Valmet Causticizing Optimization Case Study at Northeastern US Kraft Paper Mill

Danny Zuver

Process Optimization Engineer

Danny.zuver@valmet.com

Valmet

Agenda

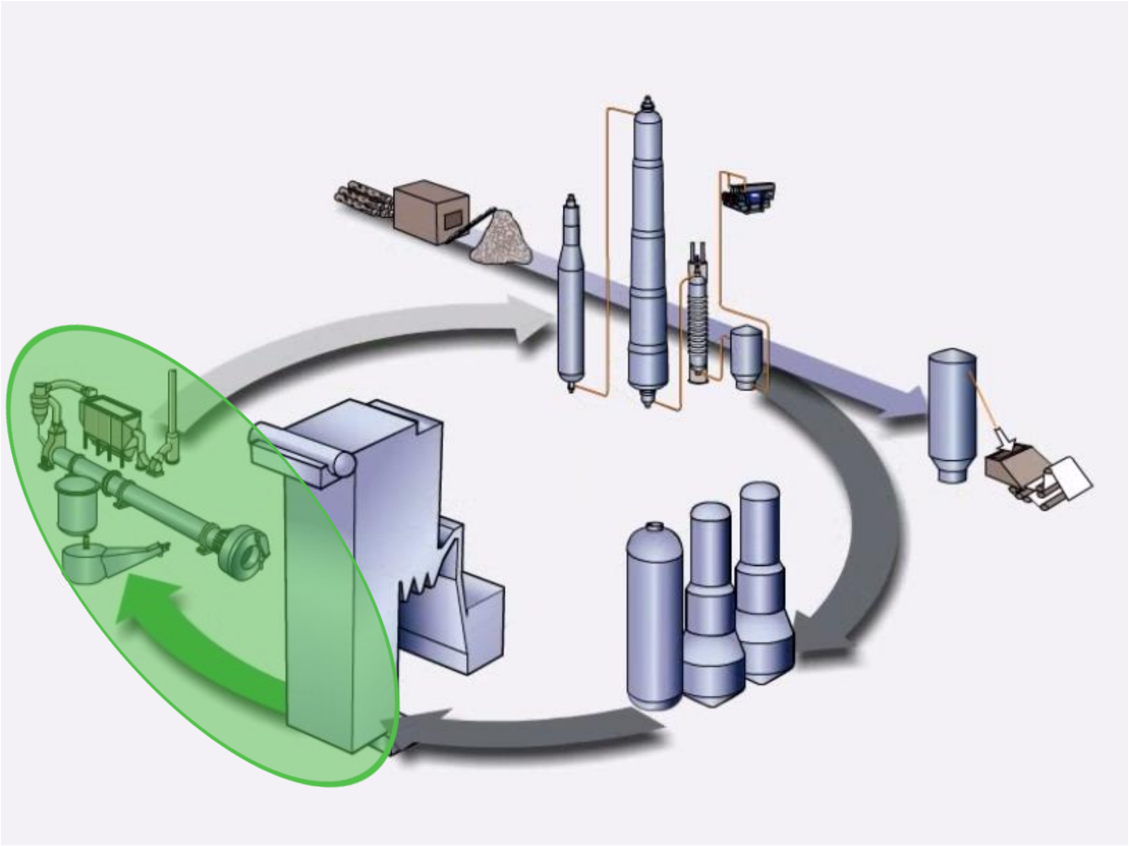
Mill Site Overview

- Located in northeastern US
- Fully integrated Kraft mill
- Produces 360,000 – 400,000 tons of uncoated freesheet and bleached hardwood and softwood market pulp
- 1 Recovery Boiler with 1 smelt dissolving tank
- 1 causticizing line with 1 slaker and 3 causticizers

© Valmet

Focus on recovery and re-causticizing

- From the dissolving tank to white liquor storage
- Process deadload takes two forms
  - Hydraulic deadload
  - Chemical deadload
- Hydraulic deadload manifests by over-dilution of green liquor or by tramp dilution in the re-causticizing area
- Chemical deadload in the form of Na_2CO_3 comes from poor conversion of GL into WL
- Reducing deadload can significantly reduce the steam requirements for the treatment of liquor throughout the liquor cycle and may lead to de-bottlenecking equipment in the recaust area



© Valmet

Managing Deadload

Measure then Manage

- Dual Titration Module Alkali-R Analyzer
  - Titrator 1 measures raw dissolving tank green liquor and GL to slaker
  - Titrator 2 measures milk of lime from 1st and last causticizer, as well as the final white liquor to digester

- Valmet Causticizing Optimizer Advanced Process Control (VCO)
  - GL TTA control via density control loops at the dissolving tank and GL to slaker
  - Causticity (CE%) controls via lime ratio control at the slaker driven by cascaded controllers
    - Slaker delta T control
    - 1st causticizer CE% control
    - Last causticizer CE% control
    - Theoretical max CE% margin controlled according to Goodwin's causticizing curve.

