UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF SIMULATED KALMAN FILTER ALGORITHM IN TUNING PID CONTROLLER'S PARAMETERS FOR COUPLED TANK SYSTEM

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Electronic Industries) with Honours.

By

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Electronics Industrial) with Honours. The member of the supervisory is as follow:

Signature: ……………………………………………….

Supervisor : AMAR FAIZ BIN ZAINAL ABIDIN

ABSTRAK

Dalam dunia hari ini, aplikasi sistem tangki pasangan, menjadi bahagian yang tidak dapat dielakkan khusus dalam industri proses kimia di mana ia memenuhi permintaan teknologi proses yang semakin berkembang. Minat dunia dalam teknologi industri proses terus berkembang apabila sistem tangki pasangan menjadi popular dalam masalah penanda aras klasik kerana ciri tingkah laku fasa bukan linear dan tidak minimum. Selain itu, proses aliran dan paras cecair di dalam tangki menjadi isu utama di mana sistem memerlukan cecair untuk dipam, disimpan di dalam tangki dan kemudian didorong ke tangki lain secara automatik. Oleh itu, cadangan projek ini dengan parameter PID optimum untuk mengawal tahap 10cm paras air yang diingini dan tindak balas sementara keadaan tetap sistem tangki yang digabungkan menggunakan pengoptimuman Penapis Simulasi Kalman. Analisa hubungan antara bilangan agen Kalman berbanding bilangan lelaran yang dilakukan. Hasil yang diperoleh adalah dibandingkan dengan bacaan sebelumnya. Penemuan menunjukkan bahawa Penapis Simulasi Kalman melakukan lebih baik dalam sistem tangki yang digabungkan berbanding dengan Penguasan zarah Kecergasan Partikel Swarm dan Prioriti berdasarkan Prioriti.

ABSTRACT

In today's world, the application of couple tank system, become an inescapable part specifically in chemical process industries where it was met out the expanding process technologies requests. The world interest in process industry technologies is continually expanding when the couple tank system becomes popular in classical benchmark control problem due to the behavior of the non-linear and non-minimum phase characteristic. Furthermore, the flow process and liquid level in the tanks become the main issue where the system required the liquid to be pumped, kept in the tank and then driven to another tank automatically. Hence, the proposed of this project by optimal PID parameters in order to controlling the 10cm of the desired water level and steady state, transient response of coupled tank system using the Simulated Kalman Filter optimization. Analysis on the relationship between the number of Kalman agents versus number of iterations is done. The result obtained was benchmarked with previous literature. The findings show that Simulated Kalman Filter performs better in coupled tank system compared to Particle Swarm and Priority based Fitness Particle swarm optimization.

DEDICATION

To my adored parents, wholly the lecturers, exclusively my supervisor Amar Faiz Bin Zainal Abidin and the late Ir. Nik Azran Bin Abdul Hadi, all my friends and relatives. Thousands of appreciations and sincere thankfulness from the bottom of my heart for all the understanding and sacrifice throughout my entire duration in pursuing this course and mainly this project.

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α	-	Coefficient discharge
A	-	Cross sectional area
cm	-	Centimeter
d	-	Dimension
e	-	Error
F	-	Fitness
H	-	Height
K	-	Kalman agent
P	-	Prior estimate
q	-	Flow rate
Q	-	Process noise
R	-	Measurement noise
s	-	Second
t	-	Time
x	-	State variable
X	-	Estimate state
Xbest	-	Best fitness
Xtrue	-	Best solution so far
z	-	Linear measurement

LIST OF ABBREVIATIONS

ARDC	Active rejection disturbance controller
CTS	Coupled Tank System
GA	Genetic algorithm
Kp	Proportional gain
Ki	Integral gain
Kd	Derivative gain
MPC	Model predictive controller
MIMO	Multi input multi output
Os	Overshoot
PID	Proportional Integral Derivative
PSO	Particle swarm optimization
PFF	Priority fitness firefly
SMC	Sliding mode controller
SISO	Single input single output
SKF	Simulated Kalman Filter
SSE	Steady state error
Ts	Settling time
Td	Delay time
Tp	Peak time
Tr	Rise time

CHAPTER 1

INTRODUCTION

1.1 Background study

In recent years, the performance requirements for chemical, petrochemical and process plants have increased. Development of new production plants to decrease wastage of material, minimize energy consumption, minimize effects on the environment, to cope with ever increasing competition and to satisfy increasing demand for flexibility requires the use of control engineering techniques to provide the desired and efficient control actions with simple and easy control algorithms. Design and implementation of a control system require the use of efficient techniques that provide simple and practical solutions which can fulfil the performance requirements in the face of the disturbances and uncertainties in the process (L. Bissonaise, 2001).

Many researchers over the world interest in the liquid level system application as the technology boom rapidly, in which it typically crucial specifically for an economic increase of the world nowadays. In current years, the performance necessities for chemical, petrochemical and method plants have enlarged. The word "process" in the industries refers to a set of operations to be performed on the different work functions to culminate on any quality assured product. However, in general, the term process tends to be used for both the processing operations and the processing equipment. Figure 1.1 shows all the applications of industries nowadays, which include water treatment facilities, pulp and paper turbines, petrochemical plant and food were as an essential requirement of the liquid level in tanks and fluid drive with the flow within the tanks (S.R. Mahapatro, 2014).

