Bleaching optimization at WestRock mill in Covington, Virginia

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ABSTRACT: The WestRock mill in Covington, VA, USA, initiated a long term diagnostic and optimization program for all three of its bleaching lines. Benchmarking studies were used to help identify optimization opportunities. Capital expenditures for mixing improvement, filtrate changes, equipment repair, other equipment changes, and species changes were outside the scope of this work. This focus of this paper is the B line, producing southern hardwood pulp in a D(EP)DD sequence at 88% GE brightness. The benchmarking study and optimization work identified the following opportunities for improved performance: nonoptimal addition of caustic and hydrogen peroxide to the (EP) stage, carryover of D_0 filtrate to the (EP) stage, and carryover of (EP) filtrate to the D_1 stage. As a result of actions the mill undertook to address these opportunities, D_0 kappa factor decreased about 5%, sodium hydroxide consumption in the (EP) stage decreased about 35%, chlorine dioxide consumption in the D_1 stage decreased about 25%, and overall bleaching cost decreased about 15%.

Application: A long term, sustainable, bleach plant optimization and cost reduction study was performed with minimal to no capital. Mills can apply similar methodologies to their own bleach plants and obtain reasonable results.

As part of a continuous improvement cost optimization program, the operating costs of each department at the WestRock mill in Covington, VA, USA, are periodically reviewed. This review includes establishment of industry benchmarks and best practices for comparison with current performance within the mill. The current operational state is also compared with the best period of sustainable operation evaluated over the past 10 years, as well as past chemical charges established through laboratory bleaching experiments performed on Covington mill produced brownstock pulp [1]. Theoretical targets were determined by employing the models of Brogdon [2,3], McDonough [4], and other techniques [1,5].

Typically, this review is performed on a 3- to 5-year cycle to assess the sustainability of operational and maintenance practices that support optimal bleach plant performance. When aspects of the bleaching process are found to drift from optimal performance, for any reason, root cause analysis for the drift is determined and production practices are established to help mitigate future deviations from optimal practice. Washer carryover, instrument calibration practices and drift, optimal pH conditions [6], and in-line probe scaling were investigated.

As part of the exercise detailed in this paper, the mill established an optimization team to evaluate the current state of bleach plant operations and to work with operators to reestablish low cost bleaching operations. ERCO Worldwide and their consultant, Douglas C. Pryke, Professional Engineer, were asked to assist the mill in the benchmarking study and in the identification of best practices. Since 1995, ERCO Worldwide and their consultants have carried out over 250 bleach plant audits at more than 100 pulp mills. The results of these benchmarking studies are compiled into an extensive database of bleach plant operations. This database allows the company and its industry partners, such as WestRock, to compare performance with industry peers [7].

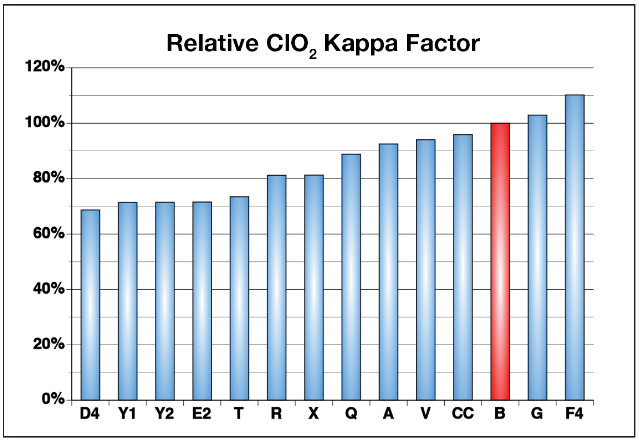
BLEACH PLANT BENCHMARKING STUDY

Bleach plant operating data from December 2011 were compiled and filtered for data inconsistencies and operating upsets, downtime, or both. December 2011 data were used as a reference for comparison to other non-oxygen delignified Southern hardwood mills that bleach a similar kappa number pulp to a similar final brightness. The key findings of the bleaching audit are described in this paper.

