Reduction of alkali loss in an ash leaching system

CARLA CÉLIA ROSA MEDEIROS, FLÁVIA AZEVEDO SILVA, SAULO GODOY PIGNATON, ESTANISLAU VICTOR ZUTAUTAS, AND KLEVERSON FIGUEIREDO

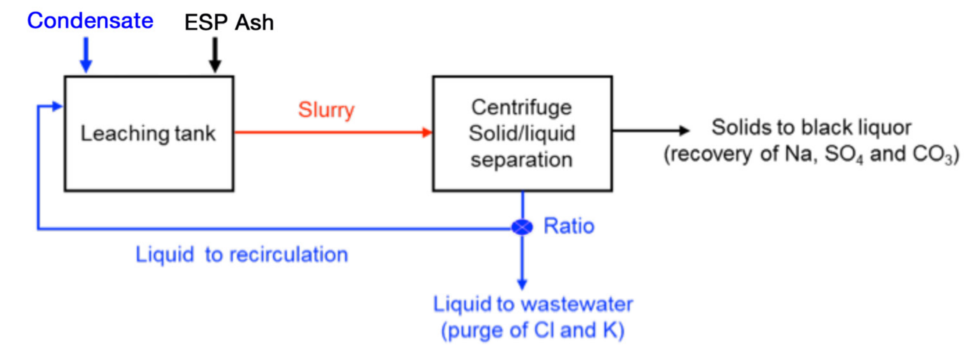
ABSTRACT: There are many points in a kraft mill where the alkaline compounds are purged from the process. Several effluents, solid waste, and air emissions contain alkali, which leads to the necessity of chemical makeups to maintain the liquor balance. The main loss of alkali at the Veracel mill is present in the wastewater from the recovery boiler; more precisely, it is from the ash leaching system, which represents 80% of the total losses.

To minimize the alkaline losses while keeping the chloride level in the recovery cycle under control, a project was developed at Veracel. Key actions were taken by adjusting the control loops of the ash leaching system, mainly on the slurry density and purge control. These adjustments led to a decrease in alkali losses and to an increase of treated ash, and kept the chloride level of the recovery boiler dust at 2.6%.

Application: This research demonstrates how alkaline losses can be reduced by automation solutions in the ash leaching system.

The Veracel mill has an ash leaching system to control the chloride (Cl) and potassium (K) level in the recovery boiler ash. This system has undergone many changes since it was installed. During previous work, a decrease in chloride level of the recovery cycle was achieved. This was pursued because the high levels of chloride in the recovery boiler ash lower the melting temperatures of carryover deposits and contribute to plugging problems, causing unscheduled shutdowns to clean the boiler [1]. The decreased level of chloride in electrostatic precipitator (ESP) dust to under 3% opened the possibility to study the alkaline losses, in order to minimize the cost for chemical makeup.

An ash leaching system follows a basic scheme, as shown in **Fig. 1**. Ash from the ESP, which consists of sodium sulfate (Na_2SO_4) with a small amount of sodium carbonate (Na_2CO_3) enriched in K and Cl [1], along with condensate from the evaporation, are fed into a tank where they are mixed, resulting in two phases of slurry: liquid and solid. The higher solubility of sodium chloride (NaCl) and potassium chloride (KCl) than Na_2SO_4 keeps chlorides in solution while Na_2SO_4 precipitates [2]. The phases are subsequently separated in a centrifuge. The liquid, which is essentially the saturated solution of the ash, contains a higher level of Cl and K and a lower content of the ions sulfate (SO^{2-}_4), carbonate (CO^{2-}_3), and sodium (Na^+) than the solid phase. Part of the liquid is purged to remove Cl and K, while the solid phase returns to the mill liquor in the mix tank for Na and sulfur (S) recovery [3]. Thus, the alkaline losses in the ash leaching are due to the sodium content of the liquid reject. According Gonçalves et al. [3], at a given degree of solid-liquid separation, a higher removal degree of Cl and K will normally generate a lower recovery degree of Na, CO_3, and SO_4. This is expected, as Na and SO_4 are also present in considerable quantities in the liquid. There-



1. Basic schematic of the ash leaching system (Cl = chlorine; K = potassium; Na = sodium ion; SO_4 = sulfate ion; CO_3 = carbon ion).

fore, the more the liquid is separated and discarded, the more Cl, K, Na, and SO_4 will be removed, and therefore the less Na and SO_4 will be recovered.

To obtain lower alkaline losses through the purge, the mill had to minimize the concentration of alkaline compounds and the flow of purge. Therefore, the aim of this project was to lower these parameters as far as possible. Further on, improvements in the density control of the tank and a new purge control were developed.

EXPERIMENTAL

This case study of the ash leaching at the recovery boiler was conducted at Veracel mill during 2015. The normal load in the recovery boiler is 5100 tons of dry solids per day, and the ash leaching load before this work was around 150 tons of ash per day.

This project opportunity was identified when the alkali losses, normally represented as mass of Na_2SO_4 (kg) per tons of air dry pulp (a.d. ton), started to increase. Then, a team of technical assistants and specialists in the recovery process and automation was created.

The team gathered input data from lab analyses and online process program, collected from the Aspen Process Explorer Version 2006.5 (AspenTech; Bedford, MA, USA). The main physical analyses were density and solids content of the purge, the slurry, and the solid phase. The chemical analyses were Na, K, Cl, sulfate, and carbonate content. The analysis of Cl and Na was based on standard methods from the American Public Health Association [4]. The sulfate analysis was performed according to an internally developed procedure.

Analyzing the data, the team observed that a way to reduce the alkali losses was to decrease the amount of solid in the liquid phase by improving the separation in the centrifuge, which could be made adjusting the torque's centrifuge. Further analysis comparing the torque with the slurry density showed that the density had an impact in the torque, which led to a change of the density control loops. Another improvement idea was to fix the volume of the purge, seeking its reduction, which was possible due to the previous stability of the chloride.

