# CHAPTER I

# INTRODUCTION

One of the most important operations in many chemical industries named distillation carried out in batch or continuous system. The selection in distillation system depends on the complexity of the liquid mixture and the volume to be separated. Many a distillation has continuous system. Most industries are continuous distillation, while fine chemical industries are batch distillation. Batch distillation is more flexible than continuous distillation; the flexibility makes it possible to handle with varying feed composition and product specifications. Also, it separates many components in a single batch column this is the main advantage of batch distillation over continuous distillation. However, batch distillation is an inherently complex and nonlinear dynamic process. The flexibility of batch distillation, combined with the inherently unsteady nature of the process, poses challenging control system design that is difficult to handle with model based control techniques; model based controllers are based on the mathematical model of processes which cannot be actually achieved.

Recently, artificial neural networks have attracted the attention of a chemical process for modeling, design, optimization, and control. The attractiveness of artificial neural networks comes from the information processing characteristics of human nervous system such as nonlinearity, robustness, and their ability to learn from examples make them efficient problem solving paradigms.

As mention previously, neural networks provide an attractive alternative in modeling application and lead to handle a batch distillation process with model based control technique.

The objectives, the scopes, the contributions, and the steps of this research are presented in the following.

## 1.1 Batch Distillation

*Batch distillation (BD)* is a very simple and efficient unit operation for the separation of multicomponent mixtures into pure components. BD plays an important role in the chemical process industries. This is due to the low scale production, the rapid change of market needs and required flexibility in purifying different mixture under a variety of operational condition. BD has the advantage of separating a multicomponent mixture in a single column whereas a number of interconnected columns are required to separate continuously the same mixture. However, BD column is much more complex in comparison with continuous distillation column as it required consideration of unsteady state behavior.

## 1.2 Neural Networks

*Neural networks (NNs)* in this thesis are referred to *artificial neural networks (ANNs)*, which can be defined in a wide variety of literatures. A NN is an information processing paradigm that is based on the parallel architecture of biological nervous system. In practical, NNs are nonlinear statistical data modeling tools. They can be used to identify complex relationship between inputs and outputs or to find patterns in data.

## 1.3 Model Predictive Control

*Model predictive control (MPC)*, also known as *moving horizon control (MHC)*, is the class of advanced control techniques that most widely apply in the process industries. The basic concept of MPC is to solve an open-loop optimal control problem at each time step. The decision variables are a set of future manipulated variable moves and the objective function is to minimize deviations from a desired trajectory; constraints on manipulated, state and output variables are naturally handled in this formulation. Feedback is handled by providing a model update at each time step, and performing the optimization again.

## 1.4 Research Objectives

The objectives of this research are:

1. to utilize NNs algorithm particularly multilayer feedforward networks for modeling in a BD process,

2. to utilize a NN as a model based controller for tracking a BD process with optimal reflux policy.

## 1.5 Scopes of Research

The scopes of this research are presented in the following:

1. The research is divided into two parts: the NN application for modeling and model based controller in a BD process.

2. A conventional BD column is considered. A ternary mixture system is examined to study the process dynamic. The mathematical model, which based on mass balance and energy balance, is used to represent the realistic operation of the actual BD process that simulated by an ideal phase equilibrium model. The performance criterion of a BD column is measured in term of maximum product.

3. Multilayer feedforward networks are investigated. Error backpropagation and Levenberge-Marquardt algorithms are used to train networks. Sigmoidal and linear transfer functions are used in hidden layer and out put layer neurons, respectively. The mean squared error , the performance index, is used to choose the appropriate NN structure.

4. MATLAB program and MATLAB toolbox are used to simulate and control a BD process.

## 1.6 Contributions

The contributions of this research are as follows:

1. The mathematical model of a BD column has been developed.
2. A BD column has been controlled via using NN to achieve the optimal reflux policy.

## 1.7 Overview of This Thesis

The organization of this research is as follows: Chapter II presents the literature review in the BD and the applications of NN in process control. Chapter III describes the methodologies of BD, NN, and MPC. Chapter IV and V present the application of NN approach in system identification and control design, respectively. Finally, the conclusions and the recommendations for future work are given in Chapter VI.