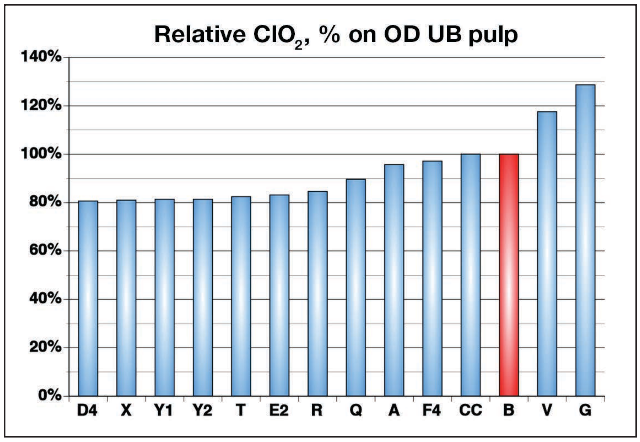
Figure 1 shows the relative chlorine dioxide (ClO_2) kappa factor (total ClO_2 expressed as % active chlorine on ovendry [o.d.] unbleached pulp divided by bleach feed kappa number). **Figure 2** shows the relative total ClO_2 consumption, comparing mill B with comparable hardwood mills in the database. Mill B relative total ClO_2 is among the highest in the database, which suggests opportunities for improved performance in each of the ClO_2 stages.

D_0 stage performance

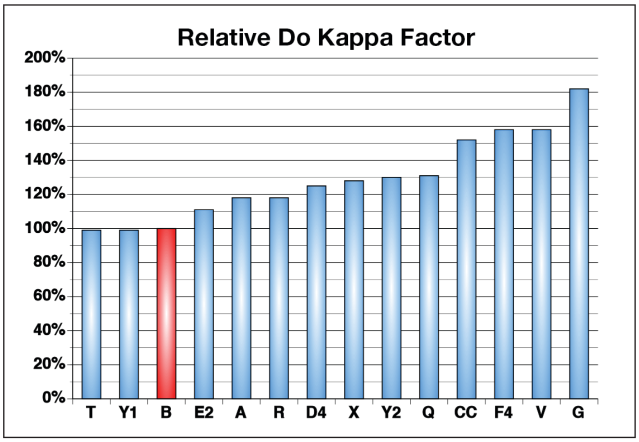
The first area to investigate for increased ClO_2 consumption is in the first stage of bleaching. **Figure 3** shows mill B D_0 kappa factor (% equivalent chlorine applied to o.d. unbleached pulp divided by unbleached kappa number) compared with similar mills in the database. Mill B kappa factor is among the lowest, which suggests good brownstock washing performance, minimum carryover, and good process control.



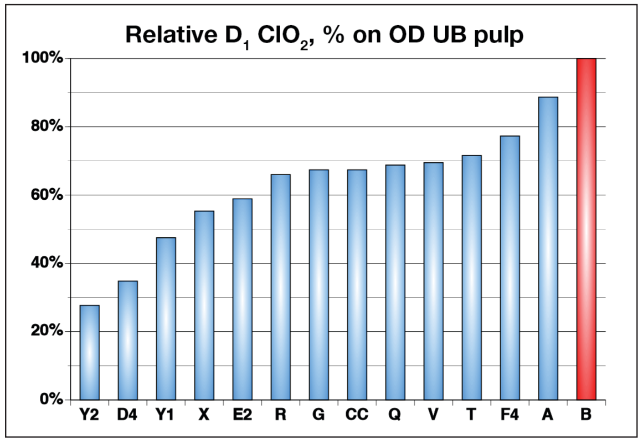
1. Relative chlorine dioxide (ClO_2) kappa factor.



2. Relative total ClO_2, % on ovendry unbleached pulp.



3. Relative D_0 kappa factor.



4. Relative ClO_2 use in D_1 stage.

D_1 stage

Figure 4 shows the relative ClO_2 consumption in the D_1 stage compared with other mills operating similar bleach plants to similar brightness levels. Given the low D_0 kappa factor, a higher ClO_2 charge in the D_1 stage was expected. However, the difference between mill B and others in the database suggested a significant optimization opportunity existed in this stage.

The brightness development in the D_1 stage further suggested an opportunity for optimization. **Figure 5** shows the brightness development for hardwood pulps as a function of the % ClO_2 applied divided by the extracted kappa number. Mill B performance in red did not reach the expected brightness in blue. The solid line and black data points are from laboratory bleaching of southern hardwood pulp, and the green data points are from reference hardwood mills in the database.

Spot tests at washed and unwashed kappa numbers showed that the unwashed kappa number was approximately 35% higher than the washed kappa number. Essentially, the carryover from the (EP) stage was consuming about 25% of the ClO_2 applied. This testing and the poor brightness development suggested a review of the operation of the (EP) stage washer was key to minimizing chemical consumption.