Minitab (Minitab; State College, PA, USA) charts were created to analyze the project results, such as time series and interval plots.

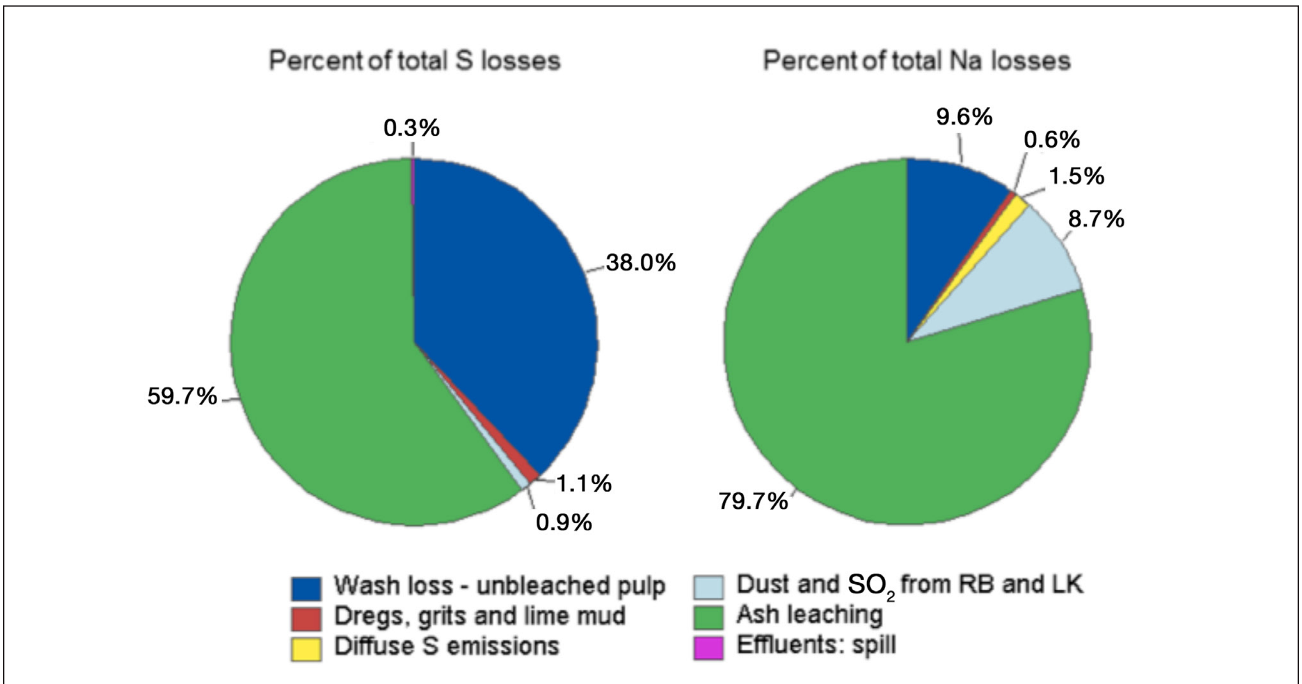
RESULTS AND DISCUSSION

The ash leaching was found to be the main cause of sodium and sulfur losses in the mill, which is shown in the comparison of losses from different process areas (**Fig. 2**). As can be seen, losses from ash leaching constituted 79.7% and 59.7 % of the Na and S losses, respectively.

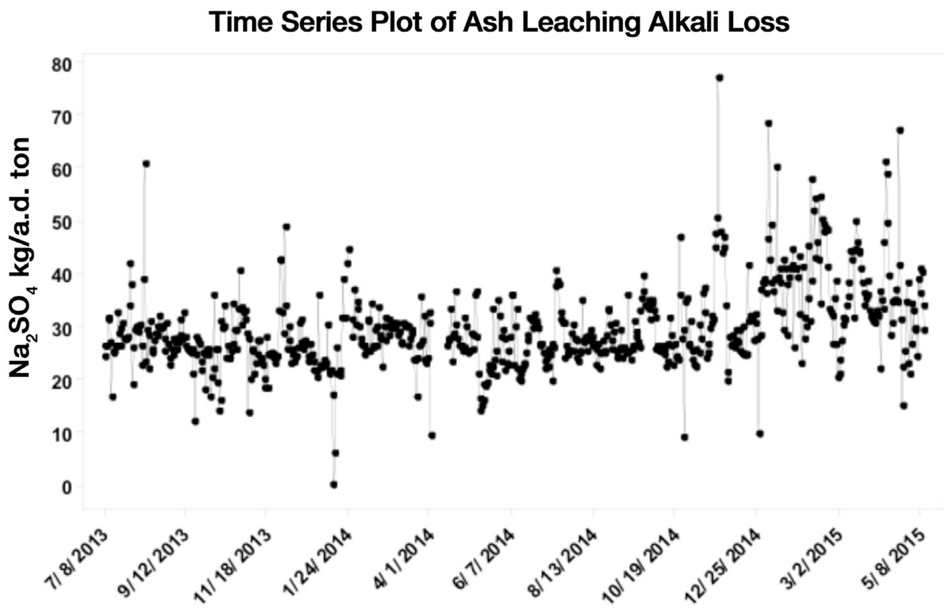
The alkali loss from the ash leaching system started to increase in November of 2014. The results of it from July 2013 to May 2015 are presented in **Fig. 3**.

Analyzing the data from Fig. 3, the following statistical values were obtained: the standard deviation was 10.04 kg Na_2SO_4/a.d. ton, the mean was 36.35 kg Na_2SO_4/a.d. ton, and the maximum and minimum value were 76.95 kg Na_2SO_4/a.d. ton and 9.7 kg Na_2SO_4/a.d. ton, respectively.

