UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF A WALL CLIMBING ROBOT FOR CLEANING CRUDE OIL STORAGE TANK

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Electrical Technology Engineering (Industrial Automation & Robotics) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor Degree of Electrical Technology Engineering (Industrial Automation & Robotics) (Hons.). The member of the supervisory and co-supervisor is as follow:

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(Mr. Mohd Zaidi Bin Mohd Tumari)

……

(En. Muhammad Syahrani Bin Johal)

ABSTRACT

Cleaning process for crude oil of above ground storage tanks can be dangerous and time consuming. This paper presents a wall climbing mobile robot with permanent magnetic adhesion mechanism which can be used for cleaning process. The architecture of mechanical system is attended to in detail. Through a static and dynamic analysis, permanent magnetic adhesion mechanism is chosen for the robot. The Neodymium magnet N42 type had been choose. The tracked locomotion mechanism and the track belt installed with magnet are used simultaneously. The robot will use MIT Apps Inventor for control the movement of the robot and the operation of the spinning brush. For the whole system control, Arduino Uno will be used.

ABSTRAK

Proses pembersihan minyak mentah tangki simpanan di atas tanah boleh membahayakan dan memakan masa. Kertas kerja ini membentangkan robot memanjat dinding dengan mekanisme magnet melekat kekal yang boleh digunakan untuk proses pembersihan. Seni bina sistem mekanikal di sertakan dalam keadaan terperinci. Melalui analisis statik dan dinamik, mekanisme magnet melekat kekal dipilih untuk robot. Magnet Neodymium N42 jenis telah pilih. Mekanisme untuk pergerakan dan tali pinggang landasan yang dipasang dengan magnet digunakan secara serentak. Robot akan menggunakan MIT Apps Inventor untuk kawalan pergerakan robot dan operasi berus berputar. Untuk kawalan keseluruhan sistem, Arduino Uno akan digunakan.

ACKNOWLEDGMENTS

Syukur Alhamdulilah, first of all, I would like to thank my supervisor, Mr. Mohd Zaidi Bin Mohd Tumari for the guidance and support through the whole project preparation. My appreciation also goes to my family members who support and give a lot of advice from the beginning to the end. Thanks to them for their trust and support to me.

DEDICATIONS

I dedicate this thesis especially to my parents. I hope this achievement will fulfil the dream that you had for me and thank you very much too to all my friends for their support and help in this project.

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CHAPTER 1
INTRODUCTION

This chapter will discuss briefly the project flow from introduction, objectives and problems statement of project. Hence, followed by the scope of work and the description of the methodology. Each sub-topic relates each other in order to make the readers understand about the flow of the project.

1.0 Project Background

The wall climbing robot are designed for purpose to clean the crude oil in the storage tank. It will climb and clean the crude oil on the interior wall. The robot will use in the industry that use tank to store the oil. A wall climbing robot with permanent magnetic adhesion mechanism for inspecting oil storage tank is put forward. The mechanical system architecture is detailed in the paper. Also, tracked locomotion mechanism is applied to the robot. By dynamic and static force analysis of the robot, design parameters about locomotion and adhesion mechanism are derived. In addition, for cleaning processes the robot will using brush. Finally, the control of the robot is implemented by using Android.

1.1 Problem Statement

Wall climbing robot had been developed to increase working efficiency and to make sure worker's safety in various prospective applications, including inspection, painting, blasting and cleaning. Attachment mechanism on walls is one of the most important aspects for developing wall climbing robot. Among the various attachment mechanisms, magnetic mechanism shows to be a good solution for designing a climbing robot, such as in the ship building industry, oil tank storage, and nuclear power plant industry. The safety of human operators is also increased, since these robotic systems allow the supervision of the work from a safe distance. As the environment cannot support much force, the fundamental objective was to make this robot as light as possible and the magnet are strong to stick to the wall.

