

IMPLEMENTATION OF AN ADVANCED THICKENER UNDERFLOW DENSITY CONTROL AT LOULO GOLD MINE, MALI

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ABSTRACT

A model based control strategy was implemented at a gold mine in Mali to stabilise the thickener underflow stream density. This stream acts as the feed to the leaching circuit. pH control of the leaching circuit was integrated with a model-based controller due to slow process dynamics that are not suited to PID control. The controller performance was quantified over a period of six months, and was compared to the performance before implementation. The model based controller reduced the process variability of both thickener underflow density and pH considerably. This resulted in a reduction in flocculant and lime consumption of 9.32 and 6.55%, respectively.

INTRODUCTION

Process control stability is critical in processing plants. Variations in ore feed characteristics which result in changes in steady state, combined with long residence times in gold leaching plants, present process control challenges because the controller needs to continuously adapt to a new steady state. Conventional PID controllers struggle under such conditions and consequently, overdosing of reagents is common, thus resulting in increased reagent costs. With leaching, adsorption, elution and regeneration costs contributing to approximately 6% of the total operational costs at this gold mine, a reduction in reagent consumption presented a significant opportunity for savings on operating expenditure.

This paper focuses on the implementation of a model predictive controller on a thickener and a Carbon-in-leach (CIL) tank at a gold mine in Mali. The aim was to stabilise the thickener underflow density, and the CIL tank pH, with the intention to minimise flocculant and lime consumption.

IMPLEMENTED CONTROL PHILOSOPHY

A Robust Non-linear Model Predictive Controller (RNMPC) was commissioned as the model based predictive controller. The RNMPC was suitable for the thickener underflow and CIL Tank pH due to its ability to handle long time delays, interactions between measured and control variables and it is also suitable for controlling non-linear processes such as pH.

The implemented control system's inputs and outputs are summarized in Figure 1. The thickener underflow density is controlled by manipulating the flocculant addition and the thickener underflow flowrate. Thickener underflow density control using flocculant has a time delay due to the rate of reaction of the flocculant with the slurry which in-turn affects the settling rate of the solids, and thus the underflow slurry density. There is also a delay in the thickener underflow density when the underflow flowrate is changed, for example, if the flowrate is increased, the already compacted solids will be discharged faster without causing the underflow density to change. Only when the previously compacted solids have been discharged will the reduced settling time have an effect on the amount of compaction of new solids entering the thickener, which in-turn will result in a reduced underflow density.

Furthermore, The RNMPC is also suitable for controlling pH dynamics which is highly non-linear due to the non-linear characteristics resulting from the feed and the ion concentration in the controlled system (Lazar et al, 2007). Conventional PID controllers struggle in the control of non-linear processes, as such, the RNMPC was more suitable for these application. At this plant, it was however found that a linear model is sufficient and that the time-delay had a bigger effect on the controller performance because the pH is controlled to a tight band around a fixed setpoint. The time-delay is related to the time it takes for additional lime to mix in the tank and the increased concentration to propagate to where it is measured by the pH probe.

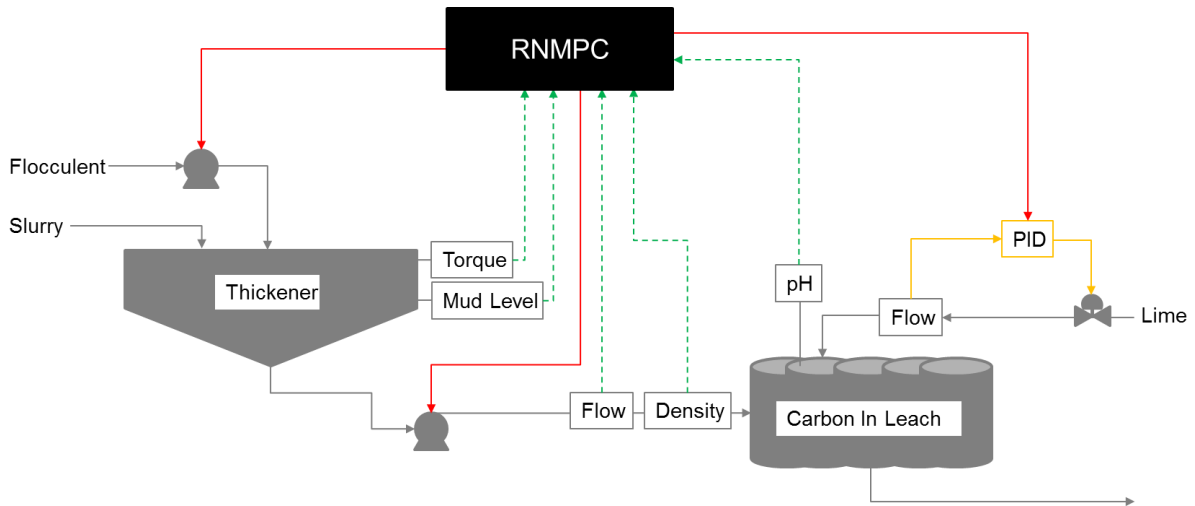


Figure 1: Process Configuration and Commissioned Control Loops

RESULTS AND DISCUSSION

Thickener Underflow Density Control

The implementation of the RNMPC around the thickener significantly improved the thickener underflow density control. A short term data analysis before and after the commissioning of the RNMPC showed that the RNMPC was able to maintain a density to setpoint error of ± 0.02 for approximately 92% of the time as compared to 66% of the time when the RNMPC was off, thus showing tight setpoint tracking using the RNMPC. A long term (six months) analysis of the RNMPC performance proved the reliability of the controller by maintaining a density to setpoint errors of ± 0.02 for approximately 82 % of the time.