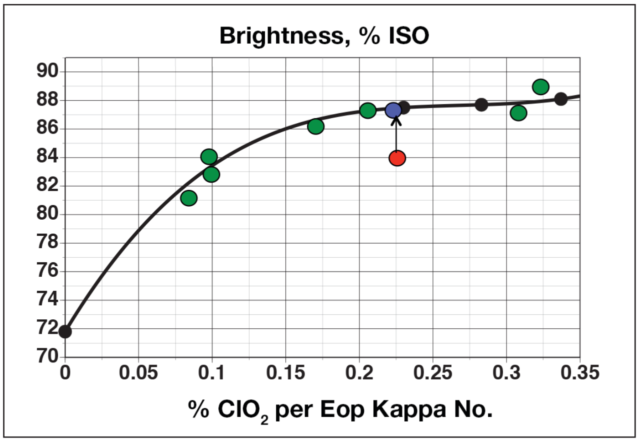
Extraction stage (EP)

Figure 6 compares mill B sodium hydroxide (NaOH) addition to the extraction stage with other comparable mills. Mill B is among the highest, which was unexpected given the relative low D_0 kappa factor discussed earlier. **Figure 7** shows that the ratio of NaOH applied in (EP) stage to the ClO_2 applied in the D_0 stage was much higher than comparable mills.

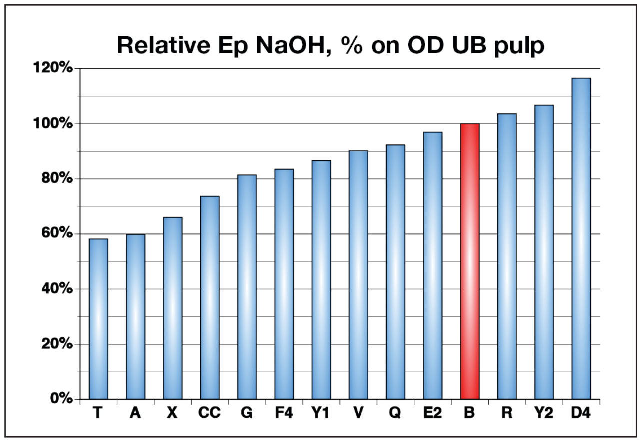
In addition, the benchmarking exercise identified that the dosage of hydrogen peroxide (H_2O_2) to the (EP) stage was lower than the distributed control system (DCS) was reporting because of an error in the assumed concentration in the made down H_2O_2. The target dosage was 3 lb/ton of pulp while the dosage being applied was 2 lb/ton of pulp. Once the H_2O_2 concentration was properly incorporated into the DCS, the proper desired dosage of H_2O_2 was delivered to the (EP) stage.

DIAGNOSTIC AND OPTIMIZATION PROGRAM

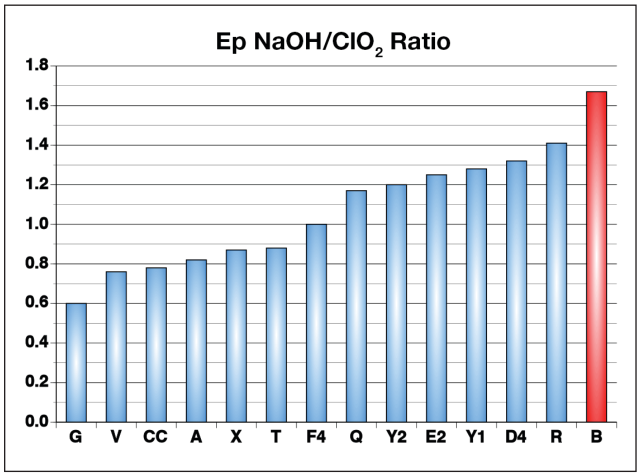
The diagnostic team established by the mill was composed of mill and corporate engineers, operators, and vendors. The team developed a list of potential cost saving projects for the bleach plant. These projects were then separated and added into different categories according to potential savings, exe-



5. D_1 stage brightness development.



6. Relative sodium hydroxide (NaOH) in the (EP) stage.



7. Pounds NaOH applied in (EP) stage divided by pounds ClO_2 in D_0 stage.

cution challenges, capital investment requirements, and completion speed. Projects requiring little to no capital with the highest potential savings and completion speed were elevated to the top of the near term implementation list. Projects that presented major process challenges were moved down the list, even if they did not require capital expenditures.