1.2 Objective

The aim of this project is to develop Wall Climbing Robot to clean the crude oil storage tank with efficiently. This can be accomplished by following these objectives:

a) To develop wall climbing robot to clean oil storage tank.
b) To design mechanical structure, electrical circuit and control for the robot.
c) To implement the magnet as an adhesive to the wall oil storage tank.

1.3 Scope of Project

The robot will climb using the magnet that installed to the wheel. Dc motor gear is needed to move the robot on the wall. For the cleaning process the robot will use DC Motor that will spin the brush. The robot is controlled via bluetooth. The control of the robot is implemented by using Arduino Uno.

a) Mechanical
   - The robot body installed by magnetic track wheel use to climb and clean the interior wall using spinning brush.

b) Electronic
   - the robot will use DC motor for spinning brush, motor driver for move the magnetic track wheel and Arduino for control.

c) Software
   - The robot will use Arduino Software (IDE) and controlled by Android Application called MIT Inventor.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

A literature review is a summary from previous research on a topic. The purpose of the literature review is to convey what ideas and knowledge have been established on a topic and what are the strengths and weaknesses. Literature review has been conducted prior to undertaking this project to obtain the information on the technology available and the methodologies that used by the other researcher on the same time topic around the world. This chapter provides the summary of literature reviews on key topics related to the Wall Climbing Robot.

Now, there has been a lot of wall climbing robots have been produced but different ways of movement and adhesion. These type of wall climbing robot appeared with much kind of method for locomotion, but with the same task. This part will discuss about the Wall Climbing Robot that exists in the industry, their specification and how it functions.

2.2 Previous Project Work

2.2.1 Electrostatic Adhesion

According to Rui Chen and Rong Liu (2013) electrostatic adhesion is an electrically controllable adhesion technology that includes actuating electrostatic charges on a wall surface utilizing a force supply associated with a particular electrode panel. The electrode panel is regularly involved at least two arrangements of independent electrodes at various possibilities. At the point when exchange positive and negative charges are incited on adjoining cathodes, the electric fields set up inverse charges on the wall surface and along these lines cause electrostatic adhesion between the electrode panel and the wall surface. We take note of that the physical instruments of the electrostatic adhesion against conductive divider and dielectric divider are marginally distinctive since the incited charges on the conductive divider are free charges created by electrostatic instigation while that on dielectric divider are polarization charges produced by dielectric polarization. Since the electrostatic grip power against conductive divider is typically much bigger than that against dielectric divider while most wall surfaces on which wall climbing robots work are dielectrics, for example, glass, wood and solid, we focus the interest for the most part on electrostatic attachment against dielectric divider in this study. The robot model proposed in this paper can likewise be connected on conductive wall surface, for example, steel plate. Figure 2.1 shows the principle of Electrostatic Adhesion.

