IMPLEMENTATION OF PID CONTROLLER ON PRASMATIC CONTROL OF UNIVERSAL STRETCH AND BENDING MACHINE (USBM) SIMPLIFIED MODEL

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Specially dedicated to my beloved mother, father, family and also to all my friend

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ABSTRACT

In this project, generally the project is about implementation of PID controller on prasmatic control of universal stretch and bending machine (USBM) simplified model. The focus on this project is to use a controller as the control algorithm to control the position and movement of servo pneumatic valve. Without controller, the servo pneumatic valve extend, retract and stop at the position that desire but the position that the servo pneumatic were stop not an exact position and the movement also not too smooth. To get the exact position and smooth movement, the method that was used is by using the controller. There are many types of controller that can be used as the control algorithm such as PID Controller, State Feedback Controller and LQR Controller. In this project, the PID Controller was used as the control algorithm to control the system. Generally, this project can be separated into 4 parts which are PLC Setup, PLC programming, PID controller and Output (Regulator and cylinder). The CJ1M CJ Series-CPU 12 type of PLC was used in this project. In this project, a controller will give a signal to regulator and the output (pneumatic valve) will move base on the signal that was given by the controller.

ABSTRAK

Projek ini secara umumnya adalah berkenaan dengan pengaplikasian pengawal algoritma perkadaran terus, kamiran dan pembezaan pada kawalan gerakan secara linear. Fokus utama dalam projek ini adalah untuk menggunakan pengawal sebagai algoritma kawalan untuk mengawal kedudukan dan gerakan silinder pneumatik. Tanpa menggunakan pngawal, silinder pneumatik akan bergerak dan berhenti pada kedudukan yang diinginkan tetapi posisi dimana silinder tersebut berhenti adalah bukan posisi yang tepat dan gerakan silinder juga tidak lancar. Untuk menyelesaikan masalah ini, salah satu kaedah yang boleh digunakan adalah menggunakan pengawal. Terdapat banyak jenis pengawal yang boleh digunakan sebagai algoritma kawalan seperti pengawal perkadaran terus, kamiran dan pembezaan (PID), pengawal 'LQR' dan juga pengawal 'State-Feedback'. Didalam projek ini, pengawal perkadaan terus,kamiran dan pembezaan digunakan sebagai algoritma kawalan kepada system. Secara keseluruhannya, projek ini boleh dibahagikan kepada 4 bahagian iaitu bahagian penyediaan pengawal logic program boleh ubah (PLC), bahagian program PLC, bahagian pengawal PID dan juga bahagian penyediaan alatan dan perlengkapan. Model PLC yang digunakan adalahdari keluarga OMRON CJ Series iaitu CJ1M-CPU12. Secara ringkasnya didalam projek ini, pengawal akan menghantar isyarat kepada alat pengatur (Regulator) dan silinder pneumatik akan bergerak mengikut isyarat yang diterima daripada pengawal.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	i
	DEDICATION	iii
	ACKNOWEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLES OF CONTENTS	vii
	LIST OF TABLES	ix
	LIST OF FIGURES	x
	LIST OF SYMBOLS	xii
	LIST OF ABBREVIATION	xiii
	LIST OF APPENDICES	xiv
CHAPTER 1	INTRODUCTION	
	1.1 Background	1
	1.2 Overview of the project	1
	1.3 Objective	2
	1.4 Scope	3
	1.5 Problem Statement	3
	1.6 Thesis Outline	3
CHAPTER 2	LITERATURE REVIEW	
	2.1 Introduction	5
	2.2 Programmable Logic Control	5
	2.3 PID Controller	7
	2.4 Cylinder Positioner	8

	2.5 Ultrasonic Sensor	9
	2.6 Electro Pneumatic Regulator	11
	2.7 CX-Programmer	11
CHAPTER 3	METHOLODGY	
	3.1 Introduction	13
	3.2 Simulation Part	15
	3.3 PLC Wiring Part	19
	3.4 PLC Setting Part	26
	3.5 Hardware Development Part	33
	3.6 Integration Between PLC and Hardware	37
	3.7 Programming Part	39
CHAPTER 4	RESULT AND ANALYSIS	
	4.1 Introduction	40
	4.2 Simulation Result	40
	4.3 Project Result	45
	4.4 Problem of the project	50
CHAPTER 5	CONCLUSION	
	5.1 Conclusion	52
	5.2 Recommendation	52
	5.3 Costing and Commercialization	53
	REFERENCES	54
	APPENDICES	
	APPENDIX A – CJ1M AI CARD MANUAL SETTING	56
	APPENDIX B – CJ1M AO CARD MANUAL SETTING	67