- Performance guarantees based on a target shift in final CE% at reduced COV and reduction in WL to digester flow

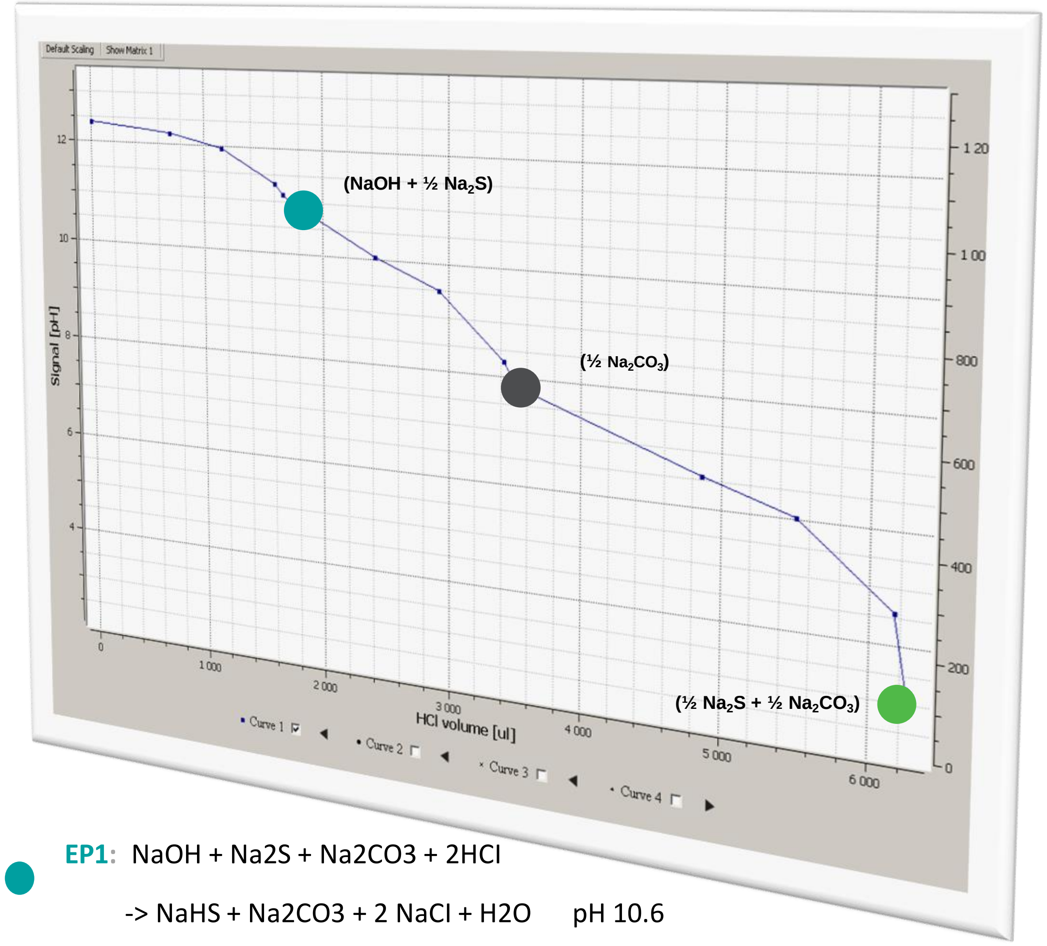
© Valmet | Danny Zuver / VCO Case Study

Valmet Recovery Analyzer (Alkali-R)

- Alkali-R measurement platform provides all the necessary measurements in one safe, convenient location
  - Automatic sampling removes the operator from hazardous environments
- The analyzer is consistently producing at least 265 full ABC titrations per day
- Reduction Degree Module Included
- User friendly interfaces for operations and maintenance
- Mill has quarterly preventative maintenance and service agreement with Valmet
- Availability since startup > 99%
- Utilization since startup > 99%

Valmet Recovery Analyzer (Alkali-R)

- Utilizes SCAN 30:85 titration method
- SCAN 30:85 is pH inflection point based rather than endpoint based and doesn't require additional chemicals such as $BaCl_2$
  - Reagent grade 1.0 N HCl is all that is needed for ABC titration
- GL titrator is equipped with reduction degree module which is capable of measuring recovery boiler reduction degree
- The analysis method is fast and precise
- Provides timely and dependable results



