PID CONTROLLER DESIGN WITH

DIFFERENT TUNING METHODS

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Bachelor of Electrical Engineering

June 2012

SUPERVISOR DECLARATION

“ I hereby declare that I have read through this report entitle “**PID CONTROLLER DESIGN WITH DIFFERENT TUNING METHODS**” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Automation and Instrumentation)”

Signature : ....

Supervisor’s Name : **Dr. Hamzah Bin Sakidin**

Date : ....

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A report submitted in partial fulfillment of the requirements for the degree of

Bachelor of Electrical Engineering

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STUDENT DECLARATION

I declare that this report entitle "**PID CONTROLLER DESIGN WITH DIFFERENT TUNING METHODS**" 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 : **MUHAMMAD JAZLI AIMAN BIN ABDUL RAHIM**

Date : ....

Dedicated to My Beloved Father, Mother, Brother, Sister and all my friends

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ABSTRACT

The purpose of this project is to design a PID controller for a heat exchange pilot plant and to study the best tuning method for the controller system. The data from the pilot plant will be used to model the system and to set the transfer function of the system by using MATLAB system identification toolbox. Once the analysis is completed, data gained will be used to tuning PID controller so that the system satisfies the required performance specification. This project also will included the studies on methods of tuning the controller such as Cohen-Coon method, Ziegler- Nichols method and other method that have been used in control system. The study of tuning method will be considered for their effectiveness and simplicity of implementation. In this tuning method studies, comparison between each method of tuning will be done included with their parameter and suitable application in control system that to be used in industrial application and to look for the best tuning method for the system design.

ABSTRAK

Tujuan projek ini adalah untuk mereka bentuk pengawal kebezaan-kamiran-kadaran (PID) bagi sebuah sistem pertukaran haba dan kajian tentang kaedah penetapan yang sesuai untuk digunakan di dalam sistem penukaran haba tersebut. Data yang diambil dari sistem perintis akan digunakan untuk mereka sistem dan untuk menetapkan persamaan bagi sistem ini dengan menggunakan program "System Identification Toolbox". Setelah analisis dilakukan, data yang diperolehi akan digunakan untuk penetapan nilai parameter PID supaya system direka dapat memenuhi spesifikasi yang diperlukan. Projek ini juga akan mengkaji mengenai kaedah-kaedah penetapan yang lain seperti kaedah Cohen-Coon, kaedah Ziegler-Nichols dan kaedah-kaedah yang lain. Kaedah penetapan ini akan dipertimbangkan berdasarkan keberkesanan dan perlaksanaan sistem. Perbandingan kaedah penetapan juga akan dilaksanakan berserta parameter dan system kawalan yang sesuai digunakan berdasarkan kaedah penetapan yang dikaji untuk digunapakai di dalam industri dan untuk menentukan kaedah penetapan yang terbaik untuk sistem penukaran haba ini.

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HEX	Heat Exchanger
FOPDT	First Order Plus Dead Time
PID	Proportional , Integral, Derivative
Z-N	Ziegler-Nichols
C-C	Cohen-Coon
IMC	Internal Model Control
Mac-PID	Maclaurin-PID
Kp	Proportional gain
Ki	Integral gain
Kd	Derivative gain
%OS	Percent overshoot

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CHAPTER 1

INTRODUCTION

1.0 The Project Overview

Many control method from the technology advancement that have been applied in the industry brings benefit to the mankind. To obtain higher efficiency productivity many control process offers substantial improvement.

Nowadays, heat exchanger is widely used in industry for cooling and heating industrial process. Principle of heat exchange is where two fluid with different temperature are brought into close contact but are prevented mixing by physical barrier. Heat exchange used to recover heat and put the heat for use by heating a different stream in the process. There is only one variable can be controlled which the amount of heat exchange. The heat is simply exchanged from one fluid to the other and vice versa.

By using SIMULINK as a programming tool, this project is going to develop a PID controller design for heat exchange system and comparing the suitable tuning method for the system. This project used data from pilot plant to model the system and to set the transfer function for the system. This project includes with graph display, different controller selection and calculation for the controller performance.

1.1 Problem Statement

Most of the PID controller is tuned with different method, so this project is to determine the best and most suitable tuning method for the system. Develop the model for the plant by employing system identification from MATLAB software where a lot of improvement can be achieved for its control strategy and improve the performance of the plant.

