UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY A PNEUMATIC CONTROL SYSTEM AND SIMULATION FOR INSECT WALKING ROBOT

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotic and Automation) with Honours.

by

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DECLARATION

"I declare this report is on my own work except for summary and quotes that I have mentioned its sources"

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) with honours. The member of the supervisory committee is as follow:

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EN. KHAIROL ANUAR BIN RAKIMAN

ABSTRACT

In this project, the primary objective to study and design a pneumatic control system for insect walking robot. Usually, insect walking robot such as hexapod use stepper motor to move their legged and show the sequence that have it make. The locomotion of walking robot is more important to any robot no matter for insect robot, wheel robot or bipedal walking such as in term of the number of possible gaits and degree of freedom (DOF). To make improvement for this robot, pneumatic system will be apply and show the mechanism sequence how it work or move. In order to keep insect walking robot in smooth motion there is necessary to develop structured pneumatic control system circuit in term of sequential and logic criteria. The robot controller uses tripod gait for their movement. Numerous works focused on insect walking robot graphic simulation and complete design of pneumatic control circuit.

ABSTRAK

Dalam rancangan ini, objektif utama adalah untuk mempelajari dan merancang suatu sistem kawalan pneumatik untuk robot serangga berjalan. Kebiasanya, robot serangga berjalan seperti hexapod menggunakan motor stepper untuk menggerakkan kaki dan menunjukkan pergerakan yang dibuat. Pergerakan robot berjalan lebih penting bagi setiap robot tidak kira sama ada robot serangga, robot berkaki dua roda atau berjalan seperti dari segi jumlah gaits dan darjah kebebasan (DOF). Untuk membuat pembaikan untuk robot ini, sistem pneumatik akan digunakan dan menunjukkan pergerakan mekanisma bagaimana ia bekerja atau bergerak. Dalam mereka rangka robot serangga berjalan dalam keadaan lancar, litar kawalan pneumatik diperlukan dari segi pergerakan dan kriteria logik. Sistem kawalan robot menggunakan cara berjalan jenis *tripod gait.* Kebanyakan kerja yang dilakukan terutama kepada grafik bergerak dan menyelesaikan rekabentuk litar kawalan pneumatic.

DEDICATION

Specially dedicated to my beloved father ABD AZIZ BIN HASHIM and my mother SHARIPAH BINTI ARSHAD who had been so consistently and patiently supporting me in this research. Besides that, I also dedicated all of this to all of my lecturers and colleagues who interested in this research.

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LIST OF ABBREVIATIONS

PSM	-	Projek Sarjana Muda
UTeM	-	Universiti Teknikal Kebangsaan Malaysia
COG		Center Of Gravity
PLC		Programmable Logic Controller
LPM		Liter per Minute

CHAPTER 1
INTRODUCTION

1.1 Background

In this chapter will describes and simple briefly about the design a pneumatic control system for insect walking robot. In this chapter also include the problem statement of the design for insect walking robot, objective of this project, research scope, and lastly important of the research.

1.2 Insect Walking Robot

Insect walking robot is combination between insect nature and mechanical robotic technology. Most walking machines follow the animal locomotion by using a high number of similar legs with many degrees of freedom (DOF). This approach leads to complex design needs a complex control system that use static walking. Static walking at least are listed six legs or more are required.

Since a robot can be statically stable on three or more legs, an insect robot has a great deal of flexibility in how it can move. If legs become disabled, the robot may still be able to walk. Furthermore, not all of the robot's legs are needed for stability. So, the gait of locomotion is very important to any robot because it’s a part of their mechanism to move.

However, there are many different types of insect walking robots from bipeds or human of different joint configurations and intelligence, to walking animal like quadrupeds, many legged insect styles and even snake emulating robots. The basic components of a robot are:

a) Moving parts that perform an action like arms and legs.
b) An actuator to power moving parts and sensors to detect environment.
c) A control system that makes decisions and overlooks the overall operation.

Most often, any robot such as human robot or insect robot are controlled by gaits, which allow the robot to move forward, turn, and perhaps side-step. Some of the most common gaits are as follows as alternating tripod with 3 legs on the ground at a time, quadruped, and also crawl to move just one leg at a time. Beside, gaits for insect walking robot are often stable, even in slightly rocky and uneven terrain. This is because gait is characterized as the sequence of lift and release events of the individual legs is depend on the number of legs and also the number of possible event N for a walking machine with k leg is (Sven, B., 2000):-

$$\boxed{N= (2k-1)!} \qquad (1)$$

where:

N = number of possible different event or number of sequence leg

k = number of possible number of walking machine

1.3 Problem Statement

Robot is a relatively modern technology at this time. At present this technology is exposed to some countries, particularly in developed countries. European countries such as Germany, USA and other country have done develop robotic technology in this century. This technology to produce a lot of robots, especially robotic insects, swarm robots, robot military, delivery robots, industrial robot and more. At this time, the system used by the insect robot mostly used a motor such as stepper motor but the insect robot using a pneumatic system is not much highlighted or introduced especially in this country.

