Technical Considerations for a Very Large Scale Air Separation Unit for a Coal Fired Power Plant Application

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IEAGHG International Oxy-Combustion Network
3rd Workshop
Yokohama, Japan
5 - 6 March 2008
Agenda

- Introduction to Air Products
- Very Large Air Separation Units
- Air Products’ track record
- Air Products as a solution company
  - Air Separation Unit Integration to the Oxycoal process
Who Is Air Products?

- Global atmospheric, process and specialty gases, performance materials, equipment and services provider
- Serving industrial, energy, technology and healthcare markets worldwide
- Fortune 500 company
- Operations in over 40 countries
- ~22,000 employees worldwide
- Known for our innovative culture and operational excellence
- Corporate responsibility commitment
Innovation-Driven

- FY’07 R&D spending: $140 million
- Focus on creating value in high growth / emerging markets
- Applications focus is at the heart of our brand
- Alliances / technology partnerships with universities, labs, consortia, other companies
- Investments in venture capital funds to gain technology access
- Open Innovation approach
Sale of Equipment Overview

- Global presence - All Industries
- Extensive reference list – designed and built over 1,200 plants
- ASU operating know-how translated to a cost effective equipment solution
- Cryogenic plant offerings ranges from 50 to +5000 metric ton per day
- Value Added Options:
  - Increased engineering content
  - Construction advisory services
  - Commissioning services
  - Turnkey construction
  - Start-up and Operator Training services
  - Spare Parts support services
  - Operate and Maintain contracts
“On-Site” – Sale of Gas Overview

- Air Products designs and builds a plant adjacent to the customer or pipeline
  - Reduces schedule & capital cost risk
  - Allows integration of steam & power

- Plant investment by Air Products
  - Customer typically supplies land and utilities

- Operation and maintenance by Air Products
  - Safety
  - Proven supply reliability
  - Delivery, efficiency and availability guarantees
  - Potential co-product and scale benefits
  - Merchant oxygen, nitrogen, argon
  - Shared plant or pipeline systems

- Customer buys gas from the facility under a long-term agreement
  - Enables customer to focus resources and capital on core activities
ASU Engineering and Manufacturing Locations

Wilkes Barre, PA, USA
Manufacturing

100 km from N.Y.C.

Allentown, PA, USA
Engineering
Global HQ

Hersham, UK
Engineering
European HQ

Acrefair, UK
Manufacturing

Caojing, PRC
Manufacturing

Shanghai, PRC
Engineering
China HQ

100 km from N.Y.C.
Overview Of The Process

Main and Boost Air Compression
Air Cooling and Pretreatment
Cryogenic Separation
Storage

1. Air
2. Heat
3. Oxygen
4. Heat
5. Heat
It is about more than just O2...

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

- **INTEGRATION EXPERIENCE:** Air separation plants in all integration modes—
  - Oxygen supply control system (Load following, start-up shutdown, peak-shaving)
  - MAC 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

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

- **OTHER GAS PRODUCTS:** Broad industrial gas industry experience creates synergies with H2, CO, and CO2 markets
Long-term commitment to Power since the 80’s starting with the IGCC market

Focused on safe, highly reliable, and economic ASUs

Baytown: LASU + Back-end
  - Designed, built, own and operate syngas cleanup and separation facility (“back-end”) of heavy oil gasifier in TX

The result is a broad range of experiences for Power with Cogen (including coal), Gasification, and Syngas

88 MW
Ebensburg (Cambria), PA USA

120 MW,
Orlando, FL USA

55 MW,
Stockton, CA USA

Syngas, CO, H2
Baytown, TX USA
Very Large Air Separation Units
Very Large Air Separation Units

- Air Products’ long track record providing the train size required by the project
  - Market drives ASU scale-up

- Site requirements >5000 metric ton/day in single or multitrain configurations

- Challenging cycle design, engineering, installation, and manufacturing issues

- Best train solution based on customer’s specific requirements
Number of trains based on customer’s specific requirements:

- Power vs. Capital costs
- Transport of ASU(s) to site
- Reducing construction / erection costs and risks
- Operability
- Compression integration at large scale
- Fit with customer’s use patterns
  - Turndown / ramping up
- Reliability, including spare parts handling
- Schedule
Power Costs and Design

Power is the largest component of the fully evaluated ASU cost (NPV).

- Equipment
- Manufacturing
- Construction
- Engineering
- Operations

Power consumption:
- $0.05 / kWh
- $0.09 / kWh

Technology and capital improve ASU power consumption.
Power Consumption Reduction Opportunities

2012 Vision = 150-170 kWh/metric ton (*)

(*) 1 BAR – Gaseous Oxygen only - Depending of the relative valuation of capital and power costs
Experience - Large ASU Projects and Train Scale-up

- Market drives ASU scale-up
- Proven 70% scale-up
- Quoting 5000+ metric ton/d today
A5000 (1 train view)
A5000 Single Train
A5000 (2 x 2500 trains)
A5000 (2x compression + 1 cold box view)
6xA5000 = Approx. 30,000 t/d O2
Compression: Design Considerations

Oryx- Qatar – 2x3500 TPD

- MAC—Steam Turbine—BAC
- Air Cooled Condenser
- Shop Skids
- String Test

A5000 and A7000 t/d – Single Train Compression

- Axial main air compressor (no GT integration)
- In-line boost air and nitrogen compressors
- Four large suppliers = GE, MHI, Siemens, MAN

A5000:
- GE Frame 7
- Siemens STC 1000
- MAN AR130-AR140
- MHI M501D

A7000:
- GE Frame 7 - Frame 9
- Siemens STC 1300
- MHI M501F

A5000 and A7000 t/d – (2x Compression – Multitrain)

- Integral gear (GT Copco or STC) or In-line air compressors (RIK)
- Integral gear or In-line boost air and nitrogen compressors (if N2 needed)
How Will Air Products Help Make Oxycoal Project A Success ...

- Extensive worldwide experience building and integrating Large Scale ASU
  - Geographic diversity for R&D, Engineering, Procurement, and Manufacturing
  - A focused group of individuals to support local and project specific activities such as FEED, Build, Start-up, Operation, and Optimization

- Clear understanding of the VLASU-Oxycoal integration challenges through an active participation in the following studies:
  - IEA GHG Study on New Build Supercritical PF Coal plants – 2005
  - DTI Study on retrofitting UK Coal power plants for CO2 Capture -2006
  - DTI Study on Coal Power plants with CO2 capture for the Canadian market
  - Extensive integration experience with ASUs in other Power related projects

- Air Products is looking ahead of Cryogenic technology by developing and now in advance testing Oxygen Ion Transport Membranes (ITM)
  - Step-change savings compared to state-of-the-art cryogenic technology
    - 25-35% less capital
    - 35-60% less power
  - >65 Patents
Large air separation units (ASUs)
Thank you
tell me more
www.airproducts.com