Refining System Optimization

A Six-Step Approach
**Six-Step Approach**

1. Hydraulics - Flow
2. Consistency
3. Specific Energy (kWh/t)
4. Specific Freeness Drop CSF/ kWh/t
5. Refining Intensity (Ws/m)
6. Plate Material

Process Optimization and/or Pattern and Alloy Recommendation
Hydraulics

- Why are Hydraulic Conditions Important to Refining?
  - Rotor is Stable & Centered
  - Increases Probability of Fiber Mat Formation
  - Fiber Strength Development Potential is Maximized
  - Plate Life Potential is Maximized
  - Variation is Minimized

- It’s just not a good thing to try to refine metal
### DOUBLE DISK REFINER CAPACITY CHART
#### RECOMMENDED FLOW RANGES FOR VARIOUS SIZE REFINERS
(60 HZ SPEEDS)

<table>
<thead>
<tr>
<th>Diameter mm (inches)</th>
<th>Max Power kW (Hp)</th>
<th>Normal RPM</th>
<th>No Load kW (Hp)</th>
<th>FLOW RATES – QPM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>508 (20)</td>
<td>225 (300)</td>
<td>900</td>
<td>55 (75)</td>
<td>150</td>
</tr>
<tr>
<td>610 (24)</td>
<td>335 (400)</td>
<td>720</td>
<td>85 (65)</td>
<td>250</td>
</tr>
<tr>
<td>660 (26)</td>
<td>375 (500)</td>
<td>720</td>
<td>90 (120)</td>
<td>300</td>
</tr>
<tr>
<td>762 (30)</td>
<td>450 (600)</td>
<td>600</td>
<td>95 (125)</td>
<td>375</td>
</tr>
<tr>
<td>864 (34)</td>
<td>595 (800)</td>
<td>514</td>
<td>100 (135)</td>
<td>475</td>
</tr>
<tr>
<td></td>
<td>750 (1000)</td>
<td>600</td>
<td>160 (215)</td>
<td>550</td>
</tr>
<tr>
<td>985 (38)</td>
<td>935 (1250)</td>
<td>514</td>
<td>160 (215)</td>
<td>650</td>
</tr>
<tr>
<td>1067 (42)</td>
<td>1120 (1500)</td>
<td>450</td>
<td>165 (220)</td>
<td>775</td>
</tr>
<tr>
<td></td>
<td>1305 (1750)</td>
<td>514</td>
<td>245 (330)</td>
<td>900</td>
</tr>
<tr>
<td>1168 (46)</td>
<td>1495 (2000)</td>
<td>450</td>
<td>240 (325)</td>
<td>1025</td>
</tr>
<tr>
<td>1321 (52)</td>
<td>2240 (3000)</td>
<td>400</td>
<td>285 (385)</td>
<td>1300</td>
</tr>
<tr>
<td></td>
<td>2240 (3000)</td>
<td>450</td>
<td>410 (550)</td>
<td>1475</td>
</tr>
<tr>
<td>1372 (54)</td>
<td>2240 (3000)</td>
<td>400</td>
<td>335 (450)</td>
<td>1475</td>
</tr>
</tbody>
</table>
Negatives to Low Flow

- Little or No Fiber Mat Between Plates
- Fiber Channeling
- High Pressure Rise (25-50 psi)
- Plate Clashing
- Short Plate Life
- Inefficient Refining (power vs fiber development)
- Poor Strength Development
- Increased Fines Generation
Negatives to High Flow

- Inability to Optimize Plate Design For Maximum Strength Development (Compromise)
- Short Plate Life
- Pressure Drop
- Motors Maxed Out
Possible Solutions

- **Low Flow**
  - Recirculation
  - Parallel to Series
  - Pattern Change
  - Holdback
  - Smaller Refiner

- **High Flow**
  - Pump Change
  - Series to Parallel
  - Pattern Change
  - An Additional &/or Larger Refiner
  - Increase Consistency
Six-Step Approach

1. Hydraulics - Flow
2. Consistency
3. Specific Energy (kWh/t)
4. Specific Freeness Drop CSF/ kWh/t
5. Refining Intensity (Ws/m)
6. Plate Material

Process Optimization and/or Pattern and Alloy Recommendation
### Consistency Guidelines for Various Fiber Types

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Recommended Range of Refining Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbleached Softwood Kraft</td>
<td>3.5 - 4.5%</td>
</tr>
<tr>
<td>Bleached Softwood Kraft</td>
<td>3.5 - 5%</td>
</tr>
<tr>
<td>Bleached Hardwood/Eucalyptus Kraft</td>
<td>4 - 6%</td>
</tr>
<tr>
<td>OCC</td>
<td>3.5 - 5%</td>
</tr>
<tr>
<td>Mechanical Pulps</td>
<td>4 - 6%</td>
</tr>
<tr>
<td>Unbleached Semi-Chem Hardwood</td>
<td>4.5 - 6%</td>
</tr>
<tr>
<td>Mixed Waste</td>
<td>4 - 6%</td>
</tr>
</tbody>
</table>
Consistency

