dalam. Kaedah QFD yang dilaksanakan adalah membina untuk mengetahui korelasi negatif sebelum mengimport ke penyelesaian masalah TRIZ untuk mengetahui arah reka bentuk. Masalah diselesaikan daripada korelasi negatif menggunakan alat dalam Parameter TRIZ 39 TRIZ dan 40 Prinsip Inventif untuk mengenal pasti penyelesaian terbaik untuk konsep reka bentuk. Pembangunan konsep dicipta dengan 3 konsep yang mengikut keperluan pengguna. Seterusnya, HOQ siap dibina untuk memilih konsep reka bentuk akhir. Selepas memilih reka bentuk akhir maka kami memulakan pembuatan prototaip kami dan menguji dengan Soal Selidik Pengesahan Reka Bentuk. Berdasarkan hasil tinjauan, kira-kira 50% responden memilih Penampilan, Fungsi, Sokongan Reka Bentuk Sayap dan Footplate Berterusan untuk konsep reka bentuk Kerusi Roda Korvet. Kajian ini menunjukkan keberkesanan pendekatan tiga kaedah QFD, TRIZ dan AHP dalam mencapai inovasi reka bentuk baharu dan keperluan pengguna.

Kata Kunci : *Kerusi roda, Quality Function Deployment (QFD), Analytic Hierarchy Process (AHP), TRIZ, Design Improvement*

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LIST OF SYMBOLS AND ABBREVIATIONS

QFD	-	Quality Function Deployment
HOQ	-	House of Quality
TRIZ	-	Theory of Inventive Problem-Solving
AHP	-	Analytic Hierarchy Process
VOC	-	Voice of Customer
A	-	AHP Pairwise Matrix
a	-	Unknown a
i	-	Number of rows
j	-	Number of Column
k	-	Order of the Judgement Matrix
n	-	Order of Matrix
C	-	Criterion
λ_{max}	-	The average number of total consistency measure
CL	-	Consistency Index
CR	-	Consistency Ratio

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter contains background and briefing about this project will be introduced. The problem statement, research objectives, scopes, and limitation are also stated in this chapter.

1.2 Background

There are 15 percent of world population are people with disabilities and it was consider largest minority group in world (Restuputri & Nugroho, 2021). Around 2 billion of people that depend on wheelchairs for day-to-day as their mobility (Alsibai, Manap, & Al Sibai, 2015). Wheelchair is one of the most common used assistive devices to enhance personal mobility for people enjoying their human right and living in dignity and assist people with disabilities to be more productive of their community.

The proper wheelchair allows user to move around freely to engage their daily physical life doing activities. It also gave them a courage to do whatever they need freely can increasing comfort to live more active lifestyle. One of their daily life challenges is to transfer a subject from the wheelchair to and from the bed or toilet. This is because they are feeling uncomfortable to keep lean on someone help and also can cause a health burden when transferring. Every simple task for wheelchair user has transformed into a major deal because some of activities not be possible any longer but it can be done just because using support of another person or using such a wheelchair. Moreover, for someone who has previously had leg

full use, their biggest challenge may be adjusting to idea of needing someone else help to accomplish things they used to do without thinking of them. Transferring is the most difficult things to do by their own that is moving in and out the wheelchair. The wheelchair user transfer from wheelchair to another surface that was about the same height as wheelchair seat and back again. A level of transfer should be considered because it more difficult when transferring to and from other surfaces or height. The problem sometimes is about position that didn't close to the target surface and it might be dangerous for user. In Americans, the patient age 65 and above accounted for 70.8% of injuries, 94.0% injuries that occur in home and hospital and 12.2% are related to wheelchair transfer injuries(Tsai et al., 2020).

Wheelchair use and acceptability affect how safe the wheelchair is to carry out activities including having trouble when travel along a bad road that make the wheelchair jump around over bumps or uneven surface. A wheelchair can be stable when forward facing on a downhill sloped or ramp if use a steeper slope of wheelchair it can occur ineffective braking or line action force due to gravity moves close to point. The user also having difficulties when on a sandy surface even a sidewalk that have a small amount of sand that can cause wheelchair become unbalanced, spin around and tip over. This might happen suddenly especially with a motor wheelchair. Other than a wet surface also can cause wheelchair became wet, slide, spin, tip and unfortunately fall over. This because some surface and condition are not friendly to wheelchair movement. A wheelchair design must enable users to safely and effectively use their wheelchair in rough outdoor environment need to be more stable and easier to propel over rough and uneven surface (Madanhire et al., n.d.) .

Moreover, the transferring patient from the wheelchair always an issue for helper or attender. Wheelchair is a backbone of a disable person and must be strong enough to sustain the loading of human. Another feature that distinguishes wheelchair is the type of material used

that including comfort and safety (Wicaksono et al., 2020). Therefore, tipping and falling are the most common accident of wheelchair user as example fall from the wheelchair unlock the brakes, when a slippery surface, sitting stability and hitting a large bump with one wheel that causes wheelchair become unbalanced. Deterioration of front and rear wheels also can cause a problem with manual wheelchair especially when riding on uneven surfaces.

Nowadays, world has changed with restricted mobility with advancement in technology highly furnishes for people who have a disabilities (Kumar et al., 2020). Universal Design beyond accessible design for people with disabilities include all related gender, race, and ethnicity, age, stature, disability and learning style (Burgstahler, 2009). The aspect are related to features configuration that affect user action in using a manual wheelchair to determining overall of mobility. These features are including wheelchair back packs that attach to seat and offer a secure way of storing item, rim cover that make it more comfortable to hold into the wheels for self-propelling, brake lever grip make it easier for user to locate the brakes and leg rest to release on manual wheelchair and last but not least is anti-tipper to help avoid the rear tipping and can be adjustable to change the angle. Wheelchair features are about to improve the life of physically in their daily lives by allowing independently move within assistive and straightforward interface (Mustaquim, 2015a).

Assistive Technologies (AT) according to United Nation is to make the wheelchair with functional abilities better to disable people to recover their movements and must compensate a reduced capacity and avoid future loss of daily activities (Carneiro et al., 2015). Nowadays, there are many options and many different of wheelchair such as manual wheelchair, powered wheelchair and transport wheelchair. Wheelchair consist of mechanical component basically such as the hand rims, armrest, footrest, castor, seat and back upholstery. Wheelchair also develop more over the years including easy use, more option, lightweight option, adjustable