MALACCA TECHNICAL UNIVERSITY OF MALAYSIA

Design 3 Finger Gripper for AGV

Thesis submitted in accordance with the requirements of the Malacca Technical University of Malaysia for the Degree of Bachelor of Engineering (Honours) Manufacturing (Robotic & Automation)

By

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APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering(Robotic & Automation).
The members of the supervisory committee are as follow:

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Main Supervisor

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DECLARATION

I hereby, declare this thesis entitled "Design 3 Finger Gripper for AGV" is the result of my own research except as cited in the references.

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ABSTRACT

Generally, robot is a programmable machine that imitates the actions or appearance of an intelligent creature which is usually a human. As robot is use to replace human works, there are many robot application in the world such as in military operation, manufacturing assembly, biotechnology for sample handling, space application, and the others. The designing of the end effector will start with the criteria selection to make sure the selection is the best for the robot application. Since this project is to implement the 3 finger gripper for the autonomous guided vehicle (AGV) in pick and place operation, the design is considering the factor that might be influence to the whole robot design. After that, the process will continue to their control of the end effector (gripper) for the AGV. The process also been done for their programming and finally the manufacturing process to produce the real gripper. The finger gripper design might be operate in several grasping strategy which are spherical grasping and cylindrical grasping. The design of the finger gripper is actually consider to the object of the grasping which are the weight, the size and the appearance of the object (cube, cylinder or prism). So, all of these factor will give the result for the selecting component such as the drives (electric motor, pneumatic or hydraulic system), the size of the gripper and the weight of the gripper.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AGV	-	Autonomous Guided Vehicle
SCARA	-	Selective Compliance Assembly Robots Arms
DARPA	-	Defense Advanced Research Projects Agency
PLC	-	Programmable Logic Controller
LVDT	-	Linear Variable Displacement Transducer
CAD	-	Computer Aided Design
NC	-	Numerical Control
UMDH	-	Utah/MIT Dexterous Hand
R&D	-	Research and Development

LIST OF SYMBOLS

S_f	-	Friction Grip Style Factor
S_e	-	Encompassing Grip Style Factor
F_g	-	Grip Force Required
W_o	-	Object Weight
A_G	-	Acceleration of Gravity
A_o	-	Acceleration of the Object
S	-	Jaw Style Factor
T_g	-	Torque by Gripper
T_o	-	Torque by Object
l_f	-	Finger Length
t_T	-	Total Torque
1 g	-	32 feet/sec^2 (9.75 meters/ sec^2)

CHAPTER 1

INTRODUCTION

Robot is a machine that can do human work. It's also a humanoid machine that can think and act on its own. Robots also define as machine that has self aware. (Gareth Branwyn, 2004) One of the most important areas in the design of robot systems is the design of end effectors. Most of the problems that occur in production are caused by badly designed tooling and not by faults in the robots. There are many different types of gripper available along with the vast number of specialist tools for nut running, arc welding, paint spraying and the others. These grippers are not used solely with robots however, they can be used for fixturing components anywhere in an automated or semi automated line.

There are a difference between the gripper in static robot and the gripper in mobile robot. Since the gripper is use to grip the object, the gripper is using a torque to hold the objects in transferring mode. The torque difference between the gripper in static robot and the mobile robot is the torque that affected by the acceleration of the robot mobile movement for mobile robot. The acceleration which is higher, give higher torque for gripper in mobile robot and need many factor consideration to be met.

In robotics, an end effector is a device or tool connected to the end of a robot arm. The structure of an end effector, the programming and hardware that drives it depends on the task of the robots. If a robot is designed to set a table and serve a meal, then robotic hands, more commonly called grippers, are the most functional end effectors. The same or similar gripper might be used, with greater force, as a pliers or wrench for tightening nuts or crimping wire. In a robot designed to tighten screws, however, a driver-head end effector is more appropriate which gripper is a hindrance in that application so that the driver can be attached directly to the robot arm. The driver can be easily removed and replaced with a device that operates with similar motion, such as a bit for drilling or an emery disk for sanding.

As early as 1875, studies into grasping were being conducted. Reuleaux on 1875 (F. Reuleaux, 1875) proved that a two-dimensional grasps requires at least four point contacts1 to satisfy form-closure. Over a century later in 1978, Lakshminarayana (K. Lakshminarayana, 1978) proved that in three dimensions at least seven point-contacts are required for form-closure grasps. Other early studies of grasping were conducted by Asada and Hanafusa in 1977 (H. Hanafua & H. Asada, 1977) and later by Asada in 1979 (H. Asada 1979). However, it was not until the mid-Eighties that multi fingered hands began to show up in laboratories and the importance of grasping research grew. Within only a few years, grasping papers were appearing in record numbers at almost every robotics and control conference. A few of the more notable papers were Salisbury and Roth (J.K. Salisbury & B. Roth, 1983), and Kerr and Roth (E. Steinitz 1986). In all of these papers, the problem of achieving a good grip on an object was found to be the most fundamental issue underlying the design and control of multi-fingered hands.

