Topics Covered

• Introduction to APD
• Project Approach
• Process and Site Pinch Analysis
• Distillation Optimization
• Project Examples
Aspentech’s Advanced Process Design Group

• We provide consulting services that:
  – Reduce Energy and Emissions
  – Increase Capacity
  – Produce Better Process Designs

• Our Focus Areas:
  – Process and Utilities Modeling
  – Conceptual Process Design
  – Operational Improvement

• Our Tools:
  – Aspen process simulation and equipment design software
  – Process synthesis and conceptual design tools
Energy Management Focus Areas

**Design**
- Design Utilities to maximize efficiency

**Operate**
- Operate Utilities to deliver at the lowest cost

**Utilities**
- Utilities/Supply – Provide at lowest cost

**Process**
- Design the process to use less energy & be more efficient
- Process/Demand – Use less energy

**Supply**
- Sustain the process at lowest energy cost

**Demand**

Project Approach
Energy Reduction Issues

- **Significant opportunity for improvement:**
  - Average US chemical facilities relatively old, inefficient, e.g. average EEI for US ethylene plant is 175, with State-of-the-art =100 (DOE report, 2000)
  - Older unit designs based on low energy cost
  - Design methods 20-30 years ago may not have considered all options, e.g. distillation sequencing

- **Challenges:**
  - Tight capital, short payback requirements
  - Limited resources
  - How to identify the best energy projects and turn into real savings

- **Ad-hoc addition of energy projects are often uneconomical or may not yield the expected benefits when overall impact is not considered**

- **The best approach should be systematic, holistic and based on current operation to ensure that the right opportunities are identified and that no opportunities are overlooked**
Model Centric Approach to **Process Improvement**

- High Load Test Run
- Operating data review
- P&ID review

**Pinch and Column Analysis**
Identify design improvements

**Equipment Rating**
Understand performance

**Identify operating improvement opportunities**

**Process and utilities modelling**

**Model Idea, develop Scope/Benefits/Cost**

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Evaluation of current operation and equipment performance

Identifying operating improvement opportunities:

- Are columns over-refluxed?
- If multiple column feed nozzles, is current feed location optimum?
- Are column operating pressures optimal?
- Exchangers underperforming/bypassed?
- Compressor recycles open?
Process and Site Pinch Analysis
Pinch Analysis

Evaluation of existing or new heat exchanger network

Pinch Analysis purpose:
Establish minimum utility targets
Identify location of inefficiencies in network
Develop viable energy saving projects that improve process-process heat recovery

Utility energy targets

<table>
<thead>
<tr>
<th>Name</th>
<th>Used</th>
<th>TARGET</th>
<th>Difference</th>
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<tbody>
<tr>
<td>MPS</td>
<td>75.5</td>
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<tr>
<td>LPS</td>
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<tr>
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<tr>
<td>CW</td>
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Pinch Analysis

HEN Analysis:
Identify cross-pinch exchangers in network

Use pinch design techniques to identify best modification to eliminate cross-pinch

Also consider process modifications in conjunction with pinch analysis

Cross Pinch Heat Transfer Penalties
Penalty units: MMBTU/hr

<table>
<thead>
<tr>
<th>Pinch#</th>
<th>Hxer ID</th>
<th>Ti = 153.41 F</th>
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A Systematic Approach to Site-Wide Energy / Emissions Reduction

Unit by Unit Pinch Analysis

Site Wide Pinch Analysis

Process Streams (Heat Sources)

Process Streams (Heat Sinks)

Hot utilities

Cold utilities
Site-wide Utility Infrastructure Analysis

Are your steam levels/loads optimum?

What is the optimum cogeneration system?

Smaller boilers!