A combination of external benchmarking and durational analysis was used to define process gaps suitable for project development. Usage curves were prepared for these identified gaps to determine the percentage of time a specific bleach plant's chemical application was above any specified rate. For example, the average ClO_2 usage was determined to be X lb/ton for this bleach plant. From a usage cure rate, 50% of the time ClO_2 usage was higher than X and 50% of the time ClO_2 usage was below X. Further analysis suggested that 90% of the time, the usage was above Y lb/ton; hence, Y lb/ton was considered to be the best application rate for this bleach plant according to usage curve analysis.

The areas identified as potential gaps from best-in-class performance were well documented and the gap between average and best operational rates were determined for each area. These data were presented in detail to a larger group as the basis for a series of brainstorming sessions to develop potential projects to address and minimize the gaps. These projects were then ranked by the diagnostic team using relative ease of implementation, potential for success, and lowest capital requirements as the ranking criteria.

Once the diagnostic and brainstorming sessions were completed, an optimization team composed primarily of bleach plant engineers was established to guide as many capital-free cost savings projects through to completion as possible. One project was to improve bleach plant washing by applying best practices, establishing standard operating procedures, and improving the washer showers. Another project attempted to reduce the caustic application in and carryover from the extraction stage. The E-stage residual alkali target was lowered and application rates were closely monitored. By reducing carryover from the extraction stage, less acid would be required to obtain the desired operational pH in the D_1 stage, and the amount of acid required could potentially be used as an indication of excessive caustic carryover from the extraction stage.

OPTIMIZATION RESULTS

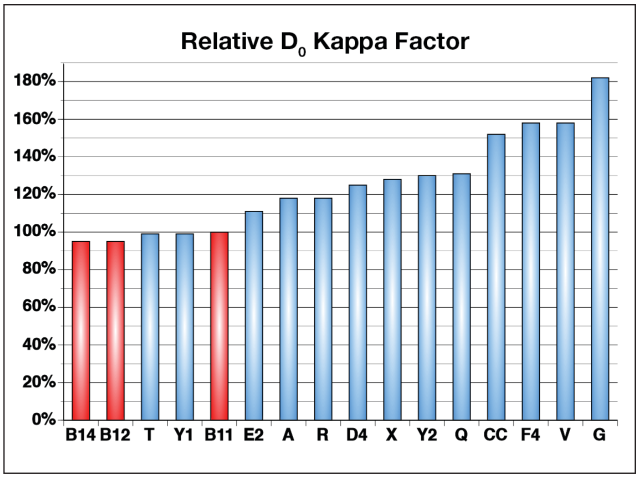
To assess the benefits of the diagnostic and optimization program, additional bleach plant audits were undertaken in June 2012 and July 2014 to ensure the achieved benefits were sustained.

D_0 stage

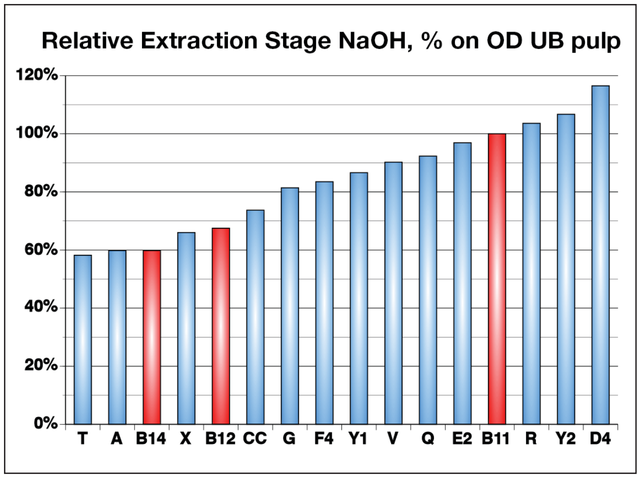
Figure 8 compares the change in D_0 kappa factor to the base case (B11) to subsequent assessments in June 2012 and July 2014 (B12 and B14, respectively). As discussed earlier, the relative D_0 kappa factor is among the lowest in the database. The operational temperature of the D_0 stage was not changed over the course of this study.

