Energy Quality and Yield Improvements in Alkylation

DH Lee
APST Inc.

Biography

• APST is Advanced Process Solutions & Technology
  – Started in 2007
  – To provide the best advanced process solutions and tech.
• Partners
  – Expertune Inc. (www.expertune.com)
  – Tips Inc. (www.tipsweb.com)
• Clients
  – Operations:
    • Hanwha Chemical, Samsung Fine Chemicals, SK Energy, POSCO, Cheil Ind., Hyundai Oilbank, Honam Petrochemical, GS Caltex, Etc.
  – Eng. & Etc.
    • Samsung Electronics, Daewoo Eng. Doosan Heavy Ind. Etc.
## Success Stories

<table>
<thead>
<tr>
<th>Client</th>
<th>DCS</th>
<th>Benefits</th>
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</thead>
</table>
• PVC Plant – Increased Safety Margin 50%, 3% Production Increase (2008.4)  
• New Plant Stabilization of Dry4/CA4 (2010.1)  
• VCM Plant Energy Savings, 2% Energy Usage & US$ 2M Savings/Yr (2010.11~2011.3) |
| Samsung Fine Chemicals      | Yokogawa        | • ECH/PTAC Process, 5.4% Energy Savings at Distillation Column (2007.10)                                                                       |
| SK Energy                   | Yokogawa        | • Process Stabilization, Reduced Alarm 90% (2008.1)                                                                                       |
| POSCO                       | Honeywell       | • improve 3% fuel savings by excess O2 Optimization and NOx control at a Power Plant (2009.5)                                                |
| Cheil Ind.                  | Honeywell       | • Energy Savings at PC Plant, 5.5% Savings by Stab. and Opt. (US$ 900K/Yr, 2008.7)                                                     |
| Hyundai Oilsbark            | Yokogawa, Yamadake, Emerson | • Whole BTX Plant Energy Savings, 4% Energy Usage (> US$ 2.5 M/Yr, 2009.3)  
• Installation Control Loops Monitoring System for the site (US$ 1M/Yr, 2009.10)  
• New Plant Stabilization of #2 HDU & Installation/PlantTriage System (2010.9~2011.5) |
| Honam Petrochemical         | Honeywell, Yokogawa | • Energy Savings at PC Plant, 2% Energy Usage (2009.9)  
• Energy Savings at BTX Plant, 2% Energy Usage (2010.3)  
• Energy Savings at DMC, EG Plant, 2% Energy Usage (2010.7)  
• Energy Savings at #3EG, MMA Plant (2010.11~2011.2)  
• Expanding to other plant (2011.3~) |
| GS Caltex                   | Honeywell, Yokogawa | • Energy Savings at Alkylation & #3 Xylene unit, Energy Savings > 2%, (2010.3)  
• New Plant Stabilization of WHCR (2010.8)  
• Energy Savings at #2KD, Energy Savings >2%, (2010.11) |

## Abstract

- By applying PlantTriage and improving their efficiency could save average 2% energy usage in plant in Korea. It shows our approaches, procedure and results in Alkylation.
PlantTriage Usage In Korea

- New Plant
  - Process Stabilization
  - PID Optimization
  - H/W Issue Diagnosis & Monitoring
  - Setting KPI Baseline & Thresholds

- Existing Plant
  - Performance Management
  - Control System KPI Management
  - PID Optimization
  - H/W Performance Monitoring

PlantTriage is ...

- Control System Performance Monitoring & Management
- Collect real-time data from DCS/Historian, Store, Analysis and Report System
- Detect Control Performance issue & Efficient tool to solve the issue
  - H/W Issue : Valve, Sensor status, Size issue
  - S/W Issue : Tuning problem, Interaction issue, APC performance
  - Root cause analysis
  - KPIs management
  - PID Optimization

PlantTriage

Control System KPI Mng.
Real Time Data Collection / Store / Trend
Assessment / Analysis
Interaction Analysis
PID Optimization / Simulation
Etc.
Working Procedure

Key factors

• Install PlantTriage first
  – Set up with basic control information
  – PlantTriage gives some hint for improvement
    • Tuning Issue / Hardware Issue / Process Characteristics / Operator Actions & etc.
• Setup Baseline
  – Set up baseline of energy usage, unit cost, product rate, loop health etc.
• Start from easy things
  – Tune PID parameters
  – Fix H/W problems as possible
  – Become a friend with operators
    • Try to solve their trivial work / Listen their ideas / Include them as project member
  – Analyze process for optimization
    • Use process simulator or data mining tool
• Make monitoring environment
  – Update PlantTriage configuration (Monitoring items, Baseline & Thresholds, Report format and etc.)
• Report with benefits
Alkylation Unit

Alkylation Reaction Mechanism

\[
\begin{align*}
\text{CH}_3\text{C} = & = \text{CH}_2 + \text{CH}_2\text{CH}_2\text{CH}_3 \\
\text{Isobutylene} & = \text{Isobutane} \\
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1\text{-Butene} & \rightarrow 2,3\text{-Dimethylpentane} \\
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\end{align*}
\]
Control Loop KPIs

