# CHAPTER VI

# CONCLUSION AND RECOMMENDATIONS

This chapter concludes this thesis and provides a summary of work done during the course of this research. Some recommendations for future work are also given at the final section.

## 6.1 Conclusions

Batch distillation is one of the most separation processes which are used in many chemical industries, especially food, pharmaceuticals, and fine chemicals. The inherently complex and nonlinear dynamic behaviors of the batch distillation are very attractive issues for determining the accuracy model and the appropriate control system. In this work, the feedforward neural network is applied for modeling and control a batch distillation process. This work is divided into two parts: *system modeling application*, and *control system application* described in the following.

The application of neural network to simulate the behavior of batch distillation process which has an inherently complex and nonlinear dynamic is investigated. The multilayer feedforward neural network trained using backpropagation algorithm and improved rate and stability using the Levenberg–Marquardt optimization method is considered in this work. For neural network design, the hidden layer size consisting of the numbers of nodes and layers are a significant issue. Therefore, the study to determine the appropriate configuration of neural network model which is determined evaluating the mean square error of the test set is concerned. Finally, the appropriate configuration for one hidden layer network is the ten hidden nodes network $(16-8-2)$ and appropriate configuration for two hidden layers network is the first hidden layer with six nodes and the second hidden layer with four nodes $(16-6-4-2)$.

For control system design, the neural network is employed as the model based controller formulated using the MPC control technique base on the neural network model. The multilayer feedforward networks with two hidden layers are employed to model the behavior of batch distillation process. The procedure of neural network modeling is the same as described in the section of system modeling application, which provide the appropriate configuration of neural network model that consists of an input with twelve nodes, an output with seven nodes, and two hidden layers with ten nodes for each layer $(12-10-10-2)$. In this work, the control objective is to track the top composition with an optimal reflux ratio profile obtained from the solution of the optimization problem defined in term of maximum distillate product. The optimal reflux ratio profiles are studied with different time interval which the number of interval is varied from one to eight. The result shows that the amount of product depended on the number of time intervals. Moreover, the tendency of the optimal reflux ratio profile increasing along the batch time. Therefore the optimal reflux ratio profile with eight time intervals is selected as the setpoint for tracking cyclohexane composition at the condenser. The performance of the controller evaluated using integrated absolute error is 259.2389. Moreover, the robustness of the controller is evaluated under two model-plant mismatch conditions: *model-plant mismatch caused by neural network model* and *model-plant mismatch caused by process change*. In the case of neural network model mismatch, it can be conclude that the NNMPC shows robust tracking capability.

## 6.2 Recommendations for Future Work

Some recommendations for future work are given below. In this work, the data for modeling the behavior of the batch distillation process is generated using the mathematical model. This data should generate from the actual process. Moreover, the neural networks for modeling the behavior of the batch distillation process may be trained online due to the network trained offline may not learn the process dynamic well. For control system design, the control actions from the NNMPC controller may be the setpoint for the reflux flow rate in the future work.