Figure 1.1: Coupled tank application in process industry

The primary objective of the process control is to maintain the process safely and effectively at the desired operating conditions considering the environment and product quality requirements. In association with this, the processing system should respond to transient conditions, such as plant startups and shutdowns, grade changes and unusual disturbances. Without effective process control, it will be difficult, to operate the large scale industrial plants (L. Bissonaise, 2001). Usually, the liquid level in each tank is very commonplace in all procedure manipulate systems today.

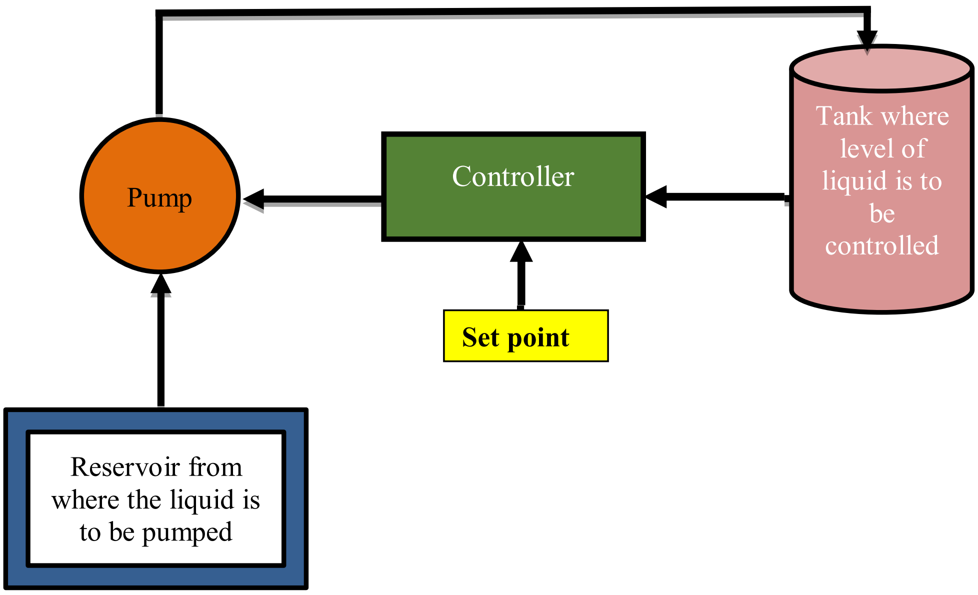

Figure 1.2: Illustration of a typical fluid level structure

Figure 1.2 presents the illustration of a typical fluid level structure commonly in coupled tank system. The coupled tank module as a reservoir which features as storage of water know as a couple tank system. The control of liquid level in tanks and flow between tanks is a basic problem in the process industries. The process industries require liquids to be pumped, stored in tanks, and then pumped to another tank. Many times, the liquids will be processed by chemical or mixing treatment in the tanks, but always the level of fluid in the tanks must be controlled, and the flow between tanks must be regulated. Often the tanks are so coupled together that the levels interact and this must also be controlled (Shahizan, 2008). The level manipulates device must be controlled by the right controller. The goal of the controller in the stage manipulate is to preserve a stage set point at a given value and can receive new set factor values dynamically. The controller will manage the water pump in order to maintain water in each tank in level as required (10cm).

For these significant of the project, the Simulated Kalman Filter (SKF) will be applied to tune the PID parameter controller. Since most of industries are using a PID controller, widely, this project is proposed on using a simple but effective PID controller for the couple's tank system. This is due to simple structure and robust performances in a wide range of operating conditions. (Hazriq et.al., 2015).

By using the PID controller output will obtain in a short time, minimal steady state error and can control the overshoot. The proportional component (Kp) provides an overall control action proportional to the error through the all pass gain factors. The integral component (Ki) was used to minimize steady state error through low frequency compensation. The derivative component used to reduce overshoot and improve transient response through high frequency compensation (Saiful, 2008).

Nevertheless, there are some problems in finding the optimal value of PID parameters. Thus, many researchers have begun to use optimization methods in finding the most appropriate values. Therefore, Simulated Kalman Filter (SKF) is chosen and implemented due to simple optimization compared to the other optimization methods that had been implemented before such as Genetic Algorithm and Cuckoo Algorithm. Developing a simple and effective tuning method for PID controller can significantly contribute to the advancement of control system knowledge and catering the industrial needs.

1.2 Problem statement

As real-time control involves algorithms to control some certain processes, and used complex algorithm (Shahizan, 2008). In order to study its performance, the control of the level of a coupled tank system is chosen. This application is widely used in the process industry, especially in chemical industries. In this project, controlling liquid level process will be done in real-time by applying Proportional-Integral-Derivative (PID) controller.

A common control problem in process industries is the control of fluids level in storage tanks, chemical blending and reaction vessels (Grega and Maciejczyk, 1994). The flow of liquid into and out of the tank must be regulated as to achieve a constant desired liquid level as fluid to be supplied at a constant rate. Many control algorithms have been implemented using various techniques to compensate with the control requirement. To achieve high performance of the system is by applying state feedback controller to the system.

As the issue of coupled tank liquid level water system demand to be controlled whilst regulating the flow within the tank. In addition, the water level that flow in and flow out from the tanks makes it is very challenging to get a constant of a desired water level. As the parameter of the coupled tank system is simply changed, so the proper optimization tuning method will be approachable to beat this issue.