Pulp & Paper Mill Enhancements for Green Productivity Benefits

2017 IPPTA AGM, Chennai, India
Brendan van Wyk, Alexis Métais, & Narain Madhavan
New pollution control measures require mills to:

- Reduce COD discharge
- Reduce effluent colour
- Reduce effluent volume
- Strive for Zero Discharge
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClO₂, kg/adt</td>
<td>14.4</td>
</tr>
<tr>
<td>H₂O₂, kg/adt</td>
<td>2.8</td>
</tr>
<tr>
<td>NaOH, kg/adt</td>
<td>12</td>
</tr>
<tr>
<td>Effluent Vol. m³ / adt</td>
<td>12</td>
</tr>
<tr>
<td>COD, kg/adt</td>
<td>28</td>
</tr>
<tr>
<td>Colour, kg/adt</td>
<td>13</td>
</tr>
</tbody>
</table>

Introducing Ozone Bleaching

Ozone bleaching benefits include:

- Lower bleaching chemical costs:
  - ozone has similar cost to chlorine dioxide, but 1.7 higher oxidation power
- Lower brightness reversion
  - thanks to ozone action on HexA
- 10% lower energy requirements for refining
- Significant reduction in COD, AOX colour discharge
Z-ECF Bleaching Sequences

- Z/D-Eop-D and Ze-D-P, for kraft pulp mills producing paper grades

- Z/D-Eop-D and Ze-D-P, for swing kraft pulp mills producing alternatively viscose and paper grades

- A-Z-P, Z/Q-P or Zq-P for kraft pulp mills producing only viscose grades

- Eop-Z-P for sulfite pulp (without prior oxygen delignification in the case of hardwood)
High Consistency (HC), 40% Pulp Consistency

Medium Consistency (MC), 10% Pulp Consistency
HC Ozone Bleaching

Courtesy of Valmet ©
Typical Ze-D-P bleach plant from Valmet ©
Lower Environmental Impact

**Effluent volume and load**
-Lower effluent volume with HC ozone

<table>
<thead>
<tr>
<th>Press based bleach plant</th>
<th>$D_{ht}(EOP)$DD</th>
<th>$(Ze)DP$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effluent volume, m$^3$/odt</td>
<td>11-12</td>
<td>5-10</td>
</tr>
<tr>
<td>COD, kg/odt</td>
<td>28</td>
<td>12-22*</td>
</tr>
<tr>
<td>AOX, kg/odt</td>
<td>0.4</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Color, kg/odt</td>
<td>13</td>
<td>7-11*</td>
</tr>
</tbody>
</table>

*Variation depends on how much (Ze)-filtrate is recycled to POW*

Source: “Follow-up and Highlights of Today”, Maria Wennerström, 3rd ZeTrac Forum, 2011
MC Ozone Bleaching

1. Dropleg
2. MC-pump
3. AZ ozone mixer
4. AZ ozone mixer
5. Ozone reactor
6. Reactor discharger with gas removal
7. Fiber scrubber
8. MC blow tube
9. MC-pump

Courtesy of ANDRITZ
Typical ZD-Eop-D bleach plant from ANDRITZ
Typical ZD-Eop-D bleach plant from ANDRITZ

Pulp final brightness 90 % ISO
ClO\textsubscript{2}, act Cl 15 kg/adt
NaOH 9 kg/adt
O3 5 kg/adt
H2O2 3 kg/adt

Effluent values:
COD 22 kg/adt
AOX <0.15 kg/adt
Volume 12 m\textsuperscript{3}/adt
Colour < 5 kg Pt/adt

RAMARK, H, Bleaching of Pulp with an MC Ozone Stage, Proceedings of China Paper 2012 Conference, Shanghai
Excellent Pulp Quality

Mixed European Hardwood
混合欧洲阔叶木浆  6 kgO₃/adt

Economics

<table>
<thead>
<tr>
<th>Molecular weight</th>
<th>e/mol for reduction to Cl₂ and O², resp.</th>
<th>g/mol e</th>
<th>OXE/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl₂</td>
<td>2</td>
<td>35.46</td>
<td>28.20</td>
</tr>
<tr>
<td>ClO₂</td>
<td>5</td>
<td>13.49*</td>
<td>74.12b</td>
</tr>
<tr>
<td>NaClO</td>
<td>2</td>
<td>37.22*</td>
<td>26.86b</td>
</tr>
<tr>
<td>O₃</td>
<td>4</td>
<td>8.00</td>
<td>125.00</td>
</tr>
<tr>
<td>H₂O₂</td>
<td>2</td>
<td>17.01</td>
<td>58.79</td>
</tr>
<tr>
<td>O₃</td>
<td>6</td>
<td>8.00</td>
<td>125.00</td>
</tr>
</tbody>
</table>

* = 35.46 g active chlorine/mol e
b = 28.20 OXE/kg active chlorine

125 / 74.12 = 1.7
Each kg ozone replaces 1.7 kg chlorine dioxide.

