New Design Methods and Algorithms for Multi-component Distillation Processes

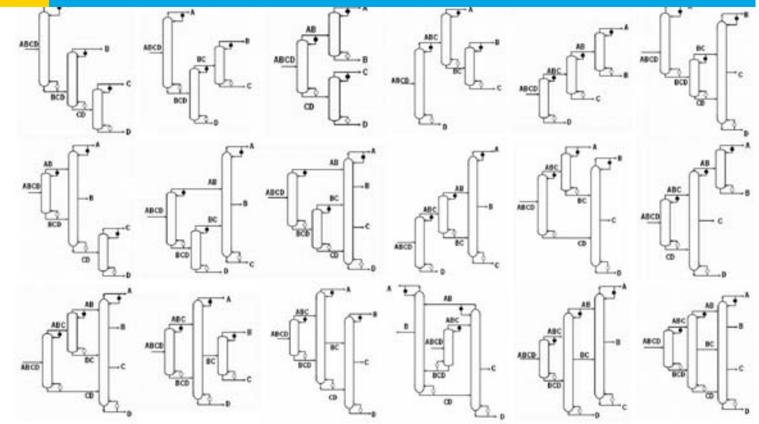

Fig 1. Four-component distillation configurations.

Illustration courtesy of Purdue University.

Improved Energy Efficiency through the Determination of Optimal Distillation Configuration

The ability to apply low-energy distillation configurations can allow chemical manufacturers to reduce energy consumption of both existing and grassroots plants. However, the determination of an appropriate configuration is limited by an incomplete knowledge of the 'search space' for a proper distillation network. Currently, no systematic method is available that reveals all possible distillation configurations to serve a particular purpose. The mathematical task and size of the problem in terms of computational effort provides an enormous difficulty in finding an optimum distillation configuration.

Researchers aim to tackle these current limitations by developing algorithms for a complete and compact search space that contains all potentially useful distillation configurations. At the same time, the search space should not burden a user with less-desirable configurations. Once the ability to quickly identify an array of useful configurations is developed, the incorporation of more rigorous thermodynamic and cost calculations should allow for the determination of optimal distillation configurations for a given multi-component separation. Any proposed new configurations should be economically attractive as they will retain the same number of distillation columns as in conventional configurations, and will not add additional reboilers or condensers.

Testing of the developed methods will occur in high-volume, high-impact industrial distillation processes of typical chemical and petrochemical plants. Ultimately, by utilizing these methods and tools a process engineer will be able to quickly screen the search space and identify efficient, low-energy distillation configurations for any given application.

Benefits for Our Industry and Our Nation

The ability to determine the optimal distillation configuration for a particular application can reduce heat duty up to 40% or more. The developed tools will provide low-energy options that can potentially lead to efficient operation schemes and attractive retrofit and grassroots options for reduced energy consumption.

Applications in Our Nation's Industry

Distillation systems are key components in chemical and petrochemical plants. Multi-component separations are involved in hydrotreating, alkylation, isomerization, reforming, and the processing of crude oil, liquefied petroleum gas (LPG), and natural gas liquids (NGL).

Project Description

The main goal of this research effort is to develop methods and software tools for the identification and analysis of optimal multi-component distillation configurations for reduced energy consumption in industrial processes. At the completion of this goal, a process engineer will be able to quickly screen the network search space and identify low-energy distillation configurations for any given application.

Barriers

- The mathematical task and computational effort required to determine optimum distillation configuration
- Development of a thorough search space that ensures that all the low-energy candidate distillation networks are identified and not eliminated

Pathways

Researchers will first ensure a complete and compact search space that will contain all the potentially useful distillation configurations without burdening the user with less-desirable configurations. Methods to quickly identify an array of useful configurations will then be developed. A method incorporating more rigorous thermodynamic analysis and cost calculations will also be developed. This should allow the search for the optimal thermally coupled as well as non-thermally-coupled distillation configurations for a given multi-component separation.

Milestones

This project started in September 2006.

- Develop a paper algorithm and illustrate how it could be used to develop multiple distillation column configurations for multi-component separation. (Completed)
- For an n-component mixture, identify a complete and compact search space such than no useful distillation configuration is excluded. (Completed)
- Develop an algorithm to sweep the search space and find an array of optimum distillation configurations for a given multi-component feed separation.
- Apply the developed tools to industrial processes.

Commercialization

Because the results of this project will be quite general and have very broad applicability, team members commit to disseminate the developed information to various chemical companies at professional meetings as well as during individual interactions. Team members plan to make all the developed methods and tools readily available to the chemicals and petrochemicals industries.

Project Partners

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DOE/EE-0415 • May 2011