Sustained performance improvement

Pulp Mill Analyzers Measurements and Process Optimizers
Valmet
Unique Process Performance Supplier

• 300 complete fiber lines and 350 recovery islands delivered
• Majority of World’s pulp is produced with Valmet Process Solutions
• Customers safety and performance is our primary focus in product development and offering
• Daily on site process performance support available
• Our offering is fully integrated to Industrial Internet

Very wide global process and benchmarking knowledge
Near 300 Advanced Process Controls & Over 40 000 Analyzers and Measurements delivered
## Sustainable performance

How customized control solutions can impact the process

### Cost reduction
- Energy consumption reduction
- Power contract management
- Chemical cost reduction

### Production increase
- Process yield improvements
- Process debottlenecking

### Quality and process variability reduction, and optimization

### Reduced environmental impact
Practical Steps of Control Project

Understanding the need

Process improvement study
• Evaluation of the potential, scope and define the ROI
• Agreement of the project targets

Project phase
• Operator interviews
• Final control design
• Reporting and monitoring tools
• Commissioning, training, final tuning
• Test run, project acceptance

Support and enhancement
• Onsite and remote support, performance follow-up, improvement and reporting
• Development meetings
• Targets for the following year
Covering the entire process
Advanced controls

**Distributed control system (DCS)**
- Process controls
- Machine controls
- Drive controls
- Information management

**Performance solutions**
- Advanced process controls
- Energy efficiency monitoring
- Condition monitoring
- Process simulators
- Safety systems and solutions

**Quality control system (QCS)**
- Profilers
- Analyzers and measurements
- Vision systems
- Pulp web inspection
- Pulp web break analysis

Industrial internet solutions
Automation services
Analyzers and measurements for chemical pulping

Consistency Management
- Valmet ROTARY
- Valmet MCA
- Valmet OC
- Valmet SP
- Valmet NOVE samplers

Process Management
- Valmet Conductivity
- Valmet Recovery Analyzer
- Valmet AT ClO2 & SO2
- Valmet Cooking Analyzer
- Valmet Kappa QC Analyzer
- Valmet Filtrate Extractor with pH
- Valmet Cormec5X
- Valmet Polarox5
- Valmet Polarox5P
- Valmet CBA

Quality Management
- Valmet DCD
- Valmet PulpExpert
- Valmet MAP
- Valmet FS5
- Valmet MR Moisture
How many APC customers globally?

Close to 300 optimizers by Valmet and estimated 100-200 by other suppliers

Batch cooking: 20
Continuous cooking: 22
Washing: 11
O2 delignification: 9
Bleaching: 40
Evaporation: 14
Recovery boilers: 42
Causticizing: 43
Lime kilns: 25
TMP and BCTMP: 22
Recycled fiber: 9
Brightness: 12
Stock preparation and Stock blending: 2
Valmet Alkali Analyzer Installations

Total 235

- Canada: 6 1
- USA: 39 11
- South America: 19 4
- Scandinavia: 39 11
- Europe: 23 2
- Russia: 2 2
- Japan: 48
- Asia: 7
- Africa: 1
- Oceania: 2 1

Valmet Recovery Analyzer: 183
Valmet Cooking Analyzer: 33
Valmet CLO2 & SO2 Analyzer: 16
Alkali-R for Causticizing Optimizer

Timo Laurila
Recovery Line Analyzers and APC
January 10 2017
Valmet Causticizing Optimizer

• Reduced TTA Standard Deviation of up to 50%
  • Allow higher TTA target
• Reduced White Liquor Strength Variability of up to 50%
  • Allow higher CE target
• Elimination of Over Liming
• Reduced Equipment Plugging
• Stabilized Lime Mud Solids
• Reduced Plant Hydraulic Loading
• Reduced Plant Dead Load

• Typical Annual Savings 300 000 € to +1 000 000€
Valmet Causticizing Optimizer

Benefit mechanism

**KEY BENEFITS**
- Increased Causticizing Efficiency
- Increased White Liquor Strength
- Reduced Hydraulic Loading
- Reduced Process Dead Load

