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Performance optimization of paste thickening at the Yara Siilinjärvi plant

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This abstract and related presentation is a shortened reproduction of the results presented at Paste 2018 Conference in Perth, Australia, 11-13 April 2018[1]. Main focus is on the results obtained by applying a multivariable, optimizing control strategy to two new paste thickeners manufactured and commissioned by Outotec for Yara Siilinjärvi plant.

The Yara Siilinjärvi plant is located in the central part of Finland, some 25 km north from Kuopio. The site consists of a mine, two sulphuric acid plants, one phosphoric acid plant, one nitric acid plant and one NPK-fertilizer plant. The Siilinjärvi mine produces about one million tons of apatite concentrate, which creates approximately 10 million tons of tailings per year.

At the beginning of 2017, tailings handling in Yara Siilinjärvi was brought to a new era, when the conventional tailings storage facility was replaced with a new tailings treatment plant. The aim was to extend the lifespan of the 1 150-hectare tailings storage area without increasing the footprint, since this would have meant new land purchases, dam increases and related permitting processes. The solution was to construct a completely new tailings treatment plant, where the water content of the tailings material is reduced so much that the resulting paste can be stacked in piles and thus the same amount of material requires much smaller physical footprint. The new plant, located 6.6 km's from the concentrator, was commissioned by Outotec and – thanks to the advanced process control solution presented here – is currently being run in un-manned mode remotely from the main plant's control room. The new high-density tailings disposal system with two deep cone-type paste thickeners increased the percentage of solids in the slurry from 45–48% to 66–69%, making it possible to deposit as paste. This extended the lifetime of the current tailings storage facility by 15 years – from 2020 until 2035.

The rheology of the tailings in Siilinjärvi is unique, due to the minerology of the slurry. In particular, the high content of coarse mica makes thickener operation challenging and makes high density pumping sensitive to disturbances. Therefore, the importance of process control cannot be underestimated. Advanced control system is needed to maintain process stability and the desired operation point in varying situations, and to enable remote operation as mentioned earlier. The presented solution is based on Outotec's Advanced Control Tools (ACT) platform, which can be cost-effectively utilized with any customer DCS/PLC system (Distributed Control System/Programmable Logic Controller). With the ready-made application package, implementation is straightforward, and only a minimal amount of system specific tailoring is needed. The ACT system in Yara is highly integrated with the plant DCS, so that the operators have full access to user interface, alarms, interlockings, history data and documentation, through the DCS displays.

The control is based on Model Predictive Control (MPC), which is nowadays included in Outotec's ACT platform. The overall control system structure is shown in Figure 1 below. Controlled variables are: Underflow density (kg/m3), Overflow solids content (%), Bed mass (%), Bed level (m) and Rake torque (%). From these variables, underflow density was selected to be a primary control variable, which has a precise target value and the highest priority during normal operation. This was a natural choice, because the main target of the whole paste plant is to produce stable and high enough underflow solids content, thereby ensuring stable pumping and good tailings beaching properties.

[1] Ruhanen, E, Kosonen, M, Kauvosaari , S & Henriksson, B 2018, 'Optimisation of paste thickening at the Yara Siilinjärvi plant', in RJ Jewell & AB Fourie (eds), Proceedings of the 21st International Seminar on Paste and Thickened Tailings, Australian Centre for Geomechanics, Perth, pp. 75-88.

