BORANG PENGESAHAN STATUS TESIS

JUDUL: **MEREKABENTUK DAN MENHASILKAN ROBOT BERJALAN YANG MENGGUNAKAN SILINDER PNEUMATIK**

SESI PENGAJIAN: 2007/ 2008

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DESIGN AND FABRICATION OF PNEUMATIC WALKING ROBOT

NORSYAMSUL SYAZWAN BIN MOHD NUJI

A report submitted in partial fulfilment of the requirements
for the award of the
Diploma of Mechanical Engineering

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

NONEMBER 2007

SUPERVISOR DECLARATION

I hereby declare that I have read this project report and in my opinion this project report is sufficient in terms of scope and quality for the award of the Diploma of Mechanical Engineering.

Signature : ....
Name of Supervisor : Mohd Fadzil Faisae bin Ab Rashid
Date : 21 NOV 2007

DECLARATION

I declare that this report entitled "DESIGN AND FABRICATION OF PNEUMATIC WALKING ROBOT " is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....
Name : Norsyamsul Syazwan bin Mohd Nuji
Date : 20/11/2007

DEDICATION

This dedication goes to, first of all my beloved family which is my father Mohd Nuji bin Nor, my mother Sharifah bte Semail, my brother Norsyamsul Harmizi bin Mohd Nuji. Not forget to all my family members for their support and advises. Special thanks also to all my friends that always support and encouragement towards this project. Thanks to all for your enduring patience, unfailing support and continuous encouragement.

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My fellow undergraduate student should also be recognised for their support. My sincere appreciation also goes to all my colleagues and others who have provided me with assistance at various occasions. Their view and tips are valuable and useful indeed. Unfortunately, it is not possible for me to state their entire name in this limited space, only a very thank you wishes I can give to you all. Not to forget I am very grateful to all my family members for their support, advises and motivation.

ABSTRACT

This report is based on the study about final year project, design and fabrication of pneumatic walking robot. The objective is to design a four legs robot using pneumatic actuator and fabricate the robot structure .In this project, the use of programming logical control software as robot legs motion controller and using pneumatic actuator to move the legs robot. This project need a study about an existing robot in order to produce a moving four legs robot, that only use four actuators because an existing four legs robot use many actuators. Normally eight actuators are use in designing a moving four legs robot. By creative thinking, four legs robot can be design for only four actuators. The method used is divided into two chapters.

The first method is by using the *SolidWork* software to design the robot's legs and body. The second method is verify the way of robot's motion tests by making a ladder diagram program with the Programming Logical Control (PLC) software. Lastly, a four legs robot's model is produced. The problems encountered were discussed.

ABSTRAK

Laporan ini adalah hasil daripada kajian dalam menyiapkan projek tahun akhir, merekabentuk dan penghasilan robot berjalan yang menggunakan pneumatik silinder. Objektif untuk projek ini ialah merekabentuk robot empat kaki yang menggunakan pneumatik silinder dan membikin badan robot. Dalam projek ini penggunaan perisian *"Programming Logical Control"(PLC)* sebagai pengawal gerakan kaki ***robot*** dan menggunakan silinder untuk menggerakkan kaki robot.Projek ini memerlukan penyelidikan tentang robot yang sedia ada untuk menghasilkan robot empat kaki yang boleh bergerak hanya menggunakan empat pneumatik silinder kerana kebanyakan robot empat kaki yang sedia ada menggunakan lapan silinder. Projek ini memerlukan pemikiran yang kreatif untuk mereka bentuk kaki robot supaya ia hanya dapat menggunakan empat penggerak sahaja.. Kaedah yang digunakan dalam menyiapkan projek ini terbahagi kepada dua bahagian.Pertama ialah mereka bentuk kaki dan badan robot dengan menggunakan perisian *SolidWork*. Kedua ialah menjalankan percubaan cara robot berjalan dengan membuat program ladder diagram menggunakan perisian "Programming Logical Control" (PLC). Akhir sekali, model robot empat kaki dihasilkan. Masalah-masalah yang dihadapi semasa menjalankan projek ini dibincangkan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The final year project title is design and fabrication of pneumatic walking robot. The project involves analysis about how four legs moving or walking carry body with stable. The field of robotic is very interesting to anyone curious about how organisms (including people) interact with the "real world". A true robot kit allows to get a closer understanding of how human animals senses work, and how memory (programming) can be used for specific tasks. Some do both and others only one of these things, but either is sufficient to separate a real robotic kit from a toy.

A real robot can move along a programmed path .It is also reacting with its environment using sensors. A real robot can also do a combination of the above tasks. For example, roaming robot could be programmed to wander about a room and change its course if a sensor hits an object, and to the right if the left sensors does.

In the robotic community ,there are two basic robotic architectures; analytical approaches (Donner,1987) and biologically inspired approaches (Brooks,1986b).the merging of these two types of architectures generates a third group of approaches-hybrid approaches that integrate the characteristics of both analytical and biologically inspired architectures (Nicolescu and Mataric, 2002).The analytical approaches generally required a mathematical model of the system and are relatively less computationally intensive.

Mataric 2002 stated that this type of approach employs general and bottom-up philosophies that support a certain degree of freedom from interpretation and computations. It can also tolerate a certain extend of false sensor information. Bekey (2000) stated that robotic control mechanisms could get more inspiration from the biological world as it exhibits greater reliability and efficiency despite the complexity of the world itself.

Robot can be categorized into two group based on their method of locomotion; wheeled robot and legged robots. Legged robots have received increasing interest as they have some advantages that are less easily achieved by wheeled robots, such as navigating in an uneven terrain. Legged robots can further be sub-classified into three major groups;

i. Biped robots that have two legs (the bipedal walking robot of Collins and Ruina, 2005).

ii. Quadruped robots that have four legs (BISAM by Iig and Berns, 1998).

iii. Insectoid robots that have more than four legs (Boadicea by Binnard, 1998).

1.2 Project Objective

1.2.1 General Project Objectives

Diploma final year project objective is to practice the knowledge and skill of the student that have been gathered before in solving problem using academic research, to born an engineer that have enough knowledge and skill. This project also important to train and increase the student capability to get know, research, data gathering, analysis making and then solve a problem by research or scientific research.

The project also will educate the student in communication like in a presentation and educate them to defend their research in the presentation. The project also will generate students that have capability to make a good research report in thesis form or technical writing. This project also can produce and train student to capable of doing work with minimal supervisory and more independent in searching, detailing and expanding the experiences and knowledge.

1.2.2 Specific Project Objectives

I. To design four legs walking robot using pneumatic system

II. To fabricate the robot structure

1.3 Scope of project

The scope of this project is restricted to four legs robot to move the robot body. A pneumatic actuator is used to move each of robot legs. The pneumatic actuator will be controlled by the Programming Logical Control to move the robot legs. This project also involves fabrication and assembly the robotic component.

1.4 Project Planning

According to the Gantt chart from figure 1.1, the project briefing started followed by collecting literature review. These include search for a project title and gathering raw data via internet, book and other source. The planning process is from week 1 until a week 7.

After that, this project was continued with design and measurement process at a week 3 and 4. This is started with sketching 3 types of pneumatic walking robot and then identifies the best design from analysis. Next, design the pneumatic walking robot that was chosen using solid work software with actual dimension.

Then the material that will use must be suitable and ease to get. The specification when choosing a material is includes strength, durability and light. This is important for fabrication process.

The fabrication was started after finish a cutting material. This process consist fabrications to part that have been designed by follow the dimension using various type of manufacturing process. The manufacturing process is determined from a literature review.

When the fabrication was finish the robot must be test using Programming Logical Control (PLC) for get to know the robot can move required or not. The ladder diagram must be draw for using programming logical control.

Evaluation stage has been implemented after fabrication stage. The evaluation is by considering the strength, durability, safety, and workability of the robot. During the evaluation, if problem occur such as malfunction, modification will be done.

Next task is the final report writing and final presentation preparation. The report is guided by UMP Thesis writing guided and also the guidance of my supervisor. Due to all problems had when doing the project the management has agreed to extend the time to submit the report and the presentation. All the task is scheduled to take about fourteen weeks overall.

1.5 Summary

This chapter has been discussed generally about project background, problem statement, question which has been formulate from the problems, objective of the project and scope of the project in order to achieve the objective as mentioned.

1.6 Gantt chart

Project Activity	Weeks														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature Review	■	■	■	■	■	■	■								
Analysis & Sketching		■	■												
Design & Drawing using solid work			■	■	■										
Finalize Design					■	■									
Presentation 1								■							
Material preparation					■	■									
Fabrication & Assembly								■	■	■	■	■			
PLC Programming											■	■			
Testing												■	■		
Evaluation & Improvement									■	■	■	■			
Report writing					■	■	■	■	■	■	■	■			
Presentation														■	
Final report check & submit													■	■	

Figure1.1: Gantt chart

CHAPTER 2

LITERATUR REVIEW

2.1 Introduction

The word 'robot' came into English language in 1923 from the translation of a 1921 Czech play R.U.R (Rossum's Universiti Robot) by Karel Capek (Capek 1975).It is derived from the Czech word 'robota' meaning slave labour.The 'robot' in the play are designed to replace human worker and are depicted as very efficient and indistinguishable from human except for their lack of emotion.Robotic is set to become a revolution in the way we live. The next 20 years will see a boom in robotics. Each type of design has their advantages and disadvantages. Nowadays, there are different types of walking robot design such as;

i. Two leg robot

ii. Four leg robot

iii. Eight leg robot

iv. Using pneumatic actuator

v. -Using hydraulic actuator

vi. -Using electric motor

2.2 Technical Review

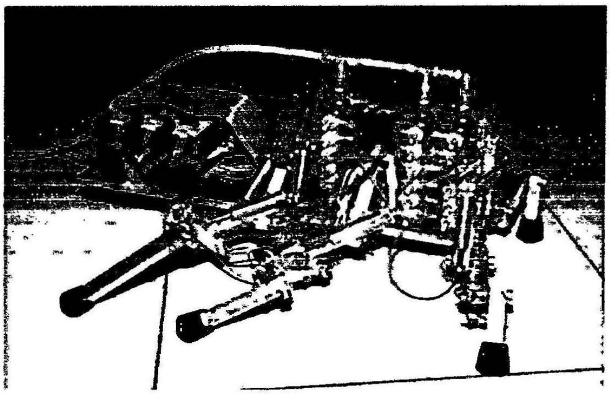

Figure 2.1: Six legs robot

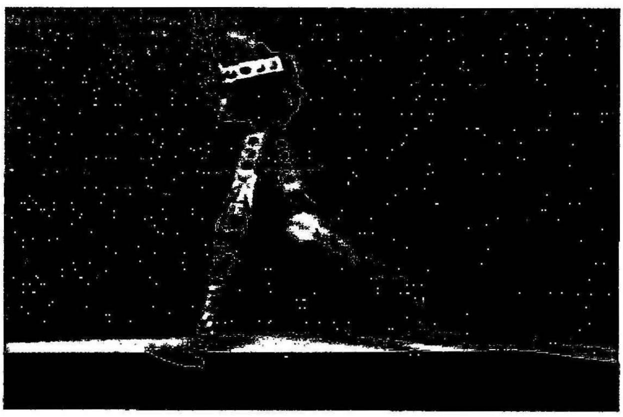

Figure 2.2: Two legs robot

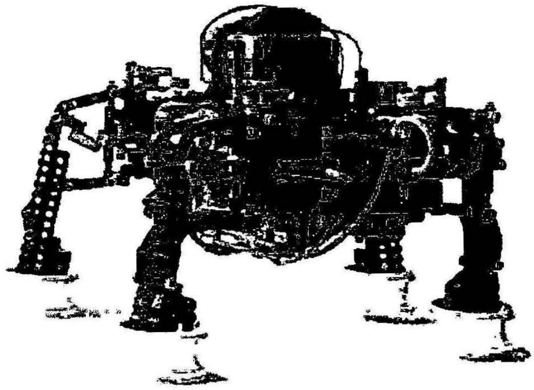

Figure 2.3: Four legs robot

Genghis, the six legged walking robot

As mentioned previously, Genghis was a legged robot in which Brooks (1989) implemented the idea of SA to enable the robot walk. Genghis is a six legged robot, build to walk on uneven terrain.

Each leg of Genghis was manipulated by two motors. The first one was used to move a leg in a forward or backward motion, while the second one was used to move a leg in an up or down motion. This resulted in each leg having two degrees of freedom (DOF), Referred to as "Forward-Backward" and "Up-Down". A picture of Genghis is shown in figure 1.4. Genghis has a wide base and low centre of gravity. This is to be contrasted with the experimental robot employed in this thesis which had four legs, a narrow base, high centre of gravity and multi-jointed legs, each with 3 degrees of freedom (i.e. "ankle"," knee" and "hip" joints).