However, in robot technology research institution of higher learning is not much to introduce the robot to walk using a pneumatic system and effectively simulation - motion. So, with the graphic simulation of the robot, students will better understand the movements a more effective for sequence mechanism simulation performed by using the pneumatic system just in a prototype or developed.

1.4 Objective

The aim of this project is to design an insect walking robot in smooth motion in graphic simulation software. Below are some important objectives that need to be achieved.

a) To develop graphic simulation on insect walking 6 legs robot using CAD software.
b) To design pneumatic control system circuit in term of sequential and logic criteria using Automation Studio.

1.5 Scope

Study the mechanism of insect walking robot. As well as project focused on insect walking robot is:

a) Identify the suitable gait into insect walking robot.
b) Develop an interactive insect walking robot simulation by using SolidWorks.
c) Design pneumatic control circuit system for insect walking robot.
d) Analyze the pneumatic system calculation such as velocity, air cylinder flow rate and also sizing of air reservoir.
e) Carry out analysis on possible load and weight for pneumatic components of insect walking robot.

1.6 Project Planning

The project planning is needed to identify and to make plan in order to achieve the objectives in a period of time was prescribed. A good planning would ensure this project goes on actual track. For a good time management planning, Gantt chart is a suitable method that always being used.

A Gantt chart is a type of bar chart that illustrates a project schedule. The Gantt charts illustrate the start time and the end of the project implementation and summary elements of a project. Project implementation and summary of a project element comprise the work breakdown structure of the project.

Table 1.1 shows the project Gantt chart that had to be punctual with the time planning. The Gantt chart is for the time planning for PSM 2.

CHAPTER 2
LITERATURE REVIEW

2.1 Background

This chapter will discuss and review available literature on Design Pneumatic Control System for Insect Walking Robot using Automation Studio and CAD software. The reviews begin with Walking Robot. This section will be including the actuator of system, control system, design and also previous projects. Then, the Automation Studio and CAD software will be discussed in this chapter.

2.2 Actuator

In this section will be describe a mechanical device which it as actuator to move or controlling a mechanism or system to convert that into some kind of motion such as electrical motor, pneumatic actuator and also hydraulic actuator. Actuators in robots are like muscles in the human body. Without the actuators, the limbs of the robot cannot move. There are many types of actuators available but only certain types suit the needs of the project. Below is a comparison of some common actuators. Following the comparison a decision was made on the method of actuation for the robot legs.

2.2.1 Electrical Motor

Electrical motor is a device which it convert electrical energy to mechanical energy following the principles of process by generator. Energy of motors used on the part and the device always perform both task and related with actuation and movement. Many type of electric motor can be run as a generator or vice-versa. Basically electrical motor can be use in alternating current (AC) and also direct current (DC) for any application. The DC motor is different from AC motor because it uses electricity and magnetic field to form what is known as torque. Both categories are further divides into different subcategories according their function (Puchstein 1976)

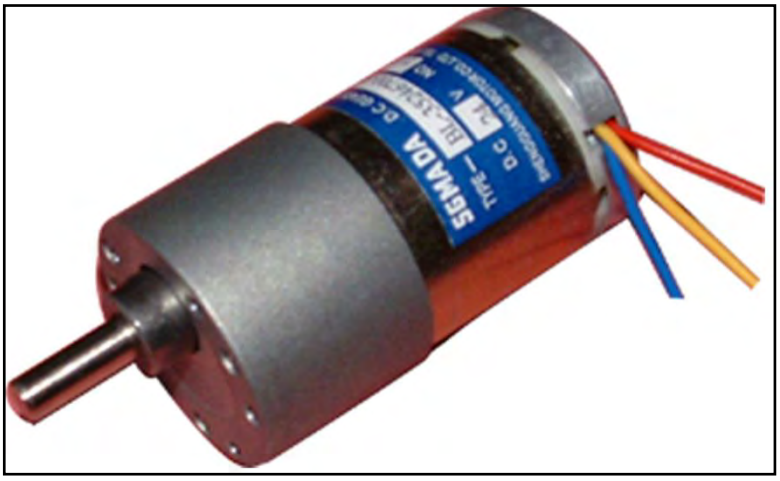

Figure 2.1: An example of DC motor (www.o-digital.com)

2.2.2 Types of Motor

Nowadays, many type of electrical motor available in the market such as direct current (DC) motor, alternating current (AC) motor, stepper motor, servo motor, universal motor and more. Every type of motor have own characteristic and purpose for application.

Table 2.1: Type of Motor

Type	Advantage	Disadvantage
AC motor	a) Simple design b) Low cost c) Reliable operation	a) Rotation slips from frequency b) Starting switch required c) More expensive
DC motor	a) It can operate directly from a battery b) Low maintenance	a) High initial cost b) Require to controller
Stepper motor	a) Precision positioning b) High holding torque	a) High initial cost b) Requires a controller
Servo motor	a) Speed control feedback b) High torque c) Easy to maintenance	a) Consume more battery

2.3 Pneumatic Actuator

Pneumatic systems are very common, and have much in common with hydraulic systems with a few key differences. The reservoir is eliminated as there is no need to collect and store the air between uses in the system. Also because air is a gas it is compressible and regulators are not needed to recirculation flow. But, the compressibility also means that the systems are not as stiff or strong. Pneumatic systems respond very quickly, and are commonly used for low force applications in many locations on the factory floor. (Hugh Jack 2007.)