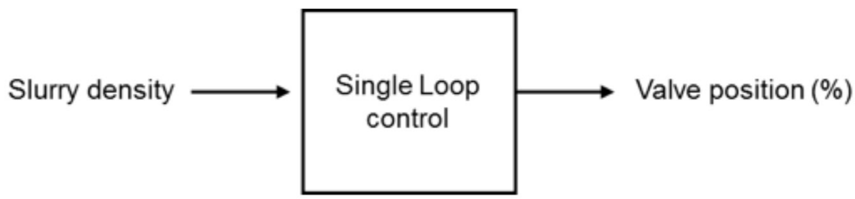
As the cost to make up all these chemical losses was quite high since November 2014, a study to decrease the alkali loss in the ash leaching system was initiated. The aim was to minimize the Na_2SO_4 concentration and the flow of the purge and



2. Percent of total sulfur (S) and sodium (Na) losses in the process based on kg sodium sulfate (Na_2SO_4)/a.d. ton.



3. Ash leaching alkali loss plot (Na_2SO_4 kg /a.d. ton) as a function of time, 2013-2015.



4. Basic schematic of the old control.

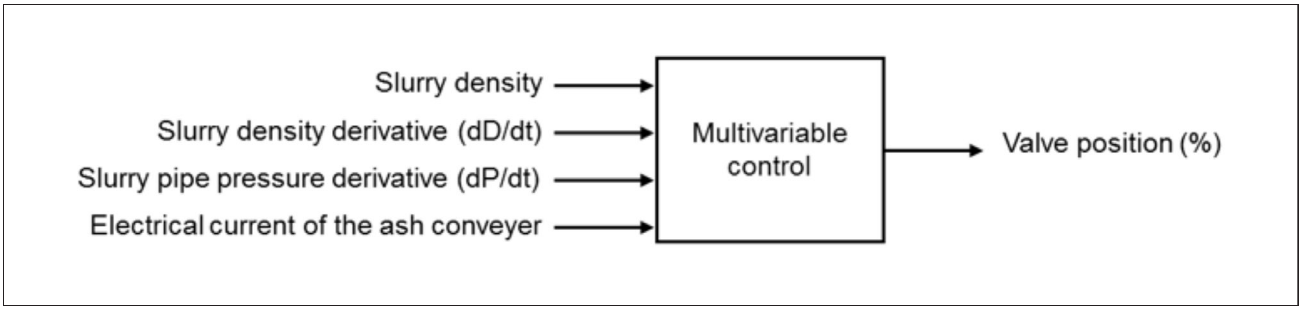
their variation, which are compounds of the alkali loss.

The purge concentration is quite linked with the degree of separation in the centrifuge. An important variable to enhance the separation of solid and liquid phases is the torque of the centrifuge, as a high torque on the machine lowers the carryover in the liquid. The torque is related to many machine variables, such as the rotation, the speed difference between the drum and the screw, and the slurry density. High density, which is related to the increase of ash content in the slurry, leads to high torque during normal operation. Thus, the first action was to evaluate a way to enhance the slurry density by improving its control loop.

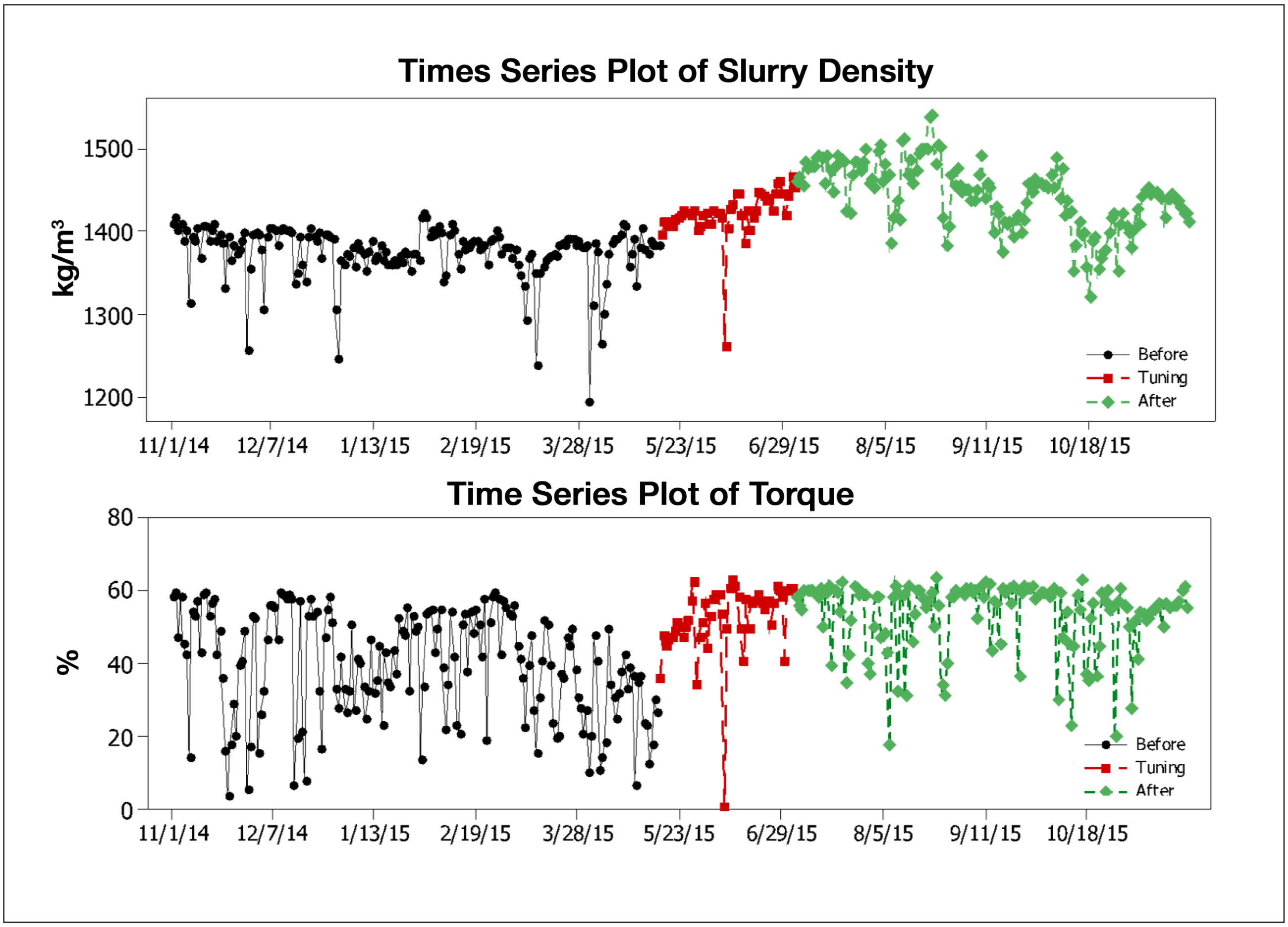
Before the project, the control was a single loop based only on the read of the slurry density (**Fig. 4**). This control then would act on the opening of the ash valve, allowing more or less ash to enter the tank, keeping the density on the setpoint. The ash for the ash leaching tank comes from the ESP in an unequal amount, meaning that for the same ash valve opening, a different amount of ash went to the tank. Due to the variation in the amount of ash, this control loop was unable to minimize the density variability.

