

MillStar and FloatStar advanced process control system at a Silver (Ag) concentrator

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ABSTRACT

In 2013, the commissioning of the MillStar Stabilisation and FloatStar Stabilisation and Optimisation controllers were completed at one of the base metal concentrators in Chile. The MillStar control system has stabilised the feed to the SAG mill as well as the density at the discharge end of the SAG mill and ball mill. The FloatStar Stabilisation and Optimisation controllers have successfully stabilised and optimised the flotation circuit to ensure consistent product quality within desired specifications.

The mill feed is controlled utilising the MillStar Solids Feed Controller. Additionally, the solid to liquid ratio into the SAG mill was controlled utilising the Mill Inlet Ratio Controller in conjunction with the Solids Feed Controller. The Robust Nonlinear Model Predictive Controller (RNMPC) was used to control the discharge end of the milling circuit, specifically the mill discharge sump level and the primary cyclone feed density, to produce a more consistent feed to the flotation circuit.

Three levels of the FloatStar control system were installed. The FloatStar Level Stabiliser (FSLs) was used to stabilise the level control on 6 flotation banks. The FloatStar Flow Optimiser (FSFO) was commissioned on the Rougher, Scavenger and Cleaner concentrate sumps to stabilise concentrate flow from the flotation cells. The FloatStar Grade Recovery Optimiser (FSGO) was commissioned on the Roughers section. Instrumentation challenges limited the overall benefit derived from the system. Once these were addressed, the performance was optimised. The overall benefit of the Advanced Process Control (APC) system was observed by the improvements in Ag recovery.

APPLICATION OF MINTEK'S ADVANCED CONTROL PHILOSOPHY

For a full description of the control strategy that was implemented, refer to the full paper published by Mantsho *et al.* (2014).

Milling Circuit

The main objectives of the MillStar Advanced Control system were to:

- Stabilise the mill feed using the MillStar Solids Feed Controller, with Mill Inlet Water Ratio Control.

- Controls the feed tonnage into the mill to setpoint by adjusting the vibratory feeder frequencies.
- Controls the solids-to-liquid ratio into the mill by adjusting the mill inlet water flowrate.
- Stabilise the mill discharge using the StarCS RN MPC.
 - Controls the cyclone feed density and sump level to setpoint whilst maintaining the cyclone feed flowrate and pressure within its constraints.

Rougher and Scavenger Flotation Circuit

The main objectives of the FloatStar Advanced Control system were to:

- Ensure a stable concentrate flow from the Rougher sump and the Scavenger sump to the Cyclone Battery D6 downstream and the Rougher flotation cell respectively, by utilising the FSFO.
 - Controls the level in the Rougher sump and the Scavenger sump to maintain it within its limits and calculates the appropriate level and air setpoints.
- Stabilise the levels in the cells utilising the FLSLS.
 - Controls the level in the cells by taking into account the interactions between flotation cells.
- Maintain the Rougher concentrate grade to a grade setpoint utilising the FSGO.

Cleaner and Column Flotation Circuit

The main objectives of the FloatStar Advanced Control system were to:

- Ensure a stable concentrate flow from the Cleaner sump to the Column flotation cell by utilising the FSFO.
 - Controls the level in the Cleaner sump to maintain it within its limits and calculates the appropriate air and level setpoints.
- Maintain the final concentrate grade to its setpoint by utilising the FSGO.
 - Controls the air and level setpoints of the Column flotation cell to maintain the final concentrate grade to its setpoint.

RESULTS AND DISCUSSION

Figure 1 displays the control achieved for a period of two months each (excluding planned shutdowns) on the cyclone feed density whilst under Mintek control and plant PID control. The results indicate that the cyclone feed density showed large variations from setpoint under plant control, as compared to Mintek control, which affects the primary classification, leading to an inconsistent feed grind to the flotation circuit.

