TEMPERATURE CONTROL USING ANALOGUE PID CONTROLLER

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MAY 2008

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drive)"

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Supervisor's Name : Syed Najib Bin Syed Salim

Date : 7 / 5 / 2008.

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This Report Is Submitted In Partial Fulfillment of Requirements for Degree of Bachelor in Electrical Engineering (Power Electronics and Drive)

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MAY 2008

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

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For my beloved father and mother

Mohamed Yusof Bin Shamsudin and Maimon Binti Hamzah

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ABSTRACT

Temperature control using PID controller is basically reversed engineering process. Reverse engineering (RE) is the process of discovering the technological principles of a device or object or system through an analysis of its structure, function and operation. The purpose of this project is to improve the system performance and to control the temperature of the tank using the PID controller. This system separate into two main parts, which are heater as a control element and PID as a controller. The controller is using basic form of PID involves three mathematical control functions working together: Proportional-Integral-Derivative. These parameters vary immensely from one control to another. To determine the values of these parameters is known as PID Tuning. RTD sensor will be use as a feedback to measure the output of the system. The sensor will give the feedback to the controller to be correct by the controller until achieved the set point value. As overall, the temperature of the tank or the plant can be control by using the PID controller. This controller will produce a precise output in order to achieve its set point value.

ABSTRAK

Kawalan suhu menggunakan pengawal PID analog merupakan proses reka bentuk berdasarkan teknologi.yang sedia ada "reverse engineering". Di mana, reka bentuk akan direka berdasarkan analisis stuktur, operasi and fungsinya. Tujuan utama projek ini adalah untuk menghasilkan pengawal suhu dalam tanki dengan menggunakan konsep PID. Manakala bagi sistem suhu terbahagi kepada dua iaitu bahagian pemanas dan juga pengesan suhu.Pengawal PID terpecah kepada 3 bahagian Proportional Integral dan Derivative. Proportional merupakan bahagian di mana kawalan ini akan mengira jika ada berlaku ralat di antara proses boleh laras dan juga nilai yang ditentukan. Kawalan ini akan memastikan nilai yang sesuai untuk ia memastikan keluaran tiada ralat. Manakala kawalan integral adalah untuk memastikan tiada berlaku ralat awal selain itu, jika sistem melampaui nilai yang ditetapkan, kawalan ini dapat mengurangkan. Bagi Derivative pula ia mengawal nilai pada proses boleh laras seterusnya mengawal keluaran sistem seperti yang dikehendaki. Untuk memastikan nilai parameter ini, proses laras dilakukan supaya keluaran seperti yang dikehendaki. Selain itu, pengesan RTD digunakan untuk mengesan suhu. RTD akan memberi bacaan baca kawalan untuk diperbetulkan dan memastikan keluaran itu tepat seperti yang dikehendaki

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LIST OF ABBREVIATION

PID	- Proportional Integral and Derivative
FLC	- Fuzzy Logic Controller
PSM	- Projek Sarjana Muda
PIC	- Peripheral Interface Controller
PCB	- Printed Circuit Board
IC	- Integrated Circuit

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CHAPTER I

INTRODUCTION

1.1 Overview

The aim of this project is to develop a controller for the temperature system. Beside that, a plant will also be developed as a control element for the controller. The controller is able to produce a precise output in order to achieve the set point value. The controller will be developed by using analogue PID concept.

PID control is most often used when associated with temperature control. In this mode, the controller attempts to keep the load at exactly user set point which can be set at the Vref. Feedback from the sensor is use to measure the actual value of the heater (output). The PID equation is:

$$\textbf{Heater Output} = P[e + I\int(e)dt + D\, de/dt] \qquad (1.1)$$

where the error (e) is defined as : e = Set point – Feedback reading

For the proportional terms, the value must be greater than zero for the control loop to operate. The value of the proportional term is multiplied by the error (e) to generate the proportional contribution to the output, $(Pout) = Pe$. For integral term, looks at error time to build the integral to the output, $(Iout) = PI\int(e)dt$ .By adding integral, the error

on the system can be eliminated. Beside that, derivative terms acts on the change in error multiplied by time to make its contribution to the output, *(Dout)* = *PD de*. The derivative is use to boost the output when the set point changes instantaneously. This will reduce the time it takes for temperature to reach the set point. It can also see the error decreasing rapidly when the temperature reaches near the set point and reduce the output for less overshoot.