Thus, a multivariable control was developed, adding new parameters in the control loop in order to minimize the change in ash amount to the tank, and consequently improve density control (**Fig. 5**). The first variable added was the electrical current of the ash conveyer to predict the volume of ash into the tank as a feedforward control. It was implemented as a feedback control: the rate of change of the slurry pipe pressure, and the density derivative (dD/dt). In other words, when the derivative of pressure or of the density start to decrease, the ash valve opens slowly. These improvements contributed to an increase in the density and the torque, as shown in **Fig. 6**.

The increase in the slurry density and torque led to the improvement of the purge quality in terms of carryover, which can be proven by the aspect of the purge and the re-



5. Basic schematic of the new control.



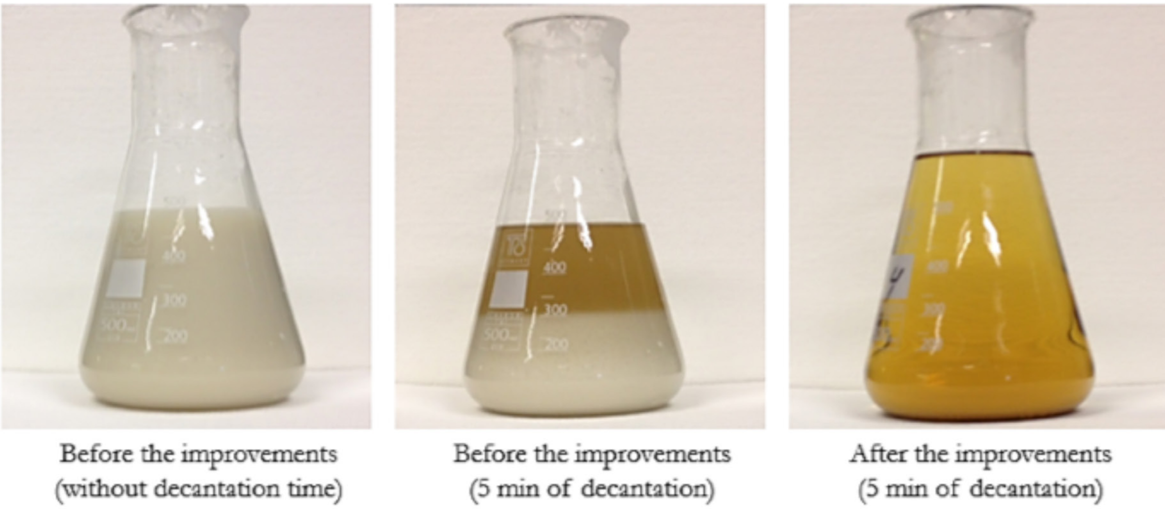
6. Time series of slurry density and centrifuge torque before the project, during the tuning phase, and after all adjustments.

duction of density and solids content in the purge before and after the improvements (**Fig. 7** and **Fig. 8**).

