MECHANICAL DESIGN AND DEVELOPMENT OF A 4 WHEELS SKID STEERING MOBILE PLATFORM SYSTEM

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

by

WONG HOW JIE

B051310131

930927-01-6245

FACULTY OF MANUFACTURING ENGINEERING

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **MECHANICAL DESIGN AND DEVELOPMENT OF A 4 WHEELS SKID STEERING MOBILE PLATFORM SYSTEM**

Sesi Pengajian: **2016/2017 Semester 2**

Saya **WONG HOW JIE (930927-01-6245)**

mengaku membenarkan Laporan Projek Sarjana Muda (PSM) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. *Sila tandakan (√)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysiasebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

_____ _____

Alamat Tetap: Cop Rasmi:

_____

_____

_____

Tarikh: _____ Tarikh: _____

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD

DECLARATION

I hereby, declared this report entitled "Mechanical Design and Development of a 4 wheels skid steering mobile platform system" is the result of my own research except as cited in references.

Signature : ……

Author"s Name : WONG HOW JIE

Date : 19 June 2017

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Robotics and Automation) (Hons). The member of the supervisory committee are as follow:

…….....

(En. Shariman Bin Abdullah)

ABSTRAK

Tujuan untuk melaksanakan project *Mechanical design and development of 4 wheels skid steering mobile robot platform system* adalah untuk mengurangkan risiko hasil semula. Dalam projek ini, *4 wheels skid steering mobile robot* telah dihasilkan berdasarkan lukisan *SolidWorks.* Pada mulanya, model robot tersebut telah dibina menggunakan *SolidWorks*, diikuti dengan mengeksport kepada *ADAMS* untuk menjalani simulasi. Terdapat tiga simulasi termasuk gerakan, tork, dan kelajuan iaitu mengaplikasi pada dua persekitaran yang berlainan. Akhirnya, keputusan yang diperolehi telah dianalisis dan tork telah dinilaikan. Bagi keputusan reka bentuk, dimensi produk sebenar tersubut adalah 50centimeter x 35centimeter x 20 centimeter dan persamaannya adalah sebanyak 90% berbanding dengan reka bentuk *SolidWorks*. Bagi keputusan simulasi, *mobile robot* tidak mampu bergerak dengan lurus tanpa bantuan pengawal. Keputusan tork juga menunjukkan minimum tork motor adalah 1.0Nm bagi melaksanakan gerakan putaran. Keputusan kelajuan menunjukkan kelajuan sebenar sentiasa kurang daripada kelajuan dikehendaki dengan factor gaya geseran dan gaya gravity. Fabrikasi adalah peringkat terakhir bagi keseluruhan projek iaitu melibatkan proses kejuruteraan bagi membangunkan strucktur mekanikal *mobile robot*. Proses-proses tersebut adalah termasuk proses menebuk, proses merata, proses pemotongan dan proses pelarikan. Maklumat tentang mekanikal reka bentuk dan proses pembangunan telah dimasuki dalam isi kandungan projek ini. Pada penghujung projek ini, *mechanical design and developmet of four wheels skid steering mobile robot platform system* telah dilengkapkan dengan berjaya dan projek ini dapat disambungkan dengan penyelidikan yang selanjutnya.

ABSTRACT

In this project, a 4 wheels skid steering mobile robot is developed based on SolidWorks design. Initially, the robot model was constructed in SolidWorks, followed by exporting to ADAMS software to carry out simulation. There are three simulations including motion, torque and speed which applied at two different environments. Eventually, the results obtained were analysed and torque parameter was evaluated. For the design result, the dimension for actual product is 50centimetre x 35centimetre x 20centimetre which its similarity is 90% compared to SolidWorks design. For simulation result, mobile robot was not able to move straight without controller. The torque result shows that minimum input torque of motor is 1.0Nm to perform rotational motion. The speed result shows that the actual speed always lesser than desired speed due to the effect of friction force and gravitational force. Fabrication was the last stage of overall project which involved engineering processes for developing mechanical structure of mobile robot. The processes are drilling, milling, cutting and turning. The detailed information related to mechanical design and process of development was included in content of report. At the end of this project, the mechanical design and development of four wheels skid steering mobile robot platform system had been completed successfully and this project can be continued with further research.

