DYNAMIC REAL-TIME OPTIMISER FOR PRECIPITATION SOLIDS CONTROL

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Abstract

Background

Maintaining the correct amount of solids in a precipitation circuit is paramount to optimal yield. The challenge lies in removing the right amount of product solids to ensure that the correct amount of solids is recycled. This is further complicated by other factors, such as:

- Planned and unplanned process variations;
- Delays of around two days between operator adjustments and the resulting effect on solids content;
- Not all the adjustments are available on the Process Control System (PCS). For example the removal to or recovery from hydrate storage are discrete field operations.

Historically the amount of solids to be removed was estimated by reviewing historical data and forecasting future process changes. This required a high degree of process experience and knowledge to determine the appropriate target.

Solution

Initially technologies already in use at the site were considered:

- Cascaded PID control loops - were not appropriate, due to the long process delays.
- Multivariable Predictive Control (MPC) - was not a viable option, as some of the manipulated variables (MVs) were not closed loop controllers.

The innovative use of a Dynamic Real-Time Optimisation technology (patent pending GDOT), created a solution able to handle the open loop and discrete MVs.

Result

The final outcome was an application that:

- Provided tighter control of the solids content (24% reduction in standard deviation);
- Resulted in a production increase of 10 000t/a;
- Is well accepted by the operations group (uptime of > 98%);
- Delivered a payback period of less than four months.

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1. Introduction

The closed loop control, and therefore optimisation, of processes with significant lags and deadtimes has always been a real challenge. This problem is further amplified in alumina refineries where these dynamics can span multiple days, i.e. the true impact on process changes made today will only be observed in a day or two.

BHP Billiton Worsley Alumina approached Apex Optimisation (Apex), in mid 2009, to propose and implement a control and optimisation solution for such a problem. The specific challenge was around the control of the solids content (and inventory) in a precipitation circuit.

2. Process Overview

Maintaining the correct amount of solids in the precipitation circuit is paramount to optimal yield. As in most alumina refineries, it is effectively controlled by removing the product solids and recycling the remaining solids to the lead precipitation tanks.

The challenge lies in removing the appropriate amount of product solids, ensuring that the correct amount of solids is recycled, amongst all the planned and unplanned process variations. The process flow is illustrated in Figure 1 below.

