Air Products Gasification Technologies Update



GASIFICATION INDIA 2020

Jeff Kloosterman December 15, 2020

Building a Better World with Innovative and Sustainable Solutions



Air Products is the Most Experienced International Gasification Company



Two industry leading technologies



Slurry Feed Gasification (from GE)

- Coal = Slurry feed
- Nearly 300 gasifiers operating and under construction
- Adaptable to wide range of feedstocks

and the second second

• 2 Configurations



Dry Feed Gasification (from Shell)

- Coal = Dry Feed
- Built 200+ gasifiers since 1950s
- Rich Operational experiences from the youngest (Lignite coal) to oldest (Petcoke or Anthracite coal)
- 2 Configurations



Air Products Dry Feed Gasification Technology



Mature core of the technology: Membrane wall with multiple burners



FEATURES AND BENEFITS

- ✓ Long residence time, high carbon conversion and low oxygen/coal consumption
- High capacity of single gasifier, easy scale up by multiple burners
- Less erosion to coal burner, long lifetime of burner
- ✓ Better slag coverage, less Energy loss and long lifetime of membrane wall



APSS dry-feed Gasification Technology Portfolio One Proven Technology: Two Demonstrated Options



- Industrially proven, mature technology
- Carbon efficiency >99%
- Highest energy efficiency, lowest consumption
- High-level steam as a very useful 'byproduct'
- Environmental: reduced water consumption, less waste water

BOTTOM WATER QUENCH



- Same basic design as syngas cooler line-up
- Carbon efficiency >99%
- Simplified line up, reduced Capex
- Even wider coal flexibility
- Easier operation and maintenance , high reliability



Outstanding Reliability

Syngas Cooler and Bottom Quench Gasifier reliability continues to improve





Broad operating experience on many different kinds of coal

FEED FLEXIBILITY Handled over 200 different kinds of coal covering the whole reactivity spectrum from lignite to anthracite, ash contents from 6-37%

 Four projects successfully used petcoke blended with coal, with excellent operational results







DEEP INSIGHT IN PROCESS

Based on extensive operating experience, several modelling tools were developed to confidently assess novel coals and optimise coal blends



Air Products' technology presence in India Utilizing domestic coals for a range of products

New project: Talcher fertilizers limited high-ash coal gasification



- EPC contract awarded in September 2019
- Final products are 2200 tpd ammonia, and 3850 tpd urea.
- Air Products dry-feed coal gasification selected, for gasifying a blend of high-ash coal (ranging from 40% to 47% ash) and petcoke (25% maximum in the blend).

Coal from Raniganj Coalfields

New project: Dankuni Coal

- Ash content less than 24%
- 25 years BOO contract
- Currently project is in Bidding phase
- AP to offer dry-feed technology



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Air Products Slurry Feed Gasification Technology



AP slurry gasification process key features

Key Features

- Simple process
- Multiple feeds feedstock flexible
- Configuration Flexible pressure and gasifier size
- Heat recovery flexibility Quench & RSC
- Wastes utilization waste water and solids
- Reliable high reliability and availability



Cost effective solution for hydrogen, chemicals & power

AP slurry Gasification-two demonstrated options

Quench

Radiant Syngas Cooler Partial Quench



- Hot syngas immediately quenched by direct water contact
- Syngas is warm and saturated with water... ideal for sour CO shift

Commercial application 12 to 86 bar

- Proven gasifier sizes up to nominal 1800ft³
 - Typical applications: chemicals, hydrogen, refinery polygen Low capital cost
- Short construction



- Hot syngas first cooled by radiant cooling before quenching
- Generates high pressure steam to ~135 bar
- Proven up to nominal 1800ft³
- Typical applications: Chemical, H2, power generation, PolyGen
- Better efficiency/Emission
- Long life-cycle, free of maintenance design



Flexible Solution in pressure and gasifier size



Syngas capacity, NCMH, single train

pressure Gasifier size	4.0 Mpag	6.5MPag	8.7Mpag
450 cuft	35000	50000	70000
900 cuft	70000	100000	140000
1800 cuft	140000	200000	-

AP Slurry process feature – highest operating pressure

- 900cuft @8.7MPa configuration

Key benefits of high - pressure gasification:

- Bigger capacity single train
 - Coal consumption ~2,400 MTPD
 - Pure O2 consumption:~ 6,3000 Nm3/h
 - H2 + CO production:~150,000 Nm³/hr
- Higher energy efficiency and methanol production cost

For a large-scale coal to methanol plant, high pressure gasification can achieve isobaric pressure methanol synthesis without fresh syngas compressor and reduce refrigeration energy in AGR.



Reliability and Availability

- High Reliability

Based on plant data, average single-train unplanned shutdowns are less than 1.55%, as indicated by the pie chart below.

- Unplanned Outages



- High Availability

With higher reliability given longer lifetimes for critical equipment/parts and a proper O&M plan, single train availability can be ~90%, and overall average availability of 20p+1sp configuration can be 96+%.

With decades of operational experience, AP's slurry gasification process has been continuously improved and optimized to provide the highest reliability and availability, with a well-proven operation record from commercialized plants.

	Sinopec Qilu Gasification plant operation record -20p+1sp quench configuration						
		continuous	single train	Two train			
	year	operation days	reliability	availability			
	Y2012	366	100%	99.3%			
	-2015.4	538	100%	99.4%			
•••••	-2018.5	777	100%	99.6%			



Gasification Process Integration

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Summary

- Air Products is the leading gasification international company after acquisition GE and Shell gasification technologies
- The dry feed technology gasifier sizes range from 2000 to >3000 ton/day for deployment in larger large projects
- The reliability continues improved with world leading reliability demonstrated at some facilities
- The slurry gasification technology has 2 RSC gasification plants, and a 3200ton/day large quench CTC project will on stream soon
- Air Products has the capability of coal to chemicals plant whole system integration to deliver the most efficient plant

Thank you tell me more





Rich operational experience with petcoke blending



Gasified 100% petcoke in demonstration plant in Houston US

Characteristic	Unit	Petcoke	Sub-bituminous coa		
Moisture	wt%	6.23	19.0		
Total sulphur	wt%	6.94	0.22		
Heat content (HHV)	MJ/kg	35	21.5		
Proximate analysis received					
Ash	wt%	0.34	7.6		
Volatile material	wt%	12.88	46.8		
Fixed carbon	wt%	86.78	45.6		
Ultimate analysis (dry)					
С	wt%	89.45	65.6		
н	wt%	2.8	4.53		
N	wt%	0.05	0.83		
CI	wt%	0.01	0.1		
 s	wt%	7.48	0.18		
 Ash	wt%	0.2	7.61		
0,	wt%	0.01	21.15		
-					



Petcoke blending gives good operational performance and reliability: YZH operated continuously for 291 days and Tianfu for 186 days. Annual longest accumulated running days: 341.