Only static balance was implemented in Genghis, which is to be contrasted with the experimental robot that deals with both static and dynamic balance. Behaviors of Genghis were composed of; stand up, simple walk, force balancing, leg lifting, whiskers, pitch stabilization, prowling, and steered prowling.

Behaviors stand up has the lowest priority, which means that this behavior will be activated if no other behavior is triggered. Behaviors simple walk enable the robot to carry out a "tri-pod" type walking, i.e. front and back legs of one side and the middle leg of the other side being on the ground to support the robot while the rest of other legs are off ground and moving forward.

Behavior force balancing and pitch stabilization will be active when the robot needs to move its leg over an obstruction. Behavior whiskers, prowling and steered prowling were used to deal with obstacles and path following. Overall, interaction of this behavior generated emergent behavior of an insect-like motion.

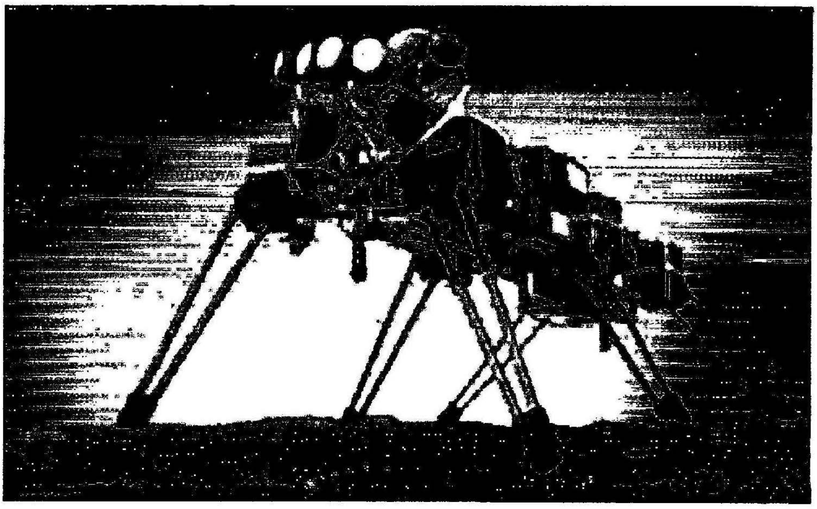

Figure 2.4: Genghis (brooks, 1989)

2.3 Basic Part

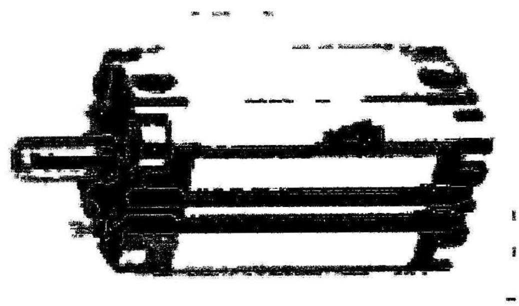

Figure 2.5: Pneumatic actuator

2.3.1 Pneumatic actuator

Pneumatic actuators are powered by compressed air. They offer rapid point-to-point linear positioning and have a high load-carrying capacity relative to their size; they are also cheap, mechanically simple and easy to maintain.

Pneumatic actuators generally operate at air supply pressures of at least 6 bars. The air released into the atmosphere at the exhaust still has a relatively high pressure - but there is no practical way to recycle it.

2.3.2 Tubing or Hose

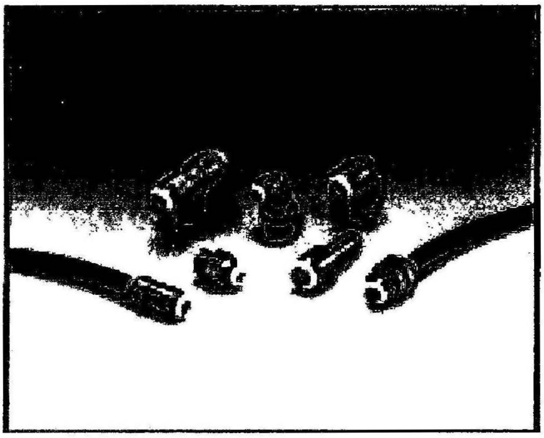

Figure 2.6: Hose

Function of tube to join air from supply to actuator. The working pressure is up to 25 bars, and working temperature is -25 to +100 Celsius. This tube has much diameter size.

2.3.3 Air filter

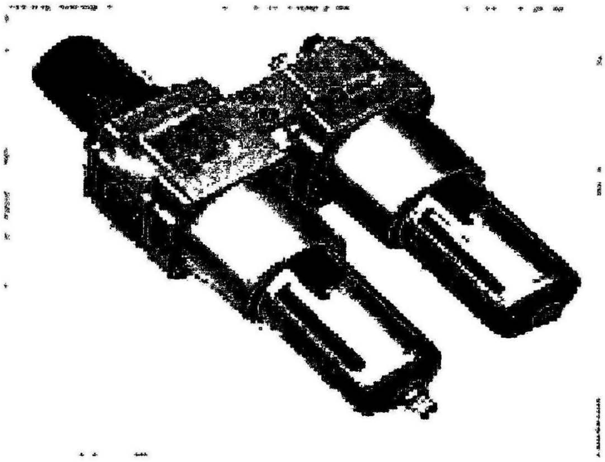

Figure 2.7: Air filter

Function of air filter to separate air from stain during air supply to actuator .Its normally using between tube and valve for guard the valve from stain.

2.3.3 Valve

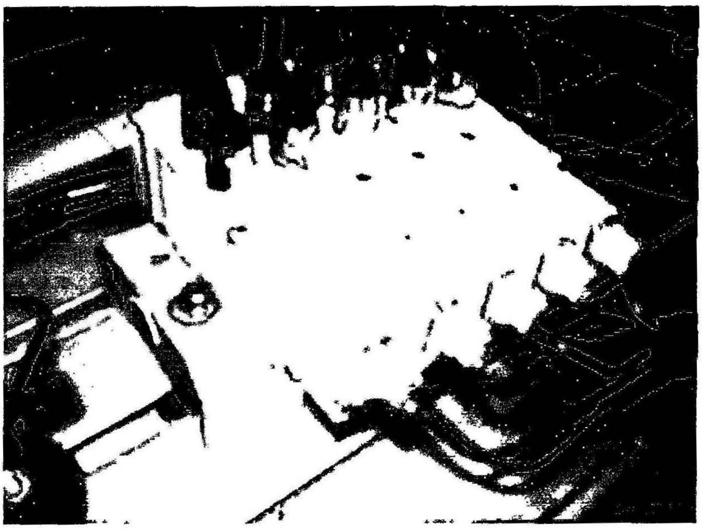

Figure 2.8: Valve

Function of valves is to control the pressure or flow rate of pressure media. It will categories five type such as Directional control valves, Non-return valves ,Flow control valves, Pressure control valves, Shut-off valves

2.3.4 Programming logical controller (PLC)

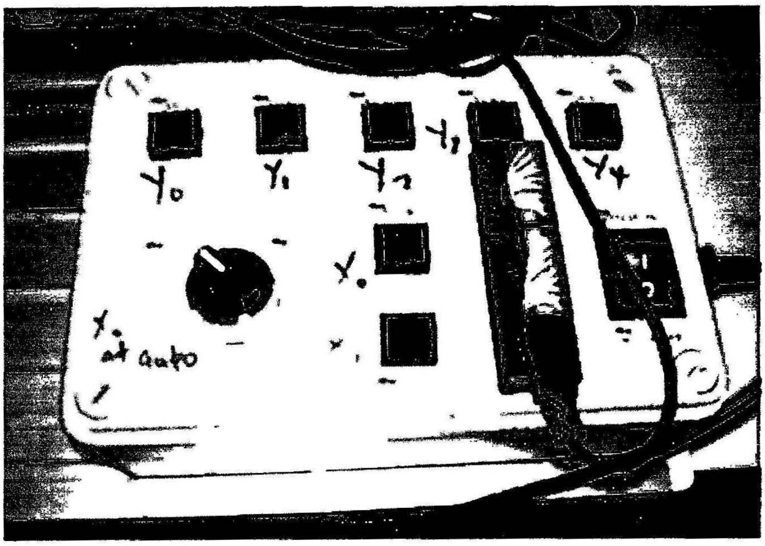

Figure 2.9: Programming logical control

NEMA, the National Electrical Manufacturers Association, defines a programmable logic controller (PLC) as:

The programmable controller is a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions, such as logic, sequencing, timing, counting and arithmetic, to control through digital or analog input/output, various types of machines or process.

Programmable Logic Controllers, programmable controllers, or PLC is solid-state devices used to control a machine or process. The advent of the PLC began in the 1960's and 1970's to replace traditional "hard-wired" controls, and has since become the predominant choice for industrial controls.

2.4 About Process

2.4.1 Turret Punch Machine

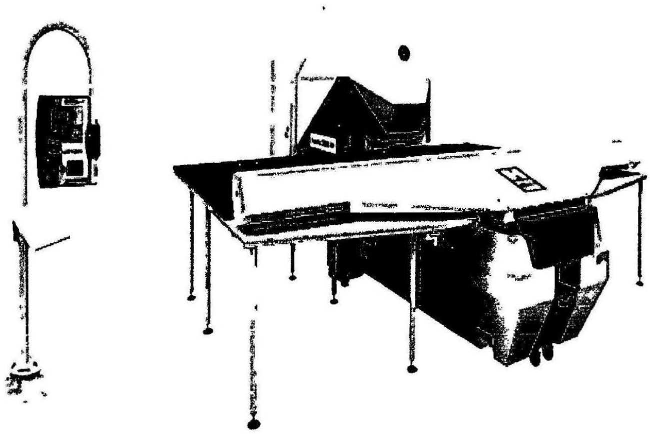

Figure 2.10: Turret punch machine

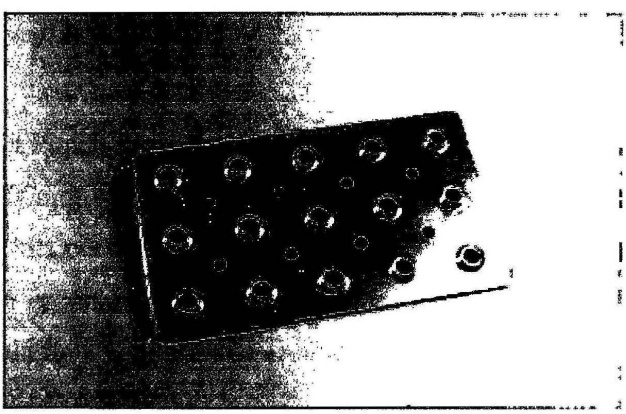

Figure2.11: Example product

Introduction

In line with industry trends, producing quality parts, lowering costs and better scheduling of production to meet customer demands. At HSM Engineering we provide many such solutions. The Plasma/ Punch shop is equipped with the technological solutions to cater for this high productivity environment.

Boasting state of the art equipment such as the Turret Punch Press, designed for fast operator set-up and cycle times. With 58 tool stations 4 of which are indelible (with an accuracy of 0.01 degrees). A series of tool configurations can be set-up on the turret and only removed for maintenance, thus set-up time is drastically reduced. The machine equipped with a Fanuc 18PC Multi-Axis CNC Control, which is used to motion the carriage and table in the X, Y direction as well as T (tool selection) and C (tool rotation). With feed-rate, ram speed and ram position controls this machine can process jobs at a faster rate than others would take to set-up tooling alone. Using the PHNC (Power Hydraulic Numerical Control) feature to set depths of the form required can control specialized forming actions. Hence a single tool can be set-up to perform several different tasks using this feature. The high-speed brush type table has reduced noise levels and back scratch of sheets. This is just another feature, which will ensure the quality of component produced for this demanding global community in which we live.

The Turret Punch Press has a 30 tonne press capacity, can handle a sheet size of 1270mm x 4000mm with one reposition to a maximum of 3.2mm gauge material. A hit rate of 360 hits per minute based on a 3mm stroke @ 25.4mm pitch or 290 hits per minute based on an 8mm stroke @25.4mm pitch. This speed can be achieved while still maintaining a high level of accuracy „b 0.1mm.

