UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF ROBOT ARM FOR STAMPING MACHINE APPLICATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTEM) for the Bachelor Degree of Manufacturing Engineering (Robotics & Automation)

By

NORSYAHIDA BINTI SOFIAN

FACULTY OF MANUFACTURING ENGINEERING

2011
TAJUK: Design and Development of Robot Arm for Stamping Machine Application

SESi PENGAJIAN: 20010/11 Semester 2

Saya NORSYAHIDA BINTI SOFIAN

mengaku membenarkan Laporan 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 berdjarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)

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

☐ TIDAK TERHAD

Alamat Tetap:
No. 17, Jalan Pandah Indah 2,
Taman Pandan Indah,
55100 Kuala Lumpur.

Tarih: 19 Mei 2011

Disahkan oleh:

PENYELIA PSM

DR. ZAMBERI BIN JAMALUDIN
Head Of Department (Robotic & Automasi)
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka

01/06/2011

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

I hereby, declared this report entitled “Design And Development Of Robot Arm For Stamping Machine Application” is the results of my own research except as cited in references.

Signature : ...........................................
Author’s Name : NORA YAHIA BINTI SOHIAN
Date : 19 Mei 2011....................................
APPROVAL

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

Supervisor
DR. ZAMBERI BIN JAMALUDIN
Head Of Department (Robotic & Automation)
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka
ABSTRAK

ABSTRACT

Projek Sarjana Muda (PSM) or Final Year Project is an academic research regarding research field that is compulsory for each of final year student of Universiti Teknikal Malaysia Melaka (UTeM), before being awarded a degree. The purpose of PSM is to enhance student’s knowledge and capability to complete the task given within academic research in order to produce a productive and competent engineer. In this paper, a Robot Arm for Stamping Machine has been designed and fabricated. Robot arm is widely used in the manufacturing system in the world. The robot arm is used to perform various tasks such as pick and place, and welding. This robot is being manufactured in order to eliminate the use of man power in the manufacturing field. Conceptually, for this project, the robot is design and simulate within the work environment virtually. The robot is design based on the pick and place concept. This robot is used to loading and unloading parts onto the stamping machine. The designing process will be conducted using CATIA software because it is easier to construct the body of the robot in the software. After adjustment had made, then the design will be transferred to the Workspace software. Then, the robot will be created according to the joints and also develop the robot’s work environment. Final stage is simulating the robot in the required situation. This is done by connecting the entire possible signal to construct the desired system. Lastly, the efficiency and accuracy of the robot will be analyzed
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF ROBOT ARM FOR STAMPING MACHINE APPLICATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTEM) for the Bachelor Degree of Manufacturing Engineering (Robotics & Automation)

By

NORSYAHIDA BINTI SOFIAN

FACULTY OF MANUFACTURING ENGINEERING

2011
ACKNOWLEDGEMENT

I would like to express my gratitude to all those who gave me the possibility to complete this project. Especially, I am obliged to my beloved parents, who are always be there for giving me support, strength, and great help in difficult times. Both of them are my source of inspiration that lead me to working hard in gaining knowledge. I also would like to share this moment of happiness with all my friends that helped me in completing this project in one way or another. This research has been done at Industrial Automation Laboratory at Universiti Teknikal Malaysia Melaka.

I am deeply indebted to my supervisor, Mr Dr. Zamberi bin Jamaludin from Manufacturing Engineering Faculty, UTeM for all his guidance and help throughout the entire time of this project being carried out. Without her wise counsel, advice and stimulating support, this project might not go well as it is.

Last but not least, I wish to acknowledge to all persons who involve in supporting, advising, and assisting neither directly nor indirectly for my final year project. Thank you so much.
# TABLE OF CONTENT

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstrak</td>
<td>i</td>
</tr>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>iii</td>
</tr>
<tr>
<td>Table of Content</td>
<td>iv</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>viii</td>
</tr>
</tbody>
</table>

## 1. INTRODUCTION

1.1 Problem Statement                      | 3    |
1.2 Objectives                              | 4    |
1.3 Scope                                   | 4    |
1.4 Benefits of the Project                 | 5    |

## 2. LITERATURE REVIEW

2.1 Introduction to robot                   | 5    |
2.2 Type of Robot                           | 6    |
2.2.1 Industrial Robot                      | 6    |
2.2.1.1 Cartesian robot/Gantry robot        | 8    |
2.2.1.2 Cylindrical robot                   | 9    |
2.2.1.3 Spherical/Polar robot               | 10   |
2.2.1.4 SCARA robot                         | 10   |
2.2.1.5 Articulated robot                   | 11   |
2.2.1.6 Parallel robot                      | 11   |
2.3 Robot Anatomy                           | 12   |
2.3.1 Mechanical Structure                  | 12   |
2.3.1.1 Frame                               | 13   |
2.3.1.2 Locomotion                          | 15   |
2.3.1.3 Gripper                             | 16   |
6.2 Suggestion 55