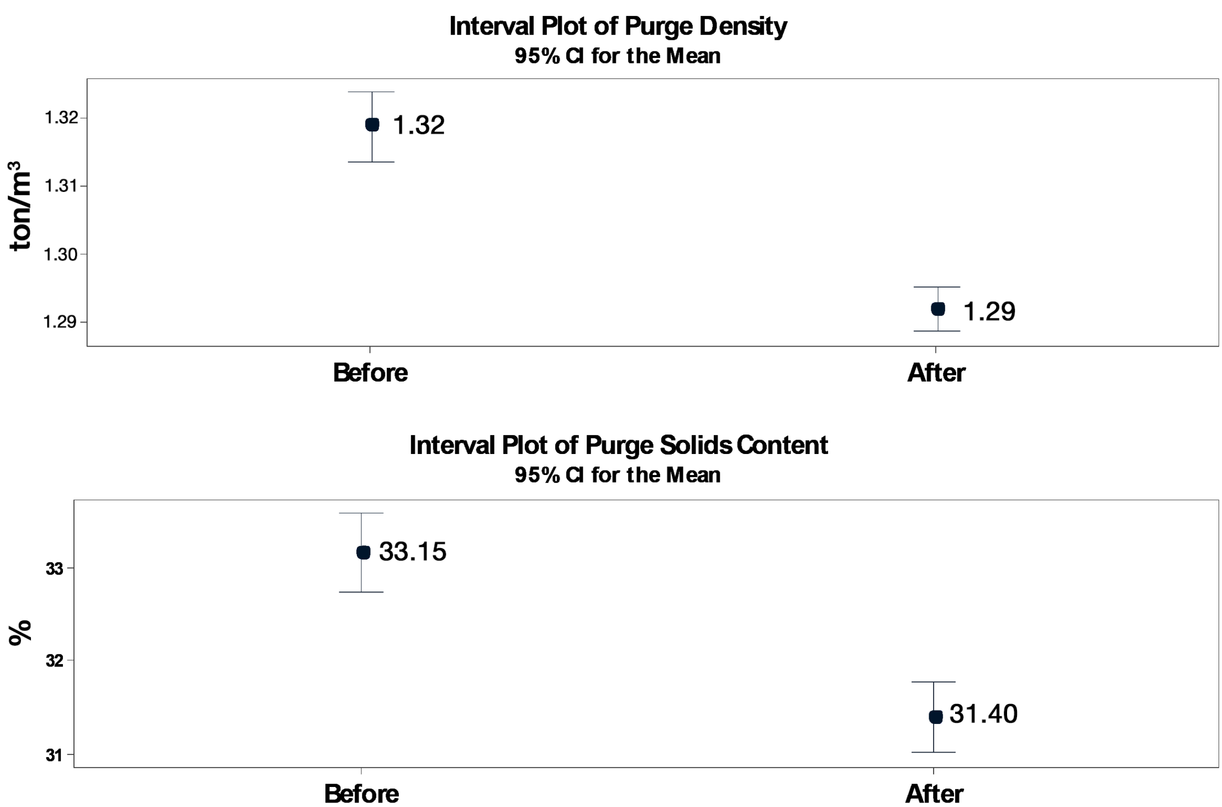
While a reduction in solids content in the purge was observed, an increase of it in the cake from 66.5% to 71.5% was seen. It means that the dryness in the cake has increased, which can be explained by the increase of the torque in the centrifuge as shown in the Fig. 6. The main benefit of increased dryness in the cake is the reduction of chloride once the liquid is enriched with this element.

Running with a higher density, the amount of treated ash was enhanced from 150 to 180 tons/day. This led to a reduction of the chloride content in the ESP ash (**Fig. 9**) from 3.0% to 2.6%. The high result during April 2015 was caused by the mill's annual shutdown and is considered an outlier.

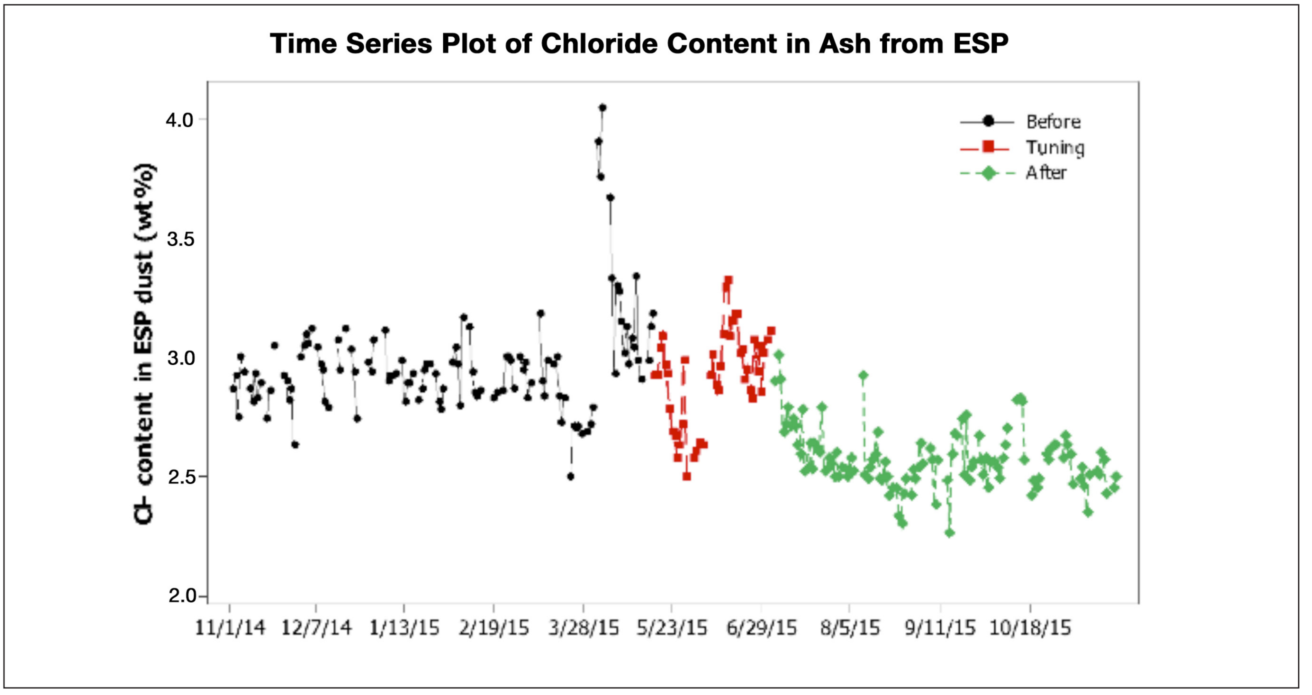
Once the carryover in the purge was minimized by the density and torque control, the next step was to develop a strategy to stabilize the purge volume. The purge flow used to change according to a fixed ratio between the purge and the recirculation flow. In order to fix the purge volume per day, since it is a main parameter, the variability was transferred to the ratio. **Figure 10** demonstrates the flow and ratio variation before and after the control. The ratio is represented based on the percentage of the purge and recirculation flow. The purge flow unit is m^3/h.