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Ziegler-Nichols Tuning Rule Table and PID Equations	16
4.1	The comparison between the current and distance value in sensor and the distance of movement of cylinder positioned	45
4.2	The data for Input 1 and Input 2	50

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
3.1	Flowchart for overall project	14
3.2	Block Diagram of the System	15
3.3	Block Diagram for Simulation in MATLAB Simulink	15
3.4	Detail Diagram for PID Controller	16
3.5	The graph for the output first exhibits sustained oscillations	18
3.6	PID Block Parameter in MATLAB Simulink	18
3.7	Table of Power and Current Consumption	21
3.8	Power Circuit on the PLC	22
3.9	Digital Input / Output Circuit	23
3.10	Analog Input / output Circuit	24
3.11	PLC Panel after Wiring	25
3.12	PLC Panel after Wiring	25
3.13	PLC Panel after Wiring	26
3.14a	Initializing PLC Card Rack	27
3.14b	Initialize Digital Input Unit	28
3.14c	Initialize Digital Output Unit	28
3.14d	Initialize Analog Input Unit	29
3.14e	Initialize Analog Output Unit	29
3.15a	Analog Input Setting in I/O table and unit setup	30
3.15b	Analog Output Setting in I/O table and unit setup	31
3.16a	Process of comparison the data of D and CIO	32
3.16b	Process of transferring the data of D and CIO	32
3.17a	Ultrasonic sensor (Level Sensor)	34
3.17b	Electro pneumatic Regulator – ITV2050-01N2S3-Q (4mA-20mA)	34
3.17c	Cylinder Positioner	35
3.17d	Air filter (filter the air from the air compressor)	35

3.17e	The combination of cylinder positioned, air filter and electro pneumatic current regulator	36
3.17f	The whole system (hardware) of the project	36
3.18a	A sensor (left) and Input Signal wire at the top of electro pneumatic regulator (right)	38
3.18b	The PLC input and output card that connect to the set point, sensor, and input signal	38
3.19	Start the new file in CX Programmer	39
4.1	Output Response without controller	41
4.2	Output Response for P mode Controller	42
4.3	Output Response for PI mode	43
4.4	Output Response for PID mode Controller	44
4.5	Ladder Diagram for checking the condition of PLC I/O card	46
4.6	Ladder Diagram for get the error data	49

LIST OF SYMBOL

Kp	-	Proportional gain
Ki	-	Integral gain
Kd	-	Derivative
Kcr	-	The first value of Kp when the output exhibits sustained oscillation
Pcr	-	A time for one cycle at the graph when Kp = Kcr
A	-	Ampere
W	-	Watt
V	-	Voltage
T_i	-	Integral Time
T_d	-	Derivative Time

LIST OF ABBREVIATION

PID	-	Proportional Integral Derivative
PLC	-	Programmable Logic Controller
AI	-	Analog Input
AO	-	Analog Output
I/O	-	Input/Output
PV	-	Process Variable
SP	-	Set Point

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	CJ1M - AI CARD MANUAL SETTING	56
B	CJ1M - AO CARD MANUAL SETTING	67

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter explains the overview of this project which includes the information of the list below:

1. Overview of the project
2. Objective
3. Scope
4. Problem statement
5. Thesis Outline

1.2 Overview of the Project

In this project, generally the project is about implementation of PID controller on prasmatic control of universal stretch and bending machine (USBM) simplified model. The focus of this project is to use a controller as the control algorithm to control the position and movement of servo pneumatic valve (Cylinder positioned). Without controller, the servo pneumatic valve extend, retract and stop at the position that is desired but the position that the servo pneumatic were stop not an exact position and the movement also not too smooth. To control the position of the valve to stop at the exact position and to smooth the movement, the method that used is by using the controller. There are many types of controller that can be use as the control algorithm like PID Controller, State Feedback Controller and LQR Controller. In this case, the PID Controller was use as the control algorithm.

