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Nova copper-nickel project optimisation of the copper rougher-scavenger circuit through advanced measurement and control

GA Gomes-Sebastiaõ[1], Z Hearne[2], S Lam [3], DdeV van der Spuy[4], M Thompson[5], N Vines[6]

1. Control System Engineer, Independence Group NL, South Perth WA 6151. Email Greg.Gomes@igo.com.au
2. Metallurgist, Independence Group NL, South Perth WA 6151. Email: Zac.Hearne@igo.com.au
3. Senior Project Metallurgist, Independence Group NL, South Perth WA 6151. Email: SaiWei.Lam@igo.com.au
4. Technical Director, Process IQ Pty Ltd, Balcatta WA 6021. Email: daniel@processiq.com.au
5. Senior Project Metallurgist, Independence Group NL, South Perth WA 6151. Email: Matthew.Thompson@igo.com.au
6. Contracting Senior Metallurgist, Independence Group NL, South Perth WA 6151. Email: Nick.Vines@igo.com.au

ABSTRACT

Construction and commissioning of the Nova Copper-Nickel project of Independence Group was completed in late 2016. The plant is in the Fraser Range of Western Australia, about 120km east of Norseman and produces separate Copper and Nickel concentrates. Since the early feasibility phases of the project, the importance of automation and control was recognised and planned for to ensure the plant performance meets the design expectations.

The site is well equipped with common as well as advanced instrumentation. It currently boasts the largest number of Blue Cube MQi (Mineral Quantifier Inline) slurry grade analysers on a single plant worldwide. It was also decided that 25 Blue Cube TempoTracks would be installed on the flotation cells. The TempoTracks provide information on froth height and velocity, hence giving continuous, quantitative measurements of the froth that is pulled off each cell, rather than relying on infrequent, subjective visual inspections.

The Nova concentrator consists of a differential flotation circuit whereby copper bearing mineral are selectively floated prior to nickel flotation. It is imperative that losses of copper to the nickel circuit, and vice versa, are minimised. The plant metallurgical team and Process IQ collaborated to develop and implement the advanced control strategy for the plant. This paper focusses on the optimisation of the copper concentrate that is pulled off the copper rougher and scavengers. This strategy was made possible by the additional measurements listed above.

The control optimisation of the copper rougher and copper rougher scavenger circuit was implemented during August 2017 on the StarCS™ advanced control platform. It continuously optimises the level and air setpoints. The control philosophy incorporates several notable techniques which include: a variable mass pull target that is a function of the quantity and grade of material entering the circuit, integrated compensation to prevent inventory build-up in cells, balancing of the froth velocity over the lip of each cell to adaptive, modular system usage and advanced error handling.

INTRODUCTION

The Nova Operation (hereafter referred to as Nova) is wholly owned by the Independence Group NL. The processing plant is in the Fraser Range of Western Australia, about 120km east of Norseman. It utilises differential flotation to produce separate Copper and Nickel concentrates (IGO 2017). Construction and commissioning of the processing plant was completed in late 2016.

Since the early feasibility phases of the project, the importance of automation and control was recognised and planned for to ensure that the plant performance would achieve the design expectations.

An advanced process control system has been implemented by Process IQ Pty Ltd on the complete milling and flotation circuits at Nova. This paper focusses on the implementation and benefits of the advanced control on the Copper Rougher-Scavenger circuit.

The control was implemented on the StarCS control platform, which was developed by Mintek (Mintek 2016). Mintek has a range of application specific modules that run on the StarCS platform, like the FloatStar Advanced Level Stabiliser which is used for stabilisation and disturbance rejection in flotation cell level control, and the FloatStar Optimisers that control the grade, recovery and concentrate pull rates on a bank of cells.

The Nova circuit was designed with automated optimisation in mind and therefore included advanced instrumentation from the start, including the Blue Cube MQi and Blue Cube TempoTracks. The Blue Cube MQi (Mineral Quantifier Inline) Slurry Analyser gives fast, accurate and reliable in-line measurements of the elemental and mineral composition of plant feed, tailing and concentrate slurries. The Blue Cube TempoTrack is designed for use on flotation cells to measure the froth velocity and froth height above the cell lip.

The objective of the control system on the Copper Rougher-Scavenger circuit was to optimise the copper recovery while minimising the nickel recovery. It was done by implementing the following strategies:

- Ensure the stability of the circuit by utilising the FloatStar Advanced Level Stabiliser.
- Ensure a stable Mass Flow is recovered in the concentrate stream by adjusting the level and air setpoints of the cells.
- Adjust the concentrate mass pull target based on the copper feed grade (from the online Blue Cube MQi) and feed rate to the circuit.
- Balance the pull rate from individual cells in the bank to a pre-defined ratio as set by the plant metallurgists. The pull rates from the individual cells are determined from the TempoTrack measurements (installed on each flotation cell).
- Maintain a steady pressure and density from the Copper Rougher Concentrate Hopper discharge. The concentrate line is equipped with a pressure gauge, flow meter and density meter (Mass flow is calculated based on the flow rate and density).

The benefits of the system will be discussed in the final sections of this paper after the implementation and interfacing is explained.

PROCESS OVERVIEW

This section provides a general overview of the processing plant in order to explain where this project fits in.

The concentrator crushing circuit comprises of a single stage, open circuit jaw crusher that reduces run of mine (ROM) ore to an 80% passing size of 90 mm and conveyors that deliver the ore to a 375 tonne surge hopper. Coarse crushed ore is ground in a two-stage grinding circuit that comprises of an open loop semi-autogenous (SAG) mill and an overflow ball mill in closed circuit with hydrocyclones. The ore is reduced to an 80% passing size of 75 µm. The cyclone overflow undergoes differential, sequential flotation to produce separate copper and nickel concentrates. Both flotation circuits are comprised of a rougher/scavenger flotation stage followed by two stages of cleaning. An on-stream analyser (OSA) and several Blue Cube MQi analysers are provided to assist in management of metallurgical performance.

The copper and nickel concentrates produced in flotation are thickened in separate high rate thickeners. The thickened concentrates are pumped to dedicated concentrate storage tanks prior to filtration via separate chamber filter presses. Filtered concentrates are loaded into trucks for shipment off site.

Two separate tailings streams are produced - a non-sulphide tailings from the nickel scavengers tails and a sulphide tailing from the nickel cleaner scavenger tails. Both tailings streams are thickened in dedicated thickeners. Non-sulphide tailings report either to the paste plant, where it is filtered by a belt filter, mixed with cement/binder and deposited as paste fill underground, or it bypasses the paste filter and mixer and is pumped to the tailings storage facility (TSF). Sulphide tailings are pumped direct to the TSF for storage.

The reagent mixing system consists of manual solid mixing facilities for potassium amyl xanthate (PAX) and sodium sulphite and automated mixing systems for the quicklime (delivered in bulk) and flocculant. Other reagents consisting of tri-ethyl tetra amine (TETA) and frother (MIBC) are delivered as solutions. PAX, sodium sulphite and TETA are delivered to the process via a system of constant head tanks and dosing valves. Frother is dosed via dedicated variable speed dosing pumps. Lime is delivered to the process via dosing valves while flocculant is delivered by dedicated variable speed dosing pumps.

Copper Rougher Scavenger Circuit Layout

Figure 1 illustrates the physical circuit layout for the Copper Rougher Scavenger Circuit at IGO's Nova site. The circuit is fed from the Copper Rougher Feed Conditioning tank. There is a Blue Cube MQi on the discharge end of this conditioning tank. The measurement from the Blue Cube MQi is used to determine the % copper in the feed. This copper measurement, along with the solids feed rate into the SAG Mill, is used in a calculation to determine the desired Mass Pull Target for the Copper Rougher-Scavenger circuit.

There is a single Rougher cell of which the level can be manipulated via a pinch valve. The air flow rate is controlled through a valve and it is the setpoints for these two variables that are used to control the mass pull from the Rougher cell. There are 4 Scavenger cells in the circuit. The levels of the first and second Scavenger cells are controlled using a single pinch valve, similarly the third and fourth Scavenger cell levels are controlled through a single pinch valve. All four cells can have their air addition flow rate individually manipulated.

The concentrate from all the cells is combined into a single concentrate hopper. The discharge of the concentrated hopper can feed the regrind circuit or bypass the regrind circuit. The discharge line of the concentrate hopper has a pressure measurement as well as a flow and density measurement that is combined to calculate the total mass pull from the circuit.