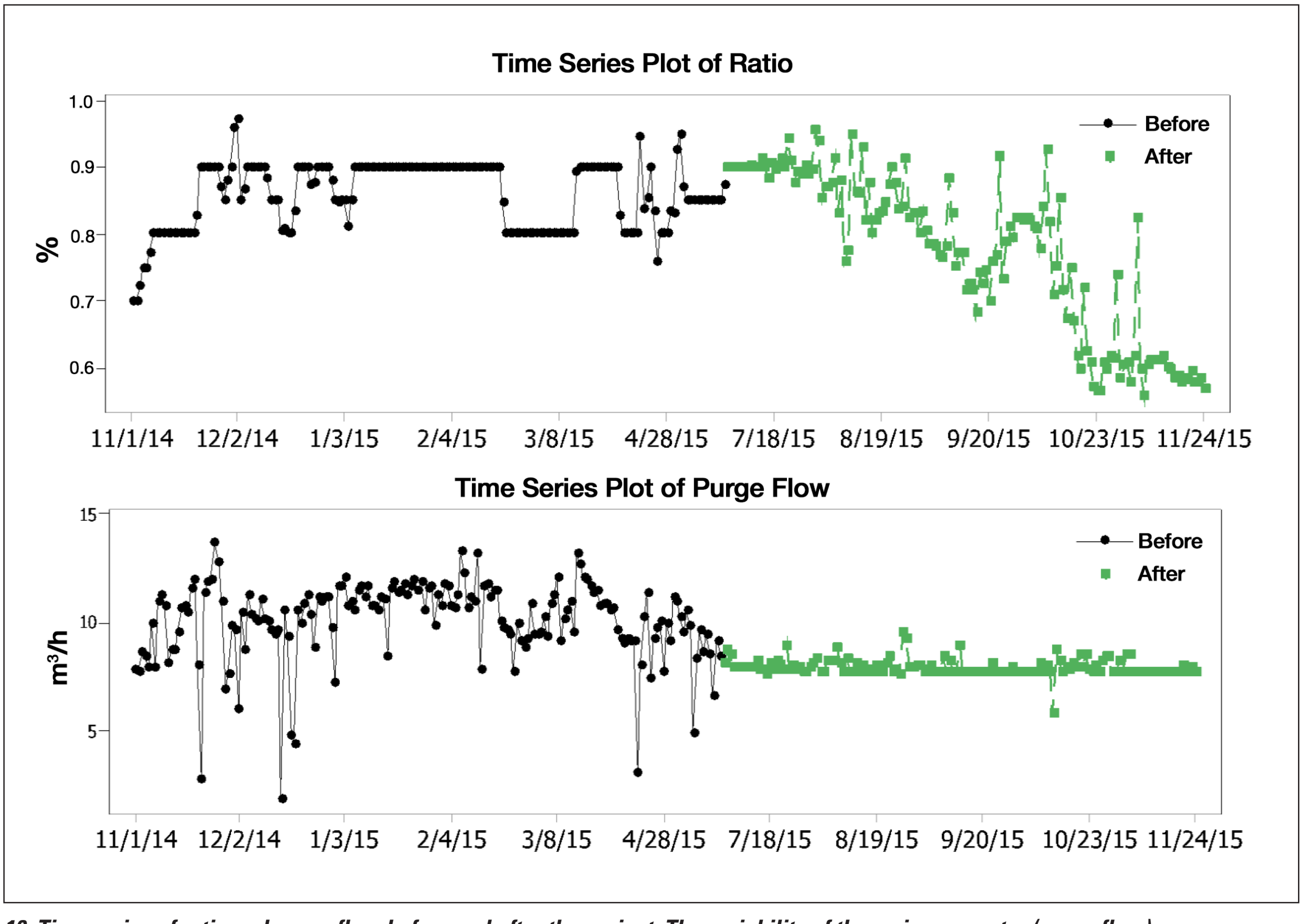
7. Pictures of the purge before and after improvements.



