Fiber and Chemical Division
The Practicalities of Converting to DP Technology
presented by Eric Wiley
Dissolving Pulp Cooking Technology Update

Current Situation

- Existing production has been predominantly sulfite based, with recent trend of sulfate pulp expansions replacing mill shutdowns and conversions to paper pulp.

- Worldwide consumption growth expected to remain steady at 2 – 3% per year (~130,000 t/a) until 2025, with emphasis in China and rest of Asia.

- Currently there are no continuous cooking references for dissolving pulp operating.

- Possible synergies with hemi-cellulose based products through pre-hydrolysis lead to potential economic benefits.

- Rest of the Fiberline (washing, screening, bleaching) can be done with existing well proven technology.
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Global Fiber Production

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Annual Production Tons</th>
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<tbody>
<tr>
<td>Oil Based Synthetic Fiber</td>
<td>40,000,000</td>
</tr>
<tr>
<td>Cotton</td>
<td>25,000,000</td>
</tr>
<tr>
<td>Viscose Fiber</td>
<td>4,000,000</td>
</tr>
<tr>
<td>Wool and other Animal Fiber</td>
<td>1,000,000</td>
</tr>
<tr>
<td><strong>Total Fiber</strong></td>
<td><strong>70,000,000</strong></td>
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</table>

2008 Data from CIRFS

Viscose fiber is the key alternate fiber for replacement of lost cotton production
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Mill Design Considerations

For a Pre-Hydrolysis Kraft Pulp Mill

- **Fiberline**
  - Hydrolysate (evaps or external usage)
  - $\alpha$ cellulose content, 92…96 (adjustable)
  - Viscosity (adjustable, may need O3 in bleaching)
  - Metals Management both Fe$^{++}$ and Mn$^{++}$ can cause S (Sulfur) to precipitate and cause problems during the dissolving process and in the spinners.
  - Segregation of sewers required due to acidic hydrolysate spills and resulting H2S risk
  - Transition Pulp, Storage Management

- **Evaporation**
  - Higher than kraft residual alkali (4…8 vs 8-10..15..22 g/l) requires special consideration for process design -> Possibility for extremely high NaOH concentrations in the 1st effect requires all-Duplex construction (High residual if Cold Caustic Extraction is used.)
  - Hydrolysate mixing and neutralization prior to mixing with black liquor to avoid lignin precipitation. In any case fouling behavior worse than kraft
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Mill Design Considerations

For a Pre-Hydrolysis Kraft Pulp Mill

- **Pulp Drying Plant**
  - Improved screening/cleaning system as any dirt or any particles which do not dissolve to viscose dope are a problem.
  - Washing module for better cleaning of pulp and pH control
  - Winder and roll packing option depending on end user request

- **Woodyard**
  - High pulp cleanliness requirements requires effective bark removal
  - Chip dimensions, thinner and shorter chips, equal size distribution in order to have uniform cooking
  - Chips from logs meet well the quality requirements
  - Market chips needs good screening and washing

- **Water & Effluent Treatment Plants**
  - Increase in Demineralized Water Demand
  - Increased Effluent Volume
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Paper Grade Kraft Pulp Fiberline
Pre-hydrolysis kraft (PHK) cooking ensures high alpha cellulose content.
  - Alpha cellulose content is adjustable (P-factor)
  - α cellulose content easily > 92

Oxygen stage
  - increases α cellulose content
  - decreases environmental load of bleaching and decreases chemical costs

Effective washing ensures low COD content to bleaching
  - lower COD effluent amount
  - lower chemical consumption
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Key Bleaching Parameters

- Effective screening reduces impurities amount without fiber losses and no knots to the cooking system
- Bleaching D0 – Eo(p)-D1-P1
  - Final brightness ≥ 90 ISO
  - Acidic stages $D_0$ and $D_1$ effective metal removal.
  - **wash water metal free**
  - $\alpha$-cellulose adjusting in EOP stage – hot alkali
  - final P-stage lowers brightness reversion
  - Oxygen and EOP stage lowers extractives amount,
- Viscose control: cooking, A-stage and alkaline stages ($O_2$ and EOP)
  - Ozone is another good option for viscosity control
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Dissolving Grade Kraft Pulp Bleach Plant with Ozone

Total Mill Effluent can increase due to no reuse of White Water in the Bleach Plant ~ 7m³/ADMT
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Auto-Hydrolysis of Wood

Moisture + Temperature (155 – 170 C) + Time (45 – 120 minutes)

Cellulose, lignin and some remaining hemicellulose still in Chip Form

+ Sugar Fragments from hemicelluloses as: monomers and oligomers

+ Acetic Acid

+ Smaller amounts of: levulinic, syringic, formic and aldobiuronic acids

+ Acid Lignin fragments

+ Gases (CO, CO2…..)

