AUTO FUZZY PID TEMPERATURE CONTROLLER

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Bachelor of Mechatronics Engineering
June 2012

“ I hereby declare that I have read through this report entitle “Auto Fuzzy PID Temperature Controller” and
found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronic Engineering”.

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Date : 2 July 2012

AUTO FUZZY PID TEMPERATURE CONTROLLER

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Mechatronic Engineering

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

YEAR 2012

I declare that this report entitle "Auto Fuzzy PID Temperature Controller" 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.

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Date : 2 July 2012

ACKNOWLEGDEMENT

During this report, I received enormous support from the lecturers who are expertised in PID, fuzzy and system controlling. They have given me a lot of advice and the concept on how those stuff work out. First of all I would like to thanks my supervisor Mr Loi Wei Sen for his guidance and encouragement. Besides that, I would like to thanks for those lecturers have helped me out in completing this report. Lastly I would like to say thank you all to my family, fellow friend and course mates giving me support and help during this report.

ABSTRACT

The accuracy and precision of control system is very important in industry to obtain the superior production. The lack of flexibility and capability of control system will burden the work of programmer or operator. Conventional PID control system is lack of flexibility and not that accurate enough, thus combination fuzzy and PID control system can enhanced or optimized the three PID gains (proportional, integral and derivative gain). The membership function set in the fuzzy logic control is adjusted by resizing the fuzzy sets and tuning for the membership function. An accurate temperature controller reduces the power consumption in order to save cost. Thus, fuzzy PID temperature controller is categorized as intelligent artificial controller will be applied in this project as well. The transient response can be reduced with the fuzzy logic controller where less overshoot and oscillation in it. There are 4 performance indices to quantitatively measure the performance of this system. Without implementation of hardware, the performance indices can use to investigate the performance of system as well. Integral square error (ISE) and integral absolute error (IAE) is used to investigate the performance of the system.

ABSTRAK

Ketepatan dalam sistem kawalan adalah amat penting dalam industri untuk menghasilkan produktiviti yang lumayan. Kelonggaran dan keupayaan sistem kawalan mempengaruhi pretasi kerja pengaturcara dan pengendali sistem. Sistem kawalan *PID* konvensional tidak cukup tepat dan kekurangan kelonggaran. Oleh itu, gabungan teknologi *Fuzzy* dengan sistem kawalan *PID* boleh meningkatkan atau mengoptimumkan 3 perolehan *PID* (*Proportional, Derivative* dan *Integral*). Fungsi keanggotaanmula kawalan *Fuzzy* logic dapat meyelaraskan saiz set *Fuzzy* untuk menyelaras perolehan *PID*. Pengawasan suhu yang tepat boleh mengurangkan penggunaan kuasa di samping menjimatkan kos elektrik. Justerus, pengawas suhu *Fuzzy* dengan *PID* boleh dikategorikan sebagai pengawal pintar yang digunakan dalam projek ini. *Fuzzy PID* dapat mengurankan ayunan dan lajakan dalam sistem kawalan. Indeks prestasi sistem boleh digunakan sebagai panduan dalam menyelaras keluaran yang optimal, *Integral Squared Error* (*ISE*) salah satu ralat digunakan dalam projek ini untuk mendapat pretasi sstem yang optimal.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In a qualitative manner, we can say the temperature is the term to describe the sensation of warmth and coldness of an object. For an example, when two objects are placed contact together the object having higher temperature will become cool while the object having lower temperature will become warm. In this condition, the objects will be achieved equilibrium temperature thus the thermal exchanges will be stopped and we will sense both of its same temperature.

A comfortable place for us to do our daily activities has few aspect such as surrounding temperature, humidity, lightness, airflow and etc. This thesis will enforce on the room temperature in form to provide a better temperature controller to control a room condition as well.

"90% of most people are comfortable when the air temperature is between 18-22˚C and the %sat is between 40-65%. This zone can be shown on the psychrometer chart and is known as the comfort zone." *Airconda.ppp*. The comfort zone is shown in Figure 1.1.