The world renowned software, Jet CAM being the package software used to program for this machine is able to interact with various CAD (Computer Aided

Draughting)/ CAM (Computer Aided Manufacture) software packages. The flexibility of this software allows for geometric files produced in a DXF or IGES format to be imported, edited, tooled and output in a GCD format to the machine. This allows maximum production time for the machine to run, while other components are being programmed. A variety of material types and gauges can be processed, thus expanding its compatibility throughout many industries.

2.4.2 Welding

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the *weld puddle*) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

MIG welding

Gas Metal Arc Welding (GMAW) is frequently referred to as MIG welding. MIG welding is a commonly used high deposition rate welding process. Wire is continuously fed from a spool. MIG welding is therefore referred to as a semiautomatic welding process.

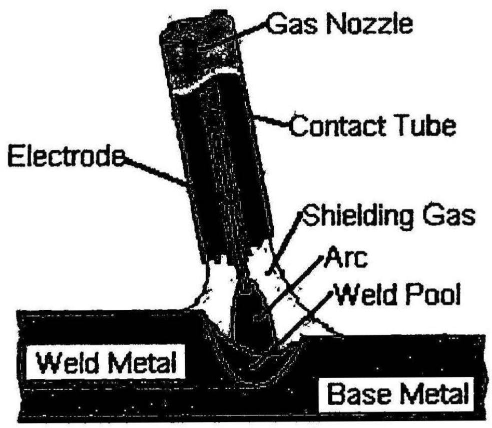

Figure 2.12: MIG Welding

MIG welding benefit

i. All position capability
ii. Higher deposition rates than SMAW
iii. Less operator skill required
iv. Long welds can be made without starts and stops
v. Minimal post weld cleaning is required

MIG welding shielding gas

The shielding gas, forms the arc plasma, stabilizes the arc on the metal being welded, shields the arc and molten weld pool, and allows smooth transfer of metal from the weld wire to the molten weld pool. There are three primary metal transfer modes:

i. Spray transfer
ii. Globular transfer
iii. Short circuiting transfer

The primary shielding gasses used are:

i. Argon
ii. Argon - 1 to 5% Oxygen
iii. Argon - 3 to 25% CO_2
iv. Argon/Helium

CO_2 is also used in its pure form in some MIG welding processes. However, in some applications the presence of CO_2 in the shielding gas may adversely affect the mechanical properties of the weld.

Common MIG welding concern

We can help optimize your MIG welding process variables. Evaluate your current welding parameters and techniques. Help eliminate common welding problems and discontinuities such as those listed below:

Weld Discontinuities

i. Undercutting
ii. Excessive melt-through
iii. Incomplete fusion
iv. Incomplete joint penetration
v. Porosity
vi. Weld metal cracks
vii. Heat affected zone cracks

MIG Welding Problems

i. Heavily oxidized weld deposit
ii. Irregular wire feed
iii. Burn back
iv. Porosity
v. Unstable arc
vi. Difficult arc starting

2.4.2 Drilling

Introduction

A drill is a tool with a rotating drill bit used for drilling holes in various materials. Drills are commonly used in woodworking and metalworking. The drill bit is gripped by a chuck at one end of the drill, and is pressed against the target material and rotated. The tip of the drill bit does the work of cutting into the target material, slicing off thin shavings (twist drills or auger bits) or grinding off small particles (oil drilling).

Types

i. Hammer Drill

The hammer drill is similar to a standard electric drill, with the exception that it is provided with a hammer action for drilling masonry. The hammer action may be engaged or disengaged as required. The hammer action is cheap but delicate. It uses two cam plates to make the chuck accelerate towards the work. However because of the relative masses of the chuck+bit and the remainder of the drill the energy transfer is inefficient and will fail to penetrate harder materials and vibrates the operators hand. The cams wear fast. Compare this to a rotary/pneumatic hammer drill where just the bit is accelerated to the work. They have relatively little vibration and penetrate most building materials. It feels as though the work is sucking the bit inwards.

Large cam hammer drills, especially transverse motor, are crude in their action. The energy delivered in each stroke is highly variable. The cheaper drill will smash its way through the work and vibrate the surroundings, this can cause lots of collateral damage. A good SDS drill will gently pulverize the work material just in front of the bit and glide into the hole without any "fuss".

ii. Rotary hammer drill

The rotary hammer drill (also known as ***roto hammer drill*** or ***masonry drill***) is an electric drill type dedicated to drilling holes in masonry. The rotary hammer drill is a percussion drill that uses a weight to create the impact force on the masonry bit. Generally, the drill chuck of the rotary hammer drill is designed to hold SDS drill bits. Some styles of this drill are intended for masonry drilling only and the hammer action cannot be disengaged. Other styles allow the drill to be used without the hammer action for normal drilling.

iii. Cordless Drill

A cordless drill is a type of electric drill which uses rechargeable batteries. These drills are available with similar features to an AC mains-powered drill. They are available in the hammer drill configuration and most also have a clutch setting which allows them to be used for driving screws.

For continuous use, a worker will have one or more spare battery packs charging while drilling, so that he or she can quickly swap them, instead of having to wait several hours during recharges.

Early cordless drills started with interchangeable 7.2V battery packs, and over the years the battery voltage has been increased to 18V, and higher, allowing these tools to produce as much torque as many mains-powered drills. The drawback of most current models is the use of nickel-cadmium (NiCd) batteries, which develop a memory effect or internal short circuits due to dendrite growth, severely limiting their useful life, and posing a hazardous materials disposal problem. Drill manufacturers are now introducing lithium ion batteries, most notably DEWALT. The main advantages are lack of memory effect and very short charging time. Instead of charging a tool for an hour to get 20 minutes of use, 20 minutes of charge can run the tool for an hour. Lithium-ion batteries also have a constant discharge rate. The power output remains constant until the battery is depleted, something that nickel-cadmium batteries also lack, and which makes the tool much more versatile. Lithium-ion batteries also hold a charge for a significantly longer time than nickel-cadmium batteries, about 2 years if not used, vs. around 4 months for a nickel-cadmium battery.

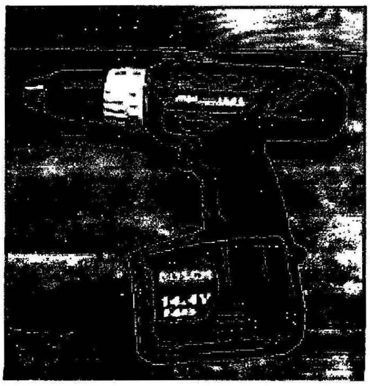

Figure 2.13: A cordless drill with clutch

iv. Drill press

A drill press (also known as pedestal drill, pillar drill, or bench drill) is a fixed style of drill that may be mounted on a stand or bolted to the floor or workbench. A drill press consists of a base, column (or pillar), table, spindle (or quill), and drill head, usually driven by an induction motor. The head has a set of handles (usually 3) radiating from a central hub that, when turned, move the spindle and chuck vertically, parallel to the axis of the column. The table can be adjusted vertically and is generally moved by a rack and pinion; however, some older models rely on the operator to lift and reclamp the table in position. The table may also be offset from the spindle's axis and in some cases rotated to a position perpendicular to the column. The size of a drill press is typically measured in terms of *swing*. Swing is defined as twice the *throat distance*, which is the distance from the center of the spindle to the closest edge of the pillar. For example, a 16-inch drill press will have an 8-inch throat distance.

A drill press has a number of advantages over a hand-held drill:

i. Less effort is required to apply the drill to the work piece. The movement of the chuck and spindle is by a lever working on a rack and pinion, which gives the operator considerable mechanical advantage.
ii. The table allows a vise or clamp to position and lock the work in place making the operation secure.
iii. The angle of the spindle is fixed in relation to the table, allowing holes to be drilled accurately and repetitively.

Speed change is achieved by manually moving a belt across a stepped pulley arrangement. Some drill presses add a third stepped pulley to increase the speed range. Modern drill presses can, however, use a variable-speed motor in conjunction with the stepped-pulley system; a few older drill presses, on the other hand, have a sort of traction-based continuously variable transmission for wide ranges of chuck speeds instead, which can be changed while the machine is running.

Figure 2.14: A drill press

v. Geared head drill

The geared head drill is identical to the drill press in most respects, however they are generally of sturdier construction and often have power feed installed on the quill mechanism, and safety interlocks to disengage the feed on over travel. The most important difference is the drive mechanism between motor and quill is through a gear train (there are no veer belts to tension) this makes these drills suitable for the larger sizes of drill.

vi. Radial arm drill

Mill drills are a lighter alternative to a milling machine. They combine a drill press (belt driven) with the X/Y coordinate abilities of the milling machine's table and a locking collet that ensures that the cutting tool will not fall from the spindle when lateral forces are experienced against the bit. Although they are light in construction, they have the advantages of being space-saving and versatile as well as being suitable for light machining that may otherwise not be affordable.

CHAPTER 3

METHODOLOGY

3.1 Project Flow Chart

For the diagram as shown in page 28, the project starts with literature review and research about the title. This consist a review of the concept of robot, robot system, robot features and type of robot used in human life. These tasks have been done through research on the internet, books and others sources.

After gathering all the relevant information, the project undergoes design process. In this step, from the knowledge gather from the review is use to make a sketch design that suitable for the project. After several design sketched, design consideration have been made and one design have been chosen. The selected design sketched is then transfer to solid modeling and engineering drawing using Solid works program. The materials and the measurement needed for the four legs robotic listed down.

Next, after the needed material is listed, acquisition step take places. There are only a few materials that need to buy such as actuators and others finishing product. Some of the needed material is well-prepared by the university.

After all the parts needed had been gathered, the project proceeds to next step that is fabrication process. The finished drawing and sketching is used as a reference by following the measurement and the type of materials needed. The fabrication process that involved is cutting, welding, drilling, punch and others. After every process was finished, the parts are checked to make sure that the output of the process obeys the product requirement.

If all the parts had been processed, the parts are joined together to produce full scaled four legs robotic. Here come the testing and evaluation process. The four legs robotic will be test to see if it will moving or walking carry body with stable or not. During the testing with PLC program, if problem occur such as do not move as required, where the error is fixed. The robot is expected to have an error that may cause the part to be re-designed and re-fabricate again. The four legs robot may be finished by doing some finishing process such as spraying.

After all the parts had been joined together, here comes the last phase of process that is data discussion. In data discussion, the draft report and all the related articles are gathered and hand over to the supervisor for error checking. The finish product will be compared with the report to make sure that there is no mistake on both project and report.

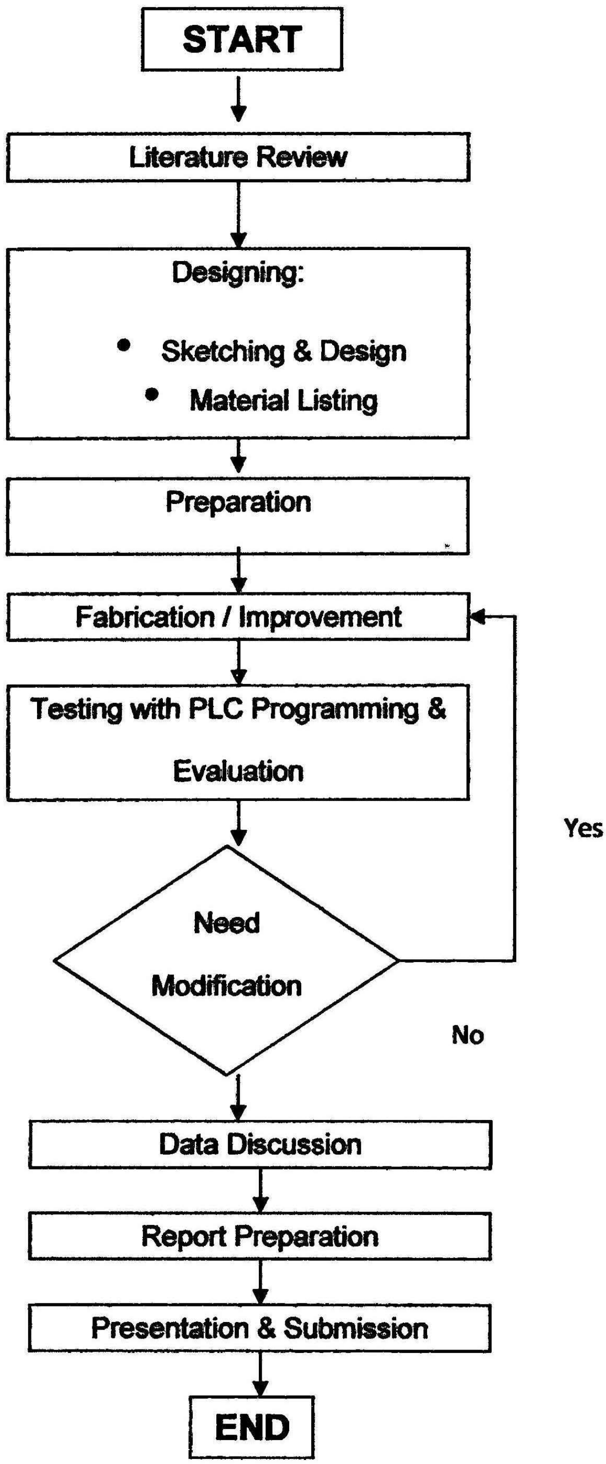

Figure 3.1: Flow chart

3.2 Design and sketching

This topic will explain about the design and sketching that had been chosen to be as the final idea to be produce or fabricate. All the design process in this project is going to be explained in details.