DEDICATION

I dedicate this work to:

my beloved father, Mr.Wong Swe Chong
my appreciated mother,Mdm.Chia Mee Hong
my supervisor,Mr.Shariman bin Abdullah
and to my beloved lecturers and friends
for giving me moral support, money, cooperation, encouragement and also understandings

ACKNOWLEDGEMENT

I would like to thank to Universiti Teknikal Malaysia Melaka and Faculty of Manufacturing Engineering, who provides me the opportunity to further my studies.

Besides, I would like to express my gratitude to my respected supervisor, Mr.Shariman bin Abdullah. His kindness, mentorship guidance and advice helps me a lot throughout the overall project. He is always the one who willing to solve difficulties when I faced problems.

Furthermore, my thanks goes to three of my panels who are Pm,Dr.Ahmad Yusairi bin Bani Hashim, Ms.Aidawaty binti Rafan and Ir.Dr.Lokman Bin Abdullah who willing to give suggestion and opinions to me in way of completing my project.

Last but not least, I would like to give a special thanks to my best friends who gave me much motivation and cooperation mentally in completing this report.

Finally, I would like to thank everybody who was important to this FYP report, as well as expressing my apology that I could not mention personally each one of you.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATIONS

3D	-	3-Dimensional
4WD	-	4 wheel drive
DC	-	direct current
DOF	-	Degree of freedom
DYC	-	Direct yaw-moment control
EPS	-	Electric power steering
FE	-	Finite element
FEA	-	Finite element analysis
GPRS	-	General Packet Radio Service
GPS	-	Global Positioning System
NASA	-	National Aeronautics and Space Administration
PID	-	Proportional integral derivative
Wi-Fi	-	Wireless fidelity

LIST OF SYMBOLS

cm	-	Centimetre
v	-	Voltage
mm	-	Millimetre
F	-	Force
m	-	Metre
ω	-	Omega
m/s	-	Metre per second
kg	-	Kilograms
s	-	second
N.m	-	newton metre
%	-	percent

CHAPTER 1

INTRODUCTION

1.1 Background

Mobile robot is known as a moveable machine that is capable of locomotion and performing tasks for human. It is widely used in various field of occupation and most of the scientists claimed that the future world will occupy with mobile robot. Mobile robot consists of three main characteristic which are mobility, perception ability and a certain level of autonomy. A functional mobile should have ability to move around the environment and able to detect and recognise the environment with its perception function. Other than performing tasks and executing multiple operations as human, a mobile robot have capable in interacting with human but restricted in limited level.

In year 1950, W. Grey Walter has built Elmer and Elsie which its appearance is a turtle-like robot. This mobile robot is equipped with light sensor which able to move towards light sources and avoid any obstacles. In year 1969, the Stanford Research institute doing research on Shakey which was the first mobile robot to be controlled by vision. Shakey had a camera, rangefinder, bump sensors and a radio link to perform tasks. In recent years, mobile robot is developed to an outstanding level which can implement in field of military and planetary. NASA JPL Rover is a robot which have achieved the target of autonomous navigation, decision-making and capability of return at planet.

Four wheels skid steering is designed and the idea of design is originally from four wheels mobile robot in order to modify and improve the weakness of other mobile robot. From the word of skid steering, the mobile robot is obviously involved and implemented mechanism of skid to drive or manoeuvre. Four wheel skid steering mobile robot can make a perfect turning which rotating about its body or centre of gravity of body. Its four wheels also provide locomotion ability and able to maintain stability of mobile robot along the moving path. With these outstanding characteristic, it is highly demanded in variety of field and worth to be one of the significance research today.

1.2 Problem Statement

Mobile robot is a greatest invention in world due to its functionality and contribution to human. No doubt, mobile robot is widely implemented into our real life environment which plays vital role in performing task that are previously conducted by human being. Mobile robot seems like a successful piece of work however, there is still a lot of problem needed to be coped and solved. For two wheels mobile robot, it is difficult to achieve stability either in static state or moving state. As its limitation on movement, a revolution on design of mobile robot is occurred and four wheels mobile robot is developed. Four wheels mobile robot is good in maintaining stability by its four wheels but most of the four wheels mobile robot is unable to turn perfectly. Development of four wheels skid steering mechanism has coped the problem and disadvantages of other mobile robots in term of improving stability and turning efficiency. However, there is a high risk of rework and reproduce the 4 wheels skid steering mobile robot due to its conventional design method. By using such method, mobile robot is modelled and designed by software such as SolidWorks, 3D-AutoCAD, and CATIA and followed by product fabrication. There is limitation that would cause failure on robot fabrication via this conventional design method. This conventional method does not ensure the functionality of mobile robot.

