

THE DEVELOPMENT OF SOFTWARE PLATFORM FOR IDENTIFICATION UNIT

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*Specially dedicated to
my beloved husband for his support and caring,
my family and family-in-law for their encouragement and blessing,
and my children..Hajar Sofea Mohamad Herman.
And lastly for my dear friends,
Thanks for your endless support to me..*

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ABSTRACT

Real time control is an approach to evaluate the process system with real time parameters by controlling selected variables to accomplish the control objective. The development of software system is to identified the real time execution of activated sludge process in wastewater treatment. The development of software uses two commercial softwares which are LabVIEW and Matlab. Matlab is used to design the subspace algorithm N4SID and included with LabVIEW design and block digram. The identification allows performing of the experiment design in real time execution, subspace identification and model analysis with the simulation. The PRBS signal is exited to the system in order to generate the data. These data will be used in the identification to construct model using subspace identification.

ABSTRAK

Kawalan dalam masa nyata adalah kaedah yang digunakan untuk mengawal proses sesuatu sistem menggunakan penilaian masa nyata dengan mengawal sesuatu pembolehubah bagi mencapai objektif kawalan. Pembangunan perisian adalah untuk mengenalpasti pelaksanaan kalawalan dalam masa nyata proses lumpur aktif didalam pemprosesan air kumbahan. Pembangunan perisian menggunakan dua perisian kormersial iaitu LabView dan juga Matlab. Matlab digunakan untuk menulis dan mencuba algoritma '*Subspace N4SID*' dan disertakan dengan gambarajah blok didalam LabVIEW. Pengenalan ini membolehkan ekperimen dapat dilakukan dalam kawalan dalam masa nyata, pengenalan Subspace dan simulasi dan analisis model. Isyarat PRBS digunakan ke dalam sistem untuk menghasilkan data. Data masuk dan data keluar daripada system akan digunakan dalam pengenalan untuk membina model dengan menggunakan pengenalan *Subspace*.

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LIST OF ABBREVIATIONS

PRBS	-	Pseudo Random Binary Signal
GUI	-	Graphical User Interface
ASP	-	Activated Sludge Process
SCADA	-	Supervisory Control and Data Acquisition
MPC	-	Model Predictive Control
PID	-	Proportional Derivative Derivative
CCA	-	Canonical Correlation Analysis
N4SID	-	Numerical Algorithm Subspace State-space Space for Identification
MOESP	-	MIMO Output-Error State Space Model
VC.NET	-	Visual C.NET
DLL	-	Dynamic Link Library
VI	-	Virtual Instruments
API	-	Application Program Interface
MIMO	-	Multi Input Multi Output

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wastewater generally contains large quantities of macrobiotic matter that of natural oxygen resources in the water. The purpose of the wastewater treatment plants are to remove solids from plastics to sand and smaller particles found in wastewater, second is to reduce macrobiotic matter and pollutants; and lastly is to restore oxygen that will ensures the water is back to the rivers or lakes that has enough oxygen to support life.

In wastewater treatment there are three steps involved which are mechanical treatment, biological treatment and chemical treatment. In wastewater treatment the activated sludge process is a process for treating a sewage and industrial wastewater using air and a biological floc that have been composed of bacteria and protozoans.

