PID CONTROLLER OPTIMIZATION FOR AVOIDING OVERSHOOT AND REDUCE RISE TIME IN TEMPERATURE ON BARREL HEATING SYSTEM USING BAT ALGORITHM

PUTERI AMALINA BINTI ZAMALUDIN

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DECLARATION

I declare that this report entitle "***PID Controller Optimization For Avoiding Overshoot And Reduce Rise Time In Temperature Of Barrel Heating System Using Bat Algorithm***" 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 : Puteri Amalina binti Zamaludin

Matrix No : B011110015

Date : ………………………………………

DEDICATION

Special word dedicated to my lovely mother Masiah bte Mohd. Husain who always give me supports, faith and constant encouragement while completing my Degree.

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ABSTRAK

Sistem Pemanasan di dalam tangki adalah sistem yang mengawal suhu mesin seperti mesin pengacuan plastik. Pelet mentah dikekalkan daripada bekas ke dalam ruang laras. Kemudian, laras dihangatkan dengan band-band pemanas rintangan di dalam zon yang berbeza. Jumlah zon pemanasan bervariasi dari mesin ke mesin tertumpu produk akhir. Akhir sekali, leburan dikekang ke angkasa cetakan, di mana ia akan dimantapkan lagi dengan pendinginan. Hal ini penting untuk menjaga suhu leburan pada nilai yang dikehendaki, untuk mengelakkan barang yang tidak siap. Oleh itu, pengawal PID adalah salah satu pengawal yang terbaik yang dapat meningkatkan sistem. Ziegler Nichols, Root Lokus, pelaras automatik dan lain-lain boleh digunakan untuk mendapatkan hasil yang terbaik di antara pelaras yang lain. Tambahan pula, terdapat penyelidik-penyelidik mula untuk menggunakan “metaheristic algorithm” untuk penambahbaikkan sesuatu sistem. Di dalam projek ini, “Bat Algorithm” telah terpilih untuk digunakan di dalam sistem pemanasan. Projek ini bermula dengan melaras pengawal PID untuk mendapatkan nilai dari pengawal bagi sistem pemanasan barel dan diikuti dengan simulasi perisian MATLAB dengan pengawal PID dan tanpa pengawal PID. Akhirnya, hasil daripada model ini telah dianalisis.

ABSTRACT

Barrel Heating System is a system that control the temperature of the machine such as plastic molding machine. The raw pellets are sustained from the container into the barrel chamber. Then, the barrel is warmed with resistive heater bands in different type of zones. The quantity of heating zones varies from machine to machine focused around the end product. Lastly, the melt is constrained into the mold space, where it gets solidify by cooling. It is important to keep up the temperature of the melt at a desired value, in order to avoid unfinished items. Therefore, the PID controller is one of the finest controller that can improve the system. Ziegler Nichols, root-locus, auto tuning and others can be used in order to get the best result among the tuning. In addition, there are many researcher turn to metaheuristic algorithm in order to improve the system. In this paper, Bat Algorithm was selected to be used in Barrel Heating System. The project started with tuning PID controller to get the value of the controller for the barrel heating system and followed by simulation of MATLAB software with and without PID controller. Finally, the result of this model was analyzed.

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LIST OF ABBREVIATIONS

ABC-BP	-	Artificial Bee Colony using BPNN
BA	-	Bat Algorithm
Bat-BP	-	Bat Algorithm based Back-Propagation
BMI	-	Body Mass Index
BPNN	-	Back-Propagation Neural Network
CPU	-	Central Processing Unit
DCS	-	Distributed Control Systems
DE	-	Differential Evolution
DG	-	Distributed Generation
DOSH	-	Department of Occupation Safety and Health
FIS	-	Fuzzy inference system
FC	-	Fuel Cell
FYP	-	Final year project
GA	-	Genetic Algorithm
HBA	-	Hybrid Bat Algorithm
HBARF	-	Hybrid Bat Algorithm Random Forests
HSA	-	Harmony Search Algorithm
HSABA	-	Hybrid Self-Adaptive Bat Algorithm
IBACH	-	Improved Bat Algorithm with CHaos

