Gasification to power kraft mill lime kilns

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Lime Kiln Fuel Consumption at Canadian Mills

Average = 2.19

Kiln Fuel Consumption (HHV GJ/ODt)
Calcination

\[ \text{H}_2\text{O} \rightarrow \text{CaCO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2 \]

\[ \text{CaCO}_3 \rightarrow \text{CaCO}_3 + \text{CO}_2 \]

- **Drying**: CaCO\(_3\) to CaCO\(_3\)
- **Calcining**: CaCO\(_3\) to CaO

Does not occur significantly below 800 °C
Can Biomass Power Lime Kilns?

• YES!! In the 1980s several European mills installed systems

• 6 mills installed wood fired gasifiers in Europe
## 1980s European Gasifiers

<table>
<thead>
<tr>
<th>Location</th>
<th>Year Started</th>
<th>Type</th>
<th>Supplier</th>
<th>Thermal Capacity</th>
<th>Fuel Source</th>
<th>Fuel Pretreatment</th>
<th>Biomass feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oy Wilh. Schauman, Finland</td>
<td>1983</td>
<td>CFB</td>
<td>Foster Wheeler</td>
<td>35 MW</td>
<td>Bark, sawdust</td>
<td>Pre-dryer, hammermill, dryer</td>
<td>133 t/d</td>
</tr>
<tr>
<td>Norrsundet, Sweden</td>
<td>1985</td>
<td>CFB</td>
<td>Foster Wheeler</td>
<td>25 MW</td>
<td>Bark</td>
<td>Pre-dryer, hammermill, dryer</td>
<td>100 t/d</td>
</tr>
<tr>
<td>ASSI Karlsborg, Sweden</td>
<td>1986</td>
<td>CFB</td>
<td>Foster Wheeler</td>
<td>27 MW</td>
<td>Slash?</td>
<td>Pre-dryer, hammermill, dryer</td>
<td>100 t/d</td>
</tr>
<tr>
<td>Portucel Rodao, Portugal</td>
<td>1986</td>
<td>CFB</td>
<td>Foster Wheeler</td>
<td>15 MW</td>
<td>Bark, sawdust</td>
<td>Pre-dryer, hammermill, dryer</td>
<td>52 t/d</td>
</tr>
<tr>
<td>Södra Värö, Sweden</td>
<td>1987</td>
<td>CFB</td>
<td>Götaverken</td>
<td>35 MW</td>
<td>Bark, sawdust</td>
<td>Screen, hammermill, dryer</td>
<td>Up to 175 t/d</td>
</tr>
<tr>
<td>Pöls, Austria</td>
<td>1987</td>
<td>CFB</td>
<td>Lurgi</td>
<td>27 MW</td>
<td>Bark</td>
<td>Hammermill, dryer</td>
<td>Up to 158 t/d</td>
</tr>
</tbody>
</table>
No recent installations: Why?

• Cost:
  – CBF technology combined with feed treatment systems make the economic return unacceptable.
  – CBF is more suited towards applications >100MW in size

• Contaminants:
  – Some systems contributed unacceptable amounts of NPEs to the mill lime cycle. This led to operational problems such as evaporator scaling.
Nexterra’s Gasification Technology

- Proven, fixed-bed, updraft gasifier
- Hog fuel (3-inch minus, 25 – 55% moisture) bottom-fed into gasifier
- Combustion air, steam and/or O₂ introduced into base of fuel pile (30% stoichoimetric)
- Partial oxidation at 1500 - 1800 °F and fuel is converted into “syngas”
- Raw syngas exits gasifier at 500 degrees F and 100 - 150 btu/ft³
- Ash migrates to the base and is removed by an automated ash grate.
Nexterra Gasifier Features

1. Design Simplicity
2. Ultra Low Particulate Emissions
3. Clean, Low Temperature Syngas
4. Free Flowing Ash
5. High Turn Down Ratio (5:1)
6. Idling Capability (48 hours)
7. Fuel Flexibility (up to 55% moisture)
8. Easy Automated Operation
Nexterra, Weyerhauser, Paprican Collaboration

- SDTC sponsored project to demonstrate the Nexterra’s gasification technology for lime kiln applications.
  - Address technical concerns
  - Replace at least 50% of fossil fuel use in the kiln
  - CFD modeling of kiln
Technical Concerns

1. Flame Temperature
   - **Issue:** Higher moisture in syngas may reduce flame temp.
   - Water vapour in syngas increases specific heat and emissivity
   - Co-firing or tuning with NG will stabilize flame temperature
   - Water can be removed from syngas through cooling

2. Kiln Gas Volumes
   - **Issues:** Syngas lower heating value and higher moisture means higher mass flow. Concerns are backend equipment (ID fan and dust collection) reduced kiln capacity.
   - Modeling of kiln should identify any productivity limitations
   - Any implications to back-end equipment must be rigorously assessed during project development for each specific site
   - Syngas heating value can be raised
3. Non-Process Elements

- Issue: Concerns about accumulation of non-process elements in the lime cycle
- Nexterra syngas has ultra low inorganic content (<100 mg/dscm) that could be reduced.
- Equates to about 34 kg/day for gasifier displacing 1500 GJ/day
- Initial assessment by pulp and paper companies, kiln suppliers is that quantities of non-process elements in syngas are not significant (34 kg/day)
NPE Study

• Measure current concentrations of NPEs in the mill liquor and lime cycles.
• Construct a mass balance of the mill.
• Predict the impact of ash in syngas on accumulation levels.
Mass Balance Schematic

- Digester
- Washers
- Recovery Boilers
- Green Liquor Clarifiers
- Mudd Treatment
- Lime Kiln
- Recaust
- Pressure Filters
- Purged Mud
- Weak Wash
- Water
- Pulped Stack
- Raw Green Liquor
- Dust
- Reburned Lime
- Clarified Green Liquor
- Dregs
- Purchased Lime
- Grits
- Recausticized Liquor
- White Liquor
Concentrations in Reburnt Lime

- Baseline
- Max Syngas
- Interior BC
- Coastal BC A
- Alberta
- Coastal BC B

mg/kg of sample (wet basis)
Concentrations in White Liquor

- Baseline
- Max Syngas
- Interior BC
- Coastal BC A
- Alberta
Conclusion

• Predicted increased concentration in NPEs is very minor.

• NPEs from syngas are very unlikely to result in operating problems.
Flame Temperature/Gas Volume

• A key operating parameter for the gasifier is temperature in the char zone. It must be kept below the ash slagging temperature.

• Potential solutions:
  – Flue gas recycle (FGR)
  – Steam cooling and cleaning (SCC)
Flame Temperature/Gas Volume

- Modeling indicated that the FGR increases the gas volume too much.

- SCC will produce a lower volume syngas with higher heating value. No major impact on kiln gas volume.
  - Wet ESP for gas cleaning
CFD Modeling

• CFD modeling by PSL was used to evaluate several options.

• Results indicate that throughput and efficiency can be maintained with SCC syngas.
Next Steps

• 2007 - Nexterra pilot plant testing
  – Modification to steam injection
  – Lime kiln burner installation
  – Firing test program

• Decision on implementation at the Kamloops kiln.
  – Installation would likely begin in 2008
Questions?