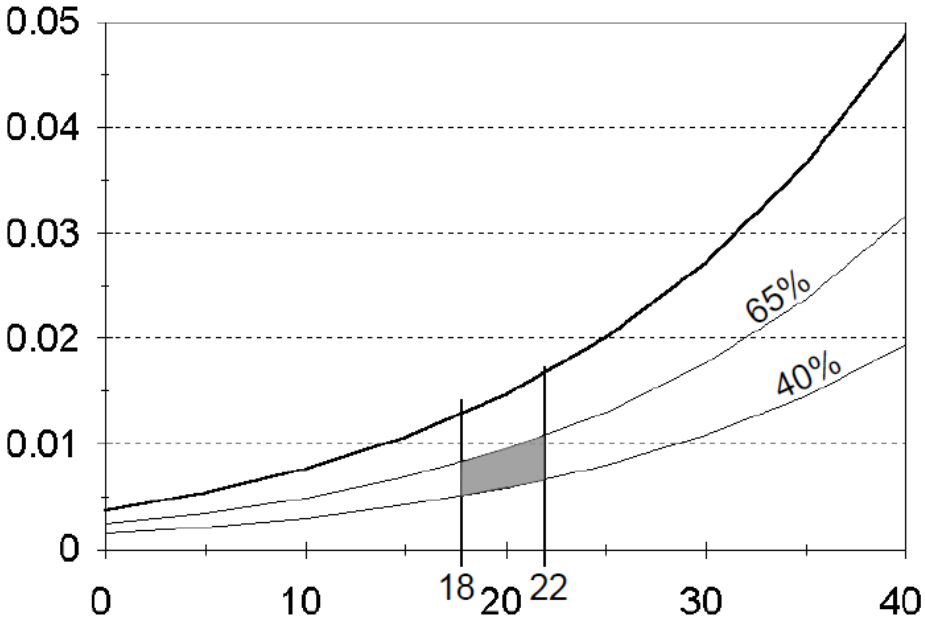

Figure 1.1 : Psychrometer Chart (Modified from Airconda.ppp)

In order to achieve this temperature range, a lot of manufacturer still using PID as controller. However there has more advance controller in tuning the system. This project will prove that PID controller can be optimized by using Fuzzy logic controller.

Proportional-integral-derivative (PID) controller is generic control loop feedback mechanism mostly used in industrial control systems. A PID controller tries to correct the error between a measured process variable and a set point by calculate the output and send a feedback to the input to do a corrective action. The proportional constant determine the reaction to the current error, the integral determines the reaction based on the total of recent error and the derivative constant determine the reaction to the rate of the error has been changing.[1] There is three constant can be adjusted to get the desired result as the below equation :

$$u(t) = \mathrm{MV}(t) = K_p e(t) + K_i e(\tau) d\tau + K_d \frac{d}{dt} e(t) \qquad [1.1]$$

where K_p = Proportional gain, a tuning parameter

K_i = Intergral gain, a tuning parameter

K_d = Derivative gain, a tuning parameter

e = Error

t = Instantaneous time

Fuzzy logic is a form of many respected logic where it is a problem-solving control system methodology that gives itself to application in system ranging from simple and small controller to bulky control system. With traditional logic theory, binary input have two valued logic either true or false (1 or 0) while fuzzy logic has developed to handle the concept of partial truth. Fuzzy logic will determine the true and exact value might range between completely true or false where can get the result faster and more precise[2].

“Fuzzy logic began with the 1965 proposal of fuzzy set theory by Lotfi Zadeh. Fuzzy logic has been applied to many fields, from control theory to artificial intelligence” by Lotfali Askar Zadeh (1965)

1.2 Statement of Problem

Temperature controller should be accurately and precisely detect the different between the room temperature and the desired temperature. PID temperature controller will perform adequately without any improvements or tuning and do not provide optimal control. If PID controller has feedback system with constant parameters, thus the performance will be reactive and compromise compare to the open loop system. Although PID temperature controller are most widely using nowadays, but PID temperature controller is significantly limited in their capabilities. Due to PID temperature controller are only able in measuring the varying inputs and the difference between its.

An accurate and precise temperature controller can save up a lot of power losses and cost. As an example, if the air conditioner keep switch ON/OFF, there need a lot of electrical supply mean more power losses during switching. Thus a best temperature controller should not have this kind of wasting.

PID temperature controller with Fuzzy logic can optimize the constant of PID, K_p , K_i and K_d.This enchantment will produce a more accurate and precise temperature controller if compare with the PID controller stand alone as well.

The fundamental function of feedback control system to minimize the error between the existing value and desired value to zero as fast as possible. Two types out of four performance indices used to evaluate system performance where it is a guide to design controller and obtain optimal performance.