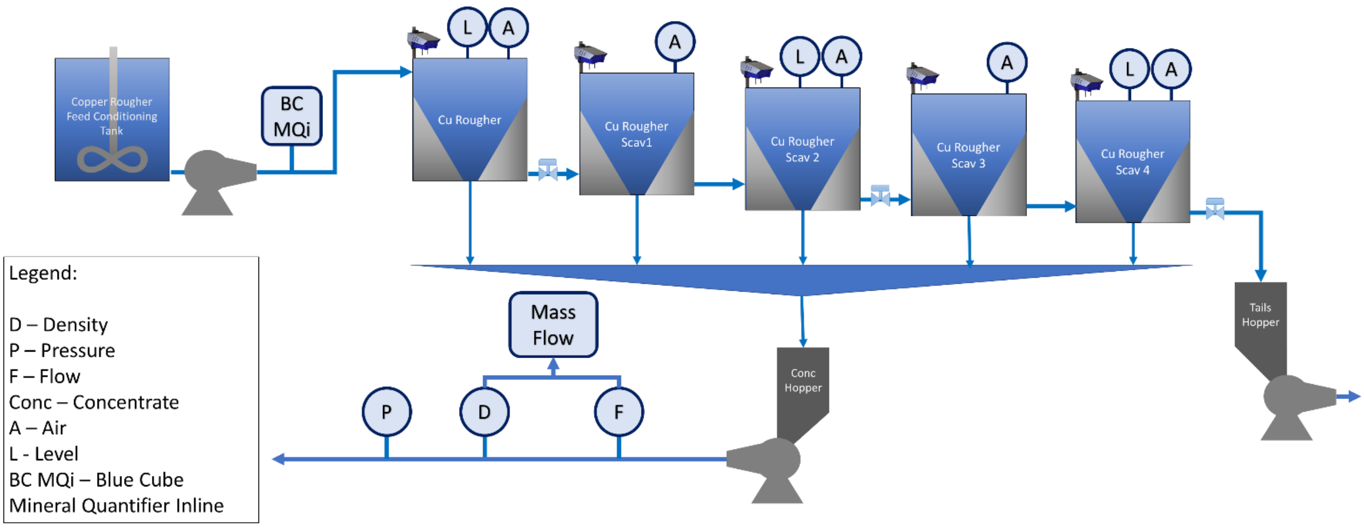

Figure 1 - Physical Layout of the Nova Copper Rougher-Scavenger Flotation Circuit at Nova.

STARCS INTERFACE WITH PLANT CONTROL SYSTEMS AT NOVA

In order to implement the advanced process control system at Nova, the plant's PLC control system was setup to interface with StarCS, which was undertaken in consultation with the EPCM company. The following sections illustrate how the StarCS system interfaces with the plant's control system.

StarCS physical setup

The hardware and network setup for StarCS is shown in Figure 2. It consists of two server computers that run the control system (and auxiliary services), one server to act as the primary and perform the required actions to control the plant. The secondary server to run in hot standby; this server reads in all the data required to be able to take over from the primary server should it fail for any reason.

Client computers were set up in the control room to run the StarCS graphical user interfaces (these are referred to as the StarCS WinClients).

The internal software structure of StarCS is built in a modular fashion to ensure stability of the system (see Figure 3). This means that if one of the non-critical components were to fail, e.g. the Historian, that the other components would be able to continue running independently. It also allows for the critical components of the system, e.g. the StarCS Executive (responsible for executing the control) to be given the highest priority on the server, hence making the control system very robust. Furthermore, this modular design allows any number of user interfaces to be setup and run on remote computers.

It is beyond the scope of this document to discuss the inner workings of the software configuration; however, it is important to emphasise the following:

- StarCS runs on dual redundant servers, so that the secondary server can take control should the primary server fail.
- The user interfaces (and client computers) run independently of the servers and the main control packages. This means that disconnecting or closing the user interfaces will not impact the execution of the control loops.

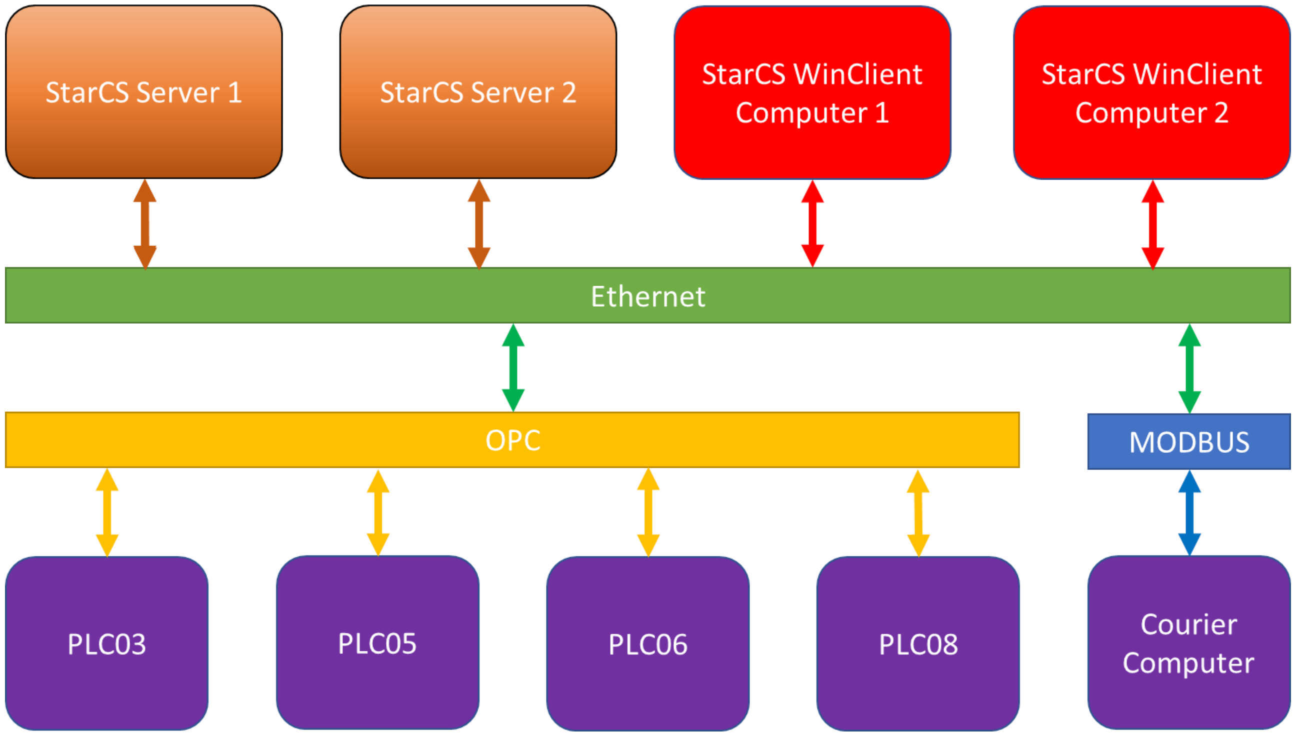

Figure 2 - Hierarchy of physical installation of StarCS at Nova.

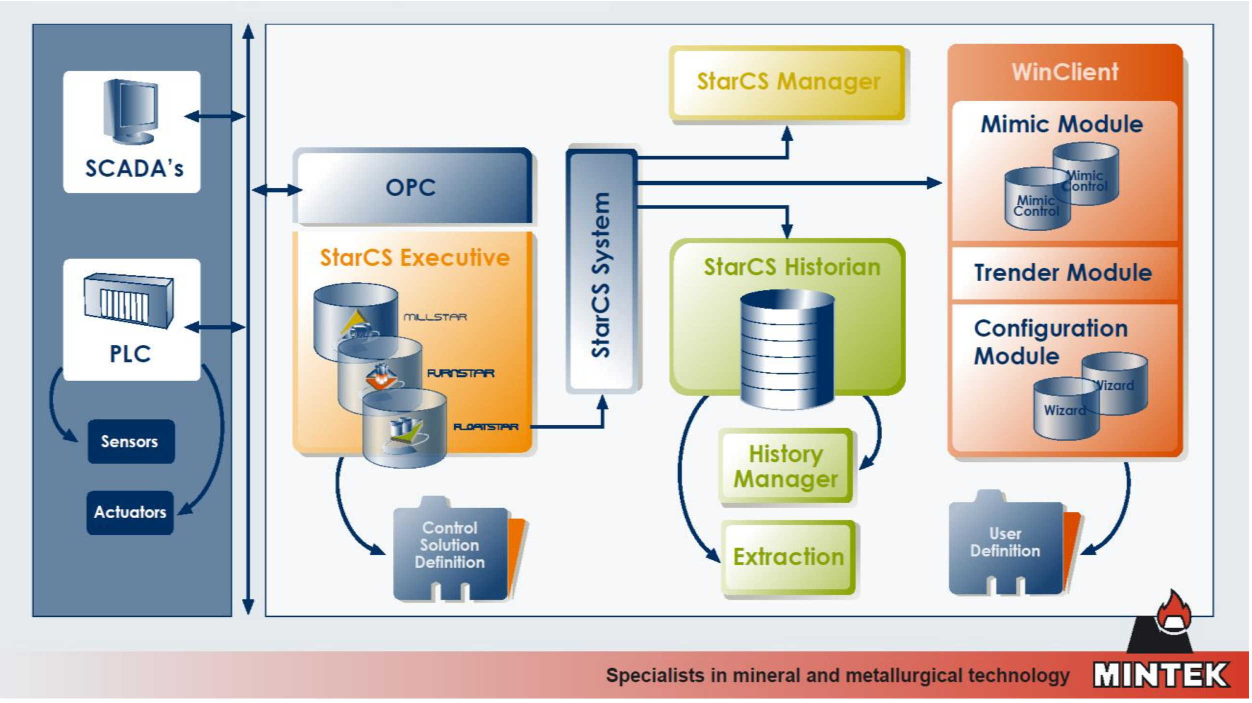

Figure 3 - StarCS modular software configuration.