EP1: NaOH + Na2S + Na2CO3 + 2HCl

-> NaHS + Na2CO3 + 2 NaCl + H2O pH 10.6

EP2: NaHS + Na2CO3 + HCl

-> NaHS + NaHCO3 + NaCl pH 8.4

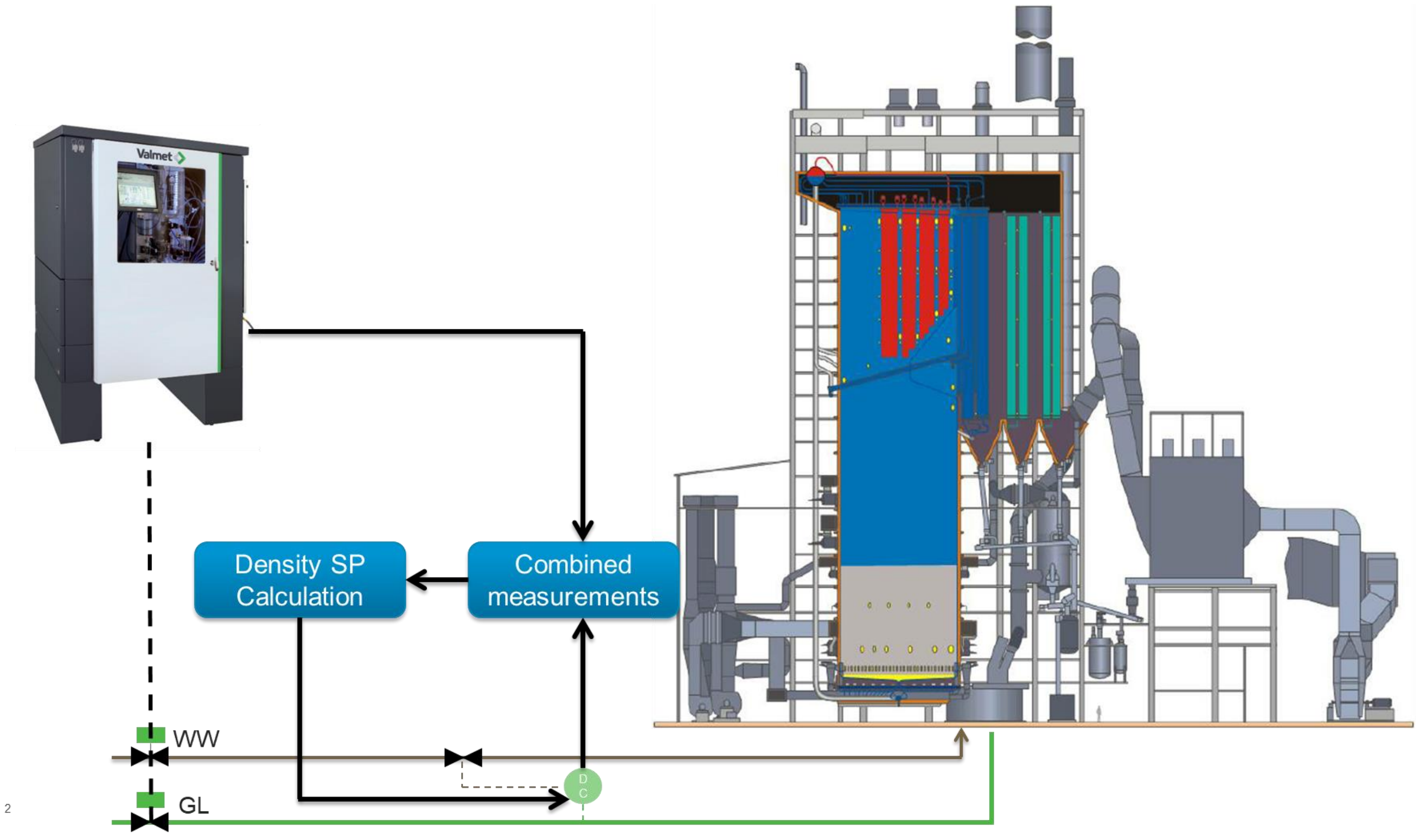
EP3: NaHS + NaHCO3 + 2 HCl

-> 2 NaCl + H2S + H2O + CO2 pH 3.8

Valmet

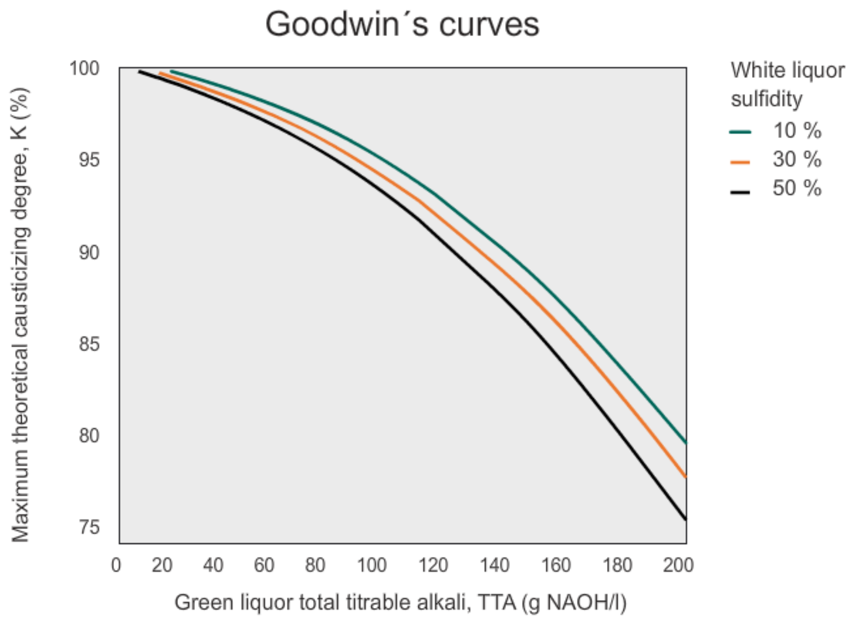
Green Liquor TTA Control

- High frequency dissolver TTA measurements provide basis for well controlled GL TTA
- Relationship between TTA (chemical density) and mill density meter (physical density) is modeled and used to control the local mill density loop
- Density meters tend to scale with pirssonite and calcite which can cause measurement drift – often resulting in TTA drifts
- TTA feedback allows for frequent and precise moves to the density controller which keeps the TTA on target
- Operators run density targets lower than optimum to maintain a safety margin to prevent scale deposits in the dissolving tank and green liquor lines
- A reduction in TTA variability prevents scale formation and allows for a target shift up in TTA



Slaker CE% Control

- Primary goal of slaker CE% control is to achieve highest CE% with respect to the theoretical maximum without over-liming
  - CE% measurements near or above the theoretical max CE% indicate over-liming in the slaker
- VCO achieves this through a series of cascade controllers that maintain the CE% to a target determined by a Theo max margin target which is set by the operator or mill management
- Lower CE% variation allows for a smaller theo max margin target
- Theo max is determined by GL to slaker liquor assay with respect to Goodwin's curves

