DESIGN AND ANALYSIS OF A MOBILE ROBOT MECHANISM FOR MAINTENANCE WORKS IN MANUFACTURING ENVIRONMENT

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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 (Robotics & Automation) (Hons.)

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics & Automation) (Hons.). The member of the supervisory is as follow:

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ABSTRAK

Laporan ini membentangkan reka bentuk dan analisis mekanisme robot mudah alih untuk kerja-kerja penyelenggaraan dalam persekitaran pembuatan. Robot mudah alih yang dicadangkan untuk melaksanakan penyelenggaraan ke atas mesin larik MOMAC SM 200. Ia sepatutnya membersihkan cecair penyejuk selepas operasi mesin untuk mengelakkan apa-apa kerosakan yang berpotensi untuk mesin. Mekanisme robot mudah alih terdiri daripada tiga bahagian asas iaitu platform mudah alih untuk pergerakan, lengan manipulator untuk manipulasi, dan akhir-efektor pelaksanaan tugas. Untuk menentukan prestasi yang terbaik untuk pelaksanaan tugas, dua reka bentuk telah dihasilkan dengan menggunakan perisian SolidWorks 2014 berdasarkan keperluan yang dikenal pasti. Reka bentuk dianalisis dengan perisian SolidWorks Simulasi dengan membangunkan prototaip maya dalam ruang kerja maya. Simulasi yang digunakan untuk melakukan dua analisis yang Analisis Usul dan Analisis Unsur Terhingga (FEA). Dalam analisis pergerakan, pergerakan robot mudah alih bagi setiap kitaran, dimana satu set ke depan dan balik akan dianggap sebagai satu kitaran dan dianalisis. Masa yang diambil olehnya untuk melaksanakan pergerakkan itu diambil sebagai pengukuran prestasi. Di FEA, tegasan dan terikan di bawah beban dalaman dan luaran akan dikira. Kedua-dua robot mudah alih akan dinilai berdasarkan data yang dikumpulkan. Bagi prospek pembangunan projek ini pada masa depan, aspek-aspek berikut seperti halangan mengelakkan untuk mengelakkan robot mudah alih daripada berlanggar dengan mesin, kaedah navigasi untuk robot mudah alih untuk bergerak dari kedudukan asal ke kedudukan akhir dan pelaksanaan sensor untuk mengaktifkan prestasi robot mudah alih dicadangkan untuk dilaksanakan.

ABSTRACT

This report presents the design and analysis of a mobile robot mechanism for maintenance works in manufacturing environment. The mobile robot is proposed to perform maintenance on MOMAC SM 200 lathe machine. It supposed to clean up the coolant fluid after the machine's operation to prevent any potential damage to the machine. The mobile robot mechanism composed of three basic parts which are mobile platform for locomotion, manipulator arm for manipulation, and end-effector task execution. In order to determine the best performance for task execution, two designs are produced by using SolidWorks 2014 software based on the requirements identified. The designs are analyzed with SolidWorks Simulation software by developing a virtual prototype in a virtual workspace. The simulation is used to perform two analysis which are Motion Analysis and Finite Element Analysis (FEA). In motion analysis, the motion of mobile robot per cycle, where one set of back and forth of the mobile robot's manipulator is considered as one cycle, is analyzed. The time taken for it to perform the motion is taken as a measurement of the performance. Where in FEA, the stresses and strains under internal and external loads is determined. The mobile robot's performance is evaluated based on the result collected. For future prospect of this project development, the following aspects such as obstacles avoidance to prevent the mobile robot from colliding with the machine, navigation method for the mobile robot to move from original position to final position and implementation of sensor to activate the mobile robot's performance is suggested to be undertaken.

DEDICATION

This project is dedicated to my beloved father, Lim Poh Chye, and both of my supportive brothers, Lim Kok Tiong and Lim Kok Yew. Thanks for their continuously support during my study process.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

UTeM	-	Universiti Teknikal Malaysia Melaka
FKP	-	Faculty of Manufacturing Engineering
FYP	-	Final Year Project
FEA	-	Finite Element Analysis
UGVs	-	Unmanned Ground Vehicles
UAVs	-	Unmanned Aerial Vehicles
AUVs	-	Autonomous Underwater Vehicles
CAD	-	Computer Aided Design
VS	-	Versus

CHAPTER 1
INTRODUCTION

The brief information of this project "Design and Analysis of a Mobile Robot Mechanism for Maintenance Works in Manufacturing Environment." is presented in this chapter.

1.1 Background

Industrial robotics plays an important role in manufacturing industries. However, the industrial robots of today are mainly lack in flexibility and are attached in a fixed location. Therefore, mobile robots that are capable of moving around are introduced in manufacturing environment to overcome the limitations in fixed industrial robots. Unlike typical industrial robots, mobile robots with manipulator are not fixed in certain position. Hence, it is possible for the mobile robots to be used in different surrounding and perform various tasks (Dang *et al.*, 2013).

The usage of mobile robots in manufacturing maintenance is still new due to the condition of most maintenance tasks requires great manipulation skills and experiences. But this does not means that mobile robot cannot be used for maintenance purposes. Mobile robots are preferable than human workers in certain cases such as task execution in human inaccessible areas (eg. the backside of manufacturing equipment). Besides, using robots instead of human workers in workplace that might be hazardous is better to prevent in putting human life at risk (Ghazali *et al.*, 2012).