General interface and Switching

The StarCS system interfaces with the PID blocks in the plant PLC by gaining authority to write to the control variables of a PID blocks (SCS mode) or to the setpoints (SCS CAS mode) or both. This authority can be granted by selecting the SCS or SCS CAS button on the PID nameplates on the SCADA system or via group buttons on the SCADA or StarCS interfaces.

When either the SCS or SCS CAS mode has been selected, the PID nameplate will show this by highlighting the buttons in light green

ADVANCED PROCESS CONTROL SETUP

The StarCS advanced process control system implemented on the Copper Rougher Scavenger (CRS) Circuit involved:

- Stabilisation of feed to and levels of the copper rougher and scavenger circuit via FloatStar Advanced Level Stabiliser.
- Balancing the mass pull rate from individual cells to a pre-defined base value or froth velocity ratio by adjusting the level and/or air setpoint.
- Achieving target mass recovery to the concentrate stream as calculated based on the copper recovery rates using:
    - Copper feed grade measurement from a Blue Cube MQi analyser
    - Mass flow measurement from the flow meter and density gauge at the Copper Rougher Scavenger Concentrate (CRSC) hopper
    - Froth velocity measurements from the Blue Cube TempoTracks (froth image analyser)

Figure 4 shows the StarCS user interface that was developed for this project.

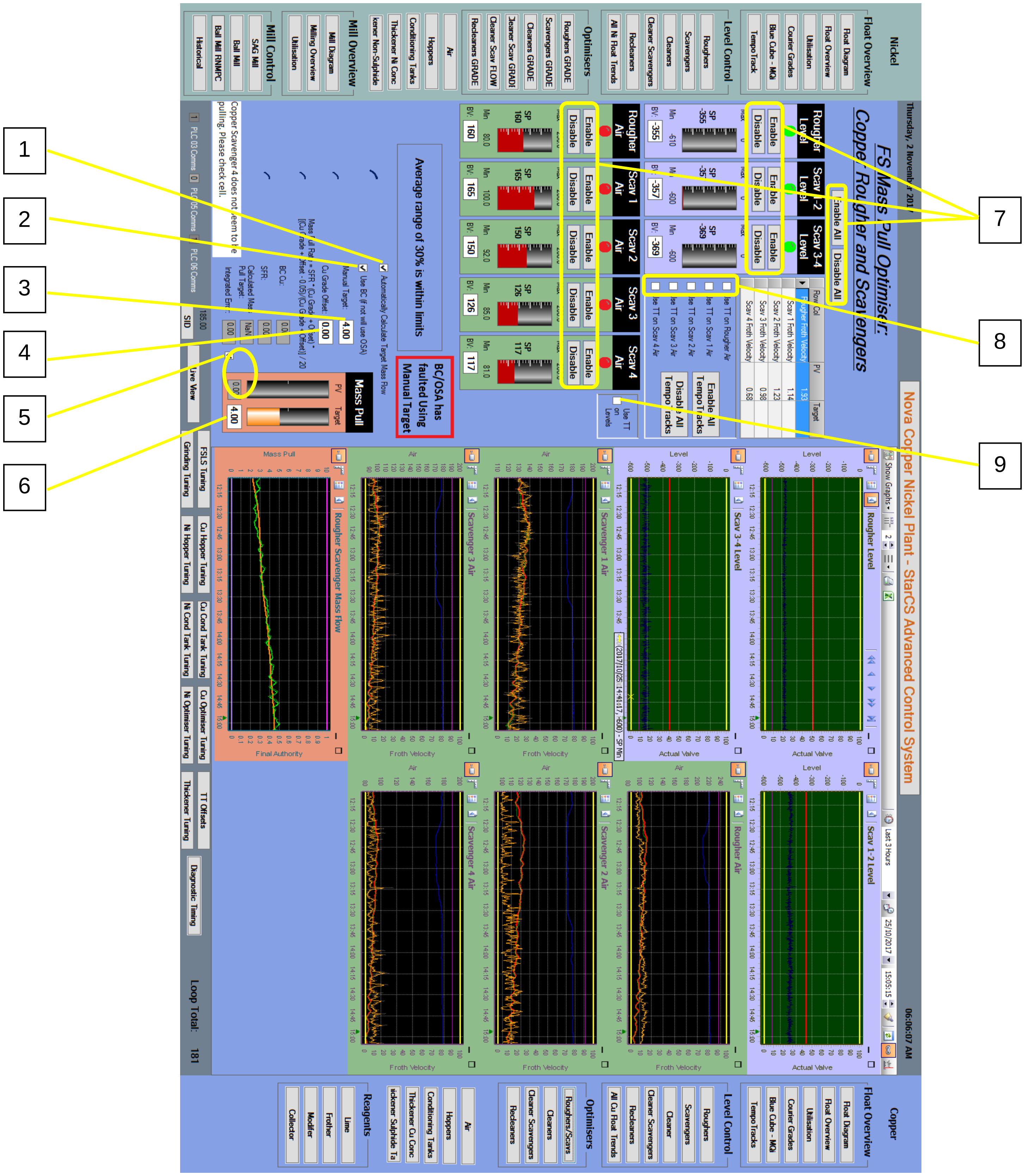

Figure 4 - StarCS Copper Rougher Scav Optimiser Interface page.

Control Philosophy for the Copper Rougher-Scavenger Concentrate Hopper

The Copper Rougher Scavenger Concentrate Hopper feeds the regrind circuit. For this reason, the CRSC Hopper controller design was aimed at maintaining a steady pressure to the regrind circuit while still maintaining the density of the hopper discharge within bounds. To achieve this, the level in the hopper is maintained by altering the flow rate for the water addition to the hopper. The hopper's pump may then be run to a pressure setpoint on the hopper discharge.

To gain a handle on the density of the hopper discharge, the pressure setpoint is altered slowly, by increasing the pressure setpoint, more water needs to be added to the hopper to maintain the hopper level, this results in a decrease in the discharge density. The converse is also true for decreasing the pressure setpoint, less water is added to the hopper and the density increases. Since fluctuations in the pressure are undesirable the density control is a very slow acting loop on the pressure setpoint (i.e. the density setpoint will not be maintained very tightly). The operator has the option to enable different parts of the control strategy (for example the pressure setpoint may be run at a manually entered value).

Separate control loops have also been implemented to aid in maintaining CRSC Hopper's Level between a minimum and maximum setpoint (user defined) during abnormal circumstances when the mass pull rate (see below) cannot be achieved. Should the hopper approach its minimum level setpoint the pump will slow down (the pressure setpoint will no longer be maintained) and the water addition setpoint to the hopper will increase more aggressively (the density setpoint will also not be maintained). Should the hopper approach its maximum level, the pump speed will increase (the pressure setpoint will no longer be maintained). The water addition setpoint will also decrease more aggressively and consequently the density setpoint will no longer be maintained. The functional schematic for this controller is illustrated in Figure 5.