In this study, an additional method known as ADAMS simulation is suggested and utilised. ADAMS simulation will work together with SolidWorks software which drawing of model will convert into ADAMS for simulation before producing a real 4 wheels skid steering mobile robot.

1.3 Objectives

The objectives for this project are:

(a) To design a four wheels skid steering mobile robot by using SolidWorks.
(b) To develop a four wheels skid steering mobile robot by using pulley-belt mechanism.
(c) To analyse motion and evaluate torque based on ADAMS software.

1.4 Scope

The scope of this study is:

(a) To design a four wheels skid steering mobile robot which the size of robot is approximately 50cm x 35cm x 20cm.
(b) To conduct simulation (motion experiment and torque experiment) of four wheels skid steering mobile robot by using ADAMS software only whereas other software are excluded.
(c) The utilisation of controller for four wheels skid steering mobile robot is excluded in project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will cover on the collection of material which related to title where all of the information is come from other researchers. Without doubt, skid steering mobile robot is one of the most widely discussed topic in technology field recently. Drive mechanism of mobile robot is emphasized in this section as main research. There are four types of difference drive mechanism which included two wheels differential drive, two wheels self-balancing, four wheels Ackermann steering, and four wheels skid steering will be discussed. Research on skid steering mechanism is compulsory as the supporting information for my consequence mobile robot modelling. Components used for each of the drive mechanism is discussed and the arrangement of components will also be stated. Issue regarding to theory for simulation using ADAMs will also be illustrated in sub-topic in this chapter. Furthermore, study on torque analysis and movement of robot will be carried out via simulation method (ADAMs). All of the information are acquired from bunch of sources such as journals, articles, research paper and books. All of the references taken are come from previous study that related to this study by other researchers. Some of the websites such as IEEE explorer and Science direct provide bunch of previous and current research paper. Throughout these studies, it provides better understanding towards the project and helps a lot in future work.

2.2 Drive Mechanism

Drive mechanism can be defined as the technique on how mobile robot to be driven or controlled. For driving a mobile robot, components play an important role because it can influence the entire control of mobile robot. Arrangement of components also determine the efficiency and performance of the mobile robot. Difference type of mobile robot may utilise difference drive mechanism to control the driving system. Drive mechanism is a system which comprises of several type machineries such as gears, pulley belt and ram. Different of drive mechanism brings different advantages and limitations to mobile robot.

2.2.1 Two Wheels Differential Drive

From the word „two wheels differential drive", it can be understood that the driving system is controlled separately in each of the wheels. Generally, there are some of the common components included wheels, motors, gears, sensors and controllers to fabricate a two wheels differential drive robot mobile. But, Nasu and Wada (2015) observe that active casters have been used as one of the driving elements in most of the mobile robots. Active casters are installed or coupled on the dual wheels by differential gears mechanism. A mechanism with two wheels can reduce the turning friction and smooth caster motion can be achieved. Besides, the suspension must be installed on each of the wheel individually. Suspension is good in maintaining two of the wheels contact with ground even it is moving on rough surface. A novel sensor system is required for detecting the position of wheels. The wheel arrangement for active-caster was in parallel arrangement and dual wheels were installed at the centre position of steering shaft. According to Maulana *et al*. (2014), both of the wheels should be placed either at front or rear of the robot chassis. There are another two wheel-shafts for active caster and motors are mounted on wheels.

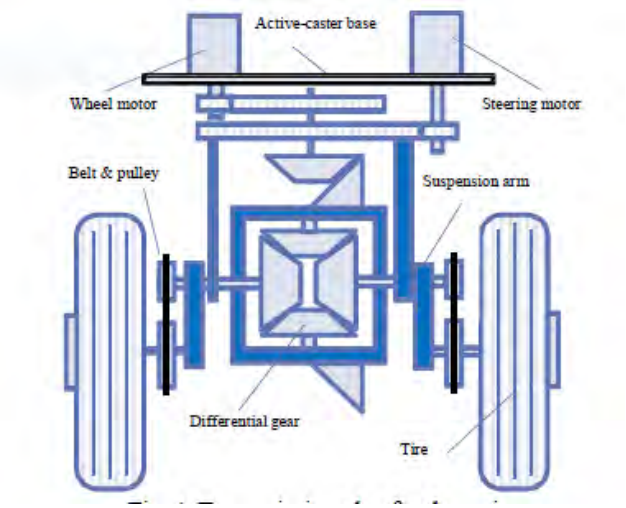

Figure 2.1: Differential gear on dual wheel

(Nasu and Wada, 2015)