REFERENCES 56

APPENDICES
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Gantt chart for PSM 1</td>
<td>39</td>
</tr>
<tr>
<td>3.2</td>
<td>Gantt chart for PSM 2</td>
<td>40</td>
</tr>
<tr>
<td>4.1</td>
<td>Machine capacity</td>
<td>46</td>
</tr>
<tr>
<td>4.2</td>
<td>Pugh’s Method</td>
<td>51</td>
</tr>
<tr>
<td>5.1</td>
<td>Cycle time table</td>
<td>54</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

1.1 Current method for material handling 2

2.2 Industrial robots assemble a vehicle underbody 7
2.3 Cartesian robot 9
2.4 Cylindrical robot 9
2.5 Spherical/Polar robot 10
2.6 SCARA robot 10
2.7 Articulated robot 11
2.8 Parallel robot 11
2.12 Extruded aluminum 14
2.13 A robot with 2-wheeled development platform 15
2.14 A 4-legged walker robot 16
2.15 Comparison between internal and external gripper 17
2.16 Parallel gripper 17
2.17 Angular gripper 18
2.18 Toggle Gripper 18
2.19 Illustration of spur gears 19
2.21 Illustration of rack 20
2.23 Illustration of face gear 20
2.24 Illustration of worm gear 20
2.26 Cutaway view of a ball bearing 21
2.27 Cutaway view of a roller bearing 22
2.28 Thrust Ball bearing 22
2.30 AC motor 23
2.31 Basic operation of an AC induction motor 24
2.32 DC motor 25
2.33 DC motor operation 26
2.34 Stepper motor 28
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.35</td>
<td>Stepper motor control</td>
<td>29</td>
</tr>
<tr>
<td>2.36</td>
<td>Universal motor</td>
<td>30</td>
</tr>
<tr>
<td>2.37</td>
<td>Chopper and Phase-angel for Universal motor</td>
<td>31</td>
</tr>
<tr>
<td>2.38</td>
<td>PLC</td>
<td>32</td>
</tr>
<tr>
<td>2.39</td>
<td>The PLC system</td>
<td>33</td>
</tr>
<tr>
<td>3.1</td>
<td>Overall Flow chart of methodology</td>
<td>36</td>
</tr>
<tr>
<td>4.1</td>
<td>The factory layout</td>
<td>47</td>
</tr>
<tr>
<td>4.2</td>
<td>First Design</td>
<td>48</td>
</tr>
<tr>
<td>4.3</td>
<td>Second Design</td>
<td>49</td>
</tr>
<tr>
<td>4.4</td>
<td>Third Design</td>
<td>50</td>
</tr>
<tr>
<td>4.5</td>
<td>The robot</td>
<td>52</td>
</tr>
<tr>
<td>4.24</td>
<td>Connection to controller board</td>
<td>95</td>
</tr>
<tr>
<td>4.25</td>
<td>Connection for external brush motor driver.</td>
<td>96</td>
</tr>
<tr>
<td>4.26</td>
<td>SPG50-180K model of DC geared motor</td>
<td>97</td>
</tr>
<tr>
<td>4.27</td>
<td>Hand hold controller layout</td>
<td>98</td>
</tr>
<tr>
<td>4.28</td>
<td>Motor driver layout</td>
<td>100</td>
</tr>
<tr>
<td>4.29</td>
<td>Connection to motor driver board</td>
<td>101</td>
</tr>
<tr>
<td>4.30</td>
<td>60JB60123600-30K model of DC geared motor</td>
<td>102</td>
</tr>
<tr>
<td>4.31</td>
<td>Installation of controller board and motor driver board</td>
<td>102</td>
</tr>
<tr>
<td>5.1</td>
<td>The entire system</td>
<td>53</td>
</tr>
</tbody>
</table>
**LIST OF ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>Acrylonitrile Butadiene Styrene</td>
</tr>
<tr>
<td>AC</td>
<td>Alternative current</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog-to-Digital Converter</td>
</tr>
<tr>
<td>BJT</td>
<td>Bipolar Junction Transistor</td>
</tr>
<tr>
<td>CCW</td>
<td>Counter Clockwise</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>CW</td>
<td>Clockwise</td>
</tr>
<tr>
<td>DAC</td>
<td>Digital-to-Analog Converter</td>
</tr>
<tr>
<td>DC</td>
<td>Direct current</td>
</tr>
<tr>
<td>EMI</td>
<td>Electromagnetic Interference</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/Output</td>
</tr>
<tr>
<td>IC</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>JFET</td>
<td>Junction gate Field-Effect Transistor</td>
</tr>
<tr>
<td>JIRA</td>
<td>Japanese Industrial Robot Association</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>LION</td>
<td>Lithium Ion</td>
</tr>
<tr>
<td>MSD</td>
<td>Musculoskeletal disorder</td>
</tr>
<tr>
<td>NiCD</td>
<td>Nickel Cadmium</td>
</tr>
<tr>
<td>NiMH</td>
<td>Nickel Metal Hydride</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>PIC</td>
<td>Programmable Integrated Circuit</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>PM</td>
<td>Permanent Magnet</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl chloride</td>
</tr>
<tr>
<td>PWM</td>
<td>Pulse Width Modulation</td>
</tr>
<tr>
<td>RAM</td>
<td>Random-access memory</td>
</tr>
<tr>
<td>SR</td>
<td>Switched Reluctance</td>
</tr>
</tbody>
</table>
Today's robots are designed and have been developed to serve the humans. Jobs which require speed, accuracy, reliability or endurance can be performed far better by a robot than a human. In manufacturing, they are used for welding, riveting, pick and placing, scraping and painting. They are also deployed for demolition, fire and bomb fighting, nuclear site inspection, industrial cleaning, laboratory use, medical surgery, agriculture, forestry, office mail delivery as well as a myriad of other tasks (Appleton, 1987).