End pH in the range of 3.3 – 3.7
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Dissolving Grade Kraft Pulp Fiberline Kappa Profile

- S: 15 – 18
  H: 8 - 10
  Down Flow Lo-Solids® Cooking

- S: 7 – 9
  H: 5
  Brownstock Washing

- Oxygen Delignification

- Deknotting & Screening

- S: 5-7
  H: < 5
  ECF bleaching

- Demin Water
  8 m³/ADMT
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Previous Experience

- Most recent continuous cooking reference, Varkaus Finland, was a conventional chip feeding system followed by a hydraulic pre-hydrolysis vessel and vapor phase continuous digester.

- Results publicly reported by the Varkaus mill show the dissolving pulp made from pre-hydrolysis birch did achieve predicted laboratory results.

Source: TAPPI (1981)

**PREHYDROLYSIS BIRCH PULPS**

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Laboratory Pulp</th>
<th>Mill Run 22.2 - 4.3.1981</th>
<th>Methods</th>
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<tbody>
<tr>
<td>Alpha Cellulose</td>
<td>91</td>
<td>91,5</td>
<td>CCAT, TPPI-3.145</td>
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<tr>
<td>Alkali Resistance R10</td>
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<td>91,2</td>
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<tr>
<td>S10 - S18</td>
<td>2</td>
<td>2,5</td>
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<tr>
<td>Alkali Solubility S18</td>
<td>8</td>
<td>8,2</td>
<td>---</td>
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<tr>
<td>Pentosans</td>
<td>8</td>
<td>7,5</td>
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<tr>
<td>Viscosity, CED</td>
<td>580</td>
<td>600</td>
<td>SCAN-C1582</td>
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<td>Viscosity, CED</td>
<td>20</td>
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<tr>
<td>DP</td>
<td>2.8</td>
<td>8.9</td>
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<td>Copper Number</td>
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<td>0.3</td>
<td>N.A.</td>
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<tr>
<td>Ash Content</td>
<td>0.06</td>
<td>0.07</td>
<td>SCAN-C662, ISO 1785/74</td>
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<tr>
<td>Silicates and Silica</td>
<td>80</td>
<td>7</td>
<td>SCAN-C862, ISO 779/74</td>
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<tr>
<td>Ca</td>
<td>60</td>
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<td>ATOMIC ABSORPTION</td>
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<tr>
<td>Mg</td>
<td>15</td>
<td>13</td>
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<tr>
<td>Fe</td>
<td>10</td>
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<tr>
<td>Mn</td>
<td>0.2</td>
<td>0.3</td>
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<tr>
<td>Co</td>
<td>&lt;0.1</td>
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<tr>
<td>Dichloromethane Extract</td>
<td>0.07</td>
<td>0.10</td>
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<tr>
<td>Brightness, ISO</td>
<td>91</td>
<td>91</td>
<td>ISO 3688/77</td>
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Dissolving Pulp Cooking Technology Update
Upgrade Projects Decided / Announced

Decided:
- 200 kt/a  Sun Paper, Yanzhou  Continuous Conversion
- 300 kt/a  CONFIDENTIAL  Continuous New
- 170 kt/a  Sodra, Morrum  Batch Upgrade
- 300 kt/a  Tiger Forest, HuaiHua  Batch Conversion
- 600 kt/a  Chenming, Zhanjiang  Continuous Conv. (Delayed)
- 110 kt/a  Fujian, Qingshan  Batch Upgrade
- 200 kt/a  Fortress, Thurso  Batch Upgrade
- 100 kt/a  CONFIDENTIAL  Continuous Conversion
- 220 kt/a  Sappi  Batch

Announced / Proposed:
- 260 kt/a  Chitianhua
- 200 kt/a  Mercer (delayed)
- 200 kt/a  Lee&Man
- ---- kt/a  Prince Albert Pulp Inc. (APP)

+ MANY more discussions
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Predominate Cooking Technology Today in NA
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State of the Art Paper Grade System
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Dissolving Pulp Configuration
Dissolving Pulp Cooking Technology Update

Predominate Cooking Technology Today in NA
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Cooking System Upgrades for Retrofit to DP Operation

- Proper Pre-Steaming System – Chip Plug Flow > 20 minutes
- Stable Chip Feed – 25% more chips due to low yield
- Feed Line Materials of Construction 316L SS and 2205 Duplex – low pH
- Pre Hydrolysis Reactor Vessel, 100 min. – Not an IV
- Digester Vessel Top Replacement – 2205 Duplex and Vapor Phase Operation
- Heat Recovery System Modified to generate Clean System
- Knots Removed From the System not Back to the Chip Bin
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Advanced Dissolving Pulp Configuration
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Conclusion

- Pre-hydrolysis kraft process has been existing > 60 years (Konigsberg, Germany)

- Previous technology selection did not allow for robust process control
  - Single vessel technology with major pH change internal to the vessel
  - Hydraulic vessel technology sensitive to feed volume variations
  - Complicated pre-treatment systems with large feed volume variations

- Experiences developed during the last 15 years have made this process attractive
  - Atmospheric steaming technology with precise feed volume control
  - Chip pumping technology with stable feed volume transfer
  - Vapor phase vessel technology insensitive to feeding variations
  - Clean steam heat recovery
  - Enhanced instrumentation and process control strategies within and outside DCS system
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Upgrade Projects Decided / Announced

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Thank You for Your Attention