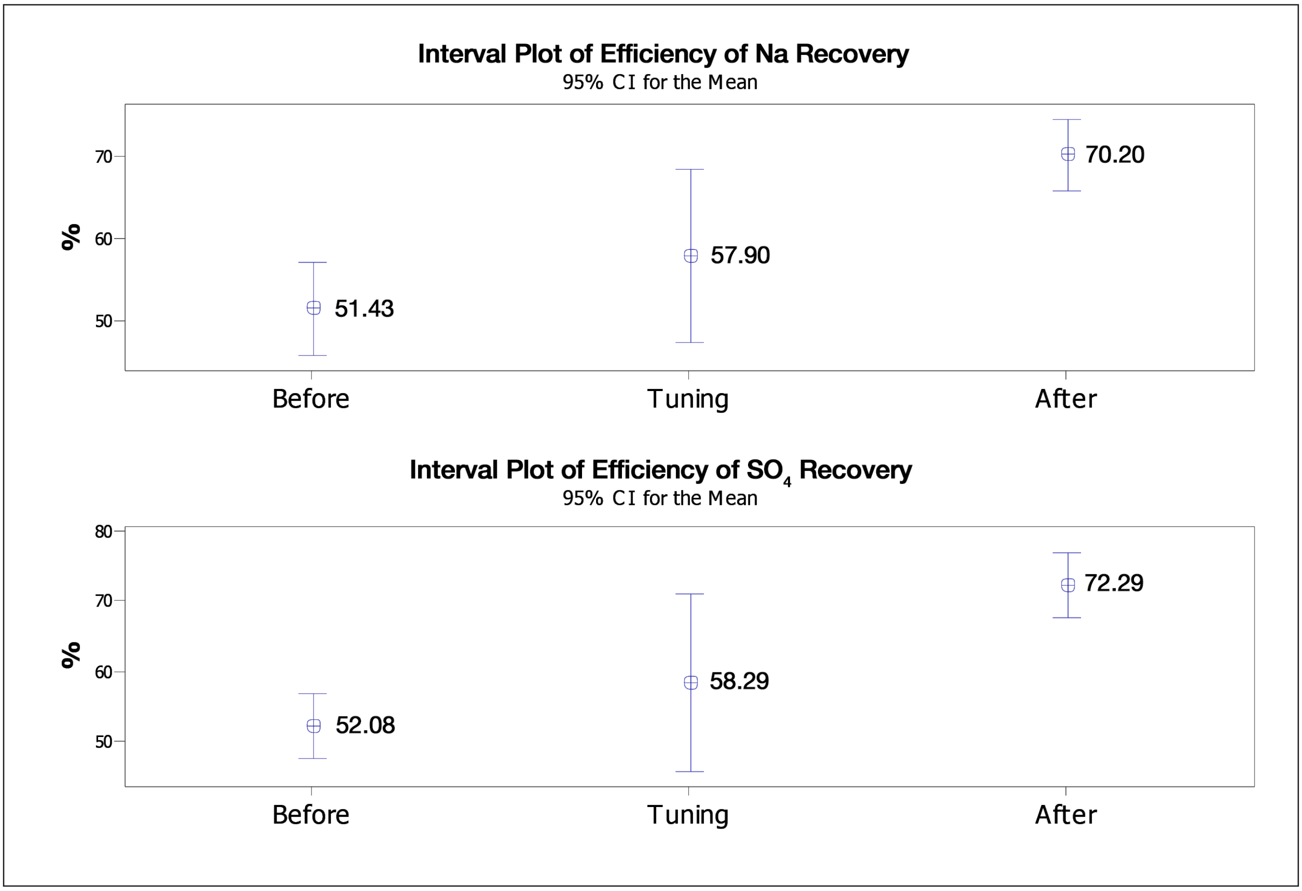
8. Interval plot of density and solids content of the purge before and after the improvements (CI = confidence interval).



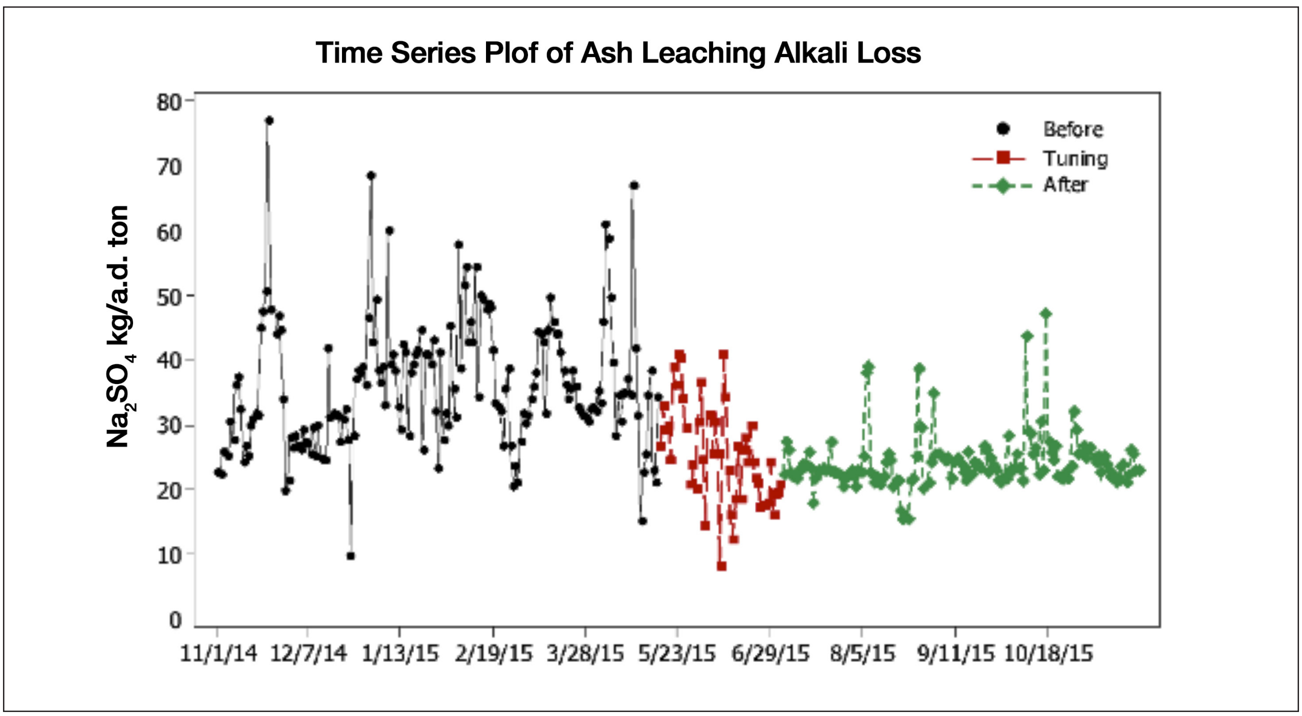
9. Time series of chloride (Cl) content in the ash from electrostatic precipitator before the project, during the tuning phase, and after all adjustments.