3.2.1 Design

The design of the four legs robotic must be compliance to several aspects. The design consideration must be done carefully so the design can be fabricated and the parts are all functioning. The aspects that must be considered in designing the four legs robotic are:

i. Using pneumatic actuator to move the robot legs
ii. Using four legs (legs can moving/walking carry body with stable)
iii. Using Programming Logical Control (PLC) as controllers

3.2.2 Drawing

The drawings are divided into two categories, which are:

i. Sketching – all the ideas for the four legs robotic fabrication are sketched on the paper first to ensure that idea selection an be made after this.

ii. CAD and Solid Works Drawing – the final idea is drawn into the CAD and SOLID WORKS drawing format with details features.

3.2.3 Sketching Drawing Selection

From the existing ideas, only three sketching that had been chosen to be considered as the final ideas, which are:

There is only three design concept to be evaluated. The first sketching is shown in figure 3.1 below.

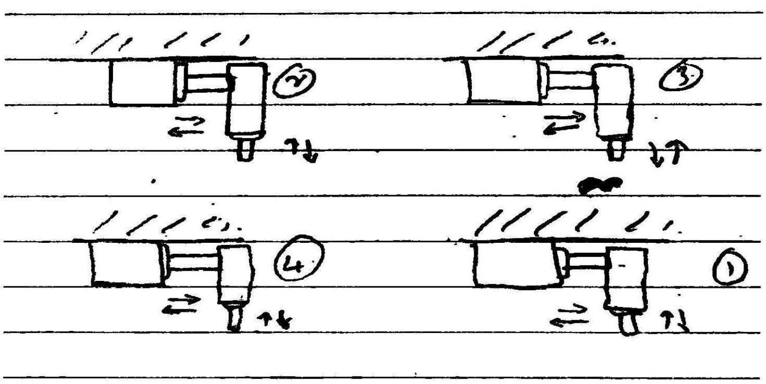

Figure 3.2: Sketching 1

This design contains of eight actuators and complex to design PLC program because there have more moving from actuator. Although this design need extra actuator but this design have more stable .With using eight actuator this design have easy to move.

The second design is shown in figure 3.2.

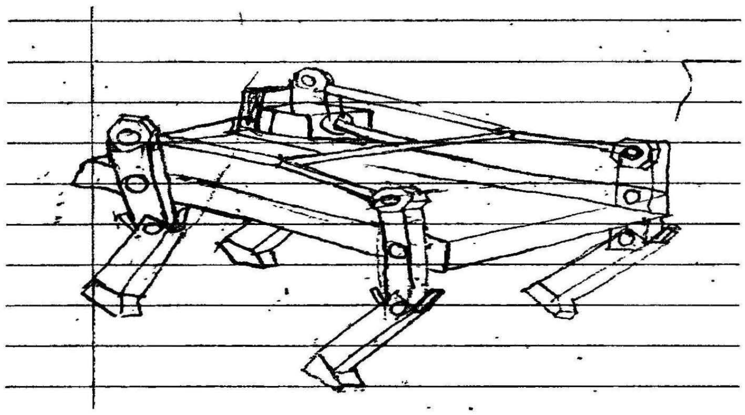

Figure 3.3: Sketching 2

This design only contains one actuator. For this design its complex to fabricate the legs because less preparation of material. This design easy to move and easy to design PLC program because it's only using one actuator but it's not move as required. All leg will control only by one actuator and the body using sheet metal.

The third design is shown in figure 3.3 below.

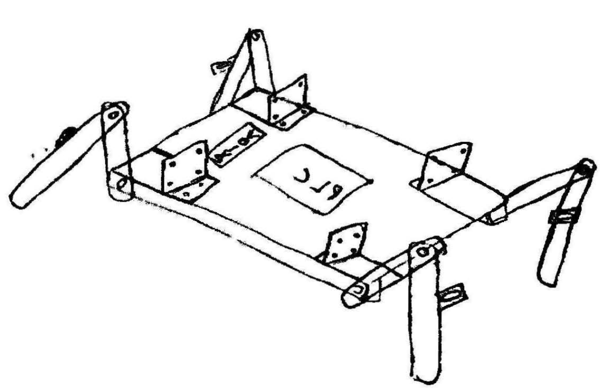

Figure 3.4: Sketching 3

This design contains four actuators to move four legs robot. The legs robot has two parts that is short leg and long leg. Short leg and long leg will combine to make one leg perfect. Each leg will control by one actuator. The body using sheet metal with thickness 2mm and rectangular hollow steel, with using sheet metal this body more lightly. This design also has four stands for each actuator. There have many components to use compare to previous design. For this design its complex to design PLC program because each actuators will control each legs to move as cat legs moving.

To choose the best design, the comparison between all the designs is performed and summarized in table 3.1 below.

Table 3.1: Design comparison

ITEM	SKETCHING 1	SKETCHING 2	SKETCHING 3
stability	More stable	More stable	stable
movement	easy	Do not move	easy
complexity	Very complex	complex	complex
Number of actuator	8	1	4
material	Body using board	Body using sheet metal	Body using sheet metal

From all the comparison in the table 3.1 the choose for the project concept is sketching three because it's move as required. It is because this concept body using sheet metal lighter and ability .It is also fabricate body using punch machine ,MIG welding, drill and grinding. This concept also using four actuators suitable with the scope.

3.2.4 Computer Aided Design Drawing

After a design has been selected, the next step in the designing process is dimensioning. The design is separated into part by part and the dimensioning process is firstly sketched on paper. The dimensioning is base on relevant dimensions.

After dimensioning, the engineering drawing of the design is drawn using Solid works application; at this stage solid modeling method is used. Part by part solid modeling created according to the dimension done before, after all part created, the 3D model is assembled with each other base on the design.

3.2.5 Overall View of The Design

3.2.6 Design Descriptions

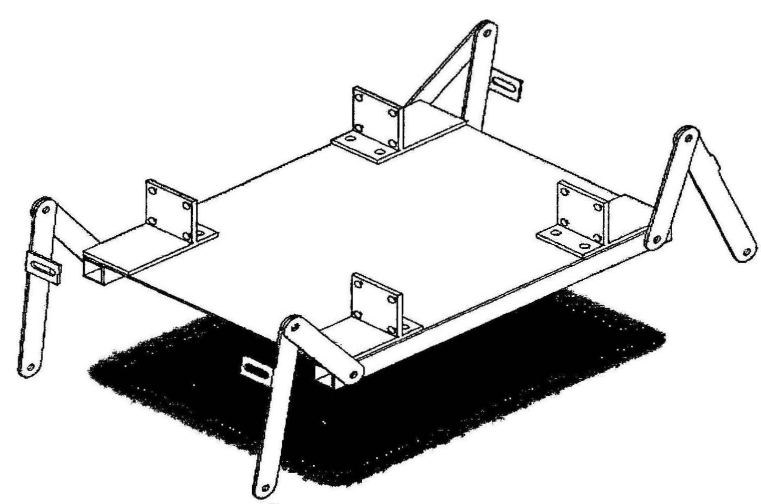

Figure 3.5: Solidwork drawing

This design contains four actuators to move four legs robot. The legs robot has two parts that is short leg and long leg. Short leg and long leg will combine to make one leg perfect. The body using sheet metal with thickness 2mm and rectangular hollow steel, with using sheet metal this body more lightly. This design in figure 3.5 also has four stands for each actuator. There have many components to use compare to previous design.

3.2.7 Component

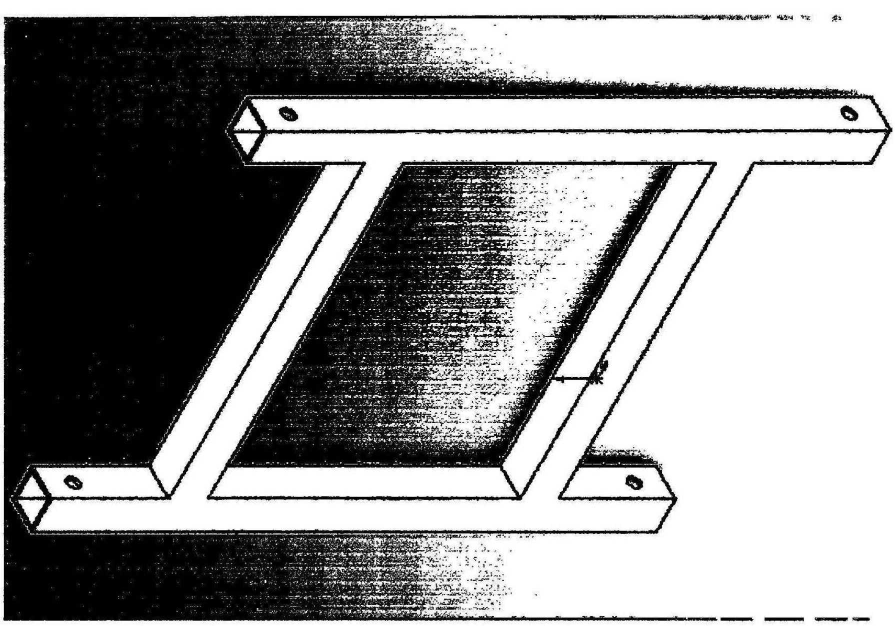

Figure 3.6: Body structure (hollow steel)

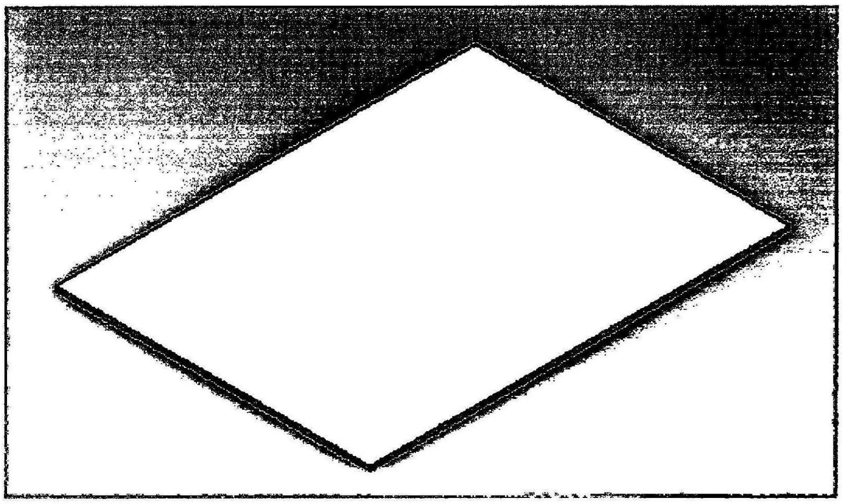

Figure 3.7: Sheet metal (300x400mm)