- Why is the Proper Consistency Important to Refining?
  - Increases the Probability of Fiber Mat Formation
  - Fiber Strength Potential Maximized
  - Plate Life Potential is Maximized
  - Variation is Minimized
Effects of Operating Outside Recommended Consistency

- **High Consistency**
  - ✓ Plate Plugging
  - ✓ Poor Fiber Development

- **Low Consistency**
  - ✓ Little to No Fiber Mat Between Plates
  - ✓ Inefficient Refining
  - ✓ Poor Fiber Development
  - ✓ Fiber Cutting
  - ✓ Plate Clashing
  - ✓ Short Plate Life
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Specific Energy

Definition: The amount of Energy Transferred from the Refiner’s Motor to the Fiber.

- $S.E. = kWh/t = \frac{\text{Motor Load (kW)} - \text{No Load (kW)}}{\text{Tons per Hour}}$

- $S.E = \text{HPD/T} = \frac{\text{Motor Load (HP)} - \text{No Load (HP)}}{\text{Tons Per Day}}$
No Load Energy

- Definition: The Energy Required to spin the rotor in a pulp slurry.

- No Load (kW) = \((2.299 \times 10^{-13})(\text{Diam}^{4.249})(\text{RPM}^3)\)

  - Diam = Plate diameter in Inches
  - RPM = Refiner rotor speed

- THE REFINER IS AN INEFFICIENT PUMP
Energy Transfer to Fiber

42” Refiner
Motor
1305 kW

No Load = 245 kW
Fiber = 1060 kW

81% Efficiency
### Specific Energy Guidelines

#### NET REFINING REQUIREMENTS FOR MAJOR GRADES

<table>
<thead>
<tr>
<th>GRADE</th>
<th>HPD/UST</th>
<th>KWH/UST</th>
<th>KWH/MT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linerboard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td>5 - 7</td>
<td>89 - 125</td>
<td>99 - 138</td>
</tr>
<tr>
<td>Top</td>
<td>10 - 12</td>
<td>179 - 215</td>
<td>197 - 237</td>
</tr>
<tr>
<td>Sack, Bag</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 - 14</td>
<td>215 - 250</td>
<td>237 - 276</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virgin HWD</td>
<td>6 - 10</td>
<td>107 - 179</td>
<td>118 - 197</td>
</tr>
<tr>
<td>Waste</td>
<td>2 - 3</td>
<td>36 - 54</td>
<td>39 - 59</td>
</tr>
<tr>
<td>Tickler</td>
<td>1.0 - 1.5</td>
<td>18 - 27</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Fine Papers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardwood</td>
<td>4 - 6</td>
<td>72 - 107</td>
<td>79 - 118</td>
</tr>
<tr>
<td>Softwood</td>
<td>6 - 8</td>
<td>107 - 143</td>
<td>118 - 158</td>
</tr>
<tr>
<td>Tickler</td>
<td>1.0 - 1.5</td>
<td>18 - 27</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Foodboard, Milk Carton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardwood</td>
<td>2 - 3</td>
<td>36 - 54</td>
<td>39 - 59</td>
</tr>
<tr>
<td>Softwood</td>
<td>3 - 4</td>
<td>54 - 72</td>
<td>59 - 79</td>
</tr>
<tr>
<td>Tickler</td>
<td>1.0 - 1.5</td>
<td>18 - 27</td>
<td>20 - 30</td>
</tr>
<tr>
<td>News</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SB Kraft</td>
<td>2 - 5</td>
<td>36 - 89</td>
<td>39 - 99</td>
</tr>
<tr>
<td>Groundwood</td>
<td>2 - 3</td>
<td>36 - 54</td>
<td>39 - 59</td>
</tr>
<tr>
<td>Grades w/ OCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCC</td>
<td>2.5 - 5.0</td>
<td>81 - 117</td>
<td>50 - 100</td>
</tr>
</tbody>
</table>
Six-Step Approach

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Process Optimization and/or Pattern and Alloy Recommendation
Freeness Drop / HPD/T

- Freeness Drop / HPD/T is a Great Measure to Determine the Refiner(s) Efficiency and if it is Operating Correctly

✓ Equation: Delta CSF / HPD/T = \[ \frac{\text{CSF In} - \text{CSF Out}}{\text{HPD/T}} \]
### Freeness Drop / HPD/T Guideline Chart

