Lignin extraction from black liquor
Per Tomani, Innventia
Outline

- My presentation will cover:
  - the LignoBoost process
  - touch on drivers
  - and consequences with lignin removal
The LignoBoost process

- Lignin OUT
- Lignin IN
  - Replacement of fossil fuel in lime kilns
  - 50 L mineral oil ptp can be saved

Evaporation → Recovery Boiler → Lime Kiln → Digester

Wood → Wood Chips → Bleaching → Pulp/Paper

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Lignoboost – Customer value today

- Increased pulp production
  - By reduced thermal load in the recovery boiler

- Reduced oil consumption – Go Green
  - Replacement of fossil fuel in the lime kiln with lignin

- Exporting revenue
  - Excess energy can be exported from market pulp mills to external users as energy, chemicals & materials

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The LignoBoost R&D history

1997: Start to work on lignin removal
2001: Breakthrough
2003: Bench scale
2004: Pilot scale (container size)
2005: Full-scale trials in a coal-fired heat & power plant in Stockholm resulted in a customer for a demo plant

June 2006: Innventia buys an old lignin plant & re-builds it
22 December 2006: Start-up of the LignoBoost demo
May 2006 – Nov 2008: Delivery of lignin and R&D
June 2008: The LignoBoost concept is sold to Metso, but Innventia still owns the Demo plant for R&D purposes.
2010: Swedish Energy Agency decides to support Södra Cell Mörrum. EU needs to give OK to this size of investment support.

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Typical LignoBoost SW lignin - from the demo plant

65-70 % DS
HHV (dry ash free): 26-27 MJ/kg

C: 63 - 66 %
H: 5.7 - 6.2 %
O: 26 - 27.5 %
S: 1.8 - 3.2 %
N: 0.1 - 0.2 %

Ash (dry): 0.2 - 1.4 %
Na: 120 - 230 g/kg ash
K: 25 - 80 g/kg ash

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The LignoBoost process

Spent acid &/or H₂SO₄ &/or
High pH

Liquor from digester

Wash liquid ~2 m³/t lignin

H₂SO₄ & Wash water pH 2.5

Washed Lignin

Liquor ~40%

Lignin lean liquor

CO₂

High pH

Low pH

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Pressfilter from Metso Minerals

- Low residual cake moisture
- High capacity
- Fully automatic operation
- Low maintenance costs due to few moving parts
- Easy to replace filter cloths

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Pressfilter operation

- Filling = Cake Formation & Filtration
- Membrane pressure
- Washing
- Membrane pressure
- Airblowing
- Open filter
  - Empty, Vibrations
- Washing of filter cloth
  - Vibrations
- Close filter
- Wait or Run

"Typical time": 15-30 minutes

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Arrangement of the filter plate pack

- Polypropylene plates
- Rubber membranes
Washing of the filter cloth

Spray nozzles

Wash water

Feed port

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Sizes and chamber data

<table>
<thead>
<tr>
<th>Chamber</th>
<th>Chamber depth</th>
<th>Volume</th>
<th>Filter area</th>
<th>Drying Area</th>
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<tr>
<td>mm</td>
<td>litre</td>
<td>m²</td>
<td>m²</td>
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<td>Demo plant</td>
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<tr>
<td>VPA 1030</td>
<td>32</td>
<td>20</td>
<td>1.3</td>
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<td>25</td>
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<td>55</td>
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<td>204</td>
<td>7.8</td>
<td>3.9</td>
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</table>

NEXT GENERATION WILL BE EVEN LARGER!

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Key numbers for the LignoBoost process

**Lignin production:**
- 175 – 295 kg lignin/ton BLS
- Average: 240 kg lignin/ton BLS

**CO₂-consumption:**
- 150 – 320 kg/tonne lignin
- Average: 220 kg/tonne lignin

**Acid consumption (H₂SO₄ &/or spent acid):**
- 120 – 255 kg/ton lignin
- Average: 175 kg/ton lignin
Na/S balance

- Very important to collect information about the existing Na/S balance!
  - How is spent acid used?
  - How much spent acid is handled and available for LignoBoost?
  - Today’s level of Recovery Boiler Dust purge?

- We will need to add at least some fresh $\text{H}_2\text{SO}_4$
Buy CO$_2$, get it “for free” from flue gases or from a ethanol production site?