Source: “Oxidation Equivalents, OXE, an Alternative To Active Chlorine”, Roland Grundelius, Vol. 76, No. 1, TAPPI Journal
Economics

Chlorine dioxide Cost: 115 INR/kg

Power Cost : 7 INR/kWh
Oxygen Cost : 8 INR/kg

1 kg Ozone requires 10 kWh and 8.3 kg Oxygen

therefore

1 kg Ozone costs \( (10 \times 7) + (8.3 \times 8) \)

\[ = 136.4 \text{ INR/kg} \]

Additional power of 1.5 kW/kg ozone is required for compression for MC bleaching

\[ 136.4 + 7 \times 1.5 = 146.9 \text{ INR/kg ozone compressed} \]
Economics

A 5 kg/adt O3 Dose would replace 8.5kg pure ClO2

\[(5 \times 1.7 \times 115)\text{ClO}_2 - (5 \times 146.9)\text{O}_3\]

\[=\]

243 INR/adt Chemical saving

243 x 1,000 adt/day

\[=\]

243,000 INR/Day Savings.

Therefore

Considering Investment costs in a full ozone bleach stage
ROI can be calculated at between 2 to 4 years
Color Removal in Final Effluent of Bleached Kraft Pulp Production

Example with a 350 mgCOD/L secondary effluent

Ozone dosage in mg/L of:
0 20 30 50 100 200 300
Ozone Action on Biological Effluent

Discoloration is the first noticeable phenomenon

Graph showing the relationship between O₃ dosage [g/m³ wastewater] and Colour [m⁻¹].

- Fast decolourization
- Slow decolourization

Lines for:
- MILL A (blue)
- MILL B (red)
- MILL C (green)
Ozone reacts with hard COD
Part of the hard COD is converted to BOD.

It results in an increase of the BOD/COD ratio and therefore of the effluent biodegradability.
Hard COD Removal in Final Effluent

3 installations in the PPI:
- UPM Ettringen and UPM Plattling in Germany
- Heinzel Laakirchen in Austria.
LEOPOLD Ultrascreen for solid loading reduction and polishing

The Ultrascreen® is a microfilter produced by Nuvoe Energie with a 20 micron SS 316L mesh and a SS 304 body that works on the tangential filtration principle. It has a plug and play design and could aid in final polishing. It supports TSS and BOD reduction in tertiary applications. Has the highest loading capacity in the industry.

LEOPOLD Conoscreen for solid recovery and loading reduction

The Conoscreen® is an extremely simple microfilter by Nuvoe Energie and is really efficient. It follows the “tangential filtration” principle. The feeding flow to the conical discs (where the filtering meshes are installed) occurs parallel to the filtration surface, differently to the other filters, where the filtration principle is of “deep-type” and orthogonal to the flow. All SS304 body. Mesh size of 250 and 500 micron.

LEOPOLD TYPE XA™ & TYPE S® FAMILY OF UNDERDRAIN

Underdrain is used to support media during filtration and to uniformly distribute backwash air and water when the filtration media needs to be cleaned. Leopold has designed a water recovery channel into its Type S® technology underdrain to help ensure uniform and continuous airflow from all of the top deck orifices. The water recovery channel is designed to allow water to re-enter the underdrain to equalize the low-pressure areas. The results of Type S technology are:
• Airflow range is 1 to 5 scfm/sf
• Low water maldistribution – less than 5 percent (total)
Conclusions

For a mill using ECF bleaching looking to improve their environmental impact while increasing production, the Best Available Technology is the installation of an Ozone (Z)stage in the bleach plant, this will:

- Reduce effluent volumes
- Reduce COD loads
- Improve Colour
- Reduce AOX

While
- Reducing chemical costs
- Improving pulp quality
Sustainable development is your ambition…

Ozone bleaching is our solution!

Thank you for your attention!

Fibria Jacarei, Brazil