The other focus in this project is to setup the Programmable Logic Control (PLC) including design the circuit, wiring the PLC and also setup the PLC to match the setting in computer software that uses, there is CX programmer. CX Programmer is software that was used to write a program (ladder diagram) for PLC in a computer. A program that writes in a computer should be transfer to the PLC unit before run the system. RS232 cable was used to connect between PLC and PC.

In this project, the types of PLC that used is CJ1M-CPU 12. This PLC has 1 unit of power supply, 1 unit of CPU-12 card, digital input/output card and analog input/output card. In this project, PLC must be integrated with the hardware and software. The program that writes in software will transfer to the PLC unit and this PLC will give a signal to the hardware system. The system will be run after the signal was transfer.

1.3 Objective

The objective of this project is to the implement PID Controller on Prasmatic Control of Universal Stretch and Bending Machine (USBM) Simplified Model. The PID Controller is the algorithm that was used to control the desired position of piston of cylinder positoner. PID Controller will reduce the error of the system to make the system better (the piston of cylinder stop at the exact value).

1.4 Scope

The first scope is to do the simulation of this project by using MATLAB Simulink. The second scope of this project is to Setup the OMROM CJ1M-CPU 12 Programmable Logic Control (PLC) including identification of the features, components, power consumption, wiring the power circuit, wiring the input/output circuit and also setting the PLC card by using CX Programmer software. The third scope it to design and setting the configuration of the hardware that including cylinder positioner, ultrasonic sensor, air filter, and electro pneumatic regulator. The fourth and last scope is to implement the PID controller by using PLC and CX Programmer software.

1.5 Problem Statement

The position control of piston of cylinder positioner is very difficult when it is done by using traditional control techniques, as it requires a very complex mathematical model. By using a controller, we can eliminate the error to make the system better. In this project, the PID Controller is implemented to the system. Controller will reduce the error of the system and will smooth the movement of the piston, stop at the exact desired position and reduce the vibration of the piston when it extend or retract. By using PLC, we can use the simulator to test the program. With this advantage, it will reduce our energy and time.

1.6 Thesis Outline

This thesis consists of five chapters including this chapter. The contents of each chapter are outlined as follows:

Chapter 1 explained the overview of the project, objective, scope and also the problem statement.

Chapter 2 contains a detailed of literature review that refer while finish this project. It is including the information about Programmable Logic Control (PLC), PID Controller, Cylinder Positioner, Ultrasonic Sensor, Electro pneumatic Regulator and CX Programmer.

Chapter 3 includes the project methodology. This will explain about the simulation part, PLC wiring part, PLC setting part, hardware development part, integration between PLC and hardware part and programming part.

Chapter 4 discussed the result of simulation by using MATLAB Simulink, the result for the system and also the problem that face in this project.

Chapter 5 discussed about the conclusion and the recommendation of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter focused on the literature review of a component and device in this project. The component and device that will be discussed in this chapter are:

1. Programmable logic control
2. PID Controller
3. Cylinder positioned
4. Ultrasonic Sensor
5. Electro pneumatic regulator
6. CX Programmer

2.2 Programmable Logic Control

The first Programmable Logic Controllers were designed and developed by Modicon as a relay re-placer for General Motor and Landis. Dick Morley invented the first PLC, model 084, in 1969 and the first commercial successful PLC, the 184, was introduced in 1973 which was designed by Michael Greenberg. However the Modicon brand was sold in 1977 to Gould Electronics, and later acquired by German Company AEG and then by Schneider Electric, the current owner.

A Programmable Logic Controller (PLC) is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program or in the other words, PLC is to control the state of devices connected as outputs. Almost any production line, machine function or process can be automated using a PLC. We can enhance the speed and accuracy of the operation using this type of control system.

By using the PLC we can create and simulate the system as many as needed and this will help us save more time [1]. It also gives a lower risk and helps to reduce complexity. It also has the ability to change and replicate the operation or process while collecting and communicating vital information. A conventional PLC, that is possible to find on the market from many companies, offers many resources to control not only pneumatic systems, but also all kinds of system that uses electrical components [1].

Since the early days, manufacturer of PLCs have added numerous features and enhancement. PLCs have also been given the capability to handle extremely complex tasks such as position control, process control and other difficult applications [2]. Their speed of operation and ease of programming has also improved.