End effectors are the tools attached to the end of the robot arm that enable it to do useful work. Most robot manufacturers either do not include end effectors with their robots or include a general purpose gripper to allow you to do simple tasks. Typically, the end effectors must be purchased or designed separately. Grippers are one of the examples of common end effectors. They provide the equivalent of a thumb and an opposing finger, allowing the robot to grasp small parts and manipulate them. Robot end effectors can also be machine tools such as drills, grinding wheels, cutting wheels and sanders. For measuring instruments, the end effectors allow the robot to precisely measure parts by running the arm lightly over the part using a measuring probe or gauge. Laser & water jet cutters of robot end-effectors use high-intensity laser beams or high-pressure abrasive water jets to cut sheet metal or fiberglass parts to shape. While the welding torches of robot end effectors that allow robots to weld parts together. These end effectors are widely used in the automotive industry.

Robots are also being classified by looking for their end effector. For example some robot with welding torches will be classified as robot welding. Gripper generally has two opposing fingers or three fingers like a lathe chuck and the new trends is likely human hand with 5 fingers. The fingers are driven together such that once gripped any part is centred in the gripper. This gives some flexibility to the location of components at the pick up point. For some tasks however where flexible or fragile objects are being handled the use of either vacuum or magnetic grippers is preferable. With these the surface of the gripper is placed in contact with the object and either a magnetic field or a vacuum is applied to hold them in contact.

Compared with a conventional two finger gripper, multi finger hands have inherent advantages: first, they have higher grip stability due to three and more contact points at the object, and second, it is possible to impart movements onto the gripped object by exerting adequate finger forces. Adequate built in sensor equipment permits easy data processing and information gathering which enables the use of robot grippers as exploration tool in unstructured environments. Another kind of application for dexterous hands is found in well structured working areas of industrial manufacturing systems: to perform complex assembly tasks, insertion operations and object manipulations.

1.1 Problem Statement

Grasping an object is the challenging task for a robot. There are many factors that must be considering in designing the finger gripper for the AGV robot for the function in grasping object. Since it will be attach to the AGV through the robot arm, the design must be light and small in order to make the AGV design and robot arm design is estimate at low cost. So, the gripper flexibility is limited for the light weight grasping application. The usage of the component is also being considered since it will reduce or increase the weight of the gripper. The increasing of the weight of the finger gripper will increase the size and weight of the robot arm and the base (AGV). The selecting of the finger gripper type is considering whether to use two opposing fingers or three fingers like a lathe chuck. This gives some flexibility to the location of components at the pick up point. The selecting will affect the grasping strategy in which there are spherical, cylindrical, hook, lateral, palmar and tip. So the problem statement is more in selecting the type of the grasping strategy and the designing for light finger gripper for mechanical design in order to match with the AGV application. The problem statement also consists in selecting and designing the sensor to implement in the gripper.

1.2 Objective of the Research

Since this project is contain gripper and the AGV, this project is purpose to design a 3 finger gripper for AGV application; finally this will produce the design of the finger gripper suitable for pick and place operation and to develop a small and light finger gripper in order to maintain the AGV structure and the robot arm.

1.3 Scope of the Project

This project will come out the design of the finger gripper that will attach to the arm robot of the AGV. The finger gripper is set to do the pick and place task or in the other word is material handling. Other considerations of the design for the finger gripper are the gripper should small and light of weight which the scope of the light weight is not exceed 0.5 kilogram. There is no critically focus on the flexibility of the gripper. And also the application is more to light weight material handling (maximum 1 pound). The project is start with the selecting and draft for the gripper design in the design of gripper procedure. Then the process will come out the conceptual design of the mechanical part and the system design of the finger gripper.

The final result will shoe the detail mechanical and electrical design, and the fabrication or the manufacturing process of the gripper.

1.4 Project Overview

The project activities contain the project understanding, literature review, design of the gripper, conceptual design (mechanical design), system design, detail mechanical and electrical design, and fabrication or manufacturing process. The project understanding is done in two month starting from the received topic from the supervisor which from July to August of 2006. The literature review is start on July 2006 until the due date of April 2007 and the design of the gripper started on August 2006 until March 2007. The conceptual design (mechanical design) started on September 2006 and the system design started on October 2006. These two activities (the conceptual design (mechanical design), and the system design) are ended on November 2006. Next, the project continued with the detail mechanical and electrical design, the processes are start on December 2006 and continue until April 2007. The final stage of this project which is the fabrication or manufacturing process will be done from January 2007 and ended on April 2007 (refer to table 1.1).