Reduction in fuel consumption

Opportunity for additional turbine to exploit IP steam sink

Power generation increased

Opportunity for new LLP steam level – increases heat recovery

Smaller CW towers!
Distillation Optimization
Column Targeting

- A tool for thermal and hydraulic analysis of distillation columns
- Column Grand Composite Curves: A graphical representation of the ideal minimum stage-wise heating and cooling demands in a distillation column

![Diagram of Column Targeting](image)

Minimum Thermodynamic Condition
Column targeting

Feed Relocation

Move the feed!

Bad Feed Location => Distorted Profile

Shaded area implies inefficiency
Column targeting

Reflux Modification

Scope for Reflux reduction
Column targeting

Feed Conditioning

CGCC (Stage-H)  CGCC (Temp-H)
Column targeting

**Side Condensing/Reboiling**

Targeting For
Side Condensing

Targeting For
Side Reboiling
Distillation Synthesis/Analysis

- Residue curve maps (generated using Aspen Split) provide a graphical tool for synthesis and analysis of **non-ideal** distillation schemes
- Helps to understand and visualize complex component interactions
- Can be applied to
  - Conceptual design for new processes
  - Re-configuration of process for low cost retrofits
  - Providing insight for operational improvement

Residue curves track the composition of residue liquid in simple distillation - Useful to represent complex distillation processes as well
Examples of Revamp Applications
Column Analysis Example 1: C2 Splitter debottlenecking

Base Case

Option 1

Use Split feed instead
C2 Splitter Options – Include 1\textsuperscript{st} column

**Option 2**

- DeC\textsubscript{2} Overhead (vapor)
- C\textsubscript{2} Splitter 1
- Ethylene
- C\textsubscript{2} Splitter 2
- Ethane

**Option 3**

- DeC\textsubscript{2} Overhead (vapor)
- C\textsubscript{2} Splitter 1
- Process cooling
- C\textsubscript{2} Splitter 2
- Ethylene

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Block D\textsubscript{8}-401-2: Column Grand Composite Curve (T-H)

<table>
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<th>Temperature $^\circ$F</th>
<th>Enthalpy Deficit MMBtu/hr</th>
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Impact of Feed conditioning option

• Potential to increase column 2 capacity by >30% (unload trays, condenser, reboiler)
• Energy saving covers capital cost, capacity “free”
• Significantly unloads refrigeration system
Issues:
• Compressor suction at atm. pres
• System sensitive to $\Delta P$ across condenser – poor heat transfer
• Column analysis shows large Condenser duty available at useful $T (>150^\circ F)$

Options Previously Considered:
• Direct integration: long lines, adds $\Delta P$ on overhead, impractical.
• Indirect integration with e.g. TW system: driving force loss, cost.
Proposed Modification

Benefits:
- ~80% of condenser Q recovered
- Reduce condenser DP
- Reduce condenser outlet temperature
- Reduce compressor load
- Option to re-pipe an existing reboiler
Split Example: Revamp for US Client

Existing process:

- Process:
  - Desired product is component $b$
  - Conventional fractionation of $b$ from $c$
  - Extractive distillation for $a$ from $b$

- Key Issues:
  - Incomplete removal of $c$, despite high number of trays and reflux on columns C1/2
  - Low product $b$ purity
Split Analysis

Ternary Map (Mass Basis)

Distillation boundary prevents complete c removal from a/b with base composition

With composition on the b-rich side of azeotrope, complete removal of c becomes possible

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Alternative Sequence Proposed

Proposed Solution:
Use only one column (C1) for sloppy split of b/c to get near distillation boundary
Use second column (C2) for final separation of c from b in absence of a
Result:
Significant improvement in product purity with >$10mil potential value upgrade
Summary

- Rigorous simulation model of process and utility systems
  - Helps to identify operational opportunities often overlooked
  - Helps to understanding and exploit unit-wide interactions/trade-offs that may simultaneously save energy/ reduce capital / increase capacity
  - Provides a consistent basis for process analysis, equipment rating and project benefit assessment

- Process analysis insights lead to more/better project ideas, more savings

- Utility system evaluation ensures savings are real

- Helps to identify most attractive projects with best payback
Questions?

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