CHAPTER VII

CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

In this thesis, HDA process with different energy integration schemes (i.e. BC 3 aux, BC min aux, RHEN1, RHEN2 and RHEN3) were studied, since five resilient heat exchanger network can be improved by introducing recycle streams and energy integration into the process. However, the recycle streams and energy integration introduce a feedback of material and energy among unit upstream and downstream. This work presents four plantwide designed control structures with five different energy integration schemes. The commercial software HYSYS was utilized to carry out both the steady state and dynamic simulations.

7.1.1 Procedures of Design Heat exchanger network

The synthesis of a resilient heat exchanger network by using (1) match pattern as operators in mapping one design state to the next and (2) heat load propagation technique can be done by the following systematic sequence:

1. Pop a match pattern operator from the ordered stack of match patterns. If all the patterns are chosen, backtrack to the parent design state and repeat the procedure. If the current state is the starting state and all parents have been tried without success the problem cannot be solved with the current knowledge in the rule-based system. A trade-off between cost and resiliency may be needed.
2. Choose a pair of hot and cold streams from the set of unmatched process streams. If all streams have been chosen and none were satisfied, go back to the first step to try a new pattern.
3. Apply the match pattern to the selected pair of streams. If the streams satisfy the pattern test and the resiliency requirement go to the next step. Otherwise go back to the previous step to select a new pair of streams.

Match pattern test: Check whether the heat load, input temperature and heat flow rate capacity satisfy the match pattern description.

Resiliency test: Check whether the disturbance load of the smaller heat load stream can be shifted to the larger heat load stream.

4. Create a new state to support the new fact. A new state is a descendant of a current one. Change the parameters of the larger heat load stream: the supply or target temperature, the heat load and the disturbance load.
5. For a pinch match of stream i and j for which $Wj > Wi$ and $Lj > Li$, the disturbance of a residual stream j:

$$D_j = D_i + \left(D_{j,pinch} - D_{i,pinch}\right) \qquad (1)$$

6. If there are unmatched hot and cold streams, go to the second step. Otherwise go to the next step.
7. Match the only hot or cold streams with the utility streams.
8. If there are other unused match patterns go to the first step. This is equivalent to saying that there might be other solutions available, continue.

7.1.2 Procedures of Design Control Structure

1. Use Bypass stream for controlling. The bypass stream should be settled on the cold side because it would be safer to equip measure equipment and control valve on the hot side. On the other hand, it should settle bypass stream on the controlling side regardless whether it is hot or cold stream. However, the selection must bring about the best performance of control system.
2. Control loop must be settled for reducing the disturbance load path. Calandranis and Stephanopoulos (1988) claimed that it should select the disturbance load path related to the least number of heat exchanger namely the shortest path way in order to reduce the effect of disturbance on another part of network.
3. From the economic point of view, we strongly suggest to:
   (3.1) shift D^+ of cold stream or D^- of the hot stream to the cooler utility, thus its duty will be decreased.
   (3.2) shift D^- of cold stream or D^+ of the hot stream to the heater utility, thus its duty will be decreased.
4. A selective controller with low selector switch (LSS) should be employed to select

an appropriate heat pathway through the network to carry the associated load to the utility unit.

5. A selective controller with low selector switch (LSS) should be employed to select an appropriate heat pathway through the network to carry the associated load to the utility unit.
6. The number of LSS to be used in a particular case can be determined as follows:
   (6.1) Identify the heat pathway of disturbance
   (6.2) If there is only one heat pathway, it do not need to be set the LSS.
   (6.3) If there are more than one heat pathway, it need to be set the LSS between the outlet temperature of Heat exchanger.

In this study, IAE method is used to evaluate the dynamic performance of the control system. For the change in the disturbance loads of the hot steam on HDA process case the four control systems compared with those in HDA process BC 3 aux, BC min aux, RHEN1, RHEN2 and RHEN3, i.e. the value of IAE in HDA process RHEN3 with CS3 is smaller than those in another resilient heat exchanger network with another control structures, for the change in the disturbance loads of the cold steam on HDA process case the four control systems compared with those in HDA process BC 3 aux, BC min aux, RHEN1, RHEN 2 and RHEN3, i.e. the value of IAE in HDA process RHEN3 with CS3 is smaller than those in another resilient heat exchanger network with another control structures and the change in the disturbance loads of the total toluene feed flowrates on HDA process case the four control systems compared with those in HDA process BC 3 aux, BC min aux, RHEN1, RHEN 2 and RHEN3, i.e. the value of IAE in HDA process RHEN3 with CS3 is smaller than those in another resilient heat exchanger network with another control structures

We can conclude that the plants with higher level of heat integration can have control performance as good as the base case plant with lower heat integration if the suitable control structures can be found. More importantly, we can avoid the control difficulties associated with the heat integration by choosing the suitable heat integrated structure and proper control structures. This can be done in real time domain using rigorous process dynamic simulator like HYSYS.

7.2 Recommendation

Since the tray temperature control of recycle column has oscillations very large, so we should improve the performance of this loop by understanding and applying control techniques such as feed forward control and cascade control etc.