The most widely used of robot is the industrial robot. An industrial robot is officially defined by ISO as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The field of robotics may be more practically defined as the study, design and use of robot systems for manufacturing (a top-level definition relying on the prior definition of robot). Typical applications of robots include welding, painting, assembly, pick and place, packaging and palletizing, product inspection, and testing, all accomplished with high endurance, speed, and precision. There are a lot of industrial applications that require the use of robot-arms in order to move objects (pick and place behavior). In these applications, robot-arms have to be programmed in a well-known environment, to avoid possible collisions between tools and objects.

Therefore, this project is developed because of the high demand of the pick-and place robot in the manufacturing. Since, Malaysia is expanding the manufacturing sector; the
be project is reliable and appropriate to be exploited. Hence, a robot arm for the stamping machine application is chose to fulfill the need of the industrial robot application.

1.1 Problem statement:

Madetill(M) Sdn Bhd, Balakong produces automotive component for Perodua and Toyota. The core process in the factory is stamped metal sheet. There are various process related to stamped metal such as forming, bending, piercing and blanking. The stamping machines range from 60 ton to 250 ton.

Currently, these processes are performed manually. It is desired that an automated process is designed and develop for loading and unloading of material onto stamping machine based on pick & place concept. This robot is used to replace operator for operating the stamping machine. The proposed mechanism will utilize programmable logic circuit (PLC) to function.

Figure 1.1 Current methods for material handling
1.2 Objective:

This project is aiming several goals that are intended to be attained throughout the completion of the work. It is roughly similar to purpose of aim, the anticipated result which guides reaction, or an end, which is an object, either a physical object or an abstract object, that has intrinsic value. It is desired to reach the goals within a given time. Below are the objectives of this particular project:

i. To design a robotic arm,
ii. To simulate a robotic arm for material handling system,
iii. Develop an automated material handling system via simulation

1.3 Scope

In order to build an operational robot that can be used to perform the pick and place process, scopes are required to assist and guide the growth of the project. The scope should be acknowledged and intended to achieve the objectives of the project successfully on time. The following are the scope of the project:

i. Design a articulated robot for a pick and place application in a stamping machine application.
ii. Construct the mechanism between the actuators and the control system.
iii. Analyze system performance such as the positioning accuracy and robot motion efficiency.
1.4 Significant of Studies

Robot is needed for a variety of task in this challenging world. There are a few general applications of the robot that is very useful to human as below:

i. The task that human cannot perform such as space and underwater exploration.

ii. The task that humans do not want to perform. For example: repetitive precision-boring, tedious work such as assembly line work, ship cleaning.

iii. The tasks that is dangerous for humans such as chemical-related work, hot work, explosive material manipulation and other conditions harmful to humans.

1.5 Overview of Report

This report consists of Chapter One that explains and defines the problem statement, objectives and scopes of this project. The following Chapter Two describes literature review on the types of robot, the robot anatomy and the electrical components within the robot. Then Chapter Three will illustrate the methodology to be followed.
CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Robots are capable of performing many different tasks and operations precisely and do not require common safety and comfort elements human needs. However, it takes much effort and many resources to take a robot function properly. In the fast paced world now, only the companies that made industrial robots are remain in the market (such as Adept Robotics, Fanuc Robotics, and Staubli Robotics). Early predictions about the possible number of robots in industry never materialized, because high expectations could not be satisfied with the present’s robots. As a result, although there are many thousands of robots in industry, they have not overwhelmingly replaced workers. They are used where they are useful. As long as they are designed properly for the intended purpose, they are very useful and will continue to be used. (K. H. Low, 2007)

The Robot Institute of America (1979) had appointed a widely-accepted standard for defining a robot which is “A robot is a re-programmable, multi-function manipulator designed to move materials, parts, or specialized devices through variable programmed motions for performance of a variety of tasks”.