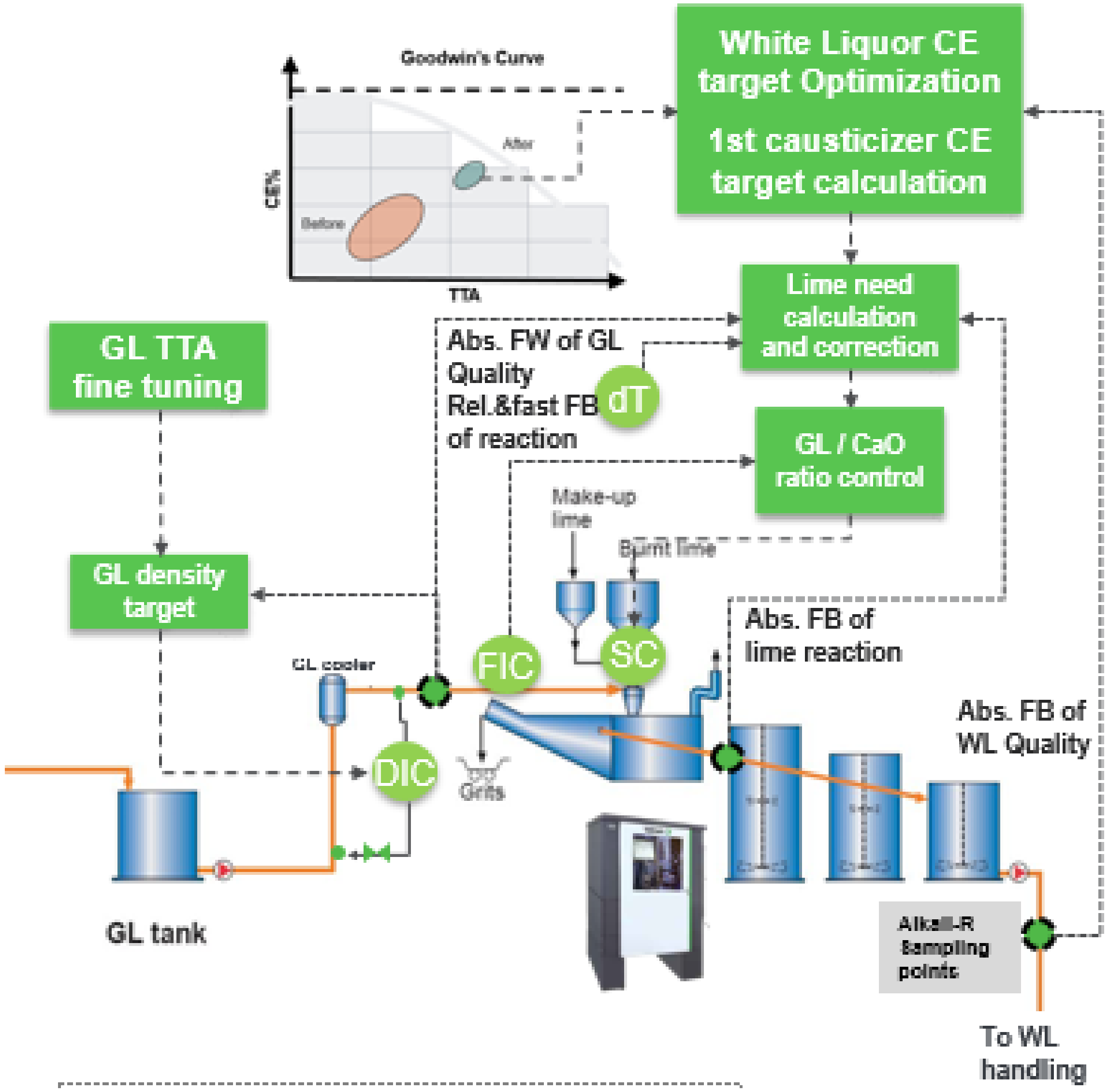


 © Valmet

OPTI Slaker CE% Control

- OPTI CE% control mode has 5 main components:
  - Last causticizer CE% target (determined by GL quality)
  - 1st causticizer or slaker CE% target (determined by Last CE% controller)
  - Slaker delta T target (determined by 1st causticizer CE% controller)
  - Lime ratio target (determined by delta T controller)
  - Reburn and purchased lime screw speed targets (determined by green liquor flow to slaker via lime ratio controller)

- Green liquor temperature can also be controlled to maximize slaker temperature short of boiling



© Valmet

OPTI CE% Control Continued

- Control loops cascade from slow to fast
  - Theo max margin → Last CE% SP (~4-5 hours)
  - Last CE% → 1st CE% SP (~3 hours)
  - 1st CE% → Delta T SP (~60-90 minutes)
  - Delta T → Lime Ratio SP (~10-15 minutes)
  - Lime Ratio → Reburn screw speed OP (~ 5-10 seconds)
- Direct lime control option if there are issues with the slaker temperature or green liquor temperature measurement
  - C1 CE% → Lime Ratio
- Disadvantage of direct lime control is that it is unable to compensate for lime quality variations in real time as they are detected by the slaker temperature probe
- Conductivity had been used in lieu of a Delta T, however it was only temporarily implemented while slaker and GL temp measurements were OOS

Pros and Cons of Conductivity Control

- Conductivity can be used as an output for the C1 CE% control
- Measurement tends to drift as the probe scales which is OK if the probe is cleaned on a regular basis
- Controls need to be turned off during probe cleanings, so maintenance needs to coordinate with the control room – if not the lime ratio will make drastic cuts when the measurement shifts after cleaning
- Valmet controls automatically account for the measurement shift once controls are turned back on which ensures a bump-less transfer for the Lime Ratio controller
- Conductivity measurement is much slower to respond to changes in lime quality compared to delta T
- Moving the measurement to the slaker bowl does not solve the problem of measurement speed because the measurement becomes too unstable and is still slower than the temp measurement

Results

- Results from a 14-day performance run were compared to a historical baseline dataset
- Performance data was also compared to Alkali-R titration data after the analyzer startup and prior to the commissioning of the VCO controls
- Data from the performance run was filtered for process availability and control uptime
- Minimal filtering was required because the process uptime was 100% throughout the performance period and the control element utilization was high
  - Dissolver TTA Control: 98.3%
  - Slaker CE% Control: 96.0%
  - Analyzer Availability: 100%
- Baseline KPI data is shown in the table below

