Reduction of Hydrated Lime Consumption in a Bauxite Beneficiation Plant

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Abstract

Lime suspension is added to the bauxite slurry thickening process that occurs at Hydro Paragominas, leading to a better particle coagulation and, consequently, improving sedimentation. Hydrated lime $Ca(OH)_2$ dissociates in Ca^{2+} and $CaOH^+$, liberating OH^- ions. Because of this reaction, there is a pH change of the bauxite slurry and particle coagulation occurs, which improves the thickening process. This particle coagulation occurs due to neutralization of surface charges. In 2017, there was an increase of reagent consumption, which motivated the development of this project, with the objective to find alternatives to reduce lime consumption, adjusting it to the budget. Before implementing the improvement, hydrated lime preparation was done manually, which consequently made it difficult to control solution concentration. This variation contributed negatively to adequate dosage preparation, since the amount of hydrated lime contained in the solution was difficult to calculate. An opportunity was identified to standardize the procedure to determine lime dosage set point, since the quantity to be added depended on individual technician's evaluation. The work developed focused on automating the whole hydrated lime preparation process, assuring adequate solution concentration and standardizing dosage criteria. A system that automatically adds water to the preparation tank and activates the conveyor belt, screw feeder and bag filter accordingly to the level gauge was created, which allowed precise control of lime preparation and solution concentration. To standardize the dosage, a worksheet that calculates how much solution should be added to thickener feed, solution concentration and lime consumption budgeted was created. The result of this project was a 27 % reduction of reagent consumption if comparing the post-improvement period with the previous months.

Keywords: hydrated lime, coagulant, thickener, bauxite.

1. Introduction

One of the unit operations that takes place at Hydro Paragominas is the thickening process. In this operation, the thickener is fed with a bauxite slurry containing typically about 7 – 10 % and generates an underflow with approximately 40 – 45 % solid content. To reach this specification, it is necessary to add lime suspension to the slurry. The quantity of this reagent that should be added is proportional to the bauxite mass that feeds the thickener.

In presence of water, hydrated lime $Ca(OH)_2$ dissociates in Ca^{2+} and $CaOH^+$, liberating OH^- ions. Consequently, bauxite slurry pH changes and causes particles coagulation [1], which allows to achieve a thicker underflow.

This particle coagulation process occurs due to neutralization of surface charges [1]. Figure 1 shows the coagulation mechanism that happens after adding lime.

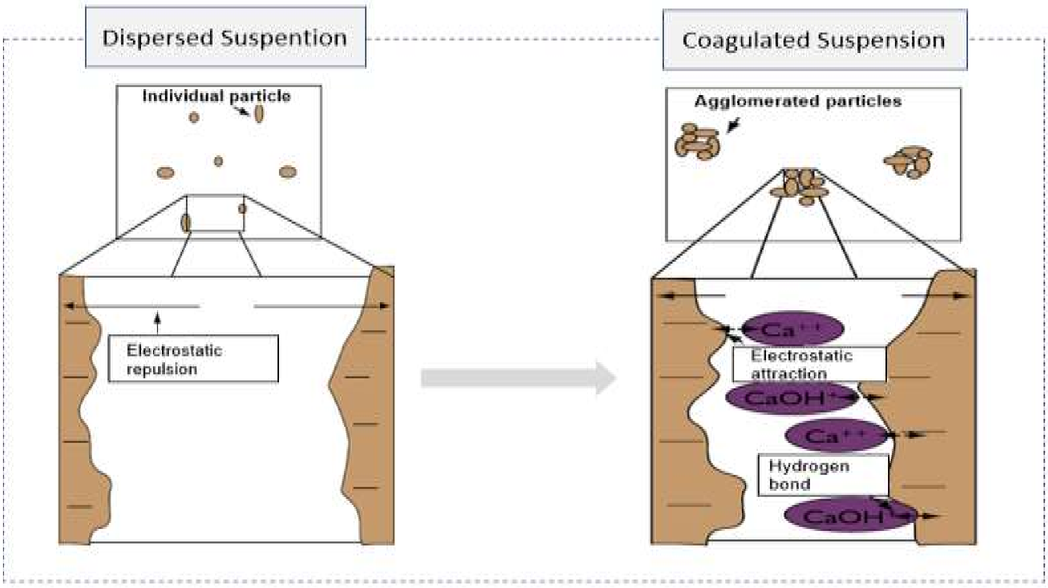


Figure 1. Forces acting on mineral particles in suspension without reagent and with lime addition.