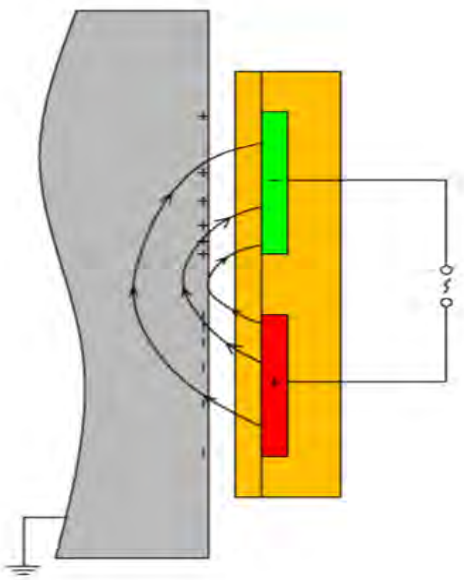

Figure 2.1: Principle of Double Tracked Electrostatic Adhesion

According to Rui Chen et. al. (2013) there are no less than three degrees of flexibility on every leg of a genuine gecko and the body and tail are both extremely adaptable, so the gecko can dexterously get on a wall surface with diverse development modes. In any case, when planning a down to earth gecko motivated robot, we should firstly extract a natural movement model of a genuine gecko, then we can get a bionic kinematic model by some simplification. Also, for reasons of weight lessening and basic control, we encourage streamline our quadruped robot in this study into two symmetrical swing system. The robot consist four parts which are front leg, rear leg, central body and tail. Both the front leg and back leg are involved two adhesive footpads and a linkage with three degrees of flexibility two for autonomous movements of footpads lift and one for connected movement of leg swing. The front leg and back leg are associated by the focal body that is composed with two linkages associated by a turning joint. The relative development between these two linkages is vital for the turning

development of the robot. Meanwhile, the rotating joint on the central body can dispose some internale torque of the moving robot in light of insufficient synchronization of the both servomotors that had been used to achieve the associated development of legs swing. A tail is a standout amongst the most imperative appendages for climbing creatures and robots since it is of advantage to the robot hanging on the divider surface and looking after parity. An inactive tail is altered on this robot for the most part used to oppose the peeling minute brought on by the focal point of gravity balance. Figure 2.2 shows the Principle of Gecko Electrostatic Adhesion.

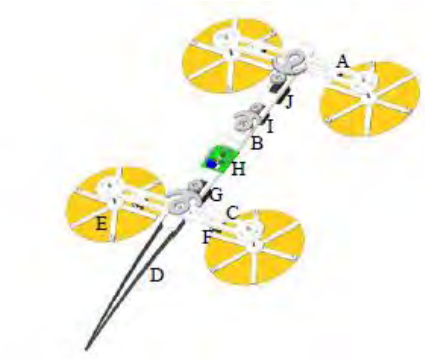

Figure 2.2: Principle of Gecko Electrostatic Adhesion

2.2.2 Passive Suction Cups

The proposed robot moves by crawler-driven system and joins by suction cups. According to Yu Yoshida and Shugen Ma (2010) the robot has one engine, which drives the back pulleys. Several suction cups are installed on the outside surface of the belt with equal intervals and the cups rotate together with the belt. The moving procedure of the robot can be described as follows. Firstly, the robot is connected to a attached by pushing and joining suction cups on the base. Next, the rotation of the crawler belts reaches and join to the wall at the front pulleys. At that point, the guide shafts slide into the guide rail. At the point when a suction cups achieves the back pulleys, it is withdrawn from the wall by the rotation of the belts. A succession of these advancement makes the robot proceed onward the wall to keep attachment. Figure 2.3 shows the principle of Passive Suction Cup.

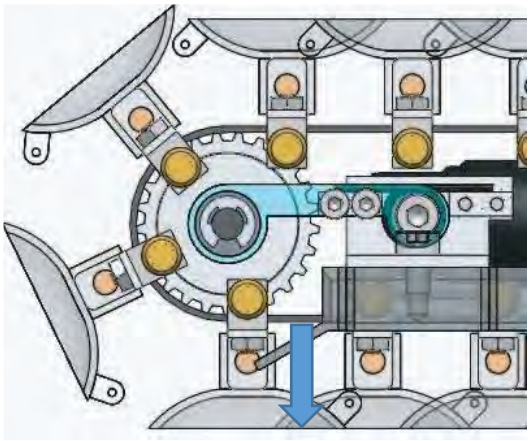

Figure 2.3: Principle of Suction Cups

2.2.3 Vibration Suction Method

According to Qingfeng Hong et. al. (2009) application of electromagnetic adsorption is restricted on the ferromagnetic surface. Suction using molecular force or electrostatic has great versatility on a wide range of surfaces, yet the previous innovation is not develop enough for useful use and the last costs quite a while to assemble the incited charge to shape the adsorption. At this point, suction cup utilizing negative pressure is the most generally utilized strategy as a part of wall climbing robot, however, application of this adsorption strategy needs bigger and heavier structure. Vibration Suction Method (VSM) is a novel negative weight suction procedure. Negative pressure is made and reinforced through the vibration of the suction cup. This suction strategy has favorable circumstances, for example, energy consumption, low noise, high suction stability, and etc. Previous reseaches concentrated for the most part on the component of VSM and a numerical model was fabricated. The rightness of the model was affirmed through trials. Figure 2.4 shows the Vibration Suction Method (VSM).