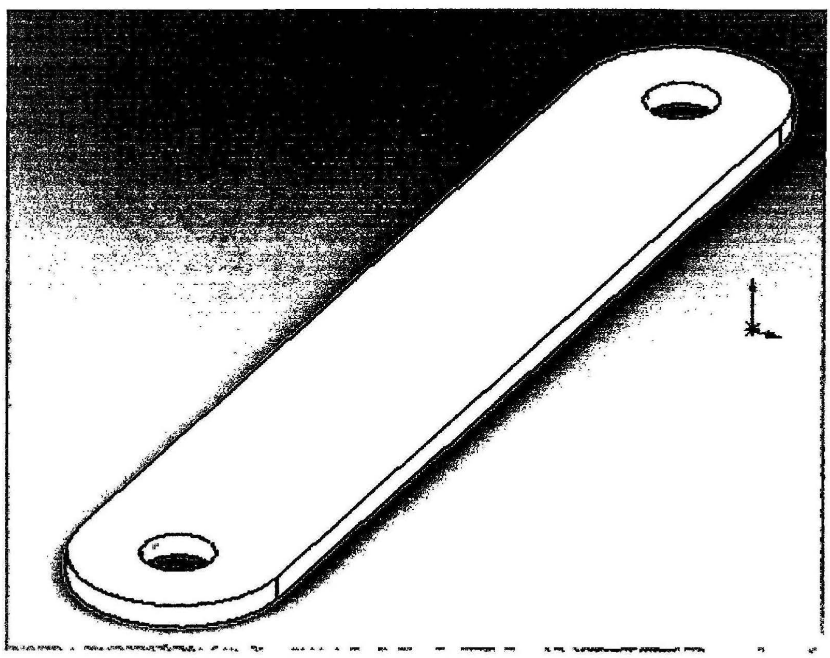

Figure 3.8: Short leg

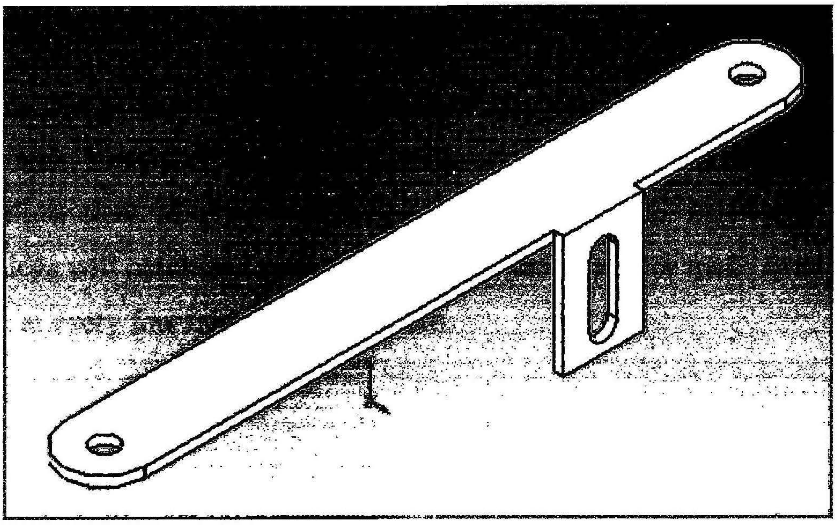

Figure 3.9: Long leg

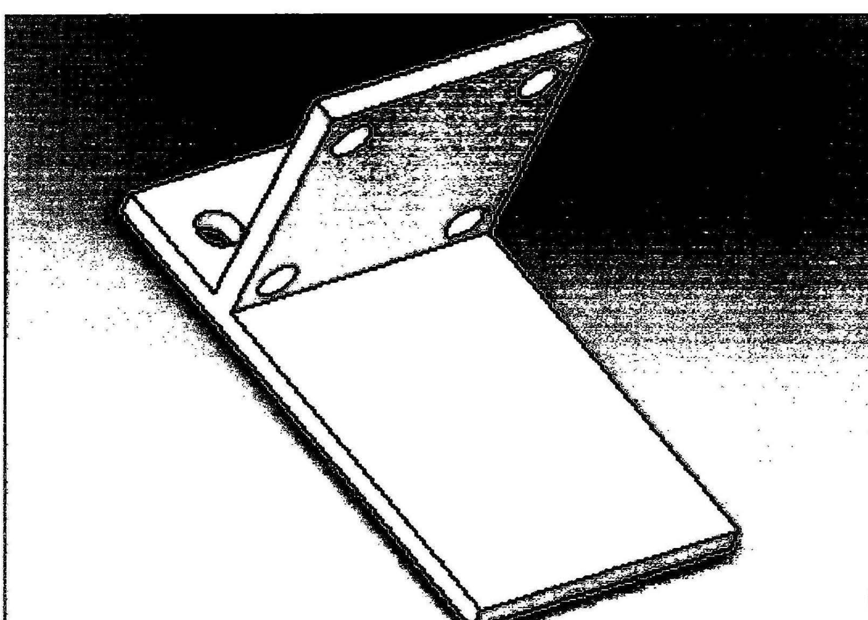

Figure 3.10: Stand actuator

This design show that the final idea of the Four Legs Robotic. Sheet metal with thickness 1mm was located on the upper platform. The lower platform was located hollow steel. Mild steel with thickness 3mm using for legs robot. Long legs and short legs will combined as one legs robot. Stand actuator made from mild steel will locate at every four edges of sheet metal.

3.2.8 Dimension Part

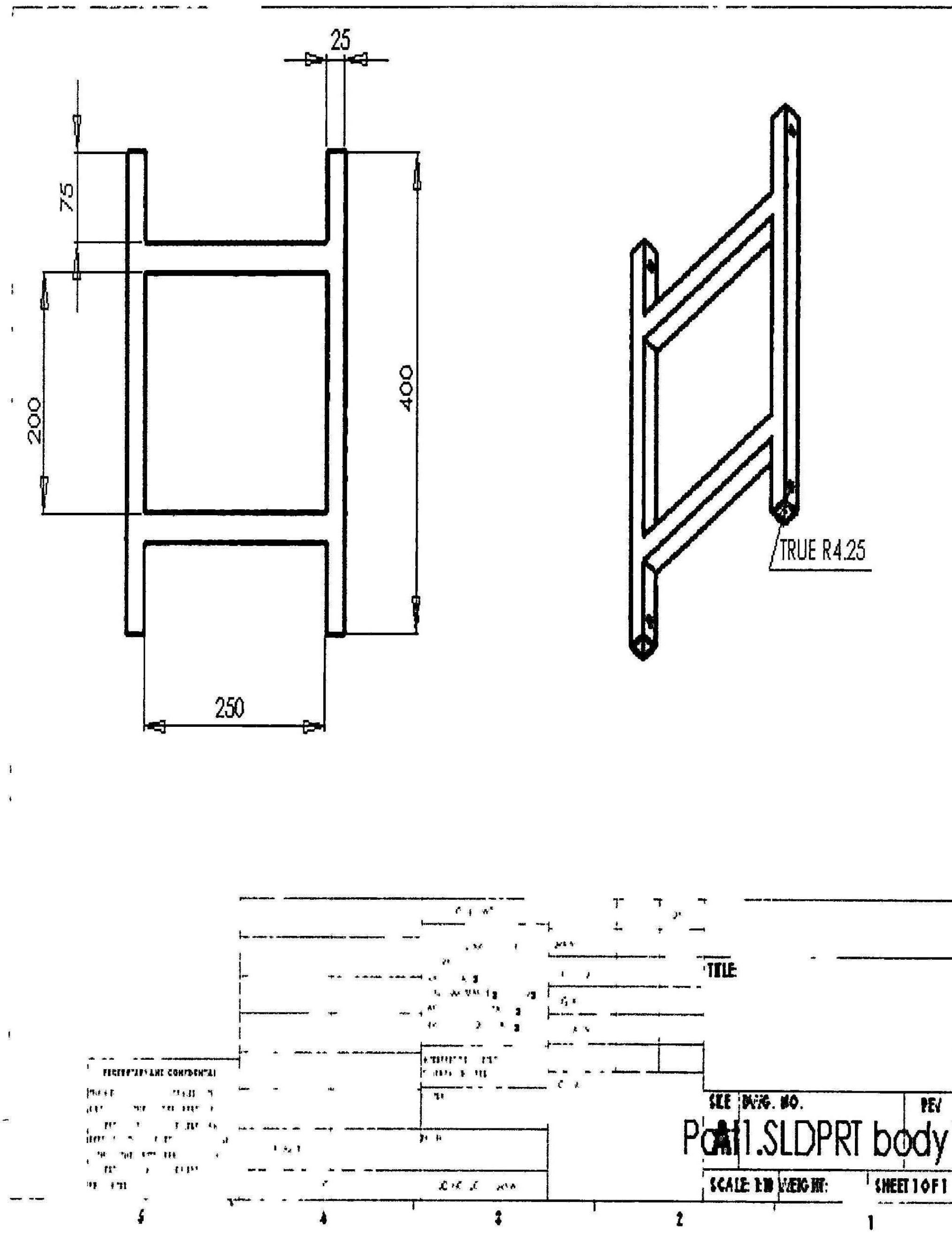

Figure 3.11: Body structure (hollow steel)

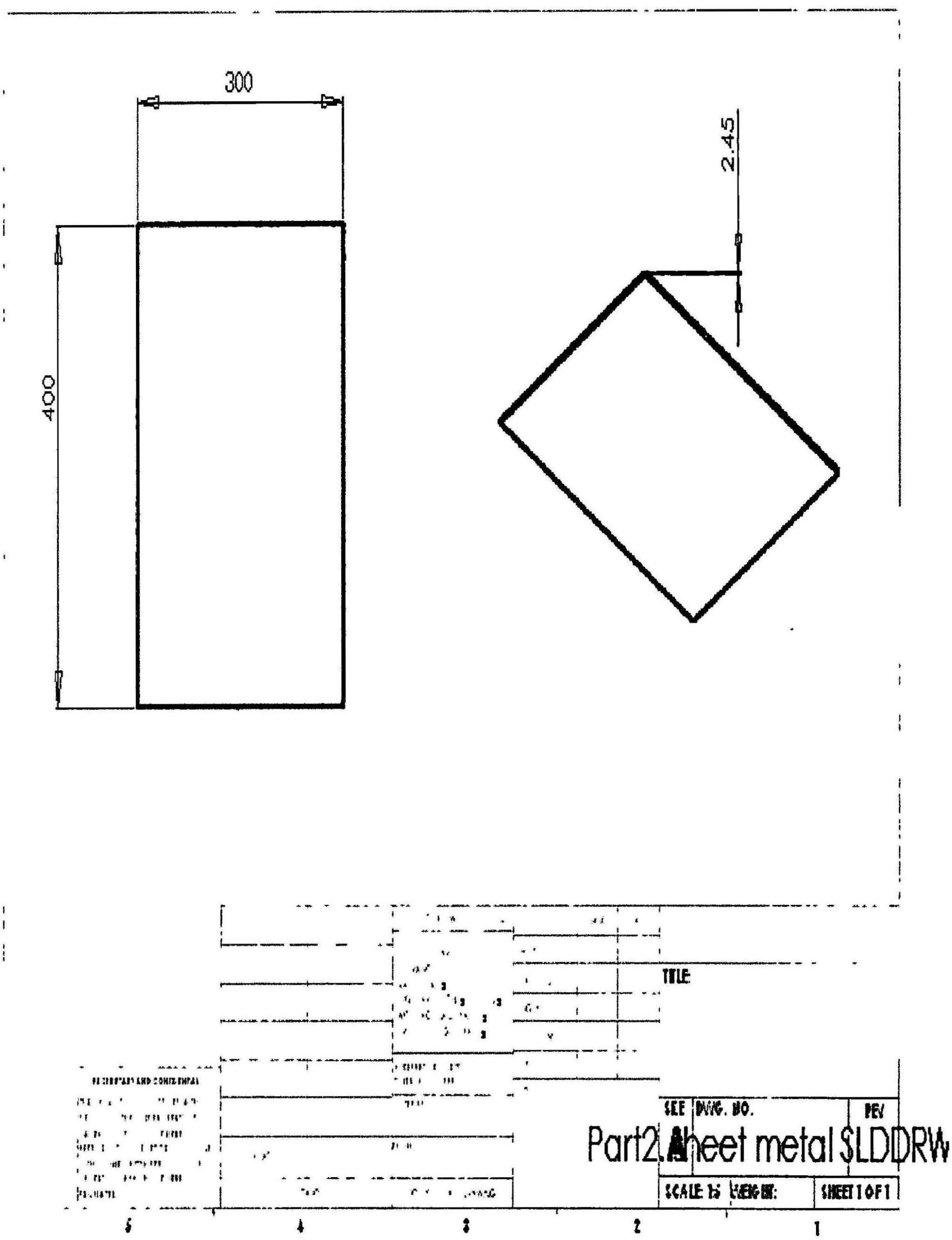

Figure 3.12: Sheet metal (300x400mm)