The slurry stability is a key factor to achieve adequate thickening performance. The solid particles must be properly agglomerated to achieve the thickening rate that meets process needs.

For many years, lime has been used as a coagulant in mineral processing. For each kind of ore and process, there is a proper dosage. The overdosage of this reagent is harmful to the particle coagulation process.

In 2017, an increase of specific lime consumption has been observed. Figure 2 shows this consumption, in percentage deviation from the target.

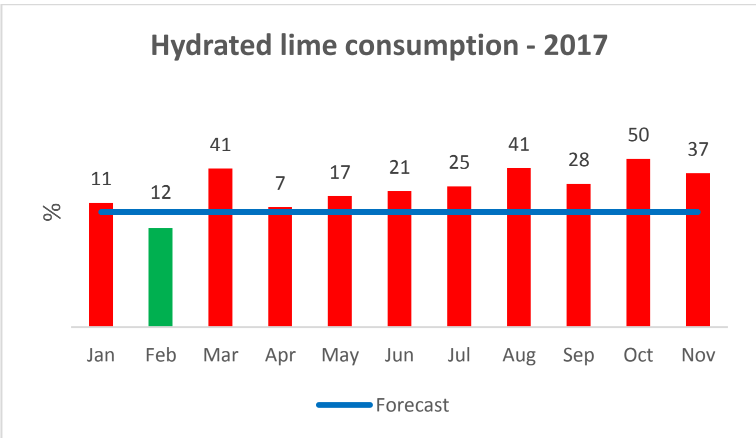


Figure 2. Hydrated lime consumption – 2017.

Taking the high reagent usage into account, an opportunity to reduce it was identified. Alternatives to not only achieve this condition, but also keep it below, forecast have been widely discussed. Figure 3 presents the gains that could be obtained if such scenario was achieved.

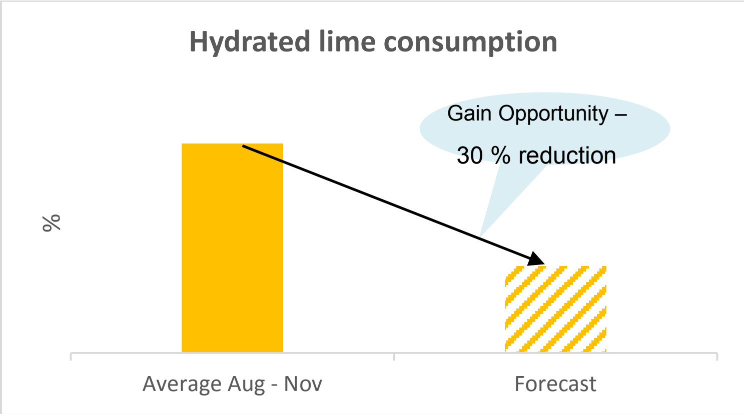


Figure 3. Hydrated lime consumption – opportunity to reduce it in 40 %.

2. Method

A detailed investigation has been carried out, by creating a cause and effect diagram to assist identifying the real cause of high lime consumption. The main possible reasons to justify the problem have been identified and are presented in the Appendix.

Among all the possible causes presented in the cause and effect diagram, the ones that presented best potential have been selected and are listed as follow:

- Manual preparation of Lime solution;
- Lime solution dosage done accordingly to individual process technician's evaluation;
- Unintended dilution of the solution from unwanted sealing water return;
- Valves used to add lime solution presenting sealing problems, allowing unintended passage of reagent;
- Low control over the prepared solution.

This investigation resulted in the creation of an action plan, which aimed to tackle all the problem sources selected. The action plan is displayed in Table 1.