In addition to tighter density control, the RNMPC was able to reduce the average flocculant consumption by approximately 9.32% since the commissioning as shown in Figure 2. The flocculant consumption slightly increased in August and September due to operational issues, however, it then consistently decreased.

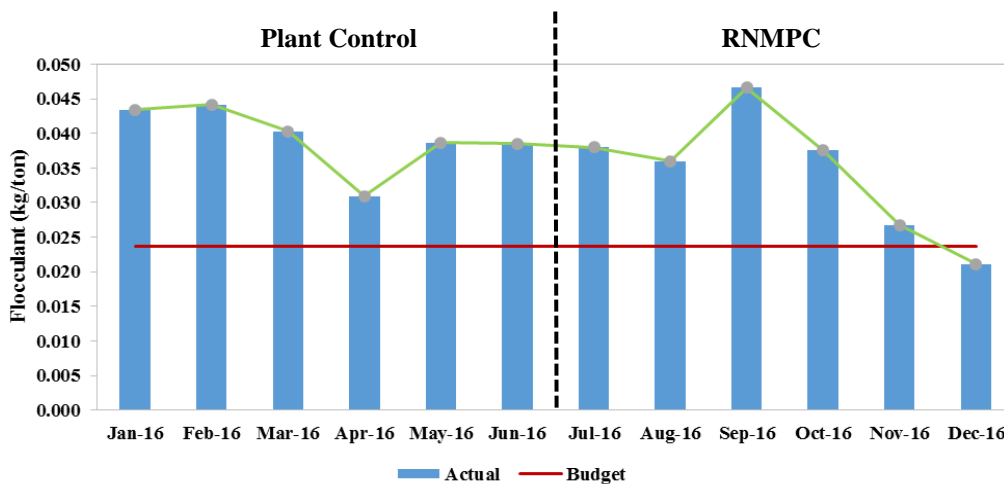


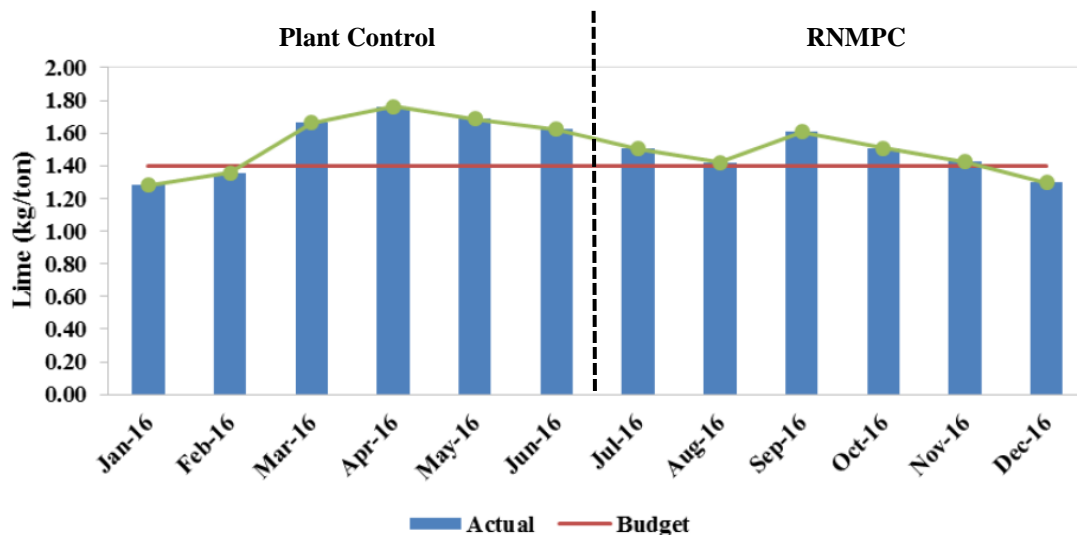
Figure 2: Average Flocculant Consumption

CIL Tank pH control

A short term comparison of the CIL Tank pH similar to that done on the thickener underflow density control could not be done due to lack of lime availability, and inconsistent lime concentration during the commissioning. Thus, the CIL Tank pH performance was evaluated in terms of setpoint variation using long term data (six months). The

RNMPC controller was able to maintain the pH control within an error of ± 0.2 for 77% of the time, despite the operational issues mentioned. The improvement in pH control by the RNMPC can be attributed to many of the controller's properties such as instantaneously (real-time) prediction of the future control actions of the control valve required to reach the desired setpoint, and the accurate modelling of the slow pH response to changes in manipulated variables

As shown in Figure 3, the RNMPC was able to reduce the average lime consumption by 6.55%. The increase in lime consumption in September was a result of high lime consuming ore that was being processed at the plant. Laboratory test work conducted on the consumption of lime by the ore being treated in September gave a higher lime consumption than usual.



CONCLUSION

The RNMPC provided tight thickener underflow density and CIL Tank 1 pH control as compared to the plant control. Consistent long term performance in the presence of process upsets was demonstrated by evaluating controller performance over a period of six months. The reduction in process variability not only benefited process stability and safety, but also resulted in a reduction in operational costs due to the reduction in reagent consumption. The average flocculant consumption decreased by 9.32%, and lime consumption decreased by 6.55% after the installation of the RNMPC. This illustrates the benefits of a model-based control strategy for processes with slow dynamics and significant variations in feed conditions.

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CONFERENCE

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REFERENCES

- Stange, W. (1999). The process design of gold leaching and carbon-in-pulp circuits. The Journal of the South African Institute of Mining and Metallurgy, 99(1), 13-25. <https://www.saimm.co.za/Journal/v099n01p013.pdf>
- Lazar, C., Pintea, R., & de Keyser, R. (2007). Nonlinear predictive control of a pH process. Computer Aided Chemical Engineering, 24(829–834).