CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Overview of different types of neural network modeling schemes available for chemical process and the ability of neural network as a tool for modeling, reported in the literature is presented. Different control schemes and the methods for estimation of parameters that are available for polymerization process in the literature are also presented.

2.2 MULTIPLE NEURAL NETWORK MODELING OF POLYMERIZATION PROCESS

Artificial Neural Networks has gained importance as versatile structures for modeling of the nonlinear steady state as well as dynamic processes. The ability of neural networks to learn complex nonlinear relationship has been exploited for the development of black box models. The application of neural network in chemical process modeling by three different approaches has been investigated by Yang et al (1999). A data driven approach for modeling and optimal set point generation for a batch /semi batch process with the help of Artificial Neural Networks has been reported by Rani and Patwardan (2004). An advantage of the ANN approach is that a complex nonlinear process model could be discovered from process data has been given by Bhat and McAvoy (1990).

The use of neural networks in chemical engineering area offers a potentially effective means of handling three problems: complexity, nonlinearity and uncertainties. The variety of available neural network architectures allows to deal with a wide range of process control problems in comparison to other empirical models, neural networks are relatively less sensitive to noise and incomplete information and they deal with higher levels of uncertainty when applied in process control problems as stated in Baughman et al (1995).

Chen et al (1998) proved that multi layer feed forward neural networks offer interesting possibilities for modeling any nonlinear process without a prior knowledge. Thus, self-learning ability of neural networks eliminates the use of complex and difficult mathematical analysis, which is dominant in traditional control methods. Neural network has been developed for a number of control applications, such as identification and control of nonlinear processes as stated by Narendra (1990).

Based on the gradient descent optimization, Back propagation is probably the most popular training algorithm for feed forward networks in the field of chemical engineering the basic back propagation algorithm has several drawbacks. The most critical ones are slow convergence, the possibility of becoming struck in local minima and computational complexity. Many variations of the basic algorithm that improve its performance have been given by Bhat et al (1990). The use of momentum term generally speeds up the convergence and smoothes the trajectory of the weights during the update procedure. During training both learning rate and momentum can be modified in order to improve convergence and to avoid local minima.

Artificial Neural Network (ANN) modeling can be used to estimate variables which are difficult to measure in semi batch polymerization reactor. The only knowledge required is reactor operating data and detailed mechanistic model is not required was given by Yang et al (1999). Ng and Hussain (2004) have proposed a method to model the polymerization process. The neural network part in the hybrid scheme was used to estimate the internal parameters that are difficult to measure, the output from the neural network are fed into the mass and energy balance equations. The conventionally adopted architecture of ANN for process modeling is the layered feed forward ANN. Before a neural network is applied to a set of data for obtaining a data driven model, factors such as the topology of the network along with the measure of the causal importance of individual input variables should be taken into account as reported by Sridhar et al (1998) and Papadokonstankakis et al (2005).

Although many applications can be implemented by both single layer feed forward neural networks and two layer feed forward neural networks, two layer feed forward neural networks may be more powerful than the single layer feed forward neural networks in most cases. Huang (2003) has proved in a novel constructive method that a two layer feed forward neural networks reduces space complexity of network for large scale applications.

2.3 CONTROL OF POLYMERIZATION PROCESS

Control of polymerization reactors is one of the most challenging issues in control Engineering. There are various difficulties in operating those processes. The main difficulties are its high non-linearity because of the complicated reaction mechanisms associated with the large numbers of interactive reactions and also lack of online measurement of important variables such as heat transfer coefficient and reaction heat. Some industrial batch reactors have to deal with different batches and ingredients and therefore different reaction dynamics are involved. This calls for special control strategies. The concept of adaptive control given by Chen et al (1995), Optimal control reported by Cuthrell and Biegler (1998), Chang et al (1995) and Model Predicitive control schemes were reported by Foss et al (1995), Lakhsmanan and Arkun (1999), Loeblin et al (1999) has been reported for polymerization process.