**Green Liquor TTA Controls**
- Lime/Green Liquor Controls
- CE% Controls

**TTA Variability Reduction**

**CE% Variability Reduction and Increase**

**Less Green Liquor Line Fouling**
- Decreased Hydraulic Loading

**Higher White Liquor Strength**
- Less Digester Steam
- Lower Evaporation Load
- Less inorganic and higher BL heat value

**Before**
- White Liquor Strength

**After**
- White Liquor Strength
Valmet Alkali-R
Online Laboratory measurements available from day one

- Provides absolute liquor chemistry titration results
- No calibration needed – online measurements available from day one
- Flexible analyzer platform and sample line structure
  - Single or dual titration module
  - Sampling points from 1 up to 16
- Automatic flushing and acid washing sequences
- Can be used to measure manual liquor samples
- Rugged design ensures high uptime (98%) and low maintenance (clear maintenance program)
- DCS and remote communication tools

Mill proven in over 600 sampling locations
Causticizing Optimizer
Best practice instrumentation with Alkali-R Analyzer

• Controlled variables:
  – Dissolving tank density
  – Green liquor density
  – Reburned lime screw speed
  – Purchased lime screw speed
  – Green liquor temperature

• Measured variables:
  – Green liquor from dissolving tank, absolute Valmet Alkali R values
  – Dissolving tank density
  – Dissolving tank temperature
  – Green liquor flow to slaker
  – Green liquor temperature
  – Green liquor density
  – Green liquor to slaker, absolute Valmet Alkali R values
  – Slaker temperature (at the top of the slaker, close to outlet)
  – Lime screw speeds (reburned and purchased)
  – After slaker/first causticizer, absolute Valmet Alkali R values
  – After last causticizer absolute, Valmet Alkali R values
Optimizing Controls
Benefits & Interactions, Causticizing

**Cooking**
More stable white liquor quality
Enables higher yield and pulp quality

**Lime Kiln**
by avoiding overliming,
lime mud DS% can be increased and stabilized
Less energy usage
More production

**Evaporation**
Stronger white liquor increases black liquor recirculation resulting in evaporation load decrease

**Recovery Boiler**
Stronger white liquor results in decreased
Water flow into recovery boiler furnace
Higher CE% means less inorganic material in black liquor higher heat value of liquor, increased steam generation

**Causticizing**
CE% deviation before 2 - 4.5
after 0.9 - 1.4
TTA deviation before 4 - 6 g/l
after 1.2 - 2 g/l
Enables highest possible white liquor strength without overliming
(Goodwing curve /green liquor system scaling)
Typical Sampling Locations
Alkali-R

- Dissolving Tank
  - GL from dissolving tank
  - Equal. tanks
  - PDG filter or GL clarifier
  - Dregs

- GL tank
- GL cooler

- GL to Slaker
  - Hot water
  - Warm water
  - Grits

- 1st Causticizer
- Make-up lime
- 954t/d Burnt lime

- After Last Causticizer

- White Liquor to Cooking
  - WW to dissolving tank
  - WL to digester

- Cond. from PDW filter

- LM tanks
- DLM
- Spill tank
- WW tank
- WL tank

- Alkali-R Sampling point

Valmet
Dissolving tank Na2CO3 Optimization

Maximum GL TTA concentration and GL system cleanability

- Operation marginal
  
  + Analyzed NaOH, Na2S

Maximum Na2CO3 concentration calculation below crystallization limit

Density target calculation

Optimized TTA target

TTA components

Maximum TTA

f(x)

Na2CO3

Na2S

NaOH

TTA g/l (Na2O)
White Liquor Concentration Optimization
Maximum WL CE and overliming elimination

Dissolving tank TTA Optimization

GL TTA fine tuning

GL density target

Abs. FW of GL
Quality
Rel. & fast FB of reaction
dT

Abs. FB of lime reaction

Abs. FB of WL Quality

White Liquor CE target Optimization
1st causticizer CE target calculation

Lime need calculation and correction

GL / CaO ratio control

Abs. FB of lime reaction

Alkali-R Sampling points

To WL handling
Causticizing Balance Change example
White liquor concentration optimization

Present AA 128 g/l (NaOH)
Future AA 136 g/l
Future AA 144 g/l

TTA 155 g/l
CE 75 %
S 30%
(Na2S/TTA)