1.2 Objective of the Project

The objective of this project is:

- To design PID controller for heat exchange system to the set point using SIMULINK software.
- To get the model for the heat exchange system and design the PID controller by using several tuning method of tuning strategies.
- To compare transient response from different tuning method and select best tuning for used in the system.

1.3 Scope of the Project

This project is going to model heat exchange system using MATLAB system identification toolbox. In this project the FOPDT model from the heat exchanger pilot plant is used for simulation purpose. In this case MATLAB version 2010b is chosen as the development design controller and tuning method comparison. The performance of all controllers are evaluated and compared by looking at the transient response.

1.4 Project Outline

This report is organized into five chapters devoted to a specific topic. Chapter 1 explains the introduction and the overview of the project. This chapter also includes problem statement, objectives of the project and project scope. Description of the system background for the heat exchange controller, modeling, system identification toolbox and PID controller are explained in Chapter 2.

In Chapter 3 will give the details of the method use for control system design, modeling and analysis by applying tuning methods. Besides, the procedure to obtain the controller system is also introduced. Chapter 4 discuss about the controller system result and the MATLAB result. Lastly, the conclusion and recommendation for further study will be presented in Chapter 5.

CHAPTER 2

LITERATURE RIVIEW

2.0 Introduction

This chapter will describe the system background for the heat exchange system. Besides that, the description of the modeling, system identification toolbox, designing PID controller, PID Tuning and parameter calculation also included.

2.1 The Heat Exchanger System

Process industry of plant now need accurate, efficient and flexible operation due to increasing concern such in energy, cost efficiency and time. The new development of technologies always required for process modeling, dynamic optimization and high performance industrial process control.

Heat exchangers (HEX) are widely use in process industries such as chemical process and petroleum process as stated by Huang and Riggs [1]. They also define heat exchanger as a specialized device in the transfer of heat from one fluid to the other liquid through a solid wall to a cooler fluid [1] and Barnett stated from his journal of 'The Fundamental of Heat Exchanger' that function of solid wall or physical barrier is to prevent two fluid of different temperature from mixing [2]. Since the heat content from the two fluids is not constant therefore the heat exchanger system has to be kept at the desired set point from the outlet temperature according to the process requirement [1].

