New Design Methods and Algorithms for Energy Efficient Multicomponent Distillation Column Trains

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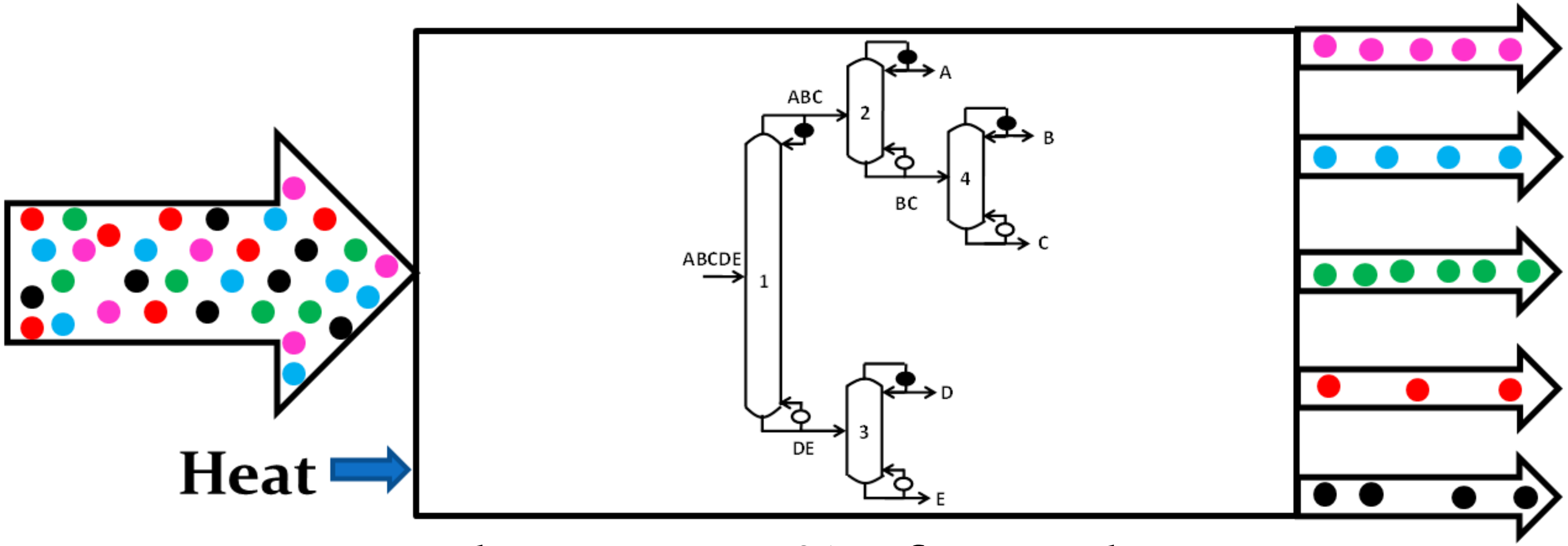
Project Objective

- Multicomponent Distillation is Ubiquitous in all Chemical/Petrochemical/Biochemical plants



- Separations contributes 40-70% of capital/operating cost of a typical processing plant.
- 90-95% of all separations in a plant are done by distillation.
- 40,000 distillation columns in operation in US, and consume equivalent of ~ 1.2 million bbl of oil per day

Project Objective (continued)

- Reducing energy consumption involves:
  - first creating the galaxy of column configurations,

    and then

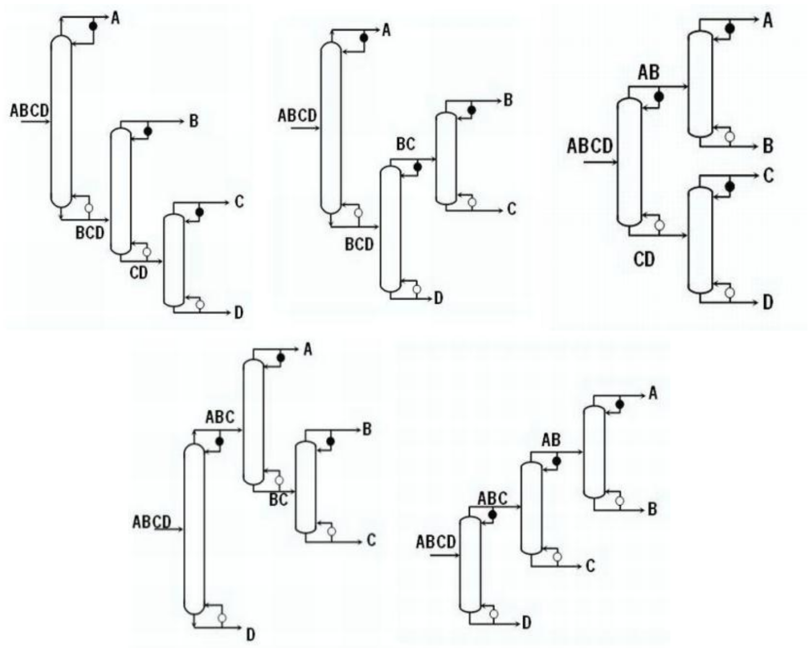
  - finding the brightest star among the numerous stars