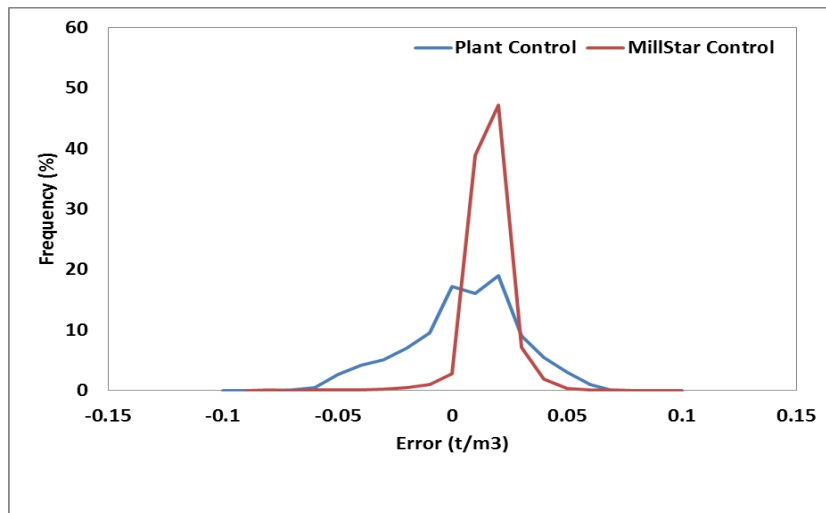


Figure 1: Cyclone feed density for MillStar and plant PID control

Figure 2 illustrates the performance of the Flow Optimiser on the Roughers, Scavengers and Cleaners concentrate streams over a period of two months. Above 90 percent of the observation on the Roughers and Cleaners are within the concentrate error -0.2 to 0.2 m³/hr. 80 percent of the observation on the Scavengers are within the concentrate error -0.4 to 0.4 m³/hr. This implies adequate stability achieved by the control system with respect to concentrate mass pulls on these sections. The concentrate flow error for the Roughers, Scavengers and Cleaners could not be calculated under plant control due to the plant only controlling concentrate sump level to setpoint and not concentrate flow.

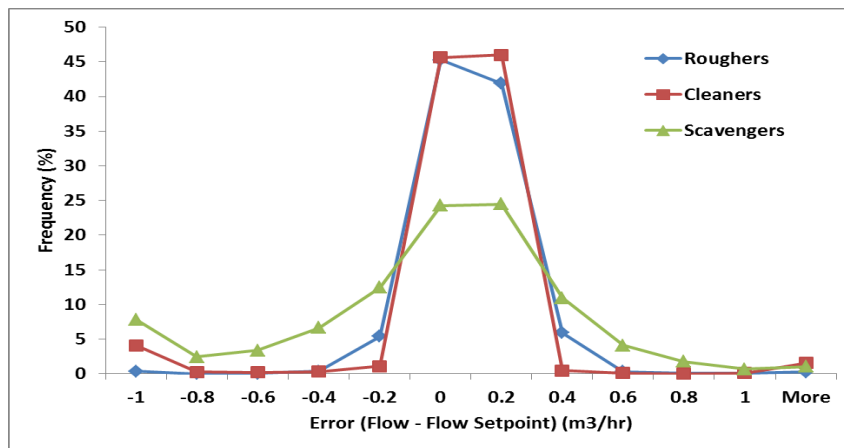


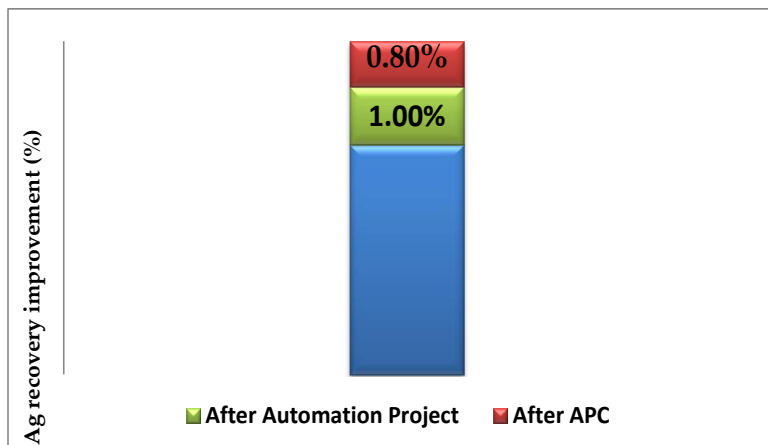
Figure 2: FloatStar Flow Optimiser performance

Table 1 shows the variability in the concentrate flow on the Roughers, Scavengers and Cleaners under Plant Control and Flow Optimiser. The flow optimiser was able to significantly reduce variability in the concentrate flow resulting in a more stable operation when compared to Plant Control.

Table 1: Concentrate flow variability (standard deviation) under Flow Optimiser and Plant Control (2 month period each)

	Roughers m³/hr	Scavengers m³/hr	Cleaners m³/hr
FloatStar Flow Optimiser	0.24	0.59	0.28
Plant Control	3.57	4.01	2.35

Figure 3 illustrates the metallurgical performance improvement provided by the Mintek control system. The plant analysed Ag concentrate grade and recovery data (based on metal accounting) for an evaluation period of 6 months before and after the implementation of the APC. A recovery improvement of 0.8% was reported since the evaluation of the APC commenced. In addition to this, a 1% Ag recovery was derived from the plant automation project. The economic benefit as illustrated below by return-on-investment (ROI) illustrates the value derived from the implementation of the APC.



	Automation	APC
ROI	3.67%	26.45%

Figure 4: Silver (Ag) recovery improvement

CONCLUSION

The milling control system showed a measurable improvement in cyclone feed density stability compared to the plant controller. The FSFO has demonstrated adequate stability on the concentrate mass pulls from the flotation section. The initial testing of the FSGO was able to control the Rougher concentrate grade tightly to the desired grade setpoints, thereby ensuring a maximum possible recovery in terms of the Ag mineral. Long term evaluation of this controller on the Rougher will be conducted when the plant is satisfied with the Blue Cube calibration on this section. Plant personnel reported that the APC system indicated a Silver (Ag) recovery improvement of 0.8% over a 6 month evaluation period.

CONFERENCE

The full paper will be presented at:

The annual IMPC Conference to be held at Hotel Sheraton, Santiago, Chile from 20-24 October 2014