CHAPTER 1

INTRODUCTION

1.1 Overview

Nowadays, the process industries such as petro-chemical industries, paper making and water treatment industries require liquids to be pumped, stored in tanks, and then pumped to another tank. The control of liquid in tanks and flow between tanks is a basic problem in the process industries. The above mentioned industries are the vital industries where liquid level and flow control are essential. Many times the liquids will be processed by chemical or mixing treatment in the tanks, but always the level fluid in the tanks must be controlled, and the flow between tanks must be regulated. Level and flow control in tanks are the heart of all chemical engineering systems.

Due to the nonlinearity of the coupled tank system, MRAC or model reference adaptive control which is one of a kind in adaptive control techniques is implemented. It is regarded as an adaptive servo system in which the desired performance is expressed in terms of reference model, which gives the desired response to a command signal. The nonlinearity occurs because the system transfer function varies or changes with the height of the liquid in a tank and the controller ought to be adaptive and robust for these changes.

1.2 Problem statements

The first and foremost important step before formulating a controller, a mathematical relationship or the governing dynamics between the input and the output of the system should be known. The underlying principle and knowledge of the system should be investigated to comprehend the occurrence of nonlinearity in the system dynamics. There are wide arrays of control techniques that can be applied to meet the control objective of the system and these depend on the factors of which the proposed design objective might rely on. There are factors such as tracking, reducing the effects of adverse conditions and uncertainty, behaviors in terms of time response (e.g., stability, a certain rise-time, overshoot, and steady state tracking error) and lastly engineering goals such as cost and reliability which is vital in industrial perspective.

Sophistication of controller scheme primarily depends on the degree of how the nonlinearity can be tolerated and assumed using the linearization theory. Moreover, apart from nonlinearities, there may be a consequence of unknown parameters which hinders the objective to obtain a complete detail model of a process available for control purpose. The factors that abstained many researchers to use conventional control theory and techniques can be listed as follows:-

i. Systems are nonlinear and may contain unknown parameters. That unknown parameters may not be estimated accurately if reliable experimental data is absent.
ii. The delays present in the process of system (coupled tank system specifically) might complicate achieving high performance control.
iii. There are several cases such as that of couple tank in industry where the process or disturbance characteristics are changing continuously. This requires simultaneous regulation of various variables in order to maintain the desired liquid level. Thus, a model must account for all of the most significant variables of the process.

Due to the above mentioned factors, it might be difficult to formulate a control strategy based on the analytical model because the mathematical model is usually linearised to account for complexity and nonlinearity which are inevitable in a complicated system. PID(proportional-integral-derivative) control is one of a kind of control scheme that uses the approach of linearised model. However, the PID controller might not capable to satisfy the control objectives or requirement at all times as it need to be regularly tuned due to the varying system dynamics.

Hence, it is desirable to have a robust and reliable control technique for modeling the complex and nonlinear system that prevails in all industrial process. MRAC or model reference adaptive control is chosen as the coupled tank's control scheme. It is regarded as a novel approach in parameter adjustment for a system where process dynamics are nonlinear.

1.3 Objectives

The objectives of the project can be outlined likewise:

i. To develop an adaptive system for a couple tank system using DMRAC (Direct Model Reference Adaptive Control).

ii. To investigate the performance of DMRAC (Lyapunov and Positivity concept) in control of coupled-tank and compare with the system controlled by PID controller.

1.4 Scope of the project

The purpose of this project can be divided into four parts, the first part is to develop and validate a mathematical dynamic model that represents the coupled-tank control apparatus. This includes models for first order and second order system as well as the nonlinear model of the system.

Then, after the models are approved of its validity, simulation will be performed using engineering simulation software like Matlab Simulink to simulate its dynamic characteristic using the actual plant parameters obtained from laboratory. A step test was performed on the nonlinear model of the coupled-tank system by simulation to observe various important dynamic characteristics at different operating conditions(water level). This is to investigate the behaviour of the system at certain range of operating conditions and thus, will give a guideline in the development of a reference model for the system to track.

The third part of the project will follow consequently after the second part and this involves the design of the controller; firstly normal PID control, then followed by the adaptive controller (DMRAC). Normal PID control, with expectation in mind, will exhibits its limitation in coping with nonlinearities and changes in process gain. DMRAC will be developed by implementing a suitable adaptive algorithm that will make the nonlinear system be able to adapt to set point changes(servo) and sudden load disturbances (regulator). The final part will comprise of brief comparative study based on performance of the two controllers.

1.5 Summary

This section explains the objective as well as the scope of the project in order to give an insight and the sense of direction of this project. The next subsequent chapter will be literature review section, discussing on the research works previously done by other researchers concerning on the liquid level control of coupled tank system. Different control strategies are demonstrated by various researchers in the literatures and are evaluated in comparison with other controllers.