OPTIMAL WASTEWATER TREATMENT PLANT BY PID CONTROLLER

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This report is submitted in partial fulfilment of requirement for the Bachelor Degree of Electronic Engineering (Telecommunication Engineering)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer (FKEKK)
Universiti Teknikal Malaysia Melaka (UTeM)

June 2017

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : **OPTIMAL WASTEWATER TREATMENT PLANT BY PID CONTROLLER**

Sesi Pengajian : 1 6 / 1 7

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It is my deepest gratitude and warmest affection that I dedicate this thesis to Dr. Sharatul Izah binti Samsudin who has been a constant source of knowledge and inspiration.

Also, my beloved mom and dad, my siblings and friends for their encouragement, support and motivated me along my excellent journey of education.

ACKNOWLEDGEMENT

First and foremost, I would like to praise to Allah S.W.T for giving me an ability and strength to do my final year project successfully and complete my report as required. I would like to express my gratitude to the Faculty of Electronic and Computer Engineering, especially to my supportive and caring supervisor Dr. Sharatul Izah binti Samsudin for providing his insightful knowledge and valuable assistance throughout this project under his guidance.

I would like to take a chance to thank all the lecturers who taught me in the past four years and great contribution that qualify me to do my final year project. I would like to thank Dr. Ahmad Sadhiqin Bin Mohd Isira and Pm. Dr. Kok Swee Leong and the other lecturers and staff that participated to arrange for iNOTEK and IoT competition, with their efforts in providing information and cooperation to help students achieving the goals of final year projects.

At the other side of appreciation is extended to my parents, for their support and encouragement throughout my studies. Their advice and reminder always give me a strengthen to complete my final year project and studies. I would like to thank all senior students who helped me to clear out the questions and guide on the software that I use for this final year project.

Thanks as well to all my friends for their guidance and knowledge they provide to me. Lastly, my thanks as well extend to whoever supported me and give some inspirational in doing my final year project and throughout my studies.

Thank you.

ABSTRACT

Activated sludge process is used to reduce the amount of dissolve organic matter from the wastewater by using the microorganism in aeration tank. The process will produce a water that can be used again without affecting the environment to avoid pollution and it is safe. This project is to design an optimal wastewater treatment plant by PID controller. The main contribution of this work is to study and compare the performance of the nonlinear PID controller for substrate and dissolved oxygen concentrations. The performance of the controller will be compared and is analyzed for better control performances. There are two nonlinear equation function that will make knon-linear PID controller that have been obtained from previous study. Both of the nonlinear controller will then be compared to an adaptive PID controller. It is expected that the developed controller is potential to control the wastewater treatment plant with 3 designs of PID controller and it is efficient.

ABSTRAK

Proses enapcemar aktif digunakan untuk mengurangkan jumlah pembubaran bahan organik daripada air sisa dengan menggunakan mikroorganisma di dalam tangki pengudaraan. Proses ini akan menghasilkan air yang boleh digunakan semula tanpa menjejaskan alam sekitar untuk mengelakkan pencemaran dan ia adalah selamat. Projek ini adalah untuk mereka bentuk loji rawatan air sisa optimum dengan pengawal PID. Sumbangan utama kerja ini adalah untuk mengkaji dan membandingkan prestasi pengawal PID tak linear untuk substrat dan kepekatan oksigen terlarut. Prestasi pengawal akan dibandingkan dan dianalisis untuk persembahan kawalan yang lebih baik. Terdapat dua fungsi persamaan tak linear yang akan membuat pengawal PID tidak linear k yang telah diperolehi daripada kajian sebelumnya. Kedua-dua pengawal tak linear kemudian akan dibandingkan dengan pengawal PID adaptif. Ia dijangka bahawa pengawal dibangunkan potensi untuk mengawal loji rawatan air sisa dengan 3 reka bentuk pengawal PID dan cukup berkesan.

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INTRODCUTION

1.1 Background of Project

Wastewater treatment process is a procedure to treat mass of crude material in water waste. Nonetheless, it was extremely hard to make an ideal wastewater treatment and make the profluent quality achieve the gauges that have been set. This case happened as a result of the propel models that need to include more strides of process operation. At the point when more strides are included, it will deliver more aggravations to the plant framework.

Therefore, the controller is expected to defeat this issue. The qualities have demonstrated change after mechanization was presented which comprise of detecting component and control circles. This venture concentrates on enhancing the dilution rate and air flow rate wastewater treatment by utilizing ideal nonlinear PID controller for wastewater treatment.

This venture explores the utilization of multivariable PID controllers to a wastewater treatment prepare. Two multivariable PID control plans are explored. The greater part of the strategies that are appropriate single-input single-output (SISO) and multiple-input different yield (MIMO) control circles that experience circle collaboration the productive execution of the water treatment handle relies on upon the ideal control of the convergence of oxygen in the air circulation tanks.