TTA 165 g/l
CE 75 %
S 30%

TTA 165 g/l
CE 82 %
S 30%

6.1% less WL
2.9% less water to evaporation

11.3% less WL
4.7% less water to evaporation

WL F to cooking
Balance example, 1000 Adt/d

Total energy savings:
262GJ/d, 6$/GJ, 350days/a = 550 k$/a

- **Cooking**: 30 GJ/d less steam
- **Evaporation**: 200 GJ/d less steam
- **Boiler**: 59 GJ/d more steam
  - 4.4% higher heat value
  - 3.5% less heat loss from smelt
- **Kiln**: 27 GJ/d more energy
  - 10.1% more retention
  - 1.51% more lime needed

**Total energy savings**: 262GJ/d, 6$/GJ, 350days/a = 550 k$/a
White liquor EA variability reduction
Burgo Ardennes mill, Belgium

Background
- The Burgo Ardennes mill produces 400,000 TPY of mixed hardwood bleached kraft pulp
- Some pulp is consumed in the integrated coated paper mill and the remainder is sold externally

Challenge
- High white liquor effective alkali variation
- Aim was to reduce white liquor TTA and CE% variability and increase EA concentration
- Stable quality allow to go higher CE% without overliming

Our Solution of Advanced Process Controls
- Audit defined instabilities, targets and solutions
- Valmet Recovery liquor analyzer and Causticizing Optimizer
- Performance Service Agreement
- Remote Support service, 24/7 help available

Valmet implemented measurement and control solutions to solve variations and lower costs.

Results:
- TTA variability reduced by 64%
- CE% variability reduced by 65%
- Increased white liquor concentration and reduced water flow to evaporation

“Causticizing project paid back in less than one year. Lime kiln operation is now better and fresh lime consumption has been significantly reduced”

Michel Hartman, Mill Manager
## Results: Brazilian SW Mill

### Benefits & Interactions

#### Causticizing Optimizer Test run results

<table>
<thead>
<tr>
<th>Value</th>
<th>Baseline</th>
<th>Guarantee</th>
<th>Result (ABS)</th>
<th>Result</th>
<th>Fulfilment</th>
</tr>
</thead>
<tbody>
<tr>
<td>White liquor CE%</td>
<td>79.4</td>
<td>82.0</td>
<td>82.3</td>
<td>+2.9 CE%</td>
<td>111.5%</td>
</tr>
<tr>
<td>White liquor AA (g/l)</td>
<td>133.76</td>
<td>140.0</td>
<td>140.9</td>
<td>+ 7.14 g/l</td>
<td>114.4%</td>
</tr>
<tr>
<td>White liquor AA deviation</td>
<td>2.03</td>
<td>-35.0%</td>
<td>1.22</td>
<td>- 39.9%</td>
<td>114.0%</td>
</tr>
</tbody>
</table>
Optimizing Controls
Benefits & Interactions, Lime Kiln

Lime kiln
- lower residual CaCO3 level
- lower std of residual CaCO3
- lower std of excess O2
- lower specific energy consumption
- higher product rate

Causticizing
- More stabile residual CaCO3
- Stabilizes white liquor quality
Valmet Lime Mud Moisture Measurement

**Technical specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>IQ Single-Sided IR Moisture Measurement</td>
</tr>
<tr>
<td>Measurement distance</td>
<td>up to 500 mm</td>
</tr>
<tr>
<td>Measurement range</td>
<td>0...65% moisture</td>
</tr>
<tr>
<td>Surface penetration</td>
<td>up to 100 g/m²</td>
</tr>
<tr>
<td>Accuracy *</td>
<td>±0.15% moisture</td>
</tr>
<tr>
<td>Repeatability *</td>
<td>±0.10% moisture</td>
</tr>
<tr>
<td>Environmental conditions</td>
<td>Max. temp 85 °C/185 °F, 10-95% RH, non-condensing</td>
</tr>
<tr>
<td>Measurement spot size</td>
<td>5...25 mm (depending on the measurement distance)</td>
</tr>
<tr>
<td>Signal output</td>
<td>Valmet DNA system bus; analogue 4...20 mA; or Modbus TCP/IP</td>
</tr>
<tr>
<td>Utilities</td>
<td>Instrument air 4...6 bar, 230 VAC /5 A, Cooling water 5 l/min (if environment temperature is higher than 70 °C/158 °F)</td>
</tr>
</tbody>
</table>
Solution components
Lime kiln Optimizer, Running Models

