MODELING AND CONTROLLER DESIGN FOR THE VVS-400 PILOT-SCALE HEATING AND VENTILATION SYSTEM

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Masters of Engineering (Electrical-Mechatronics & Automatic Control)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

NOVEMBER 2009

ABSTRACT

System modeling is an important task to develop a mathematical model that describes the dynamics of a system. The scope of work for this project consists of modeling and controller design for a particular system. A heating and ventilation model VVS-400 from Instrutek, Larvik, Norway is the system to be modeled and will be perturbed by pseudo random binary sequences (PRBS) signal. Parametric approach using ARX model structure will be use to estimate the mathematical model or approximated model plant of the VVS-400. The approximated plant model is estimated using System Identification approach. The conventional PID controller and artificial Fuzzy controller are designed based on the approximated plant model and also real plant model where the real plant model is developed by interfacing the Real-time Windows Target toolbox in Matlab with real VVS-plant by using data acquisition (DAQ) card PCI-1711. An artificial Fuzzy controller approach is incorporated in two ways which are conventional Fuzzy logic controller (FLC) and a replacement of conventional fuzzy controller known as Single Input Fuzzy Logic Controller (SIFLC). Simulations and experiment validate the equivalency of both controllers. Results reveal that SIFLC found to be better than FLC due to its less computation time compared to conventional FLC.

ABSTRAK

Permodelan sistem adalah langkah untuk memdapatkan model matematik yang menerangkan sifat sesuatu sistem itu. Ruang lingkup kerja dalam projek ini adalah terdiri daripada permodelan sistem dan mereka bentuk pengawal. Model VVS-400 dari Instrutek, Larvik, Norway adalah sistem yang akan di modelkan dengan menggunakan masukan "Pseudo Random Binary Sequences" (PRBS). Pendekatan parameter dengan struktur ARX akan digunakan untuk menerbitkan anggaran model matematik untuk sistem VVS-400. Anggaran model matematik ini boleh di terbitkan menggunakan perisian pengenalpastian sistem di dalam Matlab. Pengawal PID dan logik kabur akan di rekabentuk dengan simulasi berdasarkan anggaran model matematik dan juga berdasarkan model sebenar VVS-400 dengan menggunakan "Real-time Windows Target toolbox" dalam Matlab dan juga kad PCI 1711 sebagai pengantara. Di dalam kawalan logik kabur, terdapat dua jenis pengawal yang akan di reka bentuk iaitu logik kabur dan masukan tunggal logik kabur. Akhir sekali, perbandingan di antara logik kabur dan masukan tunggal logik kabur akan dibincangkan.

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CHAPTER 1

INTRODUCTION

1.1 Project background

The heating and ventilating system is a common process in our daily life where certain desired temperature is controlled. In industries such as pharmaceutical, ability to control temperature is crucial to ensure the quality of the product always within control. However, most of heating and ventilation plants are complex with higher-order systems, which leads to unsatisfactory performance. In this project, VVS-400 pilot-scale of heating and ventilation system is selected as a model system which needs to be maintained at a certain level of temperature. Therefore, model system has to be controlled by a suitable controller to achieve its desired temperature.

In order to control a system, model of that system must be created. The process of constructing models from experimental data is called system identification. System identification is a process in which experimental data is used to obtain a mathematical model for a particular system. This technique is widely used in industrial application mainly for nonlinear processes. There are several approaches for identification technique such as theoretical and empirical model. In this project, an empirical model will ne applied to the system where the system can be referred as a black-box model. A mathematical model will be developed through an experimental data by determined the input and output relationship. In this approach, the persistently excitation of input signal is crucial, since it influences data

sufficiency. Often, Pseudo-Random Binary Sequences (PRBS) input were chosen due to its large energy content in a large frequency range [Fazalul, 2006]. Further details in choosing the appropriate input can be found in [Barenthin, 2006]. The results from experimental data will be tested using Matlab's System Identification toolbox. From experimental data, parametric approach using Autoregressive with exogenous input (ARX) structure will be use to estimate the mathematical model (approximated model plant) of VVS-400. Controller design is also included in this project through closed loop Matlab simulation with an approximated model plant of VVS-400. There are three types of controllers that will be considered in this part which are PID controller, Fuzzy logic controller (FLC) and Single-input fuzzy logic controller (SIFLC). Then, an online control is performed with a real VVS-400 using Real-time Windows Target toolbox. Finally, discussion and conclusion are drawn.

1.2 Objectives of the project

1.2.1 To develop a mathematical model that describes the dynamics of VVS-400 using system identification approach.

1.2.2 To estimate the parameter of the VVS-400 mathematical model.

1.2.3 To design a suitable controller for the VVS-400 and to test the stability of the system.

1.3 Scope of work

1.3.1 Study the characteristics of VVS-400

1.3.2 Experimental setup and data collection

1.3.3 Study on System Identification toolbox

1.3.4 Controller design

1.4 Thesis outline

This thesis is organized in 5 chapters. The first chapter gives an overview of the project that gives the introduction of control system and its possible application.

Chapter Two covers literature review on related works, system description, system identification and controller design.

Chapter Three covers the flow of methodology and description of each procedure.

Chapter Four mainly discuss about the results and discussion of this project.

Chapter Five includes the conclusion and recommendation of the thesis.

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