Table 1.1: Ghant Chart for Design 3 Finger Gripper Project Activities

Project Activities	2006						2007			
	July	August	September	October	November	December	January	February	March	April
Project Understanding										
Literature Review										
Design of the Gripper										
Conceptual Design (Mechanical Design)										
System Design										
Detail Mechanical & Electrical Design										
Fabrication / Manufacturing Process										

CHAPTER 2

LITERATURE REVIEW

2.1 Robots

A robot is a machine designed to execute one or more tasks repeatedly, with speed and precision (Ulrich R., 1990). The another definition of robot is being giving by Robot institute of America (Gareth Branwyn, 2004) which robot is a reprogrammable, multifunctional manipulator designed to move material, part, tool or specialized devices through various programmed motion for performance of variety task. There are as many different types of robots as there are tasks for them to perform. A robot can be controlled by a human operator, sometimes from a great distance. But most robots are controlled by computer. According to the Japanese Robot Association (Gareth Branwyn, 2004), robot are group by several types which are manually operated manipulator, sequential manipulator, programmable manipulator, numerically control robots (playback robots), sensate robots, adaptive robots, smart robots and intelligent mechatronic robot system. The descriptions are given in the table 2.1.

Table 2.1: Classification of Robot According to Japanese Robot Association (Gareth Branwyn, 2004),

Robot Types	Descriptions
Manually operated manipulator	Machine slaved to human operator
Sequential manipulator	Devices that perform series task in same sequence
Programmable manipulator	Assembly line robotic arm
Numerically control robots (playback robots)	Robot that instructed to perform task through receipt of information on sequence and positioning in form of numerical data
Sensate robots	Robot that incorporate sensor feedback into their circuitry
Adaptive robots	Robot that can change the way they function in response to their environment
Smart robots	Robot that considered to posses artificial intelligent
Intelligent mechatronic robot system	Robot that have the intersection of mechanical, electrical engineering and computer control systems.

Robots are sometimes grouped according to the time frame in which they were first widely used (I.N. Tansel, 2000). First-generation robots date from the 1970s and consist of stationary, nonprogrammable, electromechanical devices without sensors. Second-generation robots were developed in the 1980s and can contain sensors and programmable controllers. Third-generation robots were developed between approximately 1990 and the present. These machines can be stationary or mobile, autonomous or insect type, with sophisticated programming, speech recognition and/or synthesis, and other advanced features. Fourth-generation robots are in the research-and-development phase, and include features such as artificial intelligence, self-replication, self assembly, and nanoscale size (physical dimensions on the order of nanometers, or units of 10^{-9} meter).

Robots also being classify by looking for the robots structure. The jointed arms give many different types of robots such as SCARA robots, (Selective Compliance Assembly Robots Arms), Tricept and Hexapod Robots, Cartesian Co-ordinate Robots, Cylindrical Co-ordinate Robots, and Polar Co-ordinate Robots (Dr Bob, 2004). These robots types different from each other because of their area of access in which each type have their on purpose for certain application such as SCARA robots that specifically designed for peg board type assembly and are heavily used in the electronics industry. They are very stiff in the vertical direction but have a degree of compliance in the horizontal plane that enables minor errors in placement of components to be accounted for. These robots tend to be fairly small and capable of operating very accurately and at high speed. They are used for assembly and machine loading.

Some advanced robots are called androids because of their superficial resemblance to human beings. Androids are mobile, usually moving around on wheels or a track drive. The android is not necessarily the end point of robots evolution. Some of the most esoteric and powerful robots do not look or behave anything like humans. The ultimate in robotic intelligence and sophistication might take on forms yet to be imagined.

2.1.1 Robots Architecture

Robots architecture gives us more clearly about robots. The architecture contains the mechanical structure, actuators, computation and controllers, sensors, communications, user interface, and power conversion unit. The mechanical structure gives the most critical part to be design for the robots. Its include a base that purpose to support the whole mechanical structure of the robots, second is the robots arm which use to move the end of the robots arm to certain location and the third is the end effector which the most important areas in the design of robots systems that purpose to do the robots task. The actuator yet use to make the robots move while the computation and controller is use to program the robots behavior and task required. Than the sensors will be the eyes for the robots and transfer the signal and information that have been detected by the sensor by using the communication line of the robots. Finally the power conversion unit is use to supply the power to the robots system.

