Air Products

Air Separation Units for Gasification: Learning by Doing US and Asia

Gasification Technologies Conference
October 15, 2013
Agenda

- Air Products LASU in Gasification
  - Edwardsport IGCC
  - Lu’an Coal to Liquid
- ASU Experience
- ASU Cycle Selection and Reliability
- Conclusions
Who Is Air Products?

• Global provider of atmospheric, process and specialty gases; performance materials; equipment; and technology
• Supplier of innovative solutions to the energy, environment and emerging markets
• Enabling customers to become more productive, energy-efficient and sustainable
• ~$10 billion in sales
• Number 265 on Fortune 500
• Operations in over 50 countries
• More than 20,000 employees around the world
• Serving semiconductor materials, refinery hydrogen, coal gasification, natural gas liquefaction, and advanced coatings and adhesives markets
How Does Air Products Help Make Gasification Projects A Success ...

- A long history of Innovation
- Geographic diversity for engineering and procurement, worldwide experience in building ASU’s
- Large scale ASU experience worldwide
- Application experience – we’ve supplied oxygen/air separation equipment for all major gasification technologies – we’ve “sweat” the details
- Reliability - first company to supply high-reliability tonnage oxygen for gasification projects without oxygen backup
- Very high pressure oxygen experience - Lead the industry in operating experience supplying tonnage oxygen to ~110 barg (or ~1,600 psig)
- A focused group of individuals to support gasification and its customers through Definition, Optimization, FEED, Execution, Startup and Operations
- We will treat the plants like one of our own
GE/Duke IGCC
Edwardsport, IN - USA

Integration Experience Building World-Class LASU

- Startup: 2011
- Onstream: 2013
- IGCC Facility (65 Barg)
- 5,400 TPD (2 Trains)
- Pumped LOX Cycle
- Air and Nitrogen Integration

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Global IGCC Experience
Proven air and nitrogen integration experience

No Integration
Various Projects
1,350 to 3,500 sTPD

N2 Integration
Tampa Electric (1996)
2,020 sTPD

Air + N2 Integration
Demkolec (1994)
1,960 sTPD
## Global IGCC Experience

Comprehensive Experience in all IGCC Cycle Configurations

<table>
<thead>
<tr>
<th>Plants</th>
<th>MW, Net</th>
<th>Gasifier</th>
<th>Start-Up</th>
<th>Integration</th>
<th>Stand Alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>LGTI</td>
<td>135 (gross)</td>
<td>Old E-Gas</td>
<td>1987</td>
<td>Full Air</td>
<td>●</td>
</tr>
<tr>
<td>Nuon/Demkolec</td>
<td>253</td>
<td>Shell</td>
<td>1994</td>
<td>Partial Air</td>
<td>● ●</td>
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<tr>
<td>Tampa Electric</td>
<td>250</td>
<td>GE</td>
<td>1996</td>
<td>Full N2</td>
<td>● ●</td>
</tr>
<tr>
<td>Duke Edwardsport</td>
<td>630</td>
<td>GE</td>
<td>2012</td>
<td>Full N2</td>
<td>● ●</td>
</tr>
<tr>
<td>KOWEPO</td>
<td>300</td>
<td>Shell</td>
<td>2015</td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>

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Lu’an CTL
Shaanxi, China

Experience Executing a Very Large, Full Scope LASU Project

- Onstream: 2016
- Oxygen to CTL Facility
- 11,000 MTPD \( \text{O}_2 \) facility (4 Trains)
- Customer: Lu’an Coal Mine Group
- AP9 (4 x 3,000 MTPD Nominal Capacity Product)
- Second Largest Single On-Site ASU Order Ever

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## Recent ASU Successes in Gasification (2011- )

<table>
<thead>
<tr>
<th>Projects</th>
<th>Applications</th>
<th>ASU Size (MTPD)</th>
<th>Trains</th>
<th>Business Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bodashidi (BDSD), China</td>
<td>Fertilizer</td>
<td>2,200</td>
<td>1</td>
<td>SOE</td>
</tr>
<tr>
<td>Xinlianxin, China</td>
<td>Fertilizer</td>
<td>2,300</td>
<td>1</td>
<td>SOG</td>
</tr>
<tr>
<td>Wison Chemical 3, China</td>
<td>CTC</td>
<td>1,650</td>
<td>1</td>
<td>SOG</td>
</tr>
<tr>
<td>Shaanxi Future Energy Chemical (Yankuang), China</td>
<td>CTL</td>
<td>3,000</td>
<td>4</td>
<td>SOG</td>
</tr>
<tr>
<td>Korea Western Power Co., Ltd. (KOWEPO), Korea</td>
<td>IGCC</td>
<td>2,200</td>
<td>1</td>
<td>SOE</td>
</tr>
<tr>
<td>Zhengyuan, China</td>
<td>Fertilizer</td>
<td>2,400</td>
<td>1</td>
<td>SOG</td>
</tr>
<tr>
<td>Lu’An Coal Mine Group, China</td>
<td>CTL</td>
<td>2,700</td>
<td>4</td>
<td>SOG</td>
</tr>
<tr>
<td>Lake Charles Clean Energy, LLC. (Leucadia), USA</td>
<td>Methanol</td>
<td>3,400</td>
<td>2</td>
<td>SOE</td>
</tr>
</tbody>
</table>
Experience - Large ASU Projects and Train Scale-up

- Market drives ASU scale-up
- Proven 70% scale-up
- Quoting 5,000+ MTPD today

Startup date

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Large air separation units (ASUs)
Process Cycle Selection Criteria

- Oxygen & Nitrogen profiles
  - Purity
  - Pressure
  - Demand pattern

- Argon co-production required?

- Power evaluation criteria

- Capex sensitivity

- Process integration philosophy

- Site constraints, e.g. logistics, steam availability & quality, water consumption

- Operating constraints, e.g. availability, reliability, time to on stream, ramp rate.
Reliability

- Air Products operates the majority of plants that it designs and builds.

- Thousands of man-years of ASU operating experience includes customers that require 100% availability of products.

  - Average plant availability is greater than 99%
    - Average duration of plant trip is ~16 hr
    - Spare parts handling strategies in place
    - Maintenance shutdown once/3+ yrs
      - Coincide with normal power plant maintenance

  - Instantaneous back-up systems in place today in safety-sensitive and electronic applications
It is about more than just $O_2$...

APPLICATION EXPERIENCE: Supplied large oxygen/air separation equipment to all type of applications and industries:
   Power, Gasification, Refining / Petrochemicals

INTEGRATION EXPERIENCE: Air separation plants in all integration modes—
   Oxygen supply control system
   Load following, start-up shutdown, peak-shaving
   Compression heat recovery
   Standalone, nitrogen integrated, and air/nitrogen integrated (IGCC)

MEGA-TRAIN EXPERIENCE: Operating very large single train air separation plants since 1997 in Rozenburg, The Netherlands (3250 MTPD); also installed a 2x3500 MTPD unit in Qatar; executing three multi-train of 3000 MTPD ASU projects in China

RELIABILITY: First company to supply high-reliability tonnage oxygen for power projects without oxygen backup

FLEXIBILITY IN EXECUTION: Willing to work with EPC partners in scope splits to optimize project execution capabilities

OTHER GAS PRODUCTS: Broad industrial gas industry experience creates synergies with H2, CO, and CO$_2$ markets

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Thank you