ABSTRACT

Jiang, Zheyu Ph.D., Purdue University, October 2018. Multicomponent Distillation – Mathematical Modeling, Global Optimization, and Process Intensification. Major Professor: Rakesh Agrawal.

Distillation is the most important separation process that accounts for 90–95% of all separations in the chemical industries. Even slight improvements can tremendously impact the landscape of the chemical economy world. The goal of this thesis is to develop mathematical modeling and global optimization approaches as well as systematic process intensification strategies to design and synthesize compact, easy-to-operate, energy-efficient, and cost-effective multicomponent distillation systems.

Towards this goal, we discuss the following aspects in this thesis:

1. We solve a longstanding challenge in chemical engineering of developing a short-cut method to determine the minimum reflux condition for any multi-feed, multi-product distillation column separating ideal multicomponent mixtures. The classic Underwood's method turns out to be a special case of our approach.

2. We develop the first enumeration based global optimization algorithm to identify optimal distillation configurations that can potentially save up to 50% of total cost or total exergy loss compared to conventional schemes from the immense configuration search space. For the first time in the literature, global optimality is guaranteed.

3. We propose a systematic and comprehensive multi-layer approach for process intensification in multicomponent distillation. For the first time, industrial practitioners have an easy-to-follow recipe to generate an array of completely new and attractive highly intensified configuration designs that further enhance operability, improve efficiency, and reduce total costs.