Integral of absolute error (IAE) = $\int_0^\infty |e(t)|.\,dt$

Integral of squared error (ISE) = $\int_0^\infty \{e(t)\}^2.\,dt$

Integral of time multiplied by absolute error (ITAE) = $\int_0^\infty t|e(t)|.dt$

Integral of time multiplied by squared error (ITSE) = $\int_0^\infty t\{e(t)\}^2.dt$

Either one of the performance indices will integrate the error and produce a result of zero. Integral of absolute error (IAE) is mostly used for digital simulation while integral of squared error (ISE) is used for analytical simulation. In long duration error response, integral of time multiplied by absolute error (ITAE) and integral of time multiplied by squared error (ITSE) are used for system which requires fast settling time.

1.3 Objective of the Study

The main objectives of this research are to

a. Provide appropriate intelligent temperature controller for a comfortable room
b. Produce a more precise controller with Fuzzy logic in tuning the PID automatically
c. Optimize the PID constant with fuzzy logic
d. Obtain constant and peak performance by using performance indices ISE.

1.4 Scope of Study

This study will focus on the simulation through the software. The tuning of the fuzzy PID controller might take up thousand times and some suggestion on hardware was make for future development. Performance indices ISE and IAE use to obtain the performance of this fuzzy PID control system. MATLAB R2009a is used as the simulator. Model M31E-1 series of Permanent Magnet DC motor use as the plant of the system.

1.5 Methodology of the Research

An extensive study on research is quite important part at the start of a research. Researching controller and its own function with doing the literature review. The knowledge or information is study form journals, references book, online journal and advice from on field lecturer.

After an extensive study of literature reviews, the modeling on DC motor should be able be done before proceeding to design the controller tuning part. The main factor to model is every different motor have it own parameter value, so that obtained transfer function only can be used for this motor. Next the transfer function will be using as plant transfer function for PID and Fuzzy PD tuning.

MATLAB R2009a is used to observe the output of the DC motor in Simulink to determine whether the output is similar or same to the experimental result in order to use the transfer function in the next procedure. This software can accurately check or simulate in short time provided the designed block diagram is correct.

The PID and Fuzzy PD controller also use the Simulink software to design its own block diagram for simulation. Overall procedure in this project concluded as Figure 1.1.

Since this project has to carry out in UTeM lab act as poultry, thus the temperature control range will be in 20°C to 27°C to suit the environment. Temperature sensor LM35 will be used as the detection of temperature. In the mean while, a 20cm x20cm x 25cm box has been constructed by following the area ratio of real poultry farm to act as poultry real situation.

