Addition of new washers to an existing brown stock wash line
Mona Henderson & Anders Hjort
Impact Operation

Solids to Evaps

Solids to Washer

Carryover to O2 Delignification

Carryover to Bleach Plant
Contradicting demands

- A low dilution factor ↔ a low carryover
- A high Weak Black Liquor (WBL) dry solids ↔ a low carryover
- A low WBL flow ↔ a low carryover
- A low WBL flow and a high DS content ↔ a low carryover
How Does Washing Impact Operation

Solids and WBL to Evaps.

Water Intrusion

Wash water
Dilution Factor (DF) or Wash Factor (WF)
(WF = DF)

\[ DF = \frac{\text{Liquor in} - \text{Liquor out with pulp}}{\text{Production}} \]
How do liquors move in a BSW line?
How is wash efficiency measured?

1. Dilution Factor (Wash Factor) typically $m^3/admt$

2. Wash Efficiency and Normalization
   - Displacement Ratio (DR) $DR_{10}$ (%)
   - Efficiency, Norden E-number $E_{10}$
Wash Efficiency

\[ DR_{10} = \frac{X_{in} - X_{out}'}{X_{in} - y_2} \]

- Normalized to 10% discharge consistency
- Not additive
- Used to compare different washers

\[ E_{10} = \frac{\ln \left[ \frac{L_{in}}{L_{out}} \cdot \left( \frac{X_{in} - y_1}{X_{out} - y_2} \right) \right]}{\ln \left( 1 + \frac{DF^*}{9} \right)} \]

*DF on bone dry basis

- Normalized to 10% discharge consistency
- Additive
- Used to compare different washers or entire wash lines
Normalization to 10 %

\[ DR = \frac{X_{in} - X_{out}}{X_{in} - y_2} \]

\[ DR_{10} = \frac{X_{in} - X_{out}'}{X_{in} - y_2} \]

15 February, 2016
Wash Efficiency

HiHeat

Radial wash

<table>
<thead>
<tr>
<th>Washer</th>
<th>$E_{10}$</th>
<th>$DR_{10}$ (Na⁺)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HiHeat wash</td>
<td>5</td>
<td>97 %</td>
</tr>
<tr>
<td>Radial wash</td>
<td>3</td>
<td>75 %</td>
</tr>
</tbody>
</table>
Wash Efficiency

<table>
<thead>
<tr>
<th>Washer</th>
<th>$E_{10}$</th>
<th>$D_{R_{10}} \ (Na^{+})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single stage atmospheric diffuser</td>
<td>4</td>
<td>85 %</td>
</tr>
<tr>
<td>Two stage atmospheric diffuser</td>
<td>5</td>
<td>95 %</td>
</tr>
</tbody>
</table>
Wash Efficiency

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<tr>
<th>Washer</th>
<th>$E_{10}$</th>
<th>DR$_{10}$ (Na$^+$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure diffuser</td>
<td>5</td>
<td>96 %</td>
</tr>
<tr>
<td>Wash press</td>
<td>5</td>
<td>93 %</td>
</tr>
<tr>
<td>One stage vacuum drum washer</td>
<td>3</td>
<td>75 %</td>
</tr>
</tbody>
</table>
Where to add a new washer?
Where to add a new washer?

What is the purpose of installing a new washing device?

- Higher solids to the evaporators
- Less carryover to the oxygen delignification
- A better oxygen selectivity
- Less carryover to the bleach plant
- Reduced wash water usage
- Reduced load on secondary treatment
- All above
- Other
Where to add a new washer

**Where to start:**

1. Measure the current wash efficiencies in the fiber-line
2. Make a liquor balance over the current BSW
3. Model the alternatives to determine impact of potential solutions
System borders
Where does a wash stage begin?
Impact of system borders

Same conditions - different system borders! In the left figure a DR is measured in the right a $\text{DR}_{10}$

DR = \frac{38,5 - 27,3}{39,5 - 18,9} = 57\%

$\text{DR}_{10} = \frac{41,1 - 20,9}{41,1 - 18,9} = 91\%$
Comparison of alternatives
Base case, an overloaded digester and fiberline with oxygen delignification

1. High carry over into the bleach plant
2. High water emissions
3. Poor selectivity in the oxygen delignification
4. $\sim 7 \ E_{10}$ as pre-oxygen wash target 12-15 $E_{10}$
5. $\sim 10 \ E_{10}$ as post oxygen wash target 10-12 $E_{10}$
Comparison of alternatives
Current situation, 50 % overload

