Case Study: Optimization of a Concentrate Thickener Circuit at a Concentrator Plant in WA, Australia

Introduction

IntelliSense.io, in partnership with BASF, recently embarked on an Optimization as a Service (OaaS) partnership with a mineral concentrator plant in Western Australia (“the client”). The aim of this and other OaaS partnerships is to provide the client with the guidance and solutions required to unlock new operational value by means of digital transformation.

This Case Study outlines and reports on the initial phases of this partnership with the WA-based client, and the results achieved thus far.

Digitalization Roadmapping

During the first phases of the project, IntelliSense.io worked with the client to map out their physical processes and operational workflows, and to understand the KPIs defining the success of their operation. IntelliSense.io and BASF did an analysis of the client’s process flowsheets and visited their site to become familiar with the client’s concentrator plant. This includes crushed ore stockpiles, a grinding, flotation, thickener and filtration circuit, as well as a large tailings storage facility.

IntelliSense.io did data analytics on the client’s historical data to review potential root causes behind the pain points described by operating personnel. In working with the on-site metallurgists, it became clear that they had a particular challenge with sufficiently drying their concentrate product without impeding on overall throughput. The concentrate drying processes, made up of the concentrate thickener- and filtration sections, were their process bottleneck. IntelliSense.io and BASF advised the client that the optimization of their concentrate thickener circuit would be a suitable focus for phase one of the OaaS partnership.

In addition to identifying the thickeners as the first area of focus, IntelliSense.io and BASF worked with the client to start mapping out what digital transformation could look like for them - delivering a continuous improvement roadmap to improve the client’s operation. In line with continuous improvement best practice, this roadmap was to be reviewed at the end of each phase, before proceeding to the next phase.

Thickener Circuit Improvements

IntelliSense.io and BASF demonstrated that the client's thickener circuit had clear room for improved performance, and that improvement on the thickener circuit would significantly impact their overall process performance.

In conversation with operating personnel, the following key pain points were identified around their thickener circuit:

Problem	Operational Impact	Business Impact
In an attempt to increase the underflow density to the desired point, operators added excess flocculant.	Excess flocculant in the thickener overflow goes to the water treatment (reverse osmosis) plant, and has a detrimental effect on its performance. • Filter cloth fouling, decreasing both the performance and life of the filters. • Increased yield stress of the slurry, leading to high rake torque. • A spongy bed, preventing the achievement of high enough hydrodynamic pressure to achieve the targeted underflow density.	These operational impacts decrease process throughput and lead to additional equipment maintenance/replace costs.
Their operators very often struggled to consistently achieve a sufficiently high underflow density (or %solids).	Concentrate with a higher water content takes more time to achieve the desired product density at the filters. This lowers the throughput of the overall concentrator plant.	Lower throughput meant a lower overall concentrate production rate, impacting the client's annual production figures & revenue.
Due to running at high flocculant doses, operators had the problem that the thickener bed started sticking to the rake. They tried to overcome this by periodically lifting the rake to "shake off" the solids.	This sticky bed not only made filtering more of a challenge (as mentioned above), but the rake lifts destabilised the whole thickener, causing high process variability that limited the thickener performance.	

A historical data analysis by IntelliSense.io and BASF confirmed the pain points mentioned above. The recommended solution involved two parts, which will now be discussed:

1. The improved control and optimization of Thickener 1
2. Recommendations to the client on sensors and base layer control

Thickener Optimization Scope

In order to help the client's metallurgists and operators with their operational decision-making around the thickeners, IntelliSense.io's Thickener Optimization Application was implemented on Thickener 1 (one of two parallel concentrate thickeners). Initially, the plan was to do real-time optimization on all the concentrate thickeners, but the instrumentation challenges (see the next section) meant that IntelliSense.io and BASF decided to proceed only with Thickener 1.