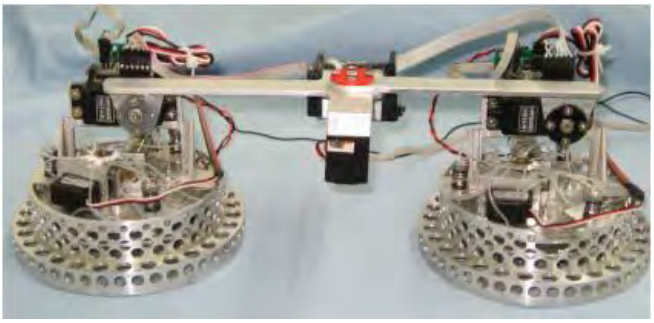

Figure 2.4: Vibration Suction Method (VSM)

2.2.4 Track-Wheel Mechanism

According to Giuk Lee et. al. (2011) The robot is made out of six connections associated by five consistent R-joints. The track-wheel instrument is made by a planning belt track with segmented polymer magnets on the belt. One prismatic (P) joint with a straight spring in the front of the robot keeps up the pressure of the belt while the robot performs moves. The direction is connected at the extremely front end to help the internal move. One driving engine is situated toward the end to pivot the belt for velocity. The fundamental normal for the component is the attractive track-wheel system with five serially associated consistent R-joints. The capacity of the agreeable R-joints can be clarified as takes after. During the internal transitions, the R-joints are turned the other way of the consistence. The R-joints build the preloads on the wall for stable internal transitioning. The R-joints are moved in the direction of the consistence in this way, the robot can perform outer moves consequently without feedback control during external transition. Since obstructions can be overcome by the working guideline of combination of internal and external transitions, obstruction overcoming limits are likewise anticipated.

To achieve the transitioning performances as per the proposed situation, the configuration parameters (DPs) ought to be decided. Four DPs will be planned in Section IV: the required attractive power of the sectioned polymer magnet, the edge of the direction, the solidness coefficients of the torsion springs, and the solidness coefficient of the straight spring. To determine the DPs, analysis of the kinematics and statics ought to be performed. Figure 2.5 shows the Principle of Track-Wheel Mechanism.

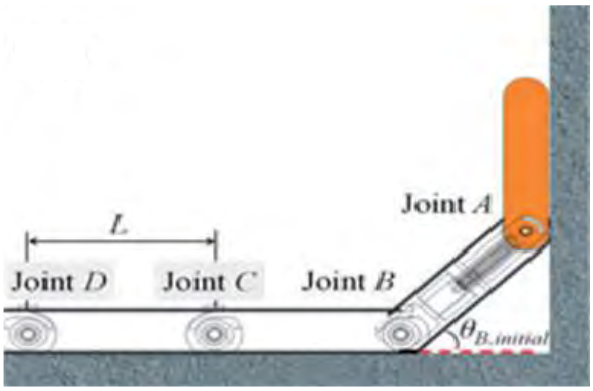

Figure 2.5: Principle of Track-Wheel Mechanism

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

Methodology is a general guideline to solve a problem that includes specific components such as phase, techniques and tools. In this chapter, the flow chart to carry out the project is presented. The flow chart describes in detail about the project development in order to avoid any mistake. This chapter focuses on how the study is being carried out and how the study identifies the desired objectives through the tools selected. The flow chart is important in creating product. It can make the developing process done step by step.

3.2 Project Flow Chart

Flow chart is important in project development. The flow chart can help process of development Wall Climbing Robot model is done step by step. The flow chart in Figure 3.1 shows the work flow of robot development.