1.2 Problem Statements

The use of advanced control strategies for such processes is necessary because wastewater plants have a nonlinear behavior and are extremely sensitive to the influent flow and load. Nonlinear numerical models typically display a higher exactness that the liner scientific models, however because of their many-sided quality, are hard to use in control framework configuration stages. Non-optimal wastewater plant may cause pollution due to system failure. Furthermore, environment effects cause by the discharge of partially treated or untreated wastewater also can cause pollution. The current controller is often malfunctioning and failed which need to be improves so that it will follow every company needs and systems and reduces the systems failure.

1.3 Objective of the Project

The main objectives of this project are as follows:

a) To develop a nonlinear PID controller for wastewater treatment
b) To compare the control performance of wastewater plant with three design of PID controller

1.4 Scope of the Project

a) The project focuses on the development of PID controller for optimal control action.
b) The design will be done in 3 designs of PID controller which is in single in single output (SISO) and the result will be research and compare.
c) Simulation of the wastewater control will be done in Mathlab Simulink.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss about the literature review on the wastewater treatment process, and designing the PID controller based on past journals and conference paper. The knowledge gained was used to provide idea about the project.

2.2 Wastewater Treatment Process

Wastewater is a water that the quality in it was affected by any biochemical during the process of industries or other process that make the quality of the water become low and not safe for human. Wastewater treatment process is a procedure to evacuate the biochemical or a substance in the water to ensure that the water was protected and can be reused once more. There are three stages in the wastewater treatment which is primary treatment, secondary treatment and tertiary treatment.

Before the wastewater go through the primary stage treatment, there is a pre-treatment which is the procedure is to evacuate crude things that can be collected easily before it harmed the pump that collected wastewater to the treatment plant.

2.2.1 Primary Treatment

Primary stage treatment is when the sewage flows through large tanks and basically the particles like oil will be skimmed and will be floating at the surface of the wastewater. The primary stage treatment tank is usually called as pre-setting basins, primary sedimentation tanks or primary clarifiers [2][4]. The primary stage treatment tank is usually equipped with the mechanicals that will continuously feed the sludge to the base of the tank where it was pumped to the sludge treatment facilities.

2.2.2 Secondary Treatment

Secondary stage treatment is a process where the biochemical in the wastewater is being degrades to make the treated water safe to the environment. In this stage, the process is executed within an aerated biological reactor. This is to ensure that the microorganisms are supplied with air and particles are kept in suspension [3]. It was placed in the aerobic tank and go through to the aerobic process. To make the process become more effective, it was adding up the microorganism that will help the decomposition process. The bacteria will have decomposed the sludge and it will have produced floc that can be removed by filtering. This process will have reduced the biochemical level contain in the water.

2.2.3 Tertiary Treatment

Finally, the tertiary treatment is a procedure to enhance the nature of the emanating that originates from the secondary treatment plant. This procedure typically set at the remainder of the treatment procedure which is before the emanating was released to the open environment.