The implementation of the Thickener Optimization Application on Thickener 1 involved:

1. Integration with the client data sources
   The connection with the client's Data Historian, so IntelliSense.io's *brains.app* decision-making platform automatically ingest both historical and live data.
2. Configuration of a Digital Process Model for the thickener circuit
   This involved the training of a machine learning based "digital twin", which predicts the thickener performance based on the feed quantities, -properties and control variable settings.
3. Configuration of the Optimizer's Value Driver
   This is the setup of Optimizer objectives and constraints, which is done with the client. This is to ensure that the Optimizer pursues "success" as defined by the client.
4. Implementation and calibration of the Thickener Optimizer
   The Digital Process Model is turned into an Optimizer, pursuing the objectives and adhering to the constraints set in the Value Driver. This Optimizer provides recommended setpoints for the available control variables, which are then implemented by control room Operators, or directly passed to lower level control systems.

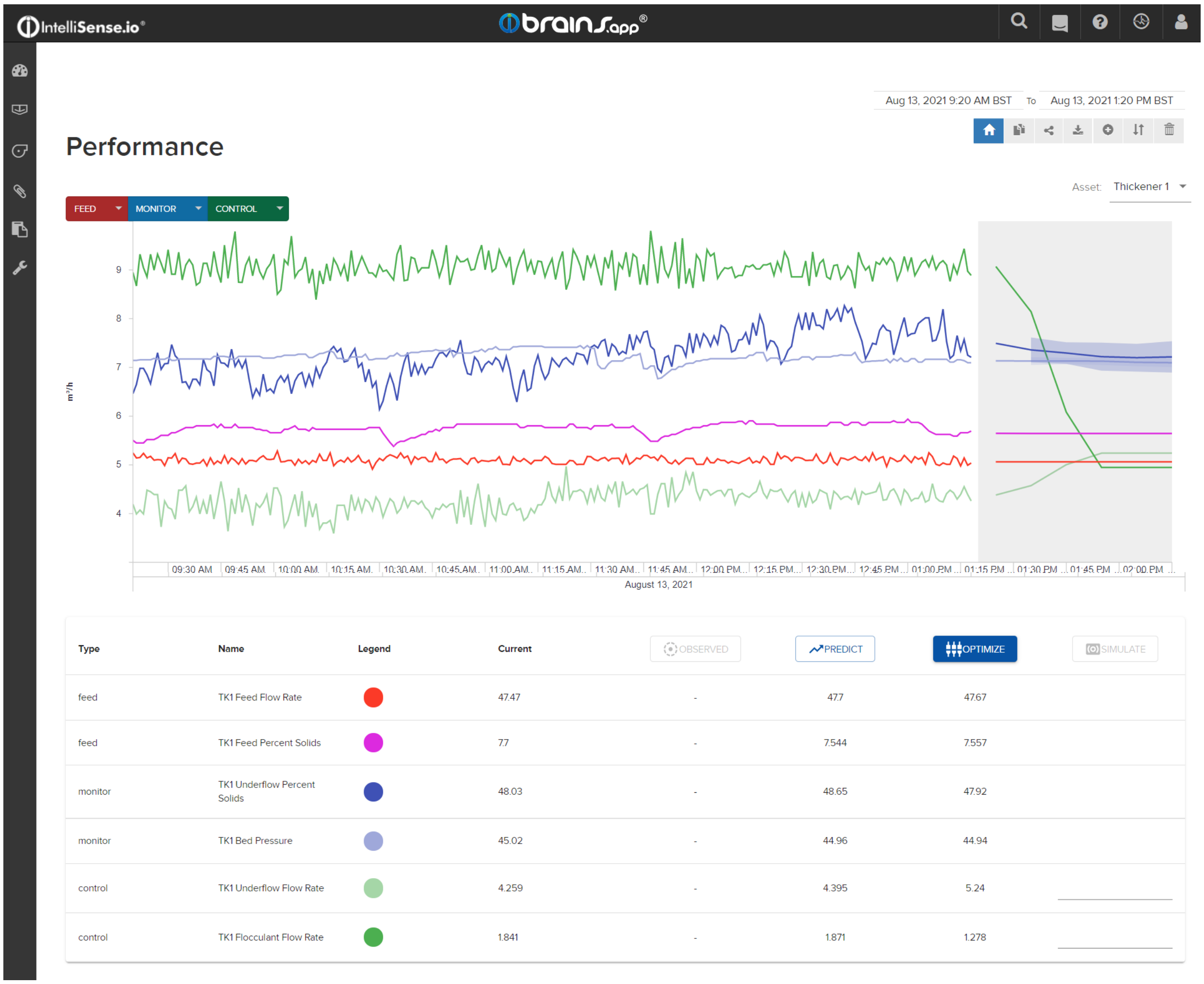

Figure 1: Example of the Thickener Application's Performance screen

The Optimization Application was configured for the following set of variables:

Feed & Disturbance Variables What the Optimizer responds to	**Target Variables** What the Optimizer targets (via the Value Driver, read below)	**Control Variables** What the Optimizer changes
Feed flow rate Feed density Candidates for next phase: Feed material properties	Underflow % solids Mass balance (solids inventory) Bed pressure Rake torque Candidates for next phase: Filter feed tank level	Underflow flow rate Flocculant flow rate Candidates for next phase: Rake height Feed flow split between thickeners

