CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Model Predictive Control (MPC) has become a major research topic during the last few decades and unlike many other advanced techniques, it has also been successfully applied in industry. It is generally accepted that the reason for this success is the ability of MPC to optimally control multivariable system under various constraints. MPC is a method in which the current control action is obtained online by solving a finite horizon open-loop optimal control problem from the current system state or from its estimate based on output measurements. MPC yields a finite length open-loop control sequence from the current state estimate. The first element of this sequence is applied to the plant. Then the plant state is sampled again and the calculations are repeated starting from the current state, yielding a new control and new predicted state path. Recent trends in MPC favour the closed-loop approach, where the measurements are incorporated into the prediction. This feature necessitates an estimator to recover the states from noisy measurements and knowledge of a process model with uncertainty.

State observer based MPC formulations make use of Kalman filter and EKF. For linear systems, Kalman filters generate optimal estimates of state from observations. Kalman filter has become more useful even for very complicated real-time applications and has attracted the attention of chemical engineering community because of the recursive nature of its computational scheme. For nonlinear systems, EKF is a natural extension of the linear theory to the nonlinear domain through local linearization. There are several variants of the basic EKF which have been evaluated by various researchers. It is well-known that the design of any good state estimator must be based on a good model of the plant. In order to incorporate more plant information into the design of the state estimator, a nonlinear process model has to be used and a plethora of such dynamic models has been proposed in control literature to describe a nonlinear dynamic system. A simple way to describe a nonlinear dynamic system using multiple linear models has been proposed by Takagi-Sugeno (T-S) and it is being used in this work to develop nonlinear state estimator based MPC for nonlinear dynamic system.

In this work, a nonlinear state estimator is proposed which will provide the estimated value of the internal states and the most significant disturbance of the process to the MPC. MPC strategies based on these nonlinear state estimators will allow tight control of the process, whereas a linear controller will not be able to control the process satisfactorily. The state estimator based NMPC can be generally applied to many types of nonlinear system. However, we present here for the control of jacketed CSTR. It should be noted that the processes considered for simulation study has been widely studied because they are highly nonlinear.

1.2 OBJECTIVE OF THE THESIS

The principal objective of this work is to present an approach for the design of NMPC with the help of nonlinear state estimator for a nonlinear dynamic system (CSTR). In this research work the specific objectives are:

1. To represent the nonlinear system as a family of local linear state space models and to design an observer or state estimator

for each local state space model using standard Kalman filter theory.

2. To develop global state estimator by combining the local state estimators.
3. To develop an observer based NMPC schemes.
4. To carry out extensive simulation studies on the CSTR processes.

1.3 ORGANISATION OF THE THESIS

The work reported in the thesis is organized into 6 chapters: Chapter 2 discusses the brief review of the literature on observer or state estimator and MPC. Chapter 3 describes the design of observer and observer based NMPC formulation. Implementation of observer design to CSTRs is presented in Chapter 4. Chapter 5 focuses on observer based NMPC for CSTRs and the conclusion drawn from the simulation studies is presented in Chapter 6.