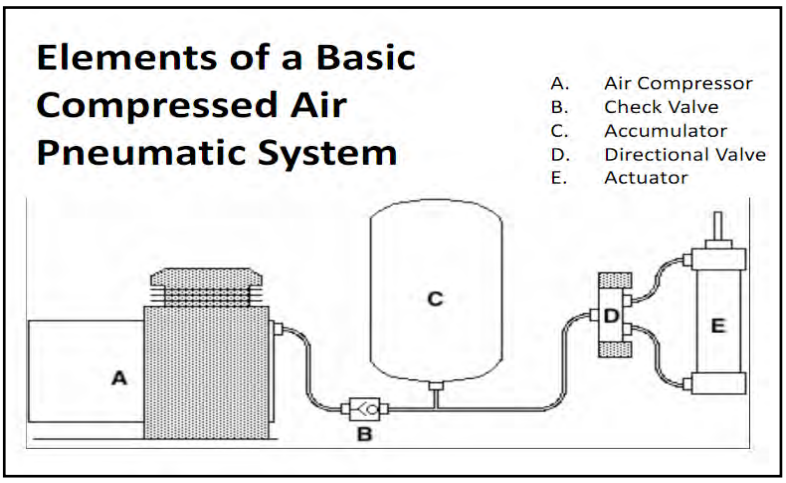

Figure 2.2: A pneumatic component (www.instruction.greenriver.edu)

2.3.1 Actuator Type Used in Project

Pneumatics cylinders double acting is used in this project because to perform their function and give a force by converting the potential energy of compressed gas into kinetic energy. So that, this actuator will be attach to all legged of insect walking robot and to make sure the function is running better.

The benefit use this pneumatic cylinder is to show the mechanism how this actuator work, to show the sequence of lift or gait for walking robot used and to reduce weight the pump or compressor can be taken off the robot. This air expansion forces a piston to move in the desired direction. The piston is a cylinder, and the piston rod transfers the force it develops to the object to be moved depend on control system.

2.3.2 Advantages of Pneumatic Actuator

Table 2.2: Advantage of pneumatic actuator

No	Characteristic	Description
1	Simplicity of design and control	i. Machines are easily designed using standard cylinders & other components. Control is as easy as it is simple ON - OFF type control
2	Reliability	i. Pneumatic systems tend to have long operating lives and require very little maintenance. ii. Because gas is compressible, the equipment is less likely to be damaged by shock. iii. The gas in pneumatics absorbs excessive force, whereas the fluid of hydraulics directly transfers force
3	Storage	i. Compressed Gas can be stored, allowing the use of machines when electrical power is lost
4	Safety	i. Very low chance of fire (compared to hydraulic oil). ii. Machines can be designed to be overload safe.

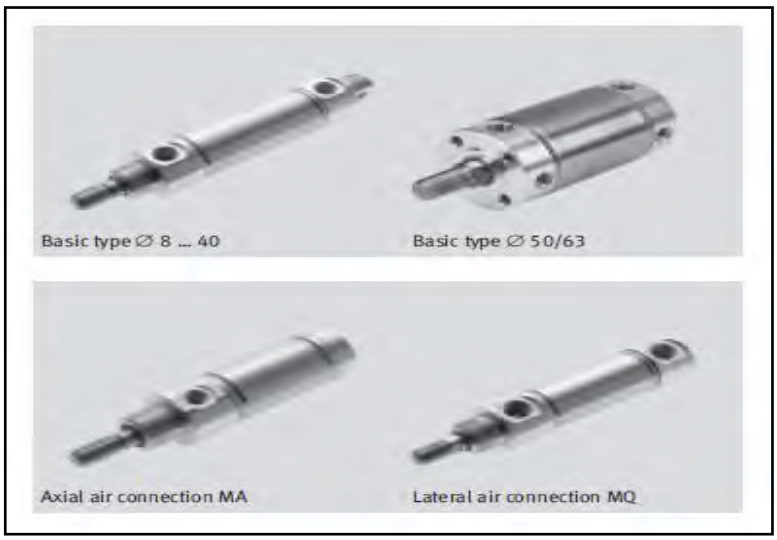

Figure 2.3: Model DSEU FESTO pneumatic cylinder

2.4 Control System Use in Project

Robots use a computer, microcontroller or a microprocessor and also PLC to manage movement and action. Like all computer, the ones for robot control need to be programmed. Although the advantage of programming languages such as functional, logic or functional logic languages for a high level completion of software systems is well known, the effect of such languages are too many actual world applications is imperfect. One reason for this might be the fact that many real world applications have not only a logical component but demand also for an appropriate modeling of the dynamic behavior of a system.

For example, systems become more important applications in our daily life than traditional software systems on general purpose computers, but the reactive nature of such systems seems to make it fairly difficult to use declare languages for their implementation (Hanus 2002).