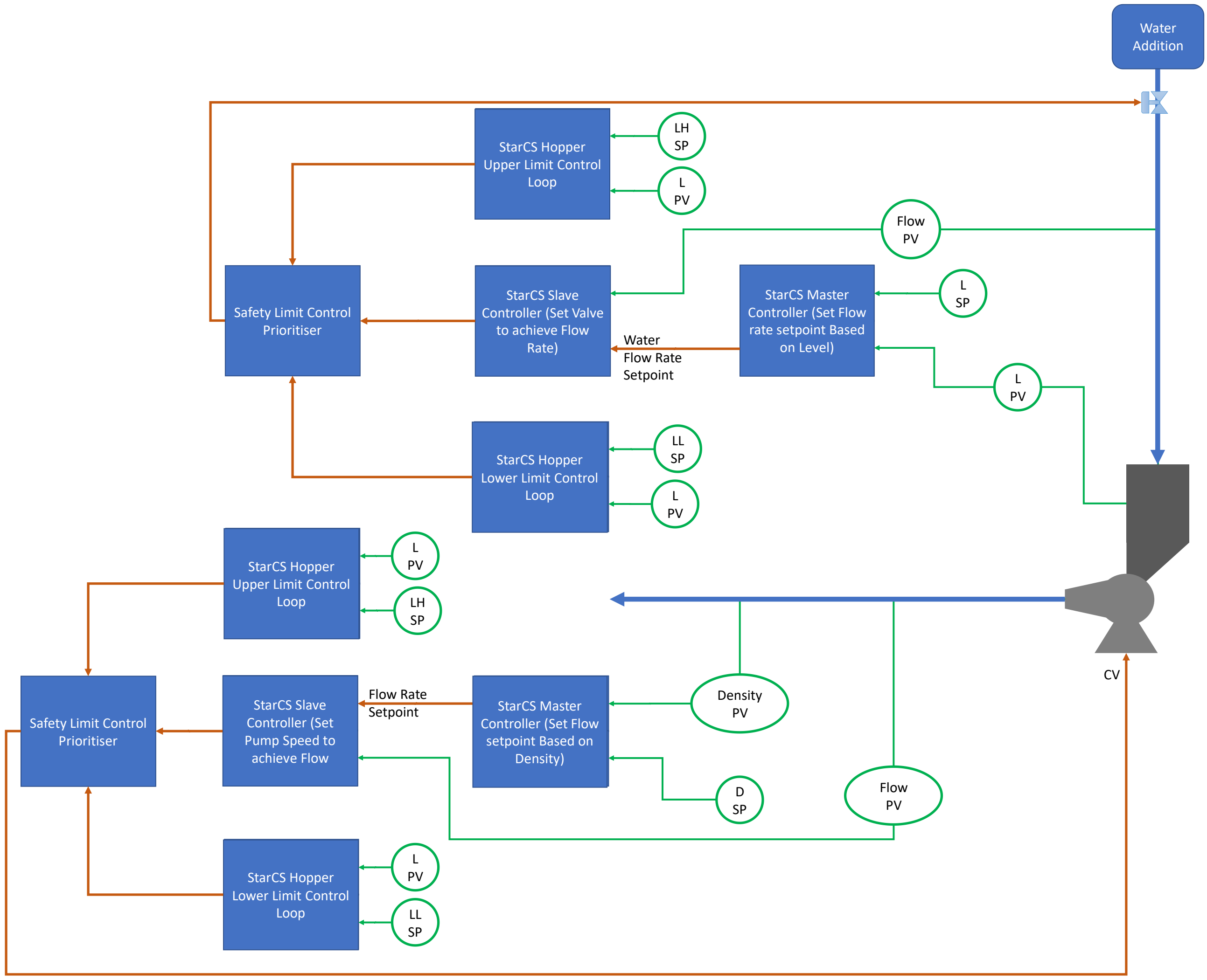

Figure 5 - Control strategy implemented on CRSC Hopper

Control philosophy for Level Stabilisation in the Copper Rougher Scavenger flotation banks

The FloatStar Level Stabiliser is an application specific module that has been developed by Mintek to stabilise flotation cell levels. The FloatStar Level Stabiliser is designed to look at the interaction between different flotation cells and is able to compensate for interactions between cells quickly and effectively. Disturbances entering a train of cells will not propagate to downstream cells, since the controller will react to these disturbances in a timely manner and allows all the valves to move appropriately in response to a disturbance. The control system will therefore not wait until the disturbances reaches a cell before it reacts, as is the case with simpler control loops that only look at individual cell levels when moving the valves.

In short, this means that the FloatStar Level Stabiliser will, in a particular flotation circuit, open downstream valves by the correct amount when a disturbance is detected in the preceding levels.

To aid stability, the effect of the flow rate into the Copper Rougher is also taken into account when controlling the banks (Feed Forward Control). The FloatStar Level Stabiliser is applied to the whole flotation plant, including the following three levels in the section under consideration:

- Copper Rougher
- Copper Rougher Scavenger cell 1-2
- Copper Rougher Scavenger cell 3-4

Mass Pull Target for the CRS concentrate stream

The target for the Mass pull rate for the controller is based on a formula that takes into account the copper units coming into the circuit and the desired recovery for the circuit. In order to aid in accounting for the time delay between the material entering the SAG Mill and the material entering the flotation circuit, a 30-minute moving average of the Solids feed rate is used in the mass pull target calculation.

There are several functions available to the user to alter the manner in which the mass pull target is calculated.

Shown on Figure 4 point 3: The option is available on the StarCS screen to enter a manual target in the cases when a copper grade measurement is unavailable. In order to tell the system to stop using the calculated target and utilise a manual target the checkbox on Figure 4 at point 1 should be unchecked. Should the Blue Cube Measurement fault, the controller will utilise the manual target. Since the manual target may become outdated when not in use, it will update once every 30 minutes to the calculated target (only when it is not in use).

If the copper grade measurement has a known offset, this can be entered on the StarCS screen to correct the calculation. This offset is entered on Figure 4 at point 4, the offset is simply added to the measured copper grade.

A build-up of an inventory in the flotation bank could result in the integrity of the froth being compromised and will influence the processes' ability to produce a concentrate. For this reason, the error between the Mass Pull Target and the actual mass pull is integrated. This integrated error is then used to increase the mass pull target (but never decrease) and thus the optimiser will be able to "catch up" if the mass pull is below target for a period of time. The integrated error will never increase the target mass pull by more than 0.5 (and never internally integrate higher than 1). This integral error is reset when the solids feed rate to the mills drops off and if the user chooses to disable this function. This function can be disabled by unchecking the box shown in Figure 4 point 5.

Since there are many factors that can influence the Mass pull target, the actual mass pull target that is being followed is shown on Figure 4 at point 6. All the values to the left of point 6 are for information purposes only. Figure 6 shows a logic diagram that is used to decide which mass pull target will be used for the system.

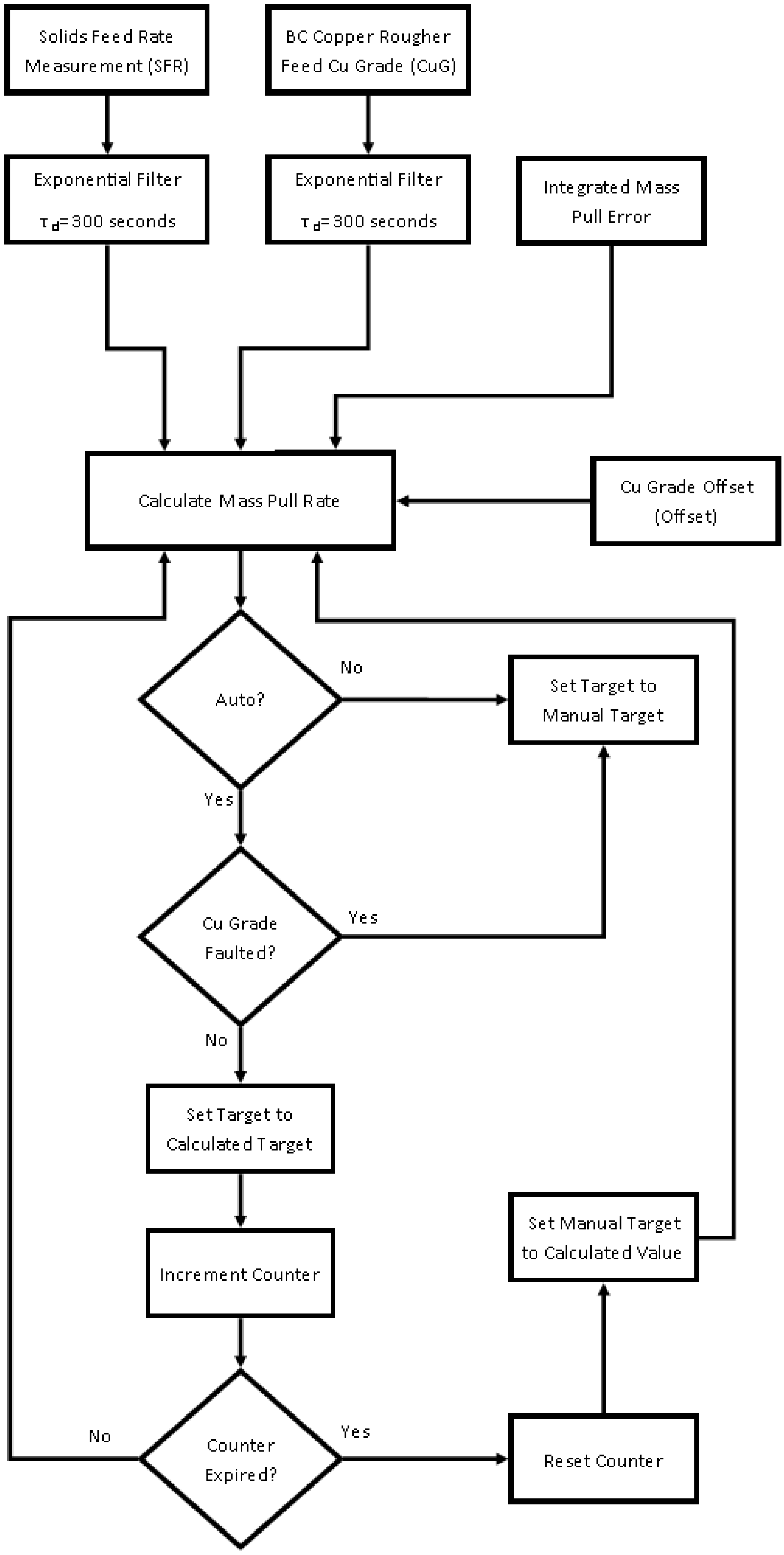

Figure 6 - Logic Diagram for calculation of Mass Pull Target.