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Reference: Henrik Wallmo, PhD Thesis
Chalmers University of Technology
Sweden
Possible pulp production increase
Flue gas limited recovery boiler, constant DS and air excess

Relative pulp production, %

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Energy situation in mill
Summary/Steam balance

Recovery boiler 15.2 GJ/ADT

<table>
<thead>
<tr>
<th>Process</th>
<th>GJ/ADT</th>
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<tbody>
<tr>
<td>Evaporation</td>
<td>5.1</td>
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<tr>
<td>Fibre line</td>
<td>4.9</td>
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<tr>
<td>Pulp drying</td>
<td>3.0</td>
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<tr>
<td>Others</td>
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<tr>
<td>Total need</td>
<td>14.0</td>
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</table>

Reference:
KAM, report A100, 2003
Energy situation in mill
Steam saving potential

<table>
<thead>
<tr>
<th>Process</th>
<th>Average</th>
<th>BAT</th>
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<tr>
<td>Evaporation</td>
<td>5,1</td>
<td>4,0</td>
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<tr>
<td>Pulp drying</td>
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<td>2,2</td>
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<tr>
<td>Lime kiln</td>
<td>1,4</td>
<td>1,4</td>
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<tr>
<td>Others</td>
<td>1,0</td>
<td>0,0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15,4</strong></td>
<td><strong>10,8</strong></td>
</tr>
</tbody>
</table>

1. KAM, report A100, 2003
Adiabatic combustion temperature, C

Min. Temp.

Softwood, 80% DS

Softwood, 72% DS

Hardwood

About 25% of available lignin in BL

Extracted lignin, tonnes/ADt

Reference: Lennart Delin, AF Consult

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Impact of lignin extraction on black liquor properties and evaporation capacity

Black liquor properties

- The black liquor viscosity will be slightly lower with lignin extraction.
- Very small impact on the boiling point elevation (BPE) by lignin extraction.

Impact on evaporation capacity

- Most likely the evaporation plant capacity will remain or be slightly improved by the lignin extraction.
- The point of crystallization (risk for scaling) might change due to the changed inorganic composition.
- Increased evaporation demand from lignin wash water corresponds to 2 m³/ton lignin or 0,25 m³/ADt at 25% lignin removal rate.

Reference: Ali Moosavifar, PhD Thesis
Chalmers University of Technology
Sweden
Costs according to a R&D Programme

Cost for a LignoBoost plant producing 50 000 tonne lignin/year (7 t/h lignin plant). This lignin production is calculated as dry but produced as 65% DS lignin cakes.

Total investment cost: USD* 12-18 million

Operational cost: USD* 60-110 / tonne dry lignin
USD* 11.5 / MWh (+/- 30 %)

Reference: The FRAM2 R&D Programme, 2005-2008

*1 USD = 7 SEK

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Some experiences

- The LignoBoost process is connected in parallel with the recovery cycle and will not interfere with the "normal" pulp production if disturbances in LignoBoost.

- Possibilities to store the lignin product = Pulp Mill Energy Balance Optimisation

- First part of the LignoBoost-concept was in commercial operation 1994 to 2005 by Borregaard LignoTech in Bäckhammar Sweden. This results in a ash-rich lignin water slurry. Continuous operation with only one yearly maintenance stop scheduled together with the pulp mill. Production of lignin on a level of 6 000 tonnes/year. This means well-proven technology.

- The second part of the LignoBoost-concept, which results in a clean product & high dry solids, is tried by Innventia on a level of 4 000 tonnes/year in the demonstration plant in Bäckhammar.

- LignoBoost-concept does not include development of new equipment. Instead we use conventional equipment, put together in a new way for a new application.

- Key component (press filters) in the LignoBoost-concept is conventional technology, very well-proven equipment in the mineral industry. Fully automatic equipment. Very large sized filters in the mineral industry.

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Collection of data to see if LignoBoost fits in your pulp mill

- Screening of potential
  - Step 1: Laboratory scale trials at Innventia

*Laboratory-scale equipment; ~10g lignin per filtration-batch.*
Collection of data to see if LignoBoost fits in your pulp mill

- Screening of potential & collection of design data
  - Step 2: Pilot scale trials at your pulp mill

*Pilot scale equipment; ~ 0.5 – 1 kg lignin per filtration-batch*

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The LignoBoost Demo Plant

VPA 1040
24 chambers
1-1.2 tonnes lignin/h

Possible to test your black liquor, produce your lignin and verify design data in real scale

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Thank you for your attention!

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