#### FREENESS DROP / NET HPD/T

**Various Furnishes**

<table>
<thead>
<tr>
<th>Furnish</th>
<th>Northern U.S.</th>
<th>Southern U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNBLEACHED SOFTWOOD KRAFT</td>
<td>15 - 25 CSF / Net HPD/T</td>
<td>15 - 30 CSF / Net HPD/T</td>
</tr>
<tr>
<td>BLEACHED SOFTWOOD KRAFT</td>
<td>25 - 50 CSF / Net HPD/T</td>
<td>25 - 60 CSF / Net HPD/T</td>
</tr>
<tr>
<td>BLEACHED HARDWOOD KRAFT</td>
<td>60 - 100 CSF / Net HPD/T</td>
<td>45 - 50 CSF / Net HPD/T</td>
</tr>
<tr>
<td>EUCALYPTUS</td>
<td>45 - 50 CSF / Net HPD/T</td>
<td></td>
</tr>
<tr>
<td>SECONDARY FIBER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCC</td>
<td>40 - 70 CSF / Net HPD/T</td>
<td></td>
</tr>
<tr>
<td>MIXED</td>
<td>50 - 70 CSF / Net HPD/T</td>
<td></td>
</tr>
<tr>
<td>NEWS</td>
<td>20 - 35 CSF / Net HPD/T</td>
<td></td>
</tr>
</tbody>
</table>
Freeness Drop / HPD/T

- Possible Causes for a Low Freeness Drop/HPD/T
  - “Tough” Fiber
  - Low or High Flow Conditions
  - Low Consistency
  - Improper Pattern Application
  - Worn Out Plate - Bar edge Rounding, Bar Wear
  - Mechanical Problem w/ Refiner - Out of Tram, a Rotor that will not Float
  - Improper Plate Installation
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Process Optimization and/or Pattern and Alloy Recommendation
Refining Intensity (SEL)

- Definition: A Term used to Define “How” the Energy is Applied to the Pulp.

- The Amount of Energy (watts) Applied Across One Meter of a Refiner Plate’s Bar Edge and Transferred to the Pulp in One Second; (Ws/m)

- Pattern Design Plays Key Role

- Equation: \( \text{Int} = \frac{\text{Motor Load (kW) - No Load (kW)}}{\frac{\text{(KM Bar Edge Crossings/Rev)}}{\text{(RPM)}} \times \frac{1}{60}} \)
Typical SEL Ranges for Various Fiber Types

<table>
<thead>
<tr>
<th>FIBER TYPE</th>
<th>TYPICAL SEL RANGE WS/M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbl. Northern SW Kraft</td>
<td>2.5 - 4.5</td>
</tr>
<tr>
<td>Unbl. Southern SW Kraft</td>
<td>2.5 - 4.5</td>
</tr>
<tr>
<td>Bl. Northern SW Kraft</td>
<td>1.5 - 3.5</td>
</tr>
<tr>
<td>Bl. Southern SW Kraft</td>
<td>1.5 - 3.5</td>
</tr>
<tr>
<td>Semi-Chem HWD</td>
<td>1.0 - 2.5</td>
</tr>
<tr>
<td>Bl. HW Kraft</td>
<td>0.5 - 1.0</td>
</tr>
<tr>
<td>Bl. Eucalyptus Kraft</td>
<td>0.5 - 1.0</td>
</tr>
<tr>
<td>TMP Post Refining</td>
<td>less than 0.5</td>
</tr>
<tr>
<td>OCC</td>
<td>.75 - 2.5 (As low as possible w/out Plugging)</td>
</tr>
<tr>
<td>Mixed Waste</td>
<td>.75 – 1.5</td>
</tr>
<tr>
<td>Deinked News / Magazine (70 / 30 mix)</td>
<td>less than 1.0</td>
</tr>
</tbody>
</table>
Impact of Intensity on the Fiber

- High Intensity Refining – Cutting
- Low Intensity Refining - Fibrillation
Effects of Refining Outside the Recommended Intensity Range

- Lower Than Recommended
  - Potentially Poor Fiber Development (All Fibers Require a Certain Intensity Level to Break Down Their Walls)
  - Maintain Fiber length
  - Inefficient Freeness drop

- Higher Than Recommended
  - Severe Fiber Cutting
  - Plate Clashing, Exceed Fiber Threshold
  - Short Plate Life
  - Poor Strength Development
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Plate Material Selection

- Failure Modes of Refiner Plates
  - Bar Wear
  - Serration
  - Bar Edge Rounding
  - Corrosion
  - Bar Breakage
  - Smearing

- Alloy Selection is Based on Dominant Failure Mode - Maximize Plate Life
Questions?

- If you have any questions on J&L’s Six Step Approach on Refiner System Optimization, or if you would like additional information on our product line, call your J&L Representative. Together with J&L's Technical Support, he can assist you in applying this Six-Step Process to ensure optimal performance of your refining system.