**Signals from Field Instruments**
- Kiln Recipe
  - COMBUSTION
  - Lime Recipe
    - LIME MUD FILTER

**Advanced Calculations**
- Production Rate Calculation
- Lime Recipe
  - LIME MUD
    - Flow (l/s)
    - Density (kg/l)

**Recipe Values**
- Lime mud density
- Combustion Gas Calculation

**Controlled Variables**
- Kiln rotating speed (rpm)
- Fuel consumption (GJ/tCaO)
- Primary air flow (Nm³/s)
- Excess (O₂ %)
- Fuel ratio (pri/sec)

**Primary Controlled Target**
- Residual Carbonate
- Dry solids content
- Conversion Nm³ -> rpm

Solution components
Lime kiln Optimizer, Running Models

**Solution components**
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**Solution components**
Lime kiln Optimizer, Running Models
## Solution components

**Lime kiln Optimizer, Running Models**

<table>
<thead>
<tr>
<th>Kiln Recipe COMBUSTION</th>
<th>Kiln rotating speed (rpm)</th>
<th>Fuel consumption (GJ/tCaO)</th>
<th>Primary air flow (Nm3/s)</th>
<th>Excess (O2%)</th>
<th>Fuel ratio (pri/sec)</th>
<th>Heat transfer, dust, ring</th>
<th>Lime bed temperature, energy</th>
<th>Flame optimization, energy</th>
<th>Temperature profile, energy</th>
<th>Fuel cost optimization</th>
<th>PRIMARY CONTROLLED TARGET</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RECIPE VALUES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>INTERMEDIATE TARGETS</strong></td>
</tr>
</tbody>
</table>

**Controlled Variables**
- Kiln rotating speed (rpm)
- Fuel consumption (GJ/tCaO)
- Primary air flow (Nm3/s)
- Excess (O2%)
- Fuel ratio (pri/sec)

**Primary Controlled Target**
- Residual Carbonate
Lime Kiln Optimization

Controls:
- Single Button management of production
- Lime mud controls
- LMD controls
- mud filter controls
- Lime kiln controls
- burning power
- temperature profile
- plugging prevention
- Efficiency monitoring
- production
- specific values
Lime Kiln Balance Change example
Energy efficiency and lime quality optimization

Balance Change

<table>
<thead>
<tr>
<th></th>
<th>Present 350 ton/d</th>
<th>Future 328 ton/d</th>
<th>Future 350 ton/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>282 ton CaO/d</td>
<td>282 ton CaO/d</td>
<td>301 ton CaO/d</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>9%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Other Inert</td>
<td>~5.0% energy savings</td>
<td>~5.0% energy savings</td>
<td>~5.0% energy savings</td>
</tr>
<tr>
<td>Present</td>
<td></td>
<td>Future</td>
<td>Future</td>
</tr>
<tr>
<td>Future</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 3% CaCO₃ increase
- 9% CaCO₃ increase
- 3% CaCO₃ increase
- ~5.0% energy savings
## Impacts to lime circulation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Impact to lime circulation</th>
<th>Impact to CaO consumption</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of Na2S or total S%</td>
<td>Na2S is active cooking chemical. Less NaOH needed for same AA.</td>
<td>Since less Na2CO3 -&gt; NaOH is needed direct CaO savings.</td>
<td>Higher Na2S and same TTA also means lower Na2CO3 concentration in GL</td>
</tr>
<tr>
<td>Increase of NaOH in green liquor</td>
<td>All GL NaOH is recirculated white liquor from lime mud filter. Recirculation increase GL flow, but not lime need/pulp ton</td>
<td>CaO consumption / M3 reduce but higher WL flow keep daily CaO consumtion the same</td>
<td>Green liquor NaOH is from lime mud washing. High weak white liquor NaOH is indicator of poor WL filtration or WL clarifier process</td>
</tr>
<tr>
<td>Increase of make-up lime and lime dust dumping. Reduction of impurities and good lime availability (85-95%)</td>
<td>Healthy amount of continuos lime replacement (5-8%) decrease amount of non reactive inert in lime.</td>
<td>No impact. Same amount of CaO is needed if GL quality and white liquor CE% target reamins the same.</td>
<td>Too low lime make up can build up heavy lead load to the circulation: 1wt% silicon formate 6wt% of calcium silicates 1wt% phosphorus formate 5wt% tricalcium phosphate</td>
</tr>
<tr>
<td>Increase of overliming</td>
<td>Overliming is unreacted Ca(OH)2 in the lime milk and after the filter in the lime mud</td>
<td>Overliming cause dead load to the lime circulation</td>
<td>Residual Ca(OH)2 makes lime mud filtration difficult and may reduce lime mud dry solids to the kiln. Lower dry solids may cause difficulties ro reach good reburned lime quality and increase CaCO3 dead load as well. If mill have white liquor clarifier, free calcium hydroxide will end to cooking and to the pulp -&gt; reduced end product quality.</td>
</tr>
<tr>
<td>High residual carbonate (CaCO3) from the lime kiln</td>
<td>Residual CaCO3 is dead load in the causticizing</td>
<td>No impact. Same amount of CaO is needed if GL quality and white liquor CE% target reamins the same.</td>
<td></td>
</tr>
</tbody>
</table>
## Impacts to lime circulation