2.2.1.1 Drive Mechanism of Two Wheels Differential Drive

Active-caster has two DOF (degree of freedom) and therefore it is usually driven at least two shafts out of three shafts. Two wheels are controlled or driven by motors respectively and the steering shaft is still passively controlled. Suspensions were installed on wheel independently as function of maintaining the wheel on ground (Nasu and Wada, 2015). Maulana *et al*. (2014) state that the driver for motor was made according to H-bridge driver circuit. There are three main aspects that had been proposed in order to control or drive the mobile robot. Utilized mechanical structure, mathematical model and control solutions are three of the theoretical aspect. It is first come out with closed loop control for tracing along the direction of mobile robot and control its position. Input commands is come from moving robot and for feedback control purpose (G.Saridis,2013). Additionally, emphasized that obstacle avoidance, path planning, and motion guidance must be analysed and modelled. The advantages of dual-wheel caster are less friction when having a turning motion with carrying object. Active caster can control the direction and its rolling direction. Disadvantages of this type of active-caster is easier to lose control when one of its wheel do not contact with ground. To compensate the weakness of dual wheel active-caster, a new wheel mechanism called as ACRO-DD is proposed which an actuator

is used to drive the steering shaft and another actuator is used to drive the wheels simultaneously. Gear was also implied with differential drive which controlled the wheels separately in different speed. Gear transmission for steering and wheel is purposely introduced to transmit the power of motor. A large wheel gear is controlled and rotated by wheel motor and transmitted power via a shaft that located through the centre of large steering gear.

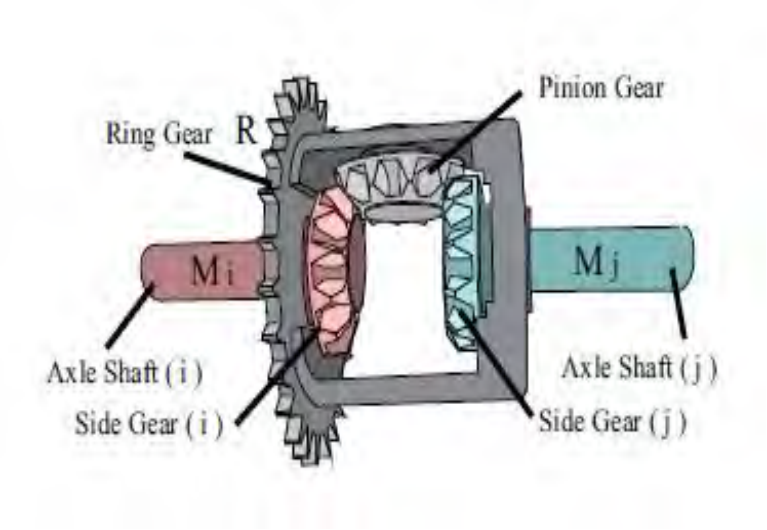

Figure 2.2: Differential gear mechanism (Fujiwara *et al*., 2015)

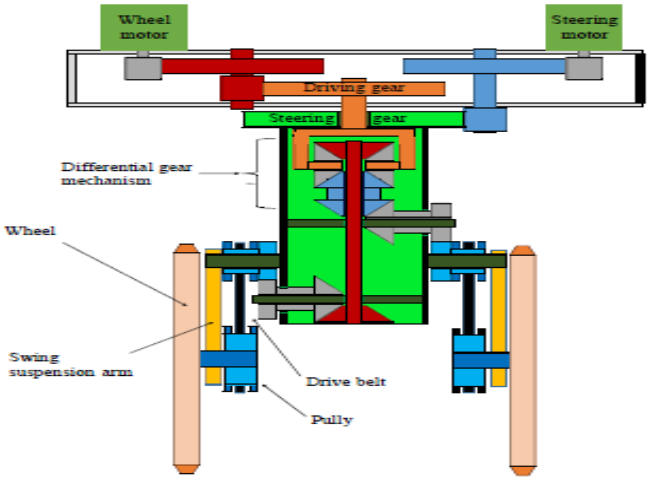

Figure 2.3: Overview of prototype design (Nasu and Wada, 2015)