Control Philosophy for the Mass pull from the cells

The Strategy implemented in StarCS to control the mass pulls from the cells is referred to as the FloatStar Optimiser. The FloatStar Optimiser has been developed by Mintek to provide continuous, online optimisation of circuit operation throughout fluctuating plant conditions (Muller 2005). The FloatStar Optimiser is highly configurable. The strategy was further expanded to incorporate froth velocity measurements to achieve the system targets.

The behaviour of the circuit (ultimately the final grade and recovery) will be influenced by, amongst others, the level setpoints, aeration rates, the bank residence times and reagent addition. The FloatStar Optimiser uses multivariable control techniques to continually optimise air and level setpoints (shown in Figure 7) to achieve the desired mass pull, while reagent additions are ratioed to what's coming into the circuit.

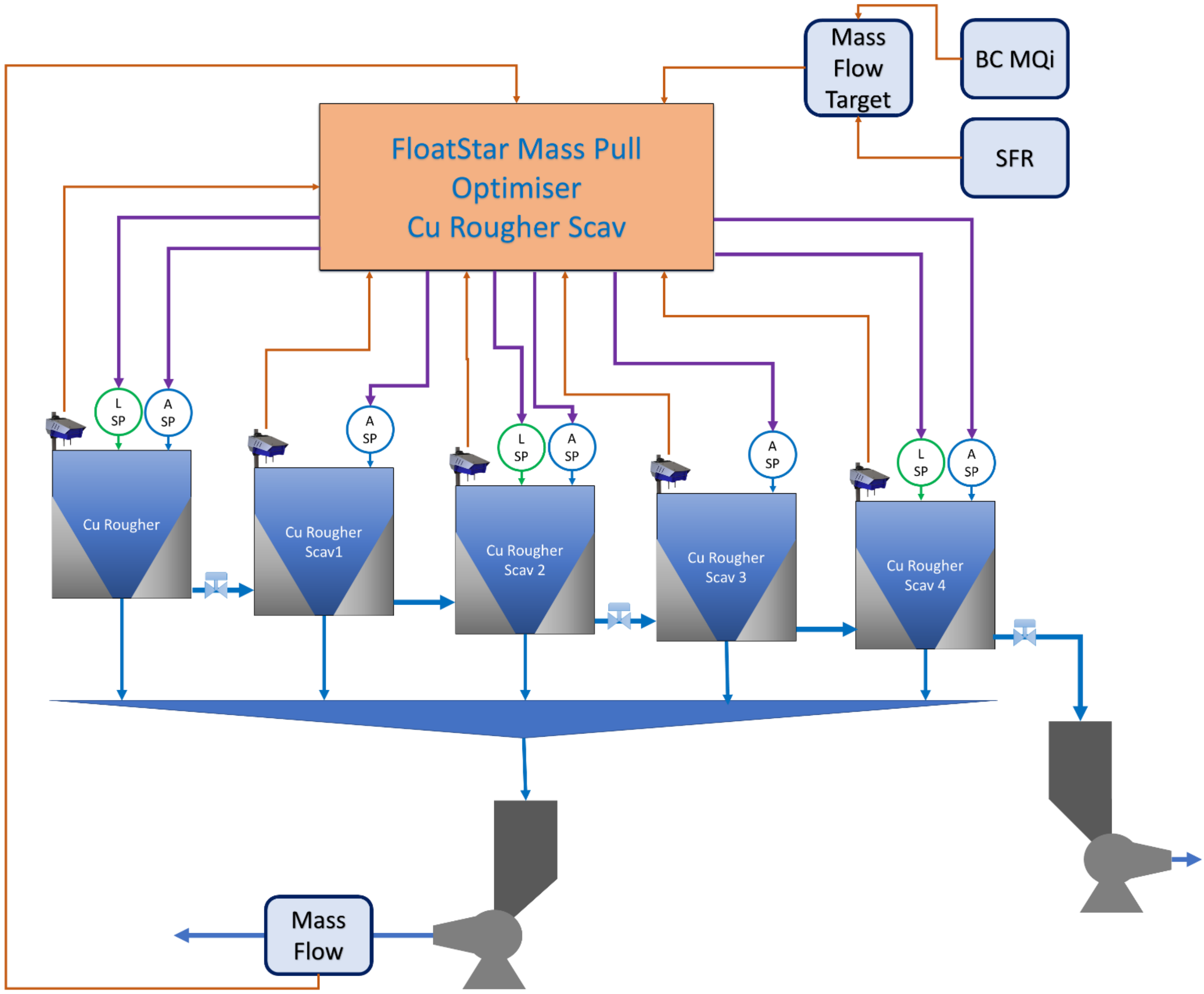

Figure 7 - StarCS Optimiser on the CRS circuit.

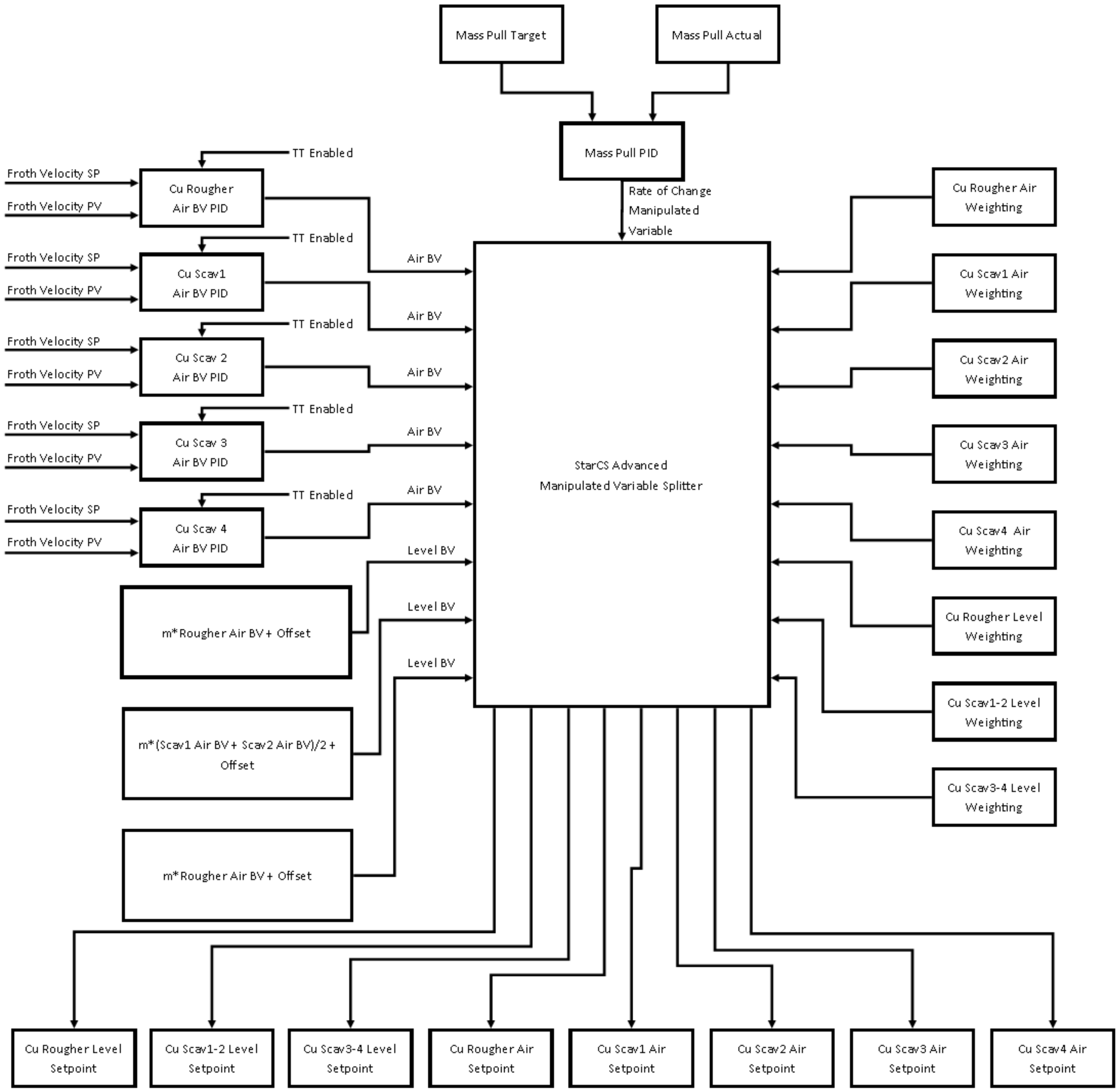

Figure 8 - Block diagram showing the main inputs and outputs required for the StarCS Optimiser.