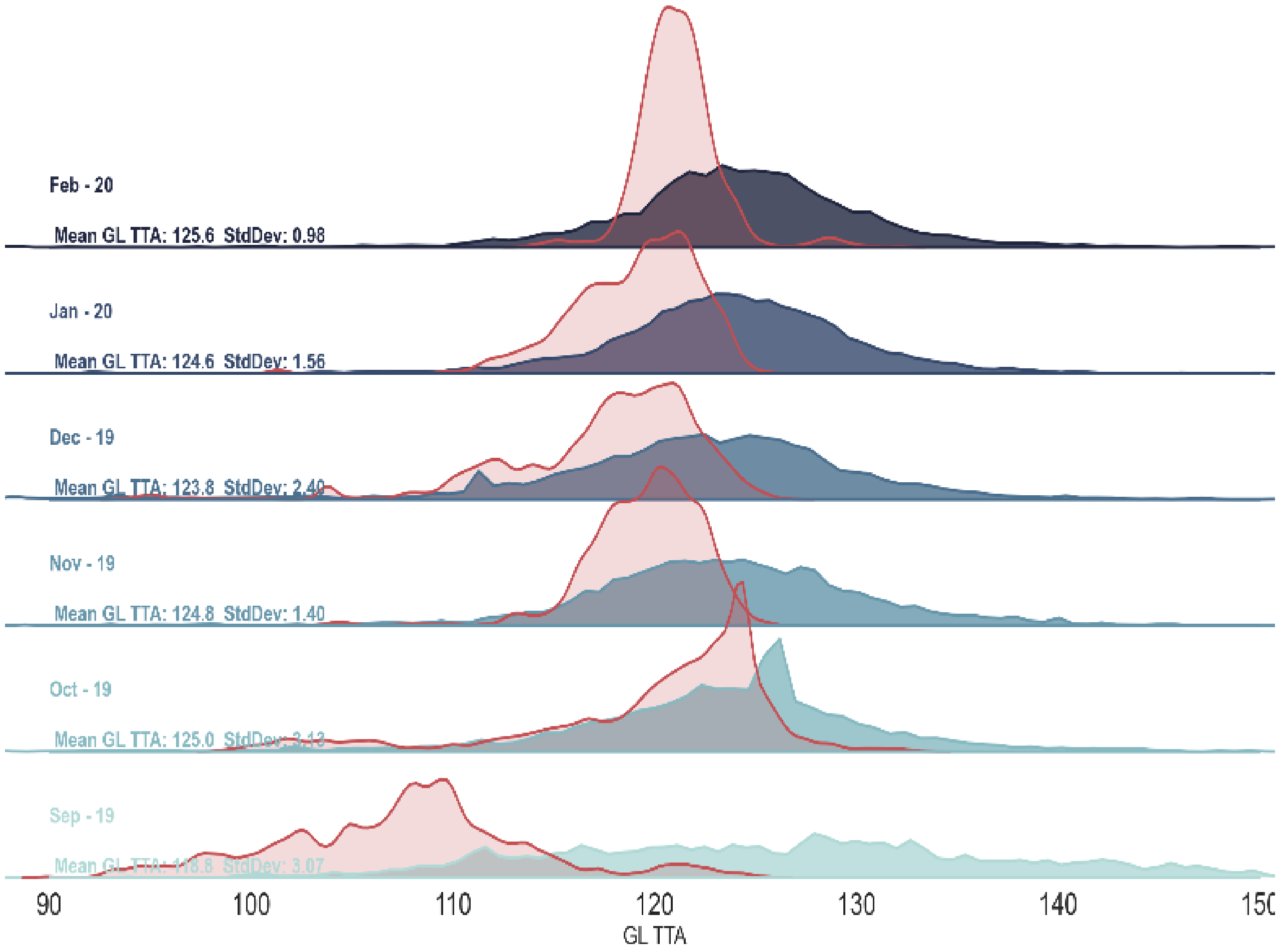
Performance Variable	Base Line Value
Causticizing efficiency coefficient of variation	2.68
Causticizing efficiency average	79.4 %
Causticizing efficiency theoretical maximum average	87.6 %
White Liquor Sulfidity average	31.4% TTA basis
White Liguor Alkali to Wood Ratio average	
Average white liquor flow	
Production rate average	740 adt/day

© Valmet

Results: Green liquor TTA

- There were a few key process optimization improvements that were made during the project phase
  - Improved filtrate management in the recaust area
  - Removing tramp dilution around green liquor clarifier and eliminating trim dilution of GL to slaker
  - Dissolver density measurement was scaled improperly making density unusable – instrument was re-scaled and the density loop re-tuned for more responsive control