<table>
<thead>
<tr>
<th></th>
<th>Before Improvement (3/1~15)</th>
<th>After Improvement (5/5~16)</th>
<th>Difference (Improvement)</th>
<th>Ref.</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop health %E</td>
<td>25.29</td>
<td>15.42</td>
<td>-9.9</td>
<td>70 – 100%</td>
<td>Overall Performance Index</td>
</tr>
<tr>
<td>Valve Travel, % /Day</td>
<td>2392</td>
<td>1380</td>
<td>-1,012</td>
<td>&gt; 2000%</td>
<td>Stability</td>
</tr>
<tr>
<td>Not In Normal , %</td>
<td>12.91</td>
<td>9.253</td>
<td>-3.7</td>
<td>About 30%</td>
<td>Usage</td>
</tr>
<tr>
<td>Avg abs error, %</td>
<td>0.4026</td>
<td>0.4142</td>
<td>0.0</td>
<td>2</td>
<td>Controller Performance</td>
</tr>
</tbody>
</table>

Actions for Improvement

◆ Increase Controller Usage

Flash Drum Level-Refrigerant Recycle

Temperature Control (Manual -> Auto), DeC3 #38
Actions for Improvement

◆ Install a New Controller

- Temp Control: New
  (Manual -> Auto), DIB #58

◆ Build Soft Sensors

Actions for Improvement

◆ Alkylate RVP Inferential vs. Analyzer

New Plot Title @ 60s/0m/0s

Analyzer

Lab_NIR

Inferential

Reduced RVP Variation

2010-05-18 10:23:10

2010-05-19 10:23:10

35.00 15.00

25.00 15.00

2010-03-19 10:23:10
Results

◆ KPIs Trend

![KPIs Trend Chart]

- Improved Process Conditions

- Stabilized I/O Ratio
- Unformed Reaction Temperature (Contactor’s DT)
Results

◆ Increased Product Quality

- Propane Purity % in DeC3 OVHD
- IC4 in NC4 / NC4 in DeC5 OVHD

Results

◆ Increased Product Rate

- Propane (By product)
- Alkylate
- NC4
## Results

### Reduced Steam Usage

![Graph showing reduced steam usage](image)

### Benefit Evaluation

<table>
<thead>
<tr>
<th>Benefit Evaluation Sheet</th>
<th>Base</th>
<th>Evaluation</th>
<th>GAP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period</strong></td>
<td>10 03.01~03.15</td>
<td>10 05.01~05.11</td>
<td></td>
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<tr>
<td><strong>Average Operating Conditions</strong></td>
<td></td>
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<tr>
<td>Contactor Temperature, °C</td>
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<tr>
<td>Isobutane/Olefin Volume Ratio</td>
<td></td>
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<tr>
<td>Isobutane Content of Recycle, vol %</td>
<td></td>
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<tr>
<td>Spent Acid Concentration, wt %</td>
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<tr>
<td><strong>Fresh Feed</strong></td>
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<tr>
<td>Olefin Feed, FC001+FC506</td>
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<tr>
<td>Isobutane/Olefin Volume Ratio</td>
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<tr>
<td>1-Butene</td>
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<tr>
<td><strong>Average Fresh Olefinic Feed Composition of Olefins, vol %</strong></td>
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<tr>
<td>Propane</td>
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<tr>
<td>i-Butane</td>
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<tr>
<td>2-Butene</td>
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<tr>
<td><strong>Average Fresh Feed Characteristics</strong></td>
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<tr>
<td>Mercaptan Sulfur, ppm (wt)</td>
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<td>Total Sulfur, ppm (wt)</td>
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<tr>
<td><strong>Average Yield Composition of Product, vol %</strong></td>
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<td>Propane</td>
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<tr>
<td>2-Butene</td>
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<tr>
<td><strong>Average Yield Composition of Product, kl/hr</strong></td>
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<td>Propane</td>
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<tr>
<td>2-Butene</td>
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<tr>
<td><strong>Average Alkylate Quality</strong></td>
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<td>Octane Number, RON</td>
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<td>Reid Vapor Pressure, PSI</td>
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<td>ASTM D-86 90% Distillation Point, °C</td>
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<td><strong>Utilized Capacity, kl/hr</strong></td>
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<td>Degumming, LP</td>
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<td>Decolorization, LP</td>
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<td>Decolorization, MP</td>
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<td>Depentanizer, LP</td>
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<td>Depentanizer, MP</td>
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<tr>
<td>Deisobutane</td>
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<td>Refrigerator Compressor, HP</td>
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Note: Benefit Calculation is skipped here
Results & Conclusions

• Business Benefits
  – ROI was normally less than 2 months
  – Average energy savings was 2% by improving control performance

• Technical Benefits
  – PlantTriage says
    • What happen in your plant operation
    • What to do next

Questions?