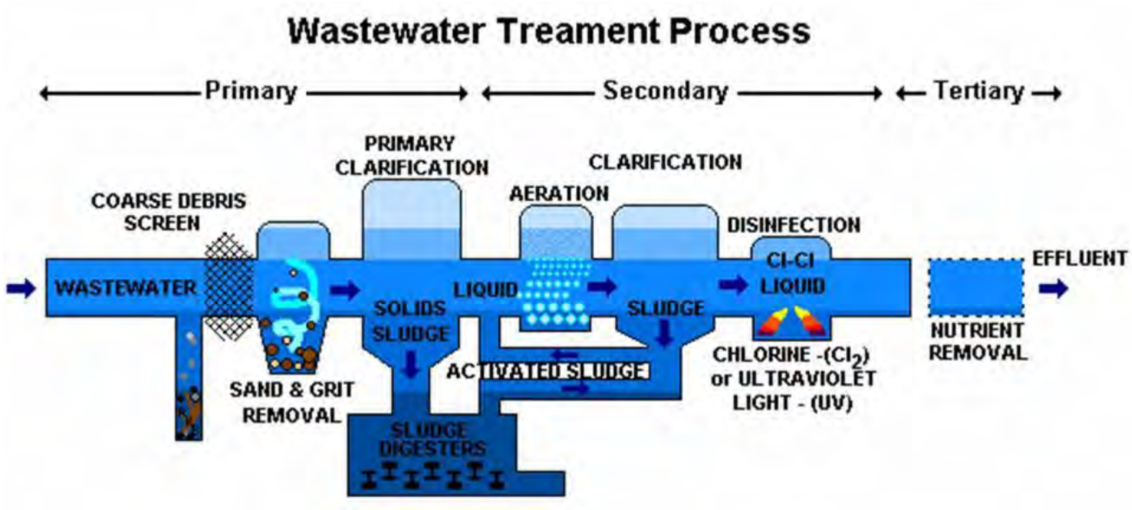

Figure 2.1 Wastewater treatment process

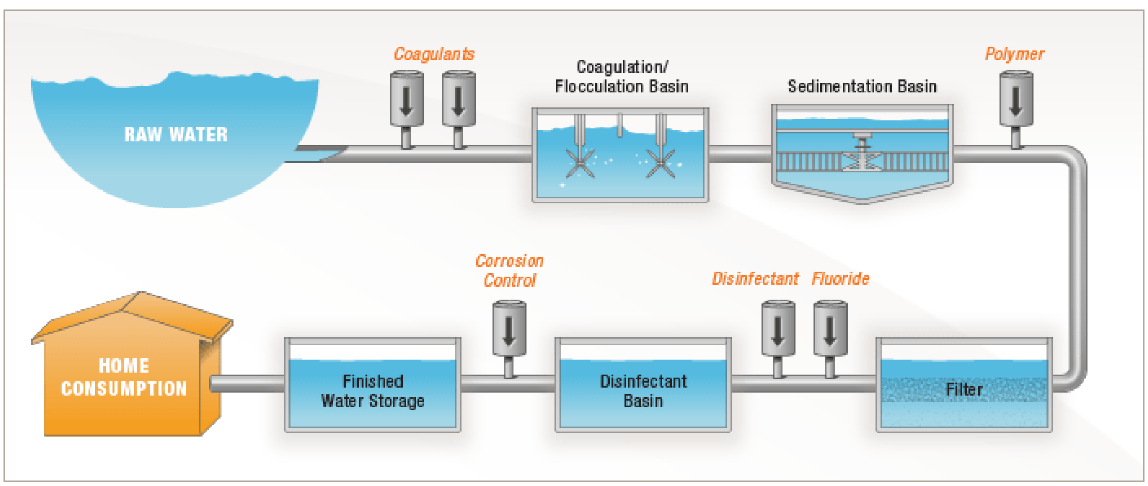

Figure 2.2 Wastewater treatment stage

2.3 Activated Sludge Process

Activated sludge process is the biological process or method for mineralize the organic matter in industrial and domestic wastewater [1]. The bacterium need a consistent energy for grow and to support their life activities. The sludge system encounters a sedimentation process [4]. The sedimentation process will take part in the aeration tanks [2]. Maintaining the dissolve oxygen concentration was crucial because it is an important material to support the bacteria activities and to make the bacteria be more active [5].

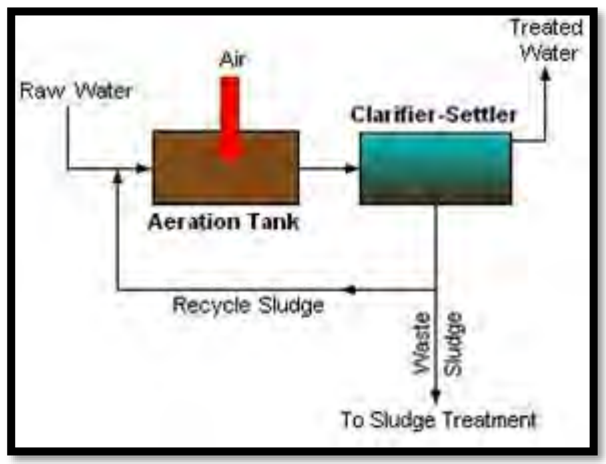

Figure 2.3 Simple configuration for the activated sludge process.

Figure 2.3 shows that the wastewater treatment plant construction for basic have 2 parts of process which is aeration tank and clarifier tank or settler tank. The air will supply to the aeration tank. This is to make sure that the bacteria will be more active and can be decompose the wastewater completely and reach the quality that needed. [1] [5]. Oxygen supplied in aerated tank is used to oxidize the organic matter. The biomass in the system is retained by the secondary clarifier to produce a high-quality effluent.

2.3.1 The flow process of Activated Sludge Process

Conventional activated sludge process has several components that is needed. It is consisting of two tanks which in aeration tanks and clarifier settler tank as shown in Figure 2.3. At first, the fluent will be pumped to the aeration tank to be decomposed by decomposition process. The bacteria in the aeration tank will help in the decomposition process to make sure that this process will running effectively and the air will blow up into the aeration tank to supply the oxygen to the bacteria so that it will be more active. The dissolve oxygen concentration in the aeration is so important so that to make sure the bacteria in the aeration tank did not die. During the process, the biochemical like substrate and dissolve oxygen was produced [5].

The mixed liquor will go to the clarifier tank from the aeration tank to allow gravitation separation of particles. The gravitation separation of particles is which the substances with higher weight will be drowned to the bottom of the tank [5]. Furthermore, there is a return sludge that was pumped back to the aeration tank to be reprocess.