- Chart at right shows the GL TTA variability reduction over the project phase



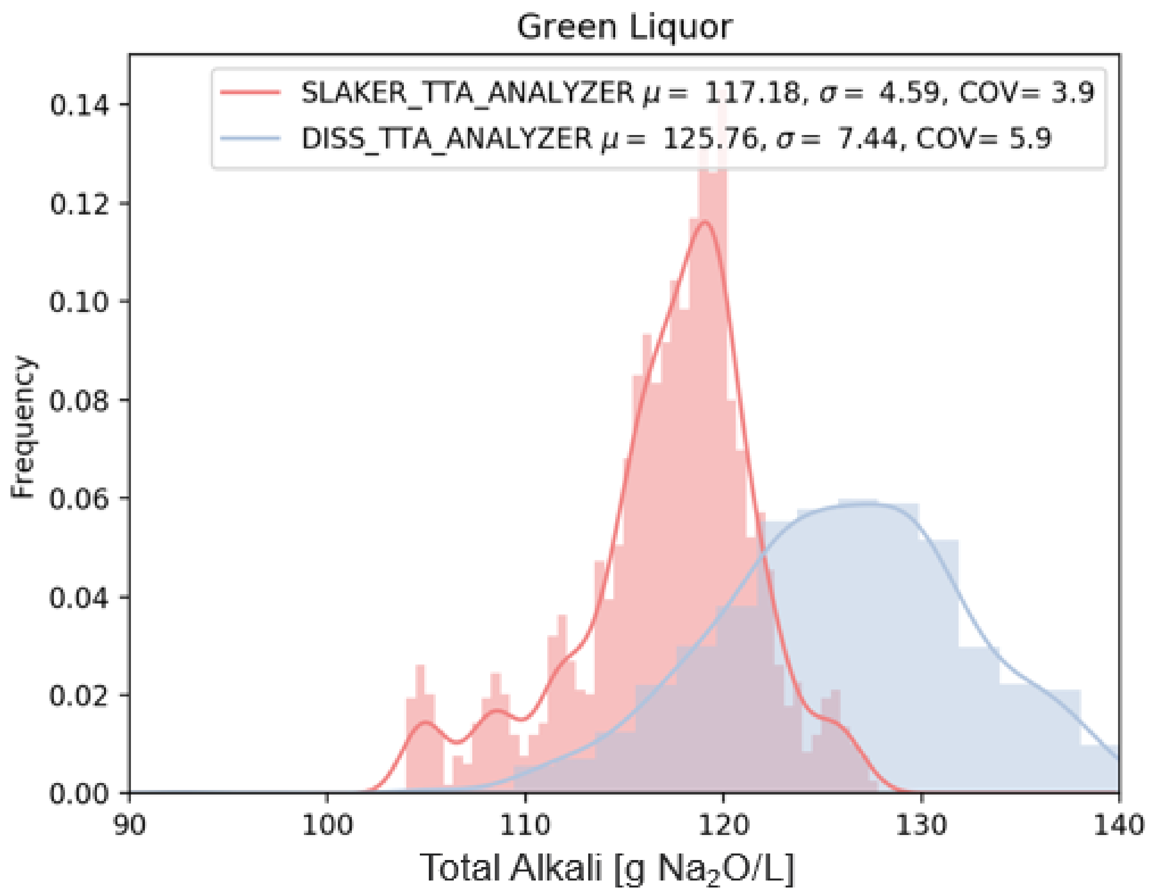
 © Valmet | Danny Zuver / VCO Case Study

