THE KRAFT PULP MILL AS A BIOREFINERY

Peter Axegård
STFI-Packforsk AB
The Pulp Mill Biorefinery

STFIs definition

Full utilization of the incoming biomass for production of fibres, chemicals and energy
STFIs Biorefinery Activities

Fibre processing

Pulpwood

Integrated Energy System

Primary treatment

Black liquor

Pulp/paper

Electricity

Chemicals

Biofuels

Forestry residues
Large Effort on Lignin Removal

- Projects:
  - KAM, 1996 - 2002
  - FRAM1, 2002- 2005
  - FRAM2, 2005 - 2008
  - Demo plant, 2006 - 2008
  - Total budget on lignin, 115 MSEK (approx. 12 m€)
Removal of Lignin from Black Liquor
Industrial Value

- Low capital-cost alternative to de-bottleneck a flow gas limited or thermally limited recovery boiler

- Lignin can replace mineral oil as a fuel and also be a feed-stock for “green” chemicals and materials
Lignin from Kraft Black Liquor

Lignin OUT

Evaporation

Wood chips

Recovery boiler

Bleaching

Wood

Pulp/paper

Lignin IN

Replacement of fossil fuel
Traditional One Stage Process

Weak Black liquor

To recovery boiler

Black liquor (30-40 % DS)

Evaporation

Dewatering and washing

Precipitation

Lignin

Acid

Cooking chemicals, organic substances
Problems With One Stage Washing

- Poor control of pH and ionic strength
- Very slow dewatering, large lignin losses and lignin with low purity and high water content
Viscosity and boiling point elevation of black liquor from the lignin extraction process and the modification of extracted lignin

Ali Moosavinia

Forest Products Department
Chalmers University of Technology
New Process for Lignin Removal

Black liquor

Cooking chemicals, organic substances

Evaporation

Dewatering and washing

Precipitation with CO2

Conditioning

Dewatering

Lignin

To recovery boiler

Cooking chemicals, organic substances
Yield of Precipitated Lignin from Kraft Mill Black Liquor
Different Scales for Lignin Removal

- **Laboratory**
  - 0.1 kg lignin/h

- **Bench scale**
  - 1 kg lignin/h

- **Pilot**
  - 100 kg lignin/h
Mill Trial 2004 With Filter Pilot (1.7 m²)
Mill Trial 2004 With Filter Pilot

Specific filtering resistance, m/kg

Filtration cycle number

Same level as kaolin
Mill Trial 2004 With Filter Pilot

Dry solid content, %

Filtration cycle number

50 55 60 65 70 75
1450 1550 1650 1750 1850 1950 2050
Lignin From Mill Pilot

60-70 % Dry solids
0.1 - 0.5 % ash
0.05 – 0.4 % Na
Heat value 26 GJ/t

Lignin Pellets
Typical Properties of Lignin

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>C</td>
<td>64.0 %</td>
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<tr>
<td>O</td>
<td>26.4 %</td>
</tr>
<tr>
<td>H</td>
<td>5.7 %</td>
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<tr>
<td>Na</td>
<td>0.03 %</td>
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<tr>
<td>Ash</td>
<td>0.2 %</td>
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Dry solids       65-70 %

Heat value       26 GJ/t
Mill Trial 2006 In Portugal
Mill Trial 2006 In Portugal
STFI Has Established A Company - LignoBoost AB

- For demonstrating the process in a demo plant
  - demo plant started late 2006
  - production 4,000 tonnes/y
  - capacity 10,000 tonnes/y
  - lignin will be used in lime kilns and other incinerators
- Sell licences, engineering and turn-key systems
- Licences to three companies have already been sold
Demonstration of Lignin Production
Start-Up December 2006

Wermland Paper, Bäckhammar mill

LignoBoost Demonstration plant
Key Machine - Filter from Metso Minerals

- Fixed Head
- Upper Rails
- Cloth Wash Spray Bars
- Filter Cloth Support
- Moving Head
- Load Cells
- Filter Cake Discharge Chute
- Parallel Hydraulic Cylinders
Metso Filter in Demo Plant
Lignin Produced First Day
Objective: Develop the LignoBoost-process and lignin incineration applications into industrial practice

Projects:
- Effect of wood species and cooking process
- Design data using bench equipment in mills
- Reduction of investment and operational costs
- CO2 from lime kiln flue gases
- Trials in lime kilns, heat/power plants and bark boilers (lignin handling included)
- Case studies for 3 - 4 mills
Nordic Biorefining Alternatives

- Pulp wood
- Forestry residues

Pulp & paper production
- Spent liquor

Lignin removal
- Lignin

Biomass gasification
- Electricity
- Methanol/DME
- FT-fuels

Paper
STFI-VTT Scheme: Integrating Biomass Gasification with Lignin Removal

- **Pulp wood**
  - Pulp & paper production
  - Spent liquor
- **Forestry residues**
  - Biomass gasification
  - Lignin removal
  - Lignin
  - CO₂
  - Fuel gas
- **Fuel gas**
  - Electricity
  - Methanol/DME
  - FT-fuels
Opportunities - Integrating Biomass Gasification with Lignin Removal

- Recovery boiler development
- Heat integration for high energy efficiency
- and …. No principal limitation in removal of valuable components from black liquor

<table>
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<tr>
<th>kg/t pulp</th>
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Potential Lignin Applications

- **Energy**
  - Heat value of 1 tonne of lignin equals 0.65 tonne of mineral oil
  - Fuel for lime kilns, heat and power, oil replacement, syngas ....

- **Chemicals**
  - Phenols, binders, dispersants, sequestering

- **Materials**
  - Carbon fibre composites, porous carbon, active carbon
Kraft Lignin as a Dispersant

Unmodified SW lignin

Sulfonated SW kraft lignin
Conclusions

- A new process, LignoBoost, for separation of lignin from kraft black liquor has been developed
- Eliminates recovery boilers bottlenecks
- The lignin has very good properties
  - 65-70 % dry solids content
  - Ash content 0.1-0.5 %
  - Sodium 0.01-0.4 %
  - Heating value 26 GJ per ton
- Promising fuel and potential chemical feed-stock
- Demonstration plant started December 2006
- Commercial installation 2007?
Other Benefits of Lignin Removal

- Good match with gasification of forestry residues
- Basically all organics in black liquor can be removed
- Future simplified recovery boilers
Thank you for your Attention!
The Future Kraft Pulp Mill is a Biorefinery Producing

- Fibers for paper and fibre based composites
- Chemicals from hemicelluloses and lignin
- Solid and liquid fuels or electricity from black liquor and forestry residues
Carbon Fibres

Activated Carbon
Xylan Applications

- Fibre functionalization, increased fibre bonding…
- Barrier in packaging etc
- Hydrogels and thickeners
- Fermentation to succinic acid or ethanol
Opportunities - Integrating Biomass Gasification with Lignin Removal

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