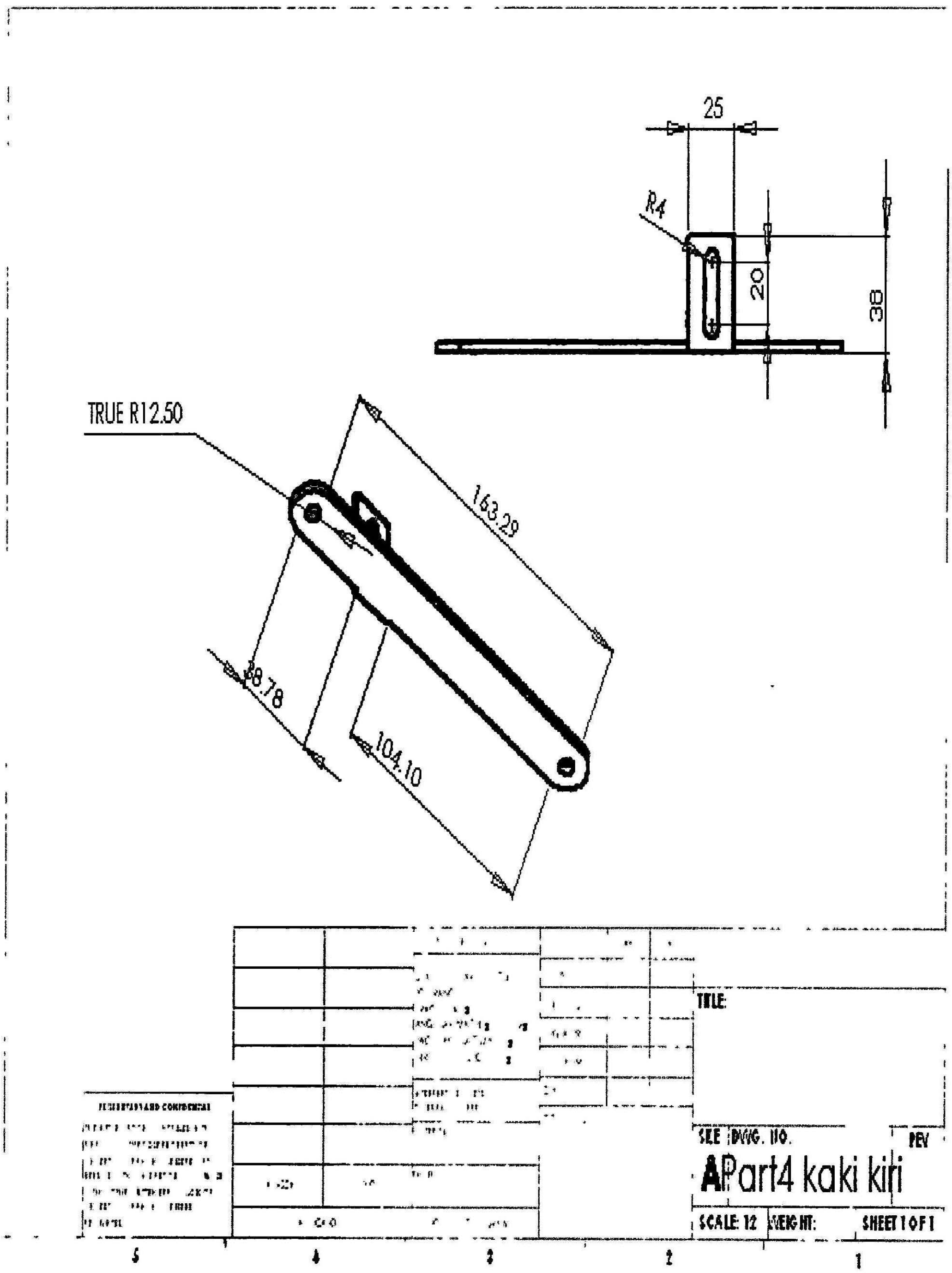

Figure 3.13: Long leg

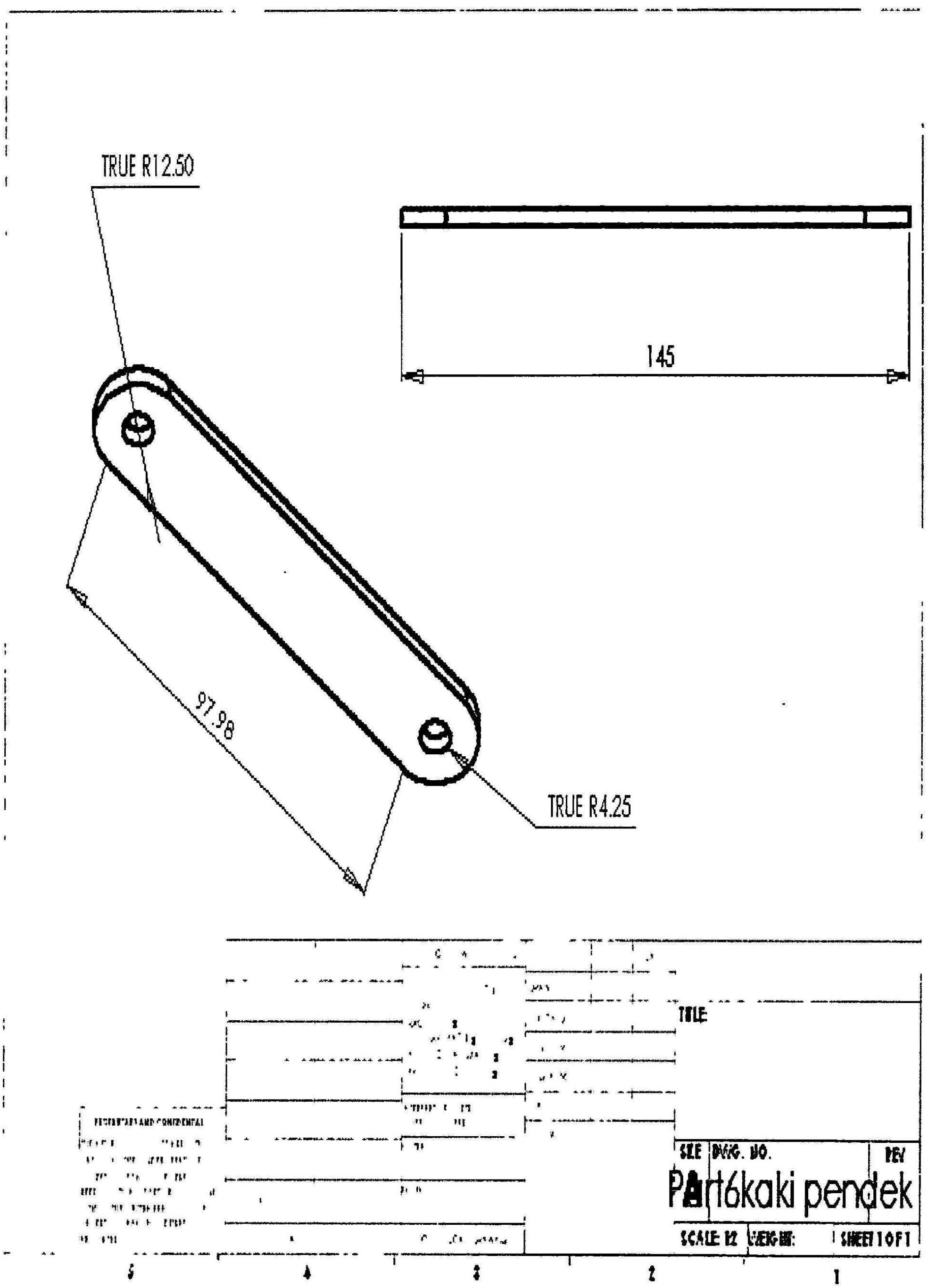

Figure 3.14: Short leg

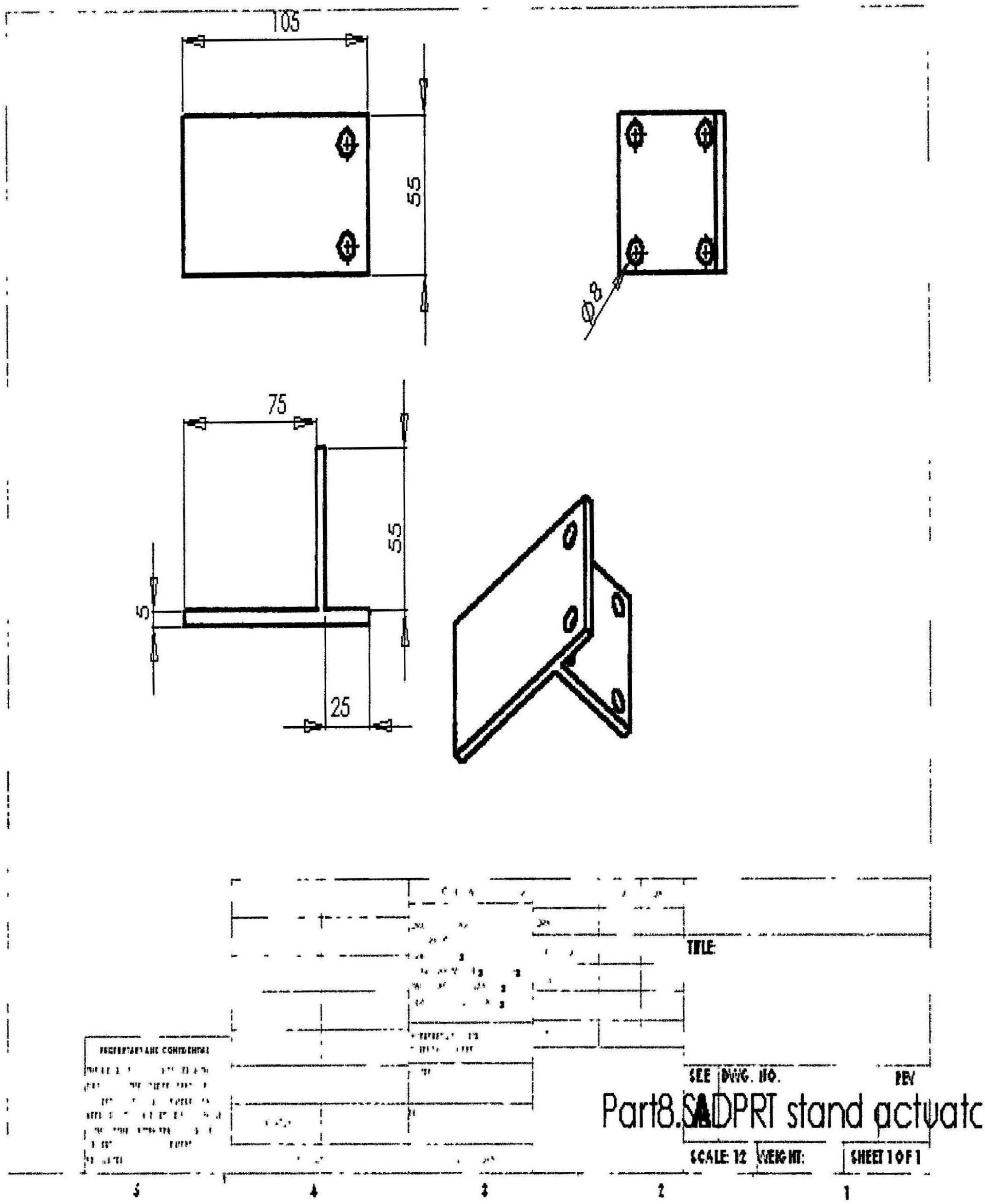

Figure 3.15: Stand actuator

3.3 Fabrication process

3.3.1 Introduction

After designing phase, fabrication process takes place. Many methods can be used to fabricate a product, like welding, fastening, cutting, drilling and many more method.

Fabrication process is a process to make only one product rather then manufacturing process that focus to large scale production. In the project fabrication process is needed to make the base plate, framework. Fabrication process was used at the whole system production. This was include part by part fabrication until assembly to others component.

3.3.2 Process Involved

In order to make the design come to reality, fabrication process needs to be done first. The fabrication process starts from dimensioning the raw material until it is finish as a desired product. The processes that involved are:

i. Measuring: Materials are measured to desired dimensions or location.
ii. Marking: All measured materials need to be marked to give precise dimension.
iii. Cutting: Marked materials are then cut into pieces.
iv. Joining: Materials joined by the method of welding and using bolt nuts.

v. Drilling: Marked holes are then drilled to make holes for bolts.

vi. Finishing: Any rough surface cause by welding spark were grind to give smooth and safe surface.

3.3.3 Step By Step Process

The fabrication process was started with measuring the material into the required dimension. 1 X 1 inch hollow steel was the first material that measured and second material is sheet metal 300x 400mm with thickness 1mm.The legs robot using mild steel with thickness 3mm, wide 1 inch and mild steel with thickness 5mm, wide 70mm for stand actuator. A total of four pieces of 1X 1 inch hollow steel , eight piece mild steel for legs robot ,one piece sheet metal for body robot and four mild steel for stand actuator. All the measuring and marking process is done by using steel ruler, measuring tape, and steel marker.