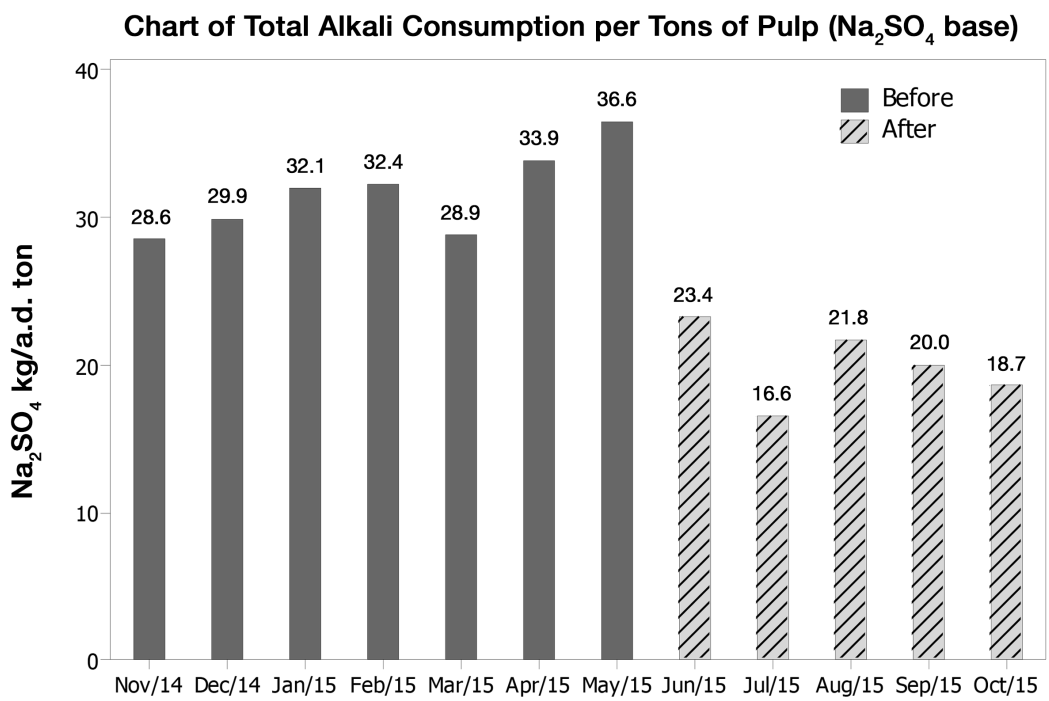
10. Time series of ratio and purge flow before and after the project. The variability of the main parameter (purge flow) was transferred to the less important one (ratio) in order to keep a fixed volume of purge per day.



11. Interval plot of sodium (Na) and sulfate (SO_4) recovery efficiency before the project, during the tuning phase, and after all adjustments (CI = confidence interval).



12. Time series of alkali loss from the ash leaching before and during the tuning phase and after all adjustments.



13. Chart of sodium hydroxide (NaOH) and sodium sulfate (Na_2SO_4) makeup consumption based on Na_2SO_4/a.d. ton before and after all the improvements.

After all these actions, the Na and SO_4 recovery in the ash leaching system increased from 51.4% to 70.2% and from 52.1% to 72.3%, respectively (**Fig. 11**). As expected, the chloride removal efficiency was reduced from 73.9% to 61.9%, since it is a tradeoff with the recovery efficiencies, as explained previously. However, as mentioned, the possibility to treat more ash and the increase of the dryness in the cake resulted in decreased chloride levels. The gain in the recovery efficiency is demonstrated in the alkali loss, which was reduced from 35.9 kg Na_2SO_4/a.d. ton to 24.0 Na_2SO_4/a.d. ton (**Fig. 12**).

The specific consumption of the makeup chemicals before and after the project is presented in **Fig. 13**. As can be seen, the use of makeup chemicals decreased, and the economic benefits were estimated to be in the order of US$2.5 million/year.

CONCLUSIONS

Alkali losses from the ash leaching unit of the Veracel mill were decreased in this study. The key to obtaining this reduction was to reduce the purge's carryover and improve the control of the purge flow. This was possible by tuning the torque control with a new strategy developed to control the slurry density and the pressure of the slurry pipe, combined with the creation of a flow control in order to limit the total purge volume per day. These actions have contributed to achieving a significantly better economy of chemical makeup, as a consequence of the ash leaching alkali loss reduction from 35.9 kg Na_2SO_4/a.d. ton to 24.0 Na_2SO_4/a.d. ton. As the improvements allowed the mill to enhance the amount of treated ash, it was also possible to reduce the chloride level from 3.0% to 2.6% in the ESP ash. **TJ**

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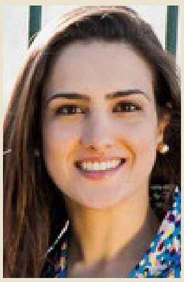
ABOUT THE AUTHORS

The ash leaching system is a relevant research topic because it is related to chloride (Cl) and potassium (K) control and alkali loss. Chloride and K in the recovery boiler ash is associated with plugging problems and alkali loss and also with makeup costs. This study is a real case from a modern pulp mill, and the improvements mentioned in this paper could be applied in other similar systems.

The most difficult aspect of this research was keeping the Cl level under control during the tuning phase of the project. Interestingly, the recovery efficiency of sodium (Na) and the removal efficiency of Cl and K are a tradeoff in the ash leaching system. With the improvements, it was possible to increase the recovery efficiency of Na and decrease the Cl and K levels, even with the decrease in the removal efficiency of Cl and K. The decrease of Cl and K was possible because the improvements enabled the increase of the treated ash amount.

Our next step is to develop an efficient maintenance program that guarantees the availability of the ash leaching system.

Medeiros is Recovery & Utilities (R&U) specialist; Silva is technical control manager; Pignaton is R&U technical assistant; and Zutautas is R&U technical coordinator, at Veracel Celulose S.A., Eunápolis, Brazil. Figueiredo is process optimization specialist, Andritz, Eunápolis, Brazil. Email Medeiros at carla.medeiros@veracel.com.br.



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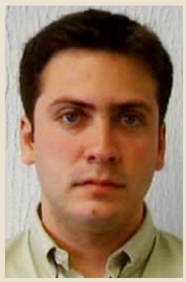

Pignaton

Zutautas

Figueiredo