1.2 The System

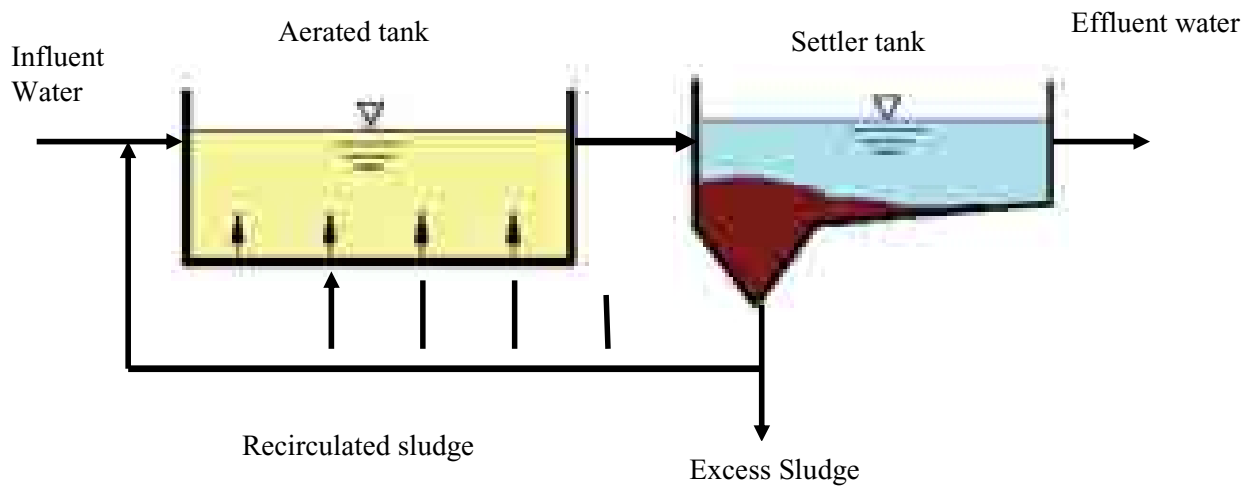


Figure 1.1 : Activated Sludge Process

Figure 1.1 shows the flow of diagram in activated sludge process this process involved with two tanks which is aeration tank and settler tank. In open aerated tank a large quantities of air or oxygen are bubbled and injected in the tank in which it's contain dissolved organic substances. Bacteria and other types of microorganisms need an oxygen in the system to support their live and grow. Settling tank is to allow the biological flocs to settle, thus separating the biological sludge from the clear treated water.

The water is separated from the sludge of bacteria and discharge from the system. Most of the activated sludge is returned to the treatment process, while the remainder is disposed of by one of several accepted methods.

1.3 Mass Balance Equations

The mass balance equation of aerator and settler gives the following set of non-linear differential equations [1].

$$\frac{dX(t)}{dt} = \mu(t)X(t) - D(t)(1+r)X(t) + rD(t)X_r(t) \quad (1.1)$$

$$\frac{dS(t)}{dt} = -\frac{\mu(t)}{Y}X(t) - D(t)(1+r)S(t) + D(t)S_{in} \quad (1.2)$$

$$\frac{dC(t)}{dt} = -\frac{K_o\mu(t)}{Y}X(t) - D(t)(1+r)C(t) + K_{La}(C_s - C(t)) + D(t)C_{in} \quad (1.3)$$

$$\frac{dX_r(t)}{dt} = D(t)(1+r)X(t) - D(t)(\beta+r)X_r(t) \quad (1.4)$$

Where,

$X(t)$ = Biomass	C_{in} = dissolve oxygen concentration in feed stream
$S(t)$ = Substrate	μ = Growth rate
$X_r(t)$ = Recycled biomass	K_o = Constant
$C(t)$ = Dissolved oxygen concentration	Y = Cell mass
$D(t)$ = Dilution rate	C_s = Maximum dissolved oxygen concentration
β = ratio wastewater flow to influent flow	K_{La} = Oxygen mass transfer coefficient
r = ratio of recycled flow to influent flow	
S_{in} = substrate in feed stream	

The inputs of this process are $D(t)$ and $W(t)$ representing the dilution rate and air flow rate. $K_{La} = \alpha W$ where $\alpha > 0$ (constant) and the output are $X(t)$, $S(t)$, $X_r(t)$, $C(t)$. In this process only consider $S(t)$ and $C(t)$ because both of the output takes hour and min to

get the result where the rest the responses are too slow because it takes one week to get the result.

The specific growth rate μ is the biomass growth and is known to be complex function of many phyco-chemical and biological factors like biomass concentration, substrate concentration and dissolved concentration and various others inhibitors. The growth rate is depends on the kinetic parameters. The kinetic is given by Olsson Model [2]:

$$\mu(t) = \mu_{\max} \frac{S(t)}{K_s + S(t)} \cdot \frac{C(t)}{K_c + C_t} \quad (1.5)$$

Where μ_{\max} is a maximum specific growth rate, K_s is the affinity constant, and K_c is the saturation constant.

1.4 Objective

The main objective of this project is to develop a software platform of identification unit in activated sludge process for wastewater treatment. In order to accomplish this project the following objectives are necessary to be achieved:

- i) To develop software platform or simulator design for the activated sludge processes.
- ii) To develop Graphical User Interface (GUI) of the program using Matlab and LabVIEW
- iii) To make the program more user friendly.