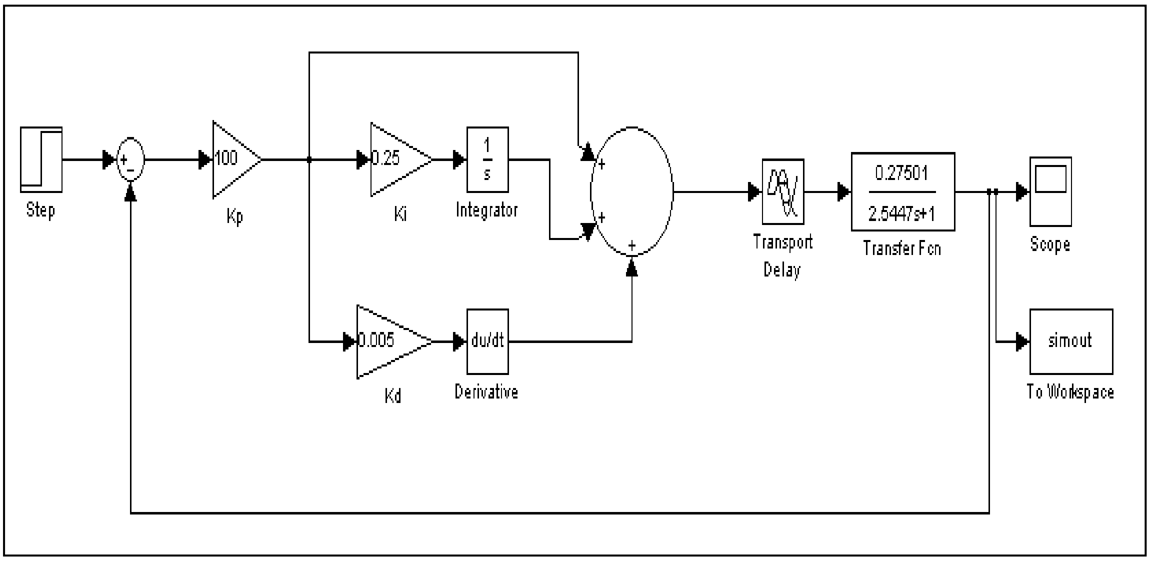

Figure 2.1: Heat Exchange Simulink diagram of PID Controller

Compared to the composition dynamics, heat exchanger typically have fast dynamic for distillation column. Normally the time constant is measured in second but could be up to a few minutes for large exchangers has been mention by Huang and Riggs [1]. It is recommended a simplified approach based on using a more effective method to calculate the steady-state exchanger exit temperatures and the delay these temperature but a first-order-lag to capture the dynamic [3,4].

Therefore, in this project heat exchanger is selected as a process that will be used for modeling. In order to achieve the objective, first order plus dead time (FOPDT) process controller is proposed and will be apply with several tuning method that suitable with the process.

2.2 Modeling and System Identification Toolbox

Modeling or System Identification is an interactive process. From Ljung article [5], he state that modeling requires a model structure where mathematical model between input and output variable that contain unknown parameter. System Identification obtains Validation Data, Estimation Data, and others. This system build mathematical model of the dynamic system by referring to measured data. System Identification measure input and output system in time domain and frequency domain. The measured input and output then use to estimate value of adjustable parameter in a model structure as stated in [5]. Then the validation data will be used for model validates purpose then this process will simulate the model and computing the residual from the model when applied to the validation data. System Identification estimate unknown model parameter by minimizing the error between the model output and measured response. From step response obtain the FOPDT model can be calculated by calculating the gain, time constant and time delay by referring to its step response curve as stated by Thyagarajan, Shanmugam and Ponnavaikko [6]. The FOPDT model is commonly used in many dynamic processes.

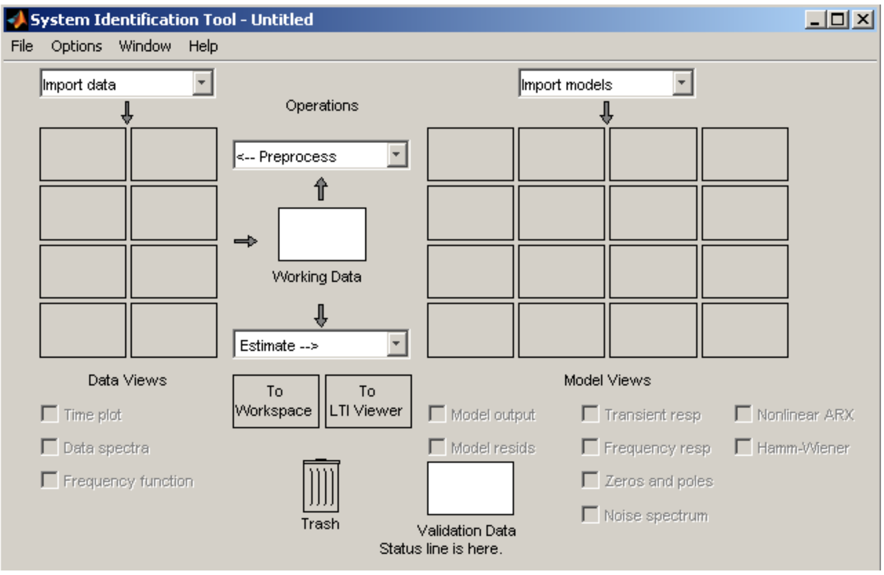

Figure 2.2: System Identification toolbox

2.3 PID controller

The PID control algorithm is the most popular approaches used in process industries due to easy to understand by operator, technician and maintenance. One algorithm of PID control can be successful in many applications such as petroleum processing, steam generation, polymer processing and many more. Willis On the author of [7] PID consists three basic mode which is Proportional mode, Integral Mode and Derivative mode. Thomas [8] briefly explained in his ‘Process Control’ book that PID control algorithm can provide good control performance for many different processes since the PID algorithm is simple and single equation. There are only 5% to 10% of industrial system that cannot be controlled by a PID controller as stated by Koivo and Tanttu [9]. Many industry use PID as their controller because of PID controller is remarkable effectiveness, simple to implant in industrial process and easy to re-tuning as concluded by Saeed and Mahdi [10]. Below is a simple diagram of control process that uses PID as controller:

