Evolution of Black Liquor Gasifier Designs

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May 14, 2003

Shamelessly based on Kevin Whitty’s “State of the Art in Black Liquor Gasification Technology” presentation for the IEA Annex XV Meeting 20-21 August 2002 Piteå, Sweden
Outline

• Introduction
• History of BLG development
• Current BLG technologies
• Future of BLG
• Conclusions
Introduction – Future Industry Needs

• Eliminate Smelt-water Explosions
• Lower Capital Cost
• Lower Energy Use
• Lower Emissions
• Less Downtime
• Less Deadload
• Less Raw Material
Black Liquor Gasification

• Promising Advantages
  – More electricity per lb steam co-generated
  – New chemical recovery options
  – Higher availability

• Development & demonstration issues
  – Competitive system cost
  – Materials lifetime
  – Overall mill impact
Prehistory…
The First Black Liquor Gasifier?
(From a patent application by G.A. Richter, 1927)

Use of gas?
Gas Scrubber
Reducing smelter
Char residue removal
First Chemicals Production from BL Syngas?
(From a patent by E.G Goodell, 1945)
First Application of Split Sulfidity?
(From a patent by W.L. Savell, 1951)
"Recent" BLG Development Efforts
(Underline = built pilot or demo facility, Bold = currently active)

• Low temperature
  – St. Regis*  
  – Weyerhaeuser  
  – Owens-Illinois  
  – ABB*  
  – KBR*  
  – Copeland

• High temperature
  – NSP*  
  – U. California*  
  – Paprican  
  – Tampella*  
  – B&W  
  – SCA-Billerud*  
  – Texaco*  
  – VTT  
  – B&W*  
  – MTCI*  
  – DARS  
  – Champion/Rockwell*  
  – SKF  
  – Ahlstrom  
  – Noell  
  – Chemrec*
Gasifier Design Categories

- High-pressure, hydro-thermal reactors
- Deconstructed/reengineered Tomlinson
- Molten salt reactors
- Bubbling beds
- Circulating fluidized beds
- Entrained flow reactors
St. Regis Hydropyrolysis Process
(~1967-1980)
Texaco Black Liquor Coking Process
(~1967-1974)
U. California PGC Process
(~1967-1980)

Black liquor

Primary pyrolyzer

Air

Char bed

Water

Smelt tank

Secondary pyrolyzer

Scruber

Boiler

Air

Flue gas
NSP Cyclone Gasifier
(~1973-1985)
Champion/Rockwell Pilot Gasifier
(~1982-1988)

- Black liquor
- Product gas outlet
- Fuse cast alumina bricks
- Castable refractory
- Insulation
- Upper air nozzles (x6)
- Lower air nozzles (x2)
- Smelt withdrawal port
- Air nozzle and liquor drain port
- Air nozzle and oil gun port
B&W Bubbling-Bed Gasifier
(~1993-1998)
State of the Art: Bubbling Bed Design

Manufacturing Technology and Conversion International (MTCI)

Steam Reforming Process
State of the Art — MTCI

- Fluidized bed (bubbling)
- Low temperature (~600°C)
- Low pressure
- Steam for reaction / fluidizing
- Medium heating value fuel gas
  - 73% \( H_2 \)
  - Approx. 13.3 MJ/Nm\(^3\)
- Essentially all sulfur to gas as \( H_2S \)
ABB CFB BLG PDU
(~1989-1997)

Cyclones
Gas cooler
Scrubber
Blower Air preheater
Black liquor
Weak wash

Circulating fluidized bed gasifier
Bed solids
Mix tank
Green liquor

Fuel gas
State of the Art: Circulating Fluidized Bed

Kellogg, Brown and Root (KBR)

Transport and Spouting Bed Gasifiers
State of the Art — KBR

- Two fluidized bed reactor concepts
  - Transport reactor
  - Spouting bed
- Enriched air-blown
- Pressurized (>20 bar)
- "Medium temperature" (800–1000°C)
- Titanate addition
  - Allow operation at higher temperature
  - Effect direct causticization
- Medium heating value fuel gas (7–12 MJ/Nm³)
- Novel sulfur removal and recovery processes
KBR Transport Reactor

- Pressurized Syngas
- Cyclone
- Dipleg
- Riser
- Disengager
- Standpipe
- J-leg
- Black Liquor, Enriched Air, and Steam
- Solids to Chemical Recovery

Source: KBR
KBR Conceptual Gasification Process

Pressurized gasifier

Black liquor, enriched air

Bed solids

Raw fuel gas

4Na₂O·5TiO₂

Sulfur-free fuel gas

WHB

Venturi

SO₂ in N₂

GT

HRSG

Flue gas

Air

HTDS/TC

Sulfur-lean white liquor

DSRP

Liquid sulfur

Auxiliary fuel gas

Polysulfide cooking liquor

H₂O

Hydrolysis reactor

Titanate separator

Sulfur-free fuel gas

Na₂O·3TiO₂ and Na₂O·6TiO₂
KBR Development Status

• Conceptual studies completed
• Initial pilot studies completed
  – 0.15 tds/day transport reactor test unit
  – Proof of concept successful
• Next stage of pilot testing planned
  – 2.4 tds/day transport reactor unit at UNDEERC
  – Verification of scale-up issues
• Titanate studies
  – Integrity and reactivity of low-attrition titanate
  – Leaching of Na from bed solids at high pressure
• Demonstration targeted for 2005-2008
SCA-Billerud Process
(~1958-1980)
Tampella Entrained-Flow Gasifier
(~1988-1993)
State of the Art: Entrained Flow Reactor

Chemrec

Entrained Flow Gasifier
State of the Art — Chemrec

• Entrained flow gasifier
• High temperature (~975°C)
• Two applications:
  – “Booster” system for capacity increase
  – “BLGCC” system to replace recovery boiler

More details in following presentation
Chemrec Gasifier Designs

Refractory design

Cooling screen design
The Future of BLG

• Continued interest in BLG is apparent
  – Pulp & paper industry
  – Utility suppliers
  – Oxygen suppliers
  
    Multi-party funding with government partners needed to overcome risk of first units

• Demonstration that “roadblocks” have been addressed
  – New Bern (refractory issues)
  – Big Island (carbon conversion)

    Success will accelerate development
The Future of BLG

• Demonstration of BLGCC / Tomlinson replacement capability
  – Performance / availability / economics
  – “First to market”

  ➢ Identification of favored technology

• Emergence of other BLG suppliers
  – BLG becomes more economically attractive
  – Improvements in BLG performance

  ➢ Competitive with Tomlinson in 15 years?
Conclusions

• Over 20 efforts to develop/commercialize BLG
  – 50/50 low/high temp
  – Mix of groups

• Currently 2 visibly active development efforts
  – MTCI
  – Chemrec

• Currently on brink of commercialization
  – MTCI involved in several commercial projects
  – Chemrec offering booster commercially
  – Chemrec progressing with BLGCC commercialization