1.5 Scope of works

The scope of work is to clearly define the chronological work in specific field of the research and to ensure that all the contents of this thesis is confine to the scope. It is begun with identify the state equation or a mass balance of the activated sludge process. From the state equation develop a model design the graphical user interface (GUI) in LabVIEW to illustrate the model analysis and simulation. Then the subspace algorithm of system

identification were develop by using the Matlab. The scope of work can be described as per following Figure1.2

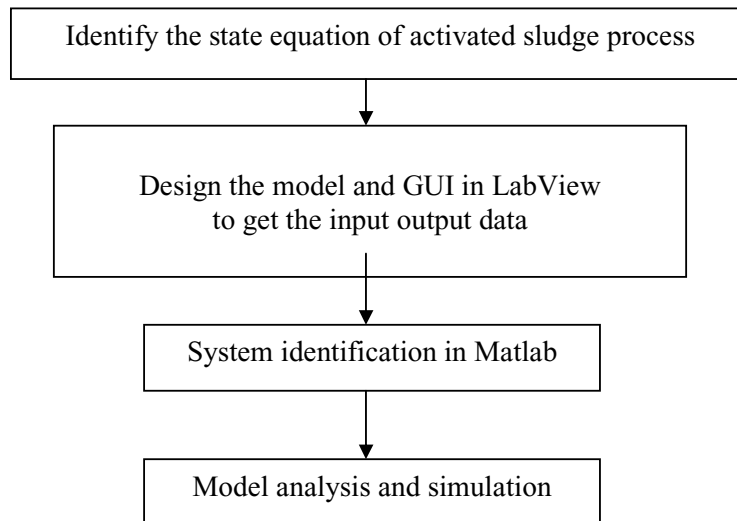


Figure 1.2 : Flowchart Representation the Scope of Work

1.6 Outline of thesis

The thesis presents the implementation of the existing non-linear state equation to develop a model of activated sludge process and implementation of software in system identification.

Chapter 2 is the literature review of the existing activated sludge process research. The explanation begins with the related existing work which it is found to be correlated to this project. This chapter then describes the existing system identification related to activated sludge process.

Chapter 3 is the methodology that is used from beginning to end out the work of this project. It covers the technical explanation and simulations of this project and the implemented technique of mathematical equations and software platform.

Chapter 4 deals with the results of the simulations and analysis from Labview and Matlab implementation. The Graphical User Interface (GUI) will also be presented in this topic.

Chapter 5 is the conclusions of the project as well as the suggestions for further development and the contribution of this project. The project outcome is concluded in this chapter. As for future developments, some suggestions are highlighted with the basis of the limitation executed in this project.

REFERENCE

1. F. Nejjari, B.D., A. Benhammou, and G. Roux, *Non-linear Multivariable Adaptive Control of An Activated Sludge Wastewater Treatment Process*. International Journal Adaptive Control and Signal Processing, 1999. **13**: p. 347-365.
2. Olsson, G., *State of the art in sewage treatment plant control*. A. I. Ch. E Symp. Ser, 1976. **72**: p. 57-76.
3. Kommunförbundet, *Avloppsteknik (in Swedish)*. 1988.
4. A.Sanchez, M.W., M. R Katebi, *On real-time control and monitoring of wastewater treatment plant*. Departamento de Automatización y Control Industrial, Escuela Politecnica Nacional, Quito - Ecuador.
5. Grussel, G., *Design of a simulator for activated sludge process for activated sludge process - JASS v3.0*, in *Department of system and control* June 2002, Uppsala University: Uppsala. p. 72.
6. Mulas, M., *Modelling and control of activated sludge process*, in *Chemical and Materials Engineering Department*. 2006.
7. Jianbo Chen, Y.G., Zhanjun Zhang, Dongwen Shi, Danli Xi, *Integrated modelling and simulation of activated sludge process*. Proceeding of the 25th chinese control conference, 2006.
8. Ruscio, D.D., *Subspace system identification theory and application*. 1995, Telemark University College: Prossgrunn, Norway.

9. Bart de Moor, P.V.O., Wouter Favoreel, *Algorithms for subspace state space system identification- an overview*. p. 273.
10. Peter Van Overschee, B.D.M., *Subspace identification for linear system, theory-implementation-application*. 1996, Kluwer Academic Publishers: Belgium.
11. C.P. Bottura, A.D.R.T., G. Barreto, A.F.T. C'aceres. *Parallel and distributed MOESP computational system's modelling*. in *Proceedings of the 10th Mediterranean Conference on Control and Automation*. 2002. Lisbon, Portugal.
12. Piley, A., *Concise encyclopedia of bioresource technology*. 2004, The Haworth Press.
13. Peter Van Overschee, B.D.M., *N4SID:Subspace identification of a glass tube manufacturing process*.
14. Ben C. Juricek, D.E.S., Wallace E. Larimore, *Identification of the Tennessee Eastman challenge process with subspace methods*. 2001.