Kp	-	Gain proportional
Ki	-	Gain integral
Kd	-	Gain derivative
LF	-	Levy Flight
MT	-	Micro Turbine
NIHL	-	Noise-Induced Hearing Loss
NiMH	-	Nickel–Metal Hydride
PID	-	Proportional, integral and derivative
PD	-	Proportional derivative
PLC	-	Programmable Logic Controllers
PSO	-	Particle Swarm Optimization
SABA	-	Self-Adaptive Bat Algorithm
Ti	-	Time integral
Td	-	Time derivative
WT	-	Wind Turbine
ZN	-	Ziegler Nichols

LIST OF SYMBOLS

A	-	Alpha
^0C	-	Degree
Γ	-	Gamma
Ni	-	Number of Agent
Nt	-	Number of Iteration
ρ_α	-	Probability
%	-	Percentage
Sec	-	Seconds
L	-	Time delay
T	-	Time constant

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Temperature control is an important part in many industrial process and heating barrel for various chemical and metallic products. The desired shape, structure and quality are attained with proper temperature control in barrel heating system for plastic injection molding industries. Overheating or under heating of plastic pellets affects the quality of product. The barrel temperature of the process directly influences the viscosity of polymer and need to be control effectively. This is one of the challenging task in plastic molding process.

The ON/OFF controller used in industries for control of the barrel heating system which are not giving satisfactory performance. While using ON/OFF controller, the power consumption is high and the heater lifetime decreases because of the continuous chattering which leads to wear out of the relay quickly. The varying temperature happen because of the quality of the product is not even at all the area. To reduce the power consumption, eliminate the temperature swings, and also to improve the product quality, the PID control algorithm can be selected. PID controllers give satisfactory performance with undershoot. Therefore, a model based PID controller can overcome these problems [1].

The bat-inspired metaheuristic algorithm, to be specific the bat algorithm, was as of late proposed by Xin-She Yang [2], referred on the echolocation of microbats [3]. In this present reality, echolocation can have just a couple of thousandths of a second (up to around

8–10 ms) with a shifting frequency in the district of 25–150 kHz, comparing to the wavelengths of 2–14 mm in the air. In the standard bat algorithm, the echolocation characteristics of microbats can be idealized as the accompanying three rules:

i. All bats use echolocation to sense separation or distance, and they likewise 'know' the contrast between food/prey and foundation obstructions in some supernatural way;

ii. Bats fly haphazardly with velocity v_i at position x_i with a settled frequency fmin, fluctuating wavelength and commotion A0 to look for prey. They can naturally alter the wavelength (or frequency) of their discharged pulses and change the rate of pulse emission $r \in [0, 1]$, contingent upon the proximity of their target;

iii. In spite of the fact that the clamour can fluctuate from various perspectives, we expect that the commotion differs from a huge (positive) A0 to a base constant value Amin. The main purpose to develop this metaheuristic algorithm is to solve problem faster, solve large complex problem and also obtain robust solution. [4]

1.2 Problem Statement

The toughest job in the plastic molding procedure is control of machine procedure parameters because of their inter-relations. The barrel temperature of the procedure specifically impacts the polymer thickness and it has to be controlled successfully which requires a quick rise time and avoid overshoot [1]. Temperature process usually have slow time constants and long delay, causing difficulties and limitation to control the system design. The PID controller computes an error esteem as the distinction between a deliberate procedure variable and a desired set point. The controller endeavours to minimize the error by modifying the procedure through the uses of a controlled variable. Basic PID Controller does not comprehensive enough in order to improve optimal solution of the system. Therefore, PID Controller optimization was used and analysed to reduce the error of barrel heating system by using different tuning. Then, the algorithm is applied in order to improve the performance on the system. Bat Algorithm had been selected for this research to studies and analyse its capability on this system.