Then, after several quantities of material had been marked, the next step is to cut the material into its desired length. This process is done using the floor cutter disc. Before proceeding with this process, safety measurement had been carried out by wearing Personal Protective Equipment (PPE) such as goggle, gloves and ear plug. These safety measurements are so important in order to prevent the projectile spatter from the process. During this process, I'm using the L-shape in order to make sure the dimension of the material length is correct and precise.

All the material that had been cut is grinded to give smooth surface on the edge to make sure that joining process can be done precisely. Then all the material was arranged into joining position. Next is the joining process.

The joining process was carried out by using the Gas Metal Arc Welding or formerly known as MIG (Metal Inert Gas). First, the welding machine is set up to make sure that the output of the process will satisfy. Face shield, apron, goggle and others PPE equipment are not to be forget. Then, all the materials were weld together. During this process, a minor movement of the materials will give bad effect to the joint and to the framework. It is because the hollow tube will expand and twist a little due to the temperature changes.

After finished welding, the entire welded places were then grinded to make sure that the entire joint surface was smooth from any spatters or sharp edge. During the process, the careless of wearing an ear plug will cause high risky damage to ears. Hand gloves and goggles are also need to give attention.

Then, several locations were drilled to make holes for bolts and nuts for the support bar. Hand drill was used during the process because all the hollow tube had been weld together. It is also one of the ways to make sure that all the joint are joint together perfectly before drilling any holes because any mistake of drilling will cause the material to damage.

After all the process had been done, come the last part that is tightening the bolt and nut of the body robot with the legs and stand actuator as figure 3.12.

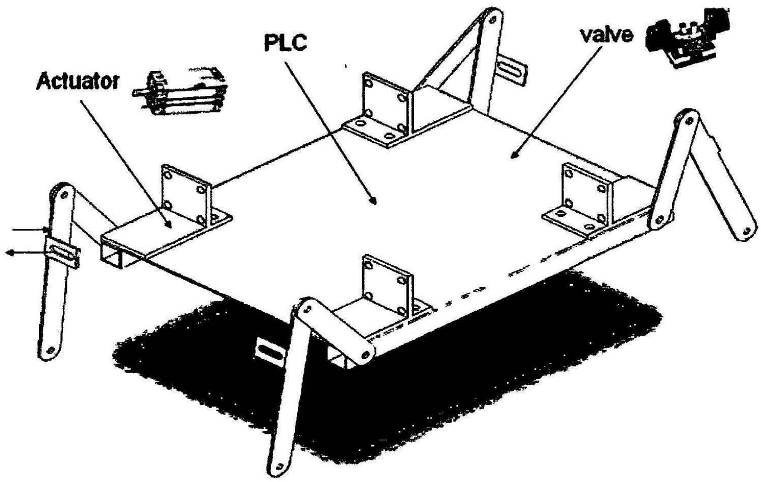

Figure 3.16: Body robot

3.4 Process

3.4.1 Cutting the material

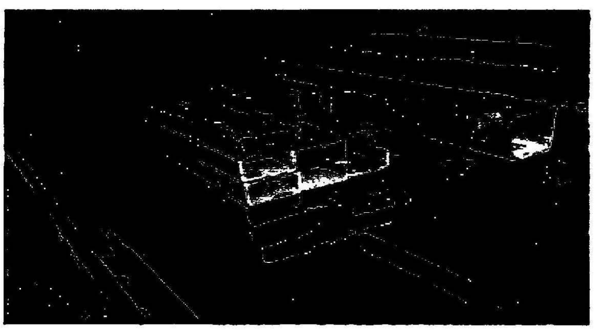

Figure 3.17: Material

Figure above introduce the material have in UMP mechanical laboratory. This rack have more type of steel like L- shape sheet, rectangular hollow steel, rectangular steel, and etc.

Figure 3.18: Measurement and making the material

After get the material, the next step is measurement and making material like figure above. The equipment used in this process is measuring tape and marker pen. The scale is from solidwork software and this scale is the true.

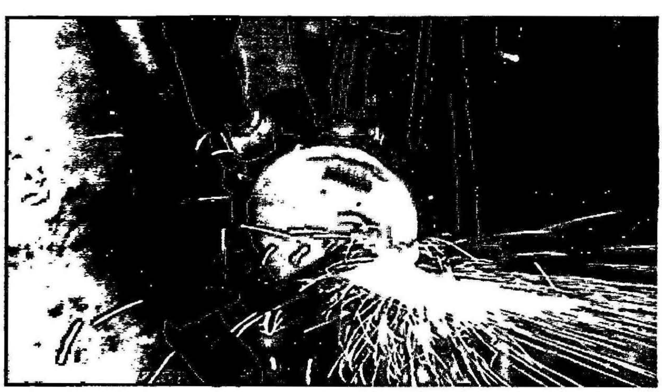

Figure 3.19: Cutting the material

Figure above introduce the process cutting the material using floor cutter disc after measurement and marking process.

Figure 3.20: Grind using hand grinding

After cutting material process the chip from work piece must remove using hand grinding. This step must take to protect form dangerous because the chip is very sharp.

3.4.2 Joining the material

Figure 3.21: Welding process

This figure introduce about joining method using MIG welding. This process is used to joining the part using steel. The joining parts are base, their frame and also the cover of frame.

Figure 3.22: Drilling process

This figure above introduce about drilling process to make the hole for nut and bolt process. The tool of the drill must be applicable with the size of nut.

3.5 Summary

This chapter has been discussed generally about project methodology and process involved. Throughout this project have learned how to fabricate and assemble the robot structure with step by step. This project can be developed the skill to manage the machine such as punch machine, shear machine, drill and welding. About the programming can learn by design the ladder diagram for Programming Logical Control (PLC) and know how to manage time in work life.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result

The pneumatic walking robot was completely developed after undergoes step by step. Start with literature review, design and sketching, technical drawing and solid modeling using Solid Work and Auto CAD application. Then the fabrication process taking parts with cutting, punching, drilling, joining and assembly.

4.1.1 Result Before Assembly

This picture shows the body and leg before assembly. Rectangular hollow steel have four pieces and its will weld with sheet metal with thickness 2mm as shown in figure 4.1 above. Each leg will take at each edge of body with bolt and nut.

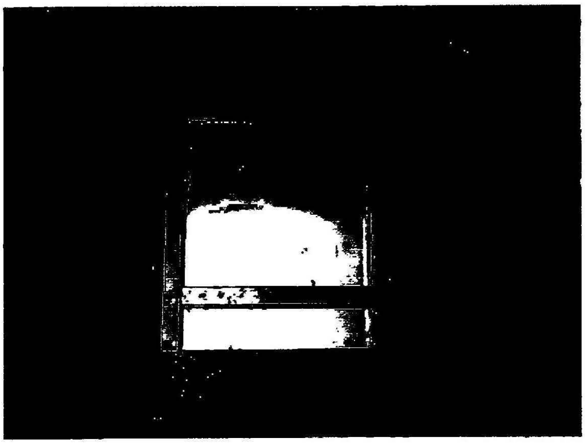

Figure 4.1: Body and leg

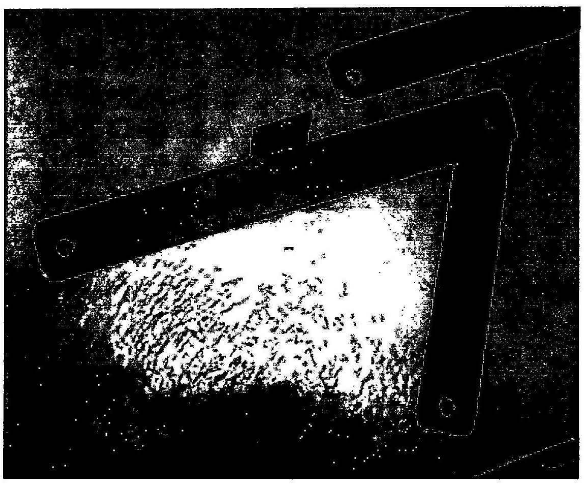

Figure 4.2: Leg robot before weld

This figure 4.2 showed the long legs and short leg. The two of leg will combine with bolt and nut for become a perfect leg.

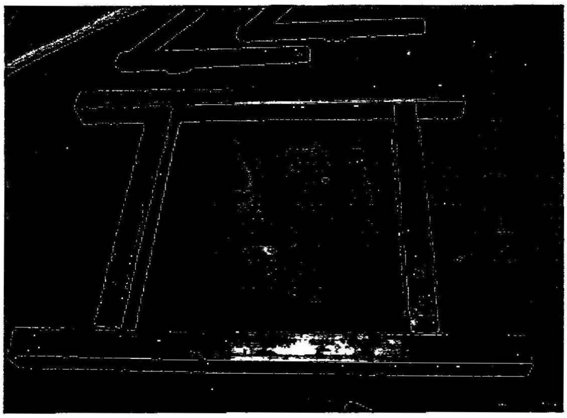

Figure 4.3: Structure body before weld

Figure 4.3 shows the structure body of rectangular hollow steel before weld. After weld with each pieces of rectangular hollow steel, the body structure will weld with sheet metal thickness 2mm as base for PLC, valve and stand actuator.

4.1.2 Result After Assembling

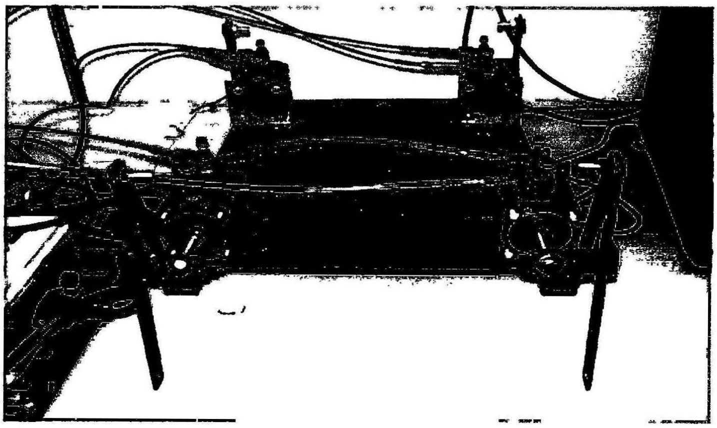

Figure 4.4: Finishing picture front view

This picture showed the actuator gets the supply air through tube or hose in figure 4.4. The hose will join with actuator on two part of hole at actuator as extend and retract holes channel. The air is not direct to the actuator but its will sift out with air filter and the air will control by the valve.

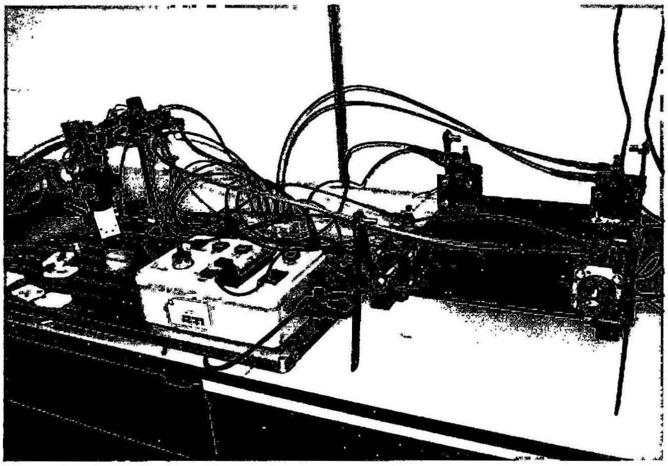

Figure 4.5: Picture leg will control with PLC

This picture showed the actuator will control by the Programming Logical Control (PLC) in figure 4.5.To control the actuator by the PLC ,the ladder diagram for the PLC will be design first with using specialize computer at the laboratory and download to the PLC.

