Comparison of Alternatives for Green Liquor Handling

Recausticizing Overview

- Smelt dissolving tank
- Green liquor handling
- Slaking
- Causticizing
- White liquor separation
- Lime mud washing
- Lime mud dewatering
- Calcining
- Lime mud

Innovation by experience
Purpose of Green liquor handling

To produce green liquor with a low dregs content

Dregs Composition

Typical dregs content in raw green liquor is 700-1500 mg/l

Dregs are composed of:
- Unburnt carbon from the recovery boiler
- Trace elements (NPE) from wood chips and purchased lime, magnesium added to O2-delignification and/or bleach plant P-stage
- Recirculated lime mud in the weak wash liquor
Non Process Elements

- Trace elements which are undesirable in the process (ex. chloride, potassium, phosphorous, silica, aluminum, magnesium, iron, manganese)

- Main sources
  - Wood
  - Purchased lime
  - Water
  - Magnesium used in O2-delig stage and/or bleach plant P-stage

Potential problems

- Chloride, potassium
  - recovery boiler plugging and corrosion
- Silica, magnesium
  - reduces lime mud filterability
- Silica, aluminum
  - aluminum-silica scaling in evaps
- Calcium, barium
  - scaling in digester and pulp washers
- Manganese, iron, copper
  - negative impact on peroxide bleaching
- Phosphorous, silica, magnesium, manganese, iron
  - high deadload in the lime cycle; reduced capacity, increased energy consumption
Nonprocess elements
Relative Solubility in causticizing

<table>
<thead>
<tr>
<th>Solubility</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble</td>
<td>chloride, potassium</td>
</tr>
<tr>
<td>Insoluble</td>
<td>calcium, magnesium, manganese, iron, barium</td>
</tr>
<tr>
<td>Partially soluble</td>
<td>aluminum</td>
</tr>
<tr>
<td>Soluble in green liquor</td>
<td></td>
</tr>
<tr>
<td>Soluble in white liquor</td>
<td>Silva</td>
</tr>
<tr>
<td>Partially soluble in white liquor</td>
<td></td>
</tr>
<tr>
<td>Insoluble in white liquor</td>
<td>phosphorous</td>
</tr>
</tbody>
</table>

Dregs carryover

- Reduces sedimentation rate and filterability of lime mud, which reduces the capacity of white liquor and lime mud filters
- Increases the requirement of purge and make-up lime

“Rule of Thumb”
A 50 mg/l increase in the dregs content of green liquor to the slaker increases the amount of purchased lime required to maintain the same lime mud properties by 4-7 kg CaO/190
Raw green liquor

Properties of raw green liquor which affect efficiency of dregs removal:
- Total titrable alkali, TTA
- Liquor temperature
- Liquor density
- Dregs particle density
- Dregs particle diameter
- Suspended solids content

An equalization tank helps minimize variations in raw green liquor properties

Process Alternatives

Clarification
- Conventional clarifier
- Compact clarifier

Filtration
- Cassette filter
- Crossflow filter
- Pressure disc filter
- (Converted tube filter)
- (Microfiltration)
Clarification
Separation of dregs from green liquor through density difference

\[ V_s = \frac{(\rho_s - \rho_l)D^2g}{18\mu} \]

Particle density \quad Liquor density \quad Particle diameter

Gravitational constant

Liquor viscosity

Conventional Clarifier
Typical rise rate max 0.5 m/h

- Drive mechanism for scraper
- Storage for clarified liquor
- Ring header
- Dregs bed
- Rake
Typical rise rate: max 2 m/h

- Polymer addition and flocculation turbine
- Even flow distribution at discharge
- Distributor arms ensure even feed over clarifier area

Clarification - potential operating problems
Poor dregs settling, high dregs content in clarified liquor

Possible causes:
- TTA of unclarified green liquor is too high
- Unclarified green liquor has uneven density or temperature
- Uneven flow to the clarifier
- High dregs content with unburnt carbon from the smelt dissolving tank
- Overdosing of MgSO_4 in O2-delig or bleach plant

Actions:
- Tuning of the smelt dissolving tank level and density control
- Addition of flocculant
- Tuning of the recovery boiler, especially primary air system
- Optimize MgSO_4 usage
**Filtration**

![Diagram of Filtration](image)

Filtrate flow = \( \frac{dV}{dt} = \frac{A^2dP}{\mu(\alpha'cV + R_m A)} \)

- **Filter area**
- **Differential pressure**
- **Liquor viscosity**
- Mass of filter cake
- Volume of filter cake
- Filter media's resistance (filter, filter cloth and/or precoats)
- Specific filtration resistance