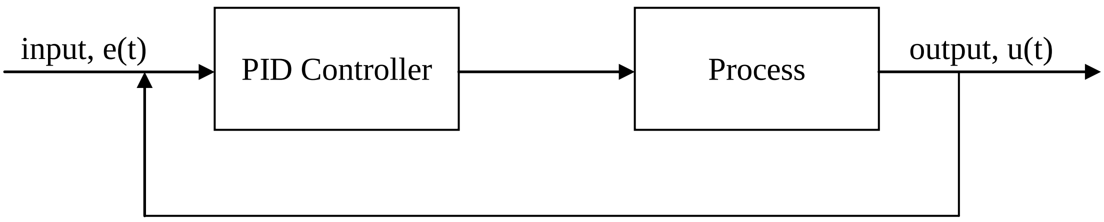

Figure 2.3: Control Systems with PID Controller

Zoran and Ognjen [12] stated Proportional, Integral and Derivative controller (PID) have three major classifications of PID which is Ideal, Series and Parallel as shown in Figure 2.4, Figure 2.5 and Figure 2.6. In ideal PID controller the algorithm is represent as (2.1). One of disadvantages of these kind of PID type, if a sudden change in set point it will cause a derivative kick to the controller since the derivate term become large as has been describe by Willis [7]. As for series PID or also known as interacting controller has a controller equation represent as (2.2). In series PID, proportional (P), Integral (I) and derivative (D) act decently. Thus, implementation of series mode can include either derivative on the error or derivative on the measurement. But for parallel mode, the proportional, integral and derivative gain act on the error signal. Since parallel mode carries the advantages of all three control mode, the transfer function of parallel PID controller can be expressed as (2.3) and (2.4).

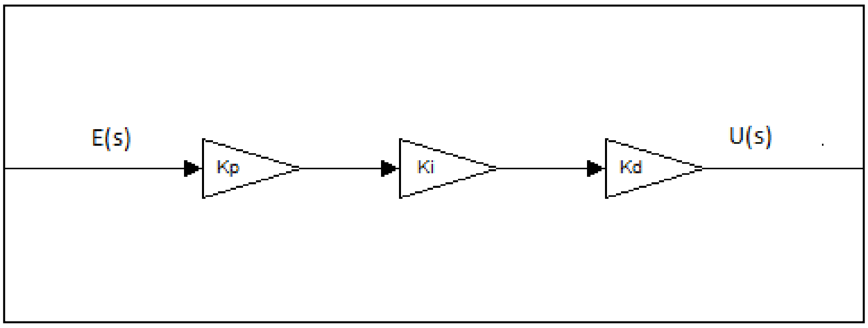

Figure 2.4: Series Form of PID Compensator [12]\

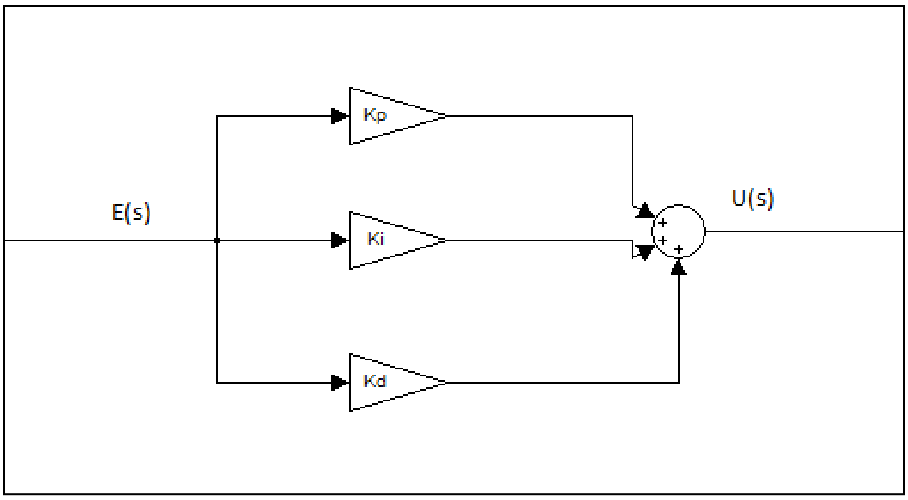

Figure 2.5: Parallel Form of PID Compensator [12]