# TRACKING PERFORMANCE OF A HOT AIR BLOWER SYSTEM USING PID CONTROLLER WITH PSO AND HARMONIC SEARCH ALGORITHM

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Dedicated to my dearest dad and mum who supported me all the time and my friends who always by my side.

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**ABSTRACT**

PT326 process trainer is a self-contained process and control equipment. The crucial part that can be seen from this system is to control the temperature of a flowing air. In this project, a PT326 process trainer, which is a hot air blower system is used. This project is conducted due to this problem. The scope of work for this research include modeling and controller design of a PT326 process trainer. PID controller is designed with MATLAB software to control the purpose of maintaining the process temperature at a desired value. The simulation result aim to make a comparison of the performances of the process temperature when using Particle Swarm Algorithm and Harmonic Search Algorithm. Simulation results demonstrated that the uses of Particle Swarm Optimization tuning algorithm provides a good performance in term of overshoot, settling time and percent of steady-state error.

# ABSTRAK

PT326 adalah sebuah peralatan proses dan kawalan serba lengkap . Bahagian yang penting dari sistem ini adalah untuk mengawal suhu udara yang mengalir. Dalam project ini, sistem penghembus udara panas PT326 akan digunakan. Projek ini dikendalikan kerana masalah ini. Skop kerja bagi kajian ini termasuklah pemodelan dan kawalan reka bentuk PT326. Pengawal PID direka dengan perisian MATLAB untuk mengawal dan mengekalkan suhu proses pada nilai yang dikehendaki. Hasil simulasi bertujuan untuk membuat perbandingan prestasi suhu proses apabila menggunakan pengoptimuman kumpulan zurah dan Algoritma Carian Harmonik. Keputusan simulasi menunjukkan bahawa pengoptimuman kumpual zurah memberikan prestasi yang baik dari segi terlajak, masa pengenapan dan peratusan ralat keadaan mantap.

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# LIST OF SYMBOLS

| | | |
|---|---|---|
| $K_p$ | - | proportional gain |
| $K_i$ | - | integral gain |
| $K_d$ | - | derivative gain |
| z | - | discrete form |
| e | - | noise |

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| GUI | - | Graphic User Interface |
| PID | - | Proportional Integral Derivative |
| ZN | - | Ziegler-Nichos |
| PSO | - | Particle Swarm Optimization |
| HSA | - | Harmonic Search Algorithm |
| ARX | - | Auto Regressive with Exogenous Input |
| FPE | - | Akaike‟s Final Error |
| AIC | - | Akaike‟s Information Criterion |
| NOP | - | Number of particle for PSO tuning method |
| Nt | - | Number of particle for HSA tuning method |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Overview

In control system design, temperature is one of the crucial control variables like motor velocity in thermal appliance. In pharmaceutical industry, the ability to control temperature is important to ensure the quality of the product always within control. Besides, the ability to control the temperature of a flowing air at certain system is important due to the efforts of various designs. The main objective of this project is to maintain the process temperature at a given value due to the non-linear and significant time delay of the system. In this project design consists of few step of process and the process began with collection of input and output data from experimental works. The data collected is used for model estimation. AutoRegressive with Exogenous Input (ARX) model is chosen as a model structure of the system. Based on the input and output data of the system, the best fit criterion and correlation analysis of the residual is analyze to determine the adequate model for representing PT326 hot air blower system. PID controller is design for controlling and implemented the model system by simulation. Lastly is to make comparison and justification based on the controller performance of the process temperature using Particle Swarm Optimization and Harmonic Search Algorithm.

So to achieve the highest performance of the PT326 hot air blower system, PID controller needs to be designed. The best mathematical model of the system is necessary required for the controller design so that the system is under control. Consequently, the mathematical model of the PT326 process using System Identification approach was considered in this work. System Identification Toolbox in MATLAB is used to make estimation for the parameters. Besides, it is also used to approximate the system models based on the mathematical models obtained. There are two methods in System Identification Approach that used to describes the mathematical models of the system, and the two methods which are parametric and non-parametric method. Moreover, AutoRegressive with Exogenous Input (ARX) is selected as the model structure of this project to do estimation and validation of the model system. To ensure the ARX model structure obtained either accepted or rejected, the Model Validation Criterion was used. Once the model structure was accepted and the model system was validated, the PID controller is designed to improve the output response of the system. Three different tuning methods: Ziegler-Nichols, Particle Swarm Optimization (PSO) and Harmonic Search Algorithm (HSA) are proposed in this work.

## 1.2 Objectives

The objectives of this project are:

1. To determine the mathematical model of the PT326 process trainer using System Identification Approach.
2. To estimate and validate the parameters of the PT326 mathematical model using ARX model structure.
3. To design PID controller for controlling the PT326 process trainer.

4. To apply PSO and Harmonic Search Algorithm in PID controller for the purpose of tuning the parameter.
5. To make a comparison and justification based on the controller performance obtained from the simulation.

## 1.3 Problem Statement

The development of this project is based on these problems:

1. Unknown plant model or mathematical model of the PT326 process trainer.
2. Unknown suitable parametric approach or model structure to be used to estimate the mathematical model of a particular system.
3. Undesired output response of the system.