The step to set up the PLC was shown below:

i. The desired requirement of the control system must be understood
ii. General flowchart of control system must be draws

iii. List all of the input and the output that will be used and set the address for all input and output base on the input/output point of the PLC
iv. Configuration of the system, identification the features, components and power consumption of the PLC
v. Assembly of the PLC components and electrical components
vi. Wiring of main PLC circuit with labeling
vii. Wiring of input/output card circuit with labeling
viii. Checking of main PLC circuit
ix. Checking of input/output card circuit[3]

2.3 PID Controller

While designing a PID controller for a system, the steps below must be followed to obtain a desired response:

i. Obtain an open-loop response and determine what needs to be improved.
ii. Add a proportional control to improve the rise time.
iii. Add a derivative control to improve the overshoot
iv. Add an integral control to eliminate the steady-state error
v. Adjust each Kp, Ki and Kd until a desired overall response was obtain.[4]

What the PID controller is looking at is the difference (or "error") between the process variable (PV) and the set point (SP). It looks at the absolute error and the rate of change of error. Absolute error means, is there a big difference in the PV and SP or a little difference? Rate of change of error means, is the difference between the PV or SP getting smaller or larger as time goes on. When there is a "process upset", meaning, when the process variable OR the set point quickly changes. The PID controller has to quickly change the output to get the process variable back equal to the set point. If you have a walk-in cooler with a PID controller and someone opens the door and walks in, the temperature (process variable) could rise very quickly. Therefore the PID controller has to increase the cooling (output) to compensate for this rise in temperature. [5]

An analog controller combines several advantages over a digital controller which can be summarized as follows.

1. An analog system provides larger bandwidth, higher speed and eliminates quantization noise.
2. An analog controller must use a reconfigurable analog array instead of a DSP. The power consumption of a DSP halves every 18 months, as postulated by Gene's Law. It is shown in, that using a reconfigurable analog array can decrease power consumed by five orders of magnitude as compared to a DSP, implying by Gene's Law a 20 year leap in power reduction.
3. High performance data converters are required for a DSP-based controller. The performance of the converter in terms of its speed, conversion precision and noise greatly influences the fidelity of the controller. An analog controller eliminates the need for ADC sand DACs, thus improving performance and saving power, space and cost. As the power of the DSP is reduced, the power consumption of the data-converters will dominate, thus their elimination is very advantageous.[6]

2.4 Cylinder Positioner

The Hydraulic/Pneumatic Positioner is operated as either a hydraulic or a pneumatic *servo* system. The word "servo" generally implies position control. The system is the conceptual first cousin of the Motomatic system that you have already studied. A user commands an output to go to a certain location. The controller senses this command and orders the actuator to move the "plant" to this new location. This is the basis for *teleoperated* systems, where a remote operator causes movements that occur at a distance from the operator's location. We've talked about airplane pilots operating the (remote) control surfaces on an airliner. Such systems are also found in marine remotely operated vehicles (ROVs) used for off-shore oil drilling and production platforms and deep-sea salvage. Maintenance and inspection of nuclear reactors is done with teleoperated systems.

Often, the device to be moved has substantial mass or rotational inertia. Such a system is challenging to control because the mass or inertia seems to have a mind of its own. It takes a large force or torque to start the motion and a large braking force or torque to stop it. For large inertial loads, motion systems often are equipped with hydraulic or pneumatic actuators.The positioning system in the lab is a linear positioning system, unlike the Motomatic. It can be actuated either hydraulically or pneumatically. In this lab we shall use pneumatic actuation. You will see that the pneumatic cylinder can produce a large force, capable of moving and stopping the mass quickly.

With the emergence of the pneumatic-servo system, pneumatic system control is extended from logical control to servo control area. Due to the substantial nonlinearities of pneumatic-servo system which is mainly caused by air compressibility_valve deadzone and saturation_and cylinder friction, it has been used mainly for relatively simple tasks. Many researchers were engaged in pneumatic-servo system because of its simple in structure, high performance to cost, and easy to operate, but rather limited in “point-to-point” positioning control.[7]

2.5 Ultrasonic Sensor

Ultrasonic sensors (also known as transducers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.[8]

This technology can be used for measuring: wind speed and direction (anemometer), fullness of a tank, and speed through air or water. For measuring speed or direction a device uses multiple detectors and calculates the speed from the