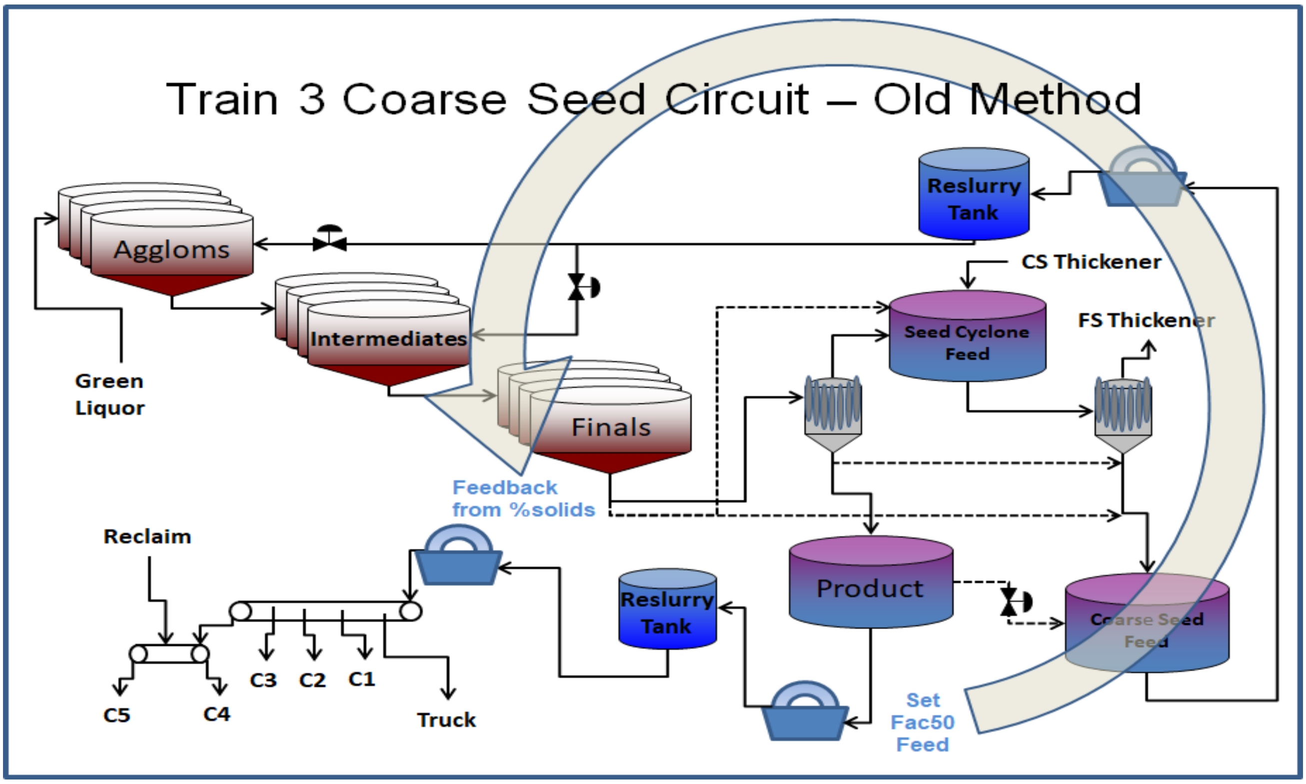

Figure 1 – Precipitation Circuit Process Flow

2.1 Challenges Faced

This particular challenge of solids content control has been complicated by a number of process factors. Some of these are:

- The delay of around two days between operator adjustments to the plant and the solids content measurement. This means that the laboratory results at any given time need to be seen in context with the changes in all the process inputs affecting the solids content. It also complicates the determination of any targets, as no real effect will be observed during the shift the changes were made.
- Some adjustments required to manage the amount of product removed are not available on the Process Control System (PCS). That is, the operator needs to co-ordinate manipulation of one closed loop control scheme in conjunction with one of two (very) discrete field operations. There is no closed loop control available at the control panel to manage the removal of product to, or recovery from, hydrate storage.
- Additional manual field adjustments are also required to maintain the correct amount of solids recycled back to precipitation circuit, e.g. online cyclone capacity.

Traditionally the solids content of the precipitation circuit was managed by setting the target for the amount of solids (product) to be removed. This target was estimated by reviewing trends of historical data and forecasting future process changes, with the assumption that the manual field manipulations will be performed correctly in order to meet the target. This approach relied upon a high degree of process experience and understanding of the interactions in order to determine the appropriate solid removal rate from the circuit.

2.2 Different Approach

The project team approached the challenge by deconstructing the control problem, allowing them to break the problem down into its core objectives. By using this strategy, the team was able to propose a new approach to solving the control problem.

Instead of setting a target for the amount of product to be removed, the new approach was to specify the appropriate amount of solids required to ensure the solids content of the combined feed streams to the precipitation circuit. The amount of solids required to be removed then becomes a (relatively) simple function of managing the solids inventory, by maintaining the tank levels in the various storage tanks. In turn the amount of product to be removed to, or recovered from, storage is determined by a mass balance.