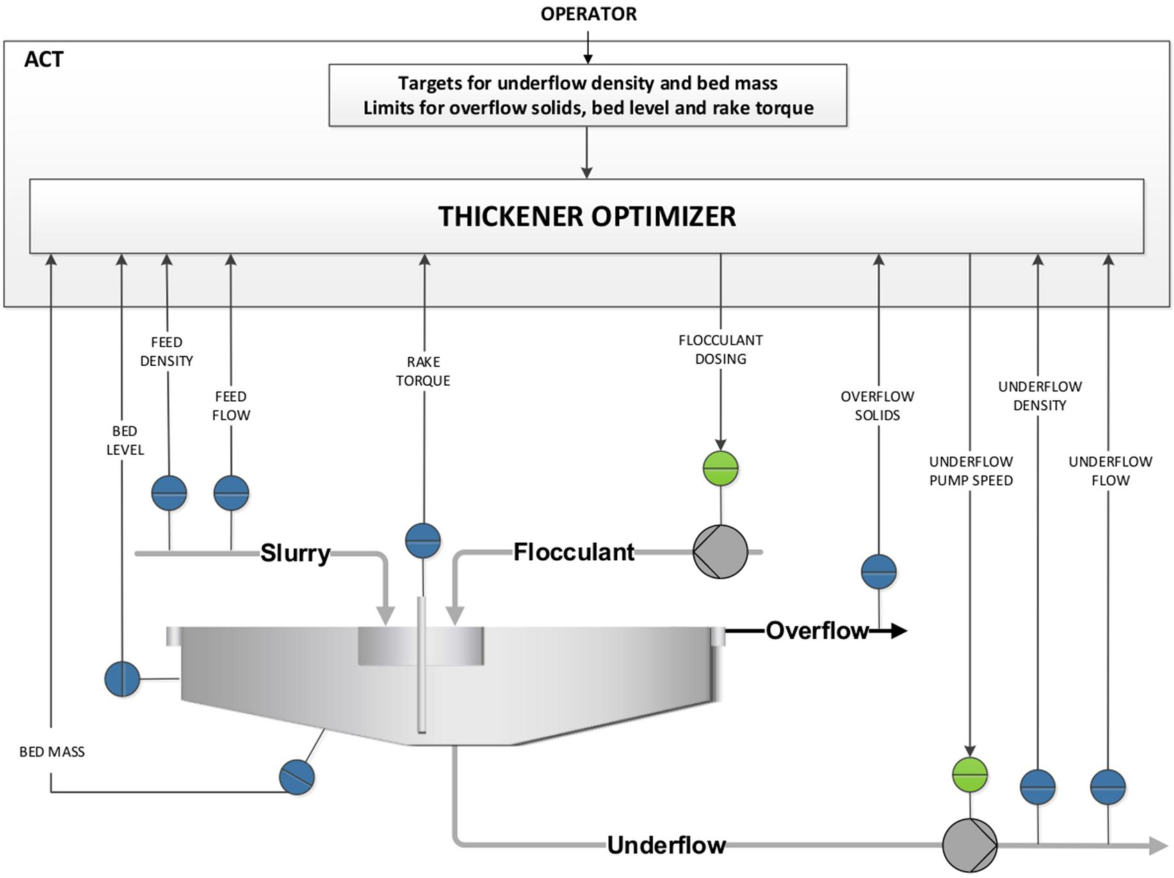

Figure 1. Structure of the controller.

Long-term follow-up (see Figure 2) shows that with the optimizing control, the Yara paste thickeners can run with underflow solids content of 66–68% to average beach slope angles[2] of 3.5 degrees (6.1%) in the tailings disposal area. Note that, the shown limits (black lines) are not used in MPC control, they just illustrate the stability of controlled solids content.

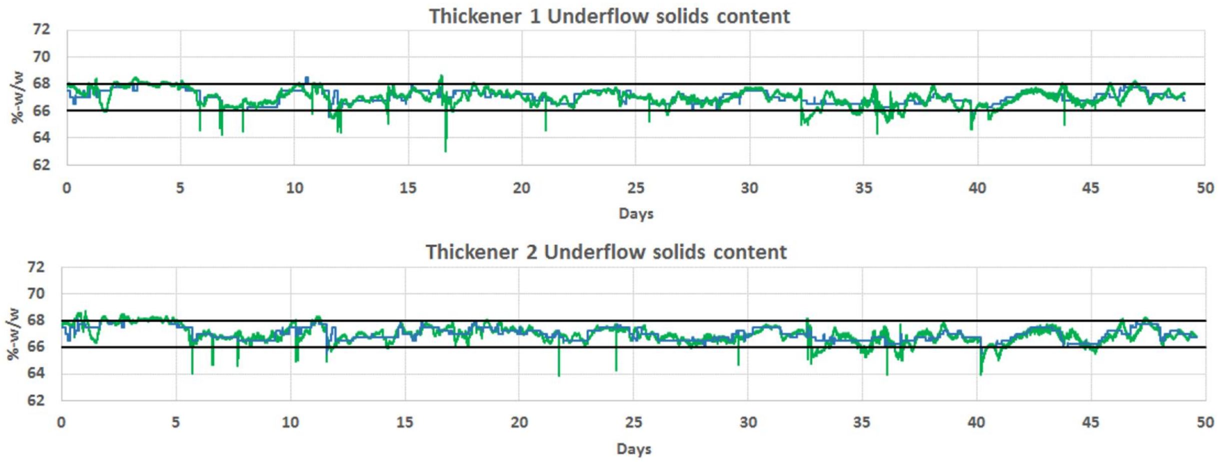

Figure 2. Long-term solids content[3] variability (*green*: measured value, *blue*: target value).

Additionally, this control system facilitates the minimum use of flocculant, which means 10-20% savings in the flocculant costs. Robust thickener operation also leads to trouble-free high-density pumping and high availability of the paste plant. One of Yara's major goals was to be able to operate the Paste Plant remotely from the main concentrator plant. Currently, the Paste Plant is fully operated remotely and only the daily process checking are done locally.

[2] Beach slope in the tailings industry refers to the surface slope of the tailings after being hydraulically or mechanical deposited from a point of discharge.

[3] Solids content calculated from the density: Cw = Ss*(S-Sl) / S*(Ss-Sl) * 100%; Cw = Concentration of solids by weight, S = Specific gravity of slurry, Sl = Specific gravity of liquid phase, Ss = Specific gravity of solids phase