

SELF-TUNING PID CONTROLLER OF AN ACTIVATED SLUDGE PROCESS
USING EVALUATIONARY ALGORITHM.

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"To only hopefulness that we live for him"

"To my beloved Father, Mother, brothers and wife"

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ABSTRACT

Proportional Integral Derivative (PID) controllers are widely used in many fields because they are simple and effective. Tuning of the PID controller parameters is not easy and does not give the optimal required response, especially with non-linear system. In the last two decades many intelligent optimization techniques were taken into attention of researchers like: Particle Swarm Optimization (PSO) and Gravitational Searching Algorithm (GSA) techniques. This research is represented the non-linear mathematical model multi input multi output MIMO and simulation of the wastewater treatment plant (WWTP) with closed loop PID controller, And is aimed to investigate a new multivariable control methodology using a self-tuning PID control algorithm to control the concentration of dissolved oxygen and nitrate of a wastewater treatment plant. The traditional PID tuning technique is proposed as a point of comparison. Relative Gain Array (RGA) is applied which yields identity matrix for both reduced model. Integral Time Square Error (ITSE) has been chosen as the objective function. Two of intelligent optimization techniques: GSA is proposed in this research, and PSO is from previous research to tune the PID controller parameters.

ABSTRAK

Pengawal Berkadar Integral derivatif (Proportional-Integral-Derivative PID) digunakan secara meluas dalam pelbagai bidang kerana mereka adalah mudah dan berkesan. *Tuning* parameter pengawal PID adalah tidak mudah dan tidak memberi tindak balas optimum yang diperlukan, terutamanya dengan sistem yang tidak liner. Dalam dua dekad yang lalu banyak teknik pengoptimuman pintar telah mengambil perhatian penyelidik seperti: Teknik *Particle Swarm Optimization* (PSO) dan *Graviti Searching Algorithm* (GSA) . Kajian ini mewakili model matematik berbilang input MIMO output berbilang bukan linear dan simulasi pesawat rawatan air sisa (WWTP) dengan pengawal gelung tertutup PID, bertujuan untuk menyiasat kaedah kawalan pembolehubah baru menggunakan algoritma diri penalaan kawalan PID untuk mengawal kepekatan oksigen terlarut dan nitrat daripada pesawat rawatan air sisa. Tradisional teknik penalaan PID adalah dicadangkan sebagai titik perbandingan . *Relative Gain Array* (RGA) digunakan yang menghasilkan matriks identiti bagi kedua-dua model dikurangkan. *Integral Time Square Error* (ITSE) telah dipilih sebagai fungsi objektif . Dua daripada teknik pengoptimuman pintar: GSA adalah dicadangkan dalam Penyelidikan ini, dan PSO adalah dari penyelidikan sebelumnya untuk mencari parameter pengawal PID yang optimum.

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LIST OF ABBREVIATIONS

WWTP	—	Wastewater Treatment Plant
ASP	—	Activated Sludge Process
DO	—	Dissolved Oxygen
MIMO	—	Multiple-Input Multiple-Output
SISO	—	Single-Input Single-Output
RGA	—	Relative Gain Array
IAE	—	Integral of Absolute Error
ITAE	—	Integral of Time multiplied Absolute Error
ISE	—	Integral of Square Error
ITSE	—	Integral Time multiplied Square Error
K_P	—	Proportional Gain
K_I	—	Integral Gain
K_D	—	Derivative Gain
PI	—	Proportional – Integral Controller
PID	—	Proportional – Integral – Derivative Controller
GSA	—	Gravitational Search Algorithm
PSO	—	Particle Swarm Optimization

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CHAPTER 1

INTRODUCTION

1.1 Background of study.

The purpose of wastewater treatment plants (WWTP) is to accelerate the natural processes that occur in those waters under controlled conditions and small size. An important reason for the development of methods of treating those waters impact on public health and the environment where the treatment was confined to remove suspended solids and floating and disposal of decomposing organic matter and some microorganisms that cause disease. There are many methods for controlling these plants, such as PID controller [1], fuzzy neural network controller [2], direct adaptive controller [9], and indirect adaptive controller [10].

Proportional Integral Derivative (PID) controllers are widely used in many fields such as wastewater treatment and process industry because effective and simple [1,6]. It has a simple control structure which was understood by plant operators and which they found relatively easy to tune. Since many control systems using PID controller have proved satisfactory, it still has a wide range of applications in industrial control. But tuning of the PID controller parameters is not easy and does not give the optimal required response, especially with non-linear system. Therefore some researchers resorted to using the intelligent optimization technique for optimization PID controller parameters.

In recent years, many heuristic optimization methods have been developed, such as Gravitation searching Algorithm (GSA) constructed based on the law of Gravity and the notion of mass interactions [3,5,7,8]. Particular Swarm Optimization (PSO)

is inspired by the behavior of birds and fish in the move from one place to another [3,1]. and Bees Algorithm (BA) inspired by the foraging behavior of honey bees in nature [6,4].

1.2 Problem statements of project.

There are several problem statements in control design of activated sludge process, multi loops applied with nonlinear mathematical model multi input multi output (MIMO) for investigated and controlled new variables in the activated sludge process (Nitrate and dissolved oxygen (DO)). Tuning of the PID controller parameters is not easy and does not give the optimal required response, especially with nonlinear system. The system requires an intelligent algorithm to optimized performance PID controllers.

1.3 Objective of project.

The objectives of this project were:

1. To design a new multivariable self-tuning PID control algorithm to control the concentration of dissolved oxygen and nitrate of a wastewater treatment plants using GSA.
2. To design a new multivariable self-tuning PID control algorithm to control the concentration of dissolved oxygen and nitrate of a wastewater treatment plants using PSO.

1.4 Report outline of project.

This section presents the outlines of the project report. This report is organized into five chapters and each of these chapter is generally explained.

- **Chapter 1** gives a brief introduction regarding on actual implementation of waste water treatment plants in real life situation. Background, Problem statement, objectives, and significant of the project work will be stated and listed clearly.
- **Chapter 2** discusses literature review on waste water treatment plants and some related works. And the development of PID controller and optimization approach for the system is reviewed based on previous researchers findings.
- **Chapter 3** discusses characteristic of waste water treatment plants and PID controller. This chapter is aimed to enhance the understanding of this project report for readers from different backgrounds. In addition to that, discusses and calculated the relative gain array (RGA).
- **Chapter 4** discusses of Intelligent optimization technique. In this chapter prepared two type of algorithms, gravitational searching algorithm (GSA) and particular swarm optimization (PSO).
- **Chapter 5** summarizes the results and discussions for all the simulations which were performed throughout the overall investigation process. Simulations are run in order to check the performance of PI and PID controllers in modes.
- **Chapter 6** draws the conclusion for this project and discussed some future research and perspectives.

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