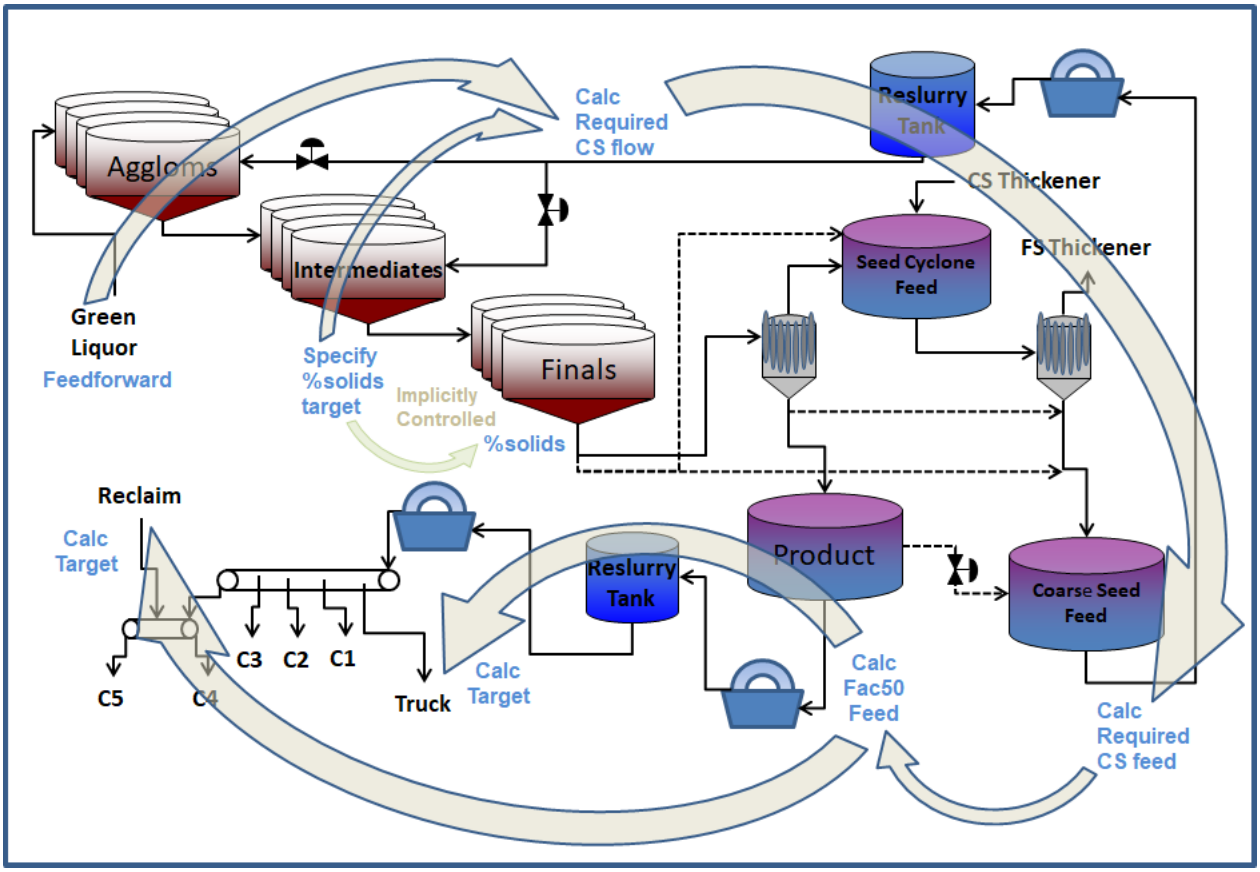

Figure 2 – New Approach to %Solids Control

This new approach was then presented to the operations group in order to get the approval and acceptance from the ultimate end users.

3. Solution

With an agreed change in approach the next challenge was to select the appropriate technology to implement the control application. Traditional technologies already in use at the site were considered such as:

- Typical advanced control approaches, available in all modern PCS's, such as cascaded PID control loops or ratio controllers were not appropriate. These types of controllers cannot handle the dominant process dynamics identified.
- Model based Multivariable Predictive Control (MPC) is very effective in handling 'tricky' process dynamics, such as the long deadtimes and lags identified. However, the problem in this case was the fact that some of the manipulated variables were not closed loop controllers. As an MPC application requires some basic closed loop controllers to implement its control solution, by setting either the setpoint or output of a PID controller, this meant MPC was not a viable option.

The decision was made to implement a Dynamic Real-Time Optimisation application, using Apex's patent pending Generic Dynamic Optimisation Technology (GDOT). GDOT is based on a "grey box" approach to the modelling of the often non-linear process relationships, implemented in a Wiener-Hammerstein model structure. This meant that the application was not susceptible to slow process dynamics, as this is directly addressed in the model structure.

An innovative approach to the control problem and use of the selected technology meant that the solution was also able to handle the open loop and discrete manipulated variables (MVs). To accommodate these exotic MVs, it was necessary to interpret the optimiser solution (targets for the discrete MVs) and translate it into a context which was more practical for the operators to implement. The information was then presented to the operator in graphical form, as well as text prompts, on the operator graphic. This resulted in the optimiser application being a hybrid between Dynamic Real-Time Optimiser (automatically writing targets to existing MPC applications) and an "Operator Advisory System" (providing the operators with text based prompts).

4. Conclusion

The first version of the Optimiser application was implemented and commissioned in August/September 2009.

The new approach to controlling the solids content was a significant paradigm shift from the approach previously used. And it took several months for all the operations groups to master the new approach and become comfortable with the new application. This was further illustrated when the operations group requested an enhancement, implemented in April 2010, to provide a simplified measurement of their 'adherence to target' KPI. This change in KPI measurement (from old to new) was further evidence of the acceptance of the new solids control paradigm and the optimiser application.

The final outcome was a robust Dynamic Real-Time Optimiser application that:

- Provided tighter control of the percent solids content of the final precipitation tanks, seen in a 24% reduction in standard deviation;
- This in turn facilitated optimisation of the solids target delivering a tangible production increase of nearly 10 000t/a;
- Is well accepted by the operations group, and assists them in meeting production targets (application uptime of > 98%);
- Delivered a payback period of less than four months, including the cost of the license fee for the new software.

5. Acknowledgements

Andrew Taylor, *Apex Optimisation*.