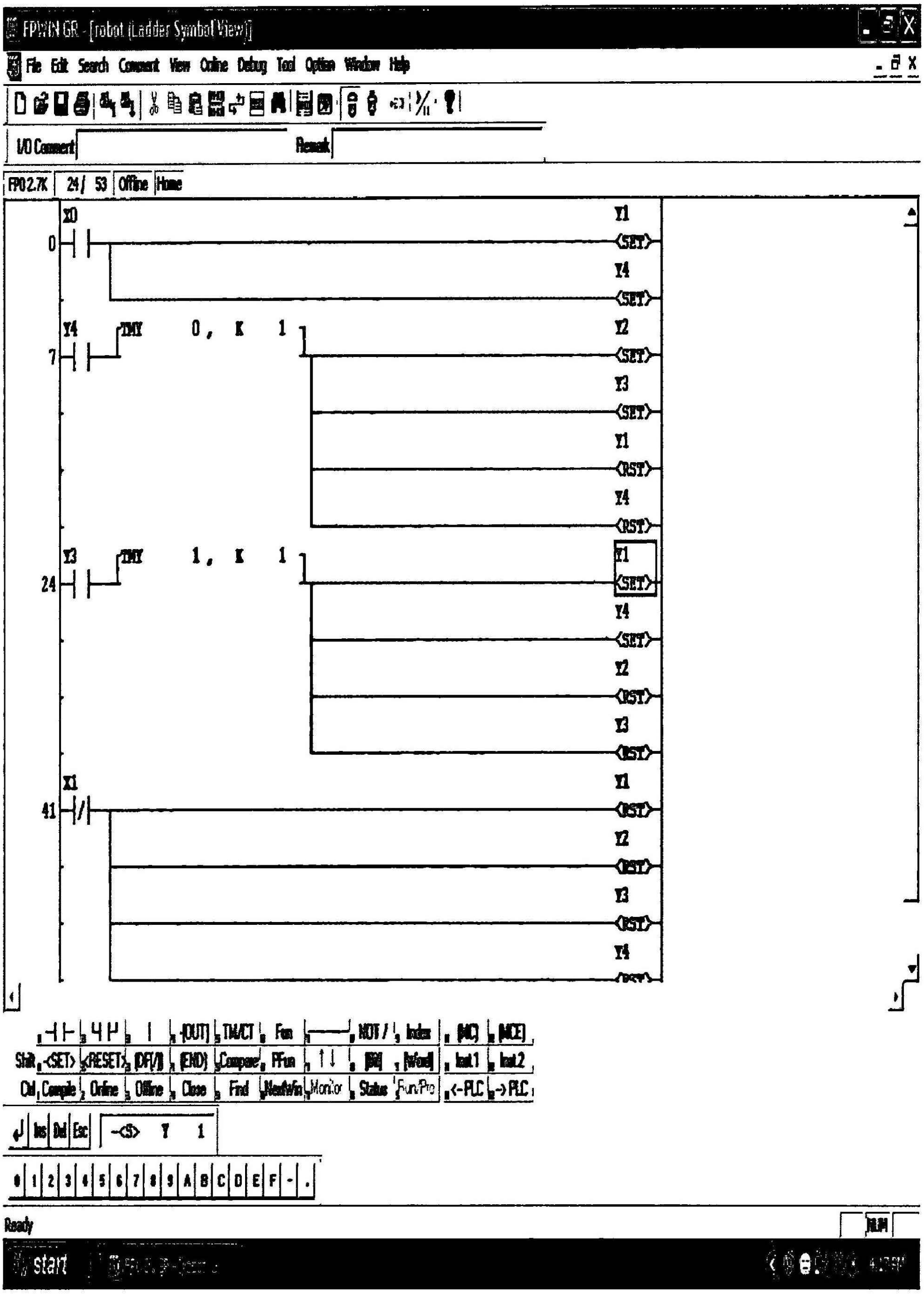

Figure 4.6: Ladder diagram

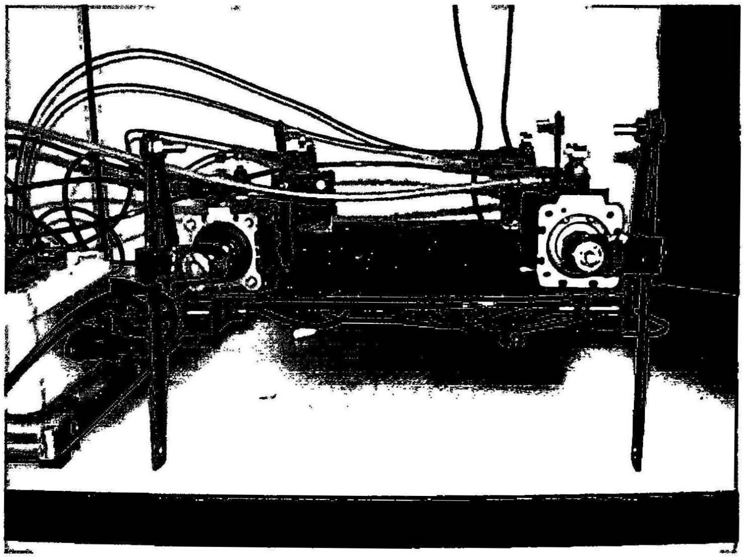

Figure 4.7: Front view robot

This picture of front view robot will showed the actuator will bolt and nut with the legs for move the leg robot in figure 4.6.The actuator will fit at the base body with bolt and nut with stand actuator.

4.2 Design Specifications

For the design specification, there are a lot of factors that were considered. The product were classified to several category such as weight, colour, wide, height and convenience. The product specification is like below.

Table4.1: Classifield

Category	Result
Weight	6 kg
Colour	Natural metal
Wide	400 mm x 300 mm
Height	250 mm
Convenience	Using pressure air for move legs robot

4.3 Discussion

4.3.1 Types of Defected

There are so many things that happen in fabrication process such as defect. This defect happen because lack of skills to operate a machine such as when handling MIG welding machine. This defect can be seen after fabrication process finished. Here were some of defects happen during conducting the project.

4.3.1.1 Not parallel

This defect happen cause by less skill when process weld the robot legs. This defect at front left legs .This defect causes the actuator hard to move the legs robot and the robot not stable at all.

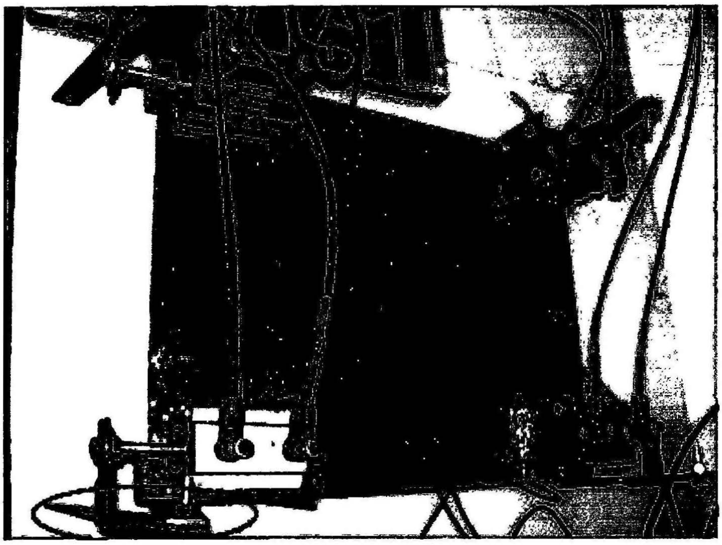

Figure 4.8: Leg robot not parallel

4.3.1.2 Bead

Figure 4.8 is example a defected in chassis. The bead is not trim from welding process. The voltage when welding process is not suitable for this material. Insufficient experience to handle this machine also cause of the defected.

Figure 4.9: Bead at the stand actuator

4.3.1.3 Error in program machine.

Figure 4.9 is another example of defected for this product. It is occur from error handling and set up program for machine punching. The side that was punch at wrong coordinated to become such as in Figure 4.9.

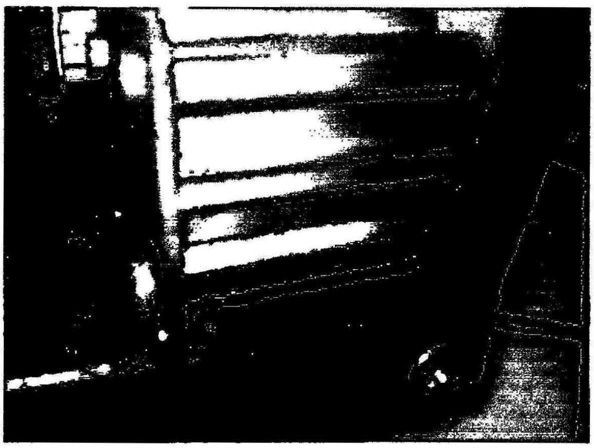

Figure 4.10: Error cutting at the holes sheet metal for place stand actuator

4.3.2 Problem in Progress

4.3.2.2 Literature Review Problems

The problem during literature review is mainly about the difficulty to know well about the title such scope, concept and how to fabricate it into reality. The raw material problem also encountered during this step because the raw material at UMP Mechanical Lab not available for the first design the project. The whole design was change to suit with material that available in UMP Mechanical Lab. Besides that, the problem like, limited resources to get the relevant and suitable material such as books and internet connection also occurred during handling this project.

4.3.2.3 Design Problems

The problems came during decision making to select the best system to fit with available machine in UMP Material Lab. During this period many concept design have to been find but when to choose one design that have all the criteria needed by the specification is very hard. After a design is selected, another problem encountered is details dimensioning, the dimension should suitable with specific test specimen in order follow to ASTM standard and fix with available machine at Material Lab.

Another problem encountered during design process is material selection, this problem as like which there are suitable material with design and how to fabricate it.

4.3.2.4 Fabrication processes problems

Problem during this stage is very critical that make the project schedule is delayed. First, the problem is to find material that suitable for title of the project. The suggestion material to produce pneumatic walking robot is not available such as mild steel for leg was end. After consider all problems about available material design for the project was changed following the available material such as mild steel which is thicker than required.

The problem also come during fabrication process, mainly is hard to fabricate the material with the design was change in order to be easy in machining process such as about usage punching machine. Punching machine not have tool diameter 3 mm, after consider advised from instructor drawing was change using diameter 5mm. Another else, is the available cutting tool – actually it enough but the problem there many cutting tools broken such as drill tool. The solution for this problem is drill was buying by our self. This project fabrication have problem when to welding part of project because gas for MIG welding was finish and wait for one month to get new gas for MIG welding.

4.3.2.5 Assembly Problem

The problem during assembly is mainly about the difficulty to find the bolt and nut suitable for join the leg and actuator on the robot body. The bolt and nut suitable is important to join the leg robot to let the leg move clearly when join with the robot body. To fit the pneumatic actuator on the stand will use long nut but the nut not found at laboratory.

4.3.2.6 Programming Problem(PLC)

During design the ladder diagram for Programming Logical Control (PLC) have a small problem to move the legs robot as required occurred because when press the start button on the PLC the leg move but not move continuously as the ladder diagram design. The problem will settle with design back the ladder diagram.

4.3.3 Project Problems

i. Literature Review: The concept and ideas review for this project are not very wide because it is not widely modified by the manufacturer. Students should come with their ideas on the project.

ii. Designing & Sketching: Because of the idea were from the student directly, so there are no references that can be referred. All the drawing and dimension need to generate by student itself.

iii. Fabrication Process: Students need to be given more time to finish fabricating their product because of slackness of training, the joining finishing was not so god but yet can still reliable.

iv. Material Preparation: Some of the needed material needs to buy at the city. University should prepare the material or either provides the place where the material can be obtained from.

v. Budget Preparation: It is not so effective to use student's money to get the materials. University should provide budget at first stage so that student's expenses are not interfere.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 Introduction

This chapter is mainly about the problems encountered during the whole project was been carried out and summary of the project in overall. In this chapter also will discuss about the conclusion of the project, concluding all the process that involved.

5.2 Summary of Project

5.2.1 Designing Process

In the design process, from the knowledge gathered from the review is use to make a sketch design that suitable for the project. After several design sketched, design consideration have been made and one design have been chosen. The selected design sketched is then transferred to solid modeling and engineering drawing using Solid works and CAD program.

5.2.2 Fabrication Process

The final drawing and sketching is used as a reference by following the measurement and the type of materials needed. The fabrication process that involved are cutting, welding, drilling, punch and others. After every process was finished, the parts are checked to make sure that the output of the process obeys the product requirement.

5.2.3 Assembly Process

If all the parts had been processed, the parts are joined together to produce full scaled four legs robotic. The long legs and short leg will be combined to with bolt and nut to produced perfect legs of robot. The actuator will fixed with bolt and nut on the stand to move the legs robot.

5.2.4 Testing Process

The four legs robotic will be tested to see either it will move with stable or not. During the testing with PLC program, if problem occur such as do not move as required, the ladder diagram need to be re-design. The robot is expected to have an error that may cause the part to be re-designed and re-fabricate again.

5.3 Conclusion

For the conclusion the project has achieves their objectives. The project four legs pneumatic walking robot was successfully design .The project also successfully fabricate and testing with Programming Logical Control (PLC).There is usually more than one way to approach the task of troubleshooting and correcting defects. There are many types of defect. Improving the defect will improve the yield. There are many causes that influence the defect.

5.4 Recommendation

Precise planning of the work progress will make sure that the project can be done in a shorter time. Having a good time management can guaranty that any of students task to complete in a good ways and also give more time to focus on others subject.

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