Table 1. Action plan

Item	Action
1	Review lime solution preparation procedure
2	Train operators according to the new procedure
3	Standardize lime bags
4	Elaborate written procedure of the automation of lime slurry
5	Install automatic water valve
6	Replace sealing water valve
7	Create automated systems according to written procedure
8	Test logic
9	Monitor logic effectiveness for two weeks
10	Carry out sedimentation tests in the laboratory
11	Standardize dosage method

The cause and effect diagram showed that one of the main causes of the rise in lime consumption is a non-standardization of solution concentration. In order to solve this problem, it was necessary to automate the whole solution preparation, thus reducing human interference. A written procedure, which contains all the steps used to create the automation, has been made and its content can be summarized as follows:

- Create a logic that sounds a horn when the preparation tank level meter indicates a 50 % value. This horn aims to alert the operator that the lime silo needs to be recharged with one big bag. At the same time, a warning screen pops up in the computer, indicating that the control room operator needs to certify, by using a radio, that the field operator is aware of the lime reposition procedure.
- When the preparation tank level indicates 15 % of its capacity, the valve opens, allowing water passage, and remains open until the level achieve 85 %, when then the valve is automatically closed.
- When the preparation tank level achieves 85 %, the conveyor belt and screw feeder (100 rpm speed) are activated for 40 minutes, which is enough time to discharge the whole silo.
- After starting the preparation process, it takes an hour to complete the procedure and then transfer the lime slurry from the preparation tank to the dosage tank, which is enough time to ensure that a homogenized solution is prepared.
- The bag filter, responsible for removing dust, is activated during both the discharge of lime bags inside the silo and during lime transfer from the silo to the preparation tank.

After preparation, the transfer of the slurry from the preparation tank to the dosage tank is carried out:

- The dosage tank level activates a pump when it achieves 25 % of its level, which starts the slurry transfer.
- The transfer between the tanks is interrupted when the preparation tank level meter indicates 15 %, starting the whole preparation cycle all over again.

3. Results and Discussion

Once the valve used to add water inside the preparation tank was replaced by an automated one, a standardization of minimum and maximum levels of water inside the tanks could be achieved. It ensured that the water quantity added would always be the same. Figure 4 and Figure 5 show the condition before (not standardized) and after (standardized) the process improvement has been done.

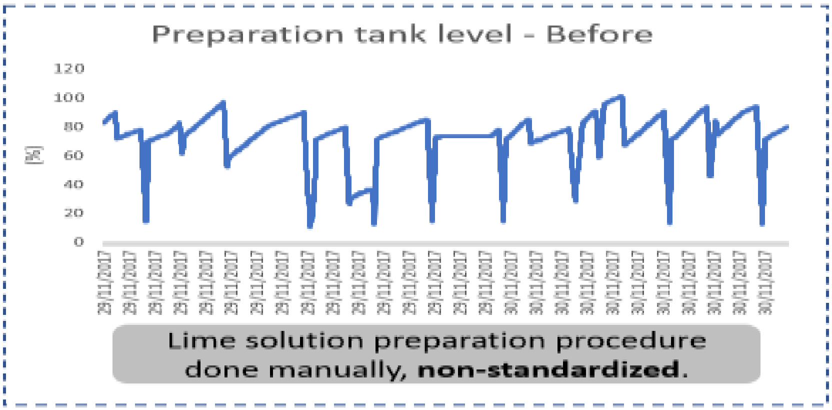


Figure 4. Preparation tank level before implementing the automation.

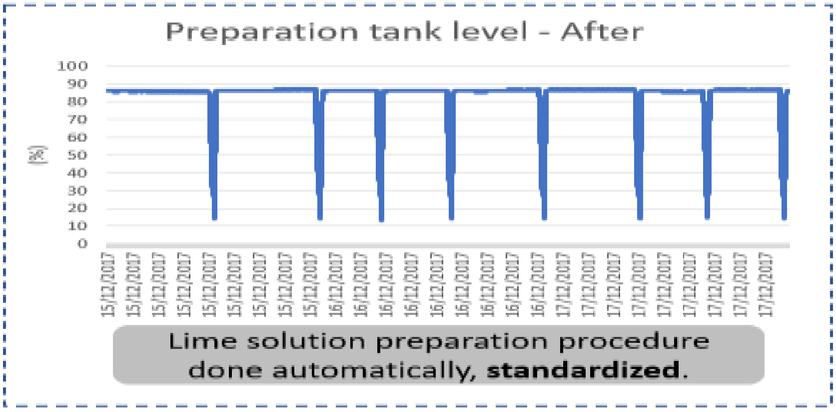


Figure 5. Preparation tank level after implementing the automation.

After automating the lime solution preparation and transfer system, it was possible to standardize the preparation and consequently the lime slurry concentration. The control chart presented in Figure 6 shows that concentration has improved by reducing variability.