Valmet

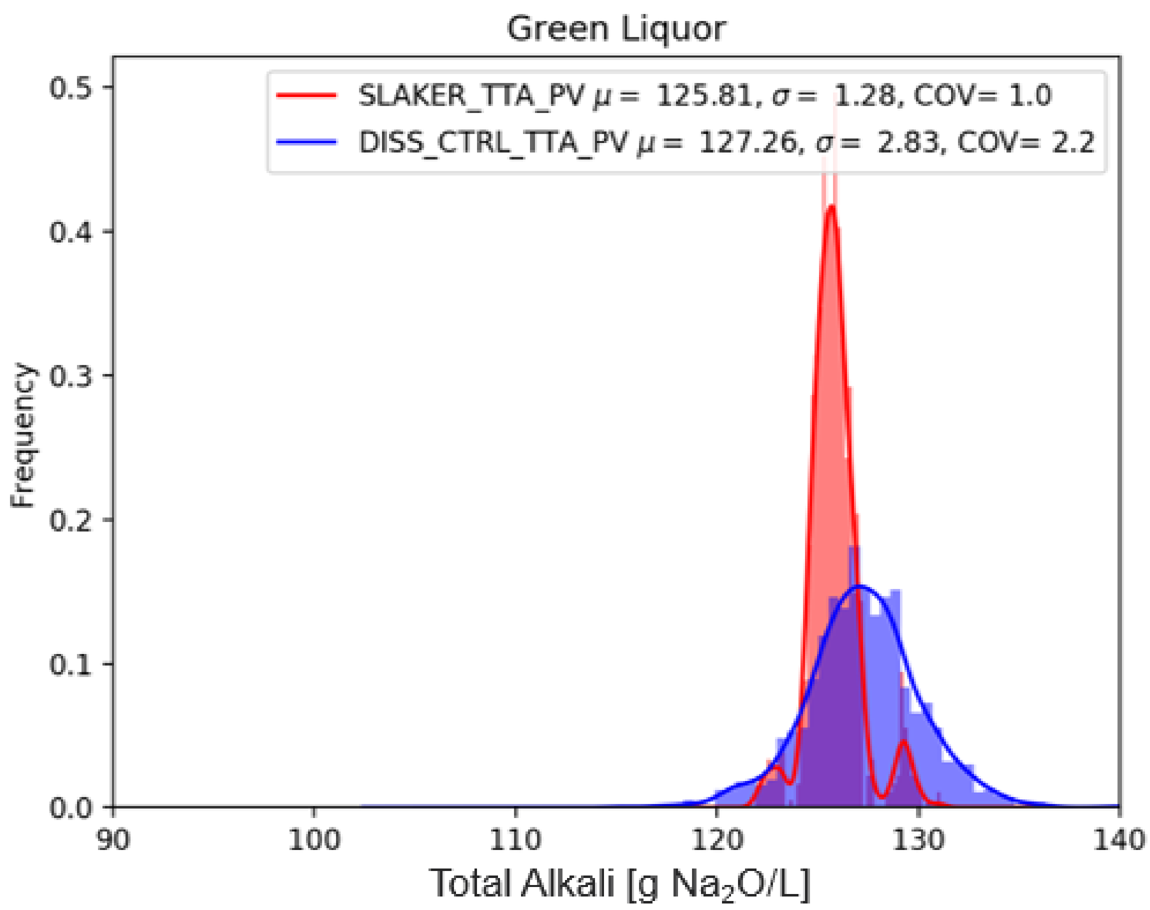
Results: Green Liquor TTA

Dissolver GL TTA, Slaker GL TTA

Before TTA Control



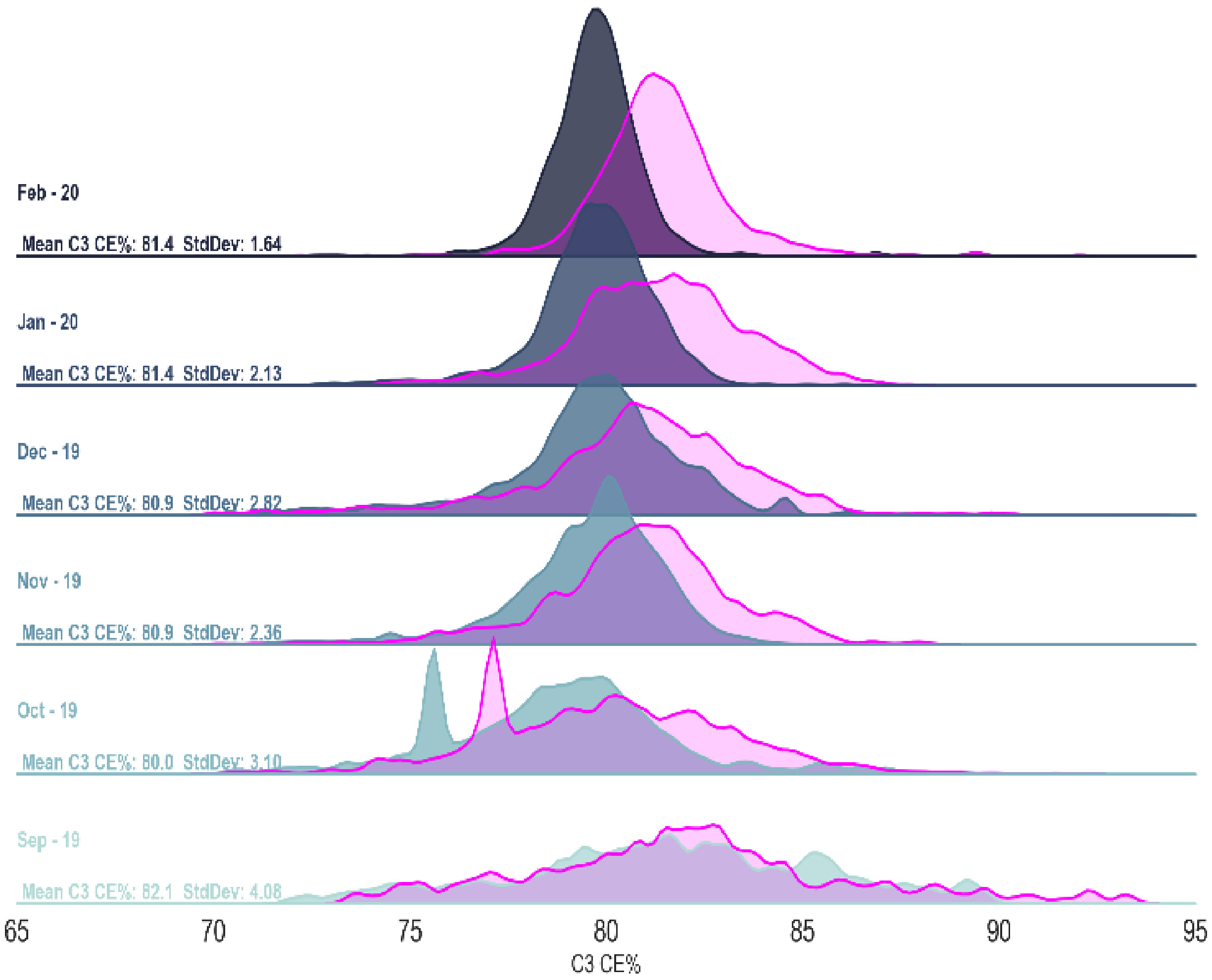
After TTA Control



Valmet

Results: White Liquor CE%

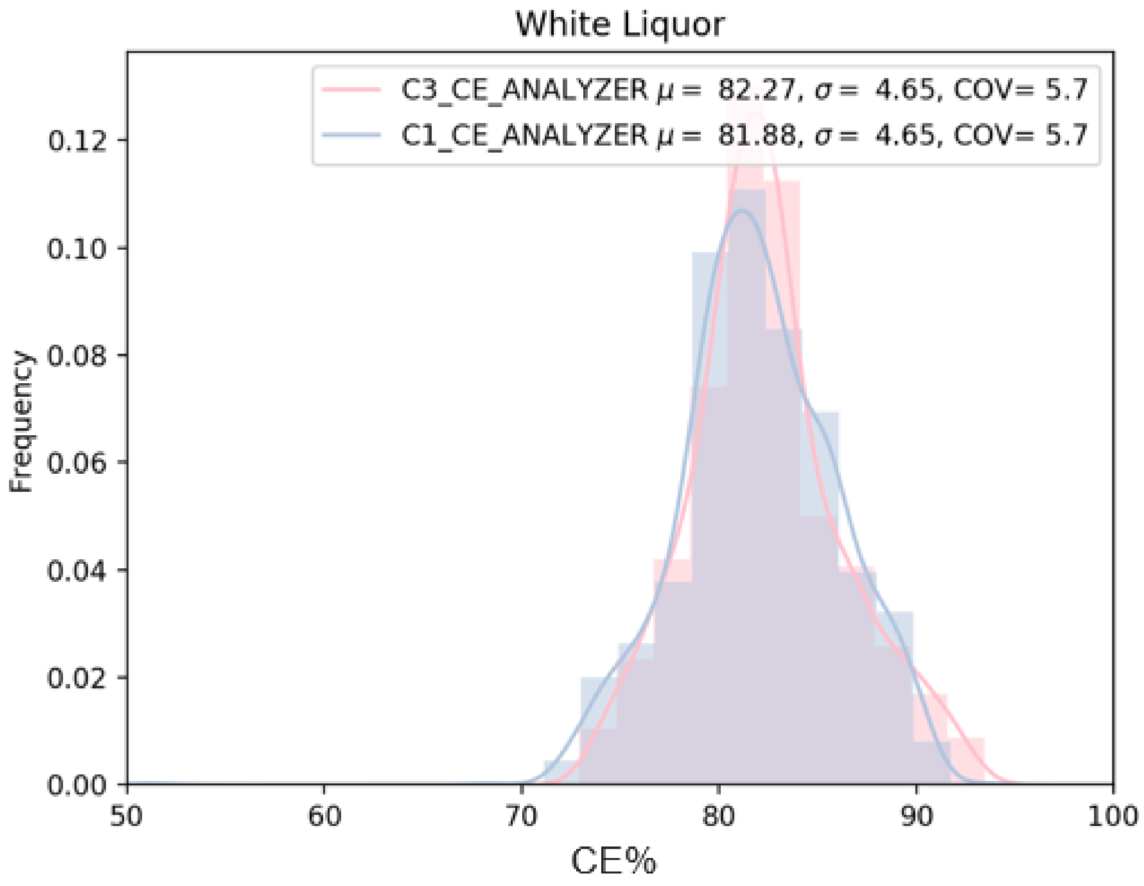
- OPTI control was initially started up using direct lime control from first causticizer feedback – performance was able to meet variability reduction guarantee but was not able to hit WL strength target without overliming at times
- Conductivity was used as D2C while slaker temperature and GL temperature measurements were being repaired
- OPTI control with Delta T D2C was fully commissioned by the end of January ‘20