Courtesy: piximggif.com

Technical Approach

- Current Industrial Practice:
  - Heuristics (experience, guess, trial and error)
  - Unable to define/explore entire galaxy of configurations
  - Often results in energy inefficient plants being built
- Systematically generated the galaxy of basic configurations*

Number of components in feed	Number of configurations
3	8
4	152
5	6128
6	506912
7	85216192
8	2.9E+10



*Developed under AMO project: DE-FG36-06GO16104

Technical Approach (continued)

- Develop tools for global optimization of a configuration
- Ranklist the entire configuration set based on energy used and other metrics
- Develop software for ease of use by practitioners
- Continue to identify methods to further reduce energy consumption and cost

Thanks to AMO Support, we are the only US academic group performing this user/manufacturing oriented research

Transition and Deployment

- Results are of interest to practitioners in broad industries
  - Chemicals, e.g. alcohols, ketones, gases, etc.
  - Petrochemicals, e.g. NGL, LNG, Crude Petroleum
  - Biochemical processes, e.g. pyrolysis, fermentation, etc.
- Process designers in above industries are prime users
  - New plants
  - Retrofits
- Develop user-friendly software and make it available to the entire industry for wide scale use
- Continue incorporation of new methods and tools in the software - continued improvement!

Measure of Success

- Industry-wide use of our methods and tools
- Guaranteed identification of low cost distillation options.
- New plants with energy-efficient/low-cost distillation configurations that have never been built before
- Retrofit of new energy-efficient options

Ultimate economic impact

- New distillation configurations will reduce energy consumption by up to 30% and capital cost by 10% to 20% when compared to conventional configurations.

Project Management & Budget

- Duration of the project: Three years

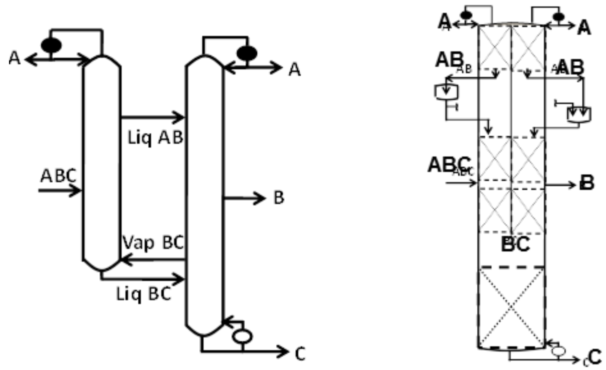
Mile-stone	Milestone Description	Verification Method	Planned Completion Date
1.1.1	Robust Covergence of NLP formulation for heat duty	CPU time of ~ 2 sec for 99% of the 5-component configurations	Q2
1.2.1	Software with total cost optimization using NLP	Software available for use	Q3
2.1.1	Availability of all DWCs for FTC	Complete derivation of equations. Submit a manuscript.	Q2
2.2.1	DWCs for any TC configuration	Finish development of the method and write a manuscript.	Q3
3.1	Heat & Mass integrated columns for improved energy efficiency	A method to draw sub column configurations will be made available.	Q4
4.1.1	Completion of the First internship	Finish first internship and submit a feedback report	Q3
4.1.2	Incorporate feedback from first internship in the software	Incorporate feedback in the computer software	Q4
4.2.1	Investigation of packaging and licensing strategies for the software	A report summarizing findings and strategy.	Q3
4.2.2	Marketing of software as a service via a web browser	Conclude feasibility analysis	Q3
4.2.3	Identification of potential marketing firms	Active dialogue with interested companies.	Q4

Total Project Budget	
DOE Investment	900,000
Cost Share	251,708
Project Total	1,151,708

Results and Accomplishments

Technical:

- New dividing wall columns, previously unchanged for over 65 years!
  - Consolidation of distillation columns in a single shell
  - More operable options
  - 10% to 30% lower cost
  - Retain lower energy use



  - Operable choices for mixtures containing more than three components are available for the first time

Results and Accomplishments (continued)

Towards Industrial Use:

- A graduate student to test our software this summer at Eastman Chemical as an intern
- In preparation, successfully improving quality of our software with faster convergence of increased number of configurations
- Internship at Dow Chemical for the summer of next year confirmed and planning started at Dow
- Discussion on the use of our algorithm by ExxonMobil experts already underway (ExxonMobil experts visited Purdue in April)
- Submitted an article on dividing wall columns to Chemical Engineering Progress (distributed to about 40,000 chemical engineers – mostly industrial practitioners)

Project Team

PI: Professor Rakesh Agrawal, School of Chemical Eng., Purdue University

Co-PI: Professor Mohit Tawarmalani, Krannert School of Management, Purdue University

Industrial Collaborators:

Dow Chemical

Eastman Chemical

ExxonMobil