SYNTHESIS OF ENERGY EFFICIENT COMPLEX SEPARATION NETWORKS

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10th International Symposium on Process Systems Engineering, August 16-20, 2009, Salvador, Bahia, Brazil

Motivation and Objectives

Distillation occupies a significant role in the chemical processing industries. The energy consumption associated with distillation is high, representing approximately 45–70% of the total operating costs. Improved distillation performance is therefore of high importance. This study investigates the energy saving potential of complex column configurations that are controlled by the temperature collocation (TC) algorithm, with the objective of developing a decision support tool for the design of complex column networks.

Complex Column Profiles

Temperature Collocation of a General Column Section

\[ \sum x_i = 1 \Rightarrow \frac{\sum x_i}{\sum x_i} = \frac{\sum x_i}{\sum x_i} \]

Column Section profile:

\[ \frac{dx}{dT} = \frac{1}{x_i} \left( \frac{1}{\sum x_i} - \frac{1}{x_i} \right) \]

Rigorous Feasibility Test 1

According to the generalization of the minimum bubble point distance approach, a complex column k is feasible if the sum of all profile distances of all adjacent sections i and i+1 is within a small tolerance (ε) close to zero. The entire network is feasible if all its columns are feasible as:

\[ Z(k) = \sum_{i=1}^{n} \frac{\text{MinBPD}}{\text{MinBPD}} < \varepsilon \]

Rigorous Feasibility Test 2

Bubble Point Temperature Distance map shows the minimum composition distance between two adjacent sections. The minimum bubble point distance (BPD) of 3.3586e-004 is located at r = 15.05 and BPD = 79.1844 °C.

Case Study - Separation of Quaternary Mixture

A quaternary mixture of methanol, ethanol, 1-propanol, and acetic acid was studied. This complex network uses two simple columns and one complex column. The complex configuration analyzed uses half total vapor rate and saves 20% of total costs compared to the simple column configuration.

Conclusions

• Temperature collocation and minimum bubble point distance (MID) algorithm were effective to find a feasible separation by intercepting profiles.

• The second case study demonstrates the current state of the art of separation synthesis in conjunction with computer simulations to fully integrate complex separation networks.

• The seamless integration of rigorous flow sheet simulators to validate the predictive results of our scientific method was demonstrated

Acknowledgements

• DOE Grant: DE-FG36-06GO16104
• Dr. Rakesh Agrawal (Purdue University)
• Dr. Chau-Chyn Chen (AspenTech)

References