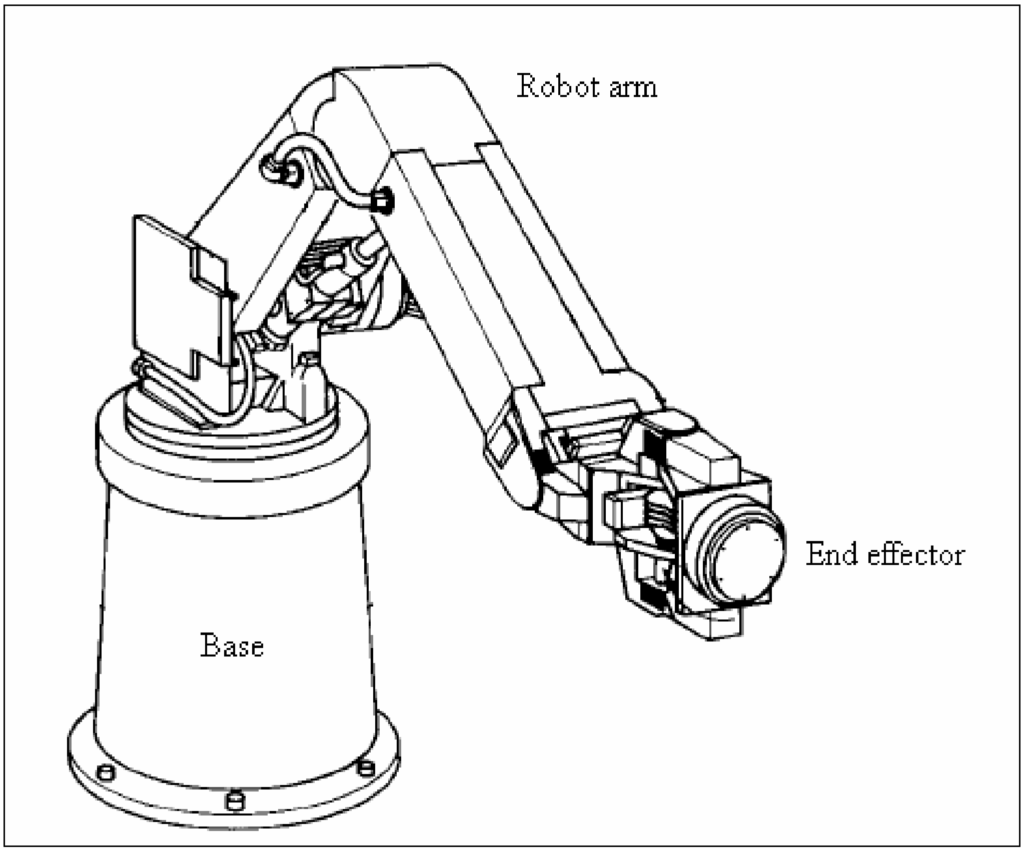

Figure 2.1: General Robot's Mechanical Structure (Dr. Bob, 2004)

2.1.2 Robots Application

Nowadays, robots are being implementing to human work and their applications are widely use especially for replacing human work. There are many causes that make robot replace human works which are to have a quality improvement, to improve the working environment; to get the better cost effectiveness and the robots itself has a flexibility to change. Most robots applications are in manufacturing industry which widely use for assembly and automation (Dr Bob, 2004). Then, robots also being implement in biotechnology which purpose for micro/nano manipulation, sample handling and automated analysis. Robots are also being use in military in order to do the danger task such as search a mine, and spy. Robots nowadays are being use for outer space application for research and investigation such as NASA/DARPA Robonaut project; humanoid robots that can function as an astronaut equivalent for spacewalks. Human operators on earth can control the robot's movements from distance.

2.2 Gripper

Gripper is one of the end effector that being implement to the robots for purpose of to grip objects, hold objects and release objects (Ulrich R., 1990). Gripping establishes a defined position and orientation of the object relative to the robots. Holding the object secures the defined position an orientation relative to the robots during the material transfer route and assembly operation. When releasing the object, the relationship between gripper and object is given up at a specific point.

Not only robots use grippers, they also use various end effectors to perform various tasks. An end effector is a tool that fastens onto the end of a robots arm that allows the robots to perform a specific job. If the robots need to accomplish a different task with another tool, then the entire end effector needs to be replaced with the new end effector. However, if the robots use a conformal gripper that can handle any object, then it will be able to simply pick up a new tool, rather than change out an entire end effector, to do another task. The robots mechanics will be much simpler if a single gripper was used instead of multiple end effectors.