However, this definition is restrictive in that it includes neither mobile robots nor the type of science fiction character we would call an android. Therefore, McKerrows (1986) had come out with more comprehensive definition of robot. He defines that robotics is the discipline that involves:

i. The design, manufacture, control, and programming of robots.
ii. The use of robots to solve problems.

iii. The study of the control processes, sensors, and algorithms used in humans, animals, and machines.

iv. The application of these control processes and algorithms to the design of robots.

2.2 Types of robot

There are no precise definitions of robot because it depends on how one described and their opinion. Therefore, as general, robot can be defined as a machine or mechanical device designed to various functions, and they appear in a variety of forms, can sense and react to its environment, and also can be programmed and reprogrammed.

As robots grow in number and complexity, they are being more widely used in industry. Most often, they are used to perform repetitive tasks. Robot can be manufactured in a wide range of sizes and can therefore handle much larger tasks than a human can. In addition, robots are useful in environments that are unpleasant or dangerous for people to work in. In real world application of the robot, the robot can be separated into two big categories which are (Craig, 2005):

i. Industrial robot

ii. Humanoid robot

However, this project only focuses on the application for the industrial robot which is in high demand. This means, many researcher are trying to develop or improved the functionality of the existing robot or trying to develop a more efficient and powerful industrial robot.

2.2.1 Industrial Robot

The International Organization for Standardization (ISO) has officially defined an industrial robot as an automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes. Most industrial robots would fall in
the category of robotic arms, as implied by the term manipulator in this definition. Other industrial robots are built to be much more flexible about the orientation of the object on which they are operating or even the task that has to be performed, which the robot may need to identify. (Craig, 2005). Figure 2.1 shows the example industrial robot in manufacturing system.

![Image](image.jpg)

**Figure 2.1:** Industrial robots assemble a vehicle underbody (New World Encyclopedia, 2008).

To be effective in a variety of applications, robots must meet several criteria, which are adaptable for many applications, reliable, easy to program, safe to operate, and capable of working in hazardous places. The rate of production of many of today’s products would not have been possible without the use of robot technology. Some of the qualities that make industrial robot commercially and technologically important are (Groover, 2008, 2008):

a) Robots can be substituted for humans in hazardous or uncomfortable work environments.

b) A robot performs its work cycle with a consistency and repeatability that cannot be attained by humans.

c) Robots can be reprogrammed. When the production run of the current task is completed, a robot can be reprogrammed and equipped with the necessary tooling to perform an altogether different task.

d) Robots are controlled by computers and can therefore be connected to other computer systems to achieve computer integrated manufacturing.
Typical industrial robots do jobs that are difficult, dangerous or dull. They lift heavy objects, paint, handle chemicals, and perform assembly work. They perform the same job hour after hour, day after day with precision. They do not get tired and they do not make errors associated with fatigue and so are ideally suited to performing repetitive tasks. The major categories of industrial robots by mechanical structure are (ROVer Ranch, 2003):

a) Cartesian robot /Gantry robot
b) Cylindrical robot
c) Spherical/Polar robot
d) SCARA robot
e) Articulated robot
f) Parallel robot

Hence, the concept of the above robot categories is discussed in the following section. These are robot types that are constantly used throughout the world.

2.2.1.1 Cartesian robot /Gantry robot

It is a robot whose arm has three prismatic joints, whose axes are coincident with a Cartesian coordinator. Used for pick and place work, application of sealant, assembly operations, handling machine tools and arc welding. The large Cartesian robots, which resemble overhead gantry cranes, are called gantry robots. Figure 2.2 illustrate the Cartesian robot concept with symbol “d₁, d₂, d₃” indicates the prismatic joints.
2.2.1.2 Cylindrical robot

It is a robot whose axes form a cylindrical coordinate system. Used for assembly operations, handling at machine tools, spot welding, and handling at die-casting machines. A typical cylindrical robot has a rotary joint ($\theta_1$) and two prismatic joints ($d_2$ and $d_3$) in order, as seen in figure 2.3. The work-space is actually between two concentric cylinders of the same height. The annular volume between the two cylinders is the zone in which the robot arm may operate, between fully retracted and fully extended.