The Optimiser is enabled by placing any of the Copper Rougher Scavenger Level or Air controllers into SCS CAS mode. This can be done from the PID interface blocks on the SCADA or from the StarCS screen (see Figure 4 Point 7). On the StarCS Screen there is the option to enable all or disable all the SCS CAS modes with a single group button. If the controllers are put into SCS CAS mode from the StarCS screen, then the controller will automatically be placed into SCS mode as well (if not already enabled). When the controllers are taken out of SCS CAS mode from the StarCS screen, they will not automatically go out of SCS mode.

Each of the flotation banks is equipped with a Blue Cube TempoTrack in the field. This instrument provides measurements of the froth velocity and froth height. These values give an indication of how much material is being pulled from each flotation bank. The measurements are modularly incorporated in the control to balance how the cells pull material (for example having the front of the train pull harder than the back end of the train). Internally the controller incorporates the use of these measurements to adjust the Base Values of each of the control variable setpoints. The Base Values define an offset from which the control variables should deviate in a configurable ratio with respect to other control variables.

The use of the TempoTrack measurements directly impacts the Base Values for the air setpoints and indirectly impacts the Base Values for the level setpoints. This is because the Base Values for the level setpoints are based on a linear relationship with the Base Values of the air flow rate setpoints. When the TempoTrack measurements are enabled for a particular cell, the Base Value for the air setpoint for that particular cell will be adjusted. These can be switched on and off from the checkboxes shown in Figure 4 Point 8. One can choose to have the level Base Values adjusted as well by checking the box shown in Figure 4 Point 9 (however not required).

The strategy was setup such that not every cell has to use the TempoTrack measurements in order for the strategy to function. If there is a problem on a particular cell the strategy can be disabled for that cell. The same is true for putting the air and level loops into SCS CAS; any cells that are experiencing problems can be left off and the controller will use the remaining cells to achieve the desired targets.

Figure 8 shows the main inputs and outputs that are used for the StarCS Optimiser. One can see that a weighting is placed on each of the control variables (level and air setpoints), these weightings are used to determine how much each of the control variables move relative to the others. This enables the user to decide for example how much faster the air flow rate setpoints will change relative to a change in the level setpoints. At the time of writing this paper the air flow rate setpoints were set to move three times faster than the level setpoints.

The froth velocity setpoints that are used in the system to alter the Base Values for the control variables are calculated as follows:

$$Froth\ Velocity\ Setpoint_y = \frac{Froth\ Velocity\ Ratio_y \ \times \sum Actual\ Froth\ Velocities}{\sum Froth\ Velocity\ Ratios}$$

Any cells that have the use of the TempoTrack froth velocities disabled or detect a fault on the froth velocity measurement, will be excluded from the above equation. If all the cells are excluded in the above equation, then the Froth Velocity setpoints will be set equal to the Froth velocity measurements obtained from the field.

Figure 9 illustrates the effectiveness of the system in maintaining the Mass Pull at the desired target. The graph in Figure 9 has been normalised for confidentiality and shows the actual mass pull versus the targeted mass pull for a full month after the system was commissioned. A comparative case of the mass pull is not shown for when the system is off since a mass pull is not targeted in this situation.

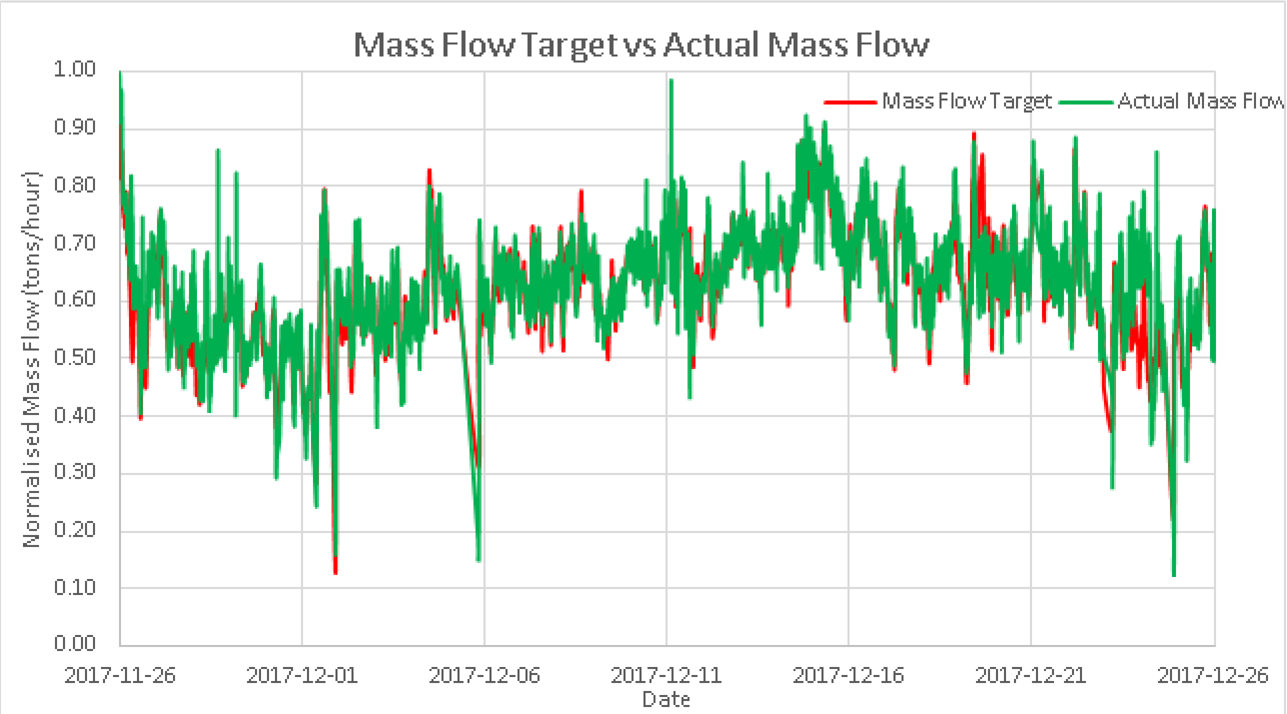

Figure 9 - Graph of Normalised values for Mass Flow Target versus the Measured Mass Flow

Fault detection and error handling within the StarCS Optimiser

A great deal of effort was put into the control system to handle errors and faults that may arise with instrumentation and equipment in the field. Since the controller was built in a modular manner, parts of the system can be disabled while still allowing the system to achieve the required targets (up to a point). The following is a list of some of the faults that the system will check for:

- Check that a froth velocity measurement does not remain unchanged for a long period of time.
- Check that the froth velocity measurements are within a predefined range.
    - If a froth velocity is below a threshold, then ensure that the level setpoint and air flow rate on that cell is not lowered further.
- Check that the Copper Feed Grade measurements are within a predefined range.
- Check that the percent solids in the copper feed is within a predefined range.
- Check that the Copper Feed Grade measurements do not remain unchanged for a long period of time.
- Check that there is feed to the SAG Mill.
- Check that the actual levels and airs are within a band from their respective setpoints.

COMPARITIVE DATA TO DETERMINE THE BENEFIT OF THE SYSTEM

In order to evaluate the performance of the StarCS control system on the Copper Rougher scavenger circuit, the quantities of Copper and Nickel in the Tails stream has been evaluated. Data has been extracted from various sources to illustrate the decrease in copper losses and the improvement in copper recovery.

Copper present in the Scavenger Tails

As can be seen from Figure 1 material leaves the circuit through the Concentrate stream and the Scavenger Tailings line. A Blue Cube MQi is installed on the Scavenger Tail line and measures, amongst other things, the copper and nickel grade in the tails line. A reduction in the copper present in the Scavenger Tailings would indicate an improvement in the recovery of the circuit.

For the evaluation, 7 months of plant data has been used, covering the period from July 2017 to January 2018. The StarCS Optimiser commissioning was deemed complete at the end of August 2017. The StarCS Optimiser was largely disabled until this time, except for tests conducted during commissioning. From September 2017 to January 2018 the StarCS Optimiser was enabled (either entirely or partially) for 90.1% of the time. Periods where the feed rate to the SAG mill was below half its normal operating region have been excluded from the data set. Data where the Blue Cube MQi reported a fault has also been excluded from the data set.

Table 1 shows the average and standard deviation of the copper present in the Scavenger Tails line for when the optimiser is enabled and when the optimiser is disabled. Table 2 shows the results of a t-test that was conducted on the two sets of data to confirm that the difference in tails grade is significant. It can be seen that the confidence level is nearly 100% (p-value is very low at 2.4×10^{-24}), much greater than the widely accepted 95%.