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<th>Impact to CaO consumption</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of retention time over the causticizers, if time is <em>less than 2h</em></td>
<td>Increase of retention time over the critical limit, will reduce unreacted Ca(OH)2 in lime milk and lime mud.</td>
<td>Unreacted Ca(OH)2 is dead load over the process and back to kiln or out to the cooking.</td>
<td>Higher TTA target will increase retention time, by reducing water dead load from the green liquor.</td>
</tr>
<tr>
<td>Increase of slaker temperature if slaker temperature is <em>less than 100°C</em></td>
<td>Increase of slaker temperature with higher GL temp can increase reaction speed and drop less unreacted CaO to slaker dregs removal system</td>
<td>All reduced CaO waste as an dregs out from the slaker is reduced CaO need</td>
<td>This is theoretical but possible</td>
</tr>
<tr>
<td>Leak in the white liquor filter</td>
<td>Lost CaCO3 to the white liquor tank. Increase make-up need, but less lime mud to the kiln. Same lime need to causticizing.</td>
<td>No impact to CaO need, but lost CaCO3 must be repalced with make-up lime. Less lime to lime kiln.</td>
<td>High CaCO3 concentration in the lime mud will end to final product and reduce pulp quality. Increased make-up lime cost</td>
</tr>
<tr>
<td>Too much make-up NaOH to the white liquor tank</td>
<td>Too much make-up NaOH, reduce white liquor need from causticizing.</td>
<td>Less Na2CO3 -&gt; NaOH conversion needed, less CaO needed</td>
<td>Over dosing of NaOH make-up is expensive way to reduce lime need</td>
</tr>
<tr>
<td>Very hard shell (sintrated) lime granulates from the lime kiln</td>
<td>Poor reaction and part of the granulates dumped out as an dregs from the slaker</td>
<td>Causticizing reaction need same CaO for same AA, but part of the CaO is lost as an dregs from the slaker</td>
<td>Not typical, but possible</td>
</tr>
</tbody>
</table>
Valmet Lime Kiln Optimizer

Control results, temperature stability

July 2016, control uptime 0.0%

August 2016, control uptime 96.3%
APC degradation without proper support

Non-supported advanced controls over time
Ensuring enhanced and sustained performance

Sustainability

- APC support and enhancement solutions
  - Process analysis and consulting
  - Continuous monitoring of performance
  - Operator training
  - System maintenance and application tuning
  - Evaluation and implementation of new solution components
  - Debottlenecking of controller constraints
  - Maximizing controller utilization
  - Proactive troubleshooting

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Maximizing performance and improving potential
Long-term Valmet Performance Solutions

Advanced process support and enhancement

System profitability

Long-term system support

System enhancement and process consulting

Controller commissioned

Time