## 1.4 Scope of work

The scope of work for this project consists of model identification and estimation continued by controller design of a hot air blower system (PT326 process trainer). A PT326 process trainer is the system to be modeled. Parametric approach using ARX model structure is used to estimate the mathematical model or approximated plant model. The approximated plant model is estimated using System Identification approach. PID controller is then designed to improve the output performance of the system. Besides, PSO and Harmonic Search Algorithm will be used to optimize the PID Controller in order to improve the dynamic and steady static characteristic of PT326. Lastly, the comparison study and justification is made based on the performance of the controller.

## 1.5 Thesis Outline

Chapter 1 is the part of introduction. In this part, introduction was included to briefly explain some important parts of the whole project, objective of project, problem statement of project and scope of work.

Chapter 2 represents the part of literature review. In this part, review on the related journal, books and internet resources will be done. This is due to study the related project in order to obtain the smallest possible value for the rise time, overshoot, settling time and steady state error by using the PID Controller.

Chapter 3 represents the methodology. In this chapter, the overall design and methods to apply in this study had been stated. The main methodology that been stressed out related to the PID Controller and data collection from the MATLAB simulation.

Chapter 4 shows the part of result and discussion. In this chapter, simulation result and discussion of this project is discussed in this chapter. The simulation results of the system performance have been observed. Besides, the implementation of PID Controller using Particle Swarm Optimization (PSO) and Harmonic Search Algorithm will be done in order to achieve the objectives. Discussion also be done discuss about the problem faced along the project.

Chapter 5 is the part of conclusion and future works. For the future recommendation, some suggestion is discussed and future improvement that possible to make also had been included. Besides, the whole projects were concluded in conclusion.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 PT326 Process Trainer

The PT326 Process Trainer is a self-contained process and control equipment. It has the basic characteristic of a large plant, enabling distance or velocity lag, transfer lag. System response, proportional and two-step control to be established. In this equipment, air drawn from atmosphere by a centrifugal blower is driven past a heater grid and through a length of tubing to atmosphere again. The process consists of heating the air flowing in the tube to the desired temperature level and the purpose of the control equipment is to measure the air temperature, compare it with a value set by the operator and generate a control signal which determines the amount of electrical power supplied to a correcting element, in this case a heater mounted adjacent to the blower. The PT326 Process Trainer is shown in Figure 2.1.

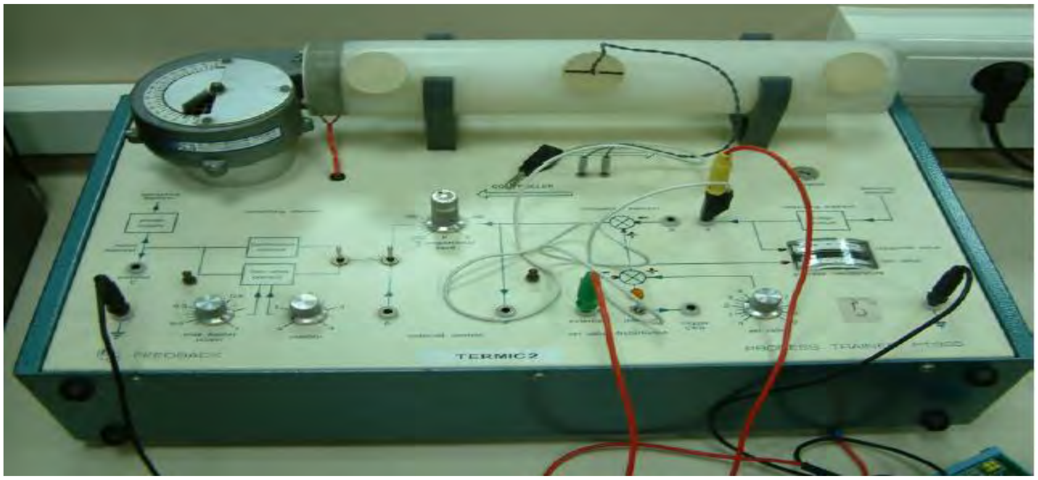


Figure 2.1: PT326 Process Trainer

To make adjusting on the mass flow of air through the tube, the opening of the throttle must be set through the setting. There are three temperature sensors which are thermistor placed at three different locations. The indication of the temperature sensors are linked to the detector terminal. Besides, the resistance of the thermistors sensor will convert to voltage through the bridge circuit of the detector and the desired temperature may be indicated by adjusting the set value knob. Additional change in the set value can be demanded by throwing the internal switch. However at external terminal, the external reference input will be provided. The difference between the positive reference input and the feedback signal is obtainable which can be applied to the heater power supply through an adjustable gain by using the proportional band knob. A proportional band of PB% corresponds to a gain factor of 100/PB. The signal at terminal „B‟ is available at terminal „A‟ after amplification by the gain factor. The switch „S‟ is use to apply the signal from terminal „A‟ directly to the heater power supply by selecting the „two-step control‟. The maximum heater power will achieve when the on-off controller is at on condition and the zero heater power will obtain once the on-off controller is under off condition. The hysteresis in the on-off controller can be adjusted by using the knob marked „overlap‟ while the maximum heater power to be supplied can be adjusted by using the knob marked