The plots for the Normal Distribution Curves of the copper in the Scavenger Tails for periods where the StarCS Optimiser was enabled and disabled have been combined in Figure 10. From Figure 10 it can be seen that both the mean and standard deviation show a significant improvement when the StarCS Optimiser is enabled. This is statistically significant and represents lower copper losses when the StarCS Optimiser is enabled. Figure 11 shows the Histogram plots for the copper in the Scavenger Tails (having used the same data source as that of Figure 10). Figure 11 contains the data from 700 samples; 376 samples from when the StarCS Optimiser is enabled and 324 from when the StarCS Optimiser is disabled.

	Mean of the Copper in the Scavenger Tails	Standard deviation of the Copper in the Scavenger Tails
StarCS Optimiser Enabled (376 samples used)	0.083	0.051
StarCS Optimiser Disabled (324 samples used)	0.201	0.362

Table 1 - Comparative average and standard deviation of Copper in the Scavenger tails.

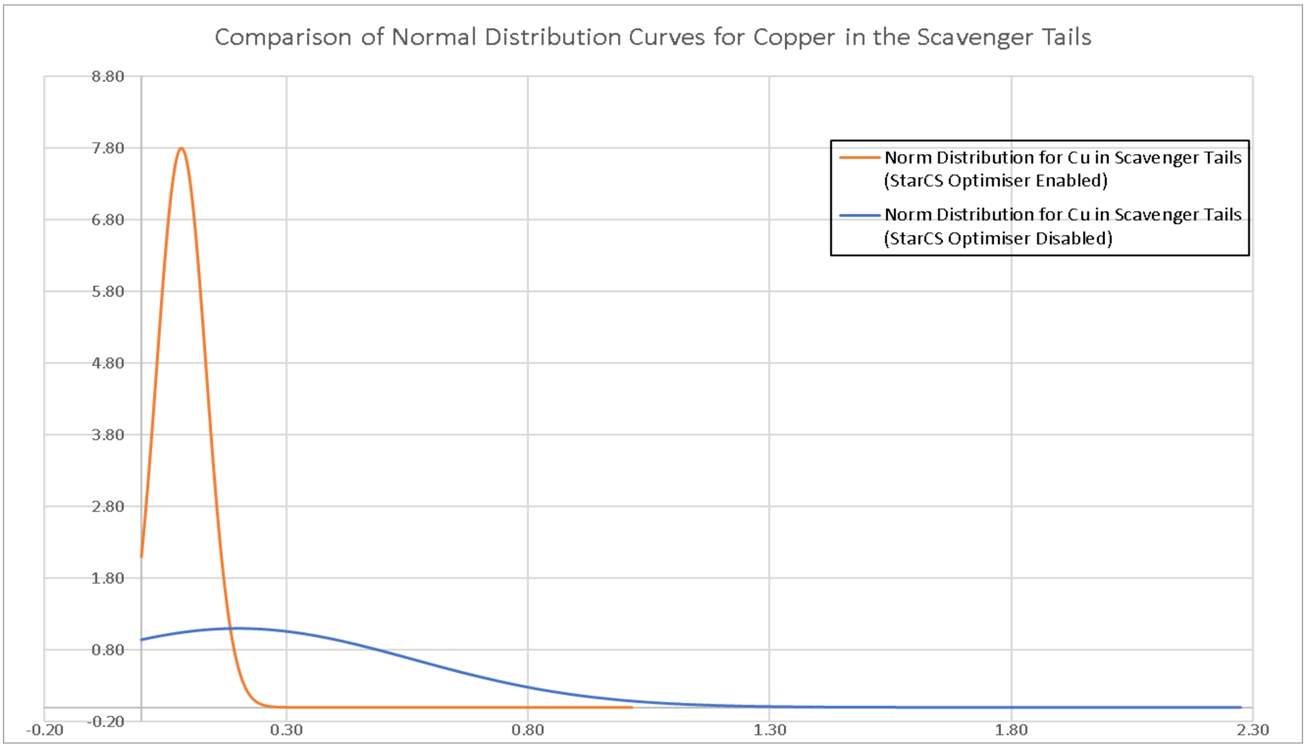

Figure 10 - Normal Distribution Curves for the copper in the Scavenger Tails with the StarCS Optimiser Enabled and Disabled

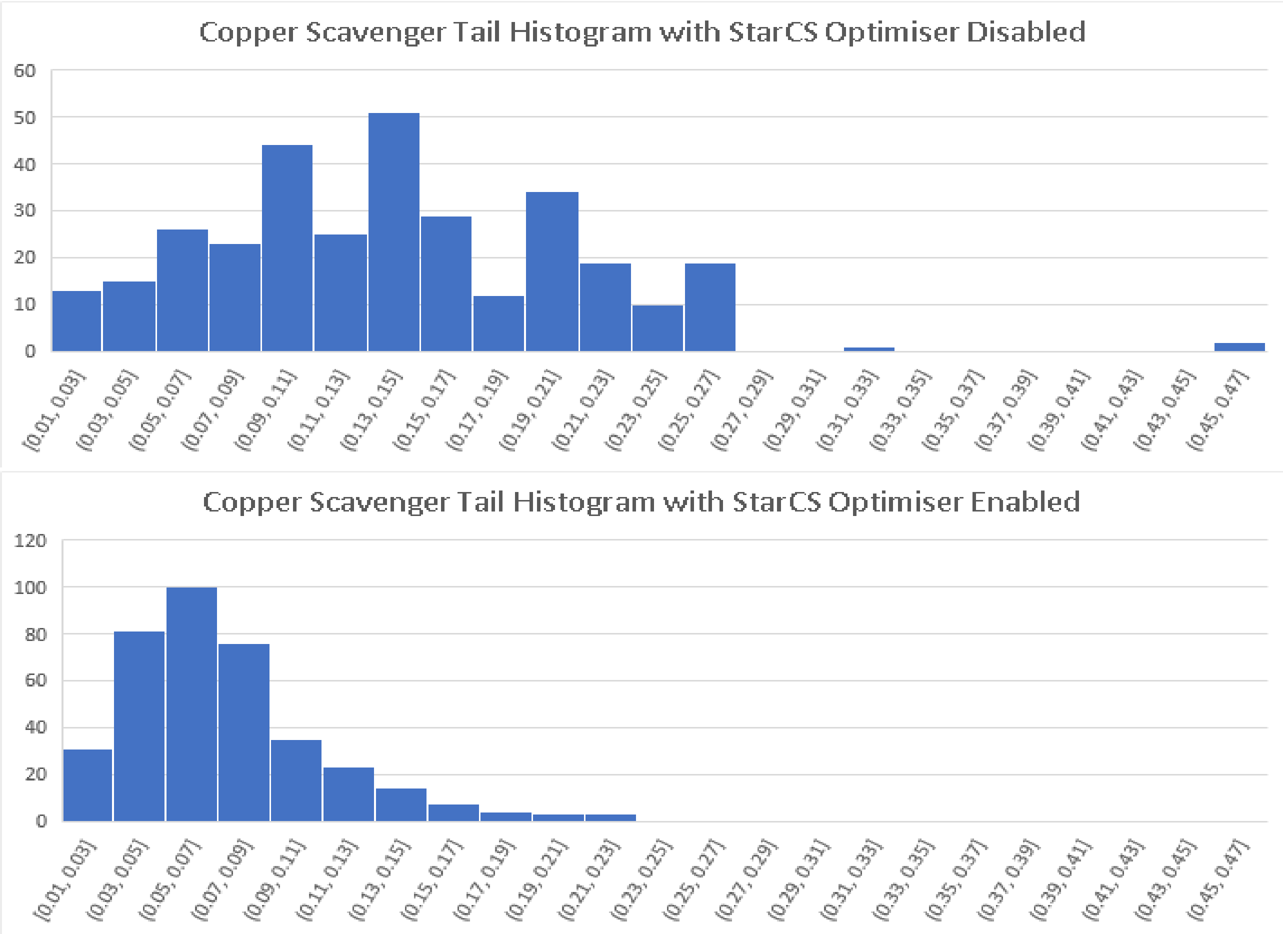

Figure 11 – Histogram plots for the copper in the Scavenger Tails with the StarCS Optimiser Enabled and Disabled

	N (samples)	p-value	Significance
Amount of Copper Present in the Copper Scavenger Tails before and after the StarCS Optimiser was implemented	700	2.37915E-42	100%

Table 2 – T-test: Proof of significance in the change of Copper grade in the Scavenger Tails (>95%)

Copper Recovery of the Copper Rougher Scavenger Circuit

To illustrate the improvement in recovery after implementation of the StarCS Optimiser, the plant samples, which are taken once over a shift and assayed in the laboratory, have been used. The results from the Blue Cube MQi measurements are similar, however have been omitted since the laboratory assay results have a higher accuracy.

