Agenda

- Proven Large-Scale Oxygen Supply: Cryogenic Air Separation Units
  - Industry experience with very large ASU
  - Overview of the process
- ASU Challenges specific to IGCC
- ASU Reliability and Operability
- Conclusions
How Will Air Products Help Make IGCC 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 and specifically the IGCC application – 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 up to 1,500 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
Experience - Large ASU Projects and Train Scale-up

- Market drives ASU scale-up
- Proven 70% scale-up
- Quoting 5,000+ MTPD today
Large air separation units (ASUs)
Power Costs and Design

Power is the single most important component of the ASU cost.

- Equipment
- Manufacturing
- Construction
- Engineering
- Operations

$0.05 / kWhr
$0.09 / kWhr

Technology and capital improve ASU Power consumption.
Process Cycle Selection Criteria

- Oxygen profile
  - Purity
  - Pressure
  - Demand pattern
- Argon co-production required?
- Power evaluation criteria
- Capex sensitivity
- Process integration philosophy
- Site constraints, e.g. logistics, utility availability & quality, water consumption
- Operating constraints, e.g. availability, reliability, time to on stream, ramp rate.
IGCC Integration 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

![Diagram of IGCC integration systems]
LASU Design challenges to IGCC power plants

Design based on customer’s specific requirements:

- Parasitic load
  - Power vs. Capital costs
  - Purity requirements
  - Co-products
  - Compression integration
  - Utility Integration

- Operability
  - Fit with customer’s use patterns
    - Turndown / ramping up
  - Advanced control capabilities
LASU Execution challenges to IGCC power plants

- Manufacturing
  - Transport of ASU(s) to site
  - Reducing construction / erection costs and risks
- Start-up
  - Shared Utilities
  - Back-up systems
  - Compression integration
- Reliability
Process Integration
Goals and Methods

- Reduce cost/improve efficiency without compromising operability

  - “Easy” integrations
    - Use of by-product energy (Steam)
    - Combined utility systems (Cooling Water)
    - Air/nitrogen integration with gas turbines

  - “Harder” integrations
    - Internal streams between process units
    - Start-up requires other units to be in operation
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
Operability: Plant Ramping & Advanced Controls

- Benefits of Advanced Control capabilities
  - Lower power consumption
  - Higher product recoveries
  - Faster disturbance response and mitigation
  - Faster response to changing product demands
  - Higher multi-plant efficiency

- ASU ramping capabilities
  - 1%/min typical
  - 2%/min achievable with advanced control
  - 3%/min possible when “designed in”
  - Higher rates possible by using liquid oxygen backup
Summary

- There is a major new industry requirement for ASUs for fossil-fuel fired power generation
- ASUs have changed a great deal in the past 15 years
  - New cycles
  - Structured packing for distillation
  - More power efficient
- Single train sizes over 5000 ton/day
- Integration opportunities
- Manufacture/erection approach is project specific
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

- **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 CO$_2$ markets
Thank you
tell me more

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