2.3.2 The component of Activated Sludge Process

2.3.2.1 Aeration Basin

Is when the wastewater comes in to meets with an active microbial biomass for treatment. In this parts oxidation will occur and the organic matter is transform into a biological floc. The organic matter that is change to the biological flocs is which the suspended and colloidal solids become integral of flocs.

2.3.2.2 Aeration and Mixing

After the primary stage, the sewages are pumped into aeration tanks which the organic waste is aerated and mixed with help of presence force of air and microorganism activities or bacteria. Mixing keeps biological flocs suspended and ensure the contact between wastewater and bacteria

2.3.2.3 Sludge Recycling

There is a return sludge that was pumped back to the aeration tank to be reprocess. The thickened sludge is pumped back to the aeration tank to maintain the desired concentration. So, the sludge is pumped back to the clarifier.

2.3.3 Bioprocess Modeling

There are several of parameters that were considered in the modeling process of bioprocess which are biomass, substrate, recycle biomass and dissolve oxygen. These four types of the biochemical were the main substance that will influence the process of treatment. Other parameters are also needed to be considered during the process.

To solved the problem of the nonlinear equation a mathematical model was created. Is it created so that to improve the system by designing the controller. For the nonlinear equation must go on a linearization process first before the controller design is done. The mass balance components used in representing the dynamic behaviors of the activated sludge process are describe in equation. The mathematical equation is shown below.

$$\frac{dX(t)}{dt} = \mu(t)X(t) - D(t)(1+r)X(t) + rD(t)X_r(t)$$

$$\frac{dS(t)}{dt} = \frac{\mu(t)}{Y}X(t) - D(t)(1+r)S(t) + D(t)S_{in}$$

$$\frac{dD_O(t)}{dt} = -K_O\frac{\mu(t)}{Y}X(t) - D(t)(1+r)DO(t) + D(t)DO_{in} + aW[DO_{max} - DO(t)]$$

$$\frac{dX_r(t)}{dt} = D(t)(1+r)X(t) - D(t)(\beta + r)X_r(t)$$

Where the variables state of $X(t)$, $S(t)$, $D_O(t)$ and $X_r(t)$ represent the concentration of biomass, substrate dissolved oxygen and recycle biomass. In addition, $D(t)$ is the dilution rate. r and β are the ratio of recycle flow and waste flow. S_{in} and DO_{in} are the substrate and dissolved oxygen concentration in feed stream. While μ is the specific growth rate Y is the yield of the mass K_O is constant DO_{max} is the maximum dissolved oxygen and aW is the oxygen mass transfer coefficient.

2.4 Controller

Controller is a device, historically using mechanical hydraulic, pneumatic or electronic techniques often in combination, but more recently in the form of a microprocessor or computer, which monitors and physically alters the operating conditions of a given dynamical system.

2.4.1 PID Controller

PID is the most common control algorithm used in process industry and wastewater treatment. PID structured is very simple and the control principle is very clear. In wastewater treatment, parameters were tuned once only at the beginning of the installation. The actual control system design will consider the control structure, control algorithm and tuning the controllers. Basically, the system of the plant will use closed loop control systems to reduce the disturbance and the sensitivity to parametric uncertainty. The PID parameters that need to be determined were shown in the equation below where the value of Kp, Ki, and Kd is needed in order to design controller.

$$C(s) = \left(K_P + K_I \frac{1}{s} + K_D s\right)$$

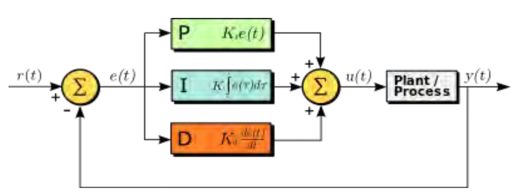

Figure 2.4 Wastewater treatment stage

2.4.1.1 Proportional Component (P)

P component will response only for the Error which is the difference between the set value and the final value of the operation. The equation for the P controller as shown below:

$$G_{\boldsymbol{c}} = K_p$$

As the proportional gain, K_P is increase, it will make the response become faster and the steady state error also will reduce but if the proportional gain is too large, the response will start to oscillate. If the gain is keep increasing, the response will become unstable.

2.4.1.2 Integral Component (I)

Integral component will remove the steady state by error by integrating the error response by time. If the value of the integral component gain is too small, it will cause the overshoot, oscillation and the instability problem. The problem of the integral component can be overcome if it is combining with the proportional component. The combination of the component called PI component and the equation is shown below.

$$G_C = K_P + \frac{K_i}{s}$$

The combination of this component will make the overshoot of the response becomes small and also it will reduce the steady state error if the used of the gain value is considerable suitable.