1.3 Objective

Objective of the project need more specific and can be measurable. The main objective is to propose a model of Bat Algorithm (BA) to optimize the PID controller for avoiding overshoot in temperature and rise time of barrel heating system.

1. To design the PID controller for barrel heating system in order to avoid overshoot and produce quick rise time.
2. To optimize the PID controller by using Bat Algorithm.
3. To analyse and compare the performance of conventional controller with Bat Algorithm (BA) in terms of rise time and overshoot.

1.4 Scope of Research

A barrel heating system is design to control and maintain the temperature in different zones to get the desired value without damaging the product. There are a lot of controllers that can be used likes PD controller, PID controller and others This project focuses on the PID controller optimization for **avoiding overshoot** and also **reduce rise time** in temperature of barrel heating system and was test by using Bat Algorithm (BA) and Harmony Search Algorithm (HSA) method. The controller was model in SIMULINK in MATLAB software. In addition, this project **does not required of hardware** on build barrel heating system.

Table 1.0: The requirement value of the project

Overshoot (%)	0 – 10
Rise Time (sec)	1 – 5

1.5 Motivation

The motivation for this research is to improve barrel heating system by using PID Controller. The function of the barrel heating system is to control and maintain on the desired temperature of the product. It is not easy to maintain the temperature of the system. The varying temperature happen because of the quality of the product is not even at all the area. To reduce the power consumption, eliminate the temperature swings, and also to improve the product quality, the PID controller was selected. PID Controller was used by using Root Locus, Ziegler Nichols and Tuning technique to optimize the controller. The changes is based on rise time, percent overshoot and stability. Besides that, Bat Algorithm (BA) is used to optimize PID controller shown signs of better result.

1.6 Report Structure

This report includes of five chapters which Chapter 1 for Introduction, Chapter 2 for Literature Review, Chapter 3 for Methodology, Chapter 4 for Result and lastly Chapter 5 for discussion on whole research.

Chapter 1 was included for introduction, discussed more about project background, objectives on the research, problem statement and also scope of the project.

For Chapter 2, this chapter is included about Literature review which is highlight the previous work and also all material principle and mathematical theory use in this research.

Then, Chapter 3 is more about methodology to use flowchart of the process and software with clear explanation to present the research. Gantt chart and flow chart also included in Chapter 3 to show the progress of whole Final Year Project.

For chapter 4 which is the final result gained from this project which included graph, diagram and table. The result of the best technique of tuning with PID Controller and link with coding for Bat Algorithm for Barrel Heating System also inserted in this chapter. This chapter also provide analysis and discussion on the result of the research, stressing the significant and implication of the finding on this system.

Lastly, Chapter 5 included a conclusion for a whole project referred on simulation in Matlab and explain the achievement from the objective. Recommendations for future work may also be included together with contributions of project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature review of previous research on temperature of barrel heating system. Beforehand, a few controllers were utilized as a part of this project. There were Proportional Derivative (PD), Fuzzy Logic controller and others. This project focuses on using PID controller only. The concept of Bat Algorithm (BA) was used to optimize the usage of PID controller. This algorithm has been actualized much of the time in many cases in engineering and software engineering study. Most of the paper specified that the BA is very efficient and prove to be superior for almost all the test problems and also in many application depends on different application and terms.

2.2 Plastic molding machine and Barrel Heating System

The usage of plastic molding machine is to manufacture plastic like bottle caps, chairs, tiny containers, toys and others. The crude pellets are sustained from the hopper into the barrel. The barrel is warmed with resistive heater bands in diverse zones. The quantity of heating zones varies from machine to machine focused around the final item. The responding screw show inside the barrel chamber pivots to push the melt towards the mold end. The melt is constrained into the mold space, where it gets solidify by cooling.

Besides, it is essential to sustain the temperature of the melt at a desired value, in order avoid uncompleted items [5, 6]. The proposed PI-PD controller was provided in this part of process in order to keep the temperature of the melt at 200 degree.