Control element for this system is the heater. Heater will heat according to the user set point and receive the signal from the controller. The controller will control the heater to ensure that the heater will not overheat or did not achieve to the set point value

RTD sensor or Resistance Temperature Detectors is used to measure the temperature by correlating the resistance of the RTD element with temperature. Most RTD element consist of a length of fine coiled wire wrapped around a ceramic or glass core. The element is usually quite fragile, so it is often placed inside a sheathed probe to protect it. The RTD element is made from a pure material whose resistance at various temperatures had been documented. The material has a predictable change in resistance as the temperature changes; it is predictable change that is used to determine temperature. This sensor will embed with signal conditioner.

1.2 Objective of Project

This project is to develop a hardware which are consisting an analogue PID controller and a control element using heater. Generally, the operation of the system is to heat the heater until achieved its reference value through an analogue PID controller. The controller will ensure the heater output achieved its reference value. Comparator will compare the actual value with reference value, if there is an error PID controller will fix the error. Beside that this system is low cost budget and user friendly.

Therefore, the main objective of this project can be concluded as:

- To control the temperature system using the controller
- To implement the PID concept to the system
- To design a hardware with low cost budget

1.3 Problem Statement

Temperature is one of the most frequently used parameters in process measurements in industry. There are many controllers can be used and one of the controller is PID. Mostly heater using an on-off method because of it was the simplest form on control. When the heater is hotter than the set point temperature the heater is switched off completely. Based on this method, the temperature is fluctuate and caused the temperature is not constant.

So based on this problem PID method has been used. PID controller provides a close loop concept in system. This close loop system will ensure that there is no error at the output. It will fix the error in order to reach the set point value.

Three terms in this controller will provide a good performance for the output. Each of this term has it own contribution for the system. When these three terms is combining, the system will perform more efficient and precise.

When using PID controller, user can be easily tuning according to the system requirement. Tuning is important in order to achieved good performance of the system. If problem occurred or the system requirement change, user can set the new tuning easy and faster.

1.4 Project Scope

Scope of the project is to design the PID controller and fabricated the design. Beside that, other circuits also need to be design such as signal conditioning circuit. Plant also will be fabricated for this system.

The scope of this project can be summaries as:

- Design and develop process control system that will controlled the temperature parameter in industrial process

Hardware application:

- Consists of hardware development application, design, redesign, testing and troubleshoot the hardware all the circuit involved.
- Hardware contains of temperature sensor, PID controller and also heater as a control element

1.5. Final Report Arrangement

This final report will be discussed by chapter. Firstly is introduction of this project in chapter I, follow by literature review in chapter II discussing about theory of my project and references from other projects. For methodology is in chapter III discussed about work plan and flow chart of my project. Analysis and results discussed in chapter IV. Finally is chapter V explains about recommendation and discussion.

CHAPTER II

LITERATURE REVIEW

2.1 Overview

In this chapter will explain the about the literature review and my project theory. In literature review, there two past project from other researcher that has been used as my references. For my theory, it explained the basic information for this project until the project completed.

2.1.1 Fuzzy Temperature Controller for Reactor

From the article of Weijing Zhang, Applications Engineer, the Film manufacture equipment is shown in Figure 1 between the electrode and the base. Dissociated argon ions crash onto the target and make atoms split out so that a film will be generated on the base. Because base temperature is critical in the process of film generation, temperature control becomes very important.

Figure 2.7 shows the system diagram of a fuzzy temperature controller used in this kind of reactor. Inputs to the controller are desired base temperature, measured base temperature, measured pressure in the reactor. Pressure is used because it has a large influence on base temperature to be controlled. High pressure results in high temperature. Output signals of the controller adjust the heater and the electromagnetic valve for the cooling water in the reactor.

