Advanced flotation process control system at a base metal concentrator

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ABSTRACT

In 2015, the commissioning of the FloatStar stabilization and optimization control system was completed in Michigan, USA. Stabilization and optimization of the flotation circuit was achieved and ensured a consistent product quality within desired specifications.

The FloatStar Level Stabiliser was commissioned to stabilize the levels in the floatation cells. The FloatStar Grade Recovery Optimizer was configured to stabilize concentrate grades and maintain recovery above a desired minimum in the Rougher and Cleaner circuits through the manipulation of mass pulls in the relevant cells.

The optimization controller on the separation circuit was configured to minimize the amount of nickel in the copper product and optimize the copper in the nickel product.

Advanced pH controllers were implemented to ensure a desired pH control that promotes selectivity of nickel and copper at bulk flotation and separation circuits respectively.

The analysis of the results indicates that the advanced process control (APC) system has improved the overall control of the plant.

Keywords: Flotation, Advanced Process Control, Stabilisation, Optimization, Grade and Recovery

Application of Mintek’s FloatStar Control System

Conditioning Tank Control

The primary objectives of the Conditioning Tank Control were to stabilize the discharge flowrate feeding the Rougher floatation cells, thus preventing the effect of surges in the floatation cells, and to control the solids percentage feeding into the Rougher flotation section. Safety controllers were commissioned to ensure that the tank never empties or runs dry.

pH Control

Since selective flotation is a highly pH dependent process, advanced pH controllers were commissioned to ensure that the process pH is controlled tightly so as to ensure consistent grades and recoveries.

Flotation Level Control

Mintek’s FloatStar Level Stabiliser controller was commissioned for the control of the levels and has proved to be able to stabilize the flotation cells and the columns, thus providing a strong platform optimization. FloatStar Level Stabiliser is a modified controller that uses a MIMO control algorithm considering the interactions between all the cells in a flotation bank to mitigate disturbances down a flotation train.
**Flotation Grade and Recovery Control**

The FloatStar Grade-Recovery and Grade Optimizer control systems continually calculate optimum air and level setpoints to control the process to desired grades while maintaining recoveries within specified limits. Figure 1 shows the two optimization loops commissioned.

![Figure 1 FloatStar Grade Optimizer Schematic](image)

**METHODOLOGY, RESULTS AND DISCUSSION**

The performance of the controllers prior to ("Plant Control") and upon completion of commissioning ("APC system") was analyzed and compared.

**Rougher FloatStar Grade-Recovery Optimizer**

Figure 2 shows a scatter plot of the Rougher Ni recovery compared to the combined (Cu +Ni) concentrate grade in this section for a period of 24 days, each for both the APC system and plant control. In this section of the plant, the target combined (Cu + Ni) grade of the Rougher concentrate was 15% under plant control and 14% under APC. Since a 1% error in the grade reading from the Courier is acceptable, there is no significant difference in the grade targets for both controllers. A minimum required nickel recovery of 92% was specified. The plant control achieved a product within desired specifications for only 48% of the time when compared to 85% achieved with the APC system. Plant control produced higher grades than desired, which resulted in a compromised nickel recovery.

![Scatter plot of Rougher Ni recovery compared to combined (Cu +Ni) concentrate grade](image)
Figure 2 Scatter plots of Nickel Recovery vs. Combined Grade

Figure 3 shows the results for the rougher concentrate grade. An analysis of the histogram for the combined concentrate grade shows a higher peak around the desired setpoint when the APC system was activated.

![Histogram of the combined Roughers concentrate grade](image)

**Figure 3** Histogram of the combined Roughers concentrate grade

The APC system on the Rougher loop was able to control the combined (Cu+Ni) concentrate grade around specified grade setpoint. A sectional recovery improvement of nickel by 1.5% was achieved by the APC system.

