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Performance optimization of copper flotation at the Boliden Kylylahti plant

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BACKGROUND

The Boliden Kylylahti plant is located in the eastern part of Finland, about 50 km east from Kuopio. The operation includes the Kylylahti underground mine in Polvijärvi and the Luikonlahti processing plant at Kaavi, 43 km from the mining area. The Kylylahti plant produces over 50 000 tons/a of copper concentrate. Other main products are zinc and gold. Copper, zinc and gold concentrates produced at Luikonlahti are delivered to Boliden's own smelters in Harjavalta and Kokkola. The concentrator plant was originally established by Myllykoski Oy in 1968 and it was operational until 1983. After a silent period of nearly two decades, Kylylahti mine was re-opened by Altona Mining Ltd. in 2012 and acquired by Boliden in 2014. Based on the latest ore reserve estimates, the mine is expected to operate until 2020.

ABOUT THE PROCESS

Fresh ore is transported with trucks to the concentrator plant, where it is first crushed and then fed to typical 3-stage grinding circuit with a targeted particle size around 100 μm. A special feature in Kylylahti's grinding circuit is that it includes a Knelson concentrator for trapping the liberated gold particles at an early stage of the process. The gold missed by the Knelson concentrator will be recovered later on, together with copper, and separated in smelting.

After the grinding, first stage of the actual separation process is copper flotation circuit. It contains four 16 m^3 roughers cells and two 16 m^3 scavenger cells. The cleaner stage is organized in three phases by twenty-two cells (2 x 30 m^3, 2 x 20 m^3, and 18 x 3 m^3). The following two flotation stages are zinc and pyrite circuits, respectively. The Advanced Process Control (APC) presented here was implemented to copper circuit because 90% of turnover comes from copper and gold. Also, the copper flotation is the first circuit of flotation process and thus stabilization and optimization of the copper stage will benefit later processing stages as well.

APC SOLUTION

APC control is implemented by using Outotec's Advanced Control Tools® (ACT) platform. ACT platform is dedicated environment for advanced process control solutions. In general, ACT platform includes (see Figure 1) engineering tools, control engine, historian database, data interface to external systems and operator interface. Typically, first four items are executed in dedicated ACT server computer and operator interface in separated ACT client computer.

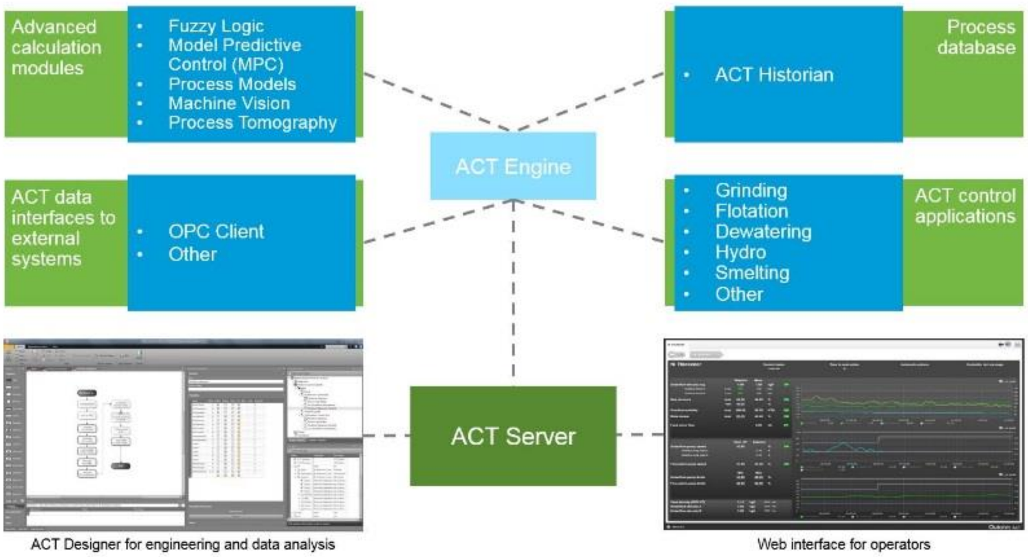

Figure 1. Outotec's Advanced Control Tools platform structure.