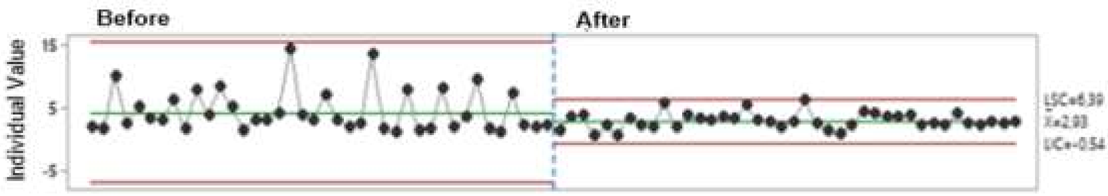


Figure 6. Control chart – Lime solution concentration.

Additionally, a reduction of turbidity of the water that comes from the thickener overflow has been observed. Consequently, there is an improvement of water quality that returns to the beneficiation process and water valve wear reduction. Figure 7 presents the boxplot graph indicating turbidity value. The data below refer to relative values, being "before" considered 100 % and "after" a proportional value corresponding to the turbidity value drop observed.

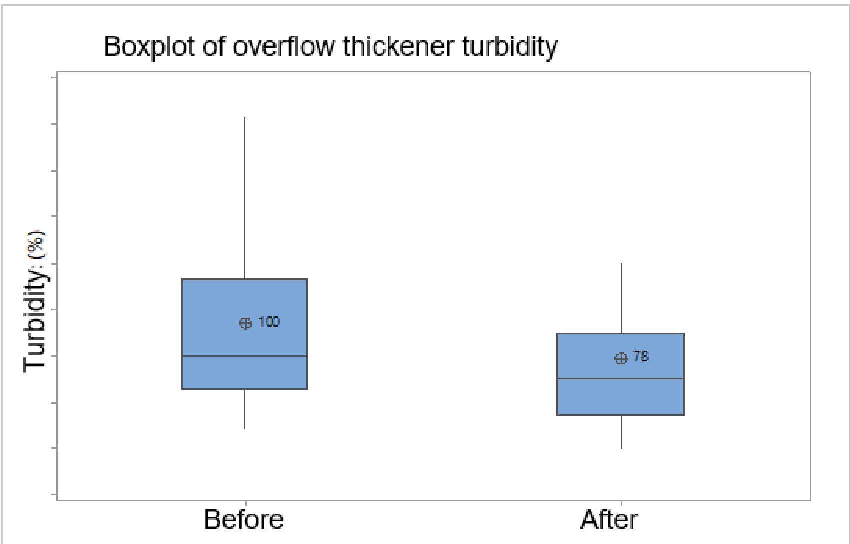


Figure 7. Boxplot – thickener overflow turbidity.

Before implementing the control measure, lime costs were increasing. After implementation, this trend has been interrupted and there has been a 30 % reduction of costs if compared to the previous months. Figure 8 shows lime consumption, comparing to the forecast.

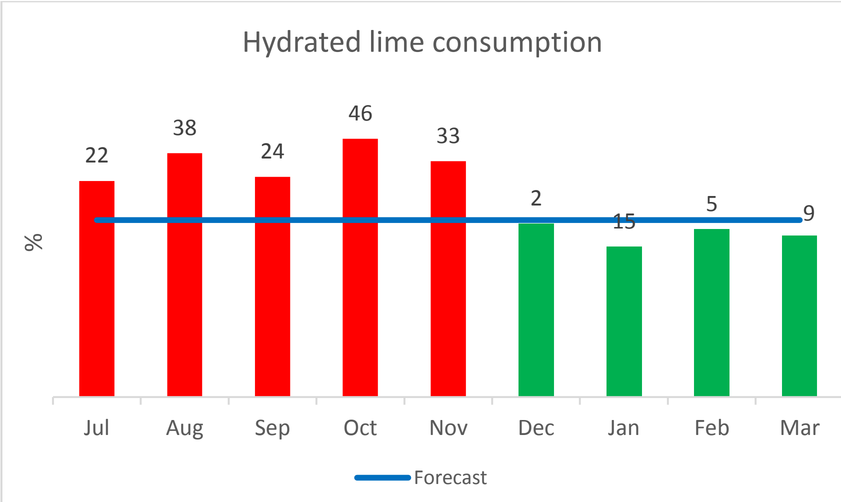


Figure 8. Hydrated lime consumption – before and after implementing the automation.