![Rougher Nickel Recovery Plant Control vs. APC system](image)

**Figure 4** Rougher Nickel Recovery Plant Control vs. APC system

Cleaner FloatStar Grade Optimizer

The flotation process included a secondary milling circuit of the Rougher concentrate before feeding the Cleaners. Ten days per control mode were evaluated. The analysis done in this section compares the performance of the operation on the Cleaner circuit under the following control modes:

- Plant Control without the Secondary Mill
- APC system without the Secondary Mill
- APC system with the Secondary Mill

Greater variability in the nickel losses in the Cleaner circuit is observed under plant control as shown in Figure 5. An improvement, relative to plant control, in minimizing the nickel losses is observed under the APC system when the secondary mill was not running. An even further improvement with
the secondary mill running is achieved under the APC system. Liberation of minerals is a crucial factor to promote floatability of minerals in the flotation process.

![Figure 5 Nickel grade in the Cleaner Final Tailings](image)

Plant personnel set a threshold for the Cleaner tails nickel grade to not exceed 40% of the nickel grade in the feed after the estimated residence time of material between Rougher feed and Cleaner tails has elapsed. This threshold grade was based on historic plant data from optimal shifts. The threshold was exceeded by only 4% under the APC system without secondary milling versus the 19% observed under plant control. With the APC and while the secondary mill was running, the nickel grade in the Cleaner tails was below the threshold by 20%

Long term analysis under APC system with secondary milling is shown in Figure 6. With secondary milling, it is apparent that the APC system is able to minimize the nickel losses in the Cleaner tails without violating the desired threshold for over 87% of the time.

![Figure 6 Long Term Analysis of Nickel grade vs. Nickel grade Threshold](image)
FloatStar Grade Optimizer of the Cleaner Columns

In Figure 7, a comparison is shown between the Grade Optimizer (FSGO ON) and the plant controller (FSGO OFF) on the Cleaner Columns loop. Histogram analysis shows that the Grade Optimizer was able to control the nickel grade closer to its setpoint of 1%. The nickel grade in the Copper Thickener feed was at or less than the threshold grade of 1%, 72.02% of the time when the Grade Optimizer was on, compared to 52% when the Grade Optimizer was off. A comparison of the spread of the data points shows that the Grade Optimizer stabilized and minimized the nickel grade in this stream.

![Graph showing error histogram for Copper Thickener feed Nickel grade](image)

**Figure 7** Error histogram of the Copper Thickener feed Nickel grade

CONCLUSION

The Advanced Surge Tank Controller was commissioned on the Rougher Conditioning Tank for the stabilization of the discharge flowrate to downstream processes. Improved stability of the discharge flowrate has been achieved with the Advanced Surge Tank Controller without compromising other process constraints.

The pH Controller was successfully commissioned. It was found that, with the pH Controller, control of the pH to the setpoint was drastically improved, with overdosing of the pH reagents completely eliminated.

Two levels of the FloatStar system were successfully installed. The FloatStar Level Stabiliser was able to provide efficient flotation stability on the flotation cells, including the columns, as demonstrated by the faster disturbance rejection and setpoint tracking in the analyzed results.

A nickel recovery improvement of 1.5% at an improved product quality was observed on the Rougher circuit after the implementation of the APC system. The Grade Optimizer on the Cleaners was able to control the combined nickel plus copper concentrate grade within the desired product specifications for 80% and 75% without and with the secondary mill. Only 45% of the product within desired specifications was produced under plant control while the secondary mill was not running. With the secondary mill running, the nickel grade in the Cleaner tails was below the threshold by 20%, which is approximately equivalent to 38% improvement relative to the observed performance under the plant control.

The FloatStar Grade Optimizer was able to minimize the nickel content in the copper product and optimize copper in the nickel product. Due to lost value caused by high nickel content in the copper product, the optimization system was successfully commissioned to prioritize the minimization of nickel reporting to the copper concentrate.
The full paper is available on: http://www.gecaminpublications.com/procemin2015/