CB&I E-Gas Technology

Progress on All Fronts

Gasification Technologies Conference

October 12, 2015

Jayesh Shah, Commercial Development Manager
The National Safety Council honored CB&I with the 2015 *Green Cross for Safety* medal

- The medal is awarded to companies demonstrating a steadfast commitment to improving safety and health in the workplace and beyond

- CB&I is the first engineering, procurement and construction company to receive the *Green Cross for Safety* medal
Wabash River Plant – Commercial Operation 20th Anniversary

E-Gas Technology Growth Under CB&I Ownership

Ongoing E-Gas Gasification Projects Worldwide
The Wabash River Gasification Project is located in West Terre Haute, Indiana and is owned by SG Solutions LLC.

- 262 MW IGCC
- Single train, petcoke
- Operational since 1995
- CB&I provides:
  - Operations
  - Management services
- Permitted, Designed and Built in 4 years
- Largest IGCC in the World in 1995
- Cleanest IGCC Power Plant
- Demonstrated Repowering of Pulverized Coal Plant
E-Gas Innovations at Wabash

- Fuel Flexibility – Bituminous Coal to Petcoke
- Efficiency – 99% Carbon Conversion and Thermal Integration with Combined Cycle
- Environmental – Low Sulfur emissions, Near Zero Particulate Emissions and Zero Liquid Discharge in Gasification Island
- Candle Filter Elements
- Carbonyl Sulfide Removal
- Sulfur Unit Tailgas Recycle
- Low Carbon in Slag
Thank You – Wabash River Plant

WVPA provides wholesale electricity to 28 distribution systems

- Collectively more than 380,000 homes, farms, businesses and industries
- Indiana, Illinois, Michigan, Missouri, Ohio
Wabash River Plant – Commercial Operation 20\textsuperscript{th} Anniversary

E-Gas Technology Growth Under CB&I Ownership

Ongoing E-Gas Gasification Projects Worldwide
E-Gas Technology Continuous Enhancements

- Improved Syngas Cooler availability
- Improved quenching system

- 2nd stage operation
  Flexibility to meet product specification

- Higher reactor pressure minimizes compression

- More reliable temperature control extends refractory life

**Paybacks**

- Availability
- Efficiency
- CapEx and OpEX

**Heat integration across process units**

**Enhanced slag Quality**
**KEY FEATURES**

- Slurry Fed, Oxygen Blown
- Entrained Flow
- Refractory Lined

**E-Gas Technology Differentiators**

- High Reliability, Small footprint, Lower CapEx
- > 99%+ “C” conversion
- Fuel flexible
- Small Liquid Effluent Stream
- High Efficiency, hands-on experience driven design
- Water recycle
- No lock hoppers

**Diagram:**
- Raw Syngas
- Slurry Oxygen
- Slag Quench Water
- Slurry
- Char Recycle
- 2nd Stage
- First Stage
Benefits for refineries enhancing processes to increase output:

- To meet increased hydrogen demand.
- Internal utilization of resid avoiding transportation and local market irregularities.
- Reduces overall oxygen consumption.

Diagram:

- Recycle Syngas Quench
- Water/Steam Quench
- Second Stage Slurry
- First stage Pitch/Steam
- First stage Slurry
- Oxygen
- Steam Production
- Syngas
  - Hydrogen
  - CO
  - Methane
- Char
- First stage Pitch/Steam
E-STR - Targeting high moisture fuels such as lignite

High value markets such as SNG production.

Coupled with a proprietary low temperature tar destruction catalyst

E-STR gasifier will produce pipeline pressure syngas to feed methanation systems.