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There were several reasons justifying the implementation effort of higher level control, namely, 1) big variations in the feed copper content, 2) low copper recovery, and 3) different control principles between shifts. The selected APC control method for Kylylahti was Model Predictive Control (MPC) and it was implemented during spring and summer 2017.

The existing process instrumentation had been recently upgraded with Outotec's FrothSense cameras (located in Cu-rougher and Cu-scavenger banks) and froth speed controls (froth speed is controlled by manipulating air feed rate and slurry level of cells equipped with FrothSense cameras). Additionally, X-Ray fluorescence based Courier 5™ analyzer provides the most important process measurements (elemental grades) for APC control.

For the MPC solution, the most important control variable is copper tailings Cu content, which correlates strongly with overall Cu-recovery. The other control variable is rougher concentrate Cu%. This has correlation with final concentrate Cu%.

APC control manipulates set points for froth speeds and reagent dosing for fulfilling the desired performance. Additionally, when the performance is on a good level, the controller minimizes reagent usage to cut costs.

RESULTS

The performance of APC control was tested by comparing copper grade and recovery results with a given feed grade (average over the test period). The control was enabled and disabled in 24-hour cycles to eliminate the effect of feed changes and, on the other hand, to obtain statistically credible results. The Figure 2 shows the feed grade changes during the test period. Feed grade, concentrate grade and recovery were based on on-line Courier analyzer values.

Figure 2. Copper feed grade (%) during the test period (15 days of data, spring 2018)

Both values, grade and recovery, are slightly higher when APC control was enabled. Figure 3 shows the online analyzer measurements during ON/OFF tests. However, more important is the stabilizing effect shown in Table 1: the standard deviations of grade and recovery were decreased significantly.

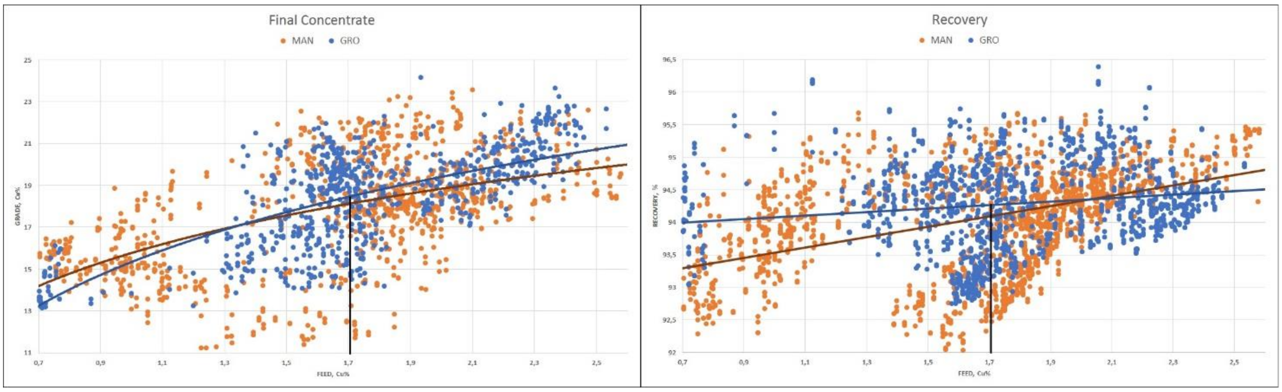

Figure 3. Grade and recovery changes during ON/OFF tests.

Table 1. Grade and recovery changes during ON/OFF tests.

	ACT control	Concentrate Cu grade (%)	Cu recovery (%)
Value at averaged feed (1,7%)	ON	18,46	94,27
	OFF	18,12	94,09
standard deviation	ON	1,59 **(-40%)**	0,67 **(-15%)**
	OFF	2,63	0,79