1.2 Motivation

To achieve superior job satisfaction, robots are working together with labour, to undertake the unsafe, exhausting or certain irritating duties and act as a free labour that is able to work in more creative or adaptive manner (Colestock, 2005). Environment with relatively low human accessibility encourages the usage of mobile robots for maintenance and repair (Parker & Draper, 1998). Human workers have higher flexibility but less reliability in performing tasks consistently. While robot are relatively less flexible because it is programed to do task with high reliability. There are less mobile robot are seen to use for maintenance in manufacturing field. Therefore, it motivates to construct a project in designing mobile robot for maintenance with consistent performance and good reliability.

1.3 Problem Statement

In manufacturing industry, lathe machine is used to perform turning operation on cylindrical product that made of metal. During the turning process, coolant is dispersed to prevent the machine from overheating. However, the coolant often contaminates the machine body parts and requires to be cleaned up to prevent potential damage to the machine. This task always done by human after the machine operation is finished. It seems like a simple task to a human but it could be dangerous when the machine malfunction. Thus, it promotes to design a mobile robot to perform this maintenance tasks in this project.

1.4 Objectives

The objectives of this project are:

(a) To design a mobile robot mechanism for maintenance works.

(b) To analyse the performance of the proposed maintenance robot.

1.5 Scope

The purpose of this project is to design a robot that is able to perform maintenance tasks in manufacturing environment. The robot is to be built in mobile state instead of static state. The maintenance tasks that can be done by the mobile robot is strictly limited in manufacturing environment. Maintenance task that focused in this project is to mechanically clean up the fluid.

Furthermore, this project is focusing on designing the proposed robot system before being simulated by a chosen software in order to clarify the performance. The performance index will be evaluated in term of motion performance as well as the ability to perform the maintenance tasks. Obstacle avoidance and navigation methods of the mobile robot are not covered in this project due to time constraint. In addition, the research done in this project is merely fundamental studies in maintenance mobile robot field.

1.6 Report Structure

In Chapter 1, a short introduction regarding on the project is shown. The introduction includes the project background, motivation behind this project, problem statement, objectives, scope of the project and lastly the report structure.

In Chapter 2, the literature review on maintenance mobile robot is written. Related information regarding on the topics are discussed. For example, mobile robot, maintenance work and application of mobile robot in maintenance.

In Chapter 3, methodology involved in this project is illustrated with the aid of flow chart. The methodologies involved are literature review, project planning, mobile robot design, and analysis.

In Chapter 4, the design development of the mobile robot is shown. The concept generation and concept development process are included. In addition, the design tools in developing the drawing is described as well.

In Chapter 5, the analysis that carried out for this project is elaborated. The experiments to be carried out is described in details. The data of the analysis result is discussed.

In Chapter 6, conclusion of this project are made. The most suitable design is opted based on the result of the analysis concluded. Furthermore, suggestion for future work is discussed to improve this project.

CHAPTER 2
LITERATURE REVIEW

This chapter illustrates the basic idea in designing a mobile robot mechanism for maintenance with reference to existing mobile robots application. This project focused on design and analysis of a mobile robot mechanism specifically to perform maintenance tasks in manufacturing industry.

2.1 Mobile Robot

Robotics has attained its greatest success as yet in the field of industrial manufacturing. However, the robots in the industrial field still lacking behind for its mobility. A fixed robot arm is limited by where it is bolted causing the range of motion is restricted. In contrast, mobile robot have the ability to move around throughout the manufacturing plant and is not fixed in one physical location (Siegwart & Nourbakhsh, 2004). The limitations of industrial robots that are either stationary or fixed in certain places had promoted the usage of mobile robot. The use of mobile robot has been awhile. Formerly, people have been controlling mobile robots by using large, heavy and expensive computer systems that were difficult to carry and need to be connected via cable or wireless devices. Nowadays, however, mobile robots can be controlled by using cheaper, smaller and lighter embedded computer systems that are carried on-board the robot (Braunl, 2006).

2.1.1 Classifications of Mobile Robot

Mobile robots can be classified according to the environment travelled. The classifications are as below:

(a) Unmanned Ground Vehicles (UGVs) which are the land or home robots,

(b) Unmanned Aerial Vehicles (UAVs) which are the aerial robots,

(c) Autonomous Underwater Vehicles (AUVs) which are the underwater robots,

(d) Polar robots.

Figure 2.1: PackBot is one of the example of UGV (Source: <http://www.irobot.com/For-Defense-and-Security/Robots/510-PackBot.aspx#PublicSafety> 28/11/14).

Figure 2.2: Camclone T21 UAV is developed for the usage of Smart Skies Project (CSIRO, 2008).

Figure 2.3: Picture of ALTEX AUV being launched in Arctic seas (MBARI, 2002).

Mobile robots can also be classified according to the method used to move. The classifications are as below:

(a) Human-like or animal-like legged robot,

(b) Wheeled robot, and

(c) Tracks.

Figure 2.4: Nao is one of the example of human-like robot (Source: <http://www.aldebaran.com/en/humanoid-robot/nao-robot> 28/11/14).

Figure 2.5: AIBO is a dog-like robot (Sony Corporation, 1999).

Figure 2.6: DuctCleaner Robot uses wheels to move around (LIFA AIR, 2008).

Figure 2.7: Nanokhod uses tracks to perform its locomotion (ESA, 2006).