Biomass to motor fuels over the black liquor route.

Status and requirements for demonstration

Patrik Löwnertz

2009-01-22
Pulp mill integrated process with biomass feedstock swap

- Existing plant-internal liquid biomass stream (black liquor) is used as motor fuels plant gasification feedstock
- Steam generation from biomass is used to make up energy content of produced biofuel
Black liquor is liquid biomass with properties uniquely suitable for gasification

• It is a liquid
  – Easy to feed to a pressurized gasifier
  – Can be atomized to fine droplets for rapid gasification rates

• It is highly reactive due to high Na/K content

Г Gasification in an entrained flow high-temperature mode can then give
  – Full carbon conversion
  – No tar formation
  – Low methane formation
  – Small reactor volume (~25 m³/1000 t BLS/d)
  – Simple gas clean-up
Feedstock swap gives full biomass feedstock flexibility

• Any biomass that can be beneficially burned in conventional high-performance steam generating boilers can be used
  – Forest logging residues (bark, tops, branches)
  – Saw mill, board mill and other wood waste
  – Agricultural residues (straw, corn stover, bagasse etc)
  – Mixed solid waste
## Typical value chain

<table>
<thead>
<tr>
<th>Activity</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestry</td>
<td>Well-established, low non-renewable resource use</td>
</tr>
<tr>
<td>Biomass extraction</td>
<td>By-product from extraction of saw logs and pulp wood</td>
</tr>
<tr>
<td>Feed stock preparation</td>
<td>Pulping to produce black liquor. Shredding /chipping of biomass for stream generation in conventional HP boiler</td>
</tr>
<tr>
<td>Raw gas post-treatment</td>
<td>Only condensing cooling/steam generation, ~5 ppm tar, low methane content</td>
</tr>
<tr>
<td>AGR and sulphur handling</td>
<td>Well-established technologies</td>
</tr>
<tr>
<td>Synthesis and product distillation</td>
<td>Well-established technologies (MeOH and DME)</td>
</tr>
<tr>
<td>Product</td>
<td>High flexibility - MeOH and DME preferred due to high conversion and vehicle efficiency, very good environmental performance, moderate investment cost.</td>
</tr>
</tbody>
</table>
Critical technologies

• Emphasis on using established technologies wherever possible:
  – ASU, AGR, sulphur recovery, synthesis and product distillation

• Scale-up of oxygen-blown, pressurized gasifier key challenge, in particular
  – Burner nozzle (atomizing efficiency, flame shape, flow patterns)
  – Quench (flow patterns, mechanical design)
  – Gas cooler steam generator (mechanical design)

• Special challenge from pulp mill integrated design:
  – Even higher demand for availability
The motor fuels plant – MeOH/DME case

Well-proven technology

Critical technology
The Gasifier - Core technology risk areas

- Black Liquor
- Oxygen
- Green Liquor
- Weak Wash
- LP-steam
- MP-steam
- Cooling water
- BFW
- Cooled raw syngas
- Condensate
- Raw syngas
Critical performance / cost areas

- Low risk in technology except for scale-up related risks for gasifier and gas cooler
- Low risk in investment cost estimates; high percentage of cost from established technologies
- Low risk in conversion / consumption related costs; high confidence in conversion efficiency
- Higher risk in project execution; can be mitigated by extensive pre-engineering and selection of contractors and contracting form. Can be in conflict with time-to-market goals.
- Start-up curve and final availability critical to overall project financial performance; first plants pose higher risk
First generation technology, > 55 000 h of full-scale operation

- Commercial atmospheric, air-blown gasifier to boost recovery capacity
- Capacity 300 t BLS/d, about 15% of total mill recovery capacity
- Installed in 1996, now operated more than 55 000 h
- Of great importance for development of refractory system and other components
- Has now reached 95% annual availability and 2 years refractory life
Existing pilot plant

- Chemrec already runs the world’s only plant for oxygen-blown, pressurized gasification of black liquor to raw syngas
- Capacity 20t solids/d, 3 MWth
- Oxygen-blown, 30 bar operating pressure
- In continuous 24/7 operation with 15 operators
- 8000+ hours of operation
BioDME plant to be operational H1 2010

Existing syngas plant

New DME pilot plant

DME production 4-5 t/d
Demonstration plant next step

• Goals of demonstration plant
  – Show successful operation of near-commercial size plant including scaled-up oxygen-blown gasifier
  – Demonstrate successful integration within motor fuels plant
  – Demonstrate successful integration with pulp mill

• Minimum plant size 500 t BLS/d or about 32 000 m³ gasoline equivalents/year

• Total investment cost €150 million of which 50% grant funding or equivalent required

• Pre-projects for two demonstration plants on-going
Demonstration plant partners needed

• Host pulp mill
• Motor fuels plant investors / operator
• Technology suppliers
• Product off-taker / Fuel distributor
• (Vehicle manufacturer)
• (Transportation buyers)
Sustainability

• Key environmental and economic sustainability issues for Chemrec black liquor gasification extensively evaluated within
  – EUCAR / Concawe / JRC WtW project
  – Renew project

• Very good scores for key variables including
  – WtW and conversion efficiencies
  – GHG emission reduction
  – Land use efficiency
  – Product cost

DME via black liquor scores high on main criteria
BioDME from Wood Waste over Black Liquor – Highest Efficiency, Lowest Emissions
High efficiency, simple system and plant integration synergies gives low product cost

Lowest fuel production cost for Chemrec’s DME plant in RENEW’s 4-year, €20 million study

*) revenues for electricity 0.15 €/kWh

Lowest fuel production cost for Chemrec’s DME plant in RENEW’s 4-year, €20 million study
Thank you!