The E-STR Process Design Package and mechanical equipment design is under way

CB&I is actively seeking and evaluating sites for a 200-400 TPD demonstration of the E-STR Technology.
Wabash River Plant – Commercial Operation 20th Anniversary

E-Gas Technology Growth Under CB&I Ownership

Ongoing E-Gas Gasification Projects Worldwide
<table>
<thead>
<tr>
<th>Project</th>
<th>Owner</th>
<th>Start-Up Year</th>
<th>Feedstock Description</th>
<th>Trains</th>
<th>NM3/hr per train (CO+H2)</th>
<th>MMSCFH per train (CO+H2)</th>
<th>Syngas Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wabash River IGCC</td>
<td>SG Solutions</td>
<td>1995</td>
<td>Bit Coal, Petcoke</td>
<td>1</td>
<td>135,000</td>
<td>5.03</td>
<td>Power</td>
</tr>
<tr>
<td>POSCO SNG</td>
<td>POSCO</td>
<td>2015</td>
<td>Sub-Bit Coal</td>
<td>2+1</td>
<td>144,000</td>
<td>5.37</td>
<td>SNG</td>
</tr>
<tr>
<td>RIL Gasification</td>
<td>Reliance Industries</td>
<td>2016</td>
<td>Petcoke, Petcoke and Sub-Bit coal blend</td>
<td>9+1</td>
<td>272,000</td>
<td>10.15</td>
<td>Power, Hydrogen Fuel, SNG Acetic Acid</td>
</tr>
<tr>
<td>CNOOC Huizhou POX</td>
<td>CNOOC</td>
<td>2017</td>
<td>Bit Coal, Petcoke and blend of both</td>
<td>2+1</td>
<td>120,000</td>
<td>4.48</td>
<td>Hydrogen, Chemical</td>
</tr>
<tr>
<td>Shandong Sincier</td>
<td>Sincier</td>
<td>2017</td>
<td>Coal or Coal and Liquid Pitch</td>
<td>2+1</td>
<td>115,000</td>
<td>4.29</td>
<td>Hydrogen, Power</td>
</tr>
</tbody>
</table>
POSCO SNG Project at Gwangyang

- Location: Gwangyang, Korea
  - Site Size: 100 Acre
- Capacity: 500 KTA of SNG
  - 5,500 TPD Sub-bituminous Coal
  - CB&I E-Gas Gasifiers 2 + 1
  - Linde Rectisol for Acid Gas and CO₂ Separation
  - HaldoTopsoe Methanation
  - Jacobs FEED Contractor
  - POSCO E&C EPC Contractor
  - Daewoo Eng. Detail Eng. Contractor
- Start-up: 4th Qtr 2015

Courtesy of POSCO
<table>
<thead>
<tr>
<th>Reliance Industries Jamnagar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syngas for Power Generation, Fuel, Chemicals and Hydrogen</td>
</tr>
<tr>
<td>Petcoke or Petcoke and Sub-bituminous coal Blend</td>
</tr>
<tr>
<td>2,720,000 NM3/hr H₂ + CO + CH₄</td>
</tr>
<tr>
<td>Training completed, Commissioning Team in Preparation</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Qtr 2016 Start-Up</td>
</tr>
</tbody>
</table>
DTA Dome & Associated Conveyors Conveyors

- **DOME**
- **Dome entry for storage conveyor**
- **Storage conveyor**
- **Transfer Tower -1**
- **Reclaim Conveyor**
- **Bypass conveyor**
- **Truck Unloading conveyor**
RIL DTA GASIFIER Module

A World of Solutions
RIL DTA Gasification Unit
Project Updates

- Wabash River IGCC
- Reliance Jamnagar Polygen
- CNOOC Huizhou Hydrogen
- POSCO Gwanyang SNG
- Sincier Shandong Hydrogen
CNOOC is constructing a new refinery line (Phase II) with the capacity of 10 million Mt/y crude oil (220,000 BBL/D), including CBI POX Unit.

