CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In this work, the application of a reactive distillation as a potential alternative method for dilute acetic acid recovery is addressed. The synthesis of butyl acetate, from esterification of dilute acetic acid with butanol in the reactive distillation is investigated using HYSYS commercial software. The reliability of a reactive distillation model obtained from HYSYS simulator software is confirmed by comparison to experimental results reported in literature. Simulation results calculated by HYSYS are in good agreement with experimental data. The studies are divided into two main parts; the first one involves the simulation of the reactive distillation under steady state condition whereas the second one focuses on the design of the control system for controlling the reactive distillation.

6.1.1 Steady-state simulation of reactive distillation

To ensure the most effective reactive distillation process, the influence of important design factors on the conversion of acetic acid is evaluated at different concentration of feed acetic acid. The simulation results show that the maximum conversion of acetic acid and purity of butyl acetate at bottom stream can be achieved when acetic acid and butanol feed of mole ratio of 1:1 are introduced to the column at the top stage of reactive section. Changing a number of stages in reactive section and non-reactive section has no significant effect on both the acetic acid conversion and butyl acetate purity. By considering the influence of reboiler heat duty, it is found that increasing the reboiler duty directly increases the acetic acid conversion and butyl acetate purity. It is also observed that when acetic acid with low concentration is used in the reactive distillation, high reboiler heat duty is required in order to obtain butyl acetate at 99.5 wt % purity. Regarding to the required heat duty, the use of 80 wt %

acetic acid as a reactant for the synthesis of butyl acetate in a reactive distillation column seems to be practical and the optimal design of the column consists of 7 rectifying, 13 reaction, and 7 stripping stages.

6.1.2 Control of reactive distillation

Based on the optimum configuration of a reactive distillation column for the production of butyl acetate from dilute acetic acid (80 wt %) and the obtained steady state conditions, control structures are designed for controlling the reactive distillation column at desired steady state conditions. From sensitivity analysis of reboiler heat duty to the column temperature, it is found that the temperature at 24^{th} stage shows liner dynamic behavior and is selected as one of the controlled variables (in CS1 and CS2). In this study, three different alternative control structures (CS) are proposed and tested under disturbance conditions (step changes in feed flow rate and concentration of acetic acid and butanol). The results show that CS1 that fixed the reflux rate constant is not able to maintain the pressure-controlled as step up acetic acid feed and step down butanol composition. The condenser level is also too much in all disturbances. So, the performance of this control structure is poor in the face of load disturbances. The CS2 (reflux ratio constant by adjusting the distillate flowrate) is used to handle the reflux drum level. The performance of the CS2 is good in all disturbances. But the bottom product purity is not received at desired value. The CS3 (directly composition-controlled) can handle with all disturbance and better control of product composition than CS2. Anyway the process responses of CS3 swing too much.

6.2 Recommendations

In this work, the optimal configuration of a reactive distillation column for butyl acetic synthesis from dilute acetic acid and butanol is determined based on information obtained from steady-state simulation. Further studies on the design of

reactive distillations should take operating and fixed cost into account as it would affect the obtained configuration of the reactive distillation.

For the control study of reactive distillation, although direct control of product composition shows a good control performance, it requires high investment on composition measurement instrument. Thus, indirect control of composition via the column temperature control should be improved.