Extraction stage (EP)

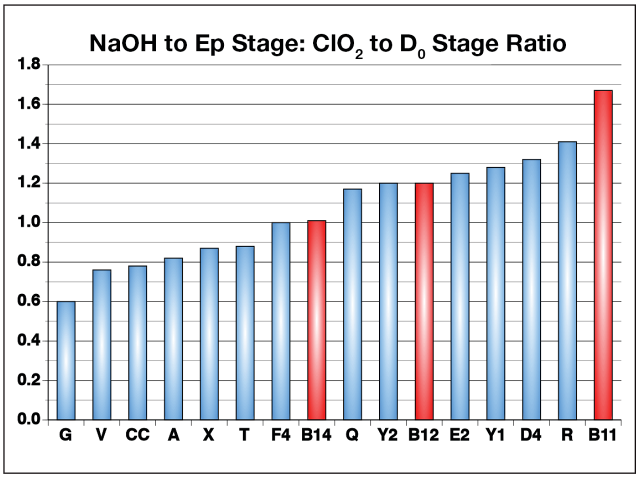
In the (EP) stage, improved chemical addition targets were established around the terminal pH. The mill started measur-



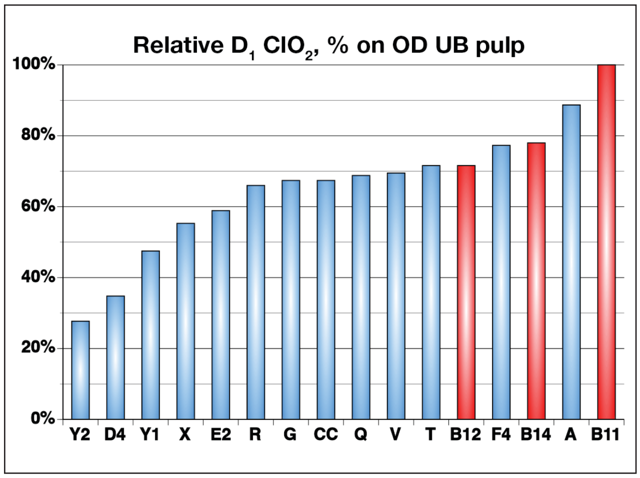
8. Relative D_0 kappa factor.



9. Relative extraction stage NaOH, % on ovendry unbleached pulp.



10. NaOH to (EP) stage: ClO_2 to D_0 stage ratio.



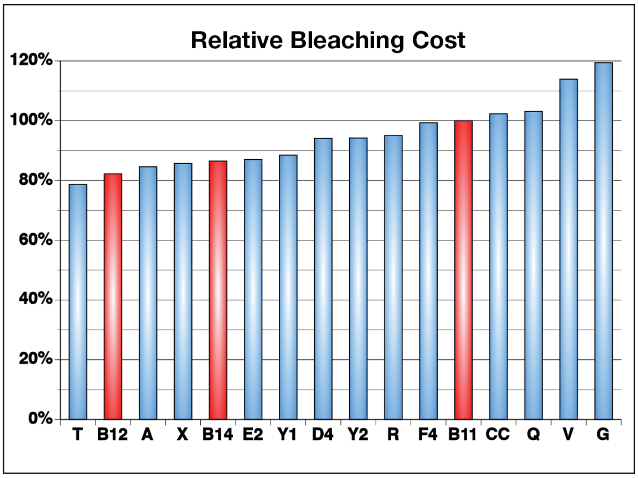
11. Relative D_1 ClO_2, % on ovendry unbleached pulp.

ing residual caustic and attempted to control the caustic addition to the (EP) stage in an alternate manner, using the residual caustic as the primary target with the terminal pH as a secondary target not to drop below. **Figure 9** shows the improvement in NaOH addition to the (EP) stage resulting from the target setting, as well as efforts to improve washing in the D_0 stage to minimize acid carryover. The washer improvements resulted in a decrease in the caustic demand relative to the amount of ClO_2 applied in the D_0 stage. **Figure 10** shows this impact as the ratio of caustic in the (EP) stage to ClO_2 in the D_0 stage. The (EP) stage temperature was not changed during the course of this study. The NaOH addition decreased approximately 35% compared with the base case.

In addition to changing the caustic chemical addition to the (EP) stage, the mill also attempted to improve the washing of the pulp leaving the (EP) stage. The washer drum speed was increased so a thinner sheet would be formed on the drum. The wash ratio was also increased slightly. Before these changes, visual color changes could be seen from top to bottom of the pulp mat leaving the (EP) stage. After these changes, the exiting pulp mat was a uniform color from top to bottom.