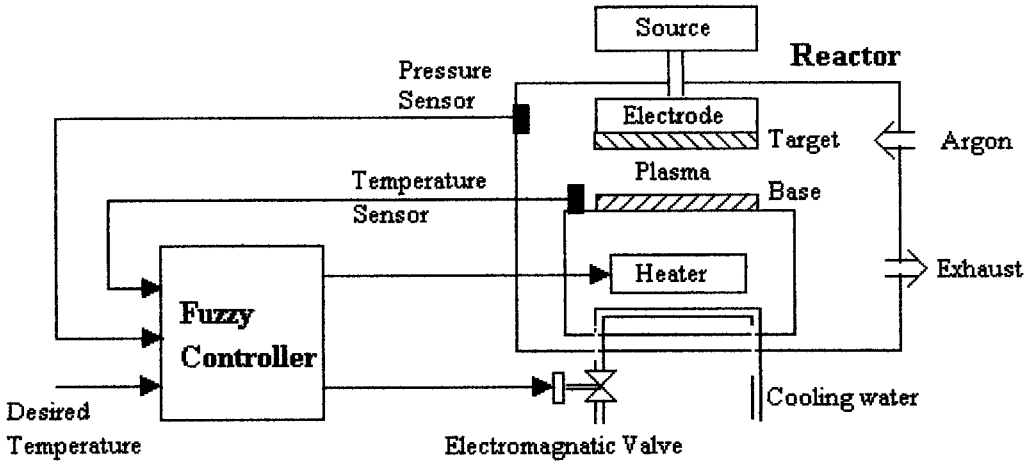

Figure 2.1: System Diagram of Reactor Temperature Control

Figure 2.8 shows the fuzzy controller that has three input variables and two output variables. Inputs can be prepared from feedback signals from sensors. The first input variable e is the difference between desired temperature td and measured temperature t, i.e. e = td – t; the second input variable □e is the variation between current temperature difference ei and previous temperature difference ei-1, variable is current pressure p. Two output variables are control signals to the heater and the cooling valve (Figure 1)

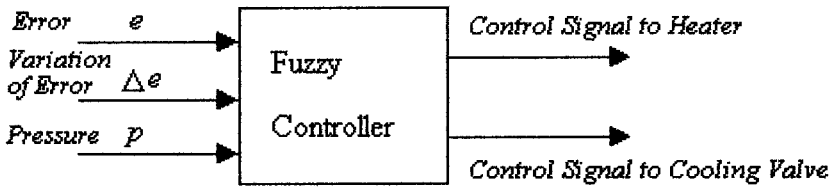

Figure 2.2 Fuzzy Temperature Controller

2.1.2 Advantages of Fuzzy Controller

A conventional single loop control system adjusts controlled output temperature only by the feedback signal from a temperature sensor. Pressure changes in the reactor are regarded as noises to this system. To design a conventional controller for this kind of system is difficult and time consuming. However, using a fuzzy controller, we can deal with this problem simply by taking factors (such as pressure), which have influence on the output, into account when designing the controller. To create a fuzzy controller for the above system, what we need to do is to write rules that contain not only temperature but also pressure in their antecedents. This design process is much easier compared with that of conventional controllers because we can write rules using commonsense knowledge and know-how from experts. No mathematical model of the process is needed as in the case of conventional control.

2.2 Oven control system using on-off controller

Charles D.H. Williams has search about an on-off controller for temperature control device. The output from the device is either on or off, with no middle state. An on-off controller will switch the output only when the temperature crosses the set point. For heating control, the output is on when the temperature is below the set point, and off above set point.

Since the temperature crosses the set point to change the output state, the process temperature will be cycling continually, going from below set point to above, and back below. In cases where this cycling occurs rapidly, and to prevent damage to contactors and valves, an on-off differential, or "hysteresis," is added to the controller operations.

This differential requires that the temperature exceed set point by a certain amount before the output will turn off or on again. On-off differential prevents the