Air Products POx Technology for Low Carbon Hydrogen Production

Presentation by
Sean Yan, Ph.D.
Product Manager

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Agenda

Introduction
Who is Air Products

Air Products’ POx Technology Features
Global Experience
Process Overview & Features

Concluding Remarks
Air Products is a leading global industrial gas company, built on deep experience, strong performance and high ambitions.
Creating Long-term Value
Through sustainability

Our products enable customers to avoid

72 M MT CO$_2$e

equivalent to emissions from 15 M cars, and 3 times our direct and indirect CO$_2$ emissions

Our products improve the environment, make our customers' processes better and fulfill societal needs

We are focused on improving our operations to manage environmental, social and governance risks

Gasification  Carbon Capture  Hydrogen

“Third by ’30” Carbon Intensity Goal

2015  92  (kg CO$_2$e/MM BTU)

2030 Goal  61  (kg CO$_2$e/MM BTU)

2020 reduction of 5%

Significant improvement later in decade as key projects come onstream
Air Products has the technology and capabilities to drive sustainable growth

- Hydrogen Global Leadership
- Large Projects capabilities
- World scale green H2
- Hydrogen for mobility
- CCUS expertise
- Strong Balance sheet

Supported by Air Products Technology

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Air Products: world hydrogen leader

The world’s largest hydrogen producer with proven reliability

1100+ kilometers of pipeline
> 32 billion Nm3/year

H₂ The world’s longest H₂ pipeline system and world-class liquid hydrogen supplier

15+ years safe fueling

250+ Hydrogen fueling projects worldwide

20+ Unique product offering for H₂ fueling

1,500,000 fueling per year

~50 patents for hydrogen fueling

20+ countries

30+ H₂ Electrolyzer projects

10 million Total fueling

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Air Products develops, owns & operates hydrogen and syngas projects using a portfolio of technologies

- The choice of technology is optimized for the project requirements

**Level of Blue H2**

- **H2 as decarbonized Fuel**
- **H2fM**
- **H2 for Fuel Upgrade**
- **H2 for Industry**
- **Liquid H2**
- **Blue NH3**
- **Blue Methanol**
- + other Blue Processes

**Application**

- NG / Oil Fed POx, NO CCS
- Solids gasification, NO CCS
- SMR, NO CCS
- NG Fed SMR + CCS (Syngas only)

**Blue POx, Gas/Liquid/Mixed Feed**

- Blue Gasification, Solids Fed
- Blue ATR, Gas Fed
- Blue SMR, Gas Fed

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Air Products’ POx technology has a long operating history

- Partial oxidation is a non-catalytic process that produces a CO-rich syngas
- Among the common syngas production processes, POx is uniquely suited for monetizing heavy feedstocks
- Decades of experience
  - 1946, Texaco started POx research
  - 1953, first commercial plant - natural gas POx to Ammonia
  - 1961, first licensed Oil POx unit in Japan
- Today’s applications for gas-fed POx are focused on carbon monoxide and syngas for chemicals:
  - Methanol, Oxo-chemicals, Acetic Acid, Isocyanates, Phosgene, Formic Acid, etc.
Air Products’ POx Technology – Reliable & Proven Worldwide

Technology with 60+ years expertise globally

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Air Products LaPorte POx Facility
Commercial syngas operation since 1996
## Air Products’ POx Flexibility – Feeds Variety

### Gas Fuel Feeds
- Natural gas (NG)
- LPG/ Refinery off-gases (ROG)
- Pyrolysis gases

### Biogenic Feed
- Renewable Gas
- Renewable diesel byproducts
- Pyrolysis oils

### Mixed Feeds
- NG, hydrocarbon liquid, and/or moderators
- NG, wastewater, heavier hydrocarbon and/or byproduct waste
- ROG, hydrocarbon residues

### Moderators
- Carbon dioxide (w/ feed gas)
- Steam (w/ feed gas or O2)
- Water (separate from steam)
Air Products POx Based Blue H2 Solution – the next generation

Owner’s Take:

- Non-catalytic process in Refractory lined vessel
- No or minimal feed pretreatment
- Zero direct CO2 emission from Process when needed
- High pressure POx → HP H2 product delivery
- Flexible in steam generation

Voice of Customer:

- **High availability & reliability** (99+%)
- **No Catalyst** for Syngas generation
- **High Syngas Pressure**, feasible & proven
- **Low CH4 slip** (0.5% or lower)
- **Near zero low S/C ratio**
Air Products’ POx Flexibility – Heat Recovery
Air Products’ POx Flexibility – Heat Recovery
Benefits of Air Products’ POx Blue Hydrogen Plant

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<th>Plant Capex</th>
<th>Plant OPEX</th>
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| - Up to 87bar operating pressure  
  • No or smaller H2 compressor  
  • Smaller syngas generator  
  • Smaller shift & CCS plant  
- Less equipment → smaller footprint  
  • Fired Furnace/Heater not required  
- High single train capacity  
- Less total installed cost with high CO2 capture in equation | - No regular proprietary catalyst replacement in Syngas generator & Pre-reformer  
- Reduced compression duties  
  • NG vs. H2 compression  
- Flexibility in steam generation  
- Flexibility in sulfur handling  
- Increased revenue from CO2 product stream  
- Simple maintenance & fast turnaround |
Key Take-aways

- Partial Oxidation is a proven commercial process with a wide range of feedstock flexibility allowing optimization of feedstock for lowest carbon intensity.

- Air Products’ proprietary POx Process for syngas generation and its integration capability offers next Gen Blue H2 Plant with
  - Ultra high CO2 capture, up to 99+%
  - Flexibility to handle various gaseous and liquid feeds
  - Utmost heat recovery flexibility for specific project

- Low carbon feedstock in combination with high capture rates offers the ability to target very low carbon intensity hydrogen.
Thank you
tell me more