2 + 1 gasification configuration (3 x 50% trains)

<table>
<thead>
<tr>
<th>Feed</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>4,075 mtpd (total feed)</td>
</tr>
<tr>
<td>Coke</td>
<td>2,825 mtpd (total feed)</td>
</tr>
<tr>
<td>Blend</td>
<td>3,021 mtpd (total feed)</td>
</tr>
</tbody>
</table>

Total Syngas: 240,000 Nm3/hr
- Syngas to H2: 225,000 Nm3/hr
- Extraction gas to Oxo Chemical: 15,000 Nm3/hr

Steam Production: 190 MT/hr @ 1750 psi
Sinopec Engineering Inc. (SEI) is the EPC contractor
Completed Basic Engineering & cost estimate - end July 2014

CNOOC internal review & approval completed
Issued PO for all major equipment by Dec 2014

Civil Works (including piling) begun in March 2015
Mechanical Completion – end 2016
Gasification start-up – early 2017
Overview

- Main products: Gasoline, Diesel, LPG, Gas Oil, Reside Oil, Petroleum Coke, Propylene, Propane and MTBE

Lummus’ Licenses with Sincier:

- CDAlky (LPG alkylation for high octane gasoline)
- CDHDS (Gasoline hydrodesulfurization)
- CDEthers/ISOMPLUS (Light gasoline etherification and normal olefins isomerization)
- CATOFIN (C3/C4 paraffin dehydrogenation)
- VRDS (Vacuum Resid Desulfurization)
- LC-MAX (Ebullated bed resid hydrocracking)
- ISOCRACKING (Gas oil hydrocracking)
- Solvent deasphalting
- E-Gas
Shandong Sincier Petrochemical Co. LTD

Hydrogen for Refinery Expansion

E-GasPlus™ Configuration

One of nine CB&I licenses to Sincier

Start-Up 2017

230,000 NM3/hr H2 + CO

2+1 Configuration

Awarded September 2014

A World of Solutions
Wuhuan Engineering Company (WEC) is the EPC contractor
Completed Basic Engineering
Detailed Engineering continuing

Civil Works (including piling) begun in Mid 2015
Mechanical Completion – 2016

Gasification start-up – 2017
CB&I: More Complete Supply Chain Solution

- Add value throughout the project lifecycle
- Operational consistency through standardization

Vertically Integrated

- Technology
- FEED
- Permitting
- Engineering
- Procurement
- Fabrication
- Construction

Project Lifecycle

Traditional EPC solutions

Specialized project lifecycle offerings

Operations & Maintenance

Close-out
E-Gas Gasification Technology is the right choice. CB&I provides the support throughout project lifecycle.
Contact us:

<table>
<thead>
<tr>
<th>CB&amp;I - Refining &amp; Gasification</th>
<th>China, North America, Russia</th>
<th>CB&amp;I – India</th>
</tr>
</thead>
<tbody>
<tr>
<td>One CB&amp;I Plaza</td>
<td>- James Knox, <a href="mailto:JAKnox@cbi.com">JAKnox@cbi.com</a></td>
<td>Gurgaon Infinity Tower</td>
</tr>
<tr>
<td>2103 Research Forest Dr.</td>
<td>Korea, SE Asia, South America</td>
<td>Gurgaon, India</td>
</tr>
<tr>
<td>The Woodlands, Texas 77380</td>
<td>- John Rubel, <a href="mailto:John.Rubel@cbi.com">John.Rubel@cbi.com</a></td>
<td>- Anil Sarin, <a href="mailto:ASarin@cbi.com">ASarin@cbi.com</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CB&amp;I - Europe</th>
<th>CB&amp;I – China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oostduinlaan 75</td>
<td>Level 3, Building 4, Universal Plaza</td>
</tr>
<tr>
<td>2596JJ The Hague, Netherlands</td>
<td>10 Jiuxianquiao Lu, Chaoyang District</td>
</tr>
<tr>
<td>- Maurice Korpelshoek, <a href="mailto:MKorpelshoek@cbi.com">MKorpelshoek@cbi.com</a></td>
<td>Beijing 10016</td>
</tr>
<tr>
<td></td>
<td>- YingSu Zhang, <a href="mailto:YSZhang@cbi.com">YSZhang@cbi.com</a></td>
</tr>
</tbody>
</table>

For more information on the E-Gas technology, contact us at the following addresses, write us at E-GasTechnologyInfoRequests@CBI.com or visit www.cbi.com/technologies/gasification-technology