*Depends on particle size and surface loading, concentration etc.*

**Cassette filter**

Typical load: 0.5 – 0.8 m³/m²h

![Diagram of Cassette Filter](image)
Cassette filter

- Cake forming filtration with drainage of liquor from the filter before backwashing
- Backwash with hot water and compressed air
- Filter cake dryness before backwash approx. 30% (prewash of dregs)
- Relatively sensitive to dregs filterability

Crossflow Filter

Typical load: 0.35 - 0.40 m³/m²h
Crossflow Filter

- Filtration without cake formation. In theory, filtration is not affected by filterability of the dregs.
- Falling film, with a large recirculation flow
- Dregs discharged at 2-4% dry solids (relatively good dregs washing)
- Hot water washing at regular intervals.

Disc filter

Typical load: 1.5-1.7 m³/m² h
Disc filter

- Cake forming filtration with lime mud precoat
- Discharge dregs with 55-65% dry solids; no separate dregs filter is required
- Cake washing on the filter is at the expense of a more dilute green liquor.

Filtration - potential operating problems

Reduced filter throughput; plugging problems

Possible causes:
- High dregs content with unburnt carbon from the smelt dissolving tank
- TTA of unclarified green liquor is too high
- Insufficient filter washing
- Overdosing of MgSO₄ in O2-delig or bleach plant

Actions:
- Tuning of the recovery boiler, especially primary air system
- Tuning of the smelt dissolving tank level and density control
- Addition alum to the weak wash
- Addition of lime mud
- Optimize filter washing sequence (frequency and duration)
- Optimize MgSO₄ usage
Equipment selection
Factors to consider

- Green liquor and dregs quality
- Layout
- Auxiliary equipment requirements
- Costs – investment, operating, maintenance
- Other

Green liquor and dregs quality
Expected performance

<table>
<thead>
<tr>
<th></th>
<th>Green liquor suspended solids mg/l</th>
<th>Dregs dry solids %</th>
<th>Dregs alkali content % NaOH on DS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional clarifier</td>
<td>50-100</td>
<td>5-7</td>
<td>20-25</td>
</tr>
<tr>
<td>Compact clarifier</td>
<td>30-50</td>
<td>3-5</td>
<td>20-25</td>
</tr>
<tr>
<td>Cassette filter</td>
<td>max 20</td>
<td>1-2</td>
<td>2-3</td>
</tr>
<tr>
<td>Crossflow filter</td>
<td>max 20</td>
<td>2-4</td>
<td>~4</td>
</tr>
<tr>
<td>Disc filter</td>
<td>max 20</td>
<td>50-60</td>
<td>5-6</td>
</tr>
</tbody>
</table>
**Layout**

Relative footprint (~13000 m$^3$/d green liquor)

- Conventional clarifier 2*30 m diameter
- Compact clarifier 20 m diameter

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**Auxiliary Equipment Requirements**

- Raw green liquor equalization tank
  - Approximately 2.5 hours retention time with a clarifier
  - Approximately 6 hours retention time with a filter
- Dregs handling equipment
  - No dregs filter required with green liquor disc filter (unless a lower residual alkali content is required)
  - Washing / Dewatering requirement varies, depending on the type of green liquor handling
- Clarified liquor storage tank
  - Required in all cases, except for conventional clarifier with storage
Relative Operating Costs
assuming normal operation and load

<table>
<thead>
<tr>
<th></th>
<th>Conventional clarifier</th>
<th>Compact clarifier</th>
<th>Cassette filter</th>
<th>Crossflow filter</th>
<th>Disc filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flocculant</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Lime mud precoat</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Power</td>
<td>low</td>
<td>low</td>
<td>higher</td>
<td>higher</td>
<td>Highest (compressors)</td>
</tr>
<tr>
<td>Acid (washing)</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Compressed air</td>
<td>low</td>
<td>low</td>
<td>higher</td>
<td>higher</td>
<td>higher</td>
</tr>
</tbody>
</table>

Relative Maintenance Costs

- A Clarifier has less equipment that requires routine maintenance compared to a filter; however, problems with clarifiers can result in lengthy downtime and expensive repairs
- Filters require routine filter cloth changes
Investment cost considerations

- Capacity
- Number of units required
- Dregs handling equipment
  - existing?
  - No dregs filter required with green liquor disc filter
- Equalization /Clarified liquor storage tanks
  - Existing?
- Space availability

Other factors to consider

- Equipment robusticity / dependability
- Ease of operation
- Control system
- Equipment complexity
Green liquor handling - installations

Trend...