Many articles have been published in the area of polymerization reactor control. Control approaches like PI cascade control designed by Chylla and Haase (1992) and Crowley and Choi (1996), Dynamic matrix control by Gobin et al (1994) and Meziou (1996) Generalized Predicitive control by Ozkan (1998), Globly linearizing control by McAuley and Macaregor (1993), Shahrokhi and Fanaci (2002) and Sorash and Kravaris (1992), and non-linear model predictive control has been reported by Ali et al (1998) and Ozkan et al (2001).

Generic Model control has been successfully used for achieving tight control of batch/semi-bath processes by Lee and Sullivan (1988). The Generic Model control (GMC) has been proposed for high relative degree systems, Rani and Gangiah (1996) have proposed a constrained non-iterative version of GMC.

Feed forward control design by extending the conventional cascade control in the framework of two degree of freedom control concept has been explained by Knut Graichen et al (2006).

Model Predictive controller combined with an extended Kalman filter for the estimation of the reaction heat and heat transfer coefficient has been proposed by Helbig (1996). The control task of keeping the reactor temperature constant during the production could be solved as an optimal control problem by minimizing a cost function for the deviation of the reactor temperature from the desired temperature by Hinsberger et al (1996). A non linear adaptive controller was designed to adjust the cooling jacket temperature Clarke – Pringle and Mac Gregor (1997). An approach by Bhat and Banavar (1998), deals with the design of a neural network controller to maintain the reactor temperature at its set point.

Rani and Patwardhan (2004) have proposed data driven modeling and optimal set point generation for a batch/semi batch process with the help of Artificial Neural Networks. Chen and Huang (2004) have developed ANN model of the batch reactor and used its linearized version at every sampling instant to update the tuning parameters of PID controller. Horn (2001) has proposed a method to desired control law using input output linearization approach with the help of ANN models for batch polymerization reactor. Rani and Patwardhan (2004) have proposed ANN based Generic Model Control (GMC) applied to semi batch processes with relative order higher than are upto a capability to handle constraints systematically. Self adaptive productive functional control algorithm for the control of the temperature in an exothermic batch reactor was given by Gorazd Karer (2008).

2.4 ESTIMATION OF PARAMETERS

The major obstacles in the application of computer control algorithms for polymerization reactor is the difficulty of finding adequate and reliable sensors for the on-line measurements of process key variables such as reactant and product concentrations. Sensors in the field of chemical processes are still very expensive and their maintenance is usually time consuming. One way to avoid these problems is to use estimation strategies.

State estimation methods have been initiated in the 1960s. The Kalman filter has been extensively used for state estimation of noisy dynamic systems Kalman (1960), Luenberger observer has been used for state estimation of deterministic linear dynamic systems by Luenberger (1971). The development of a Kalman filter for state and parameter estimation of a biotechnical process was discussed by Bellgardt et al (1986). However several studies show the inadequacy of these methods for highly non-linear processes also discussed by Titaraju and Souroush (1997), because these methods use linear approximation of the nonlinear process model as reported by Soroush (1997).

The Unscented Kalman Filter was first introduced by Julier and Uhlmann (1997) and further developed by Wan and Van der Merwe (2000) for the state estimation of nonlinear systems. Julier and Uhlmaan (2004) demonstrated the substantial performance gains of the Unscented Kalman Filter in the context of state estimation for nonlinear control.

2.5 SUMMARY

The brief overview of work on modeling, control of chemical process and estimation of nonlinear process parameters, particularly polymerization process reported so far in the literature is highlighted. The semi batch polymerization process reported by Chylla and Haase (1992) and the corrected model given by Knut Graichen et al (2006) is simulated to show the efficiency of the modeling and control method proposed in this work. Single Artificial neural network model may not be accurate for this semi batch polymerization process and hence it requires the multiple neural network structure which is attempted and the results are presented. To control this polymerization process tight temperature control is required and due to the presence time dependent parameters it necessitates the adaptive control technique. Hence self tuning control is attempted in this work. The subsequent chapter deals with the introduction to types of process, reaction and description of the Chylla-Haase polymerization reactor.