The recovery percentage shown in Figure 12 is calculated using the Copper Grade laboratory assay results and the following formula:

$$Recovery\ Percentage = 100\% * \frac{Concentrate\ Grade * (Feed\ Grade - Tails\ Grade)}{Feed\ Grade * (Concentrate\ Grade - Tails\ Grade)}$$

One can see a distinct increase in the recovery in the August 2017 period when the implementation of the system began. The recovery before August 2017 was in the 80 to 85% range. After the implementation of the StarCS Optimiser the recovery percentage has moved into the 85 to 90% range. A sample of the metallurgical accounting data for the period of 1 September 2017 to 31 December 2017 has been included to support the above data and is illustrated in Figure 13. The metallurgical accounting data shows the recovery having a mean of 86.97 % for the period of 1 September 2017 to 31 December 2017. An increase of +5% in recovery is a significant benefit for the plant and illustrates the effectiveness of the system.

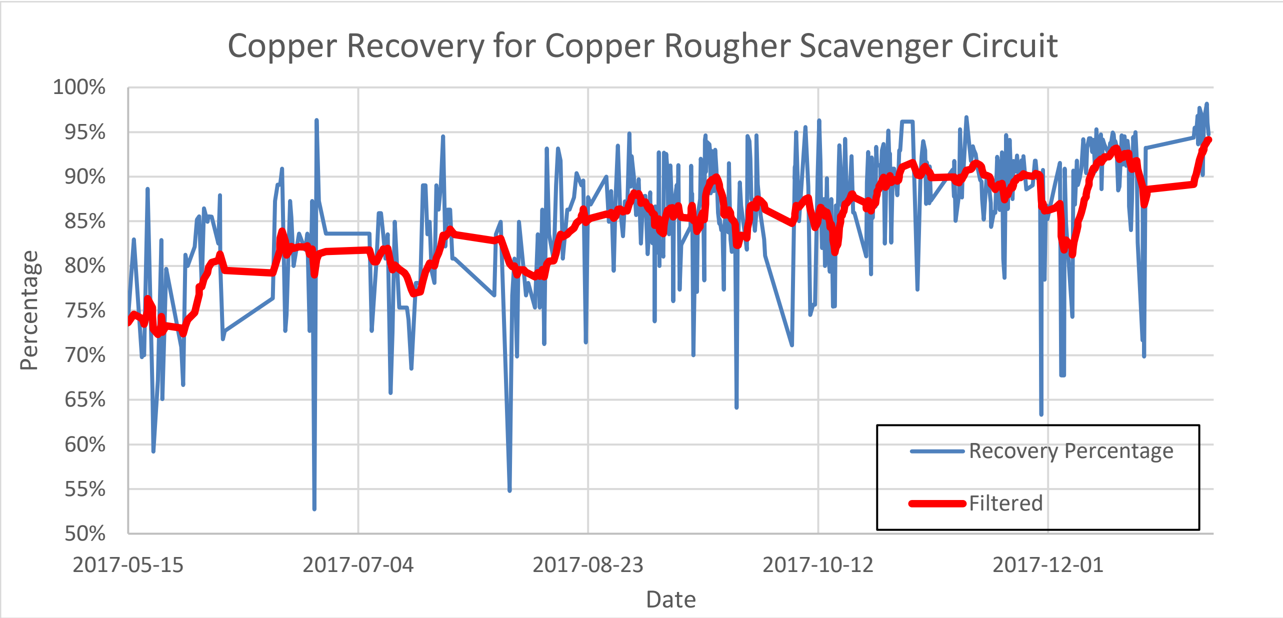

Figure 12 - Copper Rougher Scavenger Circuit Recovery

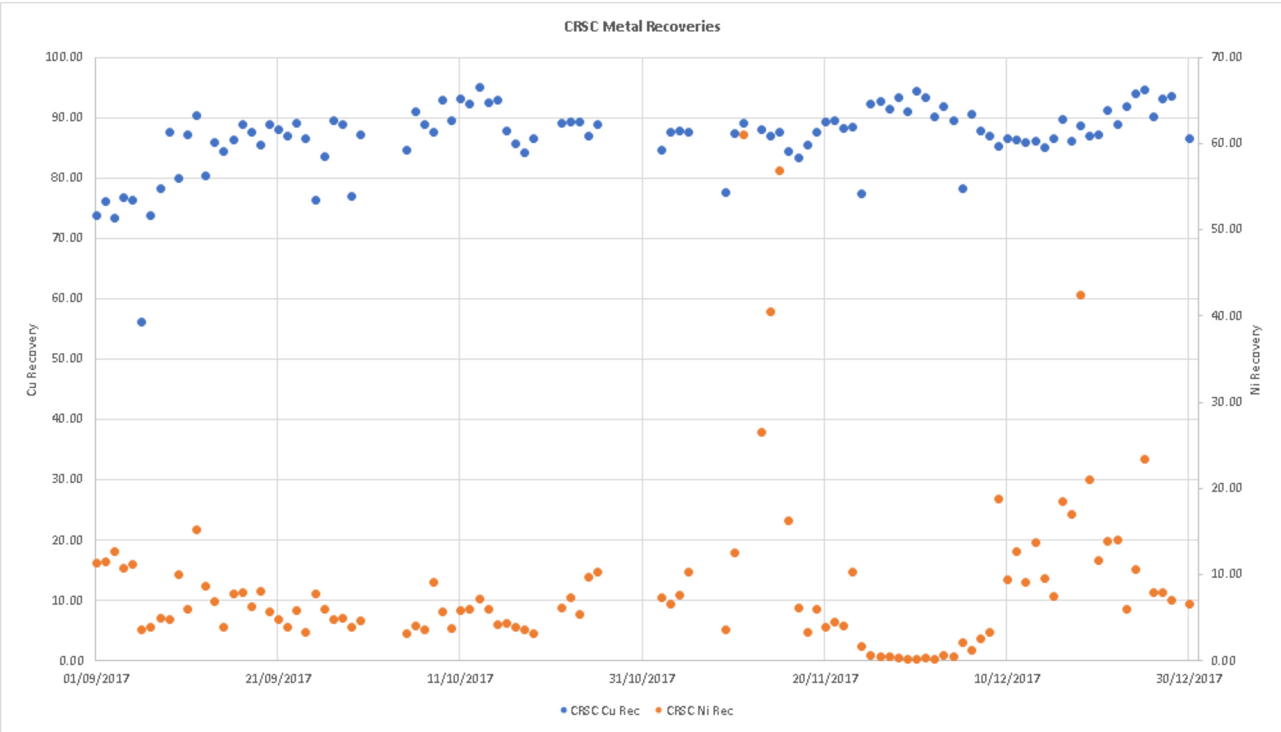

Figure 13 - Data from the balanced metallurgical accounting for the period from September 2017 to December 2017 on the Copper Rougher Scavenger Concentrate (CRSC)

CONCLUSION

Construction and design of the Independence Nova Pty Ltd processing plant with the need for advanced process control and instrumentation in mind, set the groundwork for a successful implementation of an advanced process controller.

Several notable control techniques were implemented by ProcessIQ using the StarCS Advanced Process Control platform. These include among other, varying the pull rates from the Copper Rougher Scavenger flotation cells in order to achieve a dynamic mass pull target that is based on the grade and quantity of material entering the circuit. Pull rates from individual cells can be controlled due to the availability of the froth velocity measurements from the Blue Cube TempoTracks. This aids in obtaining more consistent recoveries from the circuit. Logic was included in the system to minimise material build up that may compromise recoveries in the flotation banks.

The project has shown to provide several benefits to the plant including a reduction in copper losses in the Scavenger Tails as well as large reduction in the standard deviation of the copper present in the tails. An increase in Copper recovery in the copper concentrate stream in excess of 5% has been achieved. With the success of this project the remainder of the flotation banks were equipped with StarCS Optimisers, which rolled out the benefits to the rest of the plant.

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GLOSSARY

PLC – Programmable Logic Controller

OPC – Open Platform Communication (previously object linking and embedding for process control)

StarCS – Advance Plant Control Platform developed by Mintek

FloatStar – Application specific control module that runs on the StarCS platform aimed at stabilisation and disturbance rejection for float cell level control

Blue Cube MQi – Mineral Quantifier inline, developed by Blue Cube Systems Pty Ltd

TempoTrack – Device to measure froth velocity and height developed by Blue Cube Systems Pty Ltd

OSA – On Stream Analyser

SCADA – Supervisory Control and Data Acquisition

SCS – Plant specific term that indicates StarCS has authority to change the control variable of a PID block

SCS CAS – Plant specific term that indicates StarCS has authority to change the setpoint of a PID block

EPCM – Engineering, Procurement and Construction Management

CRS – Copper Rougher Scavenger

CRSC – Copper Rougher Scavenger Concentrate

PAX - Potassium Amyl Xanthate

TETA - Tri-ethyl Tetra Amine

Cu – Copper

Ni – Nickel

PID – Proportional, Integral and Derivative control loop

TSF – Tailings Storage Facility

MIBC – Methyl Isobutyl Carbinol; Flotation Frother Reagent