The configured Value Driver consists of the following objectives simultaneously:

- Underflow % solids: maximise, but keep below an upper limit
- Flocculant dose: minimise flocculant usage
- Bed pressure: keep below an upper limit
- Rake torque: keep below an upper limit (protect rake)
- Mass balance: keep solids inventory in check

All control variables also had minimum, maximum and rate-of-change limits.

Figure 1: Ken Plozza from BASF monitoring the Thickener process via brains.app, configured in the client control room.

Thickener Optimization Results

IntelliSense.io and BASF implemented the Thickener Optimization Application, did on-site calibration, acceptance testing and Value Driver tuning with the client, trained the client on using the system and initiated the change management process.

In order to verify the process improvements brought about by the implementation of the Thickener Optimization Application on Thickener 1, IntelliSense.io and BASF did a thorough performance evaluation. This involved a sequence of ON-OFF testing with the client. During the ON periods, operators implemented the control variable setpoints recommended by the Thickener Optimization Application - and during the OFF periods they operated the thickener as they would otherwise. This testing was done over several days.

The results showed that the optimization of Thickener 1 done in phase 1 had significantly improved the thickener's performance. When the operators followed the Thickener Optimization Application's recommendations ("ON"), **the thickener underflow density was stabilised against the upper limit provided by the client, whilst reducing flocculant usage by 16%**, compared to the OFF periods. This can be seen clearly in Figure 1:

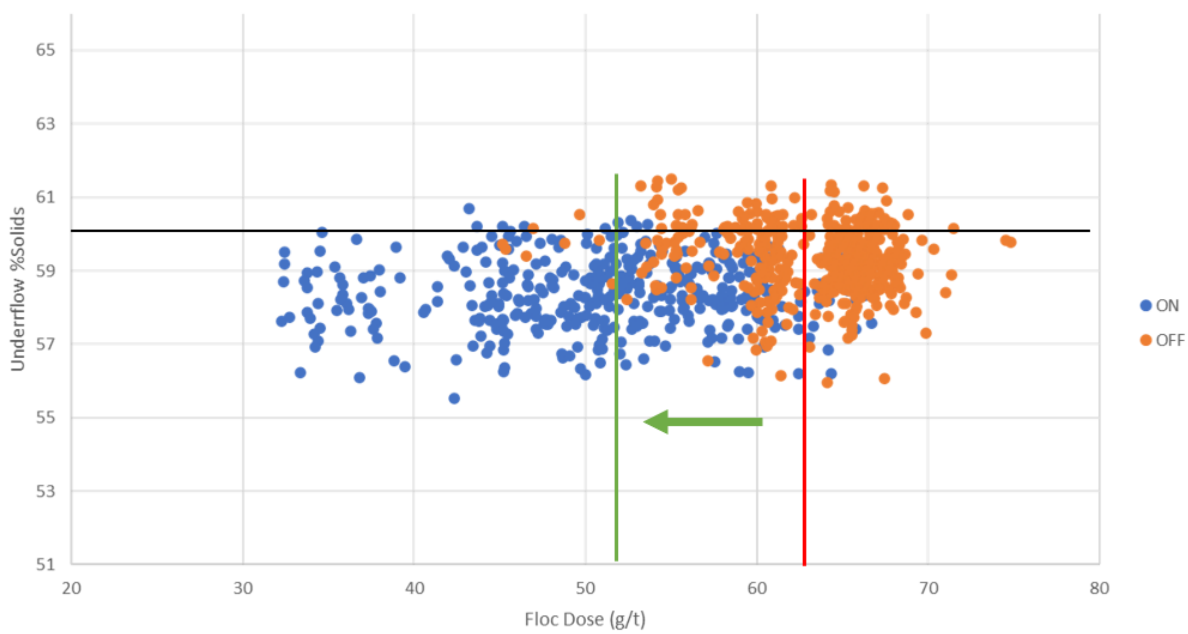

Figure 1: Example of the desired underflow %solids being achieved with much less flocculant. Flocculant variability due to adjustment to varying feed %solids and pH.

These improvements directly addressed the pain points raised by the client, and achieved what was targeted by the Value Driver. **The client is now able to run their Thickener 1 filters at a much improved overall throughput**, since:

1. The thickener achieves a higher (but not too high) underflow % solids
2. It runs at a much lower flocculant dose, decreasing the concentration of the filter-impacting flocculant in the underflow product

Additionally, the decreased flocculant dose means that the thickener overflow is made up of cleaner water, which greatly benefits the water treatment plant.

The lower flocculant doses meant that the thickener bed was less sticky and could proceed to the underflow more freely. This could be seen in the **rake torque, which was 18% lower** during the ON periods than the OFF periods, for the same rake height. It meant that operators did not have to do their characteristic “rake lifts” during the ON times, which led to more stable operation.

Sensor & Control Recommendations

A central part of IntelliSense.io and BASF’s Optimization-as-a-Service journey with a client is to review their process measurements, automated control and operational workflows. During phase 1 of this partnership, in parallel with the optimization of Thickener 1, IntelliSense.io did a review of the Data Quality and Control Quality on the client’s Thickener circuit.

These reviews revealed key areas for the client to bring improvements, which would add the most value to optimizing their thickener circuit. They were the following:

Data Quality

- Densitometer service/calibration
  IntelliSense.io’s Material Model showed that the mass balance does not hold over the flow meters and densitometers on the thickener circuit. The root cause was found to be the densitometer on the thickener feed - and IntelliSense.io and BASF advised the client that they would greatly benefit from doing a full service and recalibration of this instrument.
- Bed pressure installation/calibration
  Early data analyses showed that the bed pressure sensor on Thickener 2 was not covering the full operating spectrum, causing sensor clipping. The client was advised to adjust the sensor accordingly.

Control Quality

During the Control Quality assessment IntelliSense.io and BASF found that the level control loop on the thickener feed tank required tuning. It was found this control loop was a source of significant process variability in the overall process, and that improving the tuning of this PID controller would allow the thickener feed tank better to absorb fast upstream disturbances.

Optimization Continued

The first phase of the concentrator plant's continuous improvement and optimization has delivered measurable value. Discussions are currently underway on capitalising on the instrumentation changes, by optimizing the thickener circuit as a whole. The overall process will then be analysed to review the client's digital transformation roadmap. It is expected that the flotation circuit would provide significant room for improving the overall mineral recovery - especially as the feed material changes.

Conclusion

The initial phase of this OaaS partnership has demonstrated that it is possible to optimize the concentrate thickener circuit using an AI-based Optimization Application. The client's target underflow density was achieved whilst reducing the flocculant usage by 16% - improving throughput through the value chain. The thickener rake torque was also reduced by an average of 18%, minimising equipment wear-and-tear.

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