CHAPTER I

INTRODUCTION

The control of chemical reactors such as a continuous stirred tank reactor (CSTR) has received major attention. Inherently nonlinear and complex dynamic behavior i.e. strong parametric sensitivity and multiple steady state behavior posts some of the most challenging control problems that are difficult to handle with linear controllers. However, most chemical reactors have been traditionally controlled using linear control techniques. This mainly contributes to their simplicity, well establishment of linear control theory, and successful applications in real industries. Since it is known that linear controllers usually provide satisfactory control performance especially when a process is operated in the vicinity of a nominal operating condition, if the process is subject to large disturbances or significant set point changes, the control strategies based on a linearized model may not yield satisfactory performance. In addition, the wide range of operating conditions encountered in start-up or shut-down of continuous processes and tacking set point changed due to different product specification, also pose an important challenge for the application of nonlinear control technologies.

In recent years, a number of nonlinear control technologies have been developed, such as nonlinear control based on the differential geometric approach (Kravaris & Kantor, 1990), nonlinear model predictive control (Patwardhan, Rawlings, & Edgar, 1990), and generic model control (Lee & Sullivan, 1988). However, these approaches rely on the availability of a good process model, which is not always easy to obtain. In practice, the true process may differ from the process model. The degree of plant/model mismatch increases, the closed-loop performance may degrade away from a pre-specified trajectory. Adaptive control is the one of the effective methods to deal with plant/model mismatches, which can modify process models to track the true plants in real time. There are many researches presented the adaptive control algorithm to CSTR, it provided good control performances, but in their work was not considered the dynamic of jacket temperature, so the resulting control response would be sluggish.

In this work, a continuous stirred tank reactor (CSTR) for propylene glycol production that developed by Perez and coworker (2002) is considered. Propylene glycol is a colorless, nearly odorless, syrupy liquid that is derived from natural gas. It is soluble to various extents in a wide range of organic materials, and is completely soluble in water. Propylene glycol is used widely:

- In food – Cake mixes, salad dressings, soft drinks, popcorn, food colorings, fat-free ice cream and sour cream. It also protects food from freezing and helps as a preservative.
- In toiletries and cosmetics – Lotions, creams, some baby wipes, shampoos, antiperspirants, cosmetics, lipstick, lubricants. It is also used as excipient (non-active ingredient) in the manufacture of pharmaceutical products.
- In other household items – Room deodorizers, cleaners, sanitizers and yes, new "non-toxic" and "safe" automotive antifreezes
- And specific to the soap making and toiletry making industry, it is also used as a carrier in fragrance oils and in many melt and pour soap bases.

The study is aimed at exothermic reaction for propylene glycol production (C) from propylene oxide (A) and water containing a small quantity of H_2SO_4 (B) and methanol (M), added to prevent phase splitting because propylene oxide is not completely soluble in water. A jacket is used to maintain the temperature of continuous stirred tank reactor (CSTR) as in set point, and its dynamic is considered. A nonlinear adaptive control that combines the generic model control (GMC) with the extended Kalman filter is designed and implemented to track the temperature set point, and its performance has been evaluated in both nominal and plant/model mismatch cases, and compared with GMC and conventional Proportional Integral Derivative (PID).

1.1 Research Objective

The objective of this research is to design a nonlinear adaptive control for a continuous stirred tank reactor (CSTR) to track the temperature set point, which this use the generic model control (GMC) as a controller coupled with the extended Kalman filter (EKF) to estimate the unknown parameter, heat released from reaction, and compare the performance of nonlinear adaptive controller with GMC and conventional PID.

1.2 Scopes of research

1. The exothermic reaction for propylene glycol production from propylene oxide and water containing a small quantity of H_2SO_4 and methanol is considered in a CSTR. A jacket is used to maintain the temperature of a continuous stirred tank reactor (CSTR).

2. A mathematical model of a continuous stirred tank reactor is studied.

3. A nonlinear adaptive control that combines the generic model control (GMC) and the extended Kalman filter is implemented to track the reactor temperature set point.

4. An extended Kalman filter is used for parameter estimation.

5. The performance of nonlinear adaptive controller is compared with conventional PID.

6. Programs written to simulate and control the reactor are based on Matlab.

1.3 Contributions of research

The contributions of this research are as follows:

1. A continuous stirred tank reactor (CSTR) has been controlled via using the nonlinear adaptive controller to achieve a desire objective.

2. Unmeasurable state variable and unknown parameter of a continuous stirred tank reactor (CSTR) have been estimated.

1.4 Research procedures

1. Study the literature reviews related to adaptive control and extended Kalman filter.

2. Study the use of MATLAB program.

3. Design nonlinear adaptive control for continuous stirred tank reactor to track the temperature set point and used the extended Kalman filter to estimate the unknown parameters.

4. Simulate the nonlinear adaptive control for continuous stirred tank reactor.

5. Simulation results are collected and summarized.

1.5 Research Framework

This thesis is organized as follows: First, the literature reviews related to adaptive control and extended Kalman filter are presented in Chapter II. Second, the theories of the adaptive control, generic model control and extended Kalman filter are explained in Chapter III. Next, the application of adaptive control for continuous stirred tank reactor and simulation results are presented in Chapter IV. Finally, the conclusions and the recommendations for future work are given in Chapter V.