Straw Utilization for Fiber and Chemicals

Mark Lewis UW
March 30, 2010
Potential Biorefinery Operations

100 Tons WS

Pulping

Pulp ≈ 65 tons

Dissolved Organics in Black Liquor ≈ 35 tons (23 tons Hemicellulose)

• Concentrate
• Hydrolyze
• Purify

Hydrogenation
21 tons Glycols

Lignin for Process Energy
11 tons
Dayton Feasibility

• Reviewed various sites for Straw Mill
• Met with various farmers to discuss logistics and straw availability
• Evaluated pulp users
• Commitment from buyers for lignin and sugars
Potential Washington Agro-Industry Manufacturing Configuration

1. Pretreatment
   - Total Biomass: Ag. Residue, Waste Paper, Wood Residue
   - Soil Applications

2. Pulping/Chemical Extraction
   - Industrial Biomass
   - Ligno/Hemicellulose
   - 7, 10, 12, 13, 23, 24
   - Pulp

3. Molded Products - Paper Products
   - Paper: 7, 10, 11, 13, 14, 15, 24

4. Membrane Separation
   - Hemicellulose
   - 16, 20, 22

5. Hydrolysis - Concentration - Hydrogenation
   - Petrochemical Replacements: 16, 17, 18, 19

6. Combustion - Hydrogenation - Pyrolysis
   - Energy: 21
   - Petrochemical Replacements: 16, 17, 18, 19
   - CO/H₂

Reform

1. No longer necessary
2, 3. Commercial (2009), needs some optimization
4. Ongoing Research at UW, equipment identified
5. Process presently commercial/needs R&D for bio-sugar and glycerin feeds
6. Working with Lignin buyer to optimize
<table>
<thead>
<tr>
<th></th>
<th>Arabose</th>
<th>Galactose</th>
<th>Glucose</th>
<th>Xylose</th>
<th>Manno</th>
<th>AIL</th>
<th>ASL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooked What Straw (PWS)</strong></td>
<td>2.99%</td>
<td>0.58%</td>
<td>47.36%</td>
<td>27.81%</td>
<td>0.00%</td>
<td>21.33%</td>
<td>2.01%</td>
<td>102.09%</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>0.04%</td>
<td>0.01%</td>
<td>0.41%</td>
<td>0.32%</td>
<td>0.00%</td>
<td>0.44%</td>
<td>0.05%</td>
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<tr>
<td><strong>Original Wheat Straw</strong></td>
<td>2.96%</td>
<td>0.59%</td>
<td>42.80%</td>
<td>24.90%</td>
<td>0.00%</td>
<td>20.27%</td>
<td>2.40%</td>
<td>93.91%</td>
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<tr>
<td><strong>SD</strong></td>
<td>0.09%</td>
<td>0.01%</td>
<td>1.36%</td>
<td>0.94%</td>
<td>0.00%</td>
<td>0.26%</td>
<td>0.05%</td>
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<tr>
<td><strong>Wheat Straw Pulp</strong></td>
<td>3.04%</td>
<td>0.40%</td>
<td>60.22%</td>
<td>27.68%</td>
<td>0.00%</td>
<td>11.53%</td>
<td>1.48%</td>
<td>104.37%</td>
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<tr>
<td><strong>SD</strong></td>
<td>0.04%</td>
<td>0.02%</td>
<td>0.74%</td>
<td>0.98%</td>
<td>0.00%</td>
<td>0.45%</td>
<td>0.05%</td>
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Normal filtration occurs as the membrane prevents solids from passing and clear filtrate is able to exit the system through the drainage cloth. Membrane trays are independent modules and are installed stacked on top of each other. Up to several hundred tray layers are included in the filter pack.
Chart #1

University of Washington
Straw Black Liquor

Chart: Membrane Comparison

**NF-270**
- pH: 7.19
- Conductivity: 3.63 mS
- % Solids: 0.25%

**PES-5 Tyvek**
- pH: 7.27
- Conductivity: 9.53 mS
- % Solids: 1.19%

**NF-500**
- pH: 7.52
- Conductivity: 6.44 mS
- % Solids: 0.53%

**NF-300**
- pH: 7.52
- Conductivity: 6.00 mS
- % Solids: 0.46%

**Process Conditions**
- Temp: 25°C
- pH: 6.76
- % Solids: 2.61%

New Logic Confidential
## Grass Straw Pulping

<table>
<thead>
<tr>
<th>Pulp</th>
<th>NaOH</th>
<th>KOH</th>
<th>NH4OH</th>
<th>Time</th>
<th>Ratio</th>
<th>Temp</th>
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<td>5</td>
<td>5</td>
<td>5</td>
<td>30</td>
<td>12</td>
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<td>10</td>
<td>60</td>
<td>12</td>
<td>90</td>
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</tbody>
</table>
Ongoing Activities

• Currently manufacturing glycols from sugars at UW lab
• Meetings with for bleached wheat straw pulp from this project
Additional Info

• Currently working with another mill in Washington who is looking to switch to straw pulping at their facilities
• Major trial to occur in June
• Meeting with mill personnel and consulting engineering firm mid April