The graph above clearly shows that after implementing the control measures, there has been an overall consumption reduction (and consequently costs reduction), obtaining a 40 % saving when compared to the budget. It is important to highlight that even though hydrated lime usage was greatly reduced, all the process requisites were kept constant, as underflow density, sedimentation rate and overflow turbidity had visibly improved.

4. Conclusion

It has been observed that the main reasons that led to a high lime consumption were:

- Manual preparation of lime slurry, which limited control of solution concentration;
- No standard lime solution dosage procedure.

To tackle these problems, the main changes were:

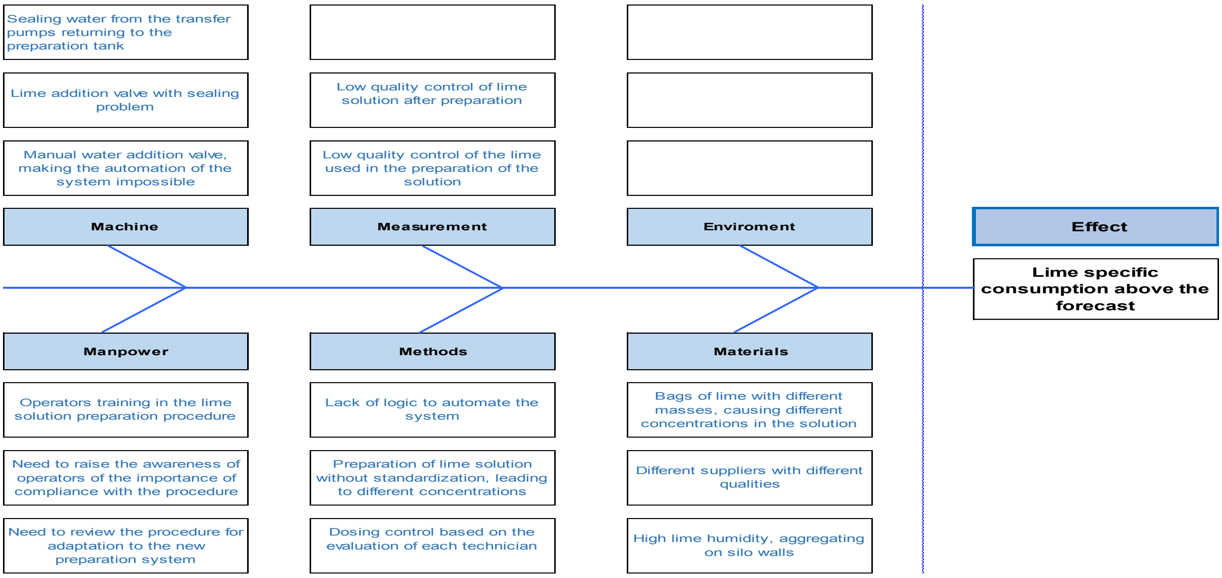
- Automating the lime slurry preparation procedure, ensuring solution concentration;
- Standardizing dosage criteria.

The automation implemented led to a lime consumption decrease, keeping it below budget. As well as a reduction in lime consumption, there has also been improvement of water quality that returns to the beneficiation plant.

5. References

1. Henrique Dias Gatti Turrer et al., Uso de coagulantes para manutenção do desempenho da filtragem de minério de ferro *Tecnol. Metal. Mater. Miner.*, São Paulo, v. 7, n. 1-2, p. 42-48, jul.-dez. 2010

6. Appendix


Sealing water from the transfer pumps returning to the preparation tank
Lime addition valve with sealing problem
Manual water addition valve, making the automation of the system impossible
Machine
Low quality control of lime solution after preparation
Low quality control of the lime used in the preparation of the solution
Measurement
Enviroment
Effect
Lime specific consumption above the forecast
Manpower
Operators training in the lime solution preparation procedure
Need to raise the awareness of operators of the importance of compliance with the procedure
Need to review the procedure for adaptation to the new preparation system
Methods
Lack of logic to automate the system
Preparation of lime solution without standardization, leading to different concentrations
Dosing control based on the evaluation of each technician
Materials
Bags of lime with different masses, causing different concentrations in the solution
Different suppliers with different qualities
High lime humidity, aggregating on silo walls