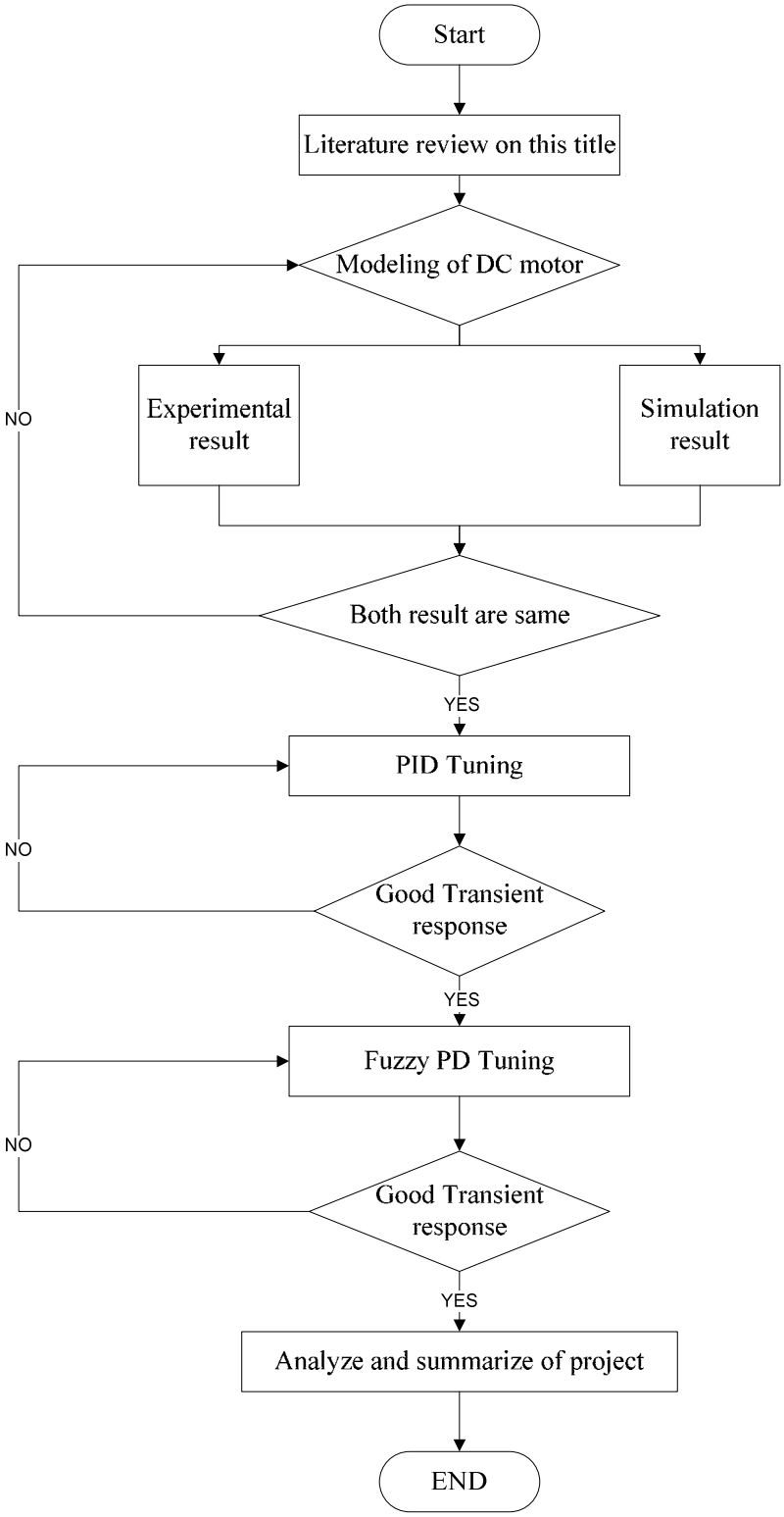

Figure 1.1 Flow of Simulation and Tuning Process

1.6 Outline of project

The project will emphasize on the tuning of Fuzzy PD controller in order to control the temperature. The supplied voltage will directly influence the speed of motor where had been attached with blade. Thus the speed of the motor is directly proportional to the supplied voltage. The Fuzzy PD should tune to the best transient response in order to provide an optimal output for the motor.

In Chapter2, it will focus on the studying of the controller, modelling of DC motor and performance indices. The Fuzzy PD is used to tune the supplied voltage before sending to plant.

In Chapter 3, the modelling of the DC motor (M31E-1 series) is summarized and the process of modelling out the transfer function of the DC motor with some required parameters. The accuracy of obtained transfer function will be analyzed with Simulink block diagram.

Chapter 4 will discuss in PID tuning either manually or auto tuning. From the obtained transfer function in chapter 3, it will use as the plant and PID controller will function in tuning the supplied voltage before injected into plant.

Chapter 5 is the most crucial part in this project. The main topic will be discuss in this chapter regarding to the tuning of Fuzzy PD in order to adjust the poultry surrounding temperature.

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Chapter 6 is the last chapter of this project where it used to conclude overall of the project and suggest some recommendation for future research or study.

1.7 Conclusion

This is the introduction chapter for whole project and clearly stated the method in complete this project. It started with background before go to statement of problem and objectives of this project. Next, best methodology will be used to solve the stated issue beside overall of this project is discussed in outline of thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Control system is a medium use to manage direct, order or regulate other devices or system. There are two most common control system, with varies combination and differences such as logic (sequential) control and linear (feedback) control. Fuzzy logic is most advanced control system where combine some of the design simplicity of logic with value of linear control. In the linear feedback system mean that output of the system is controllable thus the set point's variable can be adjusted through the feedback as shown in Figure 2.1.