D_1 stage

Efforts to improve washing in the (EP) stage resulted in significant decreases in ClO_2 consumption in the D_1 stage. In addition, optimal pH targets for the D_1 stage had drifted over the years and were re-established. Several instruments were cleaned, calibrated, and returned to service. **Figure 11** shows relative ClO_2 use decreased 20%–30%. Chlorine dioxide use remains at the high end of the database; however, this is expected given the low kappa factor in the D_0 stage. In addition, the mill maintains relatively high ClO_2 residual and slightly lower than optimal pH from a brightening perspective in this stage to ensure good shive bleaching is achieved. The mill brownstock system uses a series of hole-based Noss screens, which routinely results in shives entering the bleach plant. The D_1 stage residual is one line of defense employed by the mill for pulp cleanliness; therefore, the mill chooses to operate the D_1 stage at slightly lower than optimal brightening temperatures so brightness development is



12. Relative bleaching cost.

slightly reduced in this stage. As with the rest of this work, the target D_1 stage temperature remained constant.

Bleaching cost

As a result of optimization efforts in the D_0, (EP) and D_1 stages, bleaching cost (calculated as the cost of ClO_2, NaOH, and H_2O_2 only) decreased approximately 15% compared with the base case. The overall relative changes in chemical consumption and cost are summarized in **Table I**. Changes in the relative bleaching cost resulting from the changes implemented from this optimization effort and relative costs for several other bleach plants are shown in **Fig. 12**.

SUMMARY

The benchmarking study and optimization work identified several opportunities for improved performance in the B bleach plant producing southern hardwood pulp in a D(EP)DD sequence at 88% GE brightness. Identified by the bencharking study were: excess addition of caustic to the (EP) stage because of the use of terminal pH as the main addition control point; nonoptimal addition of H_2O_2 to the (EP) stage because of a concentration mismatch between the DCS and the H_2O_2 being supplied to the (EP) stage; carryover of D_0 filtrate to the following (EP) stage; and carryover of (EP) filtrate to the D_1 stage.

The mill undertook a number of actions to address the opportunities identified. Improved chemical addition targets were established around the terminal pH of the (EP) stage. The mill started measuring residual caustic and attempted to control the caustic addition to the (EP) stage in an alternate manner, using the residual caustic as the primary target with the terminal pH as a secondary target not to drop below a set value. Optimal pH targets for the D_1 stage had drifted over the years and were also re-established. Several instruments were cleaned, calibrated, and returned to service. As a result of these actions, D_0 kappa factor decreased about 5%; NaOH consumption in the (EP) stage decreased about 35%; a significant reduction in acid applied to the D_1 stage was realized because carryover from the (EP) stage to the D_1 stage was minimized; ClO_2 consumption in the D_1 stage decreased about 25%; and overall bleaching cost decreased about 15%. **TJ**

ACKNOWLEDGEMENTS

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	December 2011	June 2012	July 2014	Average Delta*
Final brightness, GE	87.2	87.5	87.2	–
ClO_2, %	100	81.7	89.6	85.7
NaOH, %	100	67.5	59.7	63.6
H_2O_2, %	100	150	150	150
Cost, %	100	82.1	86.5	84.3
*Average of June 2012 and July 2014 changes. The average delta is an enhanced measurement of the average sustained improvements over the 3 years of this study.				

I. Optimization results summary.

ABOUT THE AUTHORS

The mill decided to initiate a long term process optimization and cost reduction process around the bleach plant. This work documents the first several years of this process. The current effort is similar to other projects that Doug Pryke has initiated for ERCO as part of his consulting business. The difference is that the methodology and long term results have been tracked and documented.


Santos


Hart


Pryke


Vanderheide

Maintaining long term stability in the cost savings metrics was a challenge. New operating methods, targets, and procedures were established to help maintain the process in more optimal conditions than before the process was started. Surprising findings were the amount of instruments that were not properly maintained and the propensity to overuse caustic.

The current work documents no or limited capital solutions toward bleach plant optimization. Other mills should be able to follow a similar methodology to optimize their bleach plants and potentially reduce operating costs. The next step is to maintain the current gains and cycle through the entire plan again to identify more optimization and cost saving opportunities.

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