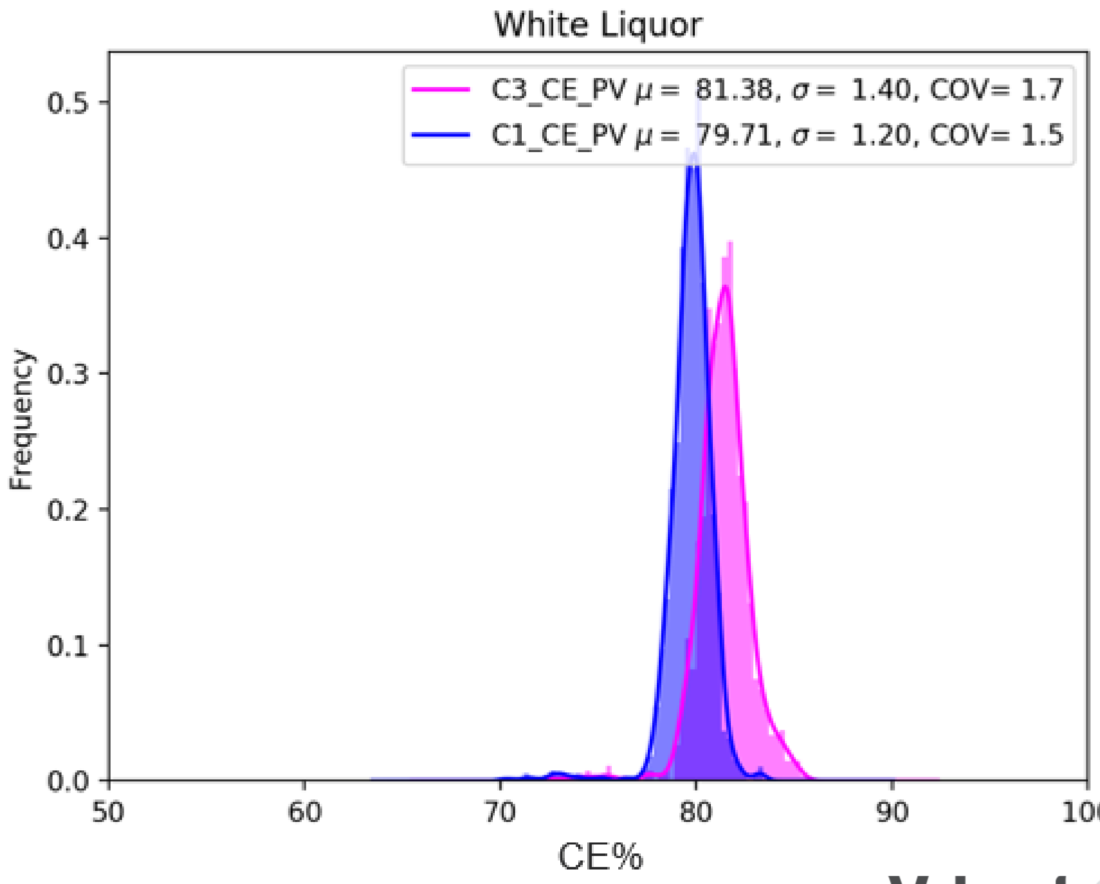
Results: White Liquor CE%

First Causticizer CE%, Last Causticizer CE%

Before OPTI Control



After OPTI Control



Conclusions

- Hydraulic and chemical deadload in the chemical recovery cycle are very costly to the Kraft paper mill economy
- KPIs can be measured at crucial points in the recaust and recovery areas using the robust Alkali-R analyzer
- The Alkali-R titration method provides fast, reliable, and highly repeatable ABC titrations
- KPI variability was dramatically decreased after implementation of VCO APC by leveraging Alkali-R measurements, along with mill instrumentation and base level process control infrastructure
  - GL TTA variability was reduced by 72%
  - Last Causticizer CE% variability was reduced by 70%
- Hydraulic and chemical deadload was reduced by target shifting KPIs during the process optimization phase of the project
  - KPI shift has saved the mill an estimated $790k in the last year of operation

Valmet FORWARD

Questions?