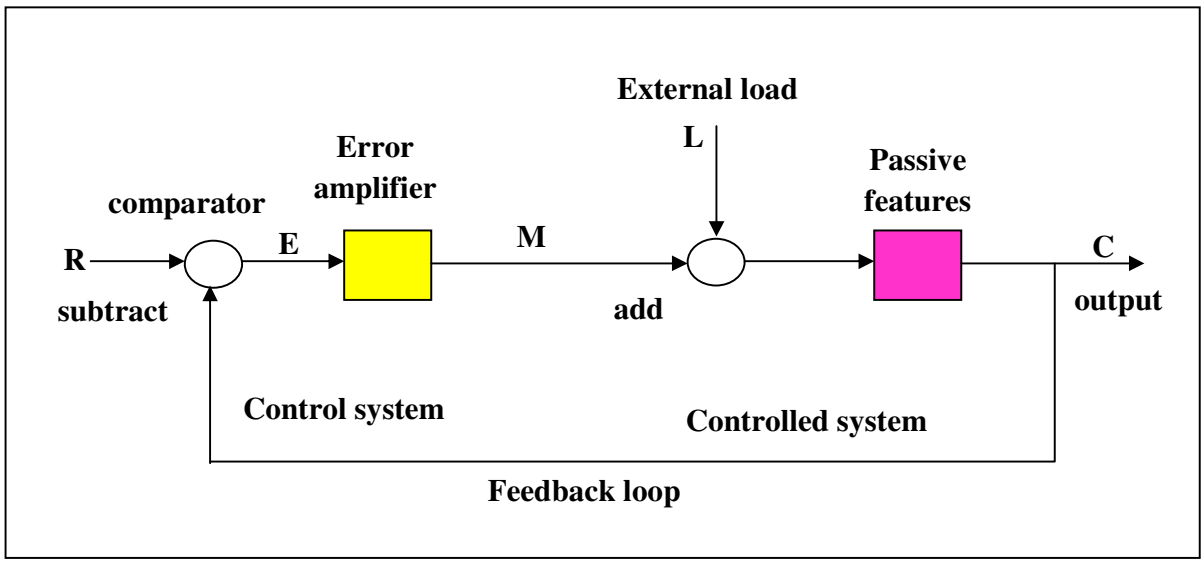

Figure 2.1 Close Loop System Block Diagram

2.2 Comparison between PID Control System and Conventional ON-OFF Control System

As mentioned above, control system is use to control or regulate the behaviour of another system or devices as well, thus the control system should be controlled the system as accurate as possible. According to Faieza Hanum Yahaya et. al.(2009), PID temperature controller is performed better than the on-off controller in maintaining the set point value of the system after the simulation and experiment. From the analysis of graph, PID controller is giving lower error percentage than on-off controller as shown in Figure 2.2.

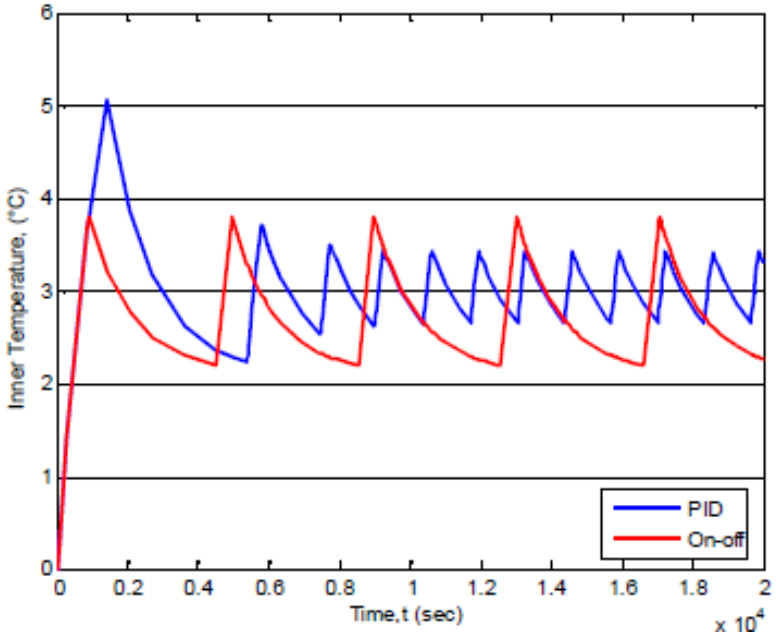

Figure 2.2 Comparison between PID and ON-OFF Controller

From the outcome, it can be concluded that PID controller is working more efficiently to maintain the temperature than ON-OFF controller.