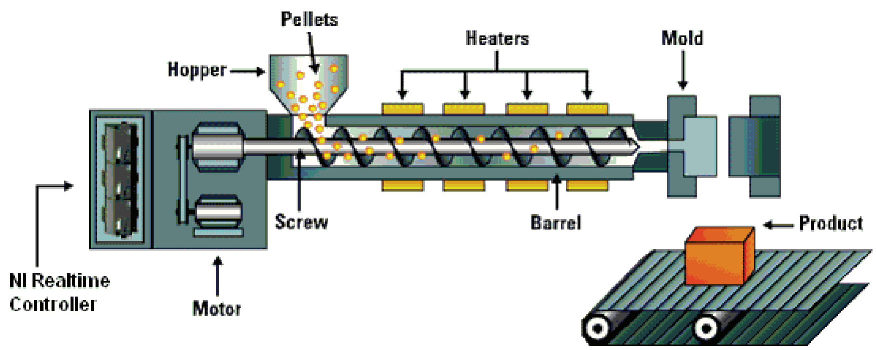

Figure 2.0: Plastic Molding Machine

2.2.1 Auto tuning of temperature control system with application to injection molding

Temperature control is essential issue in numerous industrial process, for examples are electric-resistance furnaces, crystal ovens, and heater boilers/tanks/barrels for different synthetic and metallic items. Such a thermal process usually express the integrating response characteristic throughout the heating stage, and after increasing to the set-point temperature, it have a tendency to act in a stable manner given a certain heating range due to the air convection or radiation loss into the environment. The key control challenges for such methods are to avoid overheating for an example is temperature overshoot in the heating stage and to firmly keep up the set-point temperature against load disturbance also flow of process/environment varieties [1].

Besides, thermal processes commonly have slow time constants and long-time deferral, bringing on challenges to control-system design [7]. In addition, there is an injection molding machine in the heating barrel, as indicated in Figure 2.0, the raw materials (plastic resin) fed from the hopper need to be warmed and dissolved to a temperature over 200 ^{0}c before injection molding. To guarantee consistency in item quality, the front three zones (i.e., 1–3) of the heating barrel are needed to be heated up with insignificant temperature overshoot as fast as it would and then, keep up the melting temperature, for an example 200^0C, for injection molding. Based from the earlier information of the barrel thermal inertia, previous literature created an optimal time exchanging method for heating up with a small temperature overshoot [8]. A few model-prediction control technique have been lately reported for successfully sustain the barrel temperature [9]–[11].

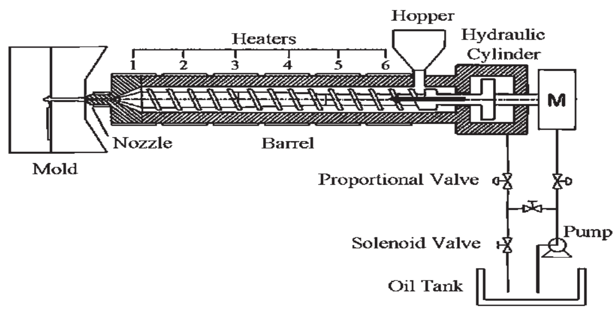

Figure 2.1: Injection Molding

2.3 PID Controller

This controller has the capacity to give an extensive variety of processes and additionally has been connected with an advancement of innovation and technology that actualized in digital form instead of pneumatic and hydraulic parts. This control component as a standalone controller and was added to functional block, for example, Programmable Logic Controllers (PLC) and Distributed Control Systems (DCS). In the PID controller, the new viable apparatuses have been included for enhancing the analysis and design systems in the fundamental of algorithm with a specific end goal to build the execution.

The PID controller calculation includes three different parameters, which are called three-term control: the proportional, the integral and derivative meant P, I, and D. Basically, these values can be translated in terms time: P relies on upon the present error, I on the accumulation of past errors, and D is an expectation of future error, referred on current rate of change [12].