<table>
<thead>
<tr>
<th>Position</th>
<th>Digester blow (1) COD (kg/admt)</th>
<th>Pulp to decker (2) DS* (%)</th>
<th>Wash liquor to decker (3) DS (%)</th>
<th>Pulp to oxygen (4) COD (kg/admt)</th>
<th>Pulp leaving (5) COD (kg/admt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design production</td>
<td>444</td>
<td>5.1</td>
<td>4.0</td>
<td>185</td>
<td>27</td>
</tr>
<tr>
<td>Production, design + 50 %</td>
<td>842</td>
<td>8.7</td>
<td>5.5</td>
<td>326</td>
<td>96</td>
</tr>
</tbody>
</table>

* Dissolved solids in liquor
Comparison of alternatives
Pressure diffuser added

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<th>Digester blow (1)</th>
<th>Pulp to decker (2)</th>
<th>Wash liquor to decker (3)</th>
<th>Pulp to oxygen (4)</th>
<th>COD leaving (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>COD (kg/admt)</td>
<td>DS* (%)</td>
<td>DS (%)</td>
<td>Total COD</td>
<td>COD from digester</td>
</tr>
<tr>
<td>Production, Design + 50 %</td>
<td>891</td>
<td>4.4</td>
<td>3.8</td>
<td>149</td>
<td>17</td>
</tr>
<tr>
<td>Change compared to design</td>
<td>+ 6 %</td>
<td>- 40 %</td>
<td>- 31 %</td>
<td>- 54 %</td>
<td>- 82 %</td>
</tr>
</tbody>
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* Dissolved solids in liquor.
Comparison of alternatives
Wash press added to post oxygen wash

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<th>Pulp to decker (2)</th>
<th>Wash liquor to decker (3)</th>
<th>Pulp to oxygen (4) COD (kg/admt)</th>
<th>Pulp leaving (5)</th>
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<tr>
<td></td>
<td>COD (kg/admt)</td>
<td>DS* (%)</td>
<td>DS (%)</td>
<td>Total COD</td>
<td>COD from digester</td>
</tr>
<tr>
<td>Production, Design + 50 %</td>
<td>870</td>
<td>9.1</td>
<td>6.0</td>
<td>348</td>
<td>97</td>
</tr>
<tr>
<td>Change compared to design + 50 %</td>
<td>+3 %</td>
<td>-5 %</td>
<td>+10 %</td>
<td>+7 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>

Dissolved solids in liquor
Comparison of alternatives
Wash press added to the pre-oxygen wash

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<th>Pulp to decker (2)</th>
<th>Wash liquor to decker (3)</th>
<th>Pulp to oxygen (4)</th>
<th>Pulp leaving (5)</th>
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<tr>
<td></td>
<td>COD (kg/admt)</td>
<td>DS* (%)</td>
<td>DS (%)</td>
<td>Total COD</td>
<td>COD from digester</td>
</tr>
<tr>
<td>Production, Design + 50 %</td>
<td>886</td>
<td>8.9</td>
<td>4.0</td>
<td>167</td>
<td>24</td>
</tr>
<tr>
<td>Change compared to design + 50 %</td>
<td>+ 5 %</td>
<td>+ 2 %</td>
<td>- 27 %</td>
<td>- 49 %</td>
<td>- 76 %</td>
</tr>
</tbody>
</table>

* Dissolved solids in liquor.
Which option is best?

1. Why add a pressure diffuser?
   I. High solids can cause operational disturbances on a decker, typically foaming and poor dewatering.
   II. A high carryover into the oxygen has a negative impact on the selectivity and increases the chemical consumptions.

   In cases as above a pressure diffuser after the digester, makes the most sense. It also has a small footprint.

2. Why add a wash press to the post oxygen washing?
   I. If COD to the bleach plant is a concern is important and the selectivity in the oxygen delignification is acceptable, a wash press added to the post oxygen washing makes most sense.

3. Why add a wash press before the oxygen delignification?
   I. If the selectivity in the oxygen is poor and the decker and screen room can handle an increased dry solid, a wash press added in the pre-oxygen washing position makes most sense.
Conclusions

1. When choosing between a wash press and a pressure diffuser the core problem must be understood. Both devices are good options.

2. When evaluating a solution, defining the system borders is important. Without properly defined borders it is impossible to evaluate and re-calculate an existing wash line.

3